A Practitioner's Guide to Innovation Policy

Instruments to Build Firm Capabilities and Accelerate Technological Catch-Up in Developing Countries

Xavier Cirera, Jaime Frías, Justin Hill, and Yanchao Li

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Preface

In the aftermath of the financial crisis, global challenges such as threats to global trade and the slowdown in productivity are putting pressure on developing economies to revise their growth strategies. The lack of economic dynamism is hindering social inclusion and shared prosperity and triggering social unrest around the world. In this context, the role of innovation policy in increasing competitiveness and accelerating job creation has been rising in importance for policy makers. This sense of urgency has been magnified by the arrival of so-called Industry 4.0: the use of new technologies such as Artificial Intelligence, the Internet of Things, blockchain, and data processing using cyber-physical systems has started to change production process as we know them, especially in more developed economies. Automation, customization, and the increased use of service inputs in manufacturing threaten to disrupt the traditional low-skilled labor models of production prevalent in many developing nations.

Within this rapidly changing environment, developing countries are at a crossroads, facing new challenges but also new opportunities. New digital technologies enhance opportunities for participation in global value chains. Digital platforms and customization also create opportunities for e-commerce and reaching new customers. Taking advantage of these opportunities requires firms in developing countries to innovate by adopting new business models, upgrading their products and processes, and adopting more sophisticated technologies.

However, the identification of successful strategies to promote business innovation has remained elusive in developing countries. *The Innovation Paradox* (2017) flagship report, argues that developing countries systematically underinvest in innovation activities and leave the Schumpeterian gains from technological catch-up unrealized due to the lack of complementary factors and market failures that riddle their economies. Innovation policies in these countries have not been able to redress this innovation underperformance, due in part to a parallel lack of capabilities of government agencies and institutions to design and implement more effective policies.

Policy practitioners usually look at the policies implemented by peers in more advanced economies in search of formulas for success, neglecting potential solutions that could be much more effective in their working environments. The little evidence that is available to guide policies has been produced largely in and for developed economies, casting doubt about the potential replicability in less developed settings. Furthermore, many policy makers continue to operate under the old paradigm that innovation is primarily about applied science and research and development (R&D) activities.

The bias toward policies that aim to create new knowledge means in practice that countries are missing out on opportunities for broad productivity growth by investing in upgrading and adopting technologies that already exist.

This practitioner's guide, a companion volume to *The Innovation Paradox* picks up where the previous report left off. It aims to help policy makers in developing countries better formulate innovation policies. It does so by providing a rigorous typology of innovation policy instruments, including evidence of impact—and more importantly, the critical conditions in terms of institutional capabilities to successfully implement these policy instruments in developing countries. The guide aims to help fill a knowledge gap by presenting not only leading-edge empirical evidence about and practical experience with innovation policy, but also systematically discussing the market and system failures that hold back innovation in developing countries.

The time has come to pay increased attention to innovation policy making in developing countries and to bring more evidence and rigor in its design and implementation.

Caroline Freund
Global Director
Trade, Investment and Competitiveness
The World Bank

Titles in the World Bank Productivity Project

Harvesting Prosperity: Technology and Productivity Growth in Agriculture. 2020. Keith Fuglie, Madhur Gautam, Aparajita Goyal and William F. Maloney. Washington, DC: World Bank.

High-Growth Firms: Facts, Fiction, and Policy Options for Emerging Economies. 2019. Arti Grover Goswami, Denis Medvedev, and Ellen Olafsen. Washington, DC: World Bank.

Productivity Revisited: Shifting Paradigms in Analysis and Policy. 2018. Ana Paula Cusolito and William F. Maloney. Washington, DC: World Bank.

The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up. 2017. Xavier Cirera and William F. Maloney. Washington, DC: World Bank.

All books in the World Bank Productivity Project are available free at https://openknowledge.worldbank.org/handle/10986/30560.

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This report is a companion volume to the *Innovation Paradox*, part of the World Bank Productivity Project. It synthesizes a large amount of accumulated knowledge about innovation policy making at the World Bank, based on the accumulated expertise obtained through innovation-related lending operations and technical assistance, and builds on previous efforts by the Manchester Institute of Innovation Research (in work commissioned by NESTA), the Organisation for Economic Co-operation and Development (OECD), and other agencies. We are specially indebted to William Maloney for his earlier work on innovation that motivated the report, and for his encouragement. Our thanks, also, to Jakob Edler (Fraunhofer Institute for Systems and Innovation Research) and his team at Manchester University; and Kirsten Bound and Albert Bravo-Biosca at NESTA, for their encouragement and for laying the groundwork to bring evidence to innovation policy.

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Abbreviations

BAN	business angel networks
BAS	business advisory services
CGS	credit guarantee scheme
CSR	corporate social responsibility
ESE	early-stage equity
EU	European Union
FDI	foreign direct investment
FoF	fund-of-funds
GVA	gross value added
GVC	global value chain
ICT	information and communications technology
IPO	initial public offering
IPRs	intellectual property rights
ISO	International Organization for Standardization
IT	information technology
M&E	monitoring and evaluation
MNE	multinational enterprises
NGO	nongovernmental organization
NIS	National Innovation System
NQI	national quality infrastructure
NTBF	new technology-based firm
OECD	Organisation for Economic Co-operation and Development
PCP	pre-commercial procurement
PPI	public procurement of innovation
PRO	pubic research organization
R&D	research and development
SME	small and medium enterprise
S&T	science and technology
Sida	Swedish International Development Cooperation Agency (Styrelsen för Internationellt Utvecklingssamarbete)
SSO	standard setting organization

STEM	science, technology, engineering, and mathematics
STI	science, technology, and innovation
STP	science and technology parks
TC	technology centers
TES	technology extension services
TRL	technology readiness level
TTO	technology transfer office
VAT	valued added tax
VC	venture capital
WTO	World Trade Organization

Note: All dollar amounts are in US dollars, unless otherwise specified.

Innovation Agencies and Programs Cited

ANVAR	Agence Nationale de Valorisation de la Recherche (France)
APLs	Arranjos Produtivo Local (Local Produtive Arrangements) (Brazil)
	Arabianranta incubators (Helsinki, Finland)
	Arena program (Norway)
ATP	Advanced Technology Program (United States)
BICRO	Croatian Agency for SMEs, Innovations and Investments (Croatia)
	BHP Billiton's cluster program (Chile)
	BioProfile contest (Germany)
	BioRegio contest (Germany)
BIRAC	Biotechnology Industry Research Assistance Council (India)
BL	Business Link program (United Kingdom)
BNDES	Banco Nacional de Desenvolvimento Econômico e Social/Brazilian Development Bank (Brazil)
CDTI	Centro para el Desarrollo Tecnologico Industrial/Centre for the Development for Industrial Technology (Spain)
CIP300	Cradle Investment Program 300 (Malaysia)
	Collaborative R&D Program (United Kingdom)
CRC	Cooperative Research Centres Program (Australia)
	Creative Credits (Manchester, United Kingdom)
CTC	Córdoba Technology Cluster (Córdoba, Argentina)
CTID	Centros de Investigación y Desarrollo Tecnológico/Technological Research and Development Centers (Mexico)
DGF	Danish Growth Fund
DOCUP	Documento Unico di Programmazione (Piedmont region, Italy)
	DUMBO Incubator (Brooklyn, New York, United States)
	Enterprise Initiative (United Kingdom)
EIF	Enterprise Incubator Foundation (Armenia)
EFG	Enterprise Finance Guarantee program, British Business Bank (United Kingdom)
	Enterprise Support Program (Mexico)

FCP	Forward Commitment Procurement (United Kingdom)
FOGAPE	Fondo de Garantía para Pequeños Empresarios (Chile)
FONDEF	Fondo de Fomento al Desarrollo Científico y Tecnológico (Colombia)
FONTAR	Fondo Tecnológico Argentino/Argentinean Technological Fund (Argentina)
FONTEC	Fondo de empleados (Colombia)
	Fraunhofer technology center (Germany)
	Fundación Chile (Chile)
	Go-Cluster (Germany)
	Growth Vouchers (United Kingdom)
	Guidance Funds (China)
HAMAG-BICRO	Agency for SMEs, Innovations, and Investments (Croatia)
	High-Tech Offensive (Bavaria, Germany)
	Horizon 2020 Program (European Union)
	Indian Technology Centers Network (India)
	Industry 4.0 Competence Centers (Germany)
	Industrial Cluster Project (Japan)
	InnoRegio (Germany)
IF	Innovation Fund (Serbia)
	InnoFund (China)
	Innovation Hub (South Africa)
IIF	Innovation Investment Fund (Australia)
	Innovation Loan scheme (United Kingdom)
	Innovation Networks (Denmark)
iNNpulsa	Business Growth Management Unit of the national government (Colombia)
IRAP	Industrial Research Assistance Program (Canada)
iSME fund	Innovation in SMEs (Lebanon)
Kafalat	Debt Guarantee scheme for SMEs (Lebanon)
KOTEC	Korea Technology Finance Corporation (Republic of Korea)
KTN	Knowledge Transfer Network (United Kingdom)
LECC	Leading-Edge Cluster Competition (Spitzencluster-Wettbewerb) (Germany)
	Limburg scheme (Netherlands)
LMI	Lead Market Initiative (European Union)
LSVCC	Labor- Sponsored Venture Capital Corporations (Canada)
MAS	Manufacturing Advisory Service (United Kingdom)

MEP	Manufacturing Extension Partnership (United States)
MPID	Macquarie Park Innovation District (Sydney, Australia)
MTC	manufacturing technology centers (United States)
NCBR	Narodowe Centrum Badan i Rozwoju/National Centre for NNResearch and Development (Poland)
NCE	Norwegian Centres of Expertise (Norway)
	New Venture Capital Fund (China)
NRC	National Research Council (Canada)
NRC	National Research Council (United States)
	New Technology Purchasing Assurance Program (Republic of Korea)
	One-North (Singapore)
	Payroll Tax Withholding Scheme (Netherlands)
PCI	Podkarpackie Center for Innovation (Poland)
PIANOo	Professional and Innovative Tendering, Network for Government Contracting Authorities initiative (Netherlands)
PIPE	Pesquisa Inovativa em Pequenas Empresas (São Paulo state, Brazil)
	Provee/Supplier Development Project for High-Technology Multinational Companies (Costa Rica)
PITEC	Panel de Innovación Tecnológica/Technological Innovation Panel (Spain)
PROFO	Proyectos Asociativos de Fomento/Programmes of Managerial Development (Chile)
SAB	Scientific Advisory Board (Singapore)
SBDC	Small Business Development Centers (United States)
SBIC	Small Business Investment Company (United States)
SBIR (US)	Small Business Innovation Research program (United States)
SBIR (Dutch)	Small Business Innovation Research Programme (Netherlands)
SBRI	Small Business Research Initiative (United Kingdom)
SDF	Scottish Development Finance (Scotland)
SDP	Supplier Development Program (Czech Republic)
	SkatteFUNN (Norway)
Smart PCP	Smart Pre-commercial Procurement (European Union)
	Stanford Research Park (Silicon Valley, United States)
SUP	Start-Up Chile (Chile)
	Tekes (Finnish Funding Agency for Technology and Innovation) (Finland)
TIA	Technology Innovation Agency (South Africa)

TPM	Technology Park Malaysia (Malaysia)
TTGV	Technology Development Foundation of Turkey (Turkey)
TusPark	Tsinghua University Science Park (China)
	Vaekstfonden/Danish Growth Fund (Denmark)
	Vlamms Innovatienet-werk (Flemish Innovation Network) (Belgium)
	Yorkshire Forward (clusters development initiative) (United Kingdom)

Overview

The central role that business innovation plays in economic growth is almost uncontested. *Business innovation*—the invention and introduction of new products, technologies, business processes, and ideas in the market—is pivotal to both historical accounts and empirical analyses of how countries achieve economic growth and prosperity. As a result, *innovation policy*—implemented with the set of public policy instruments to support innovation directly or indirectly—is central for the growth strategies of developing and developed countries.

Policy makers are increasingly using innovation policy instruments to advance economic development. However, there is less consensus about what works when it comes to innovation policy, particularly in the context of developing countries. Most of the existing evidence relies on evaluations and empirical work conducted in developed countries, many of which are members of the Organisation for Economic Co-operation and Development (OECD), and whose conditions differ significantly from those found in developing nations.

More importantly, market and system failures that hamper innovation are pervasive in developing countries, where research quality is often inadequate, the business environment imposes high costs on firms, the infrastructure for testing and prototyping new ideas is lacking, and/or innovation finance is insufficient. Furthermore, the institutions tasked to design and deliver innovation programs often lack necessary competencies, in particular the ability to accurately diagnose and articulate the problem that is constraining innovation.

This guide aims to reduce the large information gap about what works in developing countries to improve the design and implementation of innovation policy instruments and increase their effectiveness. The document concentrates on instruments that target firm-level innovation and that focus on the firm as the prominent target group. These innovation instruments are typically designed to influence the behavior of firms to induce them to innovate, with the long-term aim of achieving a given innovation policy outcome, such as increased productivity or employment. This guide examines the different types of instruments available and defines them using a typology that combines the mechanisms of intervention in public policy with innovation policy objectives. In total, the guide includes 21 instruments grouped in 10 sets of related instruments.

Beyond firms, other stakeholders in society are also important sources of innovation. For example, governments may develop innovations to improve service delivery, and civil society organizations may advance social innovations or user-driven innovations. In addition, the range of policies related to business innovation includes research excellence, public research and development, basic research, and skills development, especially in the fields of science, technology, engineering, and mathematics (STEM). While these other stakeholders, policies, and activities are important in promoting innovation, this guide discusses them only tangentially.

This guide defines *innovation* as the ability to introduce a new product, a new idea, a new technology, or a new solution. As such, innovation includes basic upgrading of processes, products, and technologies, as well as the invention of new products and technologies. Thus, the document challenges the long-standing view that innovation is primarily about science, formal research and development (R&D), and inventions. These are indeed very important, but are only a part of the innovation process, and are limited in most developing countries, where more basic forms of imitation and upgrading are important. In the case of firms in developing countries, innovation is primarily about adapting existing technologies and imitating other products and processes.

How to Use This Guide

This guide has two parts. The first part (chapters 1, 2, and 3) builds the intellectual foundation for the entire guide. The first three chapters are slightly more conceptual in nature and describe the approach to innovation policy and general guidelines about good practices in designing and implementing innovation policies. The second part (chapter 4) describes the menu of instruments available to policy makers, the evidence about their impact, and the institutional and contextual factors that determine their effective design and implementation. Chapter 5 summarizes main messages.

The best way to use this document depends on the interests of the reader. Someone with familiarity with innovation policy, and who is interested in learning about a specific instrument and the intricacies of delivering such a program, might wish to browse the instrument profiles in section 4. Someone more interested in articulating new policies and considering alternatives might start with the first part of the document, including chapters 2 and 3 (especially the section about a typology of problems and market failures). Newcomers to innovation policy, who are looking to immerse themselves in the topic, might wish to read the document from beginning to end.

The reader should keep in mind that in practice, the nature of innovation is complex and nuanced, and context matters. Policy makers may struggle to identify the market failure and target the optimal response to this problem. The language in this guide is not meant to imply that this process can be pursued with surgical precision. Nevertheless, the information provided can help anchor the problem, and in particular clarify necessary conditions to implement each instrument. For each instrument profile, the document discusses the problem that it seeks to address; the key target group; the strengths, limitations, and risks; the evidence on impact; and the extent of replicability in developing countries' institutional settings. This information can be useful to better design and implement innovation policy instruments and increase their effectiveness. This endeavor is more urgent than ever in the face of rapid technological change, which has intensified risks of divergence between advanced and developing countries.

PART I

1. The Innovation Policy Challenge and Introduction to this Guide

The central role that *business innovation*—the introduction and invention of new products, technologies, business processes, and ideas in the market—plays in economic growth is almost uncontested. Innovation drives the Schumpeterian process of creative destruction and can facilitate economic convergence for the countries farther from the frontier (Schumpeter 1942). Innovation is the critical ingredient in historical accounts of how countries achieve economic growth and prosperity. A growing body of evidence has shown that increased innovation activity has a measurable and positive impact on firms' productivity (Mohnen and Hall 2013), which in turn improves a country's overall competitiveness. As a result, *innovation policy*—implemented with the set of public policy instruments to support innovation directly or indirectly—is central for the growth strategies of developing and developed countries and is not subject to the controversies related to the use of other policies, such as industrial policy.

However, and despite the policy consensus around innovation policy, the quality and composition of innovation policies differ greatly across countries. Innovation policies in Organisation for Economic Co-operation and Development (OECD) countries tend to be broader in scope, more multifaceted, and more sophisticated than in developing countries, where innovation policies are often incipient and fragmented. More importantly, while many countries are trying to develop and deepen these policies, there is little clarity about what works and what doesn't, and about what policies are most effective at different stages of development.

This guide aims at filling this gap to support policy makers in developing countries in their quest to foster innovation. Improving the effectiveness of innovation policies is even more urgent in the current context of rapid technological change and digitalization, when the risks of increasing the technological divide between advanced and developing countries are high, and large opportunities for technological catch-up could be foregone if policies are not appropriate.

1.1 The Innovation Policy Challenge in Developing Countries

Challenge 1. Managing Complex Innovation Policies with Scarce Government Capabilities

Policy makers and practitioners in developing countries face an important challenge when designing and implementing innovation policy. Market and system failures that prevent investments in innovation activities in countries farther away from the frontier are pervasive. Insufficient research quality, a costly business environment, lack of testing and prototyping infrastructure, and/or insufficient finance for innovation are common features of these countries. But the necessary policy capabilities to diagnose problems, identify policy solutions, and implement them are very weak. This translates into an important policy dilemma: how to manage complex innovation policies with scarce government capabilities.

To confront this dilemma and minimize the risk of failed innovation policies, this guide proposes to focus on several key areas: getting the mix of policies right (chapters 2 and 3); investing in government capabilities through better processes and institutions (chapter 3); and addressing the information gap (chapter 4). The first two areas are briefly described here and developed in more detail in Cirera and Maloney (2017). The last area is the central focus in this document.

Challenge 2. Getting the Set of Policies Right—Supporting the Capabilities Escalator

A critical question is what combination of policy instruments is more appropriate to each context. While every country and context are different, the guide offers a framework to help in the choice of instruments that are more appropriate based on the stage of development of the innovation capabilities of firms and the implementation capabilities of governments: the *capabilities escalator* (Cirera and Maloney 2017). For each country, combinations of technological capabilities differ across firms, so there is no unique policy mix that can be described. However, the capabilities escalator suggests ways to deal with this heterogeneity by focusing on changing the intensities of policy support as firms accumulate capabilities and increase their technological sophistication.

Challenge 3. Addressing a Large Information Gap on How to Undertake and Support Innovation Policy

There is a significant lack of information about the right innovation policy tools for every problem and context. Policy makers are often unaware of the range of instruments available to address a specific innovation problem, and the institutional capacity and market conditions required to implement policies successfully. Despite important recent efforts to systematize evidence on the impact of innovation policy instruments,[1] the few existing studies focus primarily on OECD countries. Consequently, agencies often copy policy instruments from other countries without adequate consideration of these issues, which can lead to significant missed opportunities to formulate effective innovation policies.

A key objective of this guide is to reduce this large information gap to improve the design and implementation of innovation policy instruments and increase their effectiveness. The guide offers some guidelines on good practices in the design and implementation of innovation policy and describes the menu of instruments available to policy makers, the existing evidence about their impact, and the institutional and contextual factors that determine their effective design and implementation. The latter is particularly important given the extent of replication of innovation policies. For instance, many science, technology, and innovation ministers dream of replicating the success of Silicon Valley in their respective countries. However, given their existing domestic conditions, a “Silicon Valley solution” is inappropriate, especially given that Silicon Valley is the outcome of a unique mix of factors that cannot be replicated. In the case of firms in developing countries, innovation is primarily about adapting existing technologies for local conditions and imitating other products and processes. This guide can help policy makers ask the right questions and make more informed decisions that can lead to more appropriate and effective innovation policy instruments.

1.2 From Upgrading to Invention—A Broader Definition of Innovation

Before starting, it is important to define what this guide means by innovation and innovation policy. *Innovation* relates to the ability to introduce a new product, a new idea, a new technology, or a new solution. As such, innovation includes basic upgrading, but also the invention of new products and technologies. Thus, the guide challenges the long-standing view that innovation is only science, formal research and development (R&D), and inventions. These are very important parts of innovation, but not all of innovation.

While innovations from other stakeholders in society are also important, such as governments introducing improvements in service delivery and civil society organizations proposing social innovations or user-driven innovations, this guide focuses on public policy instruments that aim at fostering innovation activities in firms. While the authors acknowledge that science, the generation of new ideas, and other forms of nonmarket innovation are critical to create the knowledge that facilitates firm-level innovation, including these instruments would have made the scope of the guide too broad.

Specifically, this guide defines *innovation policy* as an array of policy instruments by which government intervenes in markets and in society to overcome market and systemic failures that prevent the realization of desired innovation outcomes.[2] These policy instruments try to change beneficiaries’ and stakeholders’ behavior to accomplish a given innovation policy objective. Different kinds of instruments are available. In this guide, policy instruments are defined based on a typology that combines the actual mechanism of intervention in public policy (such as grants, loans, tax incentives, and services) with a given innovation policy objective (chapter 4 provides the full description of the full array of instruments). In total, the report reviews around 20 instruments grouped in 10 sets of related instruments. This represents the bulk of the policy support offered to businesses to promote innovation in most countries.

Innovation policy usually consists of an overarching strategy with specified goals, delivered through several instruments that are used at once. Thus, innovation policy encompasses the combination of existing instruments that interact and complement one another—the so-called *policy mix*. This is important because innovation activities are usually not developed in isolation but depend on the systemic interactions among firms (Edquist 2011) and ". . . the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman 1987). As a result, innovation policy needs to respond to these intertwined set of interactions and ensure that existing framework conditions and institutions are appropriate for facilitating innovation activities.

The Imperative of Innovation Policy in the Changing Technological Era

This guide is not meant to offer rigid recommendations about the validity of each instrument. Evidence on the impact of innovation instruments around the world is limited, and success often depends on local contextual factors or the quality of design and implementation. Therefore, the recommendations aim at providing relevant information to redress the huge information gap that policy makers face in making innovation policy. However, implementing new instruments requires experimentation and finetuning, good sequencing, and more importantly, good measurement and learning to adapt and adjust the instrument to local conditions. This guide is not a substitute for having good processes in place for the design, implementation, and governance of innovation policy instruments. As chapter 3 emphasizes, building good processes and policy capabilities is critical to the effectiveness of innovation policies.

While readers are encouraged to read chapters 2 and 3, which provide more background on how to do innovation policy, more experienced readers can go straight to the discussion of specific instruments in which they are interested. However, the guide is also meant to act as a warning to be selective and honest about government capabilities—human and financial. An important goal is to prioritize policies that are more likely to be effective, rather than trying to do too many things with too few resources.

The document is structured as follows. Chapter 2 briefly makes the case for innovation policy and discusses how to set priorities. This chapter also provides some guidelines on organizing and sequencing the *policy mix* by introducing the concept of the *capabilities escalator*. Chapter 3 provides some ideas on building government capabilities by implementing basic principles for good policy making to help the design and implementation process, as well as ideas on how to better structure implementing agencies. Chapter 4 discusses the different policy instruments. This chapter starts by providing a justification for the typology of instruments used, and then for each instrument profile discusses the problem that it seeks to address; the key target group; the strengths, limitations, and risks; the evidence on impact; and the extent of replicability in developing countries' institutional settings. Chapter 5 concludes.

Notes

1. See, for example, MIoIR and Nesta, *Compendium of Evidence on the Effectiveness of Innovation Policy* (http://www.innovation-policy.org.uk/compendium/).
2. There is significant potential for overlap in objectives and instruments between SME (small and medium enterprise), industrial, and innovation policy and other areas like environment policy (such as cleaner production processes), energy policy (such as the development of renewable energy), and skills policy. This guide includes as part of innovation policy those instruments that primarily target innovation, defined as the development, introduction, and utilization of upgraded or new products, processes, technologies, marketing strategies, organizational structures, and business models.

References

Cirera, X., and W. F. Maloney. 2017. *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up*. Washington, DC: World Bank.

Edquist, C. 2011. "Design of Innovation Policy through Diagnostic Analysis: Identification of Systemic Problems (or Failures)." *Industrial and Corporate Change* 20 (6): 1–29.

Freeman, C. 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.

MIoIR (Manchester Institute of Innovation Research) and Nesta. *Compendium of Evidence on the Effectiveness of Innovation Policy.* http://www.innovation-policy.org.uk/compendium.

Mohnen, P., and B. H. Hall. 2013. "Innovation and Productivity: An Update." *Eurasian Business Review* 3 (1): 47–65

Schumpeter, J. 1942. *Capitalism, Socialism and Democracy*. New York: Harper & Brothers.

2. Innovation Policy in Developing Countries

This chapter makes the case for the need to strengthen innovation policy in developing countries. It shows how firms in developing countries tend to underinvest in activities related to innovation and provides some suggestions on why this is the case. More importantly, the chapter describes how to correct some of the existing biases and misconceptions related to innovation and suggests a framework to design more appropriate and effective policies.

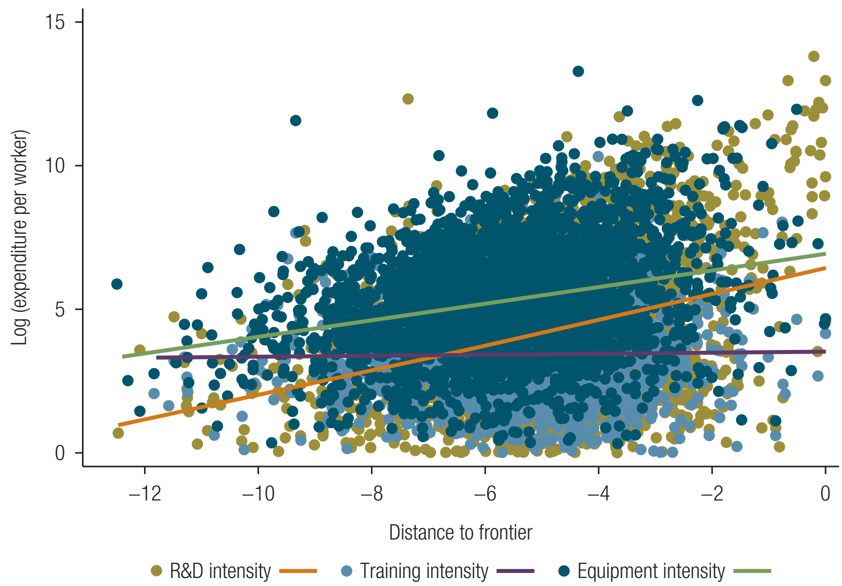
2.1 The Innovation Imperative in Developing Countries

Investments in Innovation are Lower in Lower-Income Countries

A key characteristic of Schumpeterian growth is the large potential gains from technological catch-up. The returns to innovation increase with distance to the technological frontier (defined as the countries that use leading technologies), as Griffith, Redding, and Van Reenen (2004) find for a sample of firms from member countries of the Organisation for Economic Cooperation and Development (OECD). However, firms in developing countries invest significantly less, on average, than firms that are closer to the technological frontier, despite the apparent potential. Cirera and Maloney (2017) find that for a large cross-country sample of firms surveyed by the World Bank Enterprise Surveys,[1] the further the distance to the relative productivity frontier—that is, how far a firm's labor productivity is from the top decile (90th percentile) in the sector for the entire sample—the lower the intensity of two types of innovation inputs: purchase of equipment, and research and development (R&D) (figure 2.1). By contrast, the intensity of training does not appear to be related to the distance from the technological frontier.

The same relationship can be observed at the country level. Firms in countries further away from the frontier (measured by GDP per capita) are less likely to purchase a technology license or to introduce a product that is new to the national market (figure 2.2). While firms in Africa, for example, also undertake significant innovation activity that is "new to the firm,"[2] this result likely reflects some mismeasurement (Cirera and Muzi 2016) and in most cases entails small changes rather than significant innovations that have large impacts on productivity.

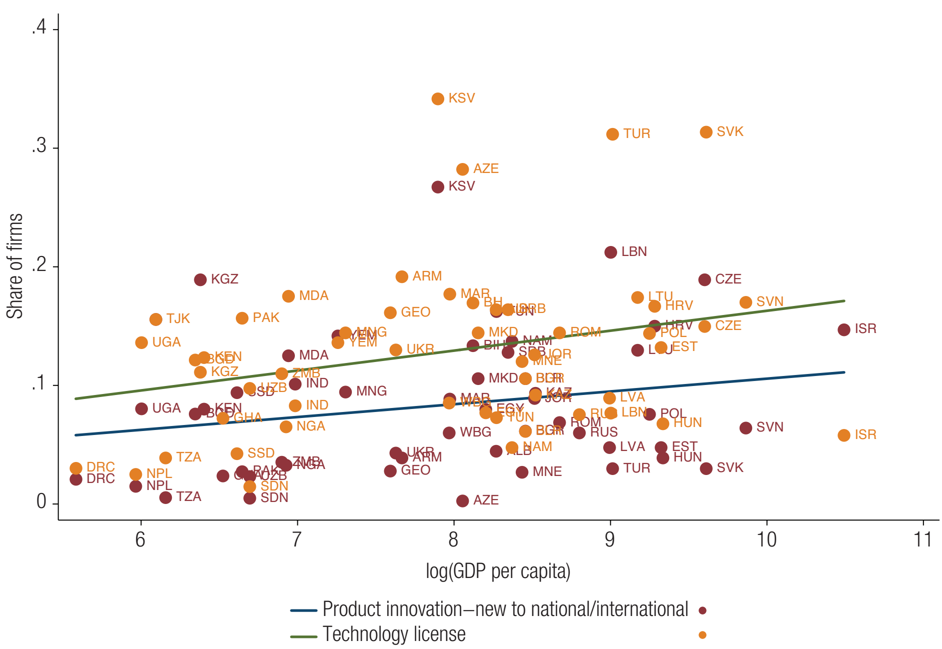
FIGURE 2.1 Innovation Investments and Distance from the Relative Productivity Frontier



Source: Elaboration using Enterprise Survey data.

Note: Intensity is measured in terms of $1000 of expenditure per worker.

FIGURE 2.2 Innovation Activities and Per Capita GDP



Source: Elaboration using Enterprise Survey data.

Note: Each point indicates the average number of firms in the country undertaking the indicated type of innovation. Country labels are International Organization for Standardization (ISO) country codes.

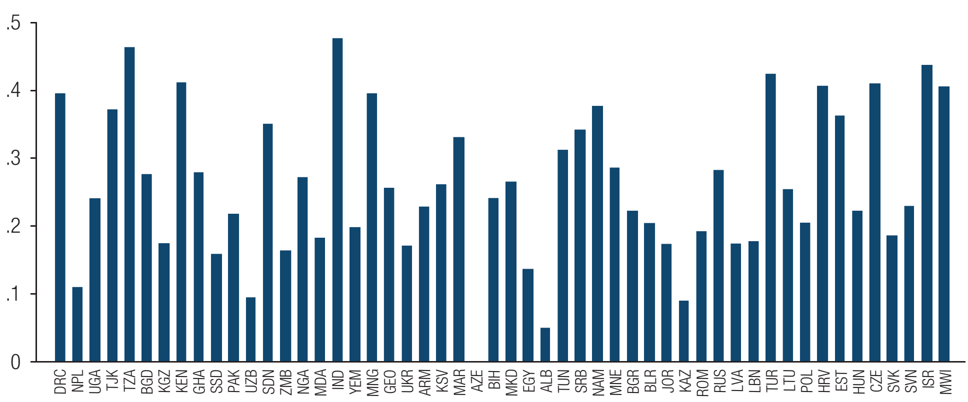
Innovation Often Does Not Require Formal R&D Activities and More "Incremental" Types of Innovation are Critical to Have a Sizeable Impact on Innovation and Productivity

A traditional view of innovation among some academics and policy makers sees innovation as a linear process—whereby science generates R&D and then is transformed into innovations in the markets by firms. This model, which has been very influential in defining innovation policies, is biased toward more radical, disruptive, and novel innovations. While such innovations are of course important, the model misses the fact that most firms can gain substantial improvements in productivity by adopting knowledge and technologies that have already been generated.

Only a minority of firms that are engaged in innovation invest in R&D. Figure 2.3 shows the share of firms that have introduced product and process innovation and that invest in R&D activities by country, based on the sample of formal firms from the Enterprise Surveys. For the whole sample, only 31 percent of innovator firms have invested in R&D activities. Innovation in developing countries, therefore, requires other activities to accumulate knowledge that are not necessarily formalized in terms of R&D, such as imports of technology or use of information from clients and suppliers, to introduce innovations in products and processes. This, as discussed later, has implications for innovation policy.

Recognizing that innovation policies in developing countries need to aim first to ensure that most firms develop the necessary capabilities to undertake this more "incremental" type of innovation is essential to attaining sizable improvements in innovation and productivity. Redressing this R&D/science bias is critical for effectively

FIGURE 2.3 Share of Innovators (Product or Process) Engaging in Formal R&D Activities



Source: Elaborations using Enterprise Survey data.

Note: Country labels are International Organization for Standardization (ISO) country codes.

targeting innovation policies. The objective is not to stop funding instruments to foster R&D, but to balance the composition of budget allocations to be more aligned with the capabilities of the private sector.

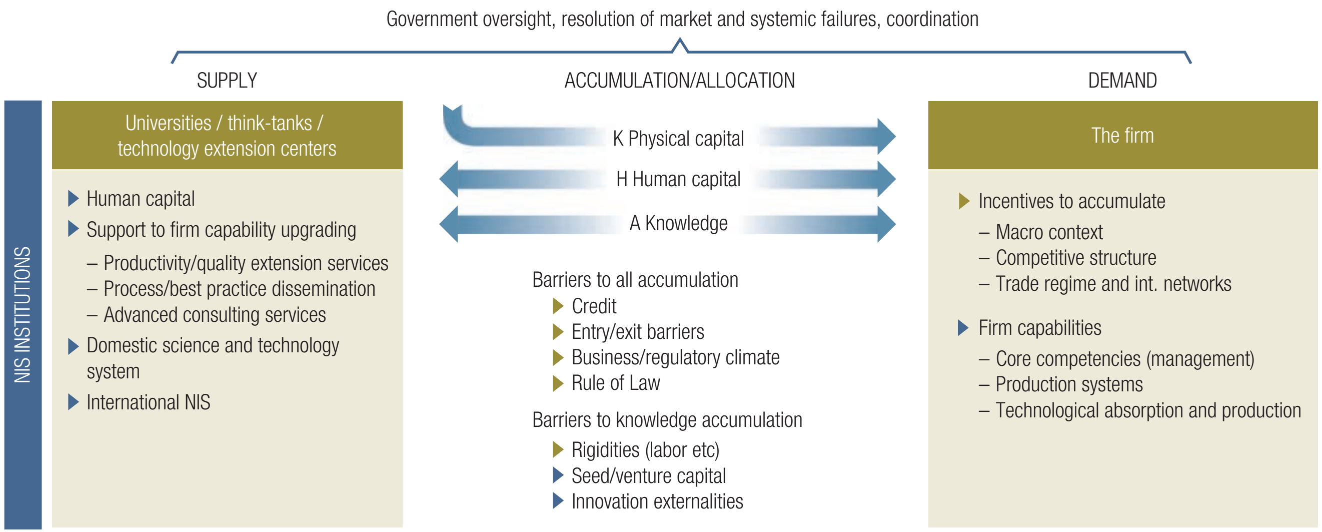
It is Important to Consider the Complementarities in the Expanded National Innovation System

The key to the significant underinvestment in innovation activities observed in developing countries is the lack of critical complementary factors, Cirera and Maloney (2017) suggest. Without elements such as appropriate skills, access to foreign technologies, competition, an enabling environment, and, more importantly, good managerial and organizational practices, innovation projects are more likely to fail, depressing the returns to innovation investments in developing countries.[3] The challenge for policy makers is to identify which critical complementarity factors are lacking within the *National Innovation System (NIS)*—the constellation of actors, policies and institutions that affect the creation of knowledge and adoption of innovation. What are the critical factors that will determine success in innovation and that often are beyond the scope of innovation policy?

Identifying these complementary factors is even more complex in developing countries, where critical infrastructure, skills, or other important factors are underdeveloped or missing. The key questions, therefore, are which factors should be the focus and priority for policy makers, and where should they draw the line. Maloney (2017) provides a graphical representation of the National Innovation System (figure 2.4) that serves to identify some of the problems and missing complementarities that are likely to affect innovation.[4] At the center of the National Innovation System is the firm (the demand side of knowledge) that uses, accumulates, and implements knowledge in the form of improved products, processes, and adoption of existing or new technologies. On the supply side of knowledge are all the institutions that generate knowledge that feed the innovation process, such as universities, research institutions, technology centers, business development providers, skills providers, or support services for small and medium enterprises (SMEs). One important element is that the supply of knowledge is also coming from outside the National Innovation System, given the fact that most innovation in developing countries is based on existing knowledge and technology primarily generated in advanced countries.

Figure 2.4 identifies some of the key complementarities needed in the National Innovation System. One important element depicted in the figure is that both the barriers and incentives to accumulate and invest in any type of factor of production, such as capital and assets, also affect investments in knowledge assets and innovation. For example, competition affects investments in capital, but also investments in innovation. Similarly, high costs of doing business that constrain investments in new premises are also likely to constrain investments in new machines, skills, and business processes. Therefore, when thinking about innovation, the policy maker

FIGURE 2.4 The National Innovation System



Sources: Cirera and Maloney 2017, based on Maloney 2017.

Note: NIS = National Innovation System.

needs to look at these general constraints and incentives in the system, as well as those that are particular to innovation, such as externalities or lack of access to technology.

Only the Well Prepared Will Benefit from Digitalization and the Fourth Industrial Revolution

The world is undergoing a significant technological transformation that is reshaping how and where goods and services are produced. Some are calling it the Fourth Industrial Revolution or Industry 4.0, where production is characterized by the integration of cyber-physical systems such as robotics, 3D printing, artificial intelligence, and machine learning. While production processes are still transitioning to this new technological regime, a significant increase in digitalization of business and production functions is already occurring, given rise to new business models and economic activities.

Some optimistic commentators see this new paradigm as an opportunity for converging to the frontier. But most commentators are more pessimistic, predicting a widening of the technological gap and the income divide. The scant evidence available supports the second group; while the speed of technology adoption across countries has accelerated, adoption within countries remains slow (Comin and Mestieri 2018). These new technologies are likely to be more demanding in some of the complementary factors needed for technology adoption across firms, such as infrastructure, the business environment, and core competences in relation to critical business practices such as marketing and management skills.

Thus, the view of potential leapfrogging is a naïve and unlikely one. Only those countries that have strengthened their National Innovation System to have the complementary factors to support digitalization and the adoption of new technologies will succeed. This increases the urgency for more effective and focused innovation policies that address the key challenges in adopting these new technologies and building the necessary capabilities. But what are these necessary capabilities?

2.2 Firm Capabilities for Innovation: The Importance of Managerial and Organizational Practices

While external factors such as competition or the cost of doing business are critical to encourage innovation, the ability of firms to innovate ultimately depends on their capabilities to implement innovation projects successfully. But what are these capabilities? Cirera and Maloney (2017) attempt to conceptualize these necessary capabilities. The interest in understanding the concept of firm capabilities is rooted in Penrose's (1959) seminal work on the nature (and growth) of the firm. However, views on the nature of these capabilities differ. On the one hand, neoclassical theories of the firm have traditionally conceptualized these capabilities and the process of technology adoption as a black box (Rosenberg 1982). Under this paradigm, firms were seen as organizations with the main objective of reducing transaction costs (Coase 1937). Important efforts were made in the late 1970s and 1980s to explain differences in firm growth, for example emphasizing managerial talent (Lucas 1978) or learning (Jovanovic 1982). These models, however, fail to offer a clear conceptualization of the processes that enable firms to learn and acquire tacit knowledge.

Organizational theory, management-related fields, and most of the innovation literature have also examined the concept of firm capabilities in more detail. These studies focus on identifying the precise set of capabilities (and combinations of capabilities) that firms must acquire, develop, and accumulate to introduce innovations or maintain competitive advantages. Although these strands overlap to some extent, they provide different conceptualizations of firm capabilities, which has resulted in a lack of a unifying framework to understand capabilities.

Sutton (2012) provides a definition of these capabilities as those elements of the production process that cannot be bought "off the shelf" on the market like a normal input and hence must be learned and accumulated by the firm. These capabilities range from basic organizational skills to logistical abilities (see Syverson 2008) to planning routines and systems of human resource management.

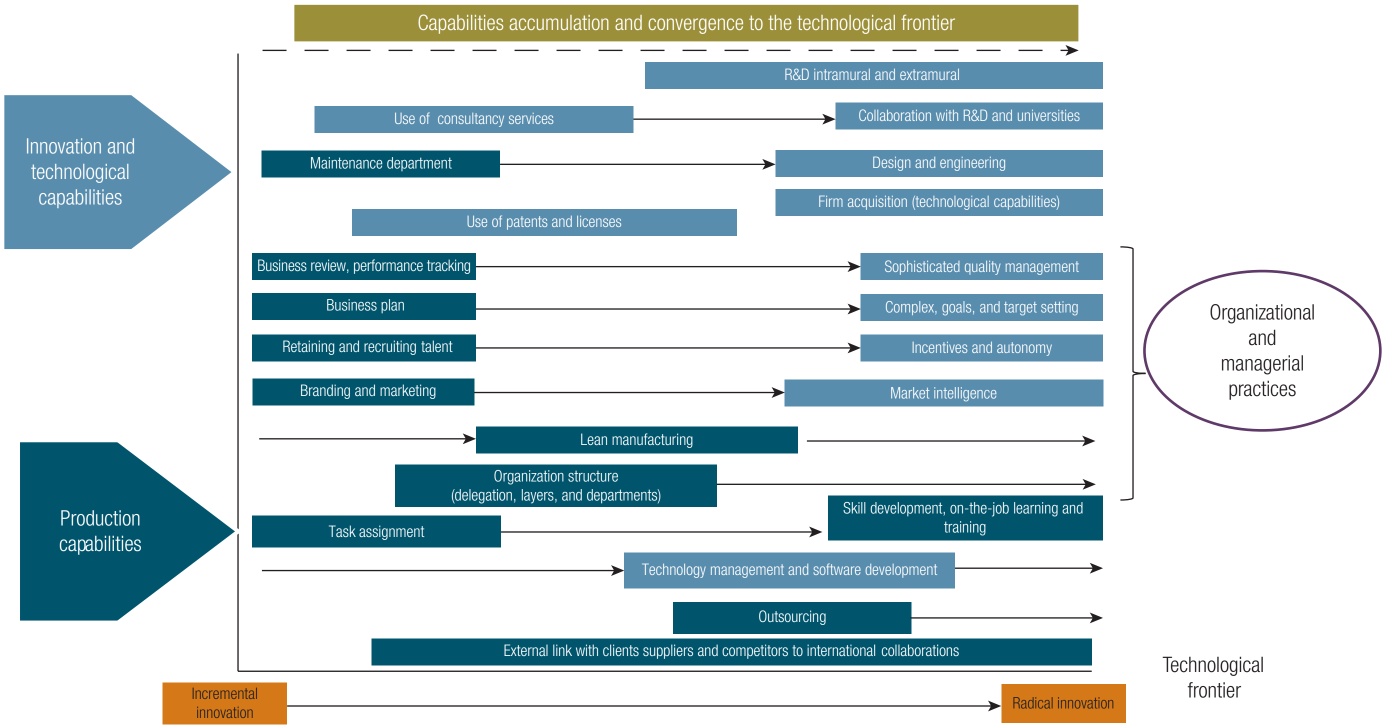
One illustration of some of these capabilities is provided in figure 2.5, which attempts to capture the breadth and need for the accumulation of capabilities across several dimensions as firms increase the sophistication of their innovation activities. Moving from left to right, the figure represents the process of catching up, where innovation shifts from simple technology adaptations and improvements in products and processes to more R&D–intensive technology and product generation. Moving toward the frontier requires increased accumulation and sophistication in some of these capabilities, as well as more specialized human capital, such as engineers and designers.

The Importance of Managerial and Organizational Competencies for Learning and Innovation

While different sectors require different specialized knowledge, some capabilities, especially managerial and organizational capabilities, are critical for innovation regardless of sector (figure 2.5). Managerial practices are essential to manage and accumulate knowledge and organize the routines needed for innovation. For example, target setting, or quality management and monitoring, are key activities to manage innovation projects across different sectors. Innovation also requires the articulation of internal incentives to ensure that workers are allocated to tasks where they can be more productive and have the incentives to propose improvements (or are not penalized).

This central role that organizational practices play in firms' knowledge management is not new. Some case studies focusing on the East Asian experience of industrial upgrading in counties like Japan; Taiwan, China; and Singapore emphasize that

FIGURE 2.5 Firm Capabilities and Innovation



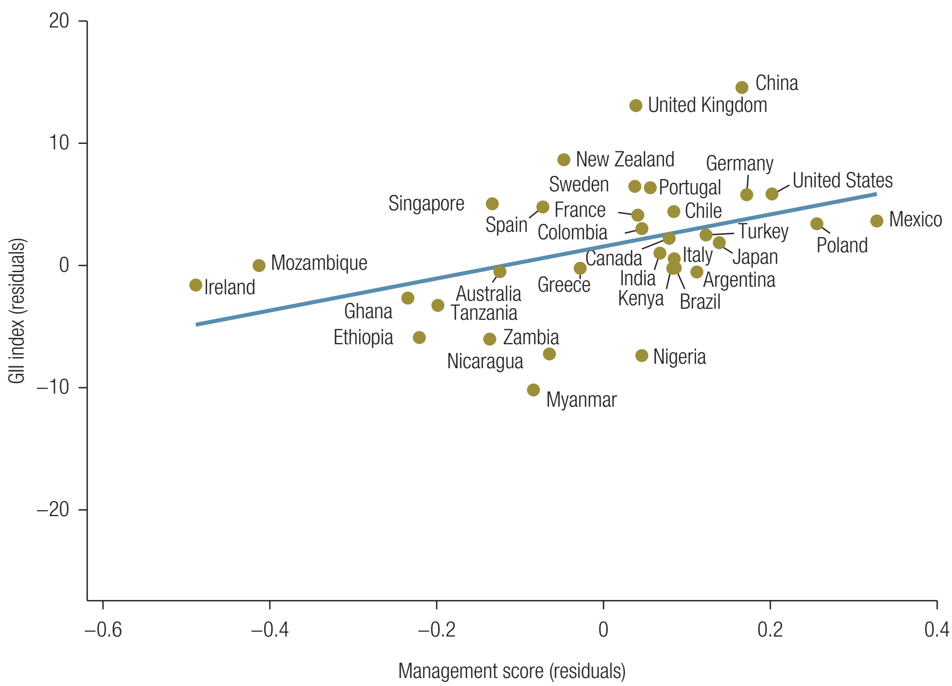
Note: R&D = research and development.

the rapid learning process previously described was facilitated by the introduction of managerial and organizational processes, establishment of dedicated design and engineering departments, and/or development of quality management processes (Bell and Figueiredo 2012).[5]

Cirera and Maloney (2017) explore this issue for a large number of countries and different types of data. Better management quality is associated with better innovation performance across countries and firms. Those countries with higher scores in management quality also have higher scores in the Global Innovation Index (figure 2.6), while firms with better management quality are more likely to introduce product and process innovations (figure 2.7).

Improving these managerial capabilities is the building block for innovation policy. Managerial and organizational practices are critical capabilities for innovation. The intuition is simple. Managing R&D projects or introducing new processes efficiently and successfully requires the effective use of human resources, the deployment of effective marketing strategies, and the efficient implementation of other key business functions. These basic competencies are necessary conditions for the successful development of innovation projects and the accumulation of learning and technological

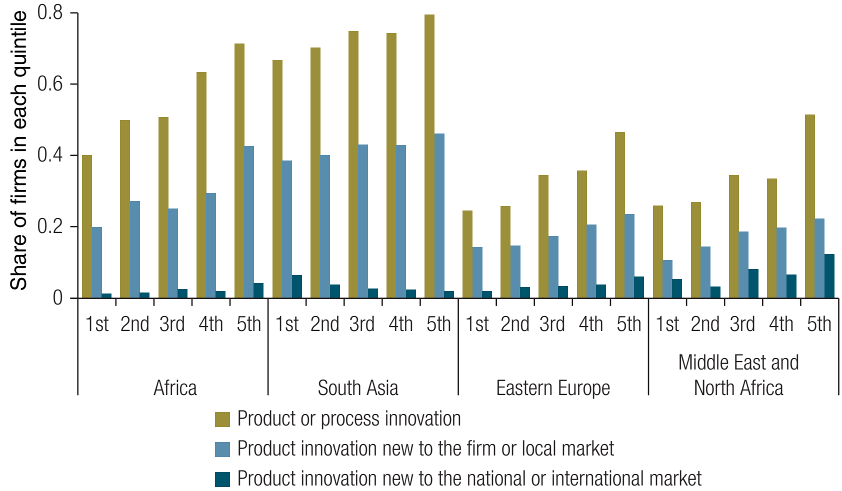
FIGURE 2.6 Management Quality and the Global Innovation Index



Source: Cirera and Maloney 2017.

Note: The Global Innovation Index is an annual ranking of countries by their capacity for, and success in, innovation published by INSEAD and the World Intellectual Property Organization.

FIGURE 2.7 Management Quality and Innovation Incidence



Source: Cirera and Maloney 2017.

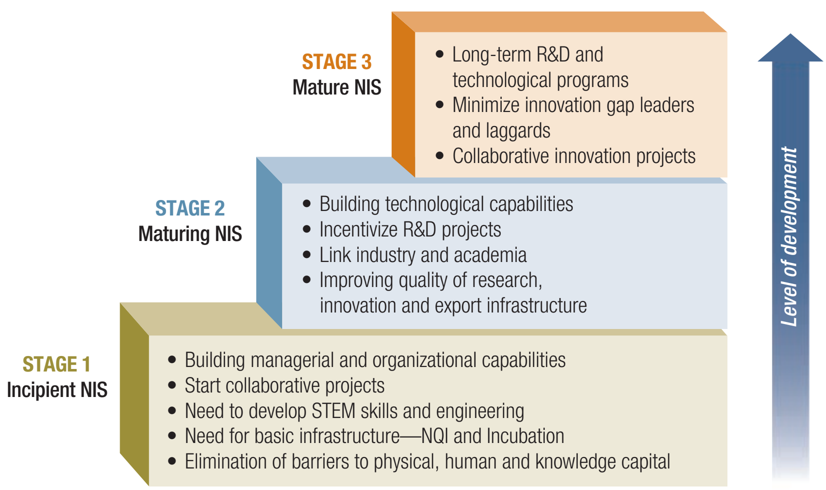
capabilities. Firms progressively build on their accumulated capabilities, facilitating more and more sophisticated innovation. Bell and Figueiredo (2012), for example, characterize innovation in the manufacturing sector as proceeding in different stages corresponding to discrete levels of innovation complexity. From implementing minor adaptations and imitation of products and processes using a few qualified technicians, successful firms move to more incremental innovation using engineers in organized units for product development and introducing better marketing and managerial practices. A second transition to more advanced innovation and catch-up involves various types of engineers and designers, R&D departments, and collaboration with knowledge providers, with more centralized knowledge management and more sophisticated lean production processes. Firms that reach the technological frontier tend to have internationally recognized R&D departments, sophisticated organizational practices and incentives, and strong collaboration with knowledge providers. A similar capabilities accumulation process, marked by gradual learning and accumulation of capabilities, can be observed for firms in services and agriculture.

2.3 The Need to Prioritize Policies Across the Capabilities Escalator

Countries face multiple system and market failures that constrain innovation, which in response requires a combination of instruments—the *policy mix*. The multidimensionality of the innovation problem can be simplified by choosing the appropriate combination of policy instruments. The need to build the capabilities for innovation highlighted previously—that is, the process of climbing the *capabilities escalator*—can discipline the choice of appropriate instruments. Firms increase their sophistication of innovation and move from being able to imitate products and process, and adopt basic technologies, to more radical innovation and the generation of new technologies and inventions. Cirera and Maloney (2017) simplify this capacity building process into three stages. In Stage 1, firms accumulate primarily production and management capabilities that allow firms to more efficiently manage basic innovation processes and adopt basic technologies. In Stage 2, firms start accumulating those technological capabilities that facilitate the adoption of technologies and the introduction of more sophisticated products and processes that tend to be new to the firm. Finally, in Stage 3, those capabilities expand to being able to replicate more sophisticated innovations, and even to generate products and processes that are new to the world: that is, new inventions and new technologies.

The need to build the policies to help firms climb the capabilities escalator highlights the imperative of considering countries' technological maturity and innovation capacity in sequencing the different combinations of instruments in the *policy mix*. Using the representation of the escalator (figure 2.8), the stages of the firm can be described in terms of the maturity of the National Innovation System. In this regard, an incipient National Innovation System, as in most low-income countries, will have a lot of firms with Stage 1 capabilities and a large number of missing critical complementary factors and large institutional bottlenecks. A maturing National Innovation System will have a mix of firms in Stage 1 and 2 capabilities, with very few firms with advanced Stage 3 capabilities. This is the case for many middle-income countries. Finally, a mature National Innovation System will have a

FIGURE 2.8 The Variation of Policies Along the Capabilities Escalator



Source: Cirera and Maloney 2017.

Note: NIS = National Innovation System; NQI = national quality infrastructure; R&D = research and development; STEM = science, technology, engineering, and mathematics.

healthier mix of policies with more firms in Stages 2 and 3, better institutions, and more availability of complementary factors. This is typically the case for advanced economies.

The framework is not meant to be deterministic. In one moment in time, countries are likely to have firms at different capabilities stages. Nevertheless, the framework is helpful to structure and sequence the combinations of innovation policy instruments that are most appropriate to support existing capabilities. Cirera and Maloney (2017) develop the suite of instruments to address these capabilities stages, most of which are identified in figure 2.8.

Innovation in firms in incipient National Innovation Systems often involves ad hoc efforts, including the adoption of managerial and organizational practices, the introduction of basic technology—such as machinery (often in the form of second-hand equipment)—the exercise of rudimentary marketing, and/or the limited use of digital technologies in business-to-business or business-to-consumer services. Even as firms become more sophisticated, innovation activities are rarely radical—involving the development of new-to-the-world inventions—because demand for novel local goods in these markets is low. As such, the policy mix should respond to the need to strengthen the *absorptive capacity* of firms (Cohen and Levinthal 1990): firm's ability to use and apply knowledge for introducing innovation. However, this response implies deliberate strategies to increase absorptive capacity. To this end, firms need to employ increasingly sophisticated strategies and develop their financial systems, market linkages, human resources, and overall management because these underpin effective innovation.

As firms within developing countries grow more sophisticated, the intensity of innovation activity increases, and the types of innovation introduced by firms tends to increase in sophistication and quality. In some cases, this development will result in higher factor costs—such as wages and infrastructure costs, creating a drive for efficiency. Likewise, if firms are looking to export or enter supply chains, they will need to improve internal systems and meet standards. In some sectors, improvements will entail greater expenditure on R&D, and adaptations in the form of more complex business model innovations. In this transition, instruments that support business R&D projects,[6] and collaboration that drives interaction across firms and between firms and other knowledge providers, become more important. Finally, as countries become developed, innovation policies become dual in nature: promoting new technologies and supporting more complex innovative projects, while enhancing productivity improvements and innovation in laggard SMEs.

The Stages of the Policy Mix and the Capabilities Escalator

Following this logic of building capabilities through the escalator, the discussion that follows describes the main features of the National Innovation System as they converge toward the technological frontier in three broad stages. Table 2.1 profiles

TABLE 2.1 The Policy Mix in Different Stages of the National Innovation System

Stage	Symptoms	Causes		Enabling conditions		Illustrative policy mix of instruments
		Absorptive capacity in firms	Knowledge generation and collaboratio capacity	Entrepreneurship ecosystem conditions	Complementary public goods for science, technology, and innovation	
Stage 1: Incipient (long distance of firms to the technological frontier). This stage is prevalent in low- and lower- middle-income countries.	Firms carry out dispersed and less systematic innovation activities. *Inputs.* Firms have basic managerial and organizational practices and conduct little formal R&D. *Outputs.* Very low quality of innovation. Patenting is virtually nonexistent. Lack of entry in export markets, and exports based primarily on commodities.	Low absorptive capacity to transfer technology from advanced to developing economies. ■ Firms have limited awareness of the potential benefits from innovation. ■ Lack of technology literacy, and low levels of technological, management, and productive capabilities reduce adoption.	■ Basic research capacity remains deficient and unaligned with needs of industry. ■ Firm's applied R&D capacity is minimal. ■ Knowledge inflows from FDI remain low. ■ Mechanisms for science-industry exchange and collaboration are weak. ■ Lack of cooperation between firms; innovations developed informally and in isolation; absence of firm clusters. ■ Low research capacity in universities and absence of industry-university collaboration.	■ Lack of export orientation reduce incentives for local firms to innovate. ■ Environmental and consumer protection and social regulations are often either weak or not properly enforced. ■ FDI penetration is usually low, and existing investments are concentrated in extractive industries, promising minimum spillovers to the local economy. ■ High rates of business informality hinder adoption of technology and innovation. ■ Significant distortions reduce competition and increase misallocation.	■ Absent or obsolete innovation infrastructure. Limited R&D and quality infrastructure makes innovation costlier for firms. ■ Low availability of laboratories, testing facilities, and other NQI systems reduce incentives for firms to acquire new innovation. ■ STEM education and postsecondary technical programs remain basic. ■ Academic competencies for research remain low. ■ Essential technological and science infrastructure is lacking. ■ A weak intellectual property rights framework slows investments in R&D.	■ Focus on employing instruments that support absorptive capacity and capabilities: ○ Technology extension and diffusion programs. ○ Early-stage infrastructure and advisory services (incubators). ○ Inducement instruments (competitive grants and prizes). ○ Standards and basic NQI infrastructure for innovation. ■ Foster collaboration and simple innovation projects, such as: ○ Vouchers for collaboration. ○ Direct grants for business innovation (with embedded advisory services).

(Table continues on the following page.)

TABLE 2.1 The Policy Mix in Different Stages of the National Innovation System *(continued)*

Stage	Symptoms	Causes		Enabling conditions		Illustrative policy mix of instruments
		Absorptive capacity in firms	**Knowledge generation and collaboratio capacity**	**Entrepreneurship ecosystem conditions**	**Complementary public goods for science, technology, and innovation**	
Stage 2: Expanding national innovation systems. This stage is more prevalent in upper-middle-income and some high-income countries.	Incremental innovation remains prevalent. Isolated cases of radical innovation occur. The generation of new technologies and more complex innovative projects is incipient. *Inputs*. Intensity of R&D and the level of sophistication of knowledge inputs increase. *Outputs*. Firms start participating in technology sectors, with increased presence of manufacturing and services exports, and incipient participation in global value chains. A few university spin-offs and patenting applications occur.	▪ Firms undertake modest investments in knowledge activities. ▪ Most learning remains informal, but firms start developing more sophisticated competencies, particularly around quality. ▪ Some learning through global value chains and participation in international markets.	▪ Specific sectors and multinational enterprises conduct formal R&D activities in-country. R&D activities remain incipient. ▪ Collaboration between firms, and between firms and universities, to conduct joint innovation activities occurs but is relatively underdeveloped. ▪ A few clusters of good and applied research in universities appear. ▪ As more publicly funded resources become available, universities start getting involved in R&D, for example, through competitive research funding. ▪ Knowledge inflows from international research partnerships are more prevalent.	▪ Increasing internal demand and participation in export markets raises performance standards for products. ▪ Higher consumer standards and safety regulations increase demand for quality infrastructure. ▪ Increased export orientation and sophistication of exports creates competitive pressures for domestic firms. ▪ The enabling environment for firms improves, but some distortions remain, and competition is lacking in specific sectors. ▪ FDI commitments are stronger, and there are signals of local content development, with modest knowledge spillovers. ▪ Business informality exists but is not prevalent.	▪ A deficit of engineers and STEM skills increases the costs of firms, as such human capital becomes unavailable or must be imported from abroad. ▪ Technological and science infrastructure is relatively available. However, the quality of testing infrastructure and R&D facilities is not sophisticated. ▪ Competitive scientific research funding is relatively available. ▪ An intellectual property rights framework is available on a limited basis.	▪ In addition to continuing to build absorptive capacity, instruments that start supporting R&D projects and university-industry collaboration become more important: ○ Technology extension programs and business advisory services. ○ Grants for innovative projects to finance prototyping, testing, and commercialization activities and technical assistance. ○ Early-stage infrastructure and advisory services (incubators) and some accelerators. ○ Innovation vouchers and grants for collaborative projects. ○ Collaborative, network, and systemic policies for innovation. ○ Loan guarantees with accompanying firm-level capacity building and advisory services. ○ Open innovation initiatives.

(Table continues on the following page.)

TABLE 2.1 The Policy Mix in Different Stages of the National Innovation System *(continued)*

Stage	Symptoms	Causes		Enabling conditions		Illustrative policy mix of instruments
		Absorptive capacity in firms	Knowledge generation and collaboratio capacity	Entrepreneurship ecosystem conditions	Complementary public goods for science, technology, and innovation	
Stage 3: Mature National Innovation System (some sectors at the technological frontier). This stage is more prevalent in higher-income economies.	*Inputs.* Presence of radical inventions. Significant R&D intensity in some sectors, but less so among SMEs. *Outputs.* A few technology-intensive sectors generate new technologies, but a significant part of the SME sector lags behind larger firms. Significant amount of university spin-offs. Large number of exporter firms and widespread import of inputs and participation in global value chains. Developed tech sector.	■ Firms have more developed competencies and are generally more inclined to conduct innovation. Some market failures still prevail—externalities in the case of tech sectors and asymmetric information for SMEs. ■ Good supply of quality services to support tech absorption and other complementary factors.	■ University research is strong, with high contractual R&D activity and patenting activities in universities. ■ Consolidated clusters exist and there is a good amount of innovation collaboration in larger companies. ■ Public funding is widely available. Several knowledge providers (including universities) remain highly engaged in conducting diverse R&D activities. ■ Knowledge partnerships between domestic providers and international research agencies are well established.	■ Business regulation promotes a relatively friendly and competitive business climate. ■ Market requirement levels are high due to high export orientation and strong consumer protection mechanisms. ■ The macroeconomic context is highly stable, and labor market rigidities are few. ■ FDI intensity remains high, and of high quality, with evident linkages of positive knowledge spillovers to the local economy. ■ The depth of credit and capital markets ensures that promising ventures enjoy funding.	■ Intellectual property rights and regulation are relatively developed. ■ Knowledge institutions offer advanced degree scholarships at a high rate, ensuring availability of specialized human capital for the local economy. ■ Universities and innovation agencies undertake advanced strategies to acquire talent, promoting knowledge exchanges with international and domestic sources of specialized skills. ■ Modern R&D infrastructure and well-developed quality and standards infrastructure ensure that transaction costs for innovative firms remain relatively low. ■ The skill base is relatively developed, although gaps may still exist, particularly in specific STEM skills.	■ The policy mix combines a variety of instruments for SMEs to ignite innovation with instruments to support the generation of frontier technology and projects with high R&D intensity. These include: ○ Tax incentives for R&D. ○ Grants to large, long-term, and collaborative R&D projects. ○ Procurement for innovation. ○ Equity finance for innovation and early-stage capital. ○ Science and technology parks. ○ Tech extension and business advisory services.

Sources: For the greater national innovation system (NIS), Maloney 2017; for complementary public goods for science, technology, and innovation, elaborations and Crespi, Fernández-Arias, and Stein 2014.

Note: FDI = foreign direct investment; NQI = national quality infrastructure; R&D = research and development; SMEs = small and medium enterprises; STEM = science, technology, engineering, and mathematics.

these development stages, describing expected symptoms and their probable causes, conditions of the entrepreneurship ecosystem,[7] and appropriate combinations of instruments to respond to these issues. This characterization will vary by country, depending on each country's endowments and institutions, but it represents a broad categorization of the most salient and prevalent innovation characteristics to guide design of the policy mix.

When countries reach the development frontier, innovation policies tend to focus on helping to generate new technologies and backing increasingly complex innovative projects, while continuing to build absorptive capacity in straggling SMEs. Considering the stages of a country's development in relation to the technological frontier, the guide highlights key elements for the design and composition of the policy mix:

- A focus on technology adoption should take precedence over technology creation in less developed countries, leading to policy combinations that increase the absorptive capacity of firms. As firms build capabilities to discover new technologies, policy mix arrangements should increase support to R&D and technology generation programs (Stage 1).
- Instruments that support absorptive capacity and capabilities (such as business advisory services and technology extension) and instruments that foster collaboration and simple innovation projects (such as vouchers for collaboration and some grant support) are likely to be more appropriate in less developed countries. Given the difficult market conditions for innovation, instruments linking these innovation activities with market opportunities (such as exports and supply chain development) can be more effective than those that just "push" innovation. Also, building basic support infrastructure, such as national quality infrastructure (NQI)[8] and standards services, underpins the ability of firms to absorb knowledge (which is also important for export/supply chain initiatives). Instruments that primarily address financial imperfections (such as loan guarantees or matching grants) without any accompanying firm-level capacity building may prove to be ineffective if absorptive capacities are low and thus firms cannot utilize these financial inputs very effectively.
- When the National Innovation System starts to mature, in addition to continuing to build absorptive capacity, the policy mix should gravitate toward instruments that support R&D projects and collaboration by companies with one another, and among companies and knowledge providers (Stage 2).
- In mature innovation systems, the policy mix should combine instruments targeting technology-intensive firms to support technology generation at the frontier and projects that are highly intensive in R&D with a variety of instruments geared toward SMEs to ignite their innovation activities, facilitate technology diffusion, and promote upgrading of their innovation capabilities (Stage 3).

This framework has an added advantage for the public sector. In addition to improving the targeting of policies to the capabilities needs of the private sector, the framework can also help policy makers develop the necessary *government capabilities* to better design and implement innovation policies (see chapter 3).

But before discussing how to support the building of these government capabilities, it is important to discuss some common myths about innovation policy that are not backed by evidence and that can result in bad policy designs and prevent or impede effectiveness.

2.4 Dispelling Some Myths About Innovation in Developing Countries

Myth 1. Success Can Be Achieved by Mimicking Successful Innovation Policy Instruments and Institutions

There is a widespread belief that the replication of successful institutional blueprints for innovation policy in one country will recreate similar results in another. Policy makers are rightly attracted to the idea of looking outside their own jurisdiction for solutions to their problems and for new approaches. After all, part of their responsibility is to understand what has worked elsewhere, and why, and to avoid "reinventing the wheel." Some policy makers may say "let's replicate Silicon Valley in my country" or "let's bring 'centers of excellence' here, so we can achieve similar rates of innovation." However, despite their good intentions, policy makers looking to graft institutional forms, structures, and arrangements from other countries into their own often fall into a trap.

The misconception that success can be easily mimicked can lead to disappointment for two main reasons. First, successful institutions usually evolve organically within a local ecosystem and are shaped by local conditions, rather than being designed or engineered. So, when they are copied elsewhere, they do not necessarily respond to all local problems in a new setting. Second, policy makers may adopt institutional forms without their proper functionality, attracted by "notional policies" and the allure of "best practices" (Andrews, Pritchett and Woolcock 2012). The lack of functionality is often related to absence of organizational capability to implement policies. In most developing countries low capabilities in the private sector are mirrored by low capabilities in the public sector. Thus, implementing innovation policies requires building capabilities in the public sector and allocating enough resources—financial and human—to effectively design and implement these policies.

This is not to say that innovation policy makers should not look for good practices and designs elsewhere. It is important that they do so, but when designing new policy instruments, there should be an honest assessment of the necessary human and financial resources needed to implement them. Also, if external models are being used, a clear idea of how local conditions should change the design and delivery of these models is critical, as discussed in the next section.

Myth 2. Innovation is a Linear Function of Science, R&D, and Inventions

As mentioned, innovation has often been viewed in policy circles as an R&D–intensive activity to generate inventions and new technologies. As shown in figure 2.3, this is a grossly misplaced focus, which is evident in the biased amount of public resources oriented to R&D,[9] as opposed to other types of innovation. The problem with this thinking is that even if countries have some firms with the capabilities to succeed in this type of "high-tech" activity, the efforts may consume scarce resources, which could be put to uses that are more relevant to broader industry.

A view of innovation that centers on R&D and invention ignores three key elements. First, innovation and invention are not equivalent. Invention is one element of innovation but needs to be made usable for customers and turned into commercially viable products that generate returns. Second, considering this broader definition of innovation implies that the set of capabilities required to imitate and to adapt existing technologies and processes are potentially broader than R&D capabilities, as depicted in figure 2.5. Adaptation and imitation require good managerial practices, the ability to identify which technologies may be most relevant, the ability to reverse engineer and adapt existing plant and equipment, problem solving, production competencies, and modern production processes and design capabilities. Third, even in cases where R&D capabilities are important, firms might not be able to capitalize on their own investment in R&D if they do not possess the required competencies, such as the ability or finance to commercialize the resulting knowledge capital. In other words, it is critical to consider the extent of complementarities between R&D and other firm-level capabilities.

Therefore, a more appropriate view of innovation policy needs a more holistic view of innovation that considers policies and institutions that aim to support the breadth of firm-level innovation capabilities, not only R&D.

Myth 3. Developing Countries are Not Ready to Benefit from Innovation Policy

Another belief is that firms in developing countries are not ready to capture the benefits from innovation policy programs, particularly because they operate in environments that lack the structural foundations that are necessary to reap the benefits (such as lack of intellectual property laws and product quality rules). However, empirical evidence suggests that many firms in developing countries do attain positive returns from investing in innovation activities (Cirera and Maloney 2014). This means that many investments will be beneficial, although in most cases below the large gains predicted by Schumpeterian theory. As discussed, this is due to the absence of "factor complementarities" at the firm level and at the national level, including firms' managerial competencies, availability of skills, the quality of scientific infrastructure, or the regulation of intellectual property. Even though this lack of complementarities depresses the returns to innovation, the returns to such investments are often positive.

Myth 4. Build the Necessary Infrastructure and Innovation Will Occur

A final myth that is been internalized in many middle- and low-income countries is an excessive focus on building *hard* science and technology infrastructure, such as science parks, technology transfer offices, incubators, and other innovation-related infrastructure, while ignoring *soft* infrastructure and critical complementarities. As shown in chapter 4, science parks require good research and university departments as well as mentoring programs, and technology transfer offices require good intellectual property protection, incentives for research, and applied commercialized research. Policy makers need to look more systemically at innovation policy and their own National Innovation Systems and consider where the necessary complementary factors are in place and what complementary polices and services are required. It is not enough to just build the infrastructure.

Notes

1. An almost identical questionnaire was implemented during the period 2013–15 in firms in 51 countries in developing Europe and Central Asia, the Middle East and North Africa, South Asia, and Sub-Saharan Africa. The survey covered more than 30,000 firms, including small firms and some microenterprises, in both manufacturing and services.
2. The Enterprise Surveys, in line with other innovation surveys, use three broad categories of novelty for firm-level innovation: whether it is new to the firm, new to a market or industry, or new to the world.
3. Investing in new product development can be problematic when there is ineffective intellectual property/product regulation/consumer protection that reduce barriers to entry by competitors or when there is no market awareness of the product. But even for productivity-enhancing innovation that is internal to the firm (such as improving processes through organizational or machinery upgrading), the lack of complementary factors like skills and effective training or reasonable finance inhibits innovation.
4. Although this figure is labelled "the National Innovation System," it can be adapted to all levels of governance, including the international level, given the increasingly more internationalized flow of knowledge and technologies. A good example is the European Union.
5. More recently, Garicano and Rossi-Hansberg (2015) have emphasized that the capacity of a firm to exploit new technologies greatly depends on its organization. Individuals are time-bound in their ability to deploy knowledge to solve problems. Organizational hierarchies relax this constraint by creating layers of teams where "expert" workers manage less knowledgeable workers, thus increasing the experts' time availability and enabling them to specialize.
6. Even in R&D projects, instruments evolve in terms of capabilities and complexity from process improvement R&D to reverse engineering R&D and new product R&D.
7. The *entrepreneurship ecosystem* is the environment for entrepreneurship, encompassing infrastructure, the incentives for start-ups, the availability of financial and nonfinancial support, and the entrepreneurial culture.
8. A *national quality infrastructure* comprises five core components to ensure quality: standardization, testing, measurement, certification, and accreditation.
9. See, for example, the R&D targets in the European Union (EU) under the Lisbon Agreement.

References

Andrews, M., L. Pritchett, and M. Woolcock. 2012. "Escaping Capability Traps through Problem-Driven Iterative Adaptation (PDIA)." Working Paper 299, Center for Global Development, Washington, DC.

Bell, M., and P. N. Figueiredo. 2012. "Innovation Capability Building and Learning Mechanisms in Latecomer Firms: Recent Empirical Contributions and Implications for Research." *Revue Canadienne d'Études du Développement* 33 (1): 14–40.

Cirera, X., and W. F. Maloney. 2017. *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up*. Washington, DC: World Bank.

Cirera, X., and S. Muzi. 2016. "Measuring Firm-Level Innovation Using Short Questionnaires: Evidence from an Experiment." Policy Research Working Paper 7696, World Bank, Washington, DC.

Coase, R. 1937. "The Nature of the Firm." *Economica* 4 (16): 386–405.

Cohen, W. M., and D. A. Levinthal. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly* 35: 128–52.

Comin, Diego, and Martí Mestieri. 2018. "If Technology Has Arrived Everywhere, Why Has Income Diverged?" *American Economic Journal: Macroeconomics* 10 (3): 137–78.

Crespi, G., E. Fernandez-Arias, and E. Stein. 2014. *Rethinking Productive Development*. New York: Palgrave Macmillan for the Inter-American Development Bank.

Garicano, L., and E. Rossi-Hansberg. 2015. *Knowledge-Based Hierarchies: Using Organizations to Understand the Economy.* NBER Working Paper 20607, National Bureau of Economic Research, Cambridge, MA.

Griffith, R., S. Redding, and J. Van Reenen. 2004. "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries." *Review of Economics and Statistics* 86 (4): 883–95.

Jovanovic, B. 1982. "Selection and the Evolution of Industry." *Econometrica* 50 (3): 649–70.

Lucas, R. E. 1978. "On the Size Distribution of Business Firms." *Bell Journal* 9: 509–23.

Maloney, W. 2017. "Revisiting the National Innovation System in Developing Countries." World Bank, Washington, DC.

Penrose, E. 1959. *The Theory of the Growth of the Firm*. New York: Oxford University Press.

Rosenberg, Nathan. 1982. *Inside the Black Box: Technology and Economics*. Cambridge, UK: Cambridge University Press.

Sutton, J. 2012. *Competing in Capabilities: The Globalization Process*. Oxford, UK: Oxford University Press.

Syverson, C. 2008. "Markets: Ready-Mixed Concrete." *Journal of Economic Perspectives* 22 (1, Winter): 217–34.

3. Building Government Capabilities for Innovation Policy

While the previous chapter discussed the importance of innovation policy and its centrality in academic and policy circles, the reality in many developing countries is that innovation policy is still fragmented and underdeveloped. Judging by the often-small allocation of public resources devoted to foster innovation and its bias toward R&D investments, innovation policies are often not appropriately designed. More importantly, the limited evidence about the impact of such policies does not suggest that governments are very effective in encouraging innovation.

An important part of the problems and challenges with innovation policy in developing countries is related to the ability to design and implement these policies effectively. This chapter focuses on how to build these government capabilities for innovation and make innovation policies more effective. It describes some key principles and processes to help minimize the risk of government failures that could lead to poor policies and wasted resources.

Solving the Innovation Policy Dilemma

Addressing the complexities of innovation policy making in developing countries requires confronting the *innovation policy dilemma*: while the complexity of innovation policy is higher in developing countries because of the combination of significant market failures and the multiplicity of missing complementary factors, the government and institutional capabilities to design, implement, and coordinate an effective innovation policy mix are weaker (Cirera and Maloney 2017). For example, efforts to support university-industry collaboration for technology transfer often face many problems. On the supply side, there is often a dearth of applied research in universities, inadequate incentives for research, and a lack of research infrastructure or an appropriate framework for intellectual property. On the demand side, firms may face some market failures—externalities or asymmetric information—that result in a lack of finance, incentives, or knowledge that discourages collaborating with universities. The dilemma, therefore, consists of where to allocate the scarce government resources available in the face of so many constraints.

A first step in confronting this dilemma is to minimize these complexities through *better sequencing of policies along the capabilities escalator* (section 2.3). This consists of encouraging the use of innovation instruments that are commensurate with the implementation capacity of government agencies and the maturity of the innovation system, thus narrowing down the multidimensionality of problems and objectives and more importantly, building in parallel firms' capabilities for innovation and government's capabilities for policy design and implementation.

The second critical element to address the dilemma is to *build the government capabilities to design and implement innovation policies*. This requires:

1. Adopting good practices in the design and implementation of innovation policy (section 3.1).
2. Designing well-functioning implementing agencies (section 3.2)
3. Improving the design of innovation policy instruments and the correct identification of the innovation "problem" (sections 3.3 and 3.4)
4. Facilitating informed choices when using policy instruments, drawing on evidence of their impact and experience from implementation of innovation policy (chapter 4).

The remainder of this chapter describes the first three elements to build these government capabilities, while the knowledge needed for addressing the information gaps in innovation policy is discussed in chapter 4.

3.1 Elements of Good Innovation Policy Making

Avoiding Copy-and-Paste Innovation Policy

Promoting business innovation often requires policy instruments that can be sophisticated in their design and complex in their implementation.[1] A natural starting point for policy makers when choosing one or another policy instrument is to replicate what "successful" countries have implemented. For example, a significant number of technology parks are commissioned after government officials visit countries such as the Republic of Korea that use this instrument extensively. While the use of evidence—even from a different country—is critical to guide the selection of instruments and their design, there are some important risks. Weak government capabilities can lead to importing policy designs and practices that may look good on paper but are not appropriate to the local context and do not achieve the desired results—a practice that has been labelled *isomorphic mimicry* (Andrews, Pritchett, and Woolcock 2012).

Adopted instruments could fail to produce the desired impact for several reasons. Problems arise when (1) the identification of the problem is poor; (2) the local context is very different than the one where the instrument is supposed to work; (3) implementation capabilities are low; (4) expectations for the impact or the amount of time it requires are unreasonable; and/or (5) the resources allocated do not match the task. While there is no mechanistic way to undertake innovation policy that will guarantee the desired impact, robust principles and processes applied in the design and implementation stages can limit the risk posed by the problems described.

There are three main areas where having good practices can aide the process of innovation policy making and minimize risks of failure. The first relates to the *rationale and design* of specific policy instruments. This requires identifying the right problem that constrains innovation activities and choosing the appropriate instrument(s) that can address it (see section 3.4). In this regard, having a clear intervention logic that establishes the direct and plausible connection between the problem, the chosen courses of action, and the desired outcome can help minimize the risks inherent in an intervention. The second is related to the *quality of implementation*. The use of good public management practices, operational experience, and evaluation practices can greatly help policy makers better implement and adapt existing instruments to enhance their efficacy. The third area relates to the *coherence and complementarities* across policy instruments. Often the efficacy of innovation policies depends on the interactions among policy instruments. The success of an instrument to create technology transfer offices to support university-industry collaboration, for instance, will critically depend on existing policies to support the quality of applied research, on university incentives to work with the private sector, and on creating demand from industry. Therefore, significant coordination is needed—possibly across government agencies, given that science and technology (S&T)/research policy functions are often separated from industry policy. Related to coherence is the maintenance of *policy consistency and predictability* over time. Some of the objectives of innovation policy, such as higher R&D intensity, can only be achieved over the medium to long term and require sustained support.

In the discussion that follows, these three key areas for policy making are discussed:

1. Develop a sound rationale and design for policy.
2. Enhance the efficacy of implementation.
3. Formulate coherent policies that address interlinked issues across the National Innovation System (NIS) and that maintain policy consistency and predictability over time.

While processes and function are critical for good policy making, innovation policy is not implemented in a vacuum, but by institutions that are subject to specific incentives and that can be potentially captured by groups of stakeholders. *Designing these institutions to have the right mandate and incentives to work with the private sector, while minimizing the risk of capture*, is also a critical element for policy efficacy. This is discussed in section 3.2.

3.1.1 Policy Design: Rationale and Justification

Using Market Failures as a Disciplining Device

The complexity of the innovation problem depicted in figure 2.4 (the National Innovation System) implies that low rates of innovation may be driven by failures or problems in any number of markets working directly or through complementary factors. Policy makers need to be especially careful to ensure that they address the true problem and do not simply "borrow" a diagnosis common in advanced countries. Firms may not innovate due to capital markets imperfections that do not permit longer-term borrowing. But it is also possible that innovation activities are constrained by information asymmetries that limit learning in firms or the availability of technology and skills, or by more general distortions that limit investments in general. Identifying the correct market failure (box 3.1) embedded in the innovation problem or constraint, therefore, is the key to identifying the appropriate instrument (see section 3.4 for a more detailed description).

The NIS literature has expressed some skepticism about the market failure approach. Instead, it views the failures that affect innovation in a more systematic light, as being related to weakness in underlying institutions and ineffective interactions between firms and entrepreneurs that are acting under the constraints of bounded rationality—that is, limited by the information they have, the cognitive limitations in their thinking, and the finite amount of time they have to make a decision.[2] The role of innovation

BOX 3.1

Market Failures Affecting Innovation Activities

The traditional justification for innovation policy is based on the well-known problem that prevents agents that develop innovations from fully appropriating all the benefits generated (the externality appropriability problem) (Arrow 1962; Nelson 1959). However, some other key market failures can also prevent innovation from occurring. These can be summarized as follows:

1. *Knowledge as a public good, spillovers, appropriability, and indivisibility*. Knowledge shares some characteristics of *public goods*, such as nonexclusivity in consumption or nonexcludability in its use. In other cases, innovation activities can *generate positive technological or knowledge externalities or spillovers* in other firms in the same cluster or location, such as the diffusion of a new technology, that also cannot be fully appropriated by the innovator. In addition, some of the knowledge investments needed for innovation are indivisible and may require large upfront investments that firms may not be able to make or afford by themselves.
2. *Imperfect and asymmetric information*. High uncertainty around the development, implementation, and commercialization of knowledge can generate significant *information asymmetries* that result in lack of adequate financing of these activities or lack of ability to develop innovation projects.
3. *Coordination failures*. More generally, there can be significant coordination failures among actors in a system. As discussed in chapter 2, firms do not innovate alone and require complementary factors to be available for their use. In some cases, firms could coordinate their efforts in the provision of specific services such as certification or technology extension, but large information asymmetries prevent them from coordinating their efforts.
4. *Missing or underdeveloped markets*. In many developing countries, some of the important inputs needed to build firm capabilities, such as technical skills or business development services, are likely to be missing in the market.

policy is, therefore, to make sure that all these different sources of knowledge and know-how are connected in the system (Dodgson et al. 2011). However, many systemic issues entail information asymmetries and coordination failures (discussed in box 3.1). These may be larger than those often assumed in the mainstream approach and hence justify the special emphases received in the systems literature. The main implication for policy is the need to anchor the identification of the innovation problem in some type of known failure to discipline policy and inform its design, while considering the systemic nature of innovation in terms of the required complementary factors and complementary policies. In practical terms, individual policy instruments need to respond to the "true" problem or constraint and need to be aligned with the rest of the *policy mix*, rather than being contradictory.

Using Good Design Practices to Manage High Levels of Complexity

Even if the right problem or constraint and its cause have been perfectly identified, the impact of each intervention will depend on the quality of the final design. An important issue is, therefore, how to manage complexity and potential risks when the levels of capabilities for satisfactorily designing policy are limited. Identifying the right problem is necessary but not sufficient for success, and government failure is a potential risk. Several design lessons that can be drawn to minimize policy failure are summarized in table 3.1.

Weak policy design often relates to mistaken assumptions about the context of the intervention, incorrect understanding of the effects of the intervention, or a lack of consideration of alternative instruments to the ones typically used by the policy makers involved. The origin of the policy instruments needs to be grounded in an identified and studied problem or constraint, rather than in some ad hoc justification that can be the result of some vested interests or pressure from some particular stakeholders. In addition, the identification of the problem, and the means to address it, should ideally be grounded in actual evidence, hopefully obtained through a systematic and rigorous appraisal of the issue.

Consideration should be given to the complementarities between the instrument proposed and other existing instruments. A critical element to guide this process is the inclusion of well-articulated goals and, more importantly, the logical framework of the intervention. The development of the logical framework will help policy makers consider all the external elements that may influence the project and what could go wrong, as well as setting the framework to guide monitoring and evaluation (M&E).

Finally, some additional elements should be considered during the design stage:

- *Weigh the relative strengths of markets and government* (Wu and Ramesh 2014). Reliance where possible on provision of services by the private sector or public-private partnerships can reduce the demands on the government.

TABLE 3.1 Good Practices for the Design of Innovation Policy Instruments

Dimension	Good practices
Origin	The policy instrument should as much as possible be based on a documented, evidence-based diagnosis, addressing the specific policy problem and established through due process under the rule of law. This recognizes the political dimension of the process of selecting goals by which legitimacy of the policy and its objectives are obtained. However, the goals of the instrument must be aligned with the identified problem. If the policy is a new version of a previous policy, the lessons learned from the previous experience must be part of the diagnosis for the new instrument.
Justification	The case needs to be made that the goals and the means selected to address the problem are linked. Ideally, this should be explicitly documented.
Relation to the policy mix	The principles of coherence and rationality call for attention to the potential interactions—both mutually reinforcing and undermining—across all instruments. The policy design calls for an analysis of these interactions, either by identifying policies for which the one in question is a good complement, or by refining the instrument so that it focuses on either features or outcomes that do not undermine other policies. Interactions and interdependencies in the policy mix usually give rise to questions of coordination across policies and among levels of government (addressed in section 3.3).
Alternative policy instruments	The diagnosis of the problem that motivates the policy often restricts the menu of available instruments, before reaching the decision-making phases, due to either the existing conditions or to limited knowledge of what instruments are available (Haapanen, Lenihan, and Mariani 2014). A good practice is to consider alternative instruments based on comparative criteria that include efficiency, effectiveness, cost-benefit ratios, and appropriateness to the context.
Objectives	Objectives should be defined in such a way that they reduce ambiguity and conflict. To accomplish this, goals must be clearly articulated, realistic, observable, and measurable, as opposed to abstract and generic.
Logic model for the use of the instrument	The logic model of the instrument needs to be clearly specified. This framework represents how the instrument is supposed to work. It does this by articulating the theory of change behind the policy and the assumptions underlying the way that inputs, activities, and outputs lead to outcomes and impacts, as well as the impact on specific stakeholders and audiences (Hatry 2016). The logic model will facilitate the ex ante evaluation of the instrument based on the outcomes and intended impact.
Criteria for selecting participants	The design of the policy instrument must explicitly establish criteria that are coherent with the policy goals and suitable for reaching the targeted population. In addition, the selection criteria should be transparent and accessible to all potential beneficiaries. Two elements are critical in this regard. First, instruments must target the population of participants that is most likely to produce the effects intended by the policy. Second, all potential participants must have a fair chance of entering the selection process and receive clear feedback on the viability of their candidacy.
Monitoring and evaluation (M&E) methods	A clear M&E framework should be in place with appropriate indicators. This will facilitate the actual use of evaluation results for progressive learning, and for improving future policy design. Furthermore, the implementation of future versions of the same instrument depends heavily on the inclusion of an M&E framework in the design phases. Evaluating the impacts embedded in the design phase will produce important information, especially in cases where the instrument starts as a pilot.

Source: Adapted from Cirera and Maloney 2017.

- *Use external services if domestic capabilities do not yet exist.* Often the supply of services will be limited until a market is established, but external services may be available. For instance, Italy and Japan benefited significantly from US management extension services after World War II.
- *Employ market incentives within initiatives where feasible.* In cases where government is required to redress a market failure—such as in schemes to upgrade firms or provide training—employing market-type incentives is likely to lead to a better allocation of resources. For example, the marginal costs of training or extension policies should be paid by the beneficiaries, or some grant support should be matched by recipients.
- *Design to avoid capture.* The likelihood of policy capture is higher in countries with less established institutions that have limited monitoring capacity and possibly weaker autonomy from political interference. Having a broad set of actors supporting the design of such policies can be a way to minimize capture. For example, private sector participation on boards of directors or research institutions can sometimes help guide the overall direction toward industry collaboration. Similarly, using external experts, including from abroad, in evaluating project proposals (such as in competitive grant programs) ensures greater autonomy and can help protect the application process from political interference.
- *Minimize market distortions and avoid crowding out viable businesses.* Loan and grant schemes should consider existing financing options available to firms and avoid introducing unfair competition to potential lenders. In addition, understanding alternative options available to small and medium enterprises (SMEs) can make tax incentives more relevant for SMEs, which usually have favorable tax conditions already. Intervention mechanisms should help catalyze underdeveloped markets, adding dynamism and steering competition.
- *Design to increase the additionality of impacts.* In a similar fashion, formulating a program that responds to the particular constraints facing firms that are underinvesting in innovation could avoid extending the benefits to enterprises that would have invested anyway. For example, an R&D tax incentive program needs to be designed to ensure that it increases the incentives for additional investments in R&D.
- *Estimate potential demand and the economic viability of instruments that provide services and rely on capital expenditures.* Incubators, accelerators, technology centers, and SME support centers are especially susceptible to failure. Before creating them, policy practitioners should identify whether there is a clearly identified demand for services and assess the feasibility of setting them up.
- *Seize opportunities to leverage investments from beneficiaries.* Schemes that cleverly induce financial contributions from beneficiaries will yield additional impact. Differential cofinancing requirements for matching grants, tax incentives that command upfront financing from beneficiaries, and cluster policies that include industry-wide cofinancing, for example, can mobilize additional resources.

3.1.2 Effectiveness of Implementation

In many developing countries, program implementation is the area in which government capabilities are weakest or missing. Often agencies may find it difficult to implement innovation policy instruments because they face constraints in resources and know-how; in some cases, there may be some overconfidence during the design stage in implementation abilities.

Many of the issues important for implementation are not specific to innovation policy but are part of a larger agenda of improving public sector management. While the literature is too vast to be covered here,[3] this guide offers some guidelines on how to adopt good practices for implementation. The objective is to ensure that implementation follows robust processes and good practices so that programs run efficiently, meet government and client expectations, and produce positive and measurable benefits.

Implementation can be grouped into four areas: learning; implementation processes; management quality; and monitoring and evaluation. The specific categories are summarized in table 3.2. It is important that policy makers try to harmonize and improve efforts to reward and disseminate good practices and to support weaker implementation units. Most of the enablers of these practices are systemic, such as having adequate information systems that integrate information across instruments, or human resource policies that provide good incentives and train program managers. It is also important to create networks and opportunities within the implementing institution (and possibly with other institutions) for program managers to discuss and to share experiences concerning implementation , as well as to reward process innovations within the institutions.

Additional elements should be considered during the implementation stage:

- *Deliver targeted solutions to differentiated groups of beneficiaries who have different needs.* For example, grants schemes should consider different spending categories (advisory services versus equipment) and types of firms—by size and age—to maximize impact.
- *Rely on proven methods of advertising and promotion to increase awareness of the program and achieve adequate participation.* These could include word of mouth, social media, and on-site demonstration to facilitate adoption of new ideas and stimulate demand. Participation in grant and uptake rates in tax incentives schemes has been low because firms do not know these are available or because the information is too complex. These schemes should build awareness of the program and communicate eligibility requirements in a simple way. Programs have relied on business associations to promote participation and to identify potential high-quality applicants.
- *Enable mechanisms to facilitate competitive applications from high-quality prospective beneficiaries.* For example, competitive grant schemes should provide

TABLE 3.2 Good Practices for Implementing Innovation Policy Instruments

Dimension	Good practices
Learning	
Knowledge management	Implementation of policy instruments should consider processes for learning in order to improve performance. The key processes are documentation of experiences and decisions to adapt to new circumstances; identification of implementation challenges that were not identified in the original design; documentation of the specific solutions that were adopted and of problems that remain; and relevant data showing how the solution improved performance. Policy makers should also reach out to peers in other jurisdictions and countries to share knowledge about their experiences.
Implementation processes	
Awareness	Clear information should be provided and widely disseminated about who is eligible, for what they are eligible, and on what terms.
Solicitation and project management	Solicitation or requests for proposals should contain clear information about the type and substance of projects to be funded/supported; the level of funding or support; eligibility criteria for participants; and application and selection processes.
Program target identification and servicing	Policy makers should identify the target audience or customer base; determine the potential take-up rate; figure out how to reach and service these customers; identify which stakeholders might support the program and how; and decide how feedback will be collected and used for program operations.
Participant selection practices	For select programs, policy makers should implement transparent and clear scoring systems. An appeal system should be put in place and the names of award recipients disclosed.
Application procedures	Application processes should be user-friendly (online when possible) and should not impose too many documentation requirements. To simplify the application process, implementing agencies should rely on existing information about the applicant, to the extent possible. Unsuccessful applicants may be excellent future candidates (or eligible for other initiatives) so there should be mechanisms to invite them back or refer them elsewhere.
Delivery mechanisms	Policy makers should identify the most appropriate delivery mechanism and who will deliver it. This will depend on whether the program involves direct financial support (tax incentives or grants), advisory services, or infrastructure. Some initiatives might best be delivered through a central national unit; others through regional channels or through third parties. Some services (such as technology extension and technology centers) might require quasi-industrial structures and very specialized consultants to be most effective. If delivery is to occur through multiple agencies or across levels of government, there may be coordination challenges to be managed.
Funding distribution	If funding is being provided, care should be taken to balance program integrity (such as distribution of funding against documented action and receipts) versus imposing excessive reporting and administrative burdens on beneficiaries, which are often small firms with limited capabilities facing cash flow constraints.
Capacity building and specialized skills	Policy makers should assess the capacity needed to implement the initiative, particularly if it is new, has a novel modality, or requires particular knowledge and skills. Capacity building and skill acquisition plans should be developed if required. If delivery is outsourced, then an assessment is needed of the skills required to select and manage the contract and delivery partners and ensure that delivery is meeting expectations.
Stakeholder engagement	Stakeholder views should be gathered and used during both program design and implementation, so there should be structures in place to ensure that stakeholders are engaged, and their feedback is considered.
Program information management	It is important to have a digital and integrated information system that enables the institution to manage applications (such as using smart forms and running a customer relationship management tool) and to determine whether firms are beneficiaries of other instruments. Ideally, the system should also be integrated with the financial management module and the monitoring & evaluation (M&E) module.

(Table continues on the following page.)

TABLE 3.2 Good Practices for Implementing Innovation Policy Instruments *(continued)*

Dimension	Good practices
Finalization of participation in the program	The program should clearly specify what determines the end of support, and what documents are needed for closure. There should be a system in place to collect follow-up information to determine impact, especially for innovation projects where some impacts will only be known in the medium or long term.
Management quality	
Budget and resources	Budget and financial resources should be adequate to fund the intervention and the regional outreach for the duration of the instrument. This aspect should not be ignored, as a program might continue with inadequate resources because of its political or symbolic value, or the interests of the agency implementing the instrument. Rules of transparency or budget management might require disbursements that are unrelated to the policy objectives, thereby distorting or undermining a policy's efficiency and efficacy. Therefore, three criteria are critical: adequate budget; disbursements in relation to program objectives; and rigorous mechanisms of financial control.
Organization management	High-quality organizational management practices should be in place, including minimizing red tape and having adequate processes to track performance. If the design team and the implementation team are different teams/organizations, they need to work closely together.
Role definition and autonomy	Systems should be designed to prevent undue or excessive external interference. Lines of authority and decision making, and approval procedures should be clearly defined.
Human resources, training	Human resources management should address the definition of roles, task autonomy, entrepreneurial capacity, investment in workers' skills, the alignment of strategic and work experience values, and merit-based reward systems that reward teams.
Incentives management	Employees should receive proper incentives to continuously improve their job performance. Increases in pay and other benefits should be linked to individual performance, although there might be limits to incentive systems in the public sector. Opportunities for career advancement are also a useful incentive.
Process monitoring	Process monitoring should be put in place with quality indicators, information, and reporting to guide potential improvements in internal processes.
Monitoring and evaluation	
Program monitoring and evaluation	External and internal evaluations are necessary for the purposes of accountability and learning. Evaluation results should inform improvements and future policy design. Clear guidelines and plans for evaluation should be established in advance.

Source: Adapted from Cirera and Maloney 2017.

support to potential applicants to understand the application process, allowing intermediaries and customer service departments to respond to queries. In addition, schemes should open independent lines to address potential challenges and disputes from rejected participants.

- *Ensure that the application process is fully transparent, and that proposals are evaluated and selected on their technical merits.* For competitive selection of participants, technical selection panels have proved to work. Publication of awardees can grant confidence and legitimacy to the selection process and results through transparency.
- *Collect feedback from beneficiaries during implementation to identify opportunities for improving the delivery of support.* User surveys have had some success in measuring overall satisfaction at different stages of implementation and the

perceived value (costs versus benefits) from participating, and in collecting recommendations for improvements.

- *Validate compliance of the project implementation with the guidelines and rules.* For example, proposals for tax incentives are typically accepted on a provisional basis, but then are verified for adherence to the ground rules required by the scheme. When necessary, equity investment programs have benefited from bringing expertise in early-stage capital financing and oversight, particularly when more than one agency is administering the scheme.

Monitoring & Evaluating (M&E) and Learning

Some of the most important implementation practices to maximize impact are related to monitoring, evaluating, and learning. The complexities and uncertainties associated with designing innovation policy instruments emphasize the need for monitoring, evaluation, and adaptation of programs along the way, creating a dynamic feedback loop from design to implementation to evaluation and back to design. However, the use of M&E frameworks and more importantly, the design of impact evaluations from the beginning of the program, is still a rare practice in many developed and developing countries.

One way to address the inherent uncertainties of innovation policy is the use of pilot projects, whereby a specific intervention is tested in a more controlled environment, such as a particular sector or geographic area, before deciding whether to scale up the intervention. Pilots need to be carefully measured and assessed in order to be effective. Too often, however, the word “pilot” or “experiment” is used without clear M&E systems or a designed impact evaluation, which means that decisions on scaling up the program will be taken without clear evidence of its impact. A pilot project makes sense only if it is accompanied by a good impact evaluation that can test its operational assumptions, analyze its impact and the potential difficulties that could arise during the scaling up phase, and in case of negative results will facilitate the decision not to scale up the program.

Similarly, for an existing program, a solid evaluation guided by a strong M&E framework can facilitate the collection of the information necessary to improve the program, to design improved versions of the policy instrument if it proves to be effective, or to make the decision to discontinue an ineffective program. Policy owners should also be able to use robust evidence when negotiating with sources of funding for ongoing support.

Evaluation can also provide a useful check on the political economy forces leading to the fragmentation and duplication of policies previously discussed and help instill a culture of justification and evaluation that encourages a more transparent and professional innovation policy. Weak government capabilities can limit the use or impact of evaluations, and policy makers often cannot recognize the value of evaluation results, which are often underutilized in decision making. They require high-level human capital to be implemented properly, the right incentives to monitor and evaluate policies, and specialized units to distill the main findings and integrate what is learned into policy design. Partnering with academia or multilateral agencies with installed capacity can help kick-start the evaluation agenda. The effectiveness of evaluations also depends on strong institutionalized learning processes whereby formal efforts are made to understand the evidence presented and to use the findings to improve programs and adapt them to changing conditions. Over time, these processes can create a de facto culture of evidence-based innovation policies.

Table 3.3 presents a checklist to manage the risks associated with the design and delivery of innovation policies.

3.1.3 Coherence Across the National Innovation System and Consistency and Predictability Over Time

Coherence refers to the extent to which the offered solutions match the key innovation problems and constraints. In addition, coherence implies that the key target group must clearly benefit from the policy introduced. Resource allocation should follow the desired policy objectives. However, in many developing countries, innovation policy budgets do not always match the stated policy priorities. Often, there is significant volatility in budget allocations related to political or economic instability and innovation policy is rarely a high priority. For example, a public expenditure review on science, technology, and innovation conducted in a country in Latin America finds that, despite the stated prioritization in the national agenda for pursuing economic diversification, only a small share of the innovation support budget supported this goal (Cirera and Maloney 2017).

Building a solid and robust innovation system represents a long-term undertaking. Ideally, it should be supported by sustained policy, financial, and institutional commitments to innovation policy. Policy consistency and predictability are important to achieve results, especially because the life cycle of innovation programs tends to be long. Business innovation typically requires firms to make nontrivial decisions concerning investment, which are often tied to capital and financial commitments. Policy uncertainty can deter firms from allocating financial and management resources to upgrading their own capabilities. By the same token, targeted policies aiming to develop capabilities at the level of the National Innovation System require irreversible financial commitments from several stakeholders.

One example is the length of the cycle for accumulating human capital and establishing connections between university and industry, which represent a critical factor in the extended National Innovation System. The lead time from the conception of a new skill curriculum to the graduation of the first cohort of professionals can be 5 to 10 years. Moreover, most world-class research universities have taken decades—if not centuries—to develop know-how, build a stock of experts, and

TABLE 3.3 Innovation Policy Design and Delivery: Risk Management Checklist

Objectives	■ Are the objectives clearly defined? ■ Can the objectives be achieved on time, on budget, and to the government's expectations? ■ Are critical success factors defined, and how will they be measured?
Scope	■ Is there a need for multiagency agreement on reform and implementation? ■ Is there agreement among relevant agencies and levels of government about program goals and delivery arrangements?
Stakeholders inclusion	■ Are there any potential hazards to the public? ■ Are there potential adverse impacts on the community or the private sector? ■ Will resistance arise in the implementation phase? ■ Can other stakeholders help in the design and implementation of the program?
Governance	■ Is there clarity in the governance structures (especially regarding roles and responsibilities)? ■ What processes are in place to manage risk and implement contingency plans to address unforeseen events? ■ Is there capability (staff know what they are doing) and capacity (enough staff to manage implementation)?
Timing	■ Is the time frame realistic? ■ Are the proposed milestones identified and achievable? ■ What is the impact of slippage and what are the relevant contingencies? ■ Is there a significantly extended roll-out or delay between delivery and impacts?
Financial	■ What is the degree of confidence with respect to the initial cost estimates? ■ What is the likelihood of unexpected costs? ■ How will changes to costs be managed?
Legislative	■ Is there a need for major and/or sensitive legislation/regulations? ■ What is the likelihood of passage through parliament/government? How would delays in passage affect delivery?
Resourcing	■ Are the necessary resources (such as people, skills, and equipment) available to implement the policy? If not, can these be accessed easily and affordably?
Related projects/ programs	■ What is the complexity of the supply-side arrangements (such as single supplier, network)? ■ Does the provider market have depth and capability? ■ Are expertise and resources available to manage suppliers?
Technical	■ To what extent does the project involve innovative solutions? ■ What is the impact on delivery organizations (for example, how much change is required)? ■ What is the impact on existing systems and data requirements?
Communications	■ How important is a communications strategy, and is the chosen strategy appropriate? ■ What are the key messages that need to be communicated and to whom (such as to raise awareness with potential customers)? ■ Can these be communicated in the time available?

develop the interconnections with industry required to disseminate knowledge and propagate ideas in the private community at large (Cirera and Maloney 2017). These processes are key parts of the National Innovation System that need consistency and continuity in policy priorities and public investments.

Policy consistency and predictability are important to the development of the National Innovation System. The policy cycle ideally follows a sequence of functions, including diagnostics and analysis of options, setting objectives, policy integration, implementation, and management. This sequence, and the individual steps, should not be shortened for political or budgetary reasons. In many countries, incoming administrations tend to dramatically redefine the policy agenda, reversing many of the program advances made in the past.

3.2. Innovation Policy Agencies and Institutions

Previous sections have emphasized the importance of having solid processes to maximize the effectiveness of innovation policy. However, innovation policy is implemented by institutions that are diverse, that have different incentives and objectives, and that are often competing for public resources and beneficiaries. This section discusses some of the key issues and problems related to public agencies that design and implement innovation policy, with the objective of identifying some basic principles that can aid the effectiveness of innovation policy. Having a clear mandate and objectives and adequate resources is critical for implementing the processes discussed in section 3.1.

The section focuses on institutions and agencies that generally have a mandate to design and/or implement innovation policies. More specialized entities that deliver innovation-related services, like public research organizations (PROs), technology and R&D centers, and other agencies that provide services or research, are excluded from the analysis. These specialized agencies merit a more specific discussion in terms of their business model or the types of services they provide, among other issues. Thus, this section focuses on innovation agencies (which some countries have established), ministries, and broader economic development agencies (which are still the more common model for design and delivery of innovation policy).

3.2.1 A Diverse Range of Institutional Arrangements

The breadth of institutional arrangements for innovation policy span well beyond innovation agencies. When looking at institutional functions along the stages of the policy life cycle (Angelelli, Luna, and Suaznabar, 2017), at least four sequential but iterative steps can be distinguished: (1) formulation of innovation strategies (long-term policy aspirations); (2) design of innovation policies; (3) implementation and supervision of innovation policy; and (4) deployment of innovation instruments and innovation activities. The cross-cutting and nonsequential functions of coordination and planning should also be added, given their importance in the context of innovation policy.

Figure 3.1 depicts illustrative institutional arrangements for innovation policy, highlighting the space that selected actors populate, ordered by the function in the policy life cycle (rows) and the general scope and application of innovation policy (columns). The figure highlights the complementary nature of human capital development, R&D, innovation, technology, entrepreneurship, product development, and export and investment promotion policies. The multidisciplinary nature of innovation policy should be evident from this table, which underscores the imperative of coordination across several institutions.

FIGURE 3.1 Illustrative Institutional Arrangements for Innovation Policy

Function \ Scope	Innovation skills & human capital	Research and development	Innovation	Entrepreneurship	Enterprise development	Investment and trade
Coordination & strategic planning	National planning agencies/ministries of finance					
Strategy formulation	National councils (public and private)					
Policy design	Education/ labor ministries	Science and technology ministries	Economic development and production ministries			Line ministries (trade/ investment)
Implementation	Science and technology agencies		Innovation (and entrepreneurship) agencies		Other complementary agencies	
Deployment of instruments and activities	Universities/ higher education and VTE	R&D institutes/ universities	Intermediaries/firms and entrepreneurs			

Focal Complementary

Source: Adapted from Angelelli, Luna, and Suaznabar 2017.

Note: R&D = research and development; VTE = vocational training and education.

Starting with "who designs and implements the overall strategy," when thinking about institutions for innovation, a first question is whether a dedicated innovation ministry or agency is needed to formulate and coordinate innovation policy, which is by nature cross-cutting. There is large variation around the world. Most countries do not have an innovation ministry with a designated role and a narrow mandate to promote innovation. Typically, the mandate to advance innovation policy is distributed across several agencies and multiple line ministries. For example, at the level of policy design, skills and human capital for innovation are typically looked after by ministries with mandates over education and labor. Science and technology policy, which often include tasks related to research and development, is often managed by dedicated ministries of science and technology, with some mandates that include information and communications technology (ICT). In addition, the domain of business innovation falls under the mandate of ministries dealing with economy, industry, and trade, including those focused on small and medium enterprises.

These models are not exhaustive, and by no means comprehensive. Countries have reconfigured the tasks, roles, and functions related to innovation in several ways, formulating different combinations of roles and defining the mandates of ministries in different ways. In some countries with significant agricultural production, policies governing innovation in agriculture are the responsibility of ministries of agriculture and rural development (as in Vietnam), ministries of plantation (as in Sri Lanka), or commodity development boards (as in Rwanda). In addition, ad hoc arrangements have increased the rank of some ministries tasked with advancing innovation policy at the level of the office of the prime minister, cabinet, or national development boards.

Desirable Institutional Arrangements are Dependent on Context

The answer to the question as to whether a country needs a specialized innovation agency is not straightforward. There seems to be no agreement about the ideal institutional arrangements to advance innovation policy effectively; successful examples have proven to be idiosyncratic and context specific. The emerging consensus is that there is no single model for an ideal innovation agency, either (Glennie and Bound 2016). Institutional arrangements that work for one country may not be transferable to others (Aridi and Kapil 2019). Glennie and Bound (2016) suggest that the important questions are what role innovation agencies should play, and how these roles can best respond to the contextual challenges that the country is facing.

What matters for policy implementation capability is not "form" but "function." Andrews, Pritchett, and Woodcock (2017) suggest that there are advantages in separating design and coordination from implementation, especially given that some of these implementing agencies can have more flexibility and leverage to hire talent, offer competitive wages, and be less bureaucratic and agile than line ministries. Implementing agencies may also have a specific area of focus (such as digital innovation or biotechnology) in which it is important to build subject-specific knowledge (although this can also happen in more generic agencies) and be more mission oriented.

The Degree of Autonomy of Agencies Varies

Organizational structure and budgets vary significantly. Typically, agencies end up being organized in one of the following ways: a ministerial unit; a government agency—but with different levels of autonomy; a government-owned agency with donor cofounding; a nonprofit; or a public-private partnership (PPP). Also, multiple sources of financial support can be consistent with different structures and levels of autonomy. Financial support can come from different sources, including the central government, ministries and domestic agencies, international partners, multinational organizations, and/or charitable foundations, and/or from fee-based services and investment income. The diversity of institutional models for innovation policy entities, and their funding schemes, are discussed in case studies in Aridi and Kapil (2019). A brief list follows:

- *Within a line ministry*. In terms of governance, autonomy, and government affiliation, these agencies could be established as departments within a ministry. An example is South Africa's Technology Innovation Agency (TIA). This structure simplifies the process of allocating funds to the agency from the ministry's budget.
- *Separate agency subject to ministry control.* Some agencies can operate as a separate body from the ministry but remain under its political control. An example is Poland's National Centre for Research and Development (NCBR), which is supervised under the Ministry of Science and Higher Education. Another semi-autonomous model is represented by Serbia's Innovation Fund (IF), which remains government owned but is funded by donors, including the European Union (EU). Donor funding is believed to have driven high standards of governance and accountability in the agency. For example, among other good practices, donors have encouraged use of a rigorous monitoring and evaluation framework to track and verify the progress of innovation programs. However, Serbia's IF is found in the same case study to lack significant operational independence from the government, as it is being run under rigid rules imposed by the bureaucracy.
- *Autonomous government agency*. A slightly different model is Colombia's iNNpulsa, a government agency with a high degree of autonomy. iNNpulsa can mobilize funding from several independent sources and can attract and retain its own staff, outside the general norms of the government.
- *Public-private partnership*. Armenia's Enterprise Incubator Foundation (EIF) and Turkey's Technology Development Foundation (TTGV) present unique public-private partnership arrangements. The distinctive feature of the model for these agencies is that they have been set up as not-for-profit entities. This public-private model presents strong advantages when it comes to the level of engagement between the agency and the private sector, which is chiefly reflected in the governance structure of its board. This close relationship strengthens the agency's reputation and credibility with respect to firms and private sector associations more generally. However, its hybrid composition can also have some disadvantages, particularly limits on the agency's ability to secure long-term unrestricted funding, which would normally come from the government budget, and which would allow its leadership to enjoy predictability in planning.

Function Matters More than Form

There is a danger in thinking that a new institution is a solution to innovation policy challenges. Politicians can be attracted to establishing new organizations and can see them as "the answer" to innovation policy. Bureaucrats may also support new entities if they perceive that the entity will have resources and autonomy. Setting up and supporting new agencies is costly and diverts attention from the actual policy challenges. They may fail to evolve into functional organizations and are never easy to shut down; many countries already suffer from a proliferation of government entities that add little value and worsen policy fragmentation. A new agency may be justified if it has some policy autonomy and the ability to "think outside the box," but it is important that it be given clear performance metrics and a clear time frame to operate, after which it could be closed, like the Malaysian innovation agency.

It is not necessary to create a specialized (and independent) innovation agency simply to implement programs.[4] Developing basic innovation program design and delivery capabilities that are robust, transparent, efficient, and fair should be the focus of policy makers and underpin any successful support for moving up the capability escalator. What matters is that there are some clear characteristics that guide any entity. Main functions include (Cirera and Maloney 2017):

- Clear mission orientation
- Ensuring independence and preventing capture by elements of the innovation system
- Collaboration and alignment with other agencies and actors (see the next section on coordination)
- Market orientation, discipline, and clear performance drivers (see section 3.2.3)
- Attracting, retaining, and building staff capabilities (see section 3.2.4)
- Securing long-term government commitment.

3.2.2 The Imperative of Coordination to Advance Innovation Policy

Effective coordination across innovation institutions is needed to maximize the combined impact of multiple efforts and instruments. For a start, central ministries (as opposed to line ministries) should help ensure the strategic relevance of innovation policy in the wider context of economic prioritization and the effective use of public funds for innovation. Ministries of finance, national planning organizations, cabinet offices, and even the Treasury can have a strong stake in the success of innovation policy. Given the dispersed mandates for innovation across ministries, these institutions possess advantages for playing an interministerial (or interagency) coordination role in innovation policy. In environments where there is little strategic coordination, but instead fragmentation and competition, the active involvement of these "central" agencies may be necessary to bring coherence and discipline to activities.

The reality is that innovation policies in most countries are very fragmented. As a result, some countries have opted to establish innovation councils that coordinate the innovation policies of all line ministries. This can be useful to bring the different actors to participate in the design stage but does not necessarily ensure the needed coordination to implement innovation policies, which requires a de facto alignment of all the ministries' policies. A variation is innovation councils that involve both government officials/ministers but also external stakeholders from across the National Innovation System. Innovation councils are more likely to have a strategic advisory role (rather than a decision-making role) but can ensure that a wider range of views are captured. Some countries have high-level advisory entities made up of international experts—such as the Scientific Advisory Board (SAB) in Singapore—to bring the global perspective to policy formulation.

Formal Mechanisms Can Facilitate Coordination

A necessary condition—although not a sufficient one—for ensuring coordination is to have an overarching innovation policy strategy with clearly stated objectives, targets, and indicators that can be monitored. Without this strategy, it is difficult to align line ministries and agencies with a common set of policies. Often, when a key line ministry responsible for science and technology has the main mandate for the design and implementation of science, technology, and innovation (STI) policies, these tend to have a bias toward these policies and downplay the demand side—the firm/industry/end-users—and the building of the necessary capabilities. The policies that tend to support these demand-related capabilities are usually fragmented in various strategies dealing with competitiveness, exports, SMEs, and the like.

Strong and formal coordination mechanisms are the surest way to effectively organize functions to advance innovation policies under several institutions and to ensure policy coherence in the National Innovation System. These formal coordination arrangements are usually guided under the direction of a high-level steering committee. At the very least, basic coordination would ensure minimum overlap in the scope of the programs across the various agencies. In addition, effective coordination can exploit potential complementarities and synergies across the programs. For example, agencies might gravitate to a natural specialization driven by goals, target beneficiaries, or other criteria. Relative specialization across agencies can offer a holistic system of support for innovation policy.

A more ambitious coordination effort would go beyond avoiding duplication and exploiting complementarities among agencies to include combined strategic planning, goal setting, regular monitoring, and evaluation. Moreover, more sophisticated coordination can exploit benefits from experimentation and learning from the results of implementation by any single agency and ensure wide dissemination of best policy practices across implementers. Other advanced coordination exercises may include not only horizontal but also vertical coordination to include regional institutions and international bodies.[5]

Aligning Different Incentives Toward a Common Goal Remains Key

Coordination can be challenging, given that more than one agency or ministry is likely to be active in innovation policy. Mandates are typically set in law or by regulation, and many organizations (public and private) find it very difficult to encourage collaboration and information sharing across instruments and at the level of the individual official. Moreover, competition over limited resources and clients can create tension among these agencies (at both a bureaucratic and a political level), particularly when the scope of policy spans both the science agenda and the industrial development agenda. Science and research agencies and their stakeholders are usually focused on government, which is the main source of funding and (directly or indirectly) runs the main institutions and sets many of the policies that directly affect them. Industry has a wide range of issues with government of which innovation is one; however, it is rarely the top priority, so industry's advocacy tends to have less traction. A result can be an innovation agenda and set of instruments that overprioritize science and research, or at least collaboration among research institutions and industry, to the exclusion of firm-level innovation instruments that do not necessarily involve science or research.

A particularly important bridge needs to be in place between the main science and technology policy entity, which is often formally tasked with innovation policy, and the industry and agriculture entity(s), which are responsible for private sector development, economic development, and competitiveness. This is because the interests, incentives, and motivations of the science and technology sector are often different from those of industry, and an appropriate balance is needed to ensure immediate policy needs are met, while longer-term capacity is also built. The starting point is, as suggested, having a good STI strategy that connects science and innovation. However, this is not sufficient to ensure effective coordination. Concrete coordination mechanisms, especially regarding joint decision making at the design and evaluation stage of specific instruments, are critical. Policy makers need to be alert to these challenges and seek to balance them, especially in their policy coordination and strategy development work.

3.2.3 Institutional Financing

As mentioned, funding arrangements can influence not only agencies' operations, activities, and services rendered, but also their autonomy and their requirements for reporting and accountability. This section describes some of the financial issues that agencies typically face, and their implications. The mere expectation of future funding will motivate the agency to keep its constituency satisfied, and if sound governance systems are in place, it will induce the agency to respond to the priorities as stated by its board. This is especially relevant if the agency's statutes stipulate that it should operate with a private constituency in mind, and by design it receives funding from private sources. Thus, determining the agency's financial modus operandi remains critical, and it should not be left to be determined accidentally.

Financing Sources

Different funding models have been adopted by innovation agencies across the world. According to Aridi and Kapil (2019), the following financing sources are used in developing countries, among others:

- *Central government*. For example, South Africa's TIA is fully funded by the central government through an annual funding allocation from the national Treasury; correspondingly, TIA's strategy and operations are aligned with the mandates from the Ministry of Science and Technology.
- *Budget of the main ministry responsible for promoting innovation.* This funding source could be applicable for both fully government-owned agencies and semi-autonomous but affiliated agencies. For example, Poland's NCBR, established as a government agency in 2007, is supervised by the Minister of Science and Higher Education. Correspondingly, its budget mainly comes from two ministries, the Ministry of Science and Higher Education and the Ministry of Economic Development.
- *Donors and multinational organizations*. For example, the Serbia IF was initially established with pre-accession funding from the European Commission and administered by the World Bank. Another example is India's Biotechnology Industry Research Assistance Council (BIRAC), which received funding and technical assistance from development agencies in Australia, France, and the United States, as well as the World Bank to address socially oriented product development needs (such as the development of the Rotavirus vaccine).
- *Charitable foundations*. Charitable foundations, such as the Bill and Melinda Gates Foundation and the Wellcome Trust, are increasingly active in providing financial resources and technical assistance, especially in areas related to addressing social challenges.
- *Self-generated income, such as fees for services and investment income*. Self-generated income can be an important factor in determining the sustainability of the funding for innovation agencies, but it requires a high level of capacity and relevance. An example of generating service-based income is the Turkish TTGV, which provides impact evaluation services to paying customers.

The agency's financial commitments will likely determine its ability to take some operational risk and influence the way the agency can respond to changes in its operating environment, such as shifts in international market conditions, or the way disruptive technologies are affecting the structure of productive systems.

Impact of Lack of Financing

Innovation agencies must have adequate and dependable financial resources to achieve their mission. According to Aridi and Kapil (2019), the two typical financial issues faced by innovation agencies are general underfunding and financial dependence on external sources.

Underfunding can be a common problem in economically constrained environments, especially for agencies in nascent innovation systems. For example, underfunding has affected Serbia's IF, Poland's NCBR, and Croatia's HAMAG-BICRO (Croatian Agency for SMEs, Innovations and Investments), in the context of Europe's unstable economic circumstances. For agencies initially established by international partners, their funding situation after the depletion of donor funds can be particularly uncertain. If not prioritized in the policy agenda, funding for innovation can be threatened by external financial shocks, which have reduced the available funding for these innovation agencies. Because many of the programs for European agencies were set up during the global financial crisis, there has been a lack of budgetary commitment for many of them. In addition, the inauspicious timing and the instability of the financial conditions hindered BICRO's 2007 attempt to create a venture capital fund.

Financial dependence can increase uncertainty and hinder not only the development of a long-term agenda but also its progress. For example, iNNpulsa in Colombia developed a novel model to generate revenue by positioning iNNpulsa as a platform that provides services to other government initiatives. However, reliance on revenue from other agencies has diverted management attention from attaining its mission. The lack of government funding can compromise an agency's ability to plan and commit to a larger agenda for change.

3.2.4 Institutional Capacity Constraints

Technical Skills May Be Inadequate

When it comes to innovation policy, the need for institutional capability is high. Advancing innovation policy is what Pritchett, Woolcock, and Andrews (2010) would label a "wicked hard" problem. These policies operate in a highly complex space and rely on changing behavior by a variety of actors in the innovation system, many of which have different incentives and varied needs for public inputs. Cornick et al. (2018) argue that productive development policies should not be conceived under the technocratic ex ante planning processes but as a process of iterative identification of challenges and solutions that undergo repeated adjustments.

Following the Andrews, Pritchett, and Woolcock (2017) framework on the typology of tasks for building state capability, delivery of innovation policy is, first, intensive in terms of transactions, given that it potentially requires many intermediaries such as regional agencies, commercial banks, and innovation centers to deliver direct or indirect benefits to firms, knowledge providers, or a combination of them. In addition, advancing innovation policy may require local agents to use their own discretion when making decisions about how to interpret operational guidelines (usually passed on to them by a line ministry), choosing who should participate, what type of support should be provided, and how to define success and whether results have been achieved, to name a few. Furthermore, implementation of innovation policy cannot be easily standardized or codified into a single known method (or technology) for delivery. Different constraints on innovation call for different solutions, which can increase uncertainty in attaining results. Moreover, effectiveness in implementation calls for intermediaries to go beyond following existing handbooks, guidelines, and protocols to customize delivery, and deal with locally contingent problems that arise during implementation.

The performance of innovation agencies, at the general level, can be indirectly measured in terms of effectiveness in meeting stated goals and evidence of impact additionality (over the portfolio of instruments and programs that fall under the direct purview of these agencies). It is critical that innovation strategies pay attention both to the local production of innovation and the use by end-users of innovation. Effective strategies need to encompass the first level of the capabilities escalator, with specific emphasis on developing innovation capabilities, investing in technology diffusion, developing skills, and working with the local science and technology base on the supply side to first obtain the necessary conditions for research and commercialization—an adequate institutional framework, incentives for applied research, and university-industry collaboration.

Aridi and Kapil (2019) provide examples of how a shortage of capacity to meet the technical demands arising from new trends and opportunities can affect agency capability. The choice of specialization by theme by Armenia's EIF seems to have imposed stringent demands on the staff's technical skills. EIF had decided to focus on promoting innovation using the digital economy as its entry point. This focus meant that staff had to acquire appropriate technical competencies and access to knowledge networks to support firms engaged in digital innovation and maintain productive relationships with stakeholders. In addition, EIF personnel were expected to act as interpreters of the new digital age for partners and domestic entities. However, the limited digital skills in Armenia's labor market—as well as limited finance and natural resources—made it challenging for the agency to build qualifications or to promote firms that could compete in the global digital market.

Sometimes external issues affect the implementation capacity of agencies. For example, a delayed restructuring hindered the operability of Croatia's HAMAG-BICRO and impaired staff morale. In this case, reforms stemming from downsizing pressures on several government agencies (that completed the merger between BICRO and HAMAG INVEST) led to a restructuring effort that took much longer than expected, resulting in attrition of qualified staff and a loss of trust from client SMEs.

Capacity May Need to be Developed in House or by Partnering with Other Agencies

Section 3.1 discussed capabilities along the policy development cycle and introduced some good practices to design policy, implement effectively, ensure policy coherence, and maintain consistency and predictability of financial resources. Institutions need to perform a realistic assessment of their human and financial resources before designing instruments that could require skills that they do not have. In this regard, the prioritization of instruments should align with major policy objectives and should reflect the sustainability and predictability of budget allocations and/or other financial resources, as well as the existing capacity to deliver these instruments. Cornick et al. (2018) have defined the set of capabilities more broadly to go beyond the technical dimension and include the political and managerial ones. Their useful and simplified framework of public capabilities (in the context of productive development policy) includes three types of capability: technical, organizational, and political (see box 3.2).

Regardless of what capabilities are considered, innovation agencies need to plan how to acquire the capabilities required to formulate and deliver policy instruments successfully. The required capabilities can be acquired either within the organization or in the orbit of the organization through partnership and alliances. This decision will rest on the type of capabilities that need to be acquired, and how strategically important it is to internalize the required expertise and specialize in its functionality.

Management has two options if the decision is made to embed these capabilities within the organization. First, the capabilities can be developed internally, either by accumulating knowledge through continuous learning and the experience obtained through the implementation of policy programs, or by training staff in the disciplines that have been identified as strategic. Second, the organization can acquire these capabilities externally, by hiring (and maintaining) new talent versed in the strategic area sought by management or by developing an affiliated network of contracted experts with knowledge in the areas previously identified. Another approach for externally acquiring capabilities, at a slightly larger scale, is to merge with a smaller team or organization that possesses the coveted skills, under what may be defined as a takeover.

BOX 3.2

Illustrative Broadly Defined Capabilities of Innovation Agencies

The capabilities of innovation agencies should include the following:

- *Technical capabilities.* This includes the competence required to design, implement, evaluate, and adjust policies, as well as scientific expertise at research centers, training skills, and international collaboration, commercial and investment skills, and industry knowledge.
- *Organizational capabilities.* This includes the ability to engage external actors through convening, dialogue, and persuasion and lead them to collaborate in the deployment of innovation policy. Cornick et al. (2018) also include in this category the ability to learn from the results of implementation efforts, and managerial capacity to attract and retain talent, conduct strategic planning, and develop goal-setting routines.
- *Political capabilities.* The competence in this domain includes the ability to mobilize political support for policies, generate commitment from political leadership to secure the agency's mandate, mitigate the risk of capture by private beneficiaries, and attain independence to drive policy adjustments through technical decisions. This guide adds to this definition the ability to generate political commitment for sustained funding to ensure budget predictability.

Source: Cornick et al. 2018.

Acquiring capabilities by forging a partnership with an external organization can be done with varying degrees of formality, depending on the risks involved, trust levels, reputation, and credibility, among other factors. International knowledge networks, such as those promoted by think tanks or the Organisation for Economic Co-operation and Development (OECD), are examples of such alliances.

Various Legal, Regulatory, and Political Issues Affect Agencies' Operations

External factors that affect the investment decisions of firms and the behavior of actors within the National Innovation System, such as the enabling business environment, macroeconomic conditions, the level of competition, and the trade regime, also indirectly affect the performance of innovation agencies.

One example is from Serbia's Investment Fund (IF), where stringent regulations and institutional restrictions are believed to have prevented the agency from advancing its mission. Serbia's IF benefited from the removal of limitations related to the Law on Innovation Activity, which are believed to have improved the quality of research and tightened linkages between science and the business community. However, Aridi and Kapil (2019) find that program implementation was hampered by a rule that recipients of a technology support grant from IF needed to demonstrate that its employees held PhD degrees. This stringent requirement disqualified potentially good candidates for the program.

Lebanon's Kafalat provides an example of how political instability can affect innovation agencies. In this case, political and social conflict prevented the agency from advancing its long-term vision.[6] It is well known that conflict-afflicted environments can preclude agencies from taking a long-term view on policy. Perhaps more than in other domains, innovation policy can take longer than other policies to yield impact because it relies on combined investment from governments and firms to attain innovation results. Political instability in Lebanon is believed to have caused delays in the implementation of the iSME fund. The delay lasted for more than two years because parliament was not in session due to the political stalemate and could not ratify the fund's implementation. Delays in implementation of programs and reforms can prevent disbursement of appropriated funds and can affect the overall performance of the portfolio of an agency.

3.3 Other Important Elements for Innovation Policy Choices

In addition to having robust design and implementation processes and well-functioning agencies, some other elements need to be considered when undertaking innovation policy. Even when the right innovation problems or constraint and its actual causes have been identified, policy makers need to ponder the type of instrument, the sector and geographical focus, and the role of the private sector in the design and implementation. This section briefly discusses some of these elements.

3.3.1 Demand-Side and Supply-Side Instruments

Demand-side measures aim to increase demand for innovations[7] by improving conditions for their uptake or by improving the articulation of demand to spur innovation and facilitate diffusion (Edler 2010). These instruments typically incorporate feedback loops in the innovation process, addressing issues such as lack of awareness and high costs of adopting a new technology. Typical demand-side measures include public procurement, and information and advocacy measures.

Supply-side measures, by contrast, aim to create incentives among firms to innovate by reducing the costs and risks of innovation. These typically include debt and risk-sharing schemes, technology extension services, government-sponsored R&D, enhanced capacities for knowledge exchange, and support for education and training.

Demand-side measures should complement supply-side ones (and not replace them), given that innovation is the outcome of the creative interaction between supply and demand. In addition, some instruments can be applied to both the supply side and the demand side. In principle, both the generation of knowledge by universities and research centers, and the availability of incentives for firms to use that knowledge, can contribute to successful innovation. However, when firms obtain external ideas for innovation, it is generally from commercial sources, such as competitors, suppliers, customers, and trade shows. Often, when they utilize this external knowledge, they also develop their own knowledge as they adapt and tailor the external technologies and approaches to the circumstances of their business.

Traditionally, public support to business innovation has mostly relied on supply-side instruments. Only in the last decade have demand-side instruments—primarily public procurement, and to a lesser extent open innovation and crowdsourcing instruments, or supplier development programs—gained significance in OECD countries. The limited evidence regarding the best combination of these instruments suggests that simultaneous deployment of both types can increase their impact.[8] However, these are generally applicable only in more mature National Innovation Systems with substantial R&D capacity to develop technologies and adequate government skills to manage competitive procurement processes.

What is more likely to be beneficial, and applicable in most contexts, are instruments in which support for firm upgrading is linked to a source of demand, such as support for SMEs seeking to supply large lead firms, global value chains (GVCs), export markets, or government procurement.[9] These types of initiatives provide an incentive to SMEs to invest in innovation with the potential access to an end market. However, they often start with very simple upgrading (5S/lean manufacturing)[10] embodied in organizational and process innovation, with participant SMEs slowly upgrading into higher-order forms of innovation over sustained periods of time by moving up the capabilities escalator.

3.3.2 Direct Versus Indirect Policy Support

OECD countries tend to use both indirect and direct financial support, reflecting their complementarities. With *direct measures*, the policy has direct influence on the firm-level innovation activity (such as by choosing which projects to support in a competitive grant scheme). With *indirect measures* (such as R&D tax incentives and loan guarantees), support is provided to any innovation activity eligible under the rules of the program, without policy makers being involved in the choice of which innovation projects to support. Direct support may require stronger government capabilities to design, supervise, and implement than indirect programs. Direct measures also imply additional costs, particularly for screening and selection of recipients. Indirect measures work well when the policy makers intend to pursue broad-based and open support to innovation. These measures tend to rely more on enhancing the preexisting plans of individual firms than do direct measures, and their scope of application is usually wide and often not directed to a specific sector.

On average, developed countries tend to spend more on direct government support than on indirect support. The use of direct public funding for business innovation enjoys a long tradition and is widespread in many countries. However, the importance of direct measures as a share of economic output varies greatly by country. In 2013, OECD member states invested approximately $40 billion in direct government funding of business R&D, equivalent to 6.9 percent of business R&D, while publicly funded indirect measures, such as R&D tax incentives, represented approximately 5.2 percent of business R&D (Appelt et al. 2016). Similarly, 80 percent of OECD countries had matching grant schemes in 2010, compared to 66 percent with tax incentive programs; 45 percent of all OECD countries used both instruments. Such programs were less common in Latin America, where 65 percent of the countries used matching grants and only 30 percent used tax incentives (Crespi and Maffioli 2014).

Direct and indirect support for innovation can have different effects. For example, direct R&D grants often fund activities that generate substantial benefits to society through spillover effects, while indirect tax incentives fund activities expected to yield proportionally greater benefits to the firms undertaking them than to society. Each measure imposes implementation challenges. Tax incentives require properly functioning tax systems and careful design features that limit distortionary behavior and tax evasion, while direct support measures usually require the capacity to administer grants, particularly to evaluate and monitor the supported innovation projects.

More importantly, the targeted beneficiaries differ in terms of economic sector and firm size. Direct grant support is particularly valuable for smaller and younger firms, which often will not generate taxable income from innovation-related projects for years. These firms can benefit from tax credits only if there are complex carry-over or credit provisions for small firms. To benefit from tax incentives, the firm must be able to frontload the investment for R&D activities and earn taxable income within a reasonable time frame.[11,12] The evaluations of tax incentives for R&D in OECD countries suggest that they increase R&D spending in firms that were already conducting R&D, but do not encourage firms that did not undertake R&D to start performing this type of innovation activity (Veugelers 2016; Dechezleprêtre et al. 2016).

Overall, there is no consensus about the best combination of instruments, but different firms will benefit from different instruments, implying that targeting remains critical.

3.3.3 Vertical and Horizontal Innovation Policies

The distinction between vertical and horizontal policies relates to whether the policy targets a particular industry/technology, or whether it applies to firms regardless of industry/technology. *Vertical policies* intend to induce business innovation among firms operating in a particular sector, such as textile and apparel manufacturing, tourism, or transport. *Horizontal innovation* policies, by contrast, aim to induce business innovation in firms, regardless of the sector in which they operate, based on acquisition of inputs (investment on R&D, specific equipment, talent, or specialized infrastructure), or other considerations. In other words, they represent cross-cutting policies that apply to several sectors simultaneously.

In practice, the distinction between vertical and horizontal innovation policies is rather artificial. In a way, most innovation policy instruments are horizontal in design but vertical in implementation. For example, policies to facilitate clusters focus on some sectors, and complex R&D projects will benefit more technologically developed sectors. In general, any innovation instrument will tend to have some clustering by sector. The important issue is that rather than focusing on "picking winners," policy targeting is consistent with the innovation objective. For example, support to technology generation sectors will focus on those sectors with some capacity to generate technologies, and programs to support diversification will focus on sectors with some capacity to generate new products.

3.3.4 Multilevel Governance

An important question for policy makers is at what level of governance—national, regional, or local—is innovation policy most effective. Figure 2.4 portraying the National Innovation System can be adapted to all levels of governance, even at the international level, given that cross-border flows of knowledge and technologies are increasingly more relevant because firms, universities, and other key actors are increasingly more internationalized. This fact is obvious in the European Union, where a big portion of innovation instruments are designed at the supranational level, but also applies to most countries where universities are part of international research consortiums, firms are part of global value chains, or regions and cities attract foreign R&D centers. Accordingly, *innovation policy needs to be implemented at different levels of governance.*

In many countries, however, most policies are national, in the sense that they are mandated and applied at the level of federal agencies, including national bureaus and ministries. These are complemented by *subnational policies*—those conceived and implemented at the level of states, provinces, municipalities, and cities—which often lack good coordination among them. Subnational instruments often can be more fine-tuned to the local context and the innovation problem to be resolved, but can be significantly constrained by lack of appropriate resources, human and financial, for implementation

In general, two principles are important when looking at the levels of governance. First, coordination and the avoidance of duplication between national and subnational policy implementation are critical. Too often instruments such as incubator networks or loan guarantees duplicate efforts across different government layers. Subnational instruments should be consistent with the higher-level national innovation strategy. This requires adequate coordination mechanisms, such as regional councils with representatives of the private sector, academia, and local and national governments.

Second, ensuring subnational level capacity to design and implement policy instruments is critical because often skills and financial resources can be limited at the subnational level. The capacity to design and implement innovation policy in large cities can be adequate, but this is often not the case in smaller cities or poorer regions. In addition, engaging subnational actors in the early stages of the design and implementation of the policy mix can pay off, as top-down strategies from the center can fail or have low take-up.

Instruments are more likely to be effective if sufficient flexibility is provided in the central design to adapt to local needs—including at the extreme the ability of local governments not to implement certain instruments that do not meet local needs (such as a science and technology park without local R&D capabilities in universities). Some instruments are developed as local public-private partnerships to solve very specific problems in the local innovation system, such as technology centers. *The generic design characteristics can be set from the center, but it is critical to adapt the design to the local context.*

3.3.5 The Role of the Private Sector

Innovation is a market-driven activity, with firms using it to improve productivity and drive growth. In order to help grow innovation systems, governments should always seek to work with the private sector in the design, implementation, and governance of innovation policy instruments, while avoiding capture. During the design stage, discussions with private sector associations and focus groups with firm representatives are essential to collect the information required for good design. During implementation, it is essential to involve entrepreneurs and industry experts in evaluation panels, which in some countries are heavily captured by academics.

Also, implementation is often more effective when public-private partnerships are used. For example, technology extension services (TES) are often more effective if delivered through a public-private partnership, as this can enable these services to be managed by and employ industry experts at private-sector salary levels, have access to the industry networks of private partners, and avoid what can be the poor reputation for government services within potential users. In the case of incubators, the record around the world of government running this early-stage infrastructure is poor. Policy makers should always seek to ensure that incubators they fund are run by professional incubator managers and are structured at least as public-private partnerships. Acceleration programs should also be delivered through industry or investor entities. The same applies to other instruments.

Governments should also seek the creation of markets in their interventions. For example, a major secondary benefit of providing innovation support to companies is that it increases demand for inputs such as knowledge and advice—a market for innovation—that becomes deeper, broader, and less reliant on government over time. Governments interventions should also seek to strengthen the supply of business advisory services. This can be done by including assessments of the quality and availability of these services and even providing training/capacity building and accreditation for these services. Similarly, most equity finance initiatives have a twin policy goal of providing financing to businesses, but also to build the pool of private sector equity finance and to "crowd in" private sector investors. This occurs by explicitly designing co-investment features and various incentives for private investors. It may also require training and capacity building both for financial professionals (such as prospective fund managers) and for potential investors (such as angel investors and angel investment groups). *The important element for policy making is helping to address missing markets.*

Finally, it is critical to involve the private sector in the governance of innovation policies, ensuring the accountability of government policies while having strong processes to avoid capture and the influence of vested interests. The private sector is always better placed to identify some of the key challenges for innovation and can help government policies improve their focus. A good example is Fundación Chile, a public-private partnership that helps the government in identifying key bottlenecks, supports the design of new interventions, and acts as a broker between the government and industry.

3.4 Some Guidelines When Searching for Policy Solutions to Innovation Problems

The final section in this chapter delves into a critical design element previously discussed: the identification of the right innovation problem or constraint. The first subsection explains why is critical to identify the right market failure in order to select the appropriate mechanism of intervention. The second subsection provides a typology of innovation problems and constraints and maps them with potential policy instruments. This can help policy makers narrow the information gap related to the choice of instrument. The last subsection highlights a complementary approach that instead of focusing directly on the problem or constraint focuses on the firm life cycle.

3.4.1 The (Mechanism) Design of Innovation Policy Instruments

As discussed in section 3.1.1, designing effective innovation policy requires understanding the true innovation problem that needs to be addressed. Identifying the reason why firms are underinvesting in innovation is central for effectiveness. The generic innovation problem described by Arrow (1962) and summarized in box 3.1—whereby firms underinvest in innovation activities because of risk, limited appropriation of externalities, and/or indivisibility of knowledge as a public good or increasing returns—can be solved by public policy differently, depending on which school of thought is applied. One school of thought frames how we see the process of innovation (focusing on what is in the policy toolkit). The other centers on understanding what the underlying problem is (focusing on in which situation the policy maker should apply these tools).

Different schools of thought emphasize different types of innovation policy approaches (Potts 2017). Within the first school, the structuralist approach emphasizes public expenditure and targeted support, as well as requirements to benefit sectors and organizations. The NIS approach (Nelson 1993) emphasizes the creation of nonmarket research organizations, such as universities or public science institutes, and the use of a systemic approach to innovation policy. Within the second school, which emphasizes market failures, approaches based on Coase (1960) focus on attaching the right intellectual property rights (IPRs) to address the appropriability problem. On the other hand, a more Pigouvian approach will tend to intervene in the market, providing tax incentives or subsidies to encourage firms to invest and thus appropriate the potential future externality.

While these approaches may lead to different combinations of instruments in the policy mix, when thinking about narrow innovation problems, the policy maker needs to understand the root cause of underinvestment in innovation. For example, why do so few firms implement innovation or R&D projects, or why are they not utilizing online marketing and commerce? The challenge in responding to these questions is that very often several problems or "failures" could explain the innovation problem. For example, firms may underinvest in R&D because (1) they cannot prevent the technology they develop from quickly being obtained by competitors, meaning they are unable to extract a decent return from the investment (lack of appropriation of returns); (2) they cannot persuade investors to finance the R&D/innovation project (asymmetric information); (3) they do not know how to manage and implement an R&D or innovation project (capabilities failure); (4) they cannot afford to engage or coordinate with other firms or the research sector so that the necessary services required to perform the R&D project—testing, prototyping, and so on—are provided (coordination failure). The challenge for policy design is that all these failures are plausible, and it is very likely that different types of firms experience different types of failures or no failure at all. Innovation policy is, therefore, a complex exercise.

However, as complex as this exercise may be, only by fully understanding the true constraints to innovation can progress be made. This is because the type of market failure dictates the type and appropriate design of the policy instrument. In the discussion that follows, some examples are provided to illustrate how the type of market failure determines the right type of policy instrument. It is based on a nascent literature that is applying mechanism design theory (Hurwicz 1973) to innovation policy, and that offers some important insights and lessons for the design of innovation policy instruments. Later in the section, the main implications for guiding practitioners are described.

3.4.1.1 Innovation Challenges and Market Failures

The discussion that follows highlights some examples of constraints to innovation that can be related to different market failures.

Challenge 1. Is innovation being constrained by the lack of appropriation of economic returns from innovation investments or the presence of asymmetric information?

Firms may be reluctant to invest in developing a new technological solution because they fear that other competitors could benefit from adopting this solution without making any investments. This problem can be addressed by establishing adequate property rights, such as a technology license that requires other firms to pay for use of the technology. However, this may not be possible. For example, the technological knowledge may be easily diffused by the hiring of engineers by some of the main competitors. In this case, some sort of subsidy in the form of a grant or tax incentive may be needed to provide firms with a sufficient incentive to innovate.

Measuring this problem and designing an effective policy, however, can be challenging First, it is very difficult for the policy maker to determine the existence and importance of potential externalities. Second, the pure subsidy solution described assumes there is no cost in using public finance to support this particular firm. However, this is never the case: government funds must be raised (through taxes) and then administered (through a program) to reach the innovator, and there are always many alternative uses of this funding (including not taxing it in the first place) that may be more useful. When the cost of financing public expenditures is high, the returns from addressing the externalities must greatly exceed the costs of deploying the instrument to justify a full subsidy. Third, if the policy maker compensates the firm ex ante for the potential externality, then it has the problem of monitoring ex post that the externalities are adequately diffused across other firms in the sector (Takalo 2012). For example, if the government provides large incentives for high-tech companies to establish themselves in the country with the aim of diffusing advanced technologies to local firms, this objective needs to be monitored. The challenge, however, is that the subsidized firm may partially or fully internalize the externality through formal or informal intellectual property protection ex post—in the previous example, by making local firms pay high technology license fees—and the policy maker has limited information and capacity to undo or revert the subsidies provided ex ante.

Challenge 2. Is a financial imperfection causing a financing gap for innovation?

An additional justification for government intervention to support innovation is the financing gap. Even in the absence of externalities, there can be a gap in financing R&D and innovation projects when the innovator and financier are different entities (Hall and Lerner 2010). This is because financing innovation with external financing is too costly, as external financiers demand very high returns. Several factors can explain this higher cost of capital. First, some R&D or innovation projects, in both incumbent firms and even more importantly in technology start-ups, produce assets that are primarily intangible and thus cannot easily rendered as collateral. Second, investment in innovation is more prone to financial market imperfections due to information asymmetries than other investments. Innovators tend to have more information on the potential success of innovation projects, so it is difficult for financiers to identify the potential returns of these projects. Adverse selection[13] issues can also arise due to principal-agent problems and the difficulties financiers or shareholders face in monitoring the innovators' performance once finance for the development of the project is provided.

Economic studies indicate that firms investing in R&D prefer self-financing versus debt financing (see a review of the literature by Hall and Lerner 2010). There is also evidence to suggest that smaller firms and start-ups in R&D-intensive sectors face higher costs of capital. However, the evidence on the innovation financing gap across types of firms and sectors is less robust. In practice, policy makers have resorted to tax incentives to finance R&D to compensate for these higher costs. However, this may not be the optimal solution if there is a financing gap, given that SMEs face difficulties in benefiting from tax incentives.

The two main reasons for the financing gap are adverse selection (difficulties in screening and identifying good innovation projects) and moral hazard (the difficulties in monitoring the implementation of the innovation project, thus transferring the risk of failure to the financier), which translate in lack of finance for innovation (see the review of the literature by Takalo 2012). Regarding the former, policy makers in innovation agencies are unlikely to be better placed than private financiers to evaluate innovation projects. It has been suggested that public interventions—for example, by providing loans via private intermediaries—can provide support to private financiers by signaling good projects (Takalo and Tanayama 2010), as well as centralizing information on innovative projects. Nevertheless, screening these projects is more likely to be more efficient when done by the private sector. On the other hand, moral hazard problems can be partially overcome by some banks, and, especially, by specialized investment funds

(Takalo 2012). In practice, separating good from bad innovation projects is difficult for both public and private actors. Some of the observed financing gap could be associated with the market doing its job—not funding bad projects—but also with underdeveloped financial markets in developing countries.

Challenge 3. Is the innovation problem a finance problem or a capabilities failure?

Firm managers in developing countries often do not know how to innovate, or they do not see any value in doing so. Thus, investment in R&D may be low because of poor managerial capacity, rather than a lack of finance. The NIS literature has labelled this a *capabilities failure* (Lee 2013). Building these innovation capabilities is critical for innovation and convergence to the technological frontier (Cirera and Maloney 2017). But the question for policy is why firm managers do not invest in learning and acquiring these capabilities. A potential explanation is some sort of bounded rationality that translates into overconfidence and unwillingness to introduce any new products or processes. Bloom and Van Reenen (2007) show how in general managers think they are better managers than they actually are, and this "overconfidence" in their own managerial capabilities seems to increase in countries further away from the managerial frontier. This overconfidence implies that firms often do not understand the value of their potential investments (Karlan and Valdivia 2011; Bloom, Schankerman, and Van Reenen 2013, which reduces firms' willingness to participate in public interventions to support these activities (McKenzie and Woodruff 2013). It is also possible that key markets for services support or key institutions that can facilitate the accumulation of these capabilities are also missing. Without these complementary institutions and knowledge, implementing innovation projects is too risky.

Regardless of what explains this potential failure, when the absence of key capabilities is the main constraint on innovation, financial instruments, such as loans and grants, or indirect subsidies, such as tax incentives, are not likely to work. Some type of technical assistance is needed to facilitate the learning process and the accumulation of these capabilities.

3.4.1.2 Implications for Policy Design

Question 1. Should governments finance only those R&D innovation projects that are "better"?

One critical question is what type of innovation projects should be selected for public support. In view of the potential problems of identifying and screening projects (adverse selection) and thus choosing the wrong projects in the face of limited public resources, it may be desirable for policy makers, as well as financial and nonfinancial intermediaries managing public funds, to have incentives to minimize risk and select what is perceived as the best (or less risky) projects. Is that premise correct? Not always.

Lach, Neeman, and Schankerman (2017) examine this question formally and suggest that policy makers should target the "middle." Those good projects with higher probability of success are likely to easily find finance and would be carried out anyway, without much additionality from public support (and with potential crowding out of private investment). On the other hand, risky projects with very uncertain rate of success are likely to have a negative expected value—for each successful project, there will be many more that will fail.

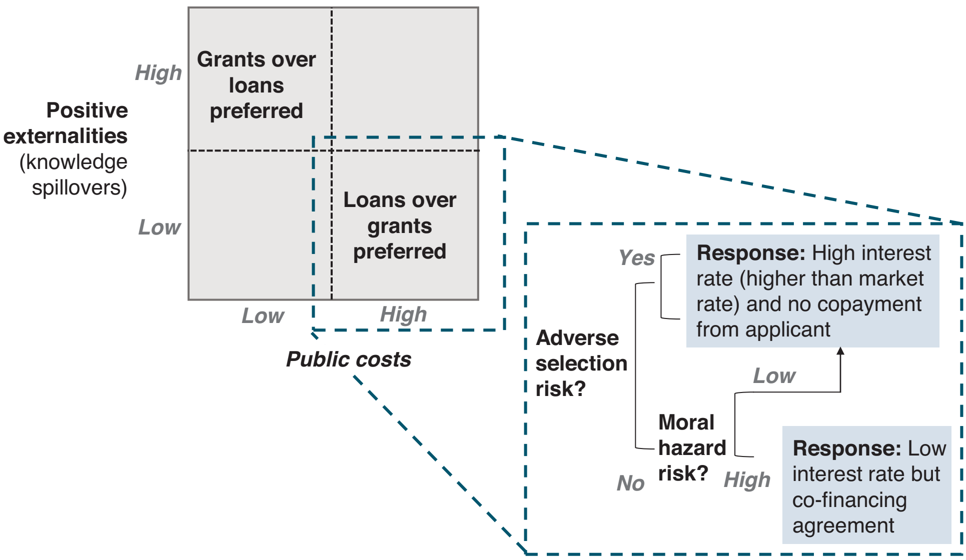
In the presence of information asymmetry and positive spillovers, generic policies involving limited targeting, such as the frequently used R&D subsidies or tax incentives, can trigger significant revenue losses by subsidizing inefficient firms (for a formal analysis, see Akcigit et al. 2018). Thus, while supporting the best firms may imply no additionality, supporting unproductive firms can generate distortions and reduce productivity growth. There are, however, combinations of policy mechanisms that may be appropriate.

Once the selection of desirable projects has been made, it can be difficult to determine the most effective means of allocating scarce resources among them. Giebe, Grebe, and Wolfstetter (2006) compare the effectiveness of different ways of allocating grants to selected projects if some ranking of project returns is available, such as ratings from expert panels. The authors show that the commonly used method—ranking projects based on these scores and giving grants in descending ranking order until the budget is exhausted—is not efficient. More additionality could be achieved by selecting the sets of projects that have a higher rating combined. This is because an R&D project with a high rating may require a large grant. The same amount of grants could be allocated to fund lower-ranking projects but with lower financing needs and larger aggregate additionality. Thus, expected returns need to be considered along with financial needs in order to maximize the additionality of public support.

Question 2. Should loans or grants, or a combination, be used?

The extent of externalities involved is important in choosing between loans or grants to support R&D projects. Based on numerical simulations, Lach, Neeman, and Schankerman (2017) show that when externalities are high and public finance is not very costly, grants should be preferred to loans to induce innovation efforts. However, when the costs of public finance are high and externalities are small, loans should be the preferred option. In this case, if the finance problem is related to the difficulties of screening and identifying good projects, the preferred policy should be a higher-than-market interest rate and no copayment from the applicant. This contrasts with observed policies in innovation agencies, which often provide a lower-than-market interest rate but require copayments. Considering moral hazard, there are two optimal policies: the same as above when moral hazard is low; and a low interest rate coupled with copayment requirements when moral hazard is high (see figure 3.2). The implication of these results is that optimal policies are likely to vary by firms and sectors.

FIGURE 3.2 Loans vis-à-vis Grants



Source: Elaboration based on Lach, Neeman, and Schankerman 2017.

Question 3. How Can Copayment Needs Be Calculated?

When some copayment is needed from applicants to ensure the right implementation and dedication to the project, the question is how much copayment is needed. This is a difficult question that is often solved by ex ante fixed copayment rates based on some firm characteristics, such as size. For example, copayments tend to be larger if beneficiaries are medium or large firms. Giebe, Grebe, and Wolfstetter (2006) propose that applicants compete in a bidding process whereby the application proposal contains the minimum copayment needed to implement the project. The authors suggest that bidding can provide a useful method for forcing applicants to reveal their true financing needs and thus maximize additionality (see box 4.1). While this approach may be difficult to implement in practice, it highlights that ex ante copayment rates pose the risk of overly subsidizing firms or reducing take-up when copayment rates are set too high.

3.4.1.3 Some Insights to Minimize Government Failure

While the application of the mechanism design literature to innovation policy is still incipient, existing work provides some important insights to aid the implementation of innovation policy (table 3.4). Interestingly, some of these insights imply policies that differ from what is observed in practice, indicating that there is a lot of room to improve the implementation of existing policy instruments.

The list that follows summarizes some of these insights to help the choice and design of policies and minimize the risk of government failure.

TABLE 3.4 Some Insights for Choosing Innovation Instruments

Failure	Problem	Options	Detail
Knowledge spillovers and lack of appropriation of returns on innovation	Firms underinvest because the risk of diffusion to the sector would prevent them from recouping their costs, or there is a potential for knowledge spillovers that could have a significant impact on the economy.	Tax incentives or grants may be preferred.	▪ Low externalities/spillovers on existing R&D/innovators favor the use of tax incentives. ▪ Very high externalities may require a grant. This can be blended with a loan to finance some components such as fixed assets, like equipment.
Information asymmetry between innovators and investors that constrains financing	Commercial banks are not funding innovation projects that seem relatively low risk and that potentially offer appropriate returns. Investors are not investing in new ventures.	Loans and guarantees, and equity, should be preferred.	▪ If the problem is only screening, use of loans or guarantees may not require subsidized interest rates. ▪ If the problem is lack of control over what innovators can do with the loan, copayment rates should be imposed. ▪ Early stages may require equity investment, which can be blended with tax credits for investors.
Low capabilities/overconfidence (lack of self-awareness, bounded rationality)	Firms do not perceive the value of innovation that would yield an economic return or lack the capabilities to design and implement innovation projects.	Some technical assistance and advisory services are required, either directly through existing networks of advisors or via financial instruments directed to finance technical assistance.	Advisory services can also be blended with loans and grants, either by financing them directly or by providing complementary advisory services (that is, firm diagnostics that would create awareness, convince owners to invest, and guide investments to areas of high returns).

Insight 1. Map expected results with innovation constraints.

Map the type of innovation outcome that you want to improve (such as improving R&D, adopting new technologies) with the problem or "failure" that undermines it (see next section for some examples). Consider the following:

- *There may be different "failures" for different types of firms, so different instruments could be needed, and each instrument may not work for all firms (targeting).*
- *What is the main cause of underinvestment in the innovation project?* How do we know that this is the root cause (what are the symptoms)?

Insight 2. To increase effectiveness, improve targeting.

Attracting the right participants to benefit from the policy is important along different dimensions:

- *Maximize additionality of impact.* The best projects may have direct access to the financial market; therefore, public support to them would yield little additionality. The worst projects may fail or yield very low returns. The best strategy may be to target the middle group of projects.
- *Screen out bad projects.* Highly uncertain and low-return projects will result in negative expected returns to public investment.
- *Select the combination that maximizes efficiency and additionality.* Consider the combination of projects selected that maximizes value for money, not only those that are better.

Insight 3. Deal with a variety of financial needs.
Maximize the returns on finance by asking applicants to reveal their true financing needs and adjust copayment rates to what is revealed.

3.4.2 Searching for Solutions to Common Innovation Problems

It is unusual for policy makers to have to consider either the performance of the whole National Innovation System or an extremely narrow innovation problem. Innovation problems often occur together. The most likely starting point for policy makers when thinking about innovation policy is to address the underperformance of specific innovation outcomes, such as low R&D, insufficient technology adoption, or low commercialization of research. This section provides an initial description of how common instruments can be used to address the most frequent innovation problems. The reader can obtain a sense of combined solutions in this section, but also can refer to each of the instruments profiled individually in chapter 4, section 4.2.

This section also discusses the range of policy instruments that can be used to address each situation, as well as a short description of which one may be more appropriate at each stage. These examples are stylized. Each country and innovation system will have its own unique features, problems, existing policies and institutions, and economic and industrial histories. As noted, it is unwise to copy from other jurisdictions without local assessments and customization. Nevertheless, the instruments proposed for each program provide an initial list on how to start addressing the innovation problem.

Table 3.5 summarizes some of the common problems and potential solutions. These six problems are then discussed in more detail.

Innovation Problem 1: Low General Innovation Performance Due to Low Capabilities
This is the most pervasive type of business innovation problem in developing countries, featuring a lack of process innovation, little introduction of new products, poor managerial capacity and skills, a lack of connections, and outdated business models.

How to identify the problem: There is very little innovation activity, compared to peer countries. Managers do not think it is important to invest in innovation activities

TABLE 3.5 Common Innovation Problems and Potential Policy Solutions

Innovation problem	Instrument	What for?
1 Low general innovation performance due to low capabilities	Business advisory services	Capabilities building (management)
	Technology extension services	Capabilities building (technology)
	National quality infrastructure	Quality and standards
	Supplier development programs	Capabilities building (management); Quality and standards
	Clusters/networks	Collaboration
	Vouchers	Collaboration
2. Use of old and outdated technology/ low technology adoption	Business advisory services	Capabilities building (technology)
	Technology extension services	Capabilities building (technology) and transfer
	Technology centers	Capabilities building (technology) and transfer
	Loans	Finance
	Grants	Finance and appropriation
3 Weakness in technology generation and commercialization	Technology transfer offices	Technology transfer
	Technology centers	Capabilities building (technology) and transfer
	Technology extension services	Capabilities building (technology) and transfer
4. Low number of young innovative ventures	Incubators (business advisory services)	Capabilities building
	Accelerators	Capabilities building and scale up
	Equity	Finance and scale up
5. Lack of collaboration leading to poor quality business innovation	Clusters/networks	Coordination and mindset
	Vouchers	Mindset and incentives
	Grants	Incentives and finance
	Technology transfer instruments	University-industry
6. Suboptimal investment in R&D	Grants	Finance and appropriation
	Loans	Finance
	Tax incentives	Incentives and appropriation

and knowledge accumulation, even informally. Often poor demand is cited as the reason for this lack of innovative activity—even if with the same low levels of demand, efficiency gains from innovation could enable firms to lower their prices and/or enjoy better margins. This is the most basic and common problem for many SMEs. It precedes the problem of innovation finance—managers do not even try to get financing for innovation activities.

Policy options: The key to address this problem is therefore to provide the necessary services, incentives, knowledge, and connections to build firms' capabilities, especially regarding business and managerial practices. This can be achieved by different instruments.

General support: The first and more general step is the use of *business advisory services (BAS)* or *technology extension services (TES)*. This can provide the necessary information to SMEs, build awareness, asses their readiness, provide or refer firms to more specialized services if needed, and help guide the implementation of changes.

Quality and standards related instruments: Often the lack of innovation activities has a very clear link to quality issues or adoption of standards, which undermine firms' ability to access export markets or link to global value chains. In these cases, these quality-related services need to be provided to upgrade production and management processes. In this regard, a first step is provision of *national quality infrastructure (NQI) and related services*, combined with active awareness programs on the importance of using these services. Another instrument, *supplier development programs*, is more targeted to participation in supply chains and/or global value chains The advantage of this type of instrument is that it brings specific certification and innovation to companies, providing a clear demand signal that investing in innovation can lead to them becoming suppliers to larger firms.

Incipient collaboration: Increasingly, innovation is seen as the outcome of firms collaborating with other firms and actors. The previous instruments try to provide external services to SMEs. However, many SMEs tend to act alone and are often reluctant to collaborate with other firms, knowledge providers, and associations. It is important to start breaking this isolation and provide incentives for some collaboration with other actors. A first step is to support *clusters and networks* through which SMEs can interact and collaborate. Other intermediaries are also needed to implement other instruments more effectively, and to facilitate cross-learning and spillovers. For those firms that may consider a first collaboration for a small innovation project, *a voucher or a small grant* for collaborating with another firm or knowledge provider to undertake innovation can also be an effective way to start with collaborative projects.

Sequencing and coordination (policy mix): Most of the instruments discussed should be core elements in any National Innovation System. They are the main instruments to support the base of the capabilities' escalator. In terms of sequencing, the starting point must be *business advisory services/technical extension services*, given their role not only in providing the necessary services to support innovation, but in trying to change the mindset of firms that are not innovating and supporting them throughout the innovation process. It is also important to support the creation of *clusters and networks*, but with a realistic expectation that these are only intermediary instruments to provide more effective interventions. Business advisory services/technical extension services can build the path to collaborative instruments and to more sophisticated grants for innovation projects.

Finally, for some sectors, either with more potential to export or to links to global value chains, *SME upgrading instruments* are easier to implement, often as part of interventions aimed at stimulating exports, sectoral development, regional development, cleaner production, and so on. Although these interventions are not typically thought of as being "innovation" initiatives, they all incorporate this type of innovation upgrading, and more effectively support building the necessary capabilities to innovate, export, and compete than distortionary and often ineffective instruments such as local content requirements.

Innovation Problem 2. Use of Old and Outdated Technology/Low Technology Adoption

The use of technology—both hard (production machinery, ICT) and soft (management, lean processes)—by industry involves a continuum of activities, starting with the adoption of existing common technologies by SMEs through to the generation of new-to-the-world technologies by frontier firms, public research organizations (PROs), and universities. For most firms, the main issue is how to adopt close-to-frontier technologies in their different business functions. However, in most developing countries, especially low-income countries, most firms operate with old and outdated technologies. The first problem is, therefore, how to support the transfer, adoption, and effective utilization of appropriate technologies to firms, and how to embed a cycle of continuous upgrading and improvement.

How to identify the problem: Field visits, technology maps, and engagements with sector associations can shed light on the extent firms are using outdated technologies and their impact on firm performance. Digital technology adoption surveys can highlight existing technological gaps, although technology is broader than what these surveys tend to measure. It is also important to analyze the domestic machinery sector as well as imports and trade of capital goods. It is critical not to assume that the technology adoption problem is narrowly confined to installing a machine in the production process, but that it is multidimensional and affects all management and production processes, and that it requires absorptive capacity and the necessary complementary skills to integrate technologies in the firm.

*Policy options:*The starting point when thinking about technology should be *business advisory services* and *technology extension services*, and whether the firm has the required absorptive capacity to integrate a new technology in the firm. Technology extension services, in addition to providing a diagnosis of the technological and complementary factors gaps, can aid the adoption of specific technologies. *Technology centers* provide more specialized advice and can also play a pivotal role as an intermediary in demonstrating new technology, facilitating the transfer of new technologies, providing specialized training, adapting existing approaches to firms' needs, and supporting firms in building the necessary capabilities.

When the problem of adoption is finance: An additional constraint is the availability of finance to acquire, test, and calibrate new machinery. In these cases, *loans*, when commercial banks lack the liquidity to finance this type of activity, or *loan guarantees*, when banks' perceptions of risk are excessive, can assist in the adoption of new technology. If the technology is part of a more complex innovation project, *grants* can be used to support the adoption of leading-edge technologies or to undertake innovation projects.

Sequencing and coordination (policy mix): It is critical that the technology adoption problem be understood in terms of the needs to first build the technological capabilities and then to ensure adequate finance. Often, developing countries struggle at both ends, and both problems are entwined. Lack of technological capabilities and clarity on the use of a new technology can lead to poor-quality loan applications to commercial banks. It is essential to understand and address both problems, starting with building the necessary technological capabilities and providing information and services to adopt new technologies. This especially applies to the adoption of more frontier technologies (Industry 4.0), given that these capabilities need to be accumulated over time. In most cases, there will also need to be capacity building on the supply side—to improve the breadth and depth of technology extension services or technology centers offerings, particularly in new areas of technology.

Dealing with market conditions. Finally, problems with adoption will always be influenced by market conditions. Barriers to investment, barriers to the import of capital goods, lack of a skilled work force, barriers to multinational enterprises (MNEs) or the hiring of foreign specialized workers, and uncertain market conditions limit the adoption of new technologies and need to be addressed.

Innovation Problem 3. Weakness in Technology Generation and Commercialization

Moving up the capabilities escalator, another challenge for most developing countries is the lack of indigenous technology generation and commercialization. For those firms and public research organizations/universities that can generate new technologies, barriers often exist during the cycle of technology development, especially related to commercialization and after the initial stages when R&D activities have generated some output.

How to identify the problem: In some cases, there is a problem with the generation of viable potential technologies; in others, the issue is that viable technologies are developed but commercialization performance is weak. The first problem may be identified through low rates of R&D, low use of intellectual property, few spin-offs from research organizations, and weak quality and quantity of entrants to incubators and accelerators. The second problem is identified by the lack of new to the market products successfully introduced, and low commercial returns from investments in R&D.

Policy options: The lack of technology commercialization is often caused by weak technology transfer mechanisms between research institutions and industry (including how to license technology or manage spin-off companies). It may also reflect a lack of knowledge and experience within the private sector about how to successfully commercialize new technologies. For firms, *technology centers* support both the adoption and the generation of new technologies, housing support measures such as provision of modern manufacturing equipment and related training and testing; and product design, development, and demonstration.

For commercialization, a typical instrument is *technology transfer offices*, which can support the transfer of technologies from universities and public research organizations on the one hand, and help entrepreneurs address knowledge gaps on the other. *Science and technology parks (STPs)*, often directly linked to universities, also support the development of technology-intensive sectors through commercialization of research and technology transfer, and through the attraction of outsourced R&D activities from multinational enterprises. *Clusters and networks* can help fill the information gaps, particularly when they can connect companies to expert sources of advice on commercialization (such as intellectual property, channels to market, product development, and fundraising), which can be provided through very specialized technology services offered by *technology extension services* or *technology centers*.

From the demand side, *public procurement* can articulate the unmet needs of public sectors and provide a "pull" force to drive the commercialization or adoption of innovative solutions in the public market.

Sequencing and coordination (policy mix): A critical issue before embarking on these types of instruments is to realistically assess the level of maturity of existing universities, public research organizations, and technological companies to generate, commercialize and transfer technologies. In most developing countries, the main technology challenge is to drive the adoption of existing technologies, so the policy challenge is to build the support intermediaries that can help with this process. However, some "islands of research excellence" in universities, public research organizations, or sectors may exist. In this regard, *technology centers* may play a key sectoral role, and technology centers and specialized *technology extension services* are critical as outreach for good public research organizations and universities. *Science and technology parks* are likely to be more effective in attracting R&D but can work in some cases when connected to strong university departments. More generally, the availability of specialized technology services and/or networks that can connect firms to local and international sources of support may be at best patchy and may need to be developed.

Other instruments can also be useful to start generating commercialization. Policy makers often believe they are not generating enough commercial returns from their investments in public sector R&D. However, even in countries with advanced science, technology, and innovation (STI) systems, commercialization often generates lower and fewer returns than is assumed, and larger companies are often best placed to commercialize public sector research. Innovation policy should focus on ensuring that investments in R&D are accompanied by knowledge exchange and utilization, rather than mere increase in short-term income through commercialization. This can occur through research consultancies, specialized training for industry, placement of researchers in industry, the movement of applied researchers to industry, and technology awareness-raising activities.

Innovation Problem 4. Low Number of Young Innovative Ventures

Increasing innovation is not only about expanding investments in innovation activities by incumbent firms, but also about generating new innovative ventures. These new innovative ventures are an important driver for growth, so increasing their numbers is a common challenge in most countries. However, their success is linked to the strength of the supporting entrepreneurship ecosystem, which encompasses infrastructure, the incentives for start-ups, the availability of financial and nonfinancial support, and the entrepreneurial culture.

How to identify the problem: The common sign of this problem is the low number of young innovative start-ups or young firms with a technological base as compared with peers (comparisons with more developed ecosystems are meaningless). This may include low levels of start-ups, but also few scale-up businesses (which have a greater impact). Other problems are related to the provision of early-stage investment and the development of angel investors and other early-stage equity funds. Often, implementing a full entrepreneurship ecosystem diagnostic is the key to identify underperformance and the main weaknesses within the ecosystem.

Policy options: Instruments to support new innovative ventures should therefore be developed systematically, to ensure that new ventures at all stages—from pre-seed to scale-up—are supported by infrastructure (such as accelerators), advisory services, and financial instruments. Because it takes time to develop ecosystems, a long-term approach is necessary. There are also a range of interventions that are not classed as innovation policy, but rather fall into entrepreneurship support, that seek to stimulate interest in entrepreneurship and incentivize potential entrepreneurs (see Profile 7 on early-stage support).

Advisory services: At the early stage, it is essential to start building expert *business advisory service networks* that can assist entrepreneurs. Dedicated infrastructure, with high-quality *incubators*, is needed to provide entrepreneurs with an enabling environment at the start-up stage of entrepreneurial activity. Following incubation initiatives, another critical need is to have in place more technology-specialized *accelerators* that target high-growth–oriented firms that are in the process of scaling up. To this end, it is important to integrate *investment readiness programs* in accelerators to improve the pipeline of projects and maximize the likelihood of investments.

The advantage of these early-stage infrastructure instruments is that they can be complemented with other more generic instruments, such as providing *grants* to help start-ups purchase services and equipment or launch projects; offering *tax incentives* for start-ups or their investors; or facilitating early-stage investment processes by launching or leveraging equity financing. Concrete measures include direct or coinvestment, tax and regulatory incentives, or provision of support for *business angel networks* (BANs).

Finance: A typical problem faced by highly innovative start-ups is that the risks involved in funding their activities are so high that there is a lack of financing sources. In developing countries, this is also largely linked to the underdevelopment of financial markets. To tackle this problem therefore requires systemic efforts to address framework conditions (such as regulations), mobilize financing resources, and provide incentives for early-stage investors.

It is important to focus on the supply of *capital (equity)*, including direct investment funds (when information asymmetry is very severe), co-investment funds, and fund-of-funds. Also, if deal flow is strong, equity investments, such as venture capital funds, can be used to prioritize support for angel investment, which has wider coverage and invests earlier. Tax incentives for early-stage investors may also encourage the availability of these funds.

Sequencing and coordination (policy mix): Many policy approaches also have a strong supply-side approach—ensuring there are many start-ups and supporting their growth—but pay far less attention to helping innovative ventures find markets for their products. However, generating sales is ultimately what drives firm growth. Broader business environment issues will invariably affect the success of innovative ventures, and policy makers should address them, where possible. They may include reforming regulatory issues such as investment law, tax issues, employment and visa issues, insolvency and business registration, national branding and marketing, and relations with diaspora groups.

The regulatory and legal framework can be a strong impediment to the development of early-stage financing. Necessary reforms need to be identified and pursued along with more direct interventions. Innovation financing schemes should be designed in concert with entrepreneurship ecosystem support to promote innovative ventures: that is, not only to strengthen the supply side of financing, but also to support the development of the demand side (investable entrepreneurs who need risk financing). A core principle must always be how to crowd in private sector investment and seek not only to attract capital, but also to raise the investment skillset within the ecosystem. This is because early-stage risk capital investing involves different skills from traditional investing, but when effective it operates as *smart capital*—bringing finance and the networks and mentoring to the recipients.

Innovation Problem 5. Lack of Collaboration Leading to Poor Quality Business Innovation

As discussed, the quality of innovation is often enhanced by firms collaborating with other firms and actors. Collaboration among firms, and among firms and research institutions, enables interactive learning and knowledge/technology transfer. Either due to a lack of investment to cover the collaboration costs or barriers related to mindset (such as risk aversion, or concerns about intellectual property), a lack of collaboration or ineffective collaboration is a common problem in most developing countries; however, the nature of innovation is increasingly making collaboration essential (see Chesbrough 2003).

How to identify the problem: Firm-level innovation data, if available, may indicate the level of collaboration by firms (and with which ones). The research sector may also be able to indicate how much collaboration they have with industry. Exploring natural industry clusters for the level of collaboration within them is another angle. If innovation grant programs exist, another indicator may be the number of applications for innovation grants among groups of firms, industry associations, consortiums, or university-industry groups. A lack of joint intellectual property and very little commercialization is often evident, with a significant divide between firms, industries, and knowledge providers.

Policy options: Problem 1 suggested some basic instruments to foster collaboration, starting with the creation of *clusters and networks*. These offer opportunities at the ecosystem level for innovation actors to interact with one another and therefore engage in more dynamic innovation processes, particularly on projects that have jointly been identified as being strategic. *Vouchers* are useful as a starting instrument to induce SMEs to embark on innovation through collaborating with knowledge providers. Initial collaborations triggered by vouchers should be supported to bring about persistent behavioral change toward long-term routines of collaborative innovation.

Collaboration grants are the most commonly used instrument to support collaborative innovation (R&D projects and beyond). The exact design of grants schemes can vary considerably, but grants can accommodate a diversity of collaborative projects. They can also accommodate different types of partnerships among firms, research consortiums, or industry-university collaboration.

Technology centers and *technology transfer offices* can facilitate technology transfer and collaborative innovation toward commercialization between research institutions and firms.

Sequencing and coordination (policy mix): A collaborative culture needs to be integrated as an essential part of innovation activities. This can begin with the use of *clusters* and *vouchers*, which are particularly useful in industry sectors with little history of collaboration (such as many service sectors). As firms collaborate in more complex innovation projects, grants can play a more important role. Innovation collaboration is often associated with R&D projects—universities working with business or small biotechnology firms working with multinational enterprises—to develop frontier technologies. Supporting these types of more complex projects is important because innovation collaboration is difficult and uncertain, and the rate of failure in collaboration is often quite high.

Innovation Problem 6. Suboptimal Investment in R&D

Lack of R&D is a common problem in firms (especially SMEs) in developing countries. Typical reasons for lack of R&D include limited appropriability resulting in unwillingness to invest in R&D, uncertainty about the market demand and technological risk, or an actual shortage of funding even if the firms want to engage in R&D. Governments may seek to support R&D in particular strategic sectors or areas of technology. However, in some cases, lack of R&D reflects the simpler problem of lack of complementary factors, such as skills or managerial practices. Effective management of an R&D project requires good organizational and business practices, with appropriate management of human resources and adequate skills.

How to identify the problem: Policy makers should start by measuring R&D activities with surveys consistent with the Frascati Manual,[14] the internationally recognized methodology for measuring and collecting R&D data, and benchmark them with peer countries. Setting arbitrary R&D investment targets based on the experience of developed countries can be counterproductive, given that developing countries may invest less because of industry structure and/or a lack of complementary factors. As a result, it is important to clearly identify the extent of underinvestment in R&D, and the reason for such underinvestment.

Policy options: For high-risk yet high-potential R&D activities with large externalities, *grants* are the most commonly used type of support. The more risky, innovative, and strategic (promising high spillovers) the project, the more generous the terms of grants tend to be in matching requirements, repayment conditions, and so on. For R&D projects with moderate levels of risks, *matching grants* are often used, requiring a certain level of copayment from beneficiaries, in order to crowd in private investment.

For R&D activities that are closer to the market, especially for those projects that firms judge to have a high potential of success, *loans* or *repayable grants* can be an effective instrument to address financial barriers. *Tax incentives* are also often provided to different types of sectors and firms as an indirect financial instrument to encourage more R&D investments, especially for those larger firms already engaged in R&D. Tax incentives are less selective or targeted compared to grants, and also more procyclical, given that the subsidy is tied to company profits.

From the demand side, *pre-commercial procurement*—or procurement of R&D, such as supported by the US Small Business Innovation Research (SBIR) program—can also offer a channel to communicate unmet public needs that require R&D to develop solutions.

Sequencing and coordination (policy mix): If firms do not generally invest in simpler types of process and product upgrading, it is unlikely that they will invest in more formal R&D projects. Therefore, for those firms that are at the bottom of the capabilities escalator, the instruments discussed in Innovation Problem 1 are the prerequisite for R&D support.

Firms do not invest in R&D to be more innovative; they invest to improve productivity (through better processes), improve product quality, or grow through new product development. However, market conditions often make it difficult to obtain returns (due to a lack of protection for intellectual property, product quality standards, weak consumer finance availability, and so on), so policy makers also need to work on these demand-side barriers. Otherwise, the financial case for R&D investments for firms will rarely be positive.

3.4.3 Innovation Policy Across the Firm Life Cycle

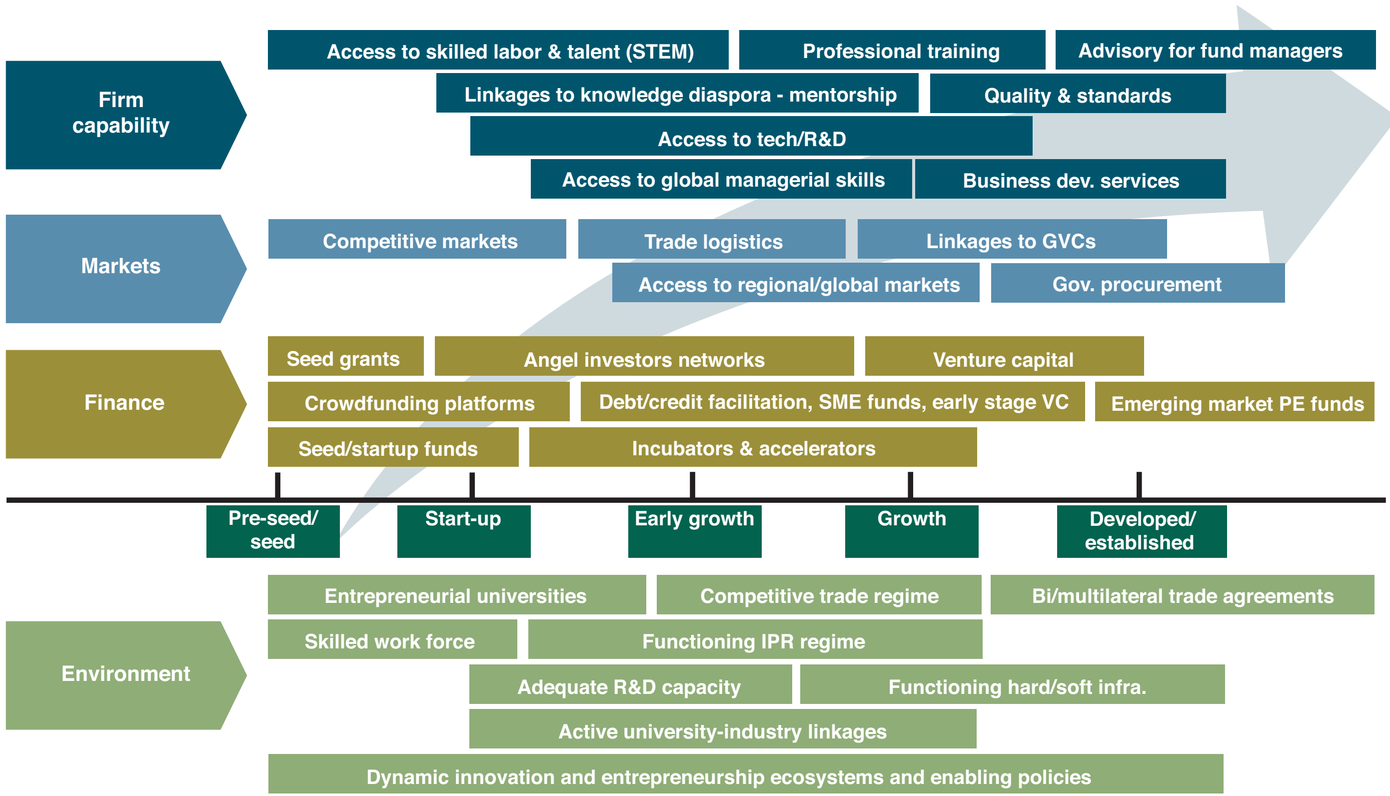
The firm life-cycle approach is a useful way of structuring the policy mix. This approach recognizes that firms can face different needs depending on their age, and so differentiates firms across sequential stages within the life of the firm, moving from its early stages of existence (pre-seed, seed, and start-up), to later stages of maturity (growth, developed, and established). Figure 3.3 portrays the life-cycle framework. This framework is useful to gain a more holistic understanding of the different issues affecting firms over their life cycle, while keeping in mind sectoral differences and specificities. Its underlying assumption is that the relevance of instruments to support a firm may depend on the firm's stage in its life cycle and the market conditions of the sector in which the firm operates.

Thus, the policy mix should seek to strike the appropriate balance of support across stages in the firm life cycle and innovation cycle. Business innovation occurs in both existing firms and in new ventures. A balanced approach that combines early-stage infrastructure and services for new firms with instruments that offer market and financial incentives to induce scaled commercial innovations from incumbent firms promises to be more holistic.

While many countries have introduced emblematic early-stage entrepreneurship/start-up programs, policy makers should consider two issues when deciding whether to increase the relative importance of these programs in the innovation policy mix. First, the potential impact of incubators and accelerators, or equity instruments that target start-ups in the tech sector, is constrained by the limited contribution of this sector to the overall economy, in terms of both employment and company growth. Regardless of the hype around start-ups, policy makers should be realistic about the potential contributions from these groups of entrepreneurs and the time frames over which these may occur. Second, several of these instruments address the early stage of the venture at the expense of sustained support over the later stages, when support may also be justified. In these cases, policy makers risk building "a bridge to nowhere" for early-stage firms they support, missing out on the substantive economic, innovation, and employment outputs that only scaled-up firms provide (Isenberg 2012).

Combinations of instruments should seek to cover all stages of the innovation cycle (although not all may be necessary for nascent sectors) if there are gaps. For the development and introduction of new innovations, this means supporting the generation of ideas, their prototyping, and their commercialization. Support for prototyping should be implemented hand in hand with financial support and commercialization, if needed. Supporting investments in R&D and research consortiums requires the availability of a well-functioning intellectual property framework and technology transfer facilities. For the application of knowledge, this means supporting awareness raising of best practices, the acquisition of relevant knowledge, and then its effective utilization within firms. It is paramount that the design of the policy mix takes into consideration these stages of the innovation cycle.

FIGURE 3.3 Firm Life-Cycle Framework to Structure the Policy Mix



Note: GVCs = global value chains; IPRs = intellectual property rights; PE = private equity; R&D = research and development; SME = small and medium enterprise; STEM = science, technology, engineering, and mathematics; VC = venture capital.

Notes

1. See section 3.3 for a detailed description of the different innovation policy instruments.
2. Several types of system failures identified by the literature are relevant when building innovation capabilities. Firms may have insufficient access to human capital, infrastructure, or technology. For example, firms in developing countries can be trapped in markets with low technological development that lack the complementary factors important for innovation, such as research centers or quality certification. Coordination failures between firms and nonmarket institutions may reduce opportunities for learning and the creation of new products and new technologies. More important are systemic failures associated with weak institutions and inadequate regulations that may distort and constrain firm innovation activities.
3. There is an incipient literature evaluating the impact of good management practices in government. A meta-analysis of 70 studies finds that the adoption of management by objectives, an early version of performance management, had a positive impact in public agencies and private sector firms (Rodgers and Hunter 1992). A more recent study supports the notion that proper implementation of performance management improves education outcomes (Sun and Van Ryzin 2014). Its application in the context of developing countries has also showed positive results (Rasul and Rogger 2018).
4. There are additional models, such as Germany's, where the delivery agency for much innovation policy is outsourced and generally occurs through a not-for-profit company rather than a government entity.
5. *Horizontal coordination* relates to organization and management of policy activities *across* multiple government agencies and ministries, to enable these to work effectively. *Vertical coordination* entails the interaction of multiple activities *within* national ministries and regional and local departments and implementing bodies, so they can all perform in harmony.
6. Kafalat is a Lebanese financial company that guarantees loans for SMEs. It is owned by the National Institute for the Guarantee of Deposits and Lebanese commercial banks.
7. In this context, demand refers to the demand for innovation by the firm, and not to the demand for knowledge from public research organizations or universities.
8. In one study for the EU, Guerzoni and Raiteri (2015) analyze the effects on innovation outcomes from using a combination of direct subsidies to R&D, tax incentives to R&D, and procurement for innovation. The authors find a positive impact of procurement for innovation and suggest that both supply and demand instruments are more effective in supporting innovation when they interact.
9. See Atkin, Khandelwal, and Osman (2016) for a randomized control trial on rug producers in Egypt and exports and Ferraz, Finan, and Szerman (2015) for an evaluation of SMEs and procurement demand in Brazil.
10. 5S is a method to organize a workspace more efficiently, based on the Japanese words translated as "Sort," "Set in order," "Shine," "Standardize," and "Sustain."
11. Busom, Martinez, and Corchuelo (2012), for example, find for a sample of Spanish firms that SMEs that are financially constrained are less likely to use tax incentives and more likely to use direct subsidies.
12. A few studies have analyzed the combined use of direct and indirect support to innovation. Bérubé and Mohnen (2009) find that Canadian firms that benefited from grants and tax credits were more likely to introduce new products and achieve success in commercializing those innovations, compared to firms that benefited only from R&D tax incentives. Thus, in the case of Canadian firms, there was some complementarity between both types of instruments when used simultaneously.

13. Adverse selection here refers to a situation in which financiers and innovators do not have the same information about the quality of the innovation project.

14. See https://www.oecd.org/sti/inno/frascati-manual.htm

References

Akcigit, U., J. Grigsby, T. Nicholas, and S. Stantcheva. 2018. "Taxation and Innovation in the 20th Century." CEPR Discussion Paper 13167, Centre for Economic Policy Research, London.

Andrews, M., L. Pritchett, and M. Woolcock. 2017. *Building State Capability: Evidence, Analysis, Action*. Oxford University Press.

Angelelli, P., F. Luna, and C. Suaznabar. 2017. *Agencias latinoamericanas de fomento de la innovación y el emprendimiento: características y retos futuros*. Inter-American Development Bank, Washington, DC. doi: http://dx.doi.org/10.18235/0000857.

Appelt, S., M. Bajgar, C. Criscuolo, and F. Galindo-Rueda. 2016. "R&D Tax Incentives: Evidence on Design, Incidence and Impacts." OECD Science, Technology and Industry Policy Paper 32, OECD Publishing, Paris.

Aridi, A., and N. Kapil. 2019. *Innovation Agencies. Cases from Developing Countries*. Washington, DC: World Bank.

Arrow, K. 1962. "Economic Welfare and the Allocation of Resources for Invention." In *The Rate and Direction of Inventive Activity: Economic and Social Factors,* 609–26. Princeton, NJ: Princeton University Press.

Atkin, D., A. K. Khandelwal, and A. Osman. 2016. "Exporting and Firm Performance: Evidence from a Randomized Trial." NBER Working Paper 20690, National Bureau of Economic Research, Cambridge, MA.

Bérubé, C., and P. Mohnen. 2009. "Are Firms that Receive R&D Subsidies More Innovative?" *Canadian Journal of Economics* 42 (1): 206–26.

Bloom, N., M. Schankerman, and J. Van Reenen. 2013. "Identifying Technology Spillovers and Product Market Rivalry." *Econometrica* 81 (4): 1347–93.

Bloom, N., and J. Van Reenen. 2007. "Measuring and Explaining Management Practices across Firms and Countries." *Quarterly Journal of Economics* 122 (4): 1351–1408.

Busom, I., E. Martinez, and B. Corchuelo. 2012. "Obstáculos a la innovación y uso de innovación de incentivos: subvenciones o estímulos fiscales?" *Economía industrial* 382: 35–44.

Chesbrough, H. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press.

Cirera, X., and W. F. Maloney. 2017. *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up*. Washington, DC: World Bank.

Coase, R. H. 1960. "The Problem of Social Cost." In *Classic Papers in Natural Resource Economics*, 87–137. London: Palgrave Macmillan.

Cornick, J., E. Dal Bó, E. Fernández-Arias, G. Rivas, and E. Stein. 2018. *Building Capabilities for Productive Development*. Washington, DC: Inter-American Development Bank.

Crespi G. A., and A. Maffioli. 2014. "Design and Evaluation of Fiscal Incentives for Business Innovation in Latin America: Lessons Learned after 20 years of Experimentation." In *Science, Technology and Innovation Policies for Development,* edited by G. Crespi and G. Dutrénit. Springer.

Dechezleprêtre, A., E. Einiö, R. Martin, K-T Nguyen, and J. Van Reenen. 2016. "Do Tax Incentives for Research Increase Firm Innovation? A RD Design for R&D." NBER Working Paper 22405, National Bureau of Economic Research, Cambridge, MA.

Dodgson, M., A. Hughes, J. Foster, and S. Metcalfe. 2011. "Systems Thinking, Market Failure, and the Development of Innovation Policy: The Case of Australia." *Research Policy* 40 (9): 1145–56.

Edler, J., 2010. "Demand-Oriented Innovation Policy." In *The Theory and Practice of Innovation Policy. An International Research Handbook*, edited by R. Smits, S. Kuhlmann, and P. Shapira. Cheltenham, UK: Edward Elgar.

Ferraz, C., F. Finan, and D. Szerman, 2015. "Procuring Firm Growth: The Effects of Government Purchases on Firm Dynamics." NBER Working Paper 21219, National Bureau of Economic Research, Cambridge, MA.

Giebe, T., T. Grebe, and E. Wolfstetter. 2006. "How to Allocate R&D (and Other) Subsidies: An Experimentally Tested Policy Recommendation." *Research Policy* 35 (9): 1261–72.

Glennie, A., and K. Bound. 2016. *How Innovation Agencies Work: International Lessons to Inspire and Inform National Strategies*. London: Nesta.

Guerzoni, M., and E. Raiteri. 2015. "Demand-side vs. Supply-side Technology Policies: Hidden Treatment and New Empirical Evidence on the Policy Mix." *Research Policy* 44 (3): 726–47.

Haapanen, M., H. Lenihan, and M. Mariani. 2014. "Government Policy Failure in Public Support for Research and Development." *Policy Studies* 35: 557–75.

Hall, B. H., and J. Lerner. 2010. "The Financing of R&D and Innovation." Chapter 14 in *Handbook of the Economics of Innovation*, Vol. 1, edited by B. H. Hall and N. Rosenberg, 609–39. Elsevier.

Hatry, H. P. 2006. *Performance Measurement: Getting Results,* 2nd edition. Urban Institute Press.

Hurwicz, L. 1973. "The Design of Mechanisms for Resource Allocation." *American Economic Review* 63 (2): 1–30.

Isenberg, D. 2012. "Focus Entrepreneurship Policy on Scale-Up, Not Start-Up." *Harvard Business Review*, November 30.

Karlan, D., and M. Valdivia. 2011. "Teaching Entrepreneurship: Impact of Business Training on Microfinance Clients and Institutions." *Review of Economics and Statistics* 93 (2): 510–27.

Lach, S., Z. Neeman, and M. Schankerman. 2017. "Government Financing of R&D: A Mechanism Design Approach." CEPR Discussion Paper 12199, Centre for Economic Policy Research, London.

Lee, Keun. 2013. *Schumpeterian Analysis of Economic Catch-up: Knowledge, Path-creation and Middle-Income Trap*. Cambridge, UK: Cambridge University Press.

McKenzie, D., and C. Woodruff. 2013. "What Are We Learning from Business Training and Entrepreneurship Evaluations around the Developing World?" *The World Bank Research Observer* 29 (1): 48–82.

Nelson, R. R. 1959. "The Economics of Parallel R and D Efforts: A Sequential-Decision Analysis." Rand Memorandum.

Nelson, R. R., ed. 1993. *National Innovation Systems: A Comparative Analysis*. Oxford University Press on demand.

Potts, J. 2017 "Complexity, Economics, and Innovation Policy: How Two Kinds of Science Lead to Two Kinds of Economics and Two Kinds of Policy." *Complexity, Governance and Networks* 1: 22–34.

Pritchett, L., M. Woolcock, and M. Andrews, M. 2010. "Capability Traps? The Mechanisms of Persistent Implementation Failure." Center for Global Development Working Paper 234, Center for Global Development, Washington, DC.

Rasul, I., and D. Rogger. 2018. "Management of Bureaucrats and Public Service Delivery: Evidence from the Nigerian Civil Service." *The Economic Journal* 128 (608): 413–46.

Rodgers, R., and J. E. Hunter. 1992. "A Foundation of Good Management Practice in Government: Management by Objectives." *Public Administration Review* 52 (1): 27–39.

Sun, R., and G. G. Van Ryzin. 2014. "Are Performance Management Practices Associated with Better Outcomes? Empirical Evidence from New York Public Schools." *The American Review of Public Administration* 44 (3): 324–38.

Takalo, T. 2012. "Rationales and Instruments for Public Innovation Policies." *Journal of Reviews on Global Economics* 1: 157–67.

Takalo, T., and T. Tanayama. 2010. "Adverse Selection and Financing of Innovation: Is There a Need for R&D Subsidies?" *Journal of Technology Transfer* 35 (1): 16–41.

Veugelers, R. 2016. "Getting the Most from Public R&D Spending in Times of Austerity: Some Insights from Simpatic Analysis." Bruegel Working Paper 2016/01, Bruegel, Brussels.

Wu, X., and M. Ramesh. 2014. "Market Imperfections, Government imperfections and Policy Mixes: Policy Innovations in Singapore." *Policy Science* 47: 305–20.

PART II

4. Instruments to Support Business Innovation

This chapter provides a detailed description of the different instruments commonly used as part of the policy mix. Each profile identifies key issues for instrument design, describes some necessary conditions for its effectiveness, and summarizes the existing evidence regarding impact. Most of the evidence evaluates instruments in member countries of the Organisation for Economic Co-operation and Development (OECD), and extrapolation of the impact to developing countries (which have less developed national systems of innovation) is risky. Therefore, this evidence needs to be interpreted as suggestive of a potential impact under similar conditions. While external validity will also depend on the capacity to implement similar instruments, important lessons can be extracted from this body of evidence. The profiles are based on practitioners' experience and practice, and on existing qualitative and quantitative evaluations of design, implementation, and effectiveness.

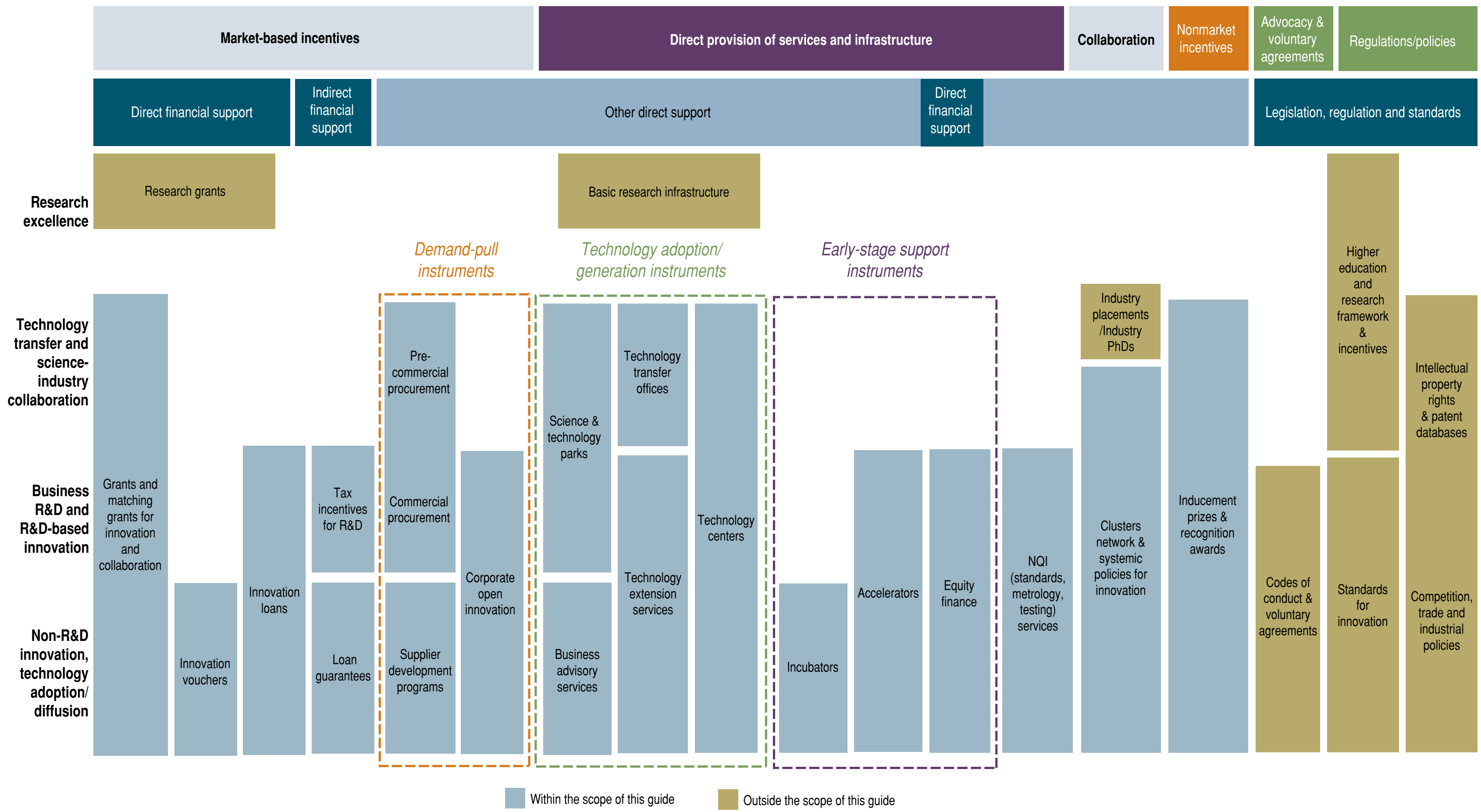
Before describing each individual profile, section 4.1 provides a broad overview of the innovation instruments "space" and justifies the selection of instruments to be analyzed. It is essential that government has the capability to design and implement the chosen instruments effectively, as described in chapter 3. Thus, the objective for policy makers should not be to occupy the entire policy space, but rather to prioritize more appropriate and relevant policy instruments based on what critical conditions and government capabilities are needed to ensure effectiveness.

4.1 The Innovation Policy "Space"

As introduced in chapter 2, *a policy instrument is the mechanism by which public policy attempts to address a specific innovation problem*. This usually requires action by public agencies, including public expenditure in the form of subsidies and tax incentives, as well as other interventions such as regulations, advisory services, and provision of different types of infrastructure.

The innovation policies addressed in this guide are summarized in figure 4.1. The vertical axis shows the different objectives of innovation policy, moving from the supply of knowledge and research to firms' demand for research and development (R&D) and non-R&D innovation activities. The horizontal axis shows types of support, including indirect and direct, and financial and nonfinancial. Moreover, the figure highlights support that involves the direct provision of services and infrastructure, regulatory requirements,

FIGURE 4.1 The Innovation Policy Space



Note: NQI = national quality infrastructure; R&D = research and development.

and efforts to increase collaboration, advocacy, or voluntary adherence to standards and codes. Also circled are families of instruments that aim at early-stage entrepreneurship, technology adoption or generation, or increased demand for innovation.

This guide does not cover all kinds of public support for innovation. Rather, it focuses on support for innovation activities by firms, or by organizations or intermediaries (such as cluster organizations and incubators) that directly support firms. As indicated in figure 4.1, governments also support the publicly funded research sector (such as through university research or specialist research institutes) and government innovation institutions (which may be regulators such as the intellectual property organization, or service providers like testing laboratories). Governments can also directly support individuals, particularly secondary and tertiary students, to raise awareness and interest in science, technology, and innovation, usually via the education system.

Of these, the most significant budgetary item is usually support for research, which usually occurs through two main instruments. The first is direct or "block" funding to institutions to cover operational costs, infrastructure services, and research activities. The second is funding for research projects through competitive grants. Many countries have long-running schemes that underpin research activity, some of which is commercialized and some of which is "early-stage, blue sky" or focused on noncommercial/public goods. This research funding is usually an important part of any government support for innovation, both from a budget expenditure perspective and because it is usually the main funding source for the creation of noncommercial formal knowledge.

Despite the importance of these instruments, they are not included in this guide because industry is not the prime recipient. The publicly funded research sector is, however, often a participant in several instruments covered in the guide, including collaborative R&D grants, technology transfer offices, incubators and accelerators, science and technology parks, and vouchers. Moreover, at least some of the research funded by mechanisms discussed in the previous paragraph will eventually have a commercial use.

The guide also excludes regulations, regulatory sandboxes, some forms of information infrastructure, and voluntary standards[1] because these work at a market and sector level. Also excluded are instruments to support skills for innovation, some of which target internships in industry. The exclusion of these instruments does not imply that they are not important for innovation. On the contrary, these are important elements of the *innovation policy mix,* but the guide needs to draw the line somewhere.

Specifically, this guide focuses on the following instruments:

1. Grants and matching grants for innovation and/or R&D projects
2. Vouchers for innovation and collaboration
3. Loans and guarantees for innovation
4. Tax incentives for R&D

5. Demand-pull instruments
    - Pre-commercial procurement
    - Public procurement of innovation during the commercial stage
    - Supplier development programs
    - Corporate open innovation
6. Technology adoption and generation instruments
    - Business advisory services
    - Technology extension services
    - Technology centers
    - Science and technology parks
    - Technology transfer offices
7. Early-stage support for innovative ventures
    - Incubators
    - Accelerators
    - Equity finance for innovative enterprises
8. Inducement instruments
9. Quality infrastructure, including standards, metrology, and testing
10. Clusters and networks for innovation.

As discussed in chapter 2, these instruments represent different mechanisms of intervention—grants, loans, advisory services, tax incentives, other services, and infrastructure—with specific goals of supporting different types of business innovation. Other typologies of instruments are also possible. But this typology integrates almost the entire set of the instruments to support business innovation and is widely used by policy makers and academics alike.

4.2 Profiles of Innovation Policy Instruments

Once the range of suitable instrument(s) for the diagnosed problem has been identified (chapter 3), it is critical to understand the characteristics of each instrument, the necessary conditions for implementation, and the evidence of impact. This section describes each instrument in detail, focusing on the following dimensions:

- Definition: The concept of the instrument, history, and trends
- Rationale: The market and system failures addressed, and how
- Target Group: The main beneficiaries or stakeholders related to this instrument
- Elements for optimal instrument design: The design issues policy makers should pay attention to
- Strengths: The strengths the instrument has, especially in comparison with others.
- Potential drawbacks and risks: The drawbacks the instrument has, and the risks the instrument is potentially subject to
- Elements for optimal instrument design: The key considerations in ensuring good policy design

- Evidence of impact: The context, beneficiaries, design, implementation, effectiveness, and other issues
- Main requirements for replicability: The enabling conditions and competencies required, and policy implications for developing countries
- Dos and don'ts when implementing these instruments.
- Checklist of questions for the design and implementation stages.

A word of caution is warranted. Most of the evidence on innovation policy is based on OECD countries. Yet each national system of innovation is different and shaped by the local context and institutions. Thus, in considering adoption of any instrument, it is important that policy makers determine whether the necessary conditions for implementation are in place in their country. To facilitate this process, each of the profiles includes a checklist of questions that a policy maker should ask during the design and implementation stages. Each profile also contains a reference list.

4.2.1 Profile 1. Grants and Matching Grants for Innovation and/or R&D Projects

This profile examines the most common type of instrument used to provide direct support to business R&D and non-R&D innovation activities, *grants and matching grants* for innovation projects. This instrument varies widely in complexity depending on the objective and complexity of the innovation project to be financed. This profile refers only to grants used to support an innovation and/or R&D project, either individually or in collaboration. The evidence from this heterogeneous instrument is quite mixed, as should be expected, yet studies agree that the design and implementation of the application process is critical for its impact. A key message is that policy makers should consider grants or matching grants when a subsidy could increase the willingness to invest in innovation in the face of some externality or information asymmetry. This is particularly important in the many developing countries undergoing fiscal consolidation and when there is pressure to shift the policy mix to reimbursable instruments such as loans or indirect instruments such as tax incentives. These instruments will not address particular innovation problems that need some direct subsidy.

Definition

Grants are a direct allocation of funding from public agencies to innovation actors to finance all or part of an innovation project. In the case of *matching grants*, public agencies match a percentage contribution of the project made by the applicant, to ensure the applicant(s)' commitment to the activity.

Grant schemes vary widely and have different policy objectives. Grants can be categorized in terms of the selection mechanism, size, matching requirement, duration, eligible activities (such as R&D, commercialization, collaborative innovation, and/or purchase of equipment and/or services); payment procedures; repayment requirements; and delivery mechanisms. They range from small grants (for example, those paid to young firms to access services such as advice on investment readiness) to the funding of large R&D projects that may occur over multiple years. Most grant schemes use competitions to select participants because the potential number of applicants is often larger than the budget available. A substantial share of grants target collaboration, for example between academia and industry. Such grants support collaboration as a core element of a project, which may involve a single small or medium enterprise, a single research team, a small or medium enterprise and a larger company, a group of small and medium enterprises (SMEs) looking to jointly upgrade, or a large multiproject/multiyear series of projects involving many stakeholders.

Very often grants are offered in conjunction with other types of innovation instruments to provide financial incentives to achieve particular policy objectives. For instance, business advisory services or technology extension services frequently provide small grants to encourage and enable businesses to act on their advice. The organizations running cluster and networking initiatives often receive grants, and also may be the mechanism through which innovation-related grants are distributed to participating SMEs. Many of the demand-side innovation instruments (such as pre-commercial procurement and corporate open innovation initiatives) use grants to distribute funding. In addition, grants are used to stimulate the purchase of national quality infrastructure and other innovation-related services.

Simplicity of operation for the client is a critical factor for success of a grant program. Thus, a simple and clear set of eligibility criteria and application process, a transparent and timely selection process, and efficient grant disbursement processes are all important.

Market and System Failures Addressed

The objective of grants is to offer incentives to firms to carry out innovation projects that would not be undertaken without a subsidy because of any of the following market and systemic failures:

- *Externalities and spillovers.* Investments in R&D and non-R&D innovation activities can generate externalities and spillovers for other firms that are not fully appropriable by the original firm, so firms tend to underinvest in innovation activities. Direct support schemes such as grants can help address this investment gap by subsidizing the costs of the R&D project.
- *Coordination failure (for collaboration grants).* Some projects could be better executed in partnership with other firms and actors. But collaboration is subject to various barriers, including a lack of motivation among innovation actors, differing priorities among potential collaborators, and high costs associated with partnerships. Grants can help address this failure by requiring collaboration and financing the costs involved.
- *Capability failure.* Firms, especially SMEs, might simply lack the capabilities and capacity needed to effectively undertake activities related to innovation. Targeted grants supporting specific activities such as training, recruitment, and the purchase of external expertise can address the capabilities and knowledge gaps that recipient firms face.

Target Group

Grant schemes often define Target Groups in terms of size, industrial sector, R&D experience and intensity, and ownership, among other factors. The most frequent Target Group consists of individual firms, and among them, SMEs. The main justification for tailoring grant schemes to support innovation in SMEs is that SMEs often face particular difficulties in accessing finance, as well as more severe market and system failures, than larger firms do. In some cases, larger firms are the target, particularly for more sophisticated innovation activities.

Another approach is to Target Groups of firms, consortiums, and/or firms and external knowledge providers where greater collaboration could spur innovation. Beneficiaries may be of all sizes and may also involve public research organizations or intermediary organizations.

Strengths

- *Selectivity.* Compared with more target-neutral instruments such as tax incentives, grants can be tailored to specific areas where intervention is particularly needed, or where innovation could achieve longer-term societal goals.
- *Relatively easy to implement.* Grant schemes with straightforward modalities are relatively easy to implement, especially when compared with more complex instruments such as public procurement. Moreover, grants are used in various areas of policy beyond innovation, so it is likely that there is expertise within the bureaucracy to assist with design and implementation, even if the instrument is new to the recipient. However, some innovation grant schemes can be very complex, particularly collaborative grant schemes that involve multiple projects and stakeholders.
- *Flexibility and control.* Through various modalities, grant schemes can easily define the conditions of support and achieve a high degree of flexibility and control. For instance, they can be designed with specific selection and disbursement mechanisms to address a particular innovation gap, such as support for the prototyping stage. Grants can also be applied to different stages of innovation, from basic research to applied research to commercialization and scaling up. This feature makes grants more widely used than any other type of instrument.
- *Signaling effects.* The process of evaluating grants can also serve the purpose of assessing and accrediting a firm's capabilities. This spillover impact can effectively address information asymmetry for private investors while providing additional benefits to applicants.

Potential Drawbacks and Risks

- *Management and bureaucratic costs.* The administrative costs of grant schemes can be high, given that the application and selection processes, grant administration, monitoring, and the efficient use of budgets all require dedicated staffing.
- *Budgetary stability needed to ensure continuity.* Grant schemes require a consistent and predictable level of funding to last long enough to ensure impact. This is particularly the case when one of the policy goals is collaboration, which generally takes a considerable period of time to develop effectively. This requires a high level of political commitment and support, which is often difficult to obtain during recessions or periods of fiscal stress.
- *Higher risks of selection bias compared with target-neutral instruments.* Given the selectivity of grant schemes—agencies need to make judgments about what projects and companies to support—there is an intrinsic risk that grant schemes will be designed or administered in a way that results in distorted allocations of funding to recipients that either do not need the funding or are bad applicants. There is also a potential risk of political interference in the process of selecting beneficiaries.

- *Risk of crowding out private funding and not generating input additionality.* If selection processes are not managed well, there is a risk of crowding out private investment and supporting projects that would have made the investments or obtained finance anyway without government support.

Elements for Good Instrument Design

Key issues to consider when designing a grant scheme include but are not limited to the following:

- *Size.* The size of grants varies from very small (a few thousand dollars, in the case of vouchers) to very large (millions of dollars for R&D collaboration projects involving multiple parties).
- *Duration.* Depending on the nature of activities supported, the duration of projects and other understandings supported by grants can be very short (six months for grants to purchase advisory services) or very long (several years for complex R&D efforts that take time to materialize).
- *Supporting individual firms versus groups of actors in collaboration.* A substantial number of grant schemes support groups of innovation actors instead of individual firms (that is, collaboration grants). In line with the open innovation paradigm, grants are increasingly given to projects that involve more than one firm or knowledge provider.
- *Selection mechanism.* Grants are often allocated through competitions, to identify projects most likely to meet program goals. Selection can involve a continuous application process whereby proposals can be received at any time, or periodic calls for applications with fixed deadlines. The marketing material and application process should clearly explain the criteria, processes, and metrics of the assessment; how the selection process works; and the availability of any appeal mechanism. Although identifying individuals involved in the selection and ultimate decision-making process can be good for transparency, it also opens them up to being lobbied by applicants.
- *Assessment process.* The assessment process should include a technical evaluation (of the merits of the innovation under development) and a business evaluation (the market potential, and the overall capacity and capabilities of applicants to succeed with the project). Independent industry/technical experts should evaluate proposals and make recommendations for funding. If the local pool of potential experts is small, then consideration should be given to using overseas experts. Once grants are awarded, the list of recipients should be made public.
- *Matching requirement.* Grants for firms typically require a matching contribution from recipients to ensure their commitment and to increase the total resources devoted to innovation (input additionality). The ratio of required cofunding can vary and is typically higher for larger firms and lower for SMEs. It may also depend on the stage of development (for example, early-stage, high-risk innovation activities undertaken by a start-up may warrant a higher level of program

contribution). Cofinancing might come from the grant recipients themselves or involve external funding sources from other parties.

- *Nonrepayble or repayable.* Grants are typically unconditional: that is, no repayment is required from the recipients (unless the funding is not fully spent by the end of the project cycle). Nevertheless, conditionality on repayment might be imposed, and the grants therefore turn into an interest-free loan, often called an *innovation credit*. A typical criterion for repayment is the accomplishment of commercial milestones, such as the generation of revenues and/or profit as a result of the supported innovation project. This type of grant might not be suitable for highly risky, early-stage innovation projects, but appears more promising in supporting projects closer to the market. Repayable grants can be very complex to administer because substantial effort and capacity are required to follow up on the progress of supported projects, and there is considerable room for firms to cheat and avoid repayment (Bravo-Biosca, Cusolito, and Hill 2014). Table 4.1 presents examples of repayable grant schemes in both developing and developed countries.

TABLE 4.1 Examples of Repayable Grant (or Conditional Loan) Schemes

Scheme name	Modality	Condition of repayment
Cradle Investment Program 300 (CIP300), a conditional grant under the portfolio of the Cradle Fund, Malaysia *Source:* https://www.cradle.com.my	Financial assistance of up to RM300,000, with a range of value added assistance, including coaching and mentoring, matchmaking with investors and Cradle's partners, business advisory services, and media and public relation support.	The grant can be converted into a loan if the recipient receives other forms of funding or financing, or a sales contract.
Matching grants program, under Innovation Fund (IF), Serbia *Source:* http://www.innovationfund.rs	Financial assistance of up to €300,000 for a two-year project, with a maximum of 70 percent from the program and 30 percent contribution from recipients.	Upon successful commercialization, royalty payments are made, based on the revenue from sales or subsequent products/services emerging from the funded technology.
Conditional loans by Tekes, Finland *Source:* Takalo and Tovainen (2018)	Loans are granted for development and piloting to cover 50 percent to 70 percent of project costs at a fixed interest rate (1 percent, currently). The use of loans in Tekes' policy tool mix has increased significantly, both absolutely and relative to grants.	If the project fails to produce commercial output, a part of the loan can be transformed into a grant.
Repayable loan scheme, New Zealand *Source:* https://www.callaghaninnovation.govt.nz/	The financial assistance contains two parts: a preincubation grant that provides up to NZ$35,000 to validate the commercial viability of complex technology, and a repayable loan (up to NZ$450,000 to match NZ$150,000 of private investment) used to fund the start-up company's costs associated with commercializing the technology.	The repayable loan is repaid by the start-up when it begins to generate revenue, in the form of a 3 percent royalty on its gross revenue from sales. The loan accrues interest daily at a rate of 3 percent per year.

Collaboration Grants

Collaboration grants focus on encouraging firms and organizations to collaborate, instead of supporting individual firms that launch projects on their own. Collaboration grants are among the most common type of innovation policy instruments around the world, in both developing and developed countries. In certain countries, such as Israel, grant schemes almost exclusively support collaboration-based innovation activities.

By rationale, collaboration grants address a coordination failure that leads to a lack of collaboration and thus less innovation. Collaboration among firms, or among firms and other knowledge providers, can improve the effectiveness of innovation by providing different sources of knowledge and perspectives. However, various barriers impede collaboration, including differences in cultures and incentives across companies and researchers, a natural suspicion of collaborating with other businesses (which may mean sharing commercial information and future plans), and uncertainty about how to structure joint work and benefits (such as intellectual property). Thus, collaboration is a difficult, learned skill that does not just happen automatically.

Projects seeking a collaboration grant will typically involve at least two, and in some cases several, parties looking to work together. These might be companies (such as an SME and a large company) or companies and research organizations and may also include other organizations (such as industry associations and/or technical bodies). For more strategic, consortium-based initiatives, support (through brokering or funding for brokering) may be justified to bring consortiums together and develop coherent proposals, given that individual businesses may not engage in such consortiums building because they may not capture all the benefits themselves. This is particularly the case in new sectors and countries that lack a history of collaboration in innovation.

Strategic collaboration grant schemes may be given for a single project or for multiple projects and may be of varying duration. The Australian Cooperative Research Centers (CRC) Program, for example, supports both long-term collaborations for periods of up to 10 years, and short-term projects for up to 3 years.

Although matching grants are typically used, collaborative projects (especially those involving the research sector) can allow this match to be in-kind, given that the research sector often faces severe financial constraints. That is, research organizations can be allowed to contribute staff time or access to equipment instead of funding, although defining and calculating such in-kind support adds complexity to implementation. public research organizations are generally more motivated and capable than firms in seeking funding through formal applications, and thus often dominate these kinds of collaboration.

The effectiveness of collaboration versus individual grants to encourage innovation depends in part on the objective of the program. Caloffi et al. (2018) compare subsidies for collaboration R&D grants versus individual R&D grants implemented in the same region in Italy in the same period. They find that targeting collaboration grants toward SMEs with little R&D can increase the number of SMEs that perform R&D. On the other hand, targeting individual or collaboration grants to SMEs with some prior R&D experience can be effective in increasing the amount of R&D. Finally, collaboration grants are more effective than individual grants in encouraging SMEs to start networking with external organizations.

Evidence of Impact

The reviewed studies cover a wide range of countries and regions in terms of institutional settings, but evidence is mainly from OECD countries.[2] Almost all the academic studies look at grants supporting R&D activities, and thus offer limited insight on the effectiveness of grants in supporting other types of innovation activities. The presence of complementary instruments or policies is very common; none of the grant schemes function in isolation.

The evidence reviewed suggests that grant schemes tend to have a positive impact on business innovation, especially in “input additionality” (that is, increasing the resources devoted to innovation) and in “behavioral additionality” (that is, encouraging firms to begin innovating). The evidence concerning the relationship between grants and output additionality (new products, new ventures, or patents) and outcome additionality (sales, productivity, or employment) is positive, although scarce, especially for developing countries. The reviewed syntheses/meta-analyses—such as García-Quevedo (2004), Zúñiga-Vicente et al. (2014), and Becker (2015)—all conclude that grants tend to result in input additionality. However, studies of behavioral additionality tend to focus on positive results. Policy makers might want to take this publication bias into account in making decisions based on this evidence.

Evaluations of specific programs generally combine different methods to evaluate grant schemes,[3] mostly on a quasi-experimental basis,[4] often featuring econometric analysis coupled with qualitative approaches. One limitation of the evidence on grants is the high sensitivity of research findings to the methodologies and data adopted. For example, a review of earlier literature reports that studies using macro-level data tended to be more positive about input additionality than studies based on lower-level data, and studies investigating countries other than the United States tended to be more positive than US-based studies (David, Hall, and Toole 2000). Another limitation of the evidence is the excessive use of self-reported data, which is typically biased toward supporting the continuation of schemes.

Evidence on the Effectiveness of Grants Compared with Other Instruments

A few studies have compared the effectiveness of grants with indirect instruments such as tax incentives, and the potential relationships between them. These studies indicate that whether grants or tax incentives perform better depends on factors such as firm characteristics and the nature of the projects supported, as summarized in table 4.2.

TABLE 4.2 Overall Effectiveness of Grants Compared With Other Instruments: Selected Studies

Study	Context	Finding
Guellec and Van Pottelsberghe De La Potterie (2003)	17 OECD countries	Direct grants and tax incentives are substitutes: that is, increasing the level of tax reduction support would compromise the effectiveness of grants.
Bérubé and Mohnen (2009)	Canada	Firms that benefited from both grants and tax incentives introduced more new products and achieved more success in commercialization than firms that only benefited from tax incentives.
Becker (2015)	Synthesis of previous studies	Tax credits have a significant effect on R&D expenditure mainly in the short term, whereas grants have a positive effect in the medium to long term.
Carboni (2011)	Italy	Tax reduction appears more effective in increasing R&D, with an average treatment effect of €1163 (t-value=2.59), compared with €690 (t-value=1.58) for grants.
Grilli and Murtinu (2012)	Italy	For new technology-based firms (NTBFs), "selective R&D subsidies outperform other types of schemes."
Busom, Corchuelo, and Martínez-Ros (2014)	Spain	Grants are better suited than tax incentives to encourage young, knowledge-based firms to engage in R&D.
Crespi and Maffioli (2014)	Latin America	Grant schemes appear to be more effective in encouraging new innovators and stimulating collaboration, although the risks of crowding-out effects are higher with grants than with loans or tax incentives.

Note: OECD = Organisation for Economic Co-operation and Development; R&D = research and development.

These results, however, are sensitive to the data used; for example, Grilli and Murtinu's (2012) main finding might only apply to new technology-based firms.

Table 4.2 shows that when compared to tax credits, grants show greater additionality in R&D expenditure in the medium to long term (Becker 2015), particularly for young, knowledge-intensive firms (Busom, Corchuelo, and Martinez-Ros 2014). However, grants also are more likely than loans or tax incentives to crowd out private innovation expenditures (Crespi and Maffioli 2014).

Evidence on Relationship Between Design and Implementation and Grant Effectiveness

Empirical literature has analyzed the impact of different grant schemes on innovation and firm performance, as illustrated in table 4.3. The main findings can be summarized as follows:

- Competition-based grants generally outperform entitlement-based grants.
- Competition-based grants remain subject to the risk of "picking winners" (the best firms) and other selection biases. Programs managers may decide to pick those firms they consider better able to implement innovation projects, but often these firms are the ones that will implement the innovation project without the need of a subsidy (meaning there is no additionality).
- The amount of cofinancing required from beneficiaries has a nonlinear relationship with effectiveness.

TABLE 4.3 Relationship Between Design and Implementation and Grants' Effectiveness: Selected Studies

Issue	Finding	Study	Context	Details
Selection mechanism	Competition-based grants in general outperform entitlement-based grants.	Colombo, Grilli, and Murinu (2011)	Italy	For high-tech start-ups, only competition-based schemes have a significant, positive impact on total factor productivity, with an estimated increase of 31.4 percent. Automatic, entitlement-based grants, in contrast, are considered inefficient.
		Crespi and Maffioli (2014)	Colombia	Firms supported by Fondo de Fomento al Desarrollo Científico y Tecnológico (FONDEF) (competition-based grants) systematically experienced more significant improvement in productivity than firms supported by Fondo de empleados (FONTEC) (entitlement-based grants), which could be due to either the incentives for collaboration (that address other market failures in addition to lack of finance) or the nature of the competitive process used for the allocation of the resources. There are important complementary effects. FONTEC produces a higher return when it is implemented together with FONDEF.
Selection mechanism	Competition-based grant schemes are subject to the risk of picking winners and other selection biases.	Cantner and Kosters (2012)	Germany	Start-ups with ex ante indicators that they are likely winners, such as innovative ideas or being academic spin-offs, are more likely to get grants. The use of team start-ups and the initial capital of a start-up tend to affect the funding decision positively. The authors argue that policy makers and funding authorities follow a strategy of "picking the winner" in targeting R&D subsidies to start-ups.
		Ruegg and Feller (2003)	United States	The Advanced Technology Program (ATP) selection process favored firms with more connections to other businesses and that were more likely to generate commercial success.
		Wang, Li, and Fuman (2017)	China	Firms more likely to succeed in getting grants from the Chinese InnoFund were— besides having winning characteristics such as better innovation and financial records—those whose founders have political connections.
Size of grants	The relationship between the designed size and cofunding rate of grants and effectiveness is not a linear or simplistic one; the relationship might be illustrated as an inverted-U shape.	Guellec and Van Pottelsberghe De La Potterie (2003)	17 OECD countries	The effectiveness of grants increases with size up to 10 percent of business R&D costs, with the strongest effectiveness occurring at average subsidization rates of 4 percent to 11 percent. Effectiveness declines as size increases beyond that. The authors clarify that these thresholds are indicative and vary across contexts.
		Zúñiga-Vicente et al. (2014)	General (literature review)	Moderate grant amounts tend to crowd in private innovation expenditures, but grants beyond a certain level tend to crowd out private expenditures.

TABLE 4.3 Relationship Between Design and Implementation and Grants' Effectiveness: Selected Studies *(continued)*

Issue	Finding	Study	Context	Details
		Aschhoff (2009)	Germany	The size of the grant compared to the size of the project affects the effectiveness of grant schemes. For a given amount of grants, the larger the project, the higher the probability that grants will encourage greater private expenditures on innovation. However, this relationship does not hold from the point where the firm's R&D capacity cannot be increased in the short term.
		Görg and Strobl (2007)	Ireland	For domestic plants, small grants tend to induce private R&D spending, while very large grants may crowd out private investment; the authors did not a find similar correlation for foreign-owned plants.
Eligible activities	The nature of projects might affect policy effectiveness.	Clausen (2009)	Norway	Grants for innovation activities that are far from the market stimulate R&D spending within firms, while grants targeting activities that are close to the market tend to be reduce such spending.

Evidence on Relationship Between Firm Characteristics and Input Additionality

In general, grant schemes tend to generate input additionality. Syntheses/meta-analyses—including García-Quevedo (2004), Zúñiga-Vicente et al. (2014), and Becker (2015)—find that the literature in general rejects the notion that the provision of a grant displaces the same amount of private expenditure on innovation. Moreover, some studies find that grants tend to encourage greater private expenditure on innovation, especially in the context of emerging economies (as noted in Özçelik and Taymaz 2008).

Many studies explore the relationship between firm characteristics and the effectiveness of grants in generating input additionality (see table 4.4). Stronger input additionality has been achieved with grants to smaller firms than with grants to larger firms, among firms with greater R&D experience, and among firms that have registered their intellectual property rights (IPRs) (so that there is a greater likelihood that the firm can enjoy the benefits of innovation). However, input additionality from grants was observed to be lower for high-tech firms than for low-tech firms.

Output and Outcome Additionality

Evidence on whether grants tend to increase innovation outputs (new products, new ventures, patents) or outcomes (sales, productivity, employment) is limited compared with that on input additionality. The academic literature offers little evidence on the increase in sales related to new products or new start-ups that is triggered by grants (see Clarysse, Wright, and Mustar 2009). Program-specific evaluations have been mostly focused on straightforward outcome measures, such as gross value added (GVA) and employment. The few existing studies find that a few iconic programs, such as the UK Collaborative R&D Program and the Argentinean Technological Fund/Fondo

TABLE 4.4 Relationship Between Firm Characteristics and Input Additionality of Grants and Matching Grants: Selected Studies

Issue	Finding	Study	Context	Details
Size	Studies overwhelmingly confirm the desirability of supporting smaller rather than larger firms in grant schemes.	González and Pazó (2008)	Spain	The induction effect (to do innovation) of grants can reach 30 percent in the case of small firms, while for big firms it is 10 percent.
		Herrera and Bravo Ibarra (2010)	Spain	Grants have a more significant impact on input additionality for smaller firms than for larger firms, but a more significant impact on output additionality for larger than for smaller firms.
		Lee and Cin (2010)	Korea, Rep.	Grants significantly increase employment in firms with fewer than 300 employees, but significantly reduce employment in larger firms.
R&D experience	While the evidence is mixed, grants provided to recipients with experience in R&D may generate greater input additionality.	Crespi and Maffioli (2014)	Latin America	Grants are more effective when provided to new innovators, while there is some evidence that grants to more experienced innovators displace other resources.
		Aschoff (2009)	Germany	Grants to experienced recipients had a positive impact on input additionality, while grants to first-time participants had no such impact.
		Czarnitzki and Lopes-Bento (2013)	Flanders	No evidence is found to justify more support to applicants without project experience than to experienced applicants.
Level of appropriability	A low level of appropriability implies a high potential for input additionality.	Gelabert, Fosfuri, and Tribó (2009)	Spain	More crowding-out effects are found for the firms with higher levels of appropriability (patents, models/designs, trademarks and copyrights, trade secrets, design complexity, and lead time).
High/medium/low-tech	Grants might generate more significant input additionality in low-tech sectors than in high-tech sectors.	González and Pazó (2008)	Spain	The induction effect of grants in low-tech sectors reaches 28 percent, versus 7 percent for high-tech sectors.
		Becker (2015)	General literature review	A higher share of government-funded R&D has a positive effect only for the low-tech industry group, while it is insignificant for the high-tech group.
Local economy	The circumstances of the local economy have an impact on grant effectiveness.	Czarnitzki and Licht (2006)	Germany	The input additionality from grants was more significant in eastern Germany (a transitioning economy) than in western Germany.

TABLE 4.4 Relationship Between Firm Characteristics and Input Additionality of Grants and Matching Grants: Selected Studies *(continued)*

Issue	Finding	Study	Context	Details
		Özçelik and Taymaz (2008)	Turkey	For Turkey, a late-industrializing economy, the authors find additional support for earlier studies reporting crowding-in effects in similar contexts. They also note an acceleration effect (increasing investment) on private R&D expenditures, especially for those of smaller firms.
Financial constraints	Input additionality tends to be stronger for firms with financial constraints.	Mateut (2018)	30 countries in Eastern Europe and Central Asia	A positive correlation between the receipt of subsidies and the innovative activities of firms is found for approximately 12,000 firms. This relationship appears to be stronger for firms that are more likely to be financially constrained.

Tecnológico Argentino (FONTAR), have resulted in significant increases in sales, employment, and gross value added. The even more limited evidence on productivity and cost-effectiveness is mixed, as summarized in table 4.5.

Behavioral Additionality

Studies provide evidence that grant schemes have a positive impact on collaboration and the propensity to innovate, as summarized in table 4.6.[5] Factors that affect behavioral additionality include the level of government (national or regional) providing the grant, the existence of complementary policies, firm characteristics, and learning patterns.

Empirical results shown in table 4.6 have demonstrated strong behavioral additionality from the use of grants, particularly in encouraging collaboration between firms and knowledge providers and in increasing the propensity of firms to innovate.

Signaling Effects

Several studies confirm that grants send positive signals to the private sector concerning the likely success of recipient firms, thus reducing information asymmetry that hinders private investment. Potential recipients' perception of this signaling effect might drive the uptake of grant schemes. For instance, Benavente, Crespi, and Maffioli (2007) find that 28 percent of the applicants to Chile's FONTEC program claimed that "signal of the quality of the project outside the firm" was one motivation to apply. Meuleman and De Maeseneire (2012), comparing a Belgian dataset of approved applications and a control group of rejected applications, find that grant support helps SMEs gain better access to debt and equity finance. Nevertheless, Wang, Li, and Furman (2017) find that receipt of China's Innofund grants reduces firms' probability of failing but does not increase their probability of innovating or accessing private investment.

TABLE 4.5 Evidence on Output and Outcome Additionality of Grant Schemes: Key Findings

Issue	Finding	Study	Context	Details
Growth–sales, employment, and GVA	A few collaboration schemes have had a significant impact on employment and gross value added.	PACEC (2011)	United Kingdom	A collaborative R&D program created 13,350 jobs (8,900 directly from the program and 4,450 from supply chains). Recipients had an estimated GVA of £2.9 billion during 2004–11.
		Hall and Maffioli (2008)	Latin America	Both FONTEC and FONTAR increased employment (by 3.1 percent for FONTEC and 1.5 percent for FONTAR) and sales (by 39.6 percent for FONTEC and 11.5 percent for FONTAR) with a lag of two years. However, there is no evidence that the schemes significantly increased productivity or appropriability of intellectual property.
		Alvarez, Crespi, and Cuevas (2012)	Chile	FONTEC increased employment levels and average wages in recipient firms by 6.4 percent and 4.6 percent, respectively.
		Czarnitzki and Lopes-Bento (2013)	Flanders	Five R&D jobs were created or secured in each project supported in Flanders.
		Warta and Rammer (2002)	France	Most of the surveyed firms benefiting from the ANVAR innovation refundable grants program estimate that their turnover has increased or will increase due to the aid; many reported that products or processes developed with the support of ANVAR resulted in job creation or enabled them to maintain workers.
Productivity	Mixed findings based on limited evidence.	Colombo, Grilli, and Murtinu (2011)	Italy	Competition-based grants result in a 31.4 percent increase in total factor productivity, but other forms of grants have no significant impact on productivity.
		Alvarez, Crespi, and Cuevas (2012)	Chile	Firms participating in FONTEC enjoyed a 6 percent increase in labor productivity; participants in FONDEF, a 10 percent increase; and participants in both programs, a 24 percent increase.
		Czarnitzki and Licht (2006)	Eastern Germany	Marginal productivity is lower for publicly financed R&D than for firm-financed R&D.
		Hottenrott and Lopes-Bento (2014)	Flanders, Belgium	Public funding is useful in encouraging firms to transform basic research into marketable product innovations.
Cost-effectiveness	Collaboration grants have increased the cost effectiveness of firms' innovation activities.	Ruegg and Feller (2003)	United States	There is a growing body of evidence that the Advanced Technology Program (APT) significantly raises the growth of firms' R&D, both by reducing the time required for projects (an early study reported a median time-savings per project of three years) and investment (an early study reported that the median economic value to the company per year saved was $5 million–$6 million).

Note: ANVAR = Agence Nationale de Valorisation de la Recherche; FONDEF = Fondo de Fomento al Desarrollo Científico y Tecnológico; FONTAR = Fondo Tecnológico Argentino; FONTEC = Fondo de empleados.

TABLE 4.6 Evidence on Behavioral Additionality of Grant Schemes: Key Findings

Issue	Study	Context	Finding
Collaboration	Chávez (2011)	Spain	National-level grants were associated with a 14.2 percent increase in collaboration between manufacturing firms and universities/technological centers; grants from regional government increased such collaboration by 8.7 percent. However, regional funding has been more effective than national funding in triggering new levels of collaboration that did not exist before
	Teirlinck and Spithoven (2012)	Belgium	Regional funding stimulates the development of new collaborations between firms and public research centers
	Busom and Fernández-Ribas (2008)	Spain	Public funding increases on average firms' propensity to collaborate with science organizations by about 28 percent.
	Autio, Kanninen, and Gustafsson (2008)	Finland	Direct grants trigger more technological learning than business learning. Thus, combining grant schemes with active efforts to increase business learning would magnify their effectiveness.
	Wanzenbock, Scherngell, and Fischer (2013)	Austria	Exporting firms are 27 percent more likely to initiate new collaborations than are firms producing for the domestic market; firms with experience in the research field are about 19 percent less likely to initiate new collaborations than are firms with no experience in research. In contrast, firms new to a field are 3.43 times more likely to collaborate with new partners than are more established firms.
	Becker (2015)	General (literature review)	Collaboration with customers or suppliers can involve the risk of revealing proprietary information. Thus, the ability of firms to protect their intellectual property (for example, through patents) is positively correlated with such collaboration.
Propensity to innovate	Chudnovsky et al. (2006)	Argentina	The beneficiaries of FONTAR-ANR increased their probability of innovating by 19.3 percent.
	Hall and Maffioli (2008)	Colombia	Participation in FONTEC generates a more proactive attitude toward innovation, especially in terms of interacting with external sources of knowledge and financing.
	Warta and Rammer (2002)	France	Three companies out of four would not have realized the project in the same way or would not have done it at all without the support of ANVAR (a French repayable grant program).
Relationship between firm characteristics and behavioral additionality	Clarysse, Wright, and Mustar (2009)	Flanders	Behavioral additionality is positively associated with congenital learning (learning from the founder) and interorganizational learning effects, but these learning effects decrease as the number of grant projects received by the company increases.
	Wanzenbock, Scherngell, and Fischer (2013)	Austria	Grants to R&D-intensive firms are 31 percent less likely to result in project additionality than are grants to firms that are not R&D-intensive. Grants to technologically specialized firms have a 25 percent higher average probability of resulting in project additionality and a 27 percent lower probability of resulting in scale additionality than grants to less specialized firms do.

Note: ANVAR = Agence Nationale de Valorisation de la Recherche; FONTAR-ANR = Non-Reimbursable Funds (ANR) program of Fondo Tecnológico Argentino/Argentinean Technological Fund (FONTAR); FONTEC = Fondo de empleados; R&D = research and development.

Main Requirements for Replicability

The literature generally finds that grants are effective in promoting innovation, especially in terms of input additionality. However, these studies offer little evidence on the relationship between grant effectiveness and specific program modalities, beyond some selection criteria. Grant programs often assume a simplistic input-output relationship between innovation investment and outcomes, while the reality is much more complex given the various influences on the likelihood of success and the many determinants of firm productivity. Before designing the program, policy makers should carefully assess the relevance of grants and the emergence of new funding models such as crowdsourcing.

Required capabilities to design and implement policy instruments. Common complaints about poorly designed and managed grant programs include that marketing is inadequate (so potentially eligible firms are not aware of the assistance, or a group of "serial grant applicants" continue to reappear in grant programs) and that eligibility rules (the prerequisites for participation) or the selection criteria (against which projects will be chosen) are unclear. In addition, the application and decision-making processes are often lengthy and opaque, and reporting is often burdensome (too frequent, and in some cases requiring pointless information) and costly in relation to the funding available. The net effect of such design features may be that key target firms either do not know about the initiative or simply do not bother engaging; that SMEs hire expensive consultants to prepare their applications, which diverts resources away from their intended purpose; that the most eligible firms do not receive support; or that both recipient firms and the government waste time and resources in processes that add little or no value.

Governments need the capability to design and implement programs that avoid these pitfalls. For example, implementing agencies should be able to simplify and reduce the costs of applications, and to raise awareness among the most suitable participants. If there is little experience with grants, then simple modalities are obviously preferable, providing that the necessary accountability and safeguards arrangements are in place. Regardless of complexity, the automation of grant application, selection, and management (for example, through smart forms, standardized contracts, and online applications, reporting, and payments) would reduce the burden of participation for firms. Making effective decisions on grant applications first requires the capacity to assess whether applications are eligible. Ideally, applications should be assessed by independent experts either autonomously or through a committee, which requires appropriate experts to be identified and contracted, and for them to be administratively supported. Transparent decision-making processes that are free from political interference are also needed. Complex collaboration grant programs often require a two-stage process and the ability to support potential applicants during both stages (for example, to help firms form consortiums and to broker joint projects). Finally, monitoring, evaluation, and learning also require significant capabilities from policy makers and adequate processes that collect the right information without overburdening recipients during the project. Processes should also enable information to continue to be gathered after the project is completed.

Required competencies from beneficiaries. Participation in grant programs requires that firms are aware of the scheme and have the capacity to prepare the required documentation. Studies of developing countries point out that many firms lack the ability to develop strong applications for competitive grants. Most SMEs have little experience in applying for grants because grant applications are not part of their core business (as opposed to many researchers, for instance).

In addition, firms may lack sufficient access to infrastructure or adequate managerial competencies. For example, programs supporting the prototyping of new products in low-income countries can fail because firms lack access to the infrastructure required to commercialize the product, or face problems with logistics and customs, or do not have an effective marketing strategy. The importance of these complementarities is, therefore, larger in developing countries than in developed countries. In addition, the evidence suggests that recipient firms' absorptive capacity, particularly their openness and learning behavior, are also important in shaping outcomes; differences in absorptive capacity can lead to varied levels of behavioral additionality and leveraging effects.

Key Design and Implementation Factors

- *Defining the Target Group.* While the evidence is inconclusive, studies do indicate a set of characteristics, all of them indicating greater elasticity, that should be sought when defining target groups.
- *Size.* Both theory and practice confirm that grants to SMEs tend to generate higher additionality than grants to larger firms. Moreover, larger firms are more likely to apply for indirect support, such as R&D tax incentives.
- *Financial constraints.* If two firms are similar in characteristics, such as the degree of innovativeness and length of innovation experience, firms that are financially constrained have a higher appropriability gap to cross to reap the benefits from innovation.
- *R&D intensity.* Firms with high R&D intensity are unlikely to undertake more R&D because of policy support, so that grants to these firms tend to generate little additionality. This is an important consideration because there may be a bias to support projects that appear to be more sophisticated, even if in those cases additionality may be more difficult to achieve.
- *Marketing and outreach.* Innovation grant programs can end up supporting a small group of firms that are effective at applying for grants and whose business model is dependent on obtaining them. Care needs to be taken to ensure there is awareness of grant schemes across all potential applicant markets.
- *Designing the matching rate.* A few studies find a nonlinear relationship between crowding-out effects and matching rates. Cofunding rates that are too low may not address the market failure constraining innovation, and thus generate little input additionality, while cofunding rates that are too high may substitute for private funding. A simple rule is not to have matching requirements for small amounts of funding or for innovation grants that involve high-risk activities;

other, more sophisticated alternatives are shown in box 4.1. Regardless of the method, it can be very useful when available funds are limited to ask applicants to disclose in advance what percentage of the project they require to be financed. This can allow policy makers to form a profile of the financing needs of different types of applicants and adjust cofinancing rates accordingly

BOX 4.1

Optimizing Matching Rates of Grant Schemes—A Few Alternative Designs Based on Bidding

A key question for the design of matching grants is how to define the percentage of matching that ensures that incentives and finance are adequate for the beneficiary to implement a project. This is key to achieving additionality. Three potential designs for matching rates are described next.

Design 1. Bidding after proposal assessment

Procedure: All applicants submit their project proposals. The grant committee then assesses each proposal and publishes a funding priority list. Each applicant, after being informed of the place on the priority list, places a bid for the matching rate to the grant issuer.

Result: The higher the bid an applicant places, the more likely the project will be selected; the matching rate for each selected project is the bid placed by its applicant.

Pro: Easy to implement.

Con: Knowing the project priority, the applicant may have an incentive to place a lower bid. Thus, the bids do not necessarily reveal applicants' real need for public funds.

Design 2. Bidding before proposal assessment

Procedure: All applicants submit their project proposal, including a bid of their matching rate. Grant committee assesses proposals based on a certain rule to combine the proposal quality and bid.

Result: The matching rate for each selected project is the bid placed by its applicant.

Pro: This procedure solves the problem of underbidding in the first design.

Con: This procedure places more burden on the grant committee.

Design 3: Bidding after proposal assessment with uniform rate (a Vickers–Clarke–Groves [VCG] auction mechanism)[a]

Procedure: The same as in Design 1; the difference is the matching rate for all selected projects is the same. It is the highest bid placed by the applicants who are *excluded* from receiving the grant.

Pro: Simplifies firms' optimal bidding strategy. Because the applicants cannot affect the final matching rate to their benefit by manipulating their own bid, all applicants should simply bid their true copayment capacity.

Con: Might not be the optimal mechanism for the grant issuer. The final copayment rate can be too low for the awarded firms. Moreover, the complexity of the bidding process might confuse applicants.

a. A Vickers-Clarke-Groves auction mechanism is the most general form of incentive-compatible double-auction.

- *Grant disbursement.* Lump-sum upfront payments that are too large can cause problems such as moral hazard because a very large amount can distort innovation efforts and firms can use funds for alternative uses while financing part of the project. The grant issuer might ask firms to provide a timeline of the project and make payments as different milestones are achieved. To guarantee the continuity of the cash flow, one option is for the grant issuer to deposit the total payment into an independent account and set up conditions such that the recipient can only withdraw a certain amount at a certain time.
- *Trade-off between scheme simplification and monitoring/assessment.* Most evaluation studies recommend simplification of grant schemes on the one hand, and systematic monitoring/assessment on the other. Policy makers need to strike a balance between simplifying procedures to control costs and attract applicants versus imposing substantive reporting requirements on recipients. The problem faced by policy makers is not whether to monitor, but how to monitor and what data to collect. Rather than merely relying on self-reporting surveys, policy makers should ideally collect data and conduct follow-up monitoring of recipients through tailored online collection approaches that require minimal effort from grant recipients, or by offering them small inducements to continue to provide information to obtain more insight into program effectiveness.
- *Learning and adapting the instrument.* Some of the studies reviewed in this profile point to the need for program adjustment, learning, and refinement based on constant monitoring and impact evaluation when possible. It is important to use the lessons learned to adapt the selection mechanism and implementation.

Dos and Don'ts of Grant Schemes

Do	Don't
▪ Consider combining grants with advisory initiatives to encourage firms to take advisory services. ▪ Consider how to build an ongoing and robust grants delivery capability that can be used and reused for different types of grant programs. ▪ Remember that the transaction costs of delivering small grants are almost as high as for large grants. ▪ Consider alternative designs of grant schemes and potential variations in size, duration, matching rate, and target (individuals versus groups).	▪ Don't assume that grants are the right instrument to adopt. Policy makers need to constantly reflect on new dynamics and patterns of innovation and the emergence of new funding models. ▪ Don't necessarily expect grant programs to generate impacts immediately. Outcomes from grant schemes may need some time to manifest. Longer-term impacts on productivity and the economy might only become apparent after three to five years of grant programs.

Dos and Don’ts of Grant Schemes

Do	Don’t
▪ Be mindful about what specific group to target. Within the same broad Target Group (for example, SMEs), firms can be very diverse and suffer from different market and system failures. Attributes such as size, R&D intensity, and financial constraints can affect firms differently. ▪ Seek to ensure political commitment, funding predictability, and policy continuity because constant changes and unpredictability can make it difficult to attract good applicants. ▪ Recognize that running grants programs is a core innovation policy capability. ▪ Design agile, simple, and quick application and grant dissemination processes to lower the administrative burden on firms. Speed is often of crucial importance in innovation, and slow payments can be the difference between success and failure. ▪ Include good marketing and awareness-raising budgets to reach out to underserved locations and to firms that are not usually beneficiaries. Guard against capture from a few “usual” firms. ▪ Consider repayable models, given that they provide an avenue for revolving funding, but consider their complexity in delivery.	▪ Don’t design complex (and costly) application processes. High costs of entry may deter the firms most in need and create a captive market for firms not necessarily in need, but that are able to cover the sunk costs of the application process, or that are building a “parasitic” consultancy market around applications for grants. ▪ Don’t collect irrelevant information from beneficiaries, require burdensome reporting regimes, or maintain slow decision-making and disbursement processes. Use other sources of information when possible and be innovative in obtaining data and reporting. ▪ Don’t assume a collaboration grant program will automatically induce effective collaboration between target organizations. Collaboration is hard, takes time, and often fails. ▪ Don’t assume that industry (especially emerging sectors) can automatically assemble consortiums to bid for collaborative activity; collaboration may need to be brokered.

Checklist for Design and Implementation of Grant Schemes

- What innovation problem do you need to address? What is the Target Group do you want to support?
- Are grants the right instrument for your purpose? What other alternatives are available to you?
- What instruments are already targeting the same group? Is there any potential for synergy with other programs? Is there any danger of overlap and competition?
- What are the indirect Target Groups? How can you leverage and maximize the effects of grants?

- What selection mechanism is more appropriate: competition-based or entitlement-based?
- What is your budget? How sustainable/stable is your funding source?
- What is the cofinancing or matching rate that would achieve maximize additionality?
- What is the duration of the innovation project?
- What is the optimal minimum and maximum grant amount?
- Do you have enough expertise (both technical and professional) to evaluate and process applications? Should this evaluation process be independent of the agency managing the grant program?
- What complementary services should be put in place to ensure uptake and effectiveness of the scheme?
- What monitoring mechanisms are needed to allow assessment while minimizing bureaucracy?

Regarding the existing grant schemes:

- Are they monitored and evaluated regularly? Against what criteria?
- Are the programs still relevant and are the original rationales still valid?
- How effective have they been?
- Is there synergy, substitution, or competition between this scheme and others?
- How can the scheme be improved to allow greater efficiency and effectiveness?

References

Alvarez, R., G. Crespi, and C. Cuevas. 2012. "Public Programs, Innovation, and Firm Performance in Chile." Technical Note IDB-TN-375, Inter-American Development Bank, Washington, DC.

Aschhoff, B. 2009. "The Effect of Subsidies on R&D Investment and Success: Do Subsidy History and Size Matter?" ZEW Discussion Paper 09–032, Zentrum Für Europäische Wirtschaftsforschung/Leibnitz Center for European Economic Research, University of Manheim.

Autio, E., S. Kanninen, and R. Gustafsson. 2008. "First- and Second-Order Additionality and Learning Outcomes in Collaborative R&D Programs." *Research Policy* 37 (1): 59–76.

Becker, B. 2015. "Public R&D Policies and Private R&D Investment: A Survey of the Empirical Evidence." *Journal of Economic Surveys* 29 (5): 917–42.

Benavente, J. M., G. Crespi, and A. Maffioli. 2007. "Public Support to Firm-Level Innovation: An Evaluation of the FONTEC Program." Office of Oversight and Evaluation Working Paper OVE/WP-05/07, Inter-American Development Bank, Washington, DC.

Bérubé, C., and P. Mohnen. 2009. "Are Firms that Receive R & D Subsidies More Innovative?" *Canadian Journal of Economics* 42 (1): 206–26.

Bravo-Biosca, A., A. P. Cusolito, and J. Hill. 2014. "Financing Business Innovation–A Review of External Sources of Funding for Innovative Businesses and Public Policies to Support Them." Working Paper 91713, World Bank, Washington, DC.

Busom, I., and A. Fernández-Ribas. 2008. "The Impact of Firm Participation in R&D Programmes on R&D Partnerships." *Research Policy* 37 (2): 240–57.

Busom, I., B. Corchuelo, and E. Martínez-Ros. 2014. "Tax Incentives . . . or Subsidies for Business R&D?" *Small Business Economics* 43 (3): 571–96.

Caloffi, A., M. Mariani, F. Rossi, and M. Russo. 2018. "A Comparative Evaluation of Regional Subsidies for Collaborative and Individual R&D in Small and Medium-sized Enterprises." *Research Policy* 47 (8): 1437–47.

Cantner, U., and S. Kosters. 2012. "Picking the Winner? Empirical Evidence on the Targeting of R&D Subsidies to Start-ups." *Small Business Economics* 39 (4): 921–36.

Carboni, O. A. 2011. "R&D Subsidies and Private R&D Expenditures: Evidence from Italian Manufacturing Data." *International Review of Applied Economics* 25 (4): 419–39.

Chávez, S. M. A. 2011. "Behavioral Additionality in the Context of Regional Innovation Policy in Spain." *Innovation: Management, Policy & Practice* 13 (1): 95–110.

Chudnovsky, D., A. Lopez, M. Rossi, and D. Ubfal. 2006. "Evaluating a Program of Public Funding of Private Innovation Activities. An Econometric Study of FONTAR in Argentina." Office of Oversight and Evaluation Working Paper OVE/WP-16/06, Inter-American Development Bank, Washington, DC.

Clarysse, B., M. Wright, and P. Mustar. 2009. "Behavioural Additionality of R&D Subsidies: A Learning Perspective." *Research Policy* 38 (10): 1517–33.

Clausen, T. H. 2009. "Do Subsidies Have Positive Impacts on R&D and Innovation Activities at the Firm Level?" *Structural Change and Economic Dynamics* 20 (4): 239–53.

Colombo, M. G., L. Grilli, and S. Murtinu. 2011. "R&D Subsidies and the Performance of High-Tech Start-ups." *Economics Letters* 112 (1): 97–99.

Crespi, G. A., and A. Maffioli. 2014. "Design and Evaluation of Fiscal Incentives for Business Innovation in Latin America: Lessons Learned after 20 years of Experimentation." In *Science, Technology and Innovation Policies for Development*, 225–53. Springer.

Czarnitzki, D., and G. Licht. 2006. "Additionality of Public R & D Grants in a Transition Economy: The Case of Eastern Germany." *Economics of Transition* 14 (1): 101–31.

Czarnitzki, D., and C. Lopes-Bento. 2013. "Value for Money? New Micro Econometric Evidence on Public R&D grants in Flanders." *Research Policy* 42 (1): 76–89.

David, P. A., B. H. Hall, and A. Toole. 2000. "Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence." *Research Policy* 29 (4–5): 497–529.

García-Quevedo, J. 2004. "Do Public Subsidies Complement Business R&D? A Meta-Analysis of the Econometric Evidence." *Kyklos* 57 (1): 87–102.

Gelabert, L., A. Fosfuri, and J. A. Tribó. 2009. "Does the Effect of Public Support for R&D Depend on the Degree of Appropriability?" *Journal of Industrial Economics* 57 (4): 736–67.

González, X., and C. Pazó. 2008. "Do Public Subsidies Stimulate Private R&D Spending?" *Research Policy* 37 (3): 371–89.

Görg, H., and E. Strobl. 2007. "The Effect of R&D Subsidies on Private R&D." *Economica* 74 (294): 215–34.

Grilli, L., and S. Murtinu. 2012. "Do Public Subsidies Affect the Performance of New Technology-based Firms? The Importance of Evaluation Schemes and Agency Goals." *Prometheus* 30 (1): 97–111.

Guellec, D., and B. Van Pottelsberghe De La Potterie. 2003. "The Impact of Public R&D Expenditure on Business R&D." *Economics of Innovation and New Technology* 12 (3): 225–43.

Hall, B., and A. Maffioli. 2008. "Evaluating the Impact of Technology Development Funds in Emerging Economies: Evidence from Latin America." *The European Journal of Development Research* 20 (2): 172–98.

Herrera, L., and E. R. Bravo Ibarra. 2010. "Distribution and Effect of R&D Subsidies: A Comparative Analysis According to Firm Size." *Intangible Capital* 6 (2): 272–99.

Hottenrott, H., and C. Lopes-Bento. 2014. "(International) R&D Collaboration and SMEs: The Effectiveness of Targeted Public R&D Support Schemes." *Research Policy 43* (6): 1055–66.

Lee, E. Y., and B. C. Cin. 2010. "The Effect of Risk-sharing Government Subsidy on Corporate R&D Investment: Empirical Evidence from Korea." *Technological Forecasting and Social Change* 77 (6): 881–90.

Mateut, S. 2018. "Subsidies, Financial Constraints and Firm Innovative Activities in Emerging Economies." *Small Business Economics* 50 (1): 131–62.

Meuleman, M., and W. De Maeseneire. 2012. "Do R&D Subsidies Affect SMEs' Access to External Financing?" *Research Policy* 41 (3): 580–91.

Özçelik, E., and E. Taymaz. 2008. "R&D Support Programs in Developing Countries: The Turkish Experience." *Research Policy* 37 (2): 258–75.

PACEC (Public and Corporate Economic Consultants). 2011. "Evaluation of the Collaborative Research and Development Programmes. Final Report to the Technology Strategy Board." PACEC, Cambridge, UK and London.

Ruegg, R., and I. Feller. 2003. "A Toolkit for Evaluating Public R&D Investment: Models, Methods, and Findings from ATP's First Decade." US Department of Commerce, Washington, DC.

Takalo, T., and O. Toivanen. 2018. "Economics of Finnish Innovation Policy." https://www.talouspolitiikanarviointineuvosto.fi/wordpress/wp-content/uploads/2018/01/Takalo_Toivanen_EPC_2018.pdf.

Teirlinck, P., and A. Spithoven. 2012. "Fostering Industry-Science Cooperation through Public Funding: Differences between Universities and Public Research Centres." *Journal of Technology Transfer* 37 (5): 676–95.

Wang, Y., J. Li, and J. L. Furman. 2017. "Firm Performance and State Innovation Funding: Evidence from China's Innofund Program." *Research Policy* 46 (6): 1142–61.

Wanzenbock, I., T. Scherngell, and M. M. Fischer. 2013. "How Do Firm Characteristics Affect Behavioural Additionalities of Public R&D Subsidies? Evidence for the Austrian Transport Sector." *Technovation* 33 (2–3): 66–77.

Warta, K., and A. Rammer. 2002. "Evaluation of ANVAR Innovation Refundable Grants Programme, 1993–1999." Plattform Forschungs-Und Technologieevaluierung Number 15, July.

Zúñiga-Vicente, J. Á., C. Alonso-Borrego, F. J. Forcadell, and J. I. Galán. 2014. "Assessing the Effect of Public Subsidies on Firm R&D Investment: A Survey." *Journal of Economic Surveys* 28 (1): 36–47.

4.2.2 Profile 2. Vouchers for Innovation and Collaboration

Vouchers are increasingly used to support innovation, especially to serve as an incentive for collaboration with knowledge providers. *Vouchers* are small, nonrepayable, entitlement-based grants that require light management with effective auditing. The simplicity of administration is a key attractiveness of these schemes; however, it requires effective brokerage (see discussion that follows) to link SMEs and knowledge providers and ensure compliance through random audits or other mechanisms. Vouchers are a good start in supporting collaboration between SMEs and knowledge providers, but more sophisticated and intensive forms of collaboration for innovation projects are better served by well-designed grants, which can be combined with lending. There is some evidence that vouchers can trigger changes in attitudes toward more collaboration in innovation projects, although the evidence is still too scarce and concentrated in EU countries. More evidence is needed on the impact of voucher schemes. Schemes that allocate vouchers randomly should be particularly easy to evaluate.

Definition

Innovation vouchers incorporate elements of small grants and are typically awarded to SMEs to purchase services from external knowledge providers. The main objective is usually to entice SMEs that are not innovating to start collaborating with knowledge organizations and knowledge providers to develop innovative projects. Vouchers can also be used to encourage innovative SMEs either to formulate projects in new areas or to start collaborating with other firms and knowledge providers. In addition, vouchers have been used to stimulate innovation in service sectors where formal R&D activities are less common.

Unlike grants, voucher schemes are often entitlement-based rather than competition-based, which means that applicants receive vouchers if they meet some preset eligibility requirements. This greatly reduces application and administration costs. Recipients use this voucher to purchase services from knowledge provider, often from a preapproved list, reducing search costs as well as mitigating the risk that an SME will engage with unqualified knowledge providers. Some voucher schemes also provide brokering by intermediaries with experience in innovation to ensure that SMEs are matched with appropriate providers and that the contracting/paperwork is kept simple. Intermediaries can also liaise with both user and knowledge providers to keep projects on track. Vouchers often involve smaller amounts than grants, given that they aim to provide an incentive to start collaborating, initially through small projects.

Market and System Failures Addressed

- *Capability failure.* Voucher schemes aim to address capability failures faced by smaller firms by inducing behavioral changes toward more proactive learning and sustainable collaboration with knowledge providers. Through collaborations, SMEs are expected to develop a wide range of innovation capabilities, including technical expertise, management skills, and experience in acquiring external advice and services. Knowledge providers can also learn about the needs of industry end-users and improve their service offerings to that market.

- *Information asymmetry.* There is often severe information asymmetry between knowledge providers (particularly public research organizations) as suppliers of innovation knowledge and SMEs as potential users. SMEs are not always aware of what solutions are available to help them adopt new technologies or products, and when aware, do not always trust the quality of potential providers. For their part, knowledge providers, especially universities and research institutions, do not always understand the needs of SMEs or have incentives to develop solutions for this segment of firms. More importantly, voucher schemes can signal "good" providers. When brokerage is also offered, they can help match the SME with the appropriate provider, thus addressing these information asymmetries.

Target Group

There are two main Target Groups: SMEs[6]—often more small than medium—and knowledge providers. SMEs tend to face higher barriers to engage in innovation compared with larger businesses. They typically have limited capacity to absorb external knowledge and, more significantly, they do not consider collaborative learning to be central to their business. Besides targeting noninnovative firms, some voucher schemes target particular sectors, such as digital, creative industries, and other knowledge-intensive services. Knowledge providers, such as public research organizations or private sector consultancy firms, tend to be more industry oriented and, therefore, better suited than universities to address the needs of SMEs.

Strengths

- *Simplicity.* Voucher schemes are among the simplest innovation policy instruments to design, implement, and evaluate. Compared with larger-scale grant schemes based on competitive selection, voucher schemes involve less bureaucracy and can adopt very straightforward procedures at low cost, given that the elaborate assessment and selection procedures used in competitive grants are not required. This simplicity makes voucher schemes particularly attractive to SMEs and policy makers.
- *Flexibility.* Compared with other types of grants, innovation vouchers are less prescriptive. Recipients have considerable freedom in deciding how to use them. The wide range of activities supported through vouchers can include applied research, operations and management improvement, intellectual property issues, e-commerce, technology transfer studies, market studies, and management training. Vouchers are a flexible incentive for testing and launching innovative activities.
- *Demand orientation.* Projects supported by vouchers are defined according to the actual needs of SMEs, which contributes to effective knowledge transfer and resource allocation, and do not entail the use of third parties (such as selection committees) to decide on the relative potential value of projects.
- *Promoting collaborative innovation suitable for SMEs*. Vouchers can trigger behavioral change of SMEs and knowledge providers to engage in collaborative

innovation, in a variety of forms that suit the various situations of SMEs. For example, follow-up collaborations can take the form of repeated use of knowledge providers (that is, the voucher may induce a "trial," which can trigger an extended commercial relationship between the SME and the knowledge provider); follow-up collaborations can also involve a joint application for public funding to continue with the innovation project kicked off through vouchers. In general, a strength of vouchers is that they provide an initial opportunity for SMEs to embark on collaboration according to their own needs and circumstances.

Potential Drawbacks and Risks

- *Risk of one-off transactions.* The one-off nature of most projects supported by voucher schemes means that there is a risk that collaboration will not be sustained and, therefore, not lead to longer-term behavioral change to more innovative behavior and practices.
- *Difficulty of reaching the intended Target Group.* The intention of voucher schemes is to entice SMEs that are not innovating to embark on innovation. Nevertheless, the entitlement-based nature of voucher schemes implies a high risk of nonadditionality, particularly if there is no investigation process to determine whether the applicant is "noninnovative" (this is a downside of the entitlement-based design). Extra marketing and outreach may be needed to find firms that are not typically involved in innovation activities. The potential mistargeting can be severe, with funding possibly going to firms that would have undertaken the projects anyway.
- *Risks of knowledge provider lock-in.* Voucher schemes typically rely on local knowledge providers so that SMEs can benefit from geographical proximity. This leads to limited search patterns and the risks of lock-in. The solutions that SMEs can find locally are not necessarily the most effective or suitable to address their needs.
- *Poor supply of advisory services.* SMEs may be restricted by the capacities and level of interest of the research and advisory sector in supplying services, and both sides may struggle to reconcile their different needs, timelines, and incentives. The inclusion of private providers in the supply pool can help address this issue, although it has its own risks (discussed later).
- *Fraudulent use of schemes.* Voucher schemes can be very flexibly designed and implemented, which implies a higher risk of misallocation of public funds. Notably, complicity with knowledge providers (often private providers) could lead to false collaborations. This risk increases as the value of vouchers increases. Some form of verification of project authenticity is needed.

Elements for Good Policy Design

Several dimensions need to be considered when designing a vouchers scheme, including:

- *Selection of recipients.* Voucher schemes are typically entitlement-based. Therefore, selection of recipients is often on a first-come, first-served or randomized

BOX 4.2

Vouchers Versus Regular Grants

A voucher is essentially a unique type of grant with specifically defined characteristics regarding the selection process, implementation mechanisms, value of the grant, and so on. When choosing one instrument over the other, policy makers need to consider the following important distinctions of vouchers compared to regular (matching) grants for innovation projects:

- Vouchers are entitlement-based rather than competition- or merit-based: that is, applicants can get vouchers if they fulfill the selection criteria set in advance.
- Vouchers are small in value: typically, the face value of vouchers is no more than a few thousand dollars, while regular grants can be much larger.
- Vouchers are intended to trigger behavioral change of noninnovative SMEs and knowledge providers to collaborate and kick off SMEs' innovation process. By contrast, regular innovation grants typically focus on input additionality, and are intended to crowd in private investment in R&D and innovation projects.
- Vouchers rely heavily on brokers, which perform the functions of advertising, ex ante consultation, diagnostics, monitoring, and ex post verification.
- Vouchers are simple in terms of administrative procedures. Disbursement occurs when knowledge providers redeem vouchers.

basis. Some schemes use a combination of the two.[7] What is important is that the application and verification processes offer some guarantee of the emergence of real collaborations.

- *Value.* A survey of EU voucher schemes suggests that the value of vouchers is typically about €3,000–€5,000 for those schemes without contributions from recipients, and about €8,000–€13,000 for those requiring financial contributions from the recipients (DG ENTR-Unit D2 2009). Matching funding from companies is often required when the cost of work requested by the firm exceeds the value of the voucher. Voucher schemes might also offer differentiated values targeting different activities. For example, smaller vouchers can be oriented toward consulting services, while larger vouchers can be targeted for product development. Although matching features can improve the likelihood of selecting firms that are committed to collaboration, they potentially can compromise behavioral additionality by supporting firms that already innovate.
- *Brokerage support.* Voucher schemes work best when they involve brokerage support to smooth the implementation process. Brokerage might be undertaken by dedicated personnel from innovation or SME/regional development agencies to deal with various transaction costs and paperwork, and to liaise between knowledge providers and SMEs. Brokerage can also be provided by accredited external private providers if there are capacities in the region that can be leveraged. Brokerage can be key to ensuring a good match between the SME and provider, and often also to ensure that the SME manages the process effectively and gets the expected results. Brokers can also help increase coordination

and referrals to other sources of SME assistance. Furthermore, brokers can help verify whether actual knowledge transfer has occurred.

- *Random monitoring.* To minimize risk of fraudulent use of vouchers, agencies can conduct random verification checks. The possibility of these checks can discourage beneficiaries from claiming services that do not exist.

Evidence of Impact

The bulk of the existing evidence draws upon evaluations and surveys of voucher programs in Europe (table 4.7). Little evidence has been found from other contexts, despite the increasing popularity of vouchers in many countries. The samples addressed by evaluations are small, the results are very much dependent on context, and the generalizability of findings is low. The main data sources employed by the evaluations include administrative data, surveys of different subgroups of the Target Group, and interviews and focus groups with stakeholders. Except for the Creative Credits evaluations, the selected evaluations only address immediate outcomes of voucher schemes. The selected studies also fall short on assessing the added value in an objective way. The data employed are overly reliant on self-reporting from stakeholders, and most studies do not have a control group. Therefore, considerable care should be taken before extrapolating the conclusions of the studies to other countries with less-developed science, technology, and innovation capabilities, and with limited local knowledge to address the needs of local SMEs.

Design, Beneficiaries, and Uptake

- *Size and sector.* All the studies show that most users involved in these schemes have fewer than 50 employees. Many of the participating firms have five or fewer employees. The sectors involved are typically service industries, such as ICT and creative industries.
- *Uptake.* The uptake ratio was low in early programs, such as the Limburg scheme (Wintjes 1999). Some SMEs adopted a "wait-and-see" attitude after receiving vouchers. Later schemes all had very high uptake rates. For example, 1,044 SMEs applied for 100 vouchers in the Dutch national scheme, and 672 SMEs applied for 150 vouchers in the Creative Credits pilot. Uptake by knowledge providers was also positive for the reviewed schemes. Some Dutch universities even offered discounts for voucher winners by doubling the voucher value (Cornet, Vroomen, and van der Steeg 2006).

TABLE 4.7 Innovation Voucher Schemes Covered by This Synthesis of Evidence

National schemes	Regional schemes
▪ Dutch scheme launched in 2004 (Cornet, Vroomen, and van der Steeg 2006) ▪ Austrian scheme launched in 2007 (Good and Tiefenthaler 2011) ▪ Swiss scheme launched in 2009 (Good and Tiefenthaler 2011) ▪ UK Growth Vouchers program launched in 2014 (UK BIS 2016)	▪ Limburg scheme in the Netherlands, 1997–99 (Wintjes 1999) ▪ Lombardy, Italy regional initiatives in 2003 (pilot) and in 2005 (adjusted initiative) (Sala, Landoni, and Verganti 2016) ▪ Creative Credits pilot, Manchester, United Kingdom, 2009–10 (randomized controlled trial) (Bakhshi, Edwards, Roper, Scully, and Shaw 2011; Bakhshi et al. 2013) ▪ Scottish scheme, United Kingdom, launched in 2009 (BiGGAR Economics 2010) ▪ Northern Ireland scheme, United Kingdom, 2008–14 (SQW 2014)

BOX 4.3

Using Randomized Design to Experiment Voucher Schemes

A major advantage of voucher schemes in terms of evaluation is that they often rely on random allocations, which makes it easy to undertake random control trials and establish control groups. For competitive grants, it is harder to adopt an experimental evaluation approach because of the risk of selection bias—if, for example, the best firms are in the program. Evaluations therefore require some randomization of selected firms or some type of regression discontinuity approach. For many voucher schemes, experimental design is already integrated in the scheme, as demonstrated in the evaluation of the Creative Credits program. Bakhshi. Edwards, Roper, Scully, and Shaw (2011) and Bakshi et al. (2013) used the randomized nature of the scheme and collected longitudinal data for voucher recipients as well as nonrecipients to assess both the short-term and the longer-term effectiveness of the scheme. If experimental evaluation is intended, efforts to collect data on nonrecipients as well as recipients should be planned at the beginning of program.

- *Characteristics of brokerage.* Concrete forms of brokerage vary significantly across schemes. In the Austrian and Swiss schemes, research organizations performed the function of brokerage, assuming the responsibility for dealing with paperwork. Most of the reviewed schemes used dedicated brokerage arrangements, such as commercialization offices in universities. In the Creative Credits pilot, the online repository "Creative Gallery" served as a brokerage facility.

Input Additionality

This is not the primary concern for voucher schemes, and most of them do not require matching contributions from recipients. The Scottish scheme with matching requirements achieved the intended level of input additionality (BiGGAR Economics 2010). As reviewed in the evaluation, for the funding supporting the 27 projects, £110,050 came from the agency in charge, and the recipients contributed £119,271 either in cash, in-kind staff time, or materials.

Output Additionality

The evaluations mostly measure output additionality, project additionality, and economic impacts in terms of gross value added (GVA) or full-time equivalent jobs (FTEs). For projects, this guide differentiates between *full additionality* (that is, the project would not have happened at all without vouchers) and *partial additionality* (that is, the project would have happened differently without the support of vouchers). Sala, Landoni, and Veranti (2016) note that innovation voucher schemes rarely generate full additionality (that is, supporting the launch of projects), but they can generate partial additionality, such as reducing the time-to-market or enlarging the scope of activities.

Table 4.8 summarizes findings on output additionality by the selected studies.

TABLE 4.8 Evidence on Output Additionality of Voucher Schemes: Key Findings

Scheme	Study	Project additionality	Economic impacts
Austrian scheme	Good and Tiefenthaler (2011)	35 percent full additionality; 45 percent partial additionality; 20 percent no additionality.	—
Northern Ireland program	SQW (2014)	—	Approximately 380 full-time equivalents and ¬£8.3 million gross value added generated.
Scottish scheme	BiGGAR Economics (2010)	55 percent full additionality; 40 percent partial additionality; 5 percent no additionality.	Immediate impacts: £27,044 gross value added and 1.9 full-time equivalents. Estimated potential future impacts: £3,566,876 gross value added and 230 full-time equivalents.
Creative Credits	Bakhshi, Edwards, Roper, Scully, and Shaw (2011)	80 percent full additionality.	Short-term additional sales of £514,000 (approximately £3,430 per voucher).
Dutch national scheme	Cornet, Vroomen, and van der Steeg (2006)	80 percent full additionality; 10 percent no additionality; 10 percent unused.	—

Note: Percentages refer to the share of respondents reporting. — = not available.

Overall, reported output additionality from participants was high: from 35 percent to 80 percent of the respondents reported full additionality, and from 40 percent to 45 percent of the respondents reported partial additionality. Respondents also reported substantial job creation (in the range of 230–380 full-time equivalents); sales (£3,450 per voucher for the Creative Credits scheme); and gross value added (£8.3 million generated by the Northern Ireland scheme).

Behavioral Additionality

This is a key indicator of effectiveness because voucher schemes aim to entice firms that are not innovating to innovate and firms that are not collaborating to collaborate. Behavioral additionality in this context refers to the extent to which recipients have followed up to maintain the relationship with knowledge providers. Table 4.9 summarizes this type of additionality.

Spillover Effects

Two-thirds of the SME respondents in the Scottish evaluation report wider business benefits, including an improved public profile, increased credibility because of working with universities, and greater technological awareness (BiGGAR Economics 2010). The evaluation of the Northern Ireland scheme finds that the voucher experience served as a first step for SMEs to "graduate" to other forms of innovation support (SQW 2014). For knowledge providers, most surveyed academics confirm that voucher schemes benefited their organizations in terms of opening new arenas of research, improving commercial awareness, and offering new teaching opportunities.

TABLE 4.9 Evidence on Behavioral Additionality of Voucher Schemes: Key Findings

Formal follow-up projects	Informal follow-up activities and higher probability/willingness of collaboration
■ Swiss scheme: 13 percent launched follow-up projects (Good and Tiefenthaler 2011). ■ Scottish scheme: 22 percent of the SME-university pairs were already working on follow-up projects by the time of evaluation (BiGGAR Economics 2010). ■ Austrian scheme: By 2011, 27 percent of SMEs that received vouchers in 2007 had launched formal follow-up projects; 41 percent of follow-up projects benefited from another innovation voucher project (Good and Tiefenthaler 2011).	■ Self-reporting surveys conducted by the studies all suggest less reluctance to cooperate, more positive attitudes toward innovation, and more inclination to use external know-how than before the program. ■ Using a control group, this evaluation of the Dutch scheme suggests that the probability that voucher recipients commission an assignment with a knowledge provider improved from 8 percent to 87 percent (Cornet, Vroomen, and van der Steeg 2006).

Main Requirements for Replicability

In terms of replicability in developing countries, the unique advantages of voucher schemes are their simplicity and low costs. The schemes in developed countries are often described in detail by the responsible agencies on their official websites, which offers good opportunities for policy makers in developing countries to understand how design issues are typically addressed.

Competencies required from the Target Group. To benefit from voucher schemes, applicants should have the capacity to: (1) identify their challenges that can be addressed by external knowledge providers; (2) provide a detailed and accurate description of the services required; and (3) benefit from university research or other knowledge providers. Given that some of these elements will often not be present, brokerage services are important to assist throughout the different stages, and business advisory services or technology extension services can help with both (1) and (2).

BOX 4.4

Persistence of Behavioral Additionality—An Important yet Under Researched Issue

Sustained behavioral change among voucher recipients to undertake innovation projects is a key goal of innovation voucher schemes. However, most of the evaluations reviewed were commissioned too early to assess this desired outcome. The findings of the two evaluations that touch upon this issue are mixed. The evaluation of Creative Credits observes strong behavioral additionality in the first six months following the completion of projects: that is, recipients were statistically more likely than nonrecipients to have introduced product or process innovations (72.4 percent versus 55.9 percent for product innovation; 63.8 percent versus 47.2 percent for process innovation). Twelve months after the completion of projects, there was no longer a statistically significant difference between recipients and nonrecipients. In contrast, the evaluation of the Austrian scheme (Good and Tiefenthaler 2011) notes that a higher percentage of the recipients are likely to commission follow-up projects as time goes by (15 percent for 2009 participants, 24 percent for 2008 participants, and 27 percent for 2007 participants).

Competences and motivation required from knowledge providers. Knowledge providers need to exhibit not only technical competencies but also sufficient motivation to deliver knowledge services. However, in developing countries, the competency and motivation of knowledge providers is often low. Policy makers need to thoroughly understand: (1) whether the knowledge providers can support and work with SMEs; and (2) whether the knowledge providers are willing and motivated to work with SMEs. Ex ante consultation can help greatly in assessing this, and effective technology transfer offices are also very useful enablers for such services.

Matching demand and supply of knowledge. The quality and diversity of expertise from potential knowledge providers should, to a great extent, match the needs and the absorptive capacity of target SMEs. Effective brokerage can help participants quickly achieve a match between supply and demand for knowledge services. Brokerage is often performed by a public agency with dedicated staff to ensure professional delivery and to avoid conflicts of interest, but can be assisted by experts in industry organizations or technology transfer offices. Having innovation service agencies undertake brokerage of vouchers can also help improve coordination among different innovation policies at different levels. Moreover, the use of online infrastructure can simplify the matching and implementation process.

Prioritizing the noninnovative first-time applicants. To encourage firms that are not innovating to get involved in innovation activity, first-time applicants should be prioritized. However, some of these SMEs often have very low awareness of the policy support available to them; thus, proactive advertising and outreach is important to enhance uptake.

Voucher schemes involve small support with limited scope. For SMEs that want to continue to grow their capabilities, vouchers should be followed up with different forms of support to take collaborative innovation to the next stage. Finally, it is critical to evaluate the longer-term impacts of vouchers schemes, especially regarding the persistence of behavioral additionality; therefore, efforts are needed to collect longitudinal data.

Dos and Don'ts of Voucher Schemes

Do	Don't
▪ Before deciding to use voucher schemes, take stock of the supply and demand of innovation-related knowledge services. ▪ Design simple application and selection procedures that have lower entry costs than matching grants. This is critical given the target population of noninnovative SMEs. If oversubscribed, use randomization or transparent selection mechanisms.	▪ Don't overcomplicate the procedure for potential voucher recipients. Although the need to collect data means that some administrative requirements are necessary, schemes should use brokerage and random audits to simplify processes. ▪ Don't leave the list of potential service providers open. Instead, define clear requirements and, if needed, provide a list of accredited providers.

Dos and Don'ts of Voucher Schemes

Do	Don't
■ Increase SMEs' awareness of the voucher schemes through proactive advertising and outreach activities, particularly if targeting sectors not usually associated with innovation. ■ Set up brokerage services throughout the policy cycle to smooth the implementation process. These can be effective in increasing the quality of the matches. ■ Provide feedback to knowledge providers from SMEs on their performance, as the former are often inexperienced at dealing with SMEs. ■ Seek to ensure the availability of simple generic templates to cover common areas such as standardized contracts and intellectual property agreements. ■ Conduct random verification of identified collaborative projects to minimize the risk of fraud. ■ Conduct systematic data collection to enable policy evaluation, learning, and improvement. Use random audits to monitor programs.	■ Don't ignore the potential roles of knowledge providers. For instance, they should be able to handle most of the paperwork involved to ease the burden on SMEs. ■ Don't overstretch the scope of voucher schemes. Although they can support a wide range of activities, keeping their scope limited helps simplify procedures and control costs. ■ Don't expect the development of large innovation projects. Vouchers are an instrument to encourage behavioral change through small projects. ■ Don't just assume public sector providers are the only providers; there may be good reason to involve private research organizations and/or providers of business advisory services.

Checklist for Design and Implementation of Voucher Schemes

- Are there communities of both small and medium firms that have the potential to engage in innovation and of knowledge providers that can assist?
- Do you foresee a high potential for output and behavioral additionalities if a voucher scheme is announced with small amounts of support?
- What Target Group, especially in terms of size and sector, should be supported?
- What is the most appropriate agency to manage such a scheme?
- How can you monitor these collaborations without imposing excessive costs, particularly given the small amount of support?
- Can you provide a strong brokerage service to support additionality?
- What brokerage mechanism is the most appropriate, such as through dedicated brokerage services, knowledge providers, or facilities such as online information repositories of knowledge providers?
- If the long-term policy goal is more sophisticated innovation, what support should be in place to "graduate" firms from the voucher scheme?

References

Bakhshi, H., J. Edwards, S. Roper, J. Scully, L. Morley, and N. Rathbone. 2013. "Creative Credits: A Randomized Controlled Industrial Policy." Nesta.

Bakhshi, H., J. Edwards, S. Roper, J. Scully, and D. Shaw. 2011. "Creating Innovation in Small and Medium-sized Enterprises–Evaluating the Short-term Effects of the Creative Credits Pilot." Nesta.

BiGGAR Economics. 2010. *Evaluation of the First Phase of the Scottish Funding Council Innovation Voucher Scheme: A Final Report to Scottish Funding Council*. Pentlandfield, UK: BiggAR Economics.

Cornet, M., B. Vroomen, and M. van der Steeg. 2006. "Do Innovation Vouchers Help SMEs to Cross the Bridge toward Science?" CPB Discussion Paper 58, CPB Netherlands Bureau for Economic Policy Analysis.

DG ENTR-Unit D2. 2009. "Availability and Focus on Innovation Voucher Schemes in European Regions." Prepared by DG ENTR-Unit D2, Enterprise & Industry Directorate General, European Commission, Brussels.

Good, B., and B. Tiefenthaler. 2011. "Innovation Voucher–Small Is Beautiful." https://www.academia.edu/1535298/Innovation_voucher_-_small_is_beautiful.

Sala, A., P. Landoni, and R. Verganti. 2016. "Small and Medium Enterprises Collaborations with Knowledge Intensive Services: An Explorative Analysis of the Impact of Innovation Vouchers." *R&D Management* 46 (S1): 291–302.

SQW. 2014. "An Evaluation of the Invest NI Innovation Vouchers Program." http://www.sqw.co.uk/files/3414/2188/1186/innovation-vouchers-final-evaluation-report-nov-2014.pdf.

United Kingdom, BIS (Department for Business Innovation & Skills). 2016. "Growth Vouchers Program Evaluation Cohort 1: Impact at Six Months." BIS Research Paper No. 259, prepared by IFF Research.

Wintjes, R. 1999. "Evaluation of the Research Vouchers Project Participants: Pilot Project." https://www.academia.edu/819562/Evaluation_of_the_Research_Vouchers_pilot_project

4.2.3 Profile 3. Loans and Loan Guarantees for Innovation

Loans and loan guarantees are instruments for debt financing[8] to support business innovation. They typically target SMEs, although large firms can also be targeted. Loans, either directly supplied by the government or via intermediaries, are direct financial policy instruments, while guarantees are indirect financial policy instruments. In the case of loans, the banks bear the credit risks in case of default, while for guarantees, the government will bear part of the credit risk—typical good practice is to guarantee up to 80 percent of the loan amount. Credit guarantees schemes (CGSs) provide third-party credit risk mitigation to lenders—the government absorbs a portion of the lender's losses—with the objective of increasing access to credit for innovation by mitigating credit market imperfections (World Bank and FIRST Initiative 2015). Guarantees allow lenders to reassign the asset recovery risk to the guarantee scheme, effectively reducing collateral requirements from borrowing firms with innovative projects. If loans carry a significant subsidy, they can be more distortive than credit guarantee schemes, which are usually regarded as market-enabling for facilitating credit, under the premise that once lenders learn from the information obtained through the interaction with beneficiaries of loan guarantees, borrowers will gain access to loans without guarantees (Vogel and Adams 1997). Loans for innovation are becoming more popular because of their reimbursable nature, but it is important to keep in mind that these are instruments to address financial market imperfections that prevent commercial banks from properly funding innovation projects, not to address other innovation problems like appropriation of externalities or lack of capacity to implement innovation projects.

In the discussion that follows, each instrument is reviewed separately.

4.2.3.1 Loans for Innovation

Definition

Subsidized loans are a direct instrument used to support the financing of innovation projects. Like credit guarantee schemes, loans are not limited to innovation policy; they represent a flexible policy instrument that can be used to address problems primarily associated with financial market imperfections (see discussion in the subsection on market and system failures addressed). Loans can be used to fully finance innovation project activities, or to provide partial financing, such as for the purchase of equipment and technologies. In the realm of innovation policy, loans typically are provided at below-market rates, either by government agencies or by intermediary financial institutions that manage government or development bank funds.

Different types of loans are used as innovation policy instruments. The most common type of loan for innovation addresses financial market imperfections by expanding the availability and reducing the cost of finance. Such loans are unconditional and require repayment regardless of the innovation outcome. A less frequent type of loan, when the innovation project presents high risk and the potential for positive externalities exists, is a conditional loan. Repayment is required only after certain objectives are met: for example, on either the successful completion of an innovation project or on the generation of revenues from it. In terms of form of repayment, traditional loans have clear schedules for debt and interest repayment, while convertible loans—an instrument with both loan and equity features—can be repaid by giving the lender a share of the equity.

Loans are typically secured: that is, guaranteed by collateral or borrowers' assets (such as real estate and equipment). Because the main assets of most innovative firms are typically intangible and thus cannot serve as collateral, loan guarantees can help such firms get external financing. Governments can work through financial institutions to provide larger loans for innovation to large firms, especially in projects that require large financial commitments and generate substantial positive externalities. (Some governments also provide loans directly, but that is not considered standard practice.)

Market and System Failures Addressed

In addition to the typical market failure associated with the potential externalities of an innovation project, loans address imperfections in financial markets that prevent innovation projects from being financed (Hall and Lerner 2012). Commercial lenders may not understand the financial viability of innovation projects proposed by borrowing companies, given information asymmetry between borrowers and lenders. In addition, projects may be difficult to monitor ex post, creating potential moral hazard problems. In some cases, assets or outcomes of innovative projects can be intangible and thus cannot serve as collateral for traditional loans. As a result, many innovative firms lack access to debt financing.

Target Group

Subsidized loans directly provided by the government and financial intermediary loans subsidized by the government or development banks typically target innovative firms that struggle to get commercial loans. Commercial lenders commonly favor established larger enterprises with a good track record of borrowing, with tangible assets as collateral, and innovative firms trying to finance riskier projects are at a disadvantage. Government interventions aim to address this disadvantage, although it often proves difficult to accurately target innovative firms.

An indirect Target Group is financial institutions that may otherwise not service this type of innovative business and that can learn to better appraise these projects and provide future financing without government subsidies.

Strengths

Some key strengths of this type of instruments include the following:

- *Tailored toward specific policy objectives.* Loans are the preferred instrument when the innovation problem is related to financial imperfections and cannot be addressed with guarantees. Loans can be designed to address specific innovation problems. For example, groups of innovative SMEs can be targeted by imposing criteria on the type of projects to be funded, the size, sector, or other performance indicators. In addition, the quantity of government loans and subsidized loans can be adjusted to reduce the impacts of economic cycles, as opposed to fully commercial loans, which tend to be procyclical and very sensitive to macroeconomic conditions. Specific activities can also be targeted, such as addressing high-growth sectors and promoting exporting.

- *Lower fiscal costs and potential for leveraging financial resources.* Policy makers can achieve a high level of financial leverage by charging low interest rates—for example, compared to nonrefundable or partially refundable grants. Loans also have the advantage that they are repayable—meaning there is little net loss to the taxpayer—and that the repaid funds can potentially be recycled.
- *Utilize existing financial infrastructure.* When delivered through established financial entities, loans can use their lending infrastructure, due diligence processes, and so on. Further, loans are generally familiar to businesses (unlike equity finance).

Potential Drawbacks and Risks

Main risks and drawbacks include:

- *Government failure when implemented directly by government institutions.* Government agencies may not have the expertise and outreach to effectively manage direct lending; public sector lending for general purposes often has had high levels of nonrepayment. In addition, implementation without financial intermediaries is unlikely to help private intermediaries learn about lending to innovative projects, thus making no contribution to the objective of achieving market provision of finance for innovation.
- *Difficulty in identifying and targeting innovative firms.* Government agencies may face difficulties in determining whether firms or projects are truly innovative or have the potential for positive externalities. As a result, loan schemes may fail to target innovative or socially productive firms. Some lenders target loans to finance the purchase of machinery. However, this does not always imply innovation or technology adoption if it does not involve the upgrading of existing machinery.
- *Difficulty in monitoring innovation outcomes.* Implementing agencies may find it challenging to follow the progress of innovation projects and to discern whether deviations from expectations are driven by internal issues of the project or external factors that are out of the control of the borrower. Lenders traditionally only care that they money is paid back, not whether a project is successful.
- *Overuse of lending programs for innovation due to fiscal consolidation.* Loans can only effectively address innovation problems due to financial imperfections; they cannot address innovation problems that involve large externalities or failures in the capabilities of firms to innovate. A risk in countries undergoing fiscal consolidation is that resources will be shifted from other direct support programs to reimbursable loans to reduce fiscal expenditures, thus reducing the government's ability to address innovation problems unrelated to financial markets.

- *Greater distortions than credit guarantees schemes if they are not targeted correctly.* Loans, especially when implemented by public banks, can crowd out private finance for innovation. Distortions can be reduced by targeting loans (particularly if subsidized) to segments that are not accessing finance from the commercial lenders (such as unattended geographical areas, certain disadvantaged sectors, or borrowers that require higher maturities than the banking sector can offer).
- *The need to exercise care over the type of innovation supported.* The business model of loan initiatives is best suited to lower-risk innovation activities in which the recipient is likely to repay. They are not suited to high-risk, early-stage support because many recipients will fail to grow.
- *Risk of deficient design.* Most government loans for innovation have lower-than-market interest rates. But when the key problem is adverse selection—difficulties in screening good projects by financial institutions—loans should have rates that are above (rather than below) market interest rates, which would even further reduce the fiscal costs of such schemes.

Elements for Good Instrument Design

Several decisions must be made upfront when designing loan schemes for innovative SMEs:

The level of government involvement must be determined. The involvement of the government can range from significant participation in the scheme and direct lending, whereby the funding comes predominantly from the government budget and the execution of the program rests primarily on a public financial institution (as explained, this is not encouraged), to partial participation, whereby the government provides subsidized funds to financial intermediaries that manage the program, and may or may not charge a fee to the beneficiaries (and the government remains in a principal position by appointing representatives to steering committees and project boards). Best practice is to use the expertise of financial intermediaries when possible, and work with these institutions to address critical information asymmetries. Loan programs should be implemented directly only in the absence of financial intermediaries and when public banks have substantial outreach capabilities.

Two Important Features of Lending Must Be Decided:

- *Short-term versus long-term loans.* Short-term loans typically require repayment within one to two years and are commonly used to support business operations. Long-term loans have longer repayment schedules that usually support long-term investment to acquire either tangible or intangible assets (such as machinery or patents). Large loans for significant innovation activities within large companies, often made due to the potential for large positive externalities, should be long term.
- *Secured versus unsecured loans.* Secured loans require some form of collateral to be seized in the event of default, typically tangible assets such as machinery and real estate, or savings accounts. Specialist loans that accept intangible assets as

collateral have been developed recently (Bravo-Biosca, Cusolito, and Hill 2014), but these remain rare in policy practice. Unsecured loans are mostly available to large firms with a track record, and therefore are rarely used in innovation loan schemes serving SMEs.

Elements of design must be chosen. The first step is to determine if there is a good business case (the need is justified) to subsidize lending for innovation. Once this case has been established, policy makers should incorporate the following into the design of programs:

- *Risk assessments.* These need to be performed by qualified credit underwriters, such as banks and other financial institutions.
- *Monitoring and evaluation.* It is imperative that policy makers are able to establish project additionality, considering that lending schemes are particularly prone to serving strong contenders that could have accessed credit without a subsidy. Therefore, monitoring mechanisms need to be strong and reliable.
- *Clear role of intermediaries and subsidies.* Practical experience suggests it is always preferable to extend credit by having the public banks fund experienced financial intermediaries. However, the rationale behind introducing subsidies should be made explicit and time-bound, so all participants have clear expectations from the outset of the scheme about the amount and duration of government assistance
- *Requirements for repayment.* Repayment can be either conditional or unconditional. One example of conditional repayment schemes is income-contingent loans, where businesses only make repayment when they earn profit from the investments (for a more detailed account, see Denniss, Yuan, and Withers 2009). Naturally, this option has been more attractive to the Target Group than unconditional loans (Cunningham, Gök, and Lardeo 2016).

It is good practice to *communicate the design of loans scheme clearly to the Target Group and to establish what elements of innovation projects are eligible for finance*. One example of clear communication is the £50 million pilot Innovation Loans scheme launched by the UK government in 2017. The key design elements are illustrated in box 4.5.

Evidence of Impact

While there is a substantial body of literature discussing the impacts of subsidized loans on firm R&D, the studies often treat loans as one of the several instruments in question (in addition to grants) and remain very limited in explaining the design features of instruments. There is a severe lack of evidence on the impact of design features, including selection criteria, and on the effectiveness of loan schemes. Most of the studies reviewed in this profile address the issue of input additionality, utilizing methodologies such as matching analysis and difference-in-differences estimation based on panel data from industrial surveys and administrative databases.

Specific programs covered in the studies include the Technology Development Foundation of Turkey program (TTGV) (Özçelik and Taymaz 2008); soft loans by Spain's

BOX 4.5

Design Elements of the Innovation Loans Scheme by Innovate UK

- *Aim:* To offer affordable, patient, flexible, interest-bearing and repayable funding for later-stage R&D projects with a clear route to commercial success.
- *Target Group:* Growth-oriented, innovative micro, small, and medium businesses that will be able to manage a loan, but that struggle to access finance from commercial lenders or schemes backed by the British Business Bank.
- *Selection mechanism:* Open competition based on proposals to be assessed by independent experts and credit committee.
- *Agency:* Innovate UK Loans Ltd, a wholly owned subsidiary of Innovate UK.
- *Interest rate:* 3.7 percent per year on outstanding amounts, payable quarterly in arrears.
- *Period:* Available for up to 3 years and extendable for 2 years. Repayable over a maximum of 5 years after the availability and extension periods.
- *Size:* £100,000–£1 million.
- *Collateral:* Take security where it is available, such as for assets purchased and intellectual property developed with the proceeds of the loan.

Source: Innovate UK government website.

Centre for the Development for Industrial Technology (CDTI) (Huergo and Moreno 2014); the Innovation Credit scheme of the Brazilian Development Bank (BNDES) (Machado, Martini, and Gama 2017); and the subsidized loans scheme (Measure 2.1b) of the Italian Piedmont regional scheme Documento Unico di Programmazione (DOCUP) (Cannone and Ughetto 2014).

Targeting of the schemes might be an issue. For example, Cannone and Ughetto (2014) report that larger and profitable firms in Italy's Piedmont region have a higher probability of being selected by the agency. IDB-OVE (2017) reports that different Brazilian programs are often highly intertwined and reach the same firms. While only 30 percent of beneficiary firms received support from more than one program, these firms received 53 percent of the total treatments given.

In addition to the effects in terms of input and output additionalities (see discussion that follows), the spillover impact has also been discussed in the study of the French innovation refundable grants program (ANVAR) by Warta and Rammer (2002). They state that the signalling effect of ANVAR may have been crucial for small companies in leading industries to access complementary financing.

Input Additionality

All the studies confirm the positive impact of loan schemes on firms' *R&D intensity*: that is, the ratio between R&D investment and their revenues. In particular, Huergo and Moreno (2014) find that the stimulation effect of loan schemes is higher than that of grants (from either the government or the European Union). Nevertheless, this

TABLE 4.10 Evidence on Input Additionality of Loans for Innovation: Key Findings

Study	Context	Finding
Özçelik and Taymaz (2008)	Turkey, Technology Development Foundation of Turkey program (TTGV)	While effects for firms in all sectors are positive, positive effects are larger for smaller firms and firms in technology-intensive sectors, leading to increases in R&D. On average, firms with R&D expenditures spent 2.27 percent of output (sales) on R&D, while the ratio was 5.98 percent for loan recipients. However, the average share of the subsidy in total R&D expenditure reached 20 percent for loan recipients.
Huergo and Moreno (2014)	Spain, Centre for the Development for Industrial Technology (CDTI) soft loans program (in comparison to national and European grants)	Participation in the CDTI soft loan funding system raises the probability of self-financing internal R&D activities by 81.8 percent, compared with 76 percent when participating in grant schemes. Firms involved in exporting activities during the last year are 4.4 percent more likely to self-finance internal R&D activities, highlighting the complementarity between internationalization and R&D investment strategies.
Cannone and Ughetto (2014)	Italy, Piedmont regional scheme, Documento Unico di Programmazione (DOCUP)	Subsidized firms show an increase of indebtedness and of total fixed assets, while there is no evidence of any impact on firm profitability. The participation of private banks in the screening process steers the selection toward firms demonstrating a solid financial situation that might have otherwise been able to attain funding from other sources (crowding out effect).
Machado, Martini, and Gama (2017)	Brazil, Brazilian Development Bank (BNDES) Innovation Credit scheme	Evidence of positive and significant effects of BNDES credit on firms' R&D expenditures is found using two approaches to estimation. According to fixed effects estimates, BNDES-supported firms tend to invest at least 30 percent more on R&D than non-supported companies in the analyzed period.

stimulation impact is small, given that the proportion of subsidies in total R&D expenditure of recipients is low (Özçelik and Taymaz 2008). Main findings on input additionality are summarized in table 4.10.

Output Additionality

Few studies address output additionality generated by loan schemes. Main findings are summarized in table 4.11.

TABLE 4.11 Evidence on Output and Outcomes Additionality of Loans for Innovation: Key Findings

Study	Context	Finding
IDB-OVE (2017)	Brazil, BNDES card scheme (preapproved low-interest credit line targeting SMEs, including equipment)	Labor productivity for recipients in the manufacturing or retail sectors was not significantly different from productivity in the control group, but productivity for recipients in services was 3 percent higher (significant at the 90 percent level). In the manufacturing sector, being treated by the BNDES card scheme was correlated with a 22.7 percent increase in capital productivity (significant at the 5 percent level), though no associated increases in total factor productivity (TFP) were found. SMEs in the manufacturing sector that received the BNDES card (and that did not participate in another type of support) were more likely to see a decrease in wages (by 3.2 percent) compared to the control group.
Huergo and Moreno (2014)	Spain, CDTI soft loans program	Participation in the CDTI loan system increases the probability of obtaining product innovations and applying for patents. However, this direct effect is absent with respect to process innovations.

Main Requirements for Replicability

Leveraging the broader commercial environment. While government loans are often justified in the context of a weak financial market, policy makers should bear in mind that the ultimate objective is to create a competitive financial market that is innovation-friendly. Before launching a loan scheme subject to substantial influence from the government, policy makers need to consider the alternatives underpinned by commercial initiatives, and work with the financial sector to reduce information asymmetries and ensure future innovation finance from the private sector.

Clear rationale for introducing specific features of the scheme. Loan schemes can be tailored to different Target Groups and policy objectives. For example, schemes can target different groups of innovation actors or different business activities by offering short-term or long-term loans or by making repayment unconditional or conditional on achieving certain benchmarks. Given this flexibility, it is crucial for policy makers to think through what changes in innovation activities they are trying to achieve before determining with commercial banks the program's features.

Complementary policy measures. Innovative firms that face financing problems can also be subject to weaknesses such as low capacity to exploit the innovation outcomes or low managerial capabilities to enable the commercialization of innovations. In such cases, complementary policy measures such as advisory services can step in to maximize the effects of financing provided by the loans scheme. More importantly, steering the policy mix toward lending instruments will not solve many innovation problems. Thus, it is critical to target loan schemes to those firms whose innovation activities are primarily constrained by access to finance.

Dos and Don'ts of Loans for Innovation

Do	Don't
■ Consider synergies with nonfinancial schemes in supporting SME innovation, such as advisory services and training, to improve innovation outcomes.	■ Don't try to achieve too many policy objectives through one scheme. Every loans scheme should be clearly targeted toward a certain innovation problem.
■ Communicate clearly to potential applicants about the rationale, scope, and requirements of the program, and provide advisory support when needed.	■ Don't rely on loans to address all innovation financing. They are more appropriate for more established firms and more developed innovation projects.
■ Implement through financial intermediaries, but if this is not possible build the necessary expertise (in-house or outsourced) to execute the program.	■ Don't expect that loans will be effective with all types of firms. Innovative firms that struggle to get commercial loans (for example, because they cannot fulfill collateral requirements) are the Target Group in need but can be difficult to identify.

Dos and Don’ts of Loans for Innovation

Do	Don’t
	▪ Don’t ignore the alternatives, especially commercial alternatives, before launching government loans funded from taxpayers’ money.

Checklist for Design and Implementation of Loans for Innovation

- Is the innovation problem that you are trying to address related to lack of finance for innovation in commercial banks? Is commercial bank lending for innovation projects limited by lack of liquidity?
- Can you support banks in screening the quality of innovation projects?
- Have you considered whether a credit guarantee would be a more suitable instrument?
- Can you design specific targeting to identify those firms that are more financially constrained to implement innovation projects?
- Can you work with financial institutions to implement the program and support gradual increased participation by financial institutions in innovation finance?
- In addition to the necessary financial due diligence, can you make sure that innovation outputs and outcomes are monitored?

References

Bravo-Biosca, A., A. P. Cusolito, and J. Hill. 2014. “Financing Business Innovation–A Review of External Sources of Funding for Innovative Businesses and Public Policies to Support Them.” Working Paper 91713, World Bank, Washington, DC.

Cannone, G., and E. Ughetto. 2014. “Funding Innovation at Regional Level: An Analysis of a Public Policy Intervention in the Piedmont Region.” *Regional Studies* 48 (2): 270–83.

Cunningham, P., A. Gök, and P. Laredo. 2016. “The Impact of Direct Support to R&D and Innovation in Firms.” Chapter 3 in *Handbook of Innovation Policy Impact*, edited by J. Edler, P. Cunningham, A. Gök, and P. Shapira, 54–107. Edward Elgar Publishing.

Denniss, A., M. Yuan, and G. Withers. 2009. “Innovation Financing and Use of Income Contingent Loans.” *Australian Journal of Labour Economics* 12 (2): 145–65.

Hall, B. H., and J. Lerner. 2012. “The Financing of R&D and Innovation.” Chapter 14 in *Handbook of the Economics of Innovation*, Vol. 1, edited by B. H. Hall and N. Rosenberg, 609–39. Elsevier

Huergo, E., and L. Moreno. 2014. “National or International Public Funding? Subsidies or Loans? Evaluating the Innovation Impact of R&D Support Programmes.” SIMPATIC Working Paper l1031, Bruegel, Brussels.

IDB-OVE (Inter-American Development Bank, Office of Evaluation and Oversight). 2017. “Assessing Firm Support Programs in Brazil.” Office of Evaluation and Oversight, Inter-American Development Bank, Washington, DC.

Machado, L., R. A. Martini, and M. Gama. 2017. “Does BNDES Innovation Credit Boost Firms’ R&D Expenditures? Evidence from Brazilian Panel Data.” https://web.bndes.gov.br/bib/jspui/bitstream/1408/13595/1/BNDES_Innovation_WorkingPaper.pdf.

Özçelik, E., and E. Taymaz. 2008. "R&D Support Programs in Developing Countries: The Turkish Experience." *Research Policy* 37 (2): 258–75.

Vogel, R. C., and D. W. Adams. 1997. "The Benefits and Costs of Loan Guarantee Programs." *The Financier* 4 (1&2): 22–29.

Warta, K., and A. Rammer. 2002. "Evaluation of ANVAR Innovation Refundable Grants Programme, 1993–1999." *Plattform Forschungs-Und Technologieevaluierung* Number 15, July.

World Bank and FIRST Initiative. 2015. *Principles for Public Credit Guarantee Schemes for SMEs*. Washington, DC: World Bank.

4.2.3.2 Loan Guarantees for Innovation (Credit Guarantee Schemes)

Definition

Loan guarantee schemes, also called *credit guarantee schemes* (CGSs), aim to cover some portion of the potential losses experienced by lenders when firms default on loans. Credit guarantee schemes are not merely an innovation policy instrument and are widely used as financial instruments for supporting SME growth in general.[9] In the context of innovation policy, they provide a mechanism for lenders to mitigate risk and work as an insurance scheme to prevent losses to lenders associated with extending credit to firms investing in innovative projects. The guarantee applies exclusively to assets that have been explicitly covered under the CGS provisions, typically representing a portion of the lender's loss on the credit extended in the case of default, in return for a fee (Beck, Klapper, and Mendoza 2008). Credit guarantee schemes are typically established with public financial support, although schemes established by development agencies and private associations are also common.

Compared to loan schemes, credit guarantee schemes are designed to induce banks to lend when they otherwise would not (such as in cases of no collateral or insufficient collateral) and thus support innovation projects that would not otherwise be undertaken or would be done on a smaller scale. A key difference between credit guarantee schemes and loan schemes is that a credit guarantee schemes can use some of the scheme's own funds. While credit guarantee schemes also tend to use government budget, they nevertheless can result in a smaller direct cost for the government than loan schemes.

Credit schemes—and thus credit guarantee schemes—become more relevant in the late phases of the innovation cycle. Other financial instruments for innovation employed during commercialization include private equity and venture financing, government equity investments, factoring, intellectual property-based asset finance, and initial public offerings (IPOs) issued in capital markets (Bravo-Biosca, Cusolito, and Hill 2014). By contrast, in earlier stages of the innovation cycle, policy makers typically use grants to support innovation. At the prototype testing and market demonstration stage, policy makers may facilitate angel investment or crowdfunding or activate pre-commercial procurement schemes. Credit guarantee schemes can be particularly important in financing process or marketing innovations.

Market and System Failures Addressed

Credit guarantee schemes address market failures relating to both innovation and to imperfections in credit markets when firms lack sufficient collateral to obtain loans (Hall and Lerner 2012.). The most prominent innovation related failures in financial markets are:

- *Information asymmetry.* An innovator typically has more information about the likelihood of success of an innovation than the potential financiers of that investment. Thus, financiers may not be in a position to correctly evaluate risk. Generally, lenders manage this uncertainty by demanding high levels of collateral. However, the assets created by innovative firms are often intangible, such as tacit knowledge, which cannot be used as collateral in loan transactions.
- *Coordination failures.* Credit guarantee schemes also can address weak institutional coordination: for example, by improving the information available on SME borrowers in coordination with credit registries and building the credit origination and risk management capacity of lenders (World Bank and FIRST Initiative 2015).

Target Group

The Target Group for CGS is usually SMEs with insufficient collateral that wish to innovate but remain credit constrained. To maximize impact, credit guarantee schemes need to increase the number and magnitude of guarantees (outreach) and to increase the access to finance by SMEs that would not have been able to borrow without the credit guarantee (additionality) (Calice 2016).

Strengths

Key strengths include:

- *Ability to be targeted to specific types of firms.* Credit guarantee schemes give policy makers the ability to target beneficiaries with specific characteristics, including size, age, sector, and degree of innovativeness. Targeting can also enable policy makers to increase additionality by discouraging participation by borrowers that would have obtained financing even in the absence of the scheme.
- *Operation through market mechanisms.* Credit guarantee schemes can leverage private capital and rely on the skills of specialized private operators because the lending decisions remain with the intermediary lender. This reduces the risks associated with a lack of capabilities of government lenders. Credit guarantee schemes rely on both subsidies and market-based arrangements for allocating credit, generating fewer distortions than grants.
- *Improvements in records about SME borrowers and lender capacity.* In weak institutional environments, where credit markets remain thin, credit guarantee schemes can assist credit registries in improving information available about borrowers and induce lenders to strengthen credit origination and risk management skills.
- *Less burden on the government budget.* Credit guarantee schemes have less of an impact on government budgets than direct financing instruments because the

scheme leverages the financing capacity of commercial financial institutions. Credit guarantee schemes should not lead to financial costs to the government, except in the case of default.

- *Offering complementarity for other financial support.* Credit guarantee schemes can be offered in combination with loans and various equity investment instruments to suit the needs of innovative enterprises and minimize the financial burden on the government. The Danish Growth Fund (Vaekstfonden) is an example of this type of policy mix.

Potential Drawbacks and Risks

Key drawbacks and risks include:

- *Trade-offs between innovation scope, eligibility, and outreach to SMEs.* The targeting of credit guarantee schemes to support only innovation projects narrowly defined may not justify the investment required to establish the scheme in the first place because the number of firms eligible to access the scheme may not support the minimum number of guarantees for the scheme to be viable.
- *Moral hazard.* If not properly designed, credit guarantee schemes can encourage screening banks to be less careful when selecting borrowers, which can lead to a higher lending rate for innovative firms and a higher default rate among borrower firms.
- *The risk of government failure.* In some cases, control over lending comes at the expense of the ability to leverage private expertise—which is usually more experienced than the staff at public agencies—to assess the creditworthiness of borrowers. In addition, government influence over credit extension brings the potential risk of political capture, which in turn can lead to misallocation of public funds.
- *Crowding out of private schemes.* Private associations can also establish credit guarantee schemes, funded, for example, by fees from borrowers. If the public guarantee fund terms are too generous, then banks may substitute public guarantees for these private schemes, particularly to make loans to borrowers that are poor credit risks.

Elements for Good Instrument Design

Different models can be adopted when designing a credit guarantee scheme. Some of the models most commonly used by policy makers include the following:

- *The individual model.* This model features a borrower, a lender, and a guarantor. In some countries, a lender may require a borrower that lacks sufficient collateral or an adequate credit history to apply to a credit guarantee scheme as a condition for receiving a loan. The guarantor is paid a fee by the borrower, which can be collected by the lender. The guarantor often assesses the borrower's application and directly approves the covered amount.
- *The portfolio model.* The guarantor and the lender agree ahead of time on conditions for lending under the scheme, including, for example, the loan size, the terms, asset turnover, and general characteristics of beneficiaries to access the

guarantee program. The lender can extend credit under the agreed conditions without the guarantor approving each transaction. This model imposes lower transaction costs on the guarantor than the individual model, but it is difficult for the guarantor to prevent the lender from using the scheme for its own clients, thus inducing guarantors to charge a fee.

- *The intermediary model.* This model specifically targets microenterprises. A specialized agency (usually a nongovernmental organization, NGO) acts as intermediary between lenders and borrowers. The agency appraises, approves, monitors, and supervises the loans. Guarantors in this scheme are usually multilateral or bilateral agencies. The lender interacts with the intermediary, but not with the borrower, thus significantly reducing transaction costs. The intermediary is held responsible for the losses sustained by the default of its borrowers.

Experience from implementation suggests that desirable design features for a credit guarantee scheme for innovation include the following:

- *Offer partial coverage.* The best approach to mitigating the risk of default is to cover a part of the loan, leaving some degree of risk for losses in the hands of beneficiaries. This can reduce moral hazard, when the borrower may take on excessive risks as a direct result of being covered by the scheme.
- *Allow for the existence of risk-based premiums.* Allowing the interest rate charged to vary according to the amount of risk can help markets obtain true signals about the degree of risk involved and to respond accordingly.
- *Promote efficient claims handling.* The satisfaction of participants and operability of the scheme will depend on the level of services rendered to process and manage the claims. Commercial or near-commercial standards should be pursued. For example, payment should be initiated when loans hit default, and not when the collateral execution process starts (as is often done), which can lead to significant delays.
- *Introduce strong monitoring.* A robust system to monitor performance of the projects and the operation of the scheme is critical to introduce timely actions and prevent unnecessary defaults.

Evidence of Impact

There are few formal evaluations of credit guarantee schemes, and most studies focus on the use of such schemes for SMEs in general and not for innovation objectives in particular. Therefore, the conclusions from the studies should be applied to innovation credit guarantee schemes only with caution, especially in contexts or schemes other than those considered in the studies. Two specific cases of CGS for innovation are reviewed: Spain's Centre for the Development for Industrial Technology (CDTI), which provides guarantees for R&D, and the Korea Technology Finance Corporation (KOTEC). Two meta-analyses of general credit guarantee schemes are also considered. The first, from the World Bank and FIRST Initiative (2015), covers 76 partial credit guarantee funds in 46 countries (20 high-income, 25 middle-income, and 1 lower-income country). The second is a 2010 OECD report that included the use of guarantees in Chile, Italy, Korea, Portugal, and Slovenia. These meta-analyses are complemented with seven case studies of SME credit guarantees in Chile, Colombia, Italy, and Malaysia.[10]

The reasons given to justify the use of credit guarantee schemes varied, while the institutions and processes were similar across schemes. The two studies of credit guarantee schemes designed to promote innovation cite the use of guarantees as a strategy to increase R&D for innovation. All others justify programs in terms of overcoming collateral constraints and compensating financial institutions for both the high risks of lending to SMEs and their frequent lack of records to support loan applications. In most cases, the design and implementing institutions for these schemes were competent, usually featuring a branch of the ministry of science and technology or a development bank. The instrument is delivered through commercial banks that assess credit applications (borrowers' creditworthiness) and issue the loans.

The profile of participating firms depended on the scheme. This discussion focuses on the credit guarantee schemes for innovation but presents more general findings on the use of credit guarantee schemes in table 4.12. Spain's CDTI targeted all firms, regardless of sector and size. However, participating companies were 20 years old on average; about two-thirds of them (67 percent) were exporters; firms featured a higher proportion of intangible assets (19.1 percent more than the control group); and about half of successful applicants had experience with previously funded development

TABLE 4.12 Evidence on Input Additionality of Public Credit Guarantee Schemes: Key Findings

Study	Context	Finding
Boocock and Shariff (1996), based on Pieda plc. (1992)	Malaysia, United Kingdom, general use of CGS, multiple reviews	Additionality reached 68 percent of the scheme lending by value, although higher additionality is usually correlated with higher default rates.
Boocock and Shariff (1996), based on Levitsky (1997)	Malaysia, general use of CGS, multiple reviews	At least 35 percent should be achieved in a properly designed scheme, but the authors argue that a 60 percent threshold for additional lending value should be the acceptable minimum for any scheme.
Boocock, and Shariff (2005)	Malaysia, general use of CGS	63 percent of the loans were additional finance, although some of the findings may have been artificially enhanced because of quotas/aggressive targets imposed by the implementing agency.
Allison, Robson, and Stone (2013)	United Kingdom, Enterprise Finance Guarantee (EFG) Program; general use of CGS	82 percent rate of additionality in loans, although it seems difficult to assess whether the owner's business judgment on this was accurate. About 30 percent of borrowers would not have proceeded with their project in the absence of the loan.
Benavente, Galetovic, and Sanhueza (2006)	Chile, Fondo de Garantía para Pequeños Empresarios (FOGAPE), general use of CGS	Firms increased their debt by around Ch$18,000 (in absolute terms, not differentially with respect to the control) and this increase was statistically significant for loans issued in the Metropolitan Region of Santiago (not so for other regions); the probability of obtaining credit was 14 percentage points higher than among a control group of nonparticipants.

Note: For the purposes of this profile, the input additionality of credit guarantee schemes (CGSs) is lending that would not have happened in the absence of the guarantees.

projects. Results suggest that the program attracted innovative firms, given that successful applicants tended to belong to high-tech manufacturing sectors (machinery and equipment) or services (computer, ICT, and R&D). Different patterns emerged from the results from KOTEC in Korea. Participants in the scheme of credit guarantees for innovation were small (firms with 50 or fewer employees accounted for 90.2 percent of the sample) and young (82.3 percent of participating firms were younger than five years). The guaranteed amounts were higher for high-tech manufacturing (computers, officer machinery, semiconductors, and electronic components) than for the software and pharmaceutical sectors. Holdings of intangible assets (such as patents) and the education of the chief executive officer (CEO) appear to be positively associated with the level of guarantees.

Credit guarantee schemes have been effective in easing access to financing for firms in general, given that the public loan guarantee lowered interest spreads significantly for all firms (Cowling, Ughetto, and Lee 2018). The study also suggests that when competition on the supply-side of loan and credit markets is high, the introduction of a credit guarantee scheme can drive general debt prices downward, easing access to finance.

Input Additionality

The probability of CDTI participants investing in R&D was 25 percent higher than among nonparticipating firms. The effect was stronger for SMEs (26.8 percent higher) than for big firms (21.7 percent). R&D investment is substantially higher for manufacturing participants than nonparticipating manufacturers, although R&D among participants in the services sector was only 9.6 percentage points higher than among nonparticipating services sector firms (Huergo, Trenado, and Ubierna 2013). Participants in Korea's KOTEC invested more in R&D than nonparticipants, but the difference is not statistically significant. However, young and technologically advanced participants had a significantly larger investment in R&D than similar, nonparticipating firms (Heshmati 2013). Additional findings regarding input additionality, which include more general uses of credit guarantee schemes, are summarized in table 4.12. This evidence suggests that the value of loans that would not have been obtained without the credit guarantee programs ranged from 30 percent to 82 percent of total borrowing.

Output Additionality

The evidence on output additionality is limited to one study of a credit guarantee scheme for innovation (KOTEC) and a study of a scheme supporting SMEs in general (FOGAPE). Korea's KOTEC is found to have a positive effect on the sales growth and productivity of participating firms (Heshmati 2013). Chile's FOGAPE is found to have little impact on firms on average, particularly retailers, but a substantial impact on manufacturing firms (Benavente, Galetovic, and Sanhueza 2006). Turnover in companies benefiting from the fund increased by 6 percent. After five years, firms participating in FOGAPE had increased their sales by 32 percent and their profits by 24 percent on average, significantly higher than the average increase in sales and profits in a control group. About half the firms backed by FOGAPE had participated in the program earlier (Larraín and Quiroz 2006), which suggests some degree of loyalty of service and deepening of relationships between the credit provider and the beneficiary. The default rate on FOGAPE loans is only 1.05 percent, compared to 1.01 percent for commercial bank loans to similar groups without FOGAPE, suggesting that banks can effectively screen firms for the ability to repay their loans, and that the availability of guarantees do not create excessive distortions. To sum up, credit guarantees are found to increase the repayment of loans and to increase turnover in the range of 6 percent to 32 percent for participant firms, compared to nonparticipants.

Main Requirements for Replicability

Implementing agencies need certain capabilities to successfully implement a CGS, including the ability to evaluate potential substitutes and complementarities, such as necessary conditions for success and potential synergies with other programs.

One of the most important questions for policy makers before establishing a credit guarantee fund for innovation concerns its viability in the light of alternative choices faced by firms. Low additionality in the Malaysian program (see table 4.12) seems to reflect the ability of firms to borrow from other sources (Shariff 2000). In addition, anticipating how the scheme may remove restrictions to R&D investments, such as collateral requirements for credit, can be critical to understand the marginal value of the scheme.

A strong legal framework for upholding creditor rights (such as processes for collection and recovery of assets in case of default) and effective contract enforcement are critical to the feasibility of establishing a credit guarantee scheme. Calice (2016) views the systems for bankruptcy, contract, collateral, consumer protection, and property laws, as well as an independent and efficiency judiciary, as among the preconditions for effective design, implementation, and evaluation of a credit guarantee scheme. However, all of these are weak in many developing countries.

Credit guarantee schemes also require a financial sector characterized by adequate solvency ratios for banks and effective transparency standards to ensure liquidity in credit guarantee schemes because these improve the ability of banks to recover the costs of their loans in instances of default. Calice (2016) indicates that accounting standards and well-regulated professionals in accounting and auditing are another precondition of success, particularly because a lack of reliable data impedes banks' ability to evaluate the riskiness of lending to SMEs. For example, if the firm's financial statements are not audited, the credit officer will not have reliable information on which to base her decisions.

In addition to these necessary conditions, the establishment of a credit guarantee scheme would benefit from the presence of a competitive banking sector that can intermediate and issue the loans effectively. The depth of the domestic capital market will also influence the willingness of banks to offer reasonably priced loans. Calice (2016) refers to this enabling factor as the availability of a "sound and liquid financial system which is able to originate and manage credit effectively."

Firms need to acquire basic competencies to participate in credit guarantee schemes successfully. Participating firms need to demonstrate a minimum capacity to design a viable innovation project proposal. At the margin, the credit guarantee scheme will help participants gain access to finance, but it will not substitute for the basic economic feasibility of the project. The firm is expected to repay the lender, even in the presence of the guarantee. In addition, the participating firm needs to be able to establish the case for using the credit guarantee scheme, justified by either the absence of financial records due to the early stage of the business or the high collateral requirements to obtain credit.

Dos and Don'ts of Credit Guarantee Schemes

Do	Don't
▪ Promote and advertise the credit guarantee scheme (CGS). Many analyses highlight how poor awareness of the existence of the scheme hindered take-up rates. ▪ Provide financial and operational independence to the CGS, ideally by its establishment as its own legal entity. ▪ Provide transparency and disclosure of public funding available, and of rules, procedures, and arrangements to generate confidence among lenders. ▪ Build an adequate governance structure for the CGS, with a competent and independent board, and sound internal control procedures. ▪ Avoid ambiguity about the eligibility criteria for SME borrowers and for lenders, which may lead to inefficiency and reduced additionality (particularly for the portfolio model). The CGS must have clear qualification criteria under specific parameters for firms (size, subsector, and age) and for lenders (lending capacity and default performance).	▪ Don't over intervene and distort the market mechanisms. Although government participation is often needed in CGSs for innovation, the role of the market should be maximized, and market expertise should be fully utilized. ▪ Don't overlook the problems that are of a systemic or structural nature. Regulatory instruments are better suited than CGSs to address systemic/structural problems.

Source: Elaborations based on Calice 2016.

Checklist for Design and Implementation of Credit Guarantee Schemes

- Is the innovation problem that you are trying to address related to lack of finance or is the problem primarily associated to the risk of the innovation project for commercial banks?

- Are there other types of credit guarantees? Do the existing guarantee programs follow best practices in terms of governance?
- Do you have a specialized agency supporting the implementation of credit guarantees for SMEs?
- Is it possible to ensure the transparency of the scheme?

References

Allison, G., P. Robson, and I. Stone. 2013. "Economic Evaluation of the Enterprise Finance Guarantee (EFG) Scheme." Department for Business Innovation & Skills, United Kingdom.

Beck, T., L. F. Klapper, and J. C. Mendoza. 2008. "The Typology of Partial Credit Guarantee Funds around the World." Policy Research Working Paper 4771, World Bank, Washington, DC.

Benavente, J. M., A. Galetovic, and R. Sanhueza. 2006. "FOGAPE: An Economic Analysis." Working Paper 222, Department of Economics, University of Chile.

Boocock, G., and M. N. M. Shariff. 1996. "Loan Guarantee Schemes for SMEs: The Experience of Malaysia" *Small Enterprise Development* 7 (2): 25–36.

Boocock, G., and M. N. M. Shariff. 2005. "Measuring the Effectiveness of Credit Guarantee Schemes: Evidence from Malaysia." *International Small Business Journal* 23 (4): 427–54.

Bravo-Biosca, A., A. Cusolito, and J. Hill. 2014. "Financing Business Innovation–A Review of External Sources of Funding for Innovative Businesses and Public Policies to Support Them." Working Paper 91713, World Bank, Washington, DC.

Calice, P. 2016. "Assessing Implementation of the Principles for Public Credit Guarantees for SMEs–A Global Survey." Policy Research Working Paper 7753, World Bank, Washington, DC.

Cowling, M., E. Ughetto, and N. Lee. 2018. "The Innovation Debt Penalty: Cost of Debt, Loan Default, and the Effects of a Public Loan Guarantee on High-tech Firms." *Technological Forecasting & Social Change* 127 (2018): 166–76.

Hall, B. H., and J. Lerner. 2012. "The Financing of R&D and Innovation." Chapter 14 in *Handbook of the Economics of Innovation*, Vol. 1, edited by B. H. Hall and N. Rosenberg, 609–39. Elsevier.

Heshmati, A. 2013. "The Effect of Credit Guarantees on R&D Investment of SMEs in Korea." IZA Discussion Paper 7851, Institute of Labor Economics (IZA), Bonn.

Huergo, E., M. Trenado, and A. Ubierna. 2013. "Impacto de los créditos blandos en el gasto en I+D empresarial La empresa española y el apoyo del CDTI a la I+D+i." Centro para el Desarrollo Tecnológico Industrial (CDTI), Madrid.

Larraín, C., and J. Quiroz. 2006. "Estudio para el fondo de garantía de pequeños empresarios." Unpublished.

Levitsky, J. 1997. "Credit Guarantee Schemes for SMEs—An International Review." *Small Enterprise Development* 8 (2, June): 4–17.

OECD (Organisation for Economic Co-operation and Development). 2010. "Facilitating Access to Finance: Discussion Paper on Credit Guarantee Schemes." OECD Publishing, Paris.

Pieda plc. 1992. "Evaluation of the Loan Guarantee Scheme." Report prepared for the UK Department of Employment, London.

Shariff, M. N. M. 2000. "An Evaluation of Government-backed Loan Scheme in Malaysia." Loughborough University Institutional Repository.

World Bank and FIRST Initiative. 2015. Principles for Public Credit Guarantee Schemes for SMEs. World Bank, Washington, DC.

4.2.4 Profile 4. Tax Incentives for R&D

Tax incentives for R&D are perhaps the most common indirect instrument used to encourage innovation, at least in high- and middle-income countries. A number of impact evaluations using quasi-experimental designs have been done, especially for OECD countries, and there are several systematic reviews of this evidence. Overall, studies find evidence that tax incentives increase R&D expenditures, but often this increase is concentrated in larger and more sophisticated firms. In line with the incentives provided, the impact on R&D expenditures tends to be greater for more profitable, larger firms; although emerging evidence suggests that young innovative firms can also benefit. The design of these schemes can be quite complex in terms of what kinds of expenses are eligible. A well-functioning tax system administration is essential to make these schemes work.

Definition

R&D tax incentives reduce the tax burden of firms that invest in eligible R&D activities, representing an indirect way of supporting investments in R&D. Based on the definitions of R&D tax incentives used in the OECD database,[11] there are two main types of tax incentives for R&D:

- *Tax incentives based on expenditures in R&D.* This is the most common type of tax support for R&D. It includes corporate tax income benefits, social security withholding tax incentives, reductions in tariffs for imported research equipment, and reimbursements of value added tax (VAT).
- *Tax incentives based on results from R&D or related innovation activities.* This type of tax support is generally applied to income generated from R&D activities and intellectual property, referred to as income-based provisions. These schemes grant a lower corporate tax rate on profits generated from patents, licensing, or asset liquidation linked to R&D. One example of this type of scheme is a patent box, whereby income derived from designated patents receives a more generous tax treatment. There are only a few examples of this type of instrument, and its impacts have not been extensively evaluated. Nevertheless, its popularity is increasing, particularly among OECD member states.

Policy makers have used both narrow and broad schemes, in terms of the scope of support and the kinds of R&D expenditures that are eligible for tax relief.[12] Most schemes are based on the definitions of R&D expenditures in the OECD Frascati Manual, which provides guidelines on the measurement of government tax relief for R&D (OECD 2015a). Policy makers in OECD countries have shown a preference for granting tax incentives for R&D labor, subcontracted and collaborative R&D, and materials and overhead. This tendency appears to reflect the potential loss of embedded knowledge when physical assets are subsequently disposed of, and the role of investments in R&D personnel in facilitating the diffusion of knowledge in the domestic economy.

Although the evidence suggests that generic and early-stage research is often riskier than applied research, only a few schemes reward basic research over applied research. Designing these differentiated schemes is complex. Their feasibility depends, among other factors, on how capable the implementing agency is in managing the complexities involved in differentiating spending by type of R&D or beneficiary, and on whether the incentives created are successful in promoting R&D spending.

A distinction is made between volume-based, incremental, and hybrid schemes. *Volume-based schemes* allow firms to deduct all eligible R&D expenditures in any given year, while *incremental schemes* allow firms to deduct only the excess amount of R&D expenditures in a given year above a base amount, typically defined as a function of past qualified R&D spending. Incremental schemes have been effective in avoiding crowding out of R&D investment, as they reward exclusively incremental spending in R&D. However, the compliance costs for incremental schemes have proven higher than for volume-based credit schemes. *Hybrid schemes* combine elements of volume-based and incremental schemes.

Market and System Failures Addressed

- *Incomplete appropriability.* Firms underinvest in R&D because knowledge spillovers (such as the movement of workers involved in R&D to other firms) and imitation of products mean that firms cannot fully reap the benefits. Thus, other firms, including competitors, can expropriate the value generated by firms that invest in R&D. Tax incentives can motivate firms to invest in R&D by reducing their tax burden and the cost of R&D.
- *Coordination failure (for tax incentives with collaboration as a criterion).* Collaborative investments in R&D between private firms and research organizations, such as universities, is often lacking. Schemes that include collaborative activities in the eligibility criteria can use tax incentives to remedy some of these coordination failures.

Target Group

Most schemes target all firms, although some are sector-specific. More recently, some tax incentives schemes have offered more generous terms to SMEs, young firms, and start-ups because the market and system failures faced by those firms are often more severe than those faced by large and mature firms. However, very few schemes have such provisions (OECD 2015b). One problem with such provisions is that young firms and start-ups normally take considerable time to generate profits, which makes corporate tax incentives less appealing (provisions to carry over tax benefits over a limited period of time can partially offset this problem and are normally used to increase participation of young and small firms). Moreover, tax incentives for SMEs tend to have little impact in countries where new SMEs already enjoy a simplified tax regime with low tax rates, although SMEs may benefit if the credit or deduction is substantial compared to the magnitude of the tax liability.

Strengths

- *Lower administrative and compliance costs than direct support instruments,* such as grants.
- *Simpler implementation.* Tax schemes are simpler to implement than direct support because they can be delivered through the corporate tax system. However, this is the case only if the process for verification of eligibility of R&D expenditures is kept simple and the number of tax exceptions is limited.
- *Flexibility for beneficiaries to choose projects.* Tax incentives allow the firm to choose the most likely profitable investments in R&D, providing greater efficiency in the selection of R&D projects, given that beneficiaries theoretically are most knowledgeable about their own projects.
- *Fewer allocative distortions.* Tax incentives do not crowd out market mechanisms. They tend to be more transparent and less distortionary than direct instruments such as R&D grants because they directly support the priority activities of the business and have a predefined set of rules, generally embedded in legislation.
- *Link to efforts to attract investment.* Tax incentives can encourage multinational enterprises (MNEs) to locate innovation activity in a country, as long as there is also a good local research base or large markets to service.

Potential Drawbacks and Risks

- *Budgetary uncertainty.* The costs of tax incentive schemes can be large and are hard to predict in advance (unless caps are imposed); thus, budgetary uncertainty is greater than with direct R&D support. Volume-based schemes have been easier to implement than incremental measures. However, volume-based schemes have been less efficient (in terms of the amount of revenues foregone per dollar of investment encouraged) because they are more likely to subsidize R&D expenditures that would have occurred anyway.
- *Difficulty in verifying eligibility.* Identifying eligible expenditures and auditing or assessing compliance is a complex, expensive task requiring specialized skills, which can be difficult for the government to find. This raises the potential for fraud, for example through relabeling and overestimating what constitute expenditures in R&D.
- *Risk of short-termism.* Tax incentives tend to induce investment only in R&D projects that generate greater profits immediately. Grants may be better suited to encourage spending on long-term R&D, given potential high externalities but high initial costs.
- *R&D wage second-order effects.* Schemes may distort labor markets, with firms overrecruiting R&D-related staff, and induce increases in the wages of R&D professionals, given that these schemes can significantly increase demand for R&D skills, but labor supply tends to be limited in the short term (OECD 2015a, based on Goolsbee 1998).
- *Limited targeting.* The evidence suggests that tax incentives usually have been designed to benefit larger incumbent R&D–intensive companies. Because the

size of the incentive is proportional to the tax bill paid by the firm, large and R&D-intensive firms often tend to benefit the most from these schemes. In addition, large firms are also more likely than smaller firms to be able to afford advice on minimizing taxes.

- *Administrative rigidity.* R&D tax incentives are usually legislated as part of the tax code, which makes them difficult to amend and change.

Elements for Good Policy Design

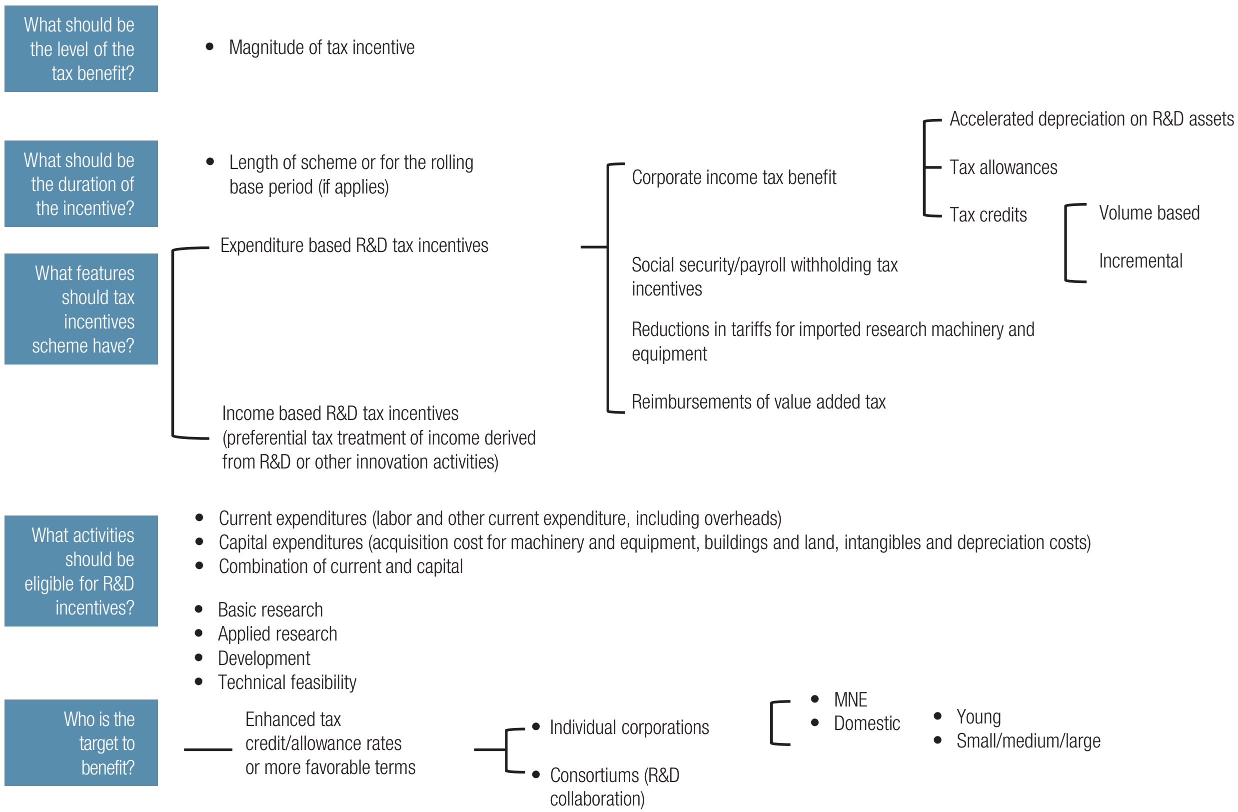
Several issues are important to consider during the policy design stage, as illustrated in figure 4.2.

- *Attaining the appropriate level of the tax benefit.* Caps and limits are often used as ceilings on the amount of eligible qualified R&D expenditure or R&D tax benefits. The share of firms' R&D expenditures subject to deduction varies across countries, from 10 percent in Italy, to 18 percent in the Netherlands, 20 percent in Canada and Korea, 30 percent in Mexico and Spain, 35 percent in Chile, and to up to 50 percent in Argentina. In addition, policy makers need to decide on the maximum amount of tax reduction subject to claim in any given year.
- *Determining the duration of the incentive scheme.* In many cases, policy makers have left terms relatively open-ended to ensure predictability and encourage companies to undertake long-term planning. This, however, has implications for budget planning over the medium term.
- *Choosing the scheme modality.* Experience has shown that clear and simple design helps increase the take-up rate of firms. In particular, policy makers must decide whether to use expenditure-based versus non-expenditure–based incentives, and volume-based versus incremental-based schemes.
- *Deciding which R&D expenses are eligible.* Depending on the scope of tax incentive schemes, eligible expenses could include current expenditures, capital expenditures, or a combination of the two. Policy makers also may choose to provide incentives only for expenditures on basic research, or to include applied research as well.
- *Defining a Target Group.* Policy makers may decide to favor a particular group of firms, sector, or collaborative entities.

Evidence of Impact

A few systematic reviews and papers have reviewed the diverse experience of developed and developing nations and the potential for replicability in different settings. While studies of programs in OECD countries cover both input and output additionality, studies of developing countries focus only on input additionality (the additional R&D expenditure resulting from a scheme). Most studies have relied on econometric approaches.[13] Recent studies have more frequently employed experimental and

FIGURE 4.2 Main Issues to Consider When Designing R&D Tax Incentives



Source: Elaborations based on OECD 2015b, table 1, Main features of R&D tax incentives provisions in selected OECD and non-OECD countries, 2015.

Note: MNE = multinational enterprise; R&D = research and development.

quasi-experimental approaches comparing participants and nonparticipants. Studies of output additionality and productivity are limited.

This synthesis reviewed 20 case studies of tax incentives in Larédo, Köhler, and Rammer (2016), and the OECD synthesis (Appelt et al. 2016), all of which relate to OECD countries. These countries feature strong implementing agencies and relatively developed science, technology, and innovation systems. Evidence on the use of R&D tax incentives in developing countries is scarce, given that these programs are far less prevalent than in developed countries. This synthesis was able to review case studies for Argentina, Colombia, Malaysia, and Mexico. For example, Crespi and Maffioli (2014) conclude that the degree of adoption of R&D tax incentives in 2012 was far lower for Latin American countries (33 percent) than for OECD member countries (66 percent).

Recent studies (Fazio, Guzman, and Stern. 2019; Mitchell et al. 2019) have looked at the specific impact of R&D tax incentives schemes on outcomes among young and innovative firms. Unfortunately, the focus remains OECD-centric. Countries where these schemes are available and where evaluations exist include Belgium, France, Ireland, Italy, the Netherlands and the United Kingdom. One of the evaluations in this evidence also includes an econometrics study featuring results from China and India, as well as Canada; Japan; Korea; and Taiwan, China (Lee 2011).

Firms that have participated in R&D tax incentive programs tend to belong to more sophisticated sectors, such as electronics, communications, pharmaceuticals, and other manufacturing industries, that are believed to have strong absorptive capacity for R&D. Bigger firms have proved to be in a better position to participate in tax incentive schemes because of their capacity to sustain the required financing for these expenditures until claims materialize and their greater internal capabilities to manage R&D. For this reason, the vast majority of programs have included special provisions to support the participation of small and younger innovative firms.

Overall Impact

Most of the studies analyzed suggest that tax incentives generate roughly a dollar-for-dollar increase in reported R&D spending on the margin. Moreover, the evidence indicates that these effects are larger in the long term than in the short term. It is unclear whether the response to these schemes is proportionally greater for smaller or larger firms. Appelt et al. (2016) find that smaller firms are more responsive to R&D tax incentives than larger firms. However, participation by small firms tends to be limited, as shown for example in the studies of Colombia and Malaysia.

This reduced participation may relate to the inherent characteristics of SMEs. Small and medium enterprises tend to enjoy lower taxes in the first place because they often are subject to simplified tax treatments or to a reduced tax rate. In addition, while tax incentives seem to present stronger results among financially constrained firms, SMEs facing financial constraints are more likely to rely on direct support than to use

R&D tax credits (Busom, Corchuelo, and Martinez Ros 2013). SMEs may also be less informed, and unaware of the availability of the scheme.[14]

Emerging evidence suggests that generic R&D tax incentives have had similar or larger effects on young companies as on companies of average age, and when compared with grants and loans (Mitchell et al. 2019). Furthermore, Fazio, Guzman, and Stern. (2019) find evidence of positive impacts of state-level R&D tax credits on the quality-adjusted quantity of entrepreneurship in a region, but these effects take time to materialize and build over time. More specifically, their analysis finds a 2 percent per year increase in the rate of net new business formation, with a 20 percent increase over a 10-year period, as a result of the introduction of R&D tax credits. Their findings also imply that R&D tax incentives work best as part of a broader set of complementary interventions aimed at promoting the formation and scaling of growth-oriented firms. Impacts are larger for volume-based incentives because they tend to be more generous. However, Lokshin and Mohnen (2012) indicate that these additionality effects tend to disappear over time, particularly for large firms, as they crowd out private investments in R&D; the crowding-out problem does not apply to small firms. Thus, tax incentives for R&D under incremental schemes generate additional support per unit of government funds than do volume-based schemes.

Finally, Appelt et al. (2016) suggest that predictability of tax incentives matters. Their study, based on Kuusi et al. (2016), indicates that a temporary tax credit for Finnish firms led to tax deductions that were less than expected. The results support the premise that R&D investments imply significant initial costs, and that returns take time to mature.

Evidence on Processes and Performance

A few studies shed light on how design might affect effectiveness. In the context of China, Wang and Kesan (2018) find that value added tax (VAT) credits without any thresholds based on R&D expenditure is "overinclusive" (expenditures are too great) because SMEs can use software development to qualify for the subsidies, regardless of whether their software products are innovative or not. However, Wang and Kesan note that VAT credits can create a spillover effect on R&D by SMEs in other technology sectors that may choose to qualify for VAT credits by adopting new software. In the context of Spain, Álvarez-Ayuso, Kao, and Romero-Jordán (2018) conclude that tax credits, particularly incremental approaches, are suitable for boosting long-term R&D investment. Alstadsæter et al. (2018) find that patent boxes (where revenues from patents are taxed at a lower rate than other commercial revenues) are particularly effective in generating patents with high earnings potential.

Input Additionality

All the selected studies from OECD countries report a positive response of R&D investments to tax incentives, with the elasticity (the change in R&D investment with respect to tax savings by firms) ranging from 0.3 to 3.0. These results are consistent with other studies that suggest, on average, that R&D tax credits produce roughly a dollar-for-dollar increase in reported R&D spending on the margin. Nine out of the 19 studies that captured input additionality report elasticities for R&D above 1. Dechezleprêtre et al. (2016) find significant effects of tax credits in the United Kingdom on both R&D and patenting that persist up to seven years after the change; aggregate UK R&D would have been around 13 percent lower in the absence of the subsidy. Conversely, Chen and Li (2018) find that R&D expenditures in Taiwan, China fell significantly following a cut in tax incentives, and that subsequently innovation outputs from companies decreased (although not among biologics companies). In developing countries, however, the additionality generated appears to be much smaller, as suggested in table 4.13.

In terms of input additionality of R&D tax incentives for young innovative firms, results are context-specific and mixed, but positive effects among young firms have been identified (Mitchell et al. 2019). There is less evidence on the effect of R&D tax incentives on R&D intensity, and these effects seem to decrease when R&D incentives have been combined with other interventions. Mitchell et al. (2019) find larger effects on R&D investment for young companies, compared to companies of average age, increases in wages for R&D staff, and positive effects on employment additionality for start-ups.

Output Additionality

Four studies[15] of OECD countries find that tax incentives were associated with an increased probability of developing new product lines and new patent applications. Evidence on the impact of R&D tax credits on productivity is mixed: some studies find no statistically significant impact, while Caiumi (2011) finds that the Italian R&D tax incentive scheme induced productivity growth, with a higher impact on firms on less productive firms (those at the lower bound of the productivity distribution).

Available evidence suggests that effects on productivity, sales, and added value are positive for young firms, although the findings are restricted to a few OECD countries (Mitchell et al. 2019). Limited impact on innovation among young companies, but positive impact on turnover, turnover share of new products and services, and labor productivity has been found (Mitchell et al. 2019). However, the evidence remains thin, and findings need to be reproduced using more robust methods.

TABLE 4.13 Input Additionality of Tax Incentives: Findings for Four Developing Countries

Study	Country	Finding
Binelli and Maffioli (2007)	Argentina	An additional 1 percent in forgone tax revenue generated 13.2 percent in additional R&D investment.
Mercer-Blackman (2008)	Colombia	The scheme generated only 5 cents (in Colombian pesos) of additional private R&D for every peso of tax savings in the short term; in the long term, the impact increased to Col$2.96.
World Bank (2015)	Malaysia	At the margin, the use of all tax incentive instruments available induced a 20.4 percent increase in R&D spending.
Calderón-Madrid (2010)	Mexico	For every dollar of tax savings by firms, investment in R&D increased 48 cents in addition to the amount they would have spent anyway.

Main Requirements for Replicability

This subsection considers some of the conditions necessary to implement tax incentive schemes effectively in developing countries, beginning with the capabilities required by policy makers and implementing agencies, and then turning to capabilities required by participating firms.

Long-term political commitment. Predictability and long-term certainty have been critical for success. All of the case studies cited were based on programs implemented for periods longer than seven years. Other experiences from OECD countries suggest that a minimum commitment to tax incentives schemes of at least five years, but probably more, is necessary to enable firms the required planning time frame for R&D investments. Developing countries may face greater political challenges in justifying forgone tax revenue than developed countries do, due to greater pressure to address pressing needs, such as social programs to alleviate poverty. Moreover, developing countries where the budget is highly dependent on sales of commodities tend to experience high levels of revenue volatility, which can increase uncertainty on the ability of the government to sustain the scheme over time.

Required competencies from implementing agencies. Capability requirements for practitioners depend on the design of tax incentives. In general, however, R&D tax incentive schemes are complex and require the ability to evaluate the merits of R&D projects, manage queries from participating firms, and raise awareness of the availability and functioning of the scheme. The latter is particularly important when the scheme offers carryover provisions intending to benefit SMEs. Sophisticated designs, such as those that differentiate between spending categories and beneficiaries, increase the complexity of implementation and thus can pose challenges for practitioners.

Successful implementation often requires effective coordination between a line agency with R&D responsibilities and capabilities, and a tax authority that can process applications through the tax collection system.

Required competencies from beneficiaries. Participation in R&D tax incentive schemes usually imposes an administrative burden on applicants, especially for SMEs and young firms. Beneficiaries need to be able to file the required forms and applications, which often requires hiring tax experts and accountants and may require substantiating the level of novelty embedded in projects.

Enabling conditions. The reviewed studies indicate a few important factors that can contribute to the effectiveness of R&D tax schemes:

- *Existence of basic research activities.* Government investments in basic research have been highly complementary to private investment in R&D.
- *Access to local knowledge networks.* The availability of knowledge networks, such as local engineering universities, consultants, and firms, can facilitate increases in private investments in R&D.

- *Conducive intellectual property framework*. A strong intellectual property protection scheme can facilitate the transition from R&D investment to R&D commercialization, which in particular enhances the impact of output related tax incentives.
- *Availability of specialized human capital*. Firms' ability to benefit from tax incentives often depends on the availability of qualified professionals who can assist firms in capitalizing on R&D expenditures, and on the presence of science and technology infrastructure.

Proposal evaluation, monitoring, and verification capacity. The studies indicate a need to simplify evaluation, monitoring, and verification of tax incentive applications. Policy makers face difficult challenges in limiting abuse of the tax incentives while minimizing the compliance burden on SMEs. A successful approach to simplification, particularly for small firms, has been the switch from a project-based to an entitlement-based system, in which the eligibility of the firm's R&D activities is presumed ex ante, applicants self-report that they are eligible, and the implementing agency conducts ex post audits to verify eligibility.

In addition, policy makers should explore enabling voluntary compliance to simplify the processes of application and verification. Complex restrictions and rules have increased uncertainty that activities firms propose as R&D-eligible expenditures may be disallowed by the tax authority, which tends to reduce participation. In many cases, such as in Croatia and Denmark, the issue has been addressed by introducing a voluntary compliance verification process. This procedure can lower the cost for firms and reduce uncertainty by enabling them to preapprove expenditure activities, increasing the rate of compliance.

Dos and Don'ts of Tax Incentives

Do	Don't
■ Carefully consider whether the tax system and its administration are sufficiently robust to operate a tax incentive. ■ Minimize the bureaucratic burden for applicants by simplifying the procedures and shortening the time needed for approval of eligible expenses. ■ Consider offering a carryover facility that can be applied when firms reach profitability. ■ If capability allows, tailor the scheme to favor R&D activities with high potential for knowledge spillovers, such as wage bills for researchers, given their labor mobility.	■ Don't change scheme features (such as eligible expenditures and exemption characteristics) frequently because R&D investment decisions need predictability over time; at least five years' commitment is desirable. ■ Don't create compliance uncertainty for prospective participants. Running a voluntary compliance verification process can enable firms to preapprove expenditure categorization to reduce uncertainty. ■ Don't rely solely on tax incentives to support innovation, given that such instruments tend to provide little support for new areas, long-term R&D, or sectors that are not R&D intensive.

Dos and Don'ts of Tax Incentives

Do	Don't
▪ If capacity allows, provide optional, immediate refunds for small companies to encourage a higher participation rate. ▪ Invest in compliance and audit, given that maintaining integrity and inhibiting abuse is vital.	▪ Don't place caps on the amount of revenue forgone, which results in overly complex designs that increase client uncertainty and diminish any additionality because only early applicants will benefit.

Checklist for Design and Implementation of Tax Incentives

- What is the market failure associated with the underinvestment in R&D? Are medium and larger firms currently underinvesting in R&D activities?
- How acceptable is the program politically, and can the government make a long-term commitment of resources (forgone tax revenue) to sustain a scheme for R&D tax incentives for innovation?
- Does the implementing agency have enough capacity to work with the tax revenue agency and implement the tax incentive scheme successfully?
- Will the target beneficiaries have the capacity to sustain R&D investments?
- Under what circumstances should the tax incentive scheme be based on credits or deductions?
- How can the tax incentive scheme include startups and what modifications would the scheme need?
- What activities should be eligible for R&D tax incentives?
- What is the scale and scope of the targeted R&D activities?
- What should the right sequencing be for the different features of the scheme? Is it advisable to start with the simplest scheme?

References

Alstadsæter, A., S. Barrios, G. Nicodeme, A. M. Skonieczna, and A. Vezzani. 2018. "Patent Boxes Design, Patents Location, and Local R&D." *Economic Policy* 33 (93): 131–77.

Álvarez-Ayuso, I. C., C. Kao, and D. Romero-Jordán. 2018. "Long-run Effect of Public Grants and Tax Credits on R&D Investment: A Non-Stationary Panel Data Approach." *Economic Modelling* 75 (November): 93–104.

Appelt, S., M. Bajgar, C. Criscuolo, and F. Galindo-Rueda. 2016. "R&D Tax Incentives: Evidence on Design, Incidence and Impacts." OECD Science, Technology and Industry Policy Paper 32, OECD Publishing, Paris.

Binelli, C., and A. Maffioli. 2007. "A Micro-Econometric Analysis of Public Support to Private R&D in Argentina." *International Review of Applied Economics* 21 (3): 339–59.

Busom, I., B. Corchuelo, and E. Martínez Ros. 2013. "Tax Incentives and Direct Support for R&D: What Do Firms Use and Why?" Working Paper 11–03, Business Economics Series, Universidad Carlos III de Madrid.

Caiumi, A. 2011. “The Evaluation of the Effectiveness of Tax Expenditures—A Novel Approach: An Application to the Regional Tax Incentives for Business Investments in Italy.” OECD Taxation Working Paper 5, OECD, Paris.

Calderón-Madrid, A. 2010. “A Micro-econometric Analysis of the Impact of Mexico´s R&D Tax Credit Program on Private R&D Expenditure.” Colegio de México. Unpublished.

Cappelen, Å., E. Fjaerli, F. Foyn, T. Hægeland, J. Møen, A. Raknerud, and M. Rybalka. 2017. “SkatteFUNN-evalueringen–Årsrapport 2006.” Rapporter 2007/17. Statistisk sentralbyrå, Oslo.

Chen, M. C., and H. Y. Li. 2018. “The Effects and Economic Consequences of Cutting R&D Tax Incentives.” *China Journal of Accounting Research* 11 (4): 367–84.

Crespi, G. A., and A. Maffioli. 2014. “Design and Evaluation of Tax Incentives for Business Innovation in Latin America, Lessons Learned after 20 Years of Experimentation.” In *Science, Technology and Innovation Policies for Development*, edited by G. A. Crespi and G. Dutrénit. Springer.

Czarnitzki, D., P. Hanel and J. M. Rosa. 2011. “Evaluating the Impact of R&D Tax Credits on Innovation: A Microeconometric Study on Canadian Firms.” *Research Policy* 40 (2): 217–29.

Dechezleprêtre, A., E. Einiö, R. Martin, K-T Nguyen, and J. Van Reenen. 2016. “Do Tax Incentives for Research Increase Firm Innovation? An RD Design for R&D.” NBER Working Paper 22405, National Bureau of Economic Research, Cambridge, MA.

Fazio, C., J. Guzman, and S. Stern. 2019. ‘The Impact of State-Level R&D Tax Credits on the Quantity and Quality of Entrepreneurship.” NBER Working Paper 26099, National Bureau for Economic Research, Cambridge, MA.

Goolsbee, A. 1998. “Does Government R&D Policy Mainly Benefit Scientists and Engineers?” *American Economic Review* 88 (2): 298–302.

Kuusi, T., M. Pajarinen, P. Rouvinen, and T. Valkonen. 2016. “A Study on the Finnish R&D Tax Credit of the Years 2013–2014.” ETLA Reports, No. 51, The *Research* Institute of the *Finnish* Economy, March.

Larédo, P., C. Köhler, and C. Rammer. 2016. “The Impact of Tax Incentives for R&D.” In *Handbook of Innovation Policy Impact,* edited by J. Edler, P. Cunningham, A. Gök, and P. Shapira. Edward Elgar Publishing.

Lee, C.Y. 2011. “The Differential Effects of Public R&D Support on Firm R&D: Theory and Evidence from Multi-Country Data”, *Technovation*, 31:256–69.

Lokshin, B., and P. Mohnen. 2012. “How Effective Are Level-based R&D Tax Credits? Evidence from the Netherlands.” *Applied Economics* 44 (12): 1527–38.

—————-. 2013. “Do R&D Tax Incentives Lead to Higher Wages for R&D Workers? Evidence from the Netherlands.” *Research Policy* 42 (3): 823–30.

Mercer-Blackman, V. 2008. “The Impact of Research and Development Tax Incentives on Colombia’s Manufacturing Sector: What Difference Do They Make?” IMF Working Paper WP/08/178, International Monetary Fund, Washington, DC.

Mitchell, J., G. Testa, M. Sanchez-Martinez, P. Cunningham, and K. Szkuta. 2019. “Tax Incentives for R&D: Supporting Innovative Scale-ups?” *Research Evaluation*, rvz026, November 23. https://doi.org/10.1093/reseval/rvz026.

OECD (Organisation for Economic Co-operation and Development). 2015a. *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development.* The Measurement of Scientific, Technological and Innovation Activities Series. Paris: OECD Publishing.

—————-. 2015b. “Data and Statistics on R&D Tax Incentives.” OECD Science, Technology and Industry Scoreboard 2015, OECD, Paris.

Wang, R., and J. P. Kesan. 2017. “Do Tax Policies Drive Innovation by SMEs in China?” Legal Studies Research Paper No. 18-3, University of Illinois College of Law.

World Bank. 2015. *Malaysia: Impact of Tax Incentives*. Washington, DC: World Bank.

4.2.5 Profile 5. Demand-Pull Instruments

As discussed in chapter 3, instruments that guarantee or support access to market segments demanding products or services can have a significant impact on firms, "pulling" them to innovate. This contrasts with most R&D and innovation support, which provides a "push" force for firms to innovate. Firms are more likely to be able to engage in innovation if it generates short-term returns in terms of new demand.

This profile discusses four instruments that are based on using demand as a pull factor for innovation investments. *Pre-commercial procurement* and *commercial government procurement* target the development of specific innovation and R&D projects at different levels of commercialization. *Supplier development programs* support firms in upgrading product quality and processes with the objective of linking them with large buyers, often multinational enterprises. *Corporate open innovation instruments* are a variation of supplier development programs to identify new supply chain opportunities for large companies—including government institutions—and link them to potential suppliers.

All four instruments have in common the use of demand to entice investments in innovation. They often entail a transfer of information and know-how from buyers to suppliers, and vice versa. Suppliers dictate product standards and requirements, and often develop new and innovative solutions for buyers.

Procurement Instruments

The use of public procurement as an instrument to encourage innovation has been around for some time, especially in sectors such as defense, aerospace, and energy. However, since the early 2000s, there has been a strong interest, primarily in the European Union, in using public procurement to drive innovation in other sectors. Several developed countries, as well as large developing countries such as Brazil, China, and Turkey, have also introduced policy initiatives linked to this demand-side instrument. Public procurement activities can support innovation through two main modalities:

1. *Procurement during pre-commercial stages*, which is typically called pre-commercial procurement (PCP) or procurement of R&D.
2. *Procurement during commercial stages*, which is typically called public procurement of innovation (PPI).

Public procurement refers to the process whereby public bodies (including government agencies at national and subnational levels, as well as state-owned enterprises) acquire various goods and services from third parties. Spending on public procurement is estimated to account for 16 percent of GDP in OECD countries. For some large developing countries, the percentage could be even higher. Public procurement has been used widely to support various policy objectives, such as seeking to ensure a certain percentage of procurement occurs from SMEs.

The discussion that follows focuses on the procurement of innovative goods and services. The main distinction between PCP and PPI lies in different commercialization stages. PCP refers to the purchase by public contractors of R&D services to satisfy their own missions and beyond the objectives of the original procurers. The deliverables of purchased R&D services can be some distance from reaching the market (such as product designs or prototypes). In contrast, PPI adopts commercial procedures to purchase innovative solutions that are already commercialized but not yet available on a large-scale basis. The core idea of PPI is that by acting as a lead user of innovative solutions, the public sector can increase innovation in firms, as well as provide better public services. This emphasis on using "demand pull" to support innovation complements the more traditional emphasis on "supply push" (such as direct R&D support), paralleling a rise of systemic thinking embedded in the design of innovation policies nowadays (Edler and Georghiou 2007).

References

Edler, J., and L. Georghiou. 2007. "Public Procurement and Innovation—Resurrecting the Demand Side." *Research Policy* 36 (7): 949–63.

4.2.5.1 Public Procurement of R&D (Pre-Commercial Procurement)

Definition

Pre-commercial procurement (PCP) aims to support the development of innovative solutions and innovative projects from the ideas stage to prototype or field-testing stages.[16] Historically, successful innovations that emerged from PCP include the Global Positioning System (GPS) and the Internet Protocol (IP). In this sense pre-commercial procurement, despite being called "procurement"—which implies a demand-side instrument—is in fact R&D funding geared toward very specific goals, defined by public needs.[17] Pre-commercial procurement can be considered a form of a scheme to share risks and benefits between public agencies and private suppliers—often SMEs, and sometimes third parties such as universities—to promote an innovation to respond to a public need. Pre-commercial procurement can facilitate the establishment of public-private partnerships, which are increasingly important in stimulating collaborative innovation.

Market and System Failures Addressed

- *Information asymmetry.* Information asymmetry in this case relates to the immaturity of the potential market and lack of clearly articulated demand, which inhibits firms from developing business cases that warrant the expenditure either of their own money or external money. Pre-commercial procurement can address this information asymmetry and perform an "accreditation function" for radically new technologies that might further attract private financing.

Target Group

Main Target Groups of pre-commercial procurement and supporting policies are prospective innovative suppliers, on the one hand, and contracting authorities (and the public they ultimately serve), on the other. On the supply side, pre-commercial procurement initiatives, especially programs along the lines of SBIR (the long-running US Small Business Innovation Research program) , often exclusively target innovative SMEs, which experience more severe financing barriers than bigger enterprises. On the demand side, pre-commercial procurement is particularly relevant for agencies with large research funding and the need for leading-edge technologies. Besides the key Target Groups, potential beneficiaries of pre-commercial procurement also include private investors and wider communities of knowledge/technology producers and users such as universities and enterprises that are not engaged in pre-commercial procurement.

Strengths

Strengths of pre-commercial procurement include the following:

- *Encouraging novel research and risk taking.* In regular procurement, public contractors define their needs in prescriptive, technical terms. This practice reduces uncertainties but limits the potential to develop technological alternatives. Through pre-commercial procurement, public agencies articulate their needs in functional rather than technical terms, giving space for suppliers to propose highly innovative alternatives.
- *Supporting disadvantaged groups.* PCP schemes, in some cases, can favor small firms and other disadvantaged groups such as businesses run by women or members of minority groups, to offer them greater market access.
- *Generating positive externalities and guiding strategic investments.* Compared with direct R&D subsidies, pre-commercial procurement is more explicitly oriented toward addressing societal challenges and government services, especially challenges related to sectors such as health care, the environment, energy, and security/defense.
- *Granting flexibility to suit different government needs.* Through pre-commercial procurement, innovation development can occur beyond the regular innovation support agency because each government agency with needs can run a PCP scheme.[18] No interdepartmental coordination mechanism is required, and agencies can design PCP flexibly to suit their circumstances.

Potential Drawbacks and Risks

- *Complexity of implementation.* Pre-commercial procurement is a complex and risky process in technological, organizational, and managerial terms. It often requires a high level of capacity in public agencies to address issues such as needs specification, market intelligence, proposal evaluation, contracting, and risk management.

- *Risk of no commercialization.* There is a gap between pre-commercial procurement and the actual commercialization of the developed technology. SBIR-type programs tend to develop technologies only to certain levels of readiness. Suppliers face the risk of spending time and effort on concept development that leads to little return. This risk can be addressed via a staged approach (see box 4.6).

Elements for Good Policy Design

Several elements are importance to consider when designing PCP policies:

- *Implementing appropriate governance arrangements to legitimize pre-commercial procurement, provide predictability for entrepreneurial investments, and reduce institutional barri*ers. For example, pre-commercial procurement in the European Union is governed by the Commission's 2007 Communication on pre-commercial procurement and specific articles in EU public procurement directives, which reduce institutional barriers hindering PCP activities.
- *Setting specific spending targets for public agencies active in R&D*. Spending targets provide transparency to prospective participants. For example, the US SBIR program sets mandatory spending targets for the main federal R&D contractors.
- *Providing direct financial support, in some cases,* to encourage public bodies to use the instrument. For example, the EU Horizon 2020 program provides financial support for networking to enable consortiums of public procurers to work together on joint PCP initiatives within the domain of research and innovation.

BOX 4.6

Typical Stages in a PCP Process

In practice, pre-commercial procurement takes the form of multiphase competitions, whereby suppliers submit their technological proposals and contracting authorities evaluate and select the most suitable options. Often more than one supplier is selected, and more than one contract is awarded, to allow exploration of alternative approaches.

The European Commission has outlined the following phases associated with pre-commercial procurement. PCP might involve part or all of Phases 0–3 and might or might not be followed by a Phase 4, the commercial procurement stage.

Phase 0. Curiosity-driven research
Phase 1. Solution exploration/design
Phase 2. Prototype development
Phase 3. Testing of initial solutions
Phase 4. Commercialization and further diffusion.

Source: European Commission.

- *Providing training and guidance for procurement practitioners and potential contractors* to ensure effective implementation. This should be accompanied with appropriate information and communication technology (ICT) infrastructure to enable peer support and learning, and to enable efficient PCP processes, such as one-stop online platforms whereby procurers, suppliers, and other stakeholders can interact with one another regarding general issues, as well as specific calls for pre-commercial procurement.[19]

Evidence of Impact

The use of pre-commercial procurement as a large-scale innovation mechanism primarily originated in the United States, with subsequent strong interest from European policy makers. Evidence on the use and effectiveness of pre-commercial procurement from the rest of the world is scarce. The programs reviewed here include the US Small Business Innovation Research (SBIR) program; the UK Small Business Research Initiative (SBRI); the Dutch Small Business Innovation Research (SBIR) Programme; Pesquisa Inovativa em Pequenas Empresas (PIPE) of the state of São Paulo, Brazil; and a variety of EU initiatives. The selected studies include academic publications, government reports, and independent reviews.[20] The US SBIR has been evaluated in an overall way, but on the basis of individual US departments rather than through a "whole scheme" assessment.

This synthesis has a strong bias toward the US SBIR experience, which is less relevant for countries at lower levels of institutional development and where SMEs possess low R&D capabilities. Assessments of the US SBIR mainly use statistical data from agencies, surveys of awardees, and interviews. Surveys are self-reporting and biased toward successful candidates. Another limitation is that there are no comparisons between the effectiveness of pre-commercial procurement and other innovation policy instruments.

Objectives, Targets, and Predictability

Table 4.14 summarizes main findings from the studies regarding the design and implementation elements of PCP programs. The evidence suggests that expectations of program results were simplistic and unrealistic, given the limited resources allocated to these programs. In addition, the narrow scope of programs did not support radical innovation by firms. The evidence also suggests that economic cycles have affected the availability of funding, adding a layer of unpredictability for stakeholders participating in the scheme.

Input Additionality

Findings about input additionality are available only for the US SBIR. US NRC (2008) reports that 51.6 percent of the surveyed awardees gained non-SBIR funding for the SBIR projects they worked on and more than 30 percent of Department of Defense

TABLE 4.14 Evidence on Input Additionality (Objectives, Targets, and Predictability) of Pre-Commercial Procurement Programs: Key Findings

Study	Context	Finding
US NRC (2008)	United States, SBIR	The program is "sound in concept and effective in practice" (page 3). During 1997–2004, SBIR supported 40,710 projects (70 percent Phase I and 30 percent Phase II),[a] with a total value of around $10 billion. There was a tendency to define topics in narrow, technical terms to keep the projects manageable. The NRC warned that this is not justified given the original objectives of SBIR to stimulate radically novel research.
MIOIR, ERC, and OMB (2015)	United Kingdom, SBRI	In 2013, the government aimed to increase the value of contracts awarded through SBRI from £40 million in 2012 to £200 million by 2015. While user departments acknowledged the potential of SBRI to contribute to their productivity and the broader economy, they found the imposed targets simplistic and inflexible, and not realistic given their limited budget.
Boekholt (2015)	Netherlands, SBIR	The use of the Dutch SBIR peaked in 2011 when the scheme fit well with the political priorities and economic circumstances that allowed generous procurement budgets. However, austerity measures from 2011 onward reduced commitment to innovation policies and the significant cut in procurement budgets made SBIR's prospects unclear.

Note: NRC = US National Research Council; SBIR (Dutch) = Small Business Innovation Research Programme; SBIR (US) = Small Business Innovation Research program; SBRI = Small Business Research Initiative.

a. As defined by the official SBIR website, the SBIR program is structured in three phases: Phase I to establish the technical merit, feasibility, and commercial potential of the proposed project; Phase II to continue the efforts initiated in Phase I; and Phase III (if applicable) to commercialize outputs from Phase I/II activities. For details, see https://www.sbir.gov/about/about-sbir.

(DoD) awardees of SBIR funding reported additional federal funding from non-SBIR schemes. Private venture capital tends to concentrate on only a few, most promising projects. The series of assessments reports by the US National Research Council (NRC) finds that awardees overwhelmingly believed it unlikely that funding alternatives to SBIR could be found, so that SBIR resources did not crowd out private funds. Around 50 percent of respondents reported additional investment in R&D internally.

Output Additionality

There is more evidence on the effectiveness of PCP programs in generating output additionality, as summarized in table 4.15. Most of the reviewed studies confirmed the impacts of PCP programs in generating intellectual property (2 programs reported that more than 50 percent of participants registered at least one patent) and start-ups (the reported additionality for registration and survival of firms ranged between 20 percent and 40 percent, which is considerable), in addition to generating reputational benefits for awardees. By contrast, the impacts of pre-commercial procurement on employment creation were mixed, with some programs reporting modest results and one reporting an increase of 29 percent in direct employment. Results on the role of pre-commercial procurement in improving the productivity of the public sector seem to be inconclusive. Although program owners favor showcasing PCP success stories on their official websites, the US National Research Council (2008) points out that the quality of those success

TABLE 4.15 Evidence on Output Additionality of Pre-Commercial Procurement Programs: Key Findings

Study	Context	Issue	Finding
US NRC (2014)	United States, US SBIR	Intellectual property and patents	In 2011 about 60 percent of awardees claimed to have obtained at least 1 patent related to SBIR-funded technologies, and 10 percent reported at least 10.
Salles-Filho et al. (2011)	São Paulo state, Brazil, PIPE		A self-reporting survey in 2006 suggests that more than 60 percent out of a sample of 106 projects reported 111 intellectual property rights (IPRs) (mainly patents) created with PIPE support. Only 20 percent of the IPRs obtained were later commercialized.
Audretsch, Weigand, and Weigand (2002)	United States, US SBIR	Start-ups	SBIR has stimulated scientists and engineers to embark on entrepreneurship; 20 percent of respondents claimed that they would not have started the firm without SBIR, and another 40 percent would not have continued the firm.
Link and Scott (2012)	United States, US SBIR	Employment creation	Projects with tangible outputs such as patents and publications retained more employees than others after completion. On average, more than 40 percent of all SBIR projects retained 0 employees after completion; thus, the direct impact of SBIR funded projects on employment is small.
US NRC (2014)	United States, US SBIR		The median size for Phase II companies grew from 17 employees at the time of award to 24 employees at the time of survey, indicating a modest job growth effect of SBIR.
Salles-Filho et al. (2011)	São Paulo state, Brazil, PIPE		Direct employees of awardees increased by 29 percent, and employment at direct employees and contractors increased by 41 percent.
US NRC (2008)	United States, US SBIR	Sales	47 percent of the surveyed Phase II awardees of the US SBIR program had generated some sales, with a further 18 percent still expecting sales at the time of assessment. Revenues generated through licensing were limited: just over 5 percent respondents reported licensee sales greater than $0.
MIOIR, ERC, and OMB (2015)	United Kingdom, SBRI		Two years after the award of the SBRI contract, sales were higher on average by £32,300 for Phase 1 winners and £224,300 for Phase 2 winners, winners estimate. Econometric analysis with control group suggests a turnover increase of around 12.7 percent on average across the contract winners.
Bound and Puttick (2010); Salles-Filho et al. (2011)	United States, US SBIR-related studies	Certification effect	The reviewed programs signaled the potential of small businesses and credibility of technologies to prospective investors. The support through pre-commercial procurement offers not only funding but also reputational benefits for awardees.

stories varies significantly, with some agencies using manuscripts written by awardees without validation.

Main Requirements for Replicability

The international experience of employing pre-commercial procurement has involved active policy transfers, notably from the United States to other developed countries as well as to leading developing countries. The absence of solid evidence on the effectiveness of pre-commercial procurement, especially with respect to its effectiveness compared with other instruments, implies that policy makers should be cautious when justifying the use of pre-commercial procurement over its alternatives. Moreover, most of the effectiveness assessments have focused on increases in inputs rather than on the impact on the public service or the public more generally, and this should be factored into decision making. When pre-commercial procurement proves to be a legitimate policy option, *a long-term political commitment* such as that of the US SBIR is necessary to keep PCP programs going.

- *Capability needs to design and implement policy instruments.* The use of pre-commercial procurement requires a high level of capacity in policy makers and implementing agencies. The flexibility required throughout implementation can be particularly challenging, which can make agencies uncertain whether pre-commercial procurement is a legitimate option and which PCP models to employ. In addition, policy design and implementation require substantial market and technological expertise to design product specifications and articulate the technological and performance requirements. The preparation involved in the initial stage (Phase 0) and the constant efforts needed to run later phases require significant managerial and technical capacity. In countries with major state-owned enterprises (SOEs), these can be the vehicle in implementing pre-commercial procurement because they may have the technological and industry capacities that ministries or departments often lack.
- *Required competencies from beneficiaries.* The complexity of PCP programs, such as the multiphase competition process, requires that beneficiary firms can develop strong applications fulfilling the performance and technological criteria specified in PCP schemes. Firms should also understand the landscape and be able to find partners with complementary competencies to form teams capable of delivering the specified products and solutions. PCP programs should be accompanied with advisory services to support firms in navigating through the application process and identify potential gaps that can be filled through partnerships and alliances with other vendors.
- *Creating a fair competition environment.* PCP schemes require a transparent and equal competition environment. Policy makers in developing countries will need to critically assess their institutional settings to minimize the likelihood of corruption or uncompetitive bidding.
- *Experimenting with pre-commercial procurement in contexts with appropriate settings*. The evidence suggests that policy makers should experiment with pre-commercial procurement only in the most suitable contexts first, such as in organizations with research and technology needs and relatively high capabilities, or in advanced regions where firms and institutions have high innovation capacity.
- *Continuing assessments and revision during implementation*. Most of the reviewed studies point to the necessity of constant monitoring and assessment for policy learning purposes. The implementation and revision of the US SBIR program

provided for the generation of data through increasingly more systemic monitoring. Reflections on early implementation enabled the improvement of the program, leading to higher efficiency.

Dos and Don'ts of Pre-Commercial Procurement Programs

Do	Don't
▪ Ensure the existence of a functioning and transparent public procurement law and of supporting institutions that could help public agencies implement these complex schemes. ▪ Before fully rolling out PCP programs, try experimenting with pilot schemes in environments with the most appropriate conditions, such as research-intensive regions or state-owned enterprises. ▪ Ensure political commitment to allow time for the impacts of PCP to manifest. PCP can be particularly vulnerable to changing macroeconomic conditions because it often implies commitments of different agencies beyond the innovation domain. ▪ Define the requirements in an open way, using criteria described in performance/outcome terms to allow suppliers to explore and thus stimulate radical innovation.	▪ Don't implement PCP programs if procurement payments will be delayed; you could bankrupt innovative firms. ▪ Don't assume PCP is the right instrument to launch without conducting a thorough feasibility analysis. Ensure the presence of supply, demand, and framework conditions before initiating such programs. ▪ Don't simply impose the task of PCP onto public agencies that already face many other policy demands. Carefully assessing how to balance the different policy objectives and existing commitments is a precondition to design feasible PCP approaches.

Checklist for Design and Implementation of Pre-Commercial Procurement Programs

- Do you have enough R&D and innovation capacity in firms to develop new technologies?
- Are there public agencies in your country that have unmet needs for R&D services that also could satisfy wider public interests?
- Do you need to build new funding channels for pre-commercial procurement, or can you use the existing R&D and/or procurement budgets?
- Do you have the political commitment to undertake pre-commercial procurement, such as sufficient funding for PCP for a considerable period of time to allow impacts to manifest?
- Do you have a good competition environment in your public R&D funding system to ensure the fairness required by pre-commercial procurement?

- What are the local circumstances of private capital? How likely is it that pre-commercial procurement would crowd out private investment?
- Are there any suitable testing grounds to experiment with pre-commercial procurement, such as capable organizations or regions with high demand for R&D services?
- Are you allowed to favor particular Target Groups (such as SMEs) in your legislation? How will you prevent supporting unintended Target Groups?
- Do you have a strategy to monitor the use of pre-commercial procurement to understand its appropriateness and effectiveness?

References

Audretsch, D. B., J. Weigand, and C. Weigand. 2002. "The Impact of the SBIR on Creating Entrepreneurial Behavior." *Economic Development Quarterly* 16 (1): 32–38.

Boekholt, P. 2015. "SBIR in the Netherlands." Presentation for The Innovation Policy Forum, The National Academies, Washington, DC, March 19. http://www.technopolis-group.com/nl/search-reports/#!/keyword_report=SBIR.

Bound, K., and R. Puttick. 2010. "Buying Power? Is the Small Business Research Initiative for Procuring R&D Driving Innovation in the UK?" Nesta Research Report (June).

Link, A. N., and J. T. Scott. 2012. "Employment Growth from the Small Business Innovation Research Program." *Small Business Economics* 39 (2): 265–87.

MIOIR, ERC, and OMB (Manchester Institute of Innovation Research, the Enterprise Research Centre, and OMB Research Ltd.). 2015. *A Review of the Small Business Research Initiative–Final Report.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/662657/A_Review_of_the_Small_Business_Research_Initiative_.pdf.

Salles-Filho, S., M. B. Bonacelli, A. M. Carneiro, P. F. D. De Castro, and F. O. Santos. 2011. "Evaluation of ST&I Programs: A Methodological Approach to the Brazilian Small Business Program and Some Comparisons with the SBIR Program." *Research Evaluation* 20 (June): 157–69.

United States, NRC (National Research Council). 2008. *An Assessment of the SBIR Program*, Vol. 1. Washington, DC: The National Academies Press. doi:10.1017/CBO9781107415324.004.

———-. 2014. *SBIR at the Department of Defense*. Washington, DC: The National Academies Press.

4.2.5.2 Public Procurement of Innovation During the Commercial Stage

Definition

In contrast to pre-commercial procurement, the procured solutions and products of *public procurement of innovation (PPI)* need to be commercially viable and functionally usable for the end users, regardless of the earlier-stage efforts required from the suppliers. Public procurement of innovation can play two roles to support innovation: (1) a "triggering role," whereby public buyers use PPI to express their needs and trigger the development of solutions that do not yet exist; and (2) a "responsive" role, whereby public buyers use PPI to absorb innovative solutions that are already commercialized but not adopted on a large-scale basis (Edler and Yeow 2016). Through both roles, public procurement of innovation can contribute to both the creation and the diffusion of innovation. While the well-known PPI examples mostly concern the creation of solutions that do not yet exist,[21] for developing countries—where innovations are typically new to the country rather than new to the world—public procurement of innovation could be better placed as an instrument to support the diffusion of existing innovations that had already been adopted by developed countries.

Market and System Failures Addressed

Market and system failures that public procurement of innovation and related policies seek to address include:

- *Information asymmetry.* Demand of the market, be it public or private, is often fragmented and not effectively articulated. This is especially the case for solutions that do not yet exist that might in fact have promising market potential. PPI can contribute by better articulating specifications and interacting with potential suppliers for innovative solutions.
- *Coordination failures.* Stakeholders directly involved in PPI processes, including suppliers, procurers, and end-users, could be highly risk averse. Interventions could provide incentives to those stakeholders through accreditation, insurance, and subsidies.
- *Institutional failures.* Innovative suppliers face barriers in accessing public markets, which often feature overly prescriptive specifications and inflexible procedures. Interventions could make access to the public market easier by providing technical assistance and remedying institutional barriers.

Target Group

PPI and related policies target three primary groups: suppliers, public procurers, and end-users (if different from procurers). For suppliers, public procurement of innovation often does not target clearly defined types of firms; rather, it is technology/solution-oriented, regardless of the characteristics of potential suppliers. Some PPI policies target SMEs. Introducing SMEs to bid in public procurement of innovation can enhance the level of competition and the chance of developing alternative solutions. Public procurers are the core Target Group that policy interventions directly influence. This group could be diverse in terms of levels of governance (such as central, regional, or local agencies); organizational characteristics (such as state-owned enterprises or government authorities); and technical expertise (such as overall or sector-specific agencies). In cases of procurers not being the actual users of innovative solutions, the end-users also need to be mobilized to support the development and uptake of innovations.

Strengths

Strengths of public procurement of innovation include the following:

- *Immediate returns for suppliers.* Compared with supply-side measures supporting R&D, PPI can identify an immediate market and generate turnover for beneficiaries, which serves as a significant incentive to suppliers and reduces the uncertainty of innovation.

- *Potential to complement the policy mix.* Procurement can complement other instruments, such as support for private demand (including product labelling and awareness-raising). One early example in this regard is the EU Lead Market Initiative (LMI), which is essentially a mix of PPI policies, standardization, and user subsidies. Moreover, PPI policies can support strategic goals of socioeconomic development: for example, the development of priority sectors such as defense, health care, energy, and education.
- *Growing public demand in developing countries.* The potential for public procurement of innovation in developing countries could be large because public demand for infrastructure and services is growing with rapid urbanization. In addition, exemptions to the commitments for lower-income countries under the World Trade Organization Agreement on Government Procurement means that in principle there is more flexibility in these countries to utilize PPI.

Potential Drawbacks and Risks

- *The need to balance different objectives.* Public procurement has both the primary function of purchasing goods and services in a transparent and accountable way, and secondary functions of promoting agendas such as innovation. Balancing an efficient use of the budget with direct support to companies that may be undertaking risky projects is challenging for practitioners.
- *Risk of fraud and corruption.* Developing countries typically lack public procurement systems that ensure transparency, quality, efficiency, and an environment for competition. The risk of corruption and clientelism during procurement processes remains a critical issue for developing countries to tackle.
- *Risk of distorting domestic markets.* The possibility of procurement practices that discriminate against foreign suppliers in supporting domestic innovation needs to be carefully considered, particularly concerning the chances of success within the targeted sectors, the technology life cycle, and more importantly, the impact on domestic markets and consumer welfare. This can result in tensions between domestic policy agendas, competition and innovation, and international trade relationships.
- *Technological and organizational risks.* Public procurement of innovation is subject to high technological risks (such as how to evaluate the innovativeness and achievability of solutions and how to deal with intellectual property issues), as well as high organizational risks (such as the extent to which PPI can ensure the effective adoption of innovative solutions by users).

Elements for Good Policy Design

Georghiou et al. (2014) suggest the following elements to ensure effectiveness of PPI instruments:

- *Setting up friendly framework conditions.* Procurement regulations should be adjusted to promote innovation. Procurement infrastructures should be digitalized to enhance transparency and efficiency.

- *Improving institutional capabilities.* Training and networking mechanisms for procurement practitioners are critical for effectiveness, such as the Dutch PIANOo initiative (Professional and Innovative Tendering, Network for Government Contracting Authorities).
- *Identifying, specifying, and signaling demand.* PPI should also include the employment of special procedures to facilitate the processes of articulating demand and interactive learning between suppliers and users, such as the use of competitive dialogues[22] in the EU.
- *Providing incentives for innovative solutions.* Policies of this type should consider including accreditation of new products and insurance for public users to compensate potential losses, such as the Forward Commitment Procurement (FCP) model in the United Kingdom, technology product certification in Korea, and catalogues of innovative products in China (for details, see Meerveld, Nauta, and Whyles 2015 and Li and Georghiou 2016). These policies are often applied together with other instruments (development and application of standards, regulations, and subsidies) to develop selected sectors, thus integrating supply-side and demand-side measures.

Evidence of Impact

In general, there is little evidence on the effectiveness of public procurement of innovation, and more evidence on policy design and implementation. The impacts of PPI can be complex and hard to capture using any existing metrics. A few notable PPI initiatives with relatively well-documented evidence have been selected to illustrate practices in design and implementation.

The reviewed studies are mostly in-depth, qualitative cases. This methodological bias is primarily because PPI policies have only recently been adopted or resurrected in those countries and large-scale empirical data are still lacking. While the qualitative studies offer very detailed descriptions of policy implementation and procurement processes, they fall short on providing solid evidence to support their claims for "soft" impacts such as behavioral additionality.

The selected studies review different types of policies that support public procurement of innovation, including: training and networking mechanisms for procurement practitioners (such as the Dutch PIANOo network); incentives mechanisms to motivate practitioners (such as the Korean New Technology Purchasing Assurance Program and China's signaling and accreditation catalogues approach); procurement for state-owned enterprises (such as Petrobras in Brazil); local government practices (such as those of the Nordic-Baltic cities); and procurement activities not particularly driven by policies. The studies outline a mixed picture in terms of policy implementation. While short-term impacts such as sales generation have been captured to an extent, longer-term impacts have not been understood thus far.

Evidence on Implementation of PPI Policies

A few studies consider the implementation process of PPI policies. Table 4.16 summarizes main findings, which indicate that the design of PPI policies can benefit from a review of the problems featured in earlier designs, and that even a well-designed PPI program can falter due to political change and institutional settings.

Input Additionality

Using data collected from 5,238 European firms by the Innobarometer, Guerzoni and Raiteri (2015) compare the effectiveness of public procurement and R&D subsidies as well as how well they work together. The authors find that, compared to R&D grants, public procurement of innovation has stronger positive impacts on the (firm's self-reported) probability of an increase in total innovation expenditure (45 percent versus 40 percent). The probability of increased innovation expenditure resulting from PPI, R&D grants, and tax credits are calculated to be 55 percent, 48 percent, and 49 percent, respectively. The authors also conclude that the best-performing policy mix is the interaction of PPI with both tax credits and R&D grants.

In an OECD study, Appelt and Galindo-Rueda (2016) use administrative data on procurement across OECD countries and explore the linkage between procurement contracts and innovation activities conducted by firms. They report that 14 percent to 36 percent of companies involved in procurement activities from 2010 to 2012 undertook an innovation activity as part of a public procurement contract, with a higher

TABLE 4.16 Evidence on Implementation of Policies Promoting Public Procurement of Innovation (PPI): Key Findings

Study	Context	Finding
Lee (2011)	Korea, New Technology Purchasing Assurance Program	The program encountered difficulties in implementation when first launched in 1996 because procurers lacked interest and confidence in new products developed by SMEs. Since 2005, the relaunched program has experienced much higher uptake rates because of the new design features, such as a performance certification system to accredit products, a performance insurance system to compensate potential losses of procurers, and complementary advisory support.
Uyarra et al. (2014)	United Kingdom, Forward Commitment Procurement (FCP)	The FCP approach features close interactions between potential buyers and suppliers, and an agreement to purchase the developed solution if the cost is justifiable given the performance. A few good practice examples emerged, but this approach has come to a standstill since the change of government in 2010. The compatibility between the efficiency agenda (value for money) and the innovation agenda of procurement is questionable.
Li and Georghiou (2016)	China, innovation catalogues	A cross-agency, cross-level coordination mechanism was designed to bridge innovation and procurement practitioners. By rationale, the design of this mechanism addresses key barriers that might hinder PPI. In practice, however, the implementation of this approach been limited, primarily because of the fragmentation of procurement functions in China and the tensions with international trade partners resulted from protectionism signaled by this policy.

share among firms that introduced new products to the market. For some countries (such as the Netherlands, Italy, Germany, and Turkey), a significant proportion of firms (47 percent to 70 percent) confirmed that innovation was an explicit requirement for getting the public contracts; in other countries (such as Austria, Finland, France, Portugal, and Sweden), this proportion was much lower, at around 20 percent.

Output and Outcome Additionality

There is more evidence on output/outcome additionality than on input additionality. As summarized in table 4.17, the main findings of the selected studies indicate that PPI contracts have generated short-term effects, such as improved public services, employment, and sales growth, and lowered product prices, because of import substitution in the cases of China and Korea.

Behavioral Additionality

A few of the studies find that PPI policies generated behavioral additionality. For example, Meerveld, Nauta, and Whyles (2015) observe that both customers and suppliers showed more willingness to engage further in PPI due to the advantage of the Forward Commitment Procurement model in reducing risks. However, the persistence of these changes—an important criterion for assessing behavioral additionality—is unknown. In the study of the Nordic-Baltic cities, Lember, Kalvet, and Kattel (2011) report immediate behavioral change of companies because of PPI practices, but do not provide detailed evidence. Uyarra (2016) notes that Dutch PIANOo has contributed to improved compliance with procurement rules and professionalism in general, but the influence of PIANOo on innovation is rather indirect and the impact has been unclear.

Main Requirements for Replicability

Given the diversity of policies supporting public procurement of innovation and the scarcity of evidence, it is difficult to draw general implications. Policy makers should consider this instrument with caution.

- *Capability needs to design and implement policy instruments.* Policy makers and implementing agencies should have the right mindset with respect to projects focused on innovation. The studies commonly recognize that a precondition for PPI to work is a shift in culture from emphasizing short-term cost effectiveness to long-term innovation and from avoiding risks to managing them. In addition, the range of capabilities needed to deploy PPI include: awareness of both procurers and suppliers; the ability to recognize how PPI could advance innovation and procurement agendas together; capabilities of procurers in technical, managerial, and legal aspects of procurement, including the ability to articulate performance criteria and product specifications (external know-how can be employed, but costs will be high); and the ability to enable interactive learning between suppliers and users throughout the procurement process, particularly when highly complex and immature technologies are involved.

TABLE 4.17 Evidence on Output and Outcome Additionality of Policies to Promote Public Procurement of Innovation: Key Findings

Study	Context	Issue	Finding
Meerveld, Nauta, and Whyles (2015)	United Kingdom, Forward Commitment Procurement (FCP)	Improved public infrastructure and services	The FCP approach resulted in reduced costs over the life of products and improved performance. In the case of lighting, the adoption of biodynamic technologies led to savings of 30 percent in energy consumption and 88 percent in maintenance. In the case of zero-waste mattresses, new solutions prevented the depositing of retired products in landfills.
Caloghirou, Protogerou, and Panagiotopoulos (2016)	Greece		The PPI led to improved productivity of the purchasing authority, which in turn offered more efficient services to the public.
Lember, Kalvert, and Kattel (2011)	Nordic-Baltic cities		A PPI conducted by Nordic-Baltic cities led to improved public transport and education services.
Li and Georghiou (2016)	China	Employment	The procurement of e-classroom solutions generated additional employment of 150 full-time equivalent workers. Profitability, however, was low (less than 10 percent) because the supplier chose to bear the costs of five-year after-sale services, which is not usually the case for normal procurement.
Li and Georghiou (2016)	China	Growth in sales of suppliers and increased new product turnover	The local water utilities company awarded an initial contract of ¥194 million, which significantly boosted the growth of the supplier.
Lee (2011)	New Technology Purchasing Assurance Program, Korea		The program led to a significant increase in contracts (from 2.2 percent in 2001 to 9.3 percent in 2009) awarded to innovative SMEs since its relaunch in 2005. The agencies collectively issued ?2,078.5 billion worth of contracts to innovative SMEs in 2009, with an average of ?990 million in revenues per project.
Aschhoff and Sofka (2009)	Germany		PPI is particularly effective for smaller firms in regional areas under economic stress (such as the eastern part of Germany) and in distributive (transportation) and technological (software) services.
Lee (2011)	Korea	Lowered product price	As of December 2008, the program generated an economic effect of 11.4 times the original funding amount due to the expected replacement of imported goods and cost reduction.
Li and Georghiou (2016)	China		The tunnel engineering procurement enabled the domestic supplier to compete with international counterparts, which led to a 20 percent fall in the market price shortly after the delivery of contracts.

- *Required competencies from beneficiaries.* Suppliers need the technical competence to meet the specified performance criteria. While this may not be a major issue in developed countries, in developing countries the lack of innovative capabilities could be a binding constraint. Without such technical competence, the risks associated with technological development are simply too high to be addressed by PPI alone. Other advisory and technical assistance instruments should be put in place first to equip suppliers, including pre-commercial procurement, which addresses an earlier stage of the innovation cycle.

- *Leveraging the power of sector-specific agencies.* Coordination costs for a generic PPI approach across different agencies could be very high. In comparison, sector-specific agencies are more likely to be competent in evaluating technologies in their own sectors and may also have access to regular procurement budgets. This could also effectively reduce the costs of implementation. Specifically, in developing countries, PPI could be particularly relevant for sectors such as public infrastructure and for technologies such as ICT, given the rapidly growing demand within government for digitally enabled services.
- *Capability building.* Capability building can help enhance the multiple functions of procurement, including promoting innovation. Government could offer learning opportunities by developing guidance, disseminating best practices, preparing sample documents, and providing tools for risk management and costing.
- *Policy experimentation.* When the public procurement system in a developing country is underdeveloped, there could be potential to test the appropriateness of this instrument through experimentation. For instance, trial PPI policies could be adopted in localities that are more developed than other parts of the country in terms of both innovation and procurement. Innovation-oriented procurement routines could be adopted by organizations with strong technical expertise and a significant demand. It is important, however, to ensure that results are rigorously measured to ensure effective learning.

Dos and Don'ts of Public Procurement of Innovation

Do	Don't
▪ Try experimenting with public procurement of innovations (PPI) in contexts with appropriate supply-side and demand-side conditions, such as regions and organizations with strong procurement budgets and expertise, as well as strong technological demand. ▪ Ensure the existence of a functioning and transparent public procurement law. ▪ Try to identify champions for this activity within delivery agencies and provide technical support to agencies for implementation.	▪ Don't try to seek a generic, one-size-fits-all approach to PPI. In developing countries, the institutions and expertise related to procurement and technology tend to vary across sectors and across regions. Thus, a differentiated PPI approach is more appropriate. ▪ Don't make domestic PPI policies without evaluating their compliance with relevant international trade relationships.

Dos and Don'ts of Public Procurement of Innovation

Do	Don't
▪ Define the solutions being sought in an open way, using criteria described in performance/outcome terms to allow suppliers to explore and to stimulate radical innovation. ▪ Consider PPI as part of a suite of innovation support, particularly recognizing the value to SMEs of obtaining government contracts in selling their innovations more broadly.	

Checklist for Design and Implementation of Public Procurement of Innovation

- Do you have unmet public needs that can be addressed by innovative solutions?
- Do you have capable suppliers that have developed, or might be able to develop, the innovative solutions you need?
- Is your procurement system agile and transparent, and does it allow competitive bidding?
- Do you have any procurement programs that offer potential for synergy between other types of procurement and public procurement of innovation, such as SME-targeted procurement or sustainable procurement?
- Do the procurement practitioners in your system have the capabilities, risk-taking attitudes, and technical/managerial expertise to implement public procurement of innovation?
- Is there a coordination channel for the procurement practitioners and innovation practitioners to cooperate with each other to implement public procurement of innovation?
- Do you have any innovative sectors/industries or state-owned enterprises that can serve as the experimental fields of public procurement of innovation?

References

Appelt, S., and F. Galindo-Rueda. 2016. "Measuring the Link between Public Procurement and Innovation." OECD Science, Technology and Industry Working Paper 2016/03, OECD Publishing, Paris.

Aschhoff, B., and W. Sofka. 2009. "Innovation on Demand–Can Public Procurement Drive Market Success of Innovations?" *Research Policy* 38 (8): 1235–47.

Caloghirou, Y., A. Protogerou, and P. Panagiotopoulos. 2016. "Public Procurement for Innovation: A Novel eGovernment Services Scheme in Greek Local Authorities." *Technological Forecasting and Social Change* 103 (February): 1–10.

Edler, J., and J. Yeow. 2016. "Connecting Demand and Supply: The Role of Intermediation in Public Procurement of Innovation." *Research Policy* 45 (2): 414–26.

Edquist, C., L. Hommen, and L. Tsipouri. 2000. *Public Technology Procurement and Innovation*. Kluwer Academic Publishers.

Georghiou, L., J. Elder, E. Uyarra, and J. Yeow. 2014. "Policy Instruments for Public Procurement of Innovation: Choice, Design and Assessment." *Technological Forecasting and Social Change* 86 (July): 1–12.

Guerzoni, M., and E. Raiteri. 2015. "Demand-side vs. Supply-side Technology Policies: Hidden Treatment and New Empirical Evidence on the Policy Mix." *Research Policy* 44 (3): 726–47.

Lee, W. 2011. "Demand-side Innovation Policies in Korea." In *Demand-side Innovation Policies.* Paris: OECD Publishing.

Lember, V., T. Kalvet, and R. Kattel. 2011. "Urban Competitiveness and Public Procurement for Innovation." *Urban Studies* 48 (7): 1373–95.

Li, Y., and L. Georghiou. 2016. "Signaling and Accrediting New Technology–Use of Procurement for Innovation in China." *Science and Public Policy* 43 (3): 338–51.

Meerveld, H., J. Nauta, and G. Whyles. 2015. "Forward Commitment Procurement and Its Effect on Perceived Risks in PPI." Chapter 5 in *Public Procurement for Innovation*, 110–44. Edward Elgar Publishing.

Uyarra, E. 2016. "The Impact of Public Procurement of Innovation. In *Handbook of Innovation Policy Impact*, edited by J. Edler, P. Cunningham, A. Gök, and P. Shapira. Edward Elgar Publishing.

Uyarra, E., J. Elder, S. Gee, and L. Georghiou. 2014. "Public Procurement of Innovation: The UK Case." In *Public Procurement, Innovation and Policy*, edited by V. Lember, R. Kattel, and T. Kalve, 233–57. Berlin and Heidelberg: Springer.

4.2.5.3 Supplier Development Programs

Definition

Supplier development programs—or *business linkages programs*—focus on supporting domestic SMEs in developing countries to gain access to international buyers (typically large multinational enterprises, MNEs), which further contributes to the integration of those SMEs into global value chains. By utilizing different support measures, such as advisory services and grants, supplier development programs enhance the innovation capabilities and performance of (potential) suppliers to better meet the needs of buyers. This capability can be relevant to existing supply chains and is also an important factor in attracting foreign investment because multinational enterprises consider the depth and breadth of the local supply base when considering new investments. Thus, the transfer of knowledge and technology can be achieved through linkages between local suppliers and large domestic and global buyers, leading to overall upgrading of local SMEs and the growth of the domestic economy of developing countries.

In many global value chains, SME suppliers face two main pressures from buyers. First, they are often required to reduce the cost of their product(s) every year via mandatory cost reduction processes, requiring constant improvements in productivity. Second, many are also under pressure to improve their existing product offering by making it stronger, lighter, more reliable, and so on. They also face constant competitive pressure from other potential suppliers. Thus, innovation is an increasingly important element of survival.

Supplier development programs offer opportunities to systematically upgrade the capabilities of SMEs in many respects. These capabilities include business strategy and planning, daily operations and management, human capital management, product development, productivity, marketing, and gaining access to finance. In this sense, supplier development programs can serve as vehicles for other instruments focused on SMEs, such as business advisory services, technology extension services, and vouchers.

Supplier development programs typically feature analytical efforts to help firms understand and serve a known market demand, as well as support measures to equip SMEs with more advanced technical capabilities and managerial skills. Some multinational enterprises have their own corporate supplier development programs, while many others need motivation or intervention from governments or development agencies to facilitate these programs. Interventions from third parties (government or development agencies) therefore play an important role in linking local suppliers and large domestic and global buyers together.

These types of initiatives can also be used to support large infrastructure projects (such as transport or mining/oil and gas development), where there is a desire to ensure spillovers from the construction phase and to build the capability to support maintenance and other inputs once the projects are operational, and export competitiveness (box 4.7).

Market and System Failures Addressed

Intervention from governments or development agencies is justified due to the following market/failures that prevent multinational enterprises and local SMEs from establishing effective business linkages:[23]

- *Coordination failure.* Coordination and communication between multinational enterprises or large firms and local SMEs often face severe barriers because of differences in their organizational routines and business cultures. Especially in developing countries, SMEs might not have been exposed to international

BOX 4.7

Export Competitiveness Programs

Export competitiveness programs are a broad category of initiatives that aim to increase the export competitiveness of SMEs by upgrading production capabilities (such as quality, standards, and efficiency) to meet demand in export markets. These programs convey information to SMEs about market trends and characteristics of demand in international markets, and include export promotion, trade missions, and development activities. Although these programs may also seek to connect SMEs with domestic buyers, most of them focus on export-driven development to enter or increase market share in larger or more developed markets. The processes and instruments employed in export competitiveness programs to drive firm-level innovation are very similar to those used by supplier development programs described in this profile.

Source: Metz, Hill, and Hristova 2017.

buyers and their standards, and might have lacked opportunities to understand potential market demand and related standards/requirements.

- *Information asymmetry.* Severe information asymmetry often exists between multinational or large enterprises and local SMEs in developing countries. On the one hand, buyers are not aware of, or confident in, the capabilities and capacity of suppliers, especially where buyers already have an existing network of suppliers that can satisfy their needs—even if there is a potential for local SMEs to offer cheaper/better solutions. On the other hand, local suppliers in developing countries are not familiar with international buyers and are not aware of their requirements or volume of demand. Supplier development programs can act as signal of quality and provide information to match buyers with potential suppliers.

Target Group

Supplier development programs essentially attempt to connect demand with supply. Their Target Groups are SMEs (on the supply side) and large companies (on the demand side). Sometimes, government agencies can play the demand role using their purchasing power (box 4.8).

Local SMEs in developing countries. This is the primary Target Group of supplier development programs. SMEs often lack the information, capabilities, and financing to serve large domestic and international buyers, although they might be able to offer competitive solutions in terms of cost and function. Supplier linkage programs therefore help explore and exploit this potential and promote the overall upgrading of local SMEs.

Large domestic firms and multinational enterprises in global value chains. Supplier development interventions from governments or development agencies target large domestic firms and MNEs that are either not motivated or capable of developing their

BOX 4.8

Applying Supplier Development Initiatives to Government Purchasing to Support SMEs

Supplier development initiatives can also be applied to government procurement in order to increase access by SMEs to these markets. Government purchases are usually a significant proportion of economic activity, and many countries have SME procurement policies (such as quotas) that are meant to apply both to ministries and state-owned enterprises. However, limited capability often impedes SMEs from accessing these opportunities, along with opaque procurement practices, stringent financial requirements, and risk aversion. In some cases, the inability of government agencies to pay in a timely manner can become the most important obstacle to supporting SMEs.

The same upgrading tools used in supplier development initiatives can be applied to government markets, with the addition of specific training on procurement rules and processes. This type of initiative targets SMEs looking to supply existing products, not new solutions, which are discussed under the previous subsections on pre-commercial and commercial procurement of innovation.

own supplier development schemes. By providing supplier review and identification as well as other linkage activities, agencies can help multinational enterprises integrate with local suppliers more effectively.

Strengths

- *Achieve multiple policy goals in an integrated way.* Supplier development programs can link the supply and demand sides together along value chains, addressing multiple policy goals, including technology and knowledge transfer, SME upgrading, SME access to markets, and SME access to finance. At a macro level, supplier development programs contribute to improving the business environment, competitiveness, and employment of host regions and host countries in general.
- *Provide standards of quality that can then be diffused to other firms.* Supplier development programs, by working with specific sectors, can increase the quality of production processes through their dissemination from supported firms to other SMEs that can see the return on these upgrading efforts.
- *Provide a link between suppliers and buyers.* Supplier development programs also act as brokers between large companies and global value chains and local suppliers, providing information about potential suppliers and potential areas for participating in supply chains.
- *Encourage networking and policy insights.* These initiatives generally involve groups of SMEs that can benefit from the networking and group learning that occur in an upgrading activity. They also provide real-world intelligence to policy makers on the needs of industry sectors in broader areas such as infrastructure, regulation, skills, and training, given that all these factors are relevant to the development of effective local supply chains.

Potential Drawbacks and Risks

- *Some uncertainty and risks regarding outcomes.* Supplier development programs do not guarantee access to buyers for their duration; they only support the development of capabilities to increase the chance that these linkages are more likely (some large buyers are happy to commit upfront to purchasing, but this occurs on a case-by-case basis). Global value chains constantly seek ways of reducing costs and improving their supply chains, so suppliers need to engage in a constant process of upgrading. When links to some of these large global value chains are very large and firms are captive—most of the production goes to the same GVC—the costs of losing access to a supply chain can be very high.
- *Complexity of implementation.* Supplier development programs can be complex, primarily due to the need to have strong capabilities in implementation agencies, especially the core facilitation team. High-level expertise is needed to assess demand, identify suppliers, and gauge their abilities. External expertise can be brought in to fulfill these needs, but agencies still need the ability to coordinate and implement programs.

- *Involvement of buyers.* Ideally, potential buyers will be heavily involved in the improvement process, especially if they have stringent requirements (such as unique standards or specific procurement processes/systems). However, some buyers simply do not see much value in participating, even given the benefits of a more robust supplier base.
- *Complexity of monitoring and evaluation.* Monitoring and evaluation can be complex processes. Because supplier development programs are highly selective when targeting SME suppliers, it is extremely hard to establish a control group, making experimental evaluation nearly impossible. It is also difficult to determine which elements of the programs actually worked because interventions tend to be dynamic and integrated, with a blend of instruments such as advisory services, funding support, and linkages events. Moreover, supplier linkages programs have complex effects, not only on the level of capabilities and behavior of individual firms, but also on supply chains, business environments, and local/domestic economies.

Elements for Good Policy Design

Supplier development programs typically involve three key components: (1) demand assessment, which involves various analytics to understand the target market and buyers' needs; (2) supplier analysis, which involves mapping, screening, identification, and diagnostics of qualified SMEs; and (3) matching of demand with suppliers, such as linkages and networking events that engage both sides.

A range of support measures can be used to support the upgrading of SMEs and the matching between supply and demand. Broadly speaking, four categories of instruments are particularly relevant:

- *Capability building.* At the firm level, instruments such as training, mentoring, advisory services (business advisory services, technology extension services), and linkages events are typically used to boost SME capabilities. These may be generic (such as ISO 9000 accreditation)[24] or quite specific to that buyer (such as particular product testing).
- *Access to market.* At the sector level, instruments such as export promotion, advance purchase agreements, trade fairs, and awareness-building schemes are often used to ease market access for SMEs. A common tool is to develop supplier databases that list potential suppliers and their capabilities.
- *Access to finance.* Various financial instruments can be adopted, either direct financing from the government (such as matching grants and loans) or indirect financial instruments leveraging intermediary financial institutions (such as credit guarantee schemes and equity investments). In addition, various supply chain finance offerings, including factoring, are becoming more common.
- *Framework conditions.* At the ecosystem or even higher level, a range of actions can be taken to improve the environment for SME upgrading, including regulatory reforms, building of infrastructure, development of institutions and

intermediaries, and provision of tax incentives, as well as cluster and network initiatives.

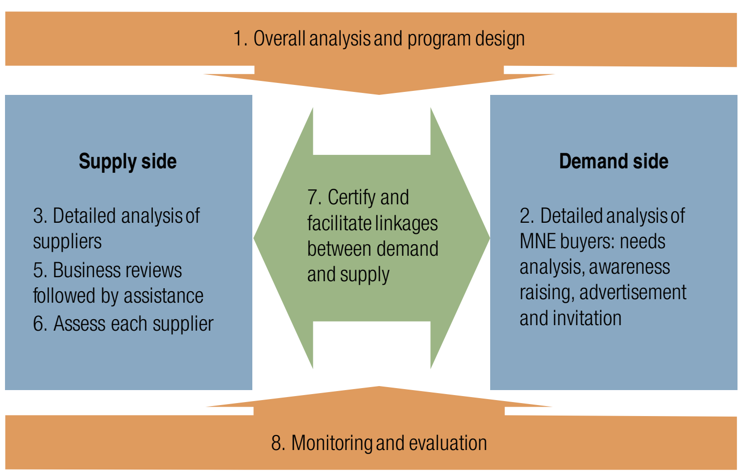
As summarized by Metz, Hill, and Hristova (2017), supplier development programs need three core elements:

- A *core facilitation team* can lead the program through the steps previously outlined, developing relationships with multinational enterprises and SMEs, identifying needs, managing the process of the business reviews, engaging experts when necessary, and ensuring that monitoring and evaluation data are collected.
- *Industry-specific experts*, typically serving as consultants, can conduct business reviews and provide advisory services.
- *Funding or in-kind support* can be provided for firms to implement improvements. Funding can come directly from the program budget in the forms of grants or other specialized facilities, or through linkages with commercial institutions. In-kind support can be technical assistance or advisory services.

Supplier development programs typically support a number of procedures to address the supply side, the demand side, and the matching between supply and demand (Metz, Hill, and Hristova 2017). These procedures, depicted in figure 4.3, can be summarized as follows:

1. *Overall analysis and program design.* Undertake a market analysis of the needs of MNEs and the situation of potential suppliers. Determine the overall objectives of the program, set targets, and design the program.

FIGURE 4.3 Typical Elements of Supplier Development Programs



Source: Visualization based on Metz, Hill, and Hristova 2017.

Note: MNE = multinational enterprise.

2. *Detailed analysis of MNE buyers.* Conduct a needs analysis of existing MNEs and potential MNEs entering the country; raise awareness about and advertise the program; invite MNEs to participate.
3. *Detailed analysis of potential suppliers.* Construct a supplier database. Screen and identify potential suppliers to find good fits for the program.
4. *Matching.* Identify market opportunities for the program.
5. *Business reviews of each participating supplier.* Identify areas for improvement and follow up with assistance to implement improvements.
6. *Supplier assessments.* Determine whether suppliers have been able to upgrade to the standards required by the buyer.
7. *Certification and facilitation of linkages between demand and supply*.
8. *Monitoring and evaluation*.

Evidence of Impact

Evaluating supplier development programs is a complex task because of their dynamic and integrated nature, and the different layers of expected outcomes and impacts. The evidence this synthesis was able to identify is limited to reviews of a few programs, as summarized in table 4.18. Typical indicators for program effectiveness include the number of new businesses due to the program, the number and value of new contracts, the number of new customers, increased value added, and the number of pairings/

TABLE 4.18 Evidence on the Impact of Supplier Development Programs: Key Findings

Study	Program/Context	Finding
Cusolito, Safadi, and Taglioni (2016)	Czech Republic, Supplier Development Program (SDP)	Eighteen months after the program pilot (2000–02), of the 45 companies that participated, 15 had gained new business that they attributed to the program, with contracts worth $18 million annually in 2003. Four companies had also found new companies abroad, and 3 had obtained contracts with higher value added content.
Hess (2015)	Costa Rica, Provee	From 2001 to 2014, Provee (the Supplier Development Project for High-Technology Multinational Companies) developed 126 new product and service linkages per year. The first transactions between suppliers and buyers stemming from these new linkages alone generated more than $80 million.
Monge-González and Rodríguez-Álvarez (2013)	Costa Rica, Provee	The program had a positive impact on the average real wage, labor demand, and probability of exporting of the participating firms. These benefits were observed up to two years beyond the initial year in which the firms participated in the program. Moreover, after having participated in the program, SMEs generated more linkages with multinational enterprises, which also had a positive effect on the performance of the beneficiary firms.
Hess (2015)	El Salvador	During 2010–14, a total of 252 SMEs and microenterprises were linked to 36 buyer companies. Of the 24 value chains, 21 showed increases of up to 41 percent in productivity and 106 percent in sales, while 19 of the 24 chains recorded cost reductions of up to 46 percent. Similarly, for 22 of the 24 linkages assessed, the average incremental investment was $176,200, while the total investment generated across all linkages was $4,229,700. In terms of job creation, new positions were created within 17 of the 24 linkages studied for a total of 362 new employees, 105 of which were women.

linkages between SMEs and multinational enterprises. Given such a small sample of existing studies, reliable conclusions cannot be drawn about the effectiveness of such programs.

Main Requirements for Replicability

Commitment from participants. Supplier development programs are essentially matchmaking efforts to bring supply and demand together. Therefore, willingness and commitment from both multinational enterprises and SMEs are a must for any programs to be effective. It is essential for the facilitation team to bear this in mind when selecting participants. Key characteristics to look for in the firms are expressed determination to commit, strategic and creative thinking, long-term vision, and willingness to contribute to project costs when justified. Early engagement with multinational enterprises (especially their high-level management) is recommended, ideally while programs are being designed, to gain their commitment to the program and to better understand the needs of buyers.

Investment promotion agencies. Supplier development programs should make full use of the role played by investment promotion agencies (UNCTAD 2010). Those agencies are instrumental in coordinating efforts to attract foreign direct investment (FDI) and providing services in a holistic fashion. They typically have the resources and authority to identify potential foreign markets and buyers in a systematic way. Their databases could also be very useful for supplier development programs to carry out diagnostics and assessment. Moreover, investment promotion agencies can advertise the country/region as a destination for investment at the global level, which offers great potential for synergies with suppliers' upgrading efforts.

Complementary measures. Although the core elements of supplier development programs can be specific and limited to such areas as analytics, advisory services, funding schemes, and matchmaking events, policy makers should be creative in putting in place measures to complement those programs in order to maximize program effectiveness. For example, at a broader level, actions should be taken to improve the investment climate and regulatory frameworks, which is typically a weakness in low-income countries; to put in place the national quality infrastructure required to carry out diagnostics and assessments of suppliers; and to build the streamlined logistics and infrastructures necessary to export efficiently.

Dos and Don'ts of Supplier Development Programs

Do	Don't
■ Ensure that there are high-quality program managers who can interact effectively with large and small companies, understand the innovation process, and can make collaboration happen.	■ Don't assume the program is static once designed and launched; constant adjustments might be necessary as more and more information is gathered throughout implementation.

Dos and Don’ts of Supplier Development Programs

Do	Don’t
▪ Utilize good quality diagnostic tools to gauge firm- level and supply chain performance, and to identify specific and actionable solutions. ▪ Customize the instruments to suit the industry-specific needs (such as standards) of multinational enterprises and SMEs that are participants in the program in a mutually beneficial way. ▪ Utilize group activity and encourage peer learning as much as possible. ▪ Recognize that building SME capabilities is not a short-term activity, so ideally support needs to be sustained. Base ongoing support on performance so that SMEs can receive sustained support only if they continue to build and invest in their capabilities and meet targets identified within the program. ▪ Keep the implementation structures flexible, to better respond to market changes and the evolving needs of participants.	▪ Don’t assume large companies will make considerable investments because it is in their economic interests. They may be supportive but may invest less than expected. ▪ Don’t treat all supply chains as similar; different industries have very different dynamics and relationships. ▪ Don’t treat these initiatives as standalone programs. They should be mechanisms to help participating firms access support from other innovation programs while providing these other programs with deal-flow that has already undergone due diligence.

Checklist for Design and Implementation of Supplier Development Programs

- Do SMEs in your country with some potential for export or supplying larger companies participate only to a limited extent in supplying global value chains or large companies?
- Do the inputs to most of your foreign direct investment (FDI) projects come from foreign suppliers?
- Do multinational enterprises in your country complain of the poor quality of local suppliers?
- Do you have other instruments to support quality upgrading?
- Can you play a brokerage role connecting buyers with suppliers?

References

Cusolito, A. P., R. Safadi, and D. Taglioni. 2016. *Inclusive Global Value Chains–Policy Options for Small and Medium Enterprises and Low-Income Countries*. Directions in Development. World Bank Group and Organisation for Economic Co-operation and Development (OECD).

Hess, E. 2015. “Supplier Development Programs in Costa Rica and El Salvador.” In *Rising Concentration in Asia-Latin American Value Chains–Can Small Firms Turn the Tide?* 243–71. ECLAC (United Nations Economic Commission for Latin America and the Caribbean).

Metz, M. R., J. Hill, and D. Hristova. 2017. “SME Upgrading Programs: Exploring Initiatives that Combine Market Linkages and Capability Strengthening.” World Bank, Washington, DC.

Monge-González, R., and J. A. Rodríguez-Álvarez. 2013. “Impact Evaluation of Innovation and Linkage Development Programs in Costa Rica: The Cases of PROPYME and CR Provee.” IDB Working Paper IDB-WP-461, Inter-American Development Bank, Washington, DC.

UNCTAD (United Nations Conference on Trade and Development). 2010. *Creating Business Linkages: A Policy Perspective*. New York and Geneva: United Nations.

4.2.5.4 Corporate Open Innovation

Definition

Another tool used to increase innovation through linkages between large firms and SMEs is *corporate open innovation programs*. A common feature of this type of instrument is that large firms (often multinational enterprises) identify a problem or an area where they need an innovative solution, and then look for solutions in an open way among suppliers (often local SMEs) and other firms or entrepreneurs. These programs can be implemented and managed directly by the private sector, but often public agencies can play an important brokering role solving coordination failures. In recent years, the number of public initiatives in this area has increased substantially, adding potential linkages in supplying solutions (often information technology) to ministries and public institutions.

Corporate open innovation uses a grant and technical assistance to develop solutions for the identified needs of the large company, and usually helps broker interactions between the large company and SMEs throughout the project cycle. The procedures of corporate open innovation initiatives are very similar to public procurement of innovation programs, except that the buyer is a large company (although these instruments can also involve government agencies). Besides monetary support, technical assistance to SMEs on quality or management issues is sometimes provided. ICT platforms are also frequently used to enhance communication between suppliers and buyers.

This type of instrument can be easily integrated with social innovation and corporate social responsibility (CSR) practices because it focuses on strengthening local capabilities and linkages with the local economy, as well as generating benefits to local communities. From the perspective of SMEs, this type of initiative can provide opportunities to improve capabilities and develop participation in supply chains over and above standard supplier development initiatives. This instrument can also involve practical collaboration with the applied research sector on a “real” problem.

Market and System Failures Addressed

- *Information asymmetry.* Local SME suppliers of large multinational enterprises often do not participate in MNEs’ activities to build core competencies of their suppliers because MNEs may not publicize their needs—and even if they do, SMEs may not know how to respond. Corporate open innovation initiatives can address this coordination failure though close communication and interaction between MNEs and suppliers.

- *Capability failure.* Local suppliers of multinational enterprises in developing countries often have low technological and business capabilities and low absorptive capacity. Corporate open innovation initiatives can help build the capabilities of local suppliers.
- *Missing markets.* Local SMEs often struggle to find markets to achieve sustained growth. Corporate open innovation initiatives can help create new markets for SMEs, as well as offer opportunities to develop solutions to address societal needs, such as water sanitation and energy saving.

Target Group

The main target group is local firms and entrepreneurs in developing countries that could become suppliers to MNEs, large companies, or government institutions, but often lack the capabilities to participate in their core technological and knowledge activities.

Strengths

- *Bringing supply and demand together.* Instead of working on only one side or the other, corporate open innovation initiatives can effectively bridge the demand side (innovation seekers) and the supply side (innovation providers), providing a dynamic incentive to innovation activities. This type of instrument can provide SMEs with a buyer, which can significantly simplify and accelerate the commercialization process.
- *Building supply chains and local innovation ecosystems.* Corporate open innovation initiatives can contribute to the development of local supply chains and nurture local innovation ecosystems and the various innovation actors involved. This can further contribute to the technological upgrading and international competitiveness of host countries.
- *Serving as an effective vehicle to improve corporate social responsibility.* Traditional approaches to corporate social responsibility often appear to be the cost an MNE or large company needs to pay to operate in host countries. Corporate open innovation initiatives can create opportunities for these large companies to fully interact with local suppliers and to contribute to local community and capacity building, while also creating value for the MNE and therefore serving as an effective vehicle to implement corporate social responsibility in new ways.
- *Providing market signals.* SMEs that are able to develop solutions for large firms not only have an immediate potential buyer but also can use this

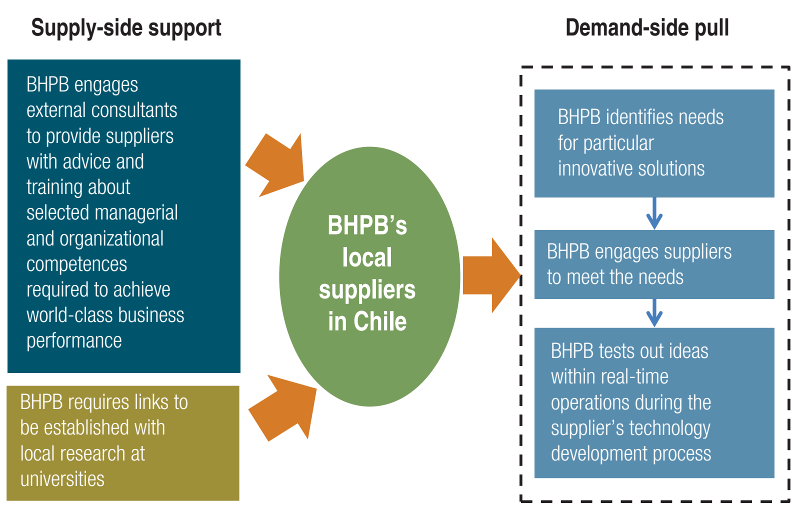
sale to a large corporate buyer to leverage further sales domestically and internationally.

- *Linking start-ups and large firms.* These initiatives offer the potential to close the often large gap in business culture between technology start-ups and large firms.

Potential Drawbacks and Risks

- *Potential conflicts around issues concerning intellectual property rights.* Open innovation approaches pose challenges to firms' strategy to manage intellectual property. Close interactions between users and suppliers, dynamic flows of knowledge, and the absence of formal contracts all entail risks for the protection of intellectual property rights for the various stakeholders.
- *High transaction costs.* Corporate open innovation programs typically feature a sophisticated process (for example, as shown in figure 4.4), which incurs high transaction costs (higher than a "standard" innovation grant) that will not be recovered if the project is not successful.
- *The danger of "going through the motions" without actually adopting innovation.* Corporate open innovation initiatives, especially when combined with agendas such as corporate social responsibility, can become an instrument for large multinational enterprises to just "check the box" without seriously engaging in the development and adoption of innovative solutions.

FIGURE 4.4 BHP Billiton's Cluster Program in Chile



Source: Elaborations based on Barnett and Bell 2011.
Note: BHPB = BHP Billiton.

Elements for Good Policy Design

Defining criteria in terms of functionality/outcome rather than technical/prescriptive requirements is important to stimulate alternative, creative designs. It is also important to provide brokering assistance and to help build and manage the relationship between large companies and SMEs. Industrial collaboration is difficult even between similar large companies, and there are various capability and cultural gaps between large companies and SMEs. Thus, having an experienced third party (which may also need to liaise with the research sector if they are involved) to broker interactions and contract issues greatly reduces the risk of projects failing.

Evidence of Impact

Launched in 2008, BHP Billiton's (BHBP) Cluster Program in Chile has shown great potential in increasing BHP Billiton's technological competencies, local suppliers' capabilities, and local supply chain development. The approach of the program is summarized in figure 4.4.

Evidence on corporate open innovation initiatives is extremely scarce; this synthesis managed to find one study, Barnett and Bell (2011), which offers limited insight into BHP Billiton's Cluster Program in Chile. By the time of the study, the impacts of BHP Billiton's Cluster Program had not yet been felt, although there was positive feedback from program participants. Formal evaluations are needed to support an in-depth understanding of the effectiveness of this type of instrument.

Main Requirements for Replicability

Designing and implementing corporate open innovation initiatives requires that companies have a high level of capabilities and substantial resources. At a minimum, commissioning companies should be able to articulate the challenge effectively, thus improving innovators' understanding of the scope and properties of required solutions. Given these large, often unexpected, costs, it is difficult to keep even large companies engaged in providing support for developing the solution and implementation. Ensuring such commitments is a necessary condition for success.

Public agencies should actively facilitate the transfer of learning from the implementation of good policy practices to multinational enterprises across different contexts and provide needed resources and services to the business stakeholders involved. Accurate identification and measurement of demand is also crucial. Multinational enterprises should be able to identify their unmet needs and explain their needs in functional rather than technical terms to allow innovative and alternative designs to be developed.

Beneficiaries also need to have the competencies necessary to participate. A certain level of absorptive capacity is required from prospective local suppliers of innovative solutions, so that they can understand the technological needs, desired performance, and functional requirements based on the specifications provided. Local suppliers should also be able to deliver prospective solutions within realistic time periods.

Dos and Don'ts of Corporate Open Innovation

Do	Don't
▪ Ensure that high-level managements in large companies share a vision of promoting open innovation and enhanced corporate social responsibility in the host economy. ▪ Ensure that there are high-quality program managers who can interact effectively with large and small companies, who understand the innovation process, and who can make collaboration happen. ▪ Ensure close communication and interaction between multinational enterprises and suppliers (and potentially R&D providers), so that the demand can be fully understood, and any risks on the supply side can be minimized. ▪ Provide simple templates for issues like intellectual property rights to reduce transaction costs.	▪ Don't overlook the issue of suppliers' capabilities. The success of BHP Billiton's cluster program in Chile does not guarantee its replicability in other developing countries. Appropriate adjustments need to be made to suit local circumstances. ▪ Don't treat the policy design and implementation process as a simple and linear one. Iterations and trials are needed to gather experience, and formal schemes should be rolled out gradually.

Checklist for Design and Implementation of Corporate Open Innovation

- Do SMEs participate to only a limited extent in supplying multinational enterprises and large companies?
- Are there any new opportunities to link local suppliers to large companies and multinational enterprises?
- Do you have commitment from large companies to participate and implement new solutions?
- Do you have other policy instruments that can support the development of new and innovative solutions and connect enterprises?
- Can your program support the implementation of the solutions developed?

References

Barnett, A., and M. Bell. 2011. "Is BHP Billiton's Cluster-Program in Chile Relevant for Africa's Mining Industry?" Policy Practice Brief 7, The Policy Practice Limited.

4.2.6 Profile 6. Technology Adoption and Generation Instruments

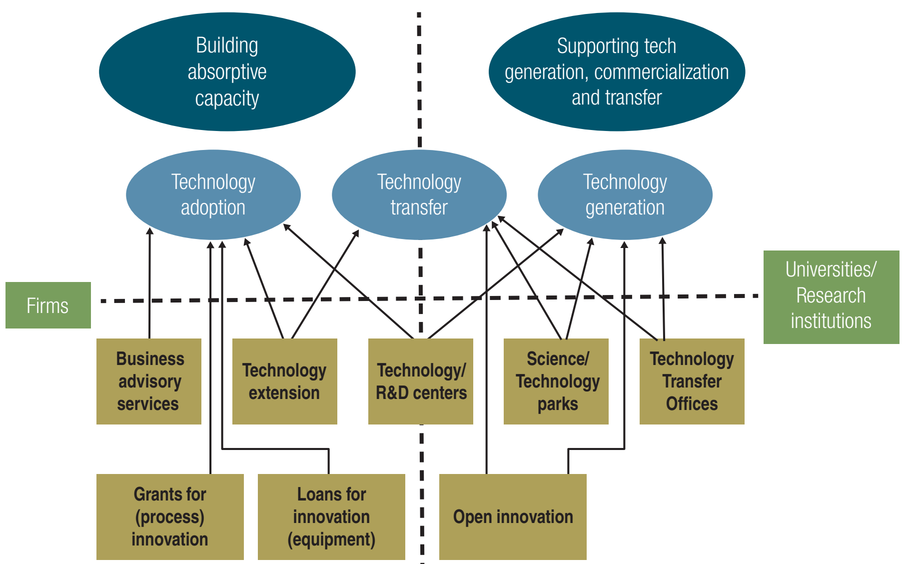
This profile covers a family of instruments related to facilitating the adoption and generation of technology. These instruments include *business advisory services, technology extension services, technology centers, science and technology parks,* and *technology transfer offices*.

Building firm capabilities and promoting the use of new and improved technology are essential to increase the productivity of firms in knowledge-based economies, especially in the context of the rapidly changing technological paradigm shift toward Industry 4.0. This is particularly important for SMEs, which must be able to adjust rapidly to evolving markets and changing circumstances, but are often limited by constraints in knowledge, expertise, and financing. Such constraints confine their capacity to invest in new technologies and skills that can improve their competitiveness and boost innovation.

As a result, governments have directly supported steps to help firms adopt, transfer, generate, and commercialize technology, providing a range of services, technology assistance, and finance. At one end of the range, governments want to promote technology upgrading among SMEs; this starts with building firms' absorptive capacity (Cohen and Levinthal 1990) and providing information and know-how on how to adopt new technologies. At the other end of the range is the objective of transferring and commercializing new technologies from universities and public research organizations.

Figure 4.5 shows the range of instruments that can be used to promote adoption, transfer, generate, and commercialize technology. It is important to highlight that

FIGURE 4.5 Instruments to Support Technology Adoption, Transfer Generation and Commercialization



some other innovation policy instruments already discussed can also support these technology objectives.[25] For example, grants that support process innovation or loans for innovation can facilitate the purchase and adoption of technologies; open innovation and other collaborative instruments can have the objective of developing new technological solutions Some R&D projects are oriented toward generating new technologies, and therefore instruments that support engaging in these R&D projects will also influence technology. Given that these instruments also support other types of innovation beyond technology, they are described in other sections, but they are part of the policy mix to promote technology adoption and generation as well.

The five instruments that focus more directly on equipping firms with the capabilities of using and/or generating technologies are: business advisory services (BAS); technology extension services (TES); technology centers (TCs); science and technology parks (STPs); and technology transfer offices (TTOs). Specifically, *business advisory services* focus on building absorptive capacity for technology adoption, while *technology extension services* focus on helping SMEs adopt technologies and their related capabilities. *Technology centers* support both adoption and the generation of new technologies. *Science and technology parks* aim at attracting technology-intensive firms with the objective of generating spillovers with local universities and industries. *Technology transfer offices* support the generation and commercialization of technologies from universities and public research organizations. In some cases, they are used to help entrepreneurs address knowledge gaps in the commercialization process. In other cases, they target established SMEs to enter the market and then start climbing the capabilities escalator. The forms of these technology services instruments vary greatly, especially in the case of business advisory services and technology centers.

These five instruments are the main ones that can be used more directly to implement digitalization, Industry 4.0 strategies, and technology maps, especially business advisory services, technology extension services, and technology centers. They are all based on providing services and infrastructure that can be used in the development of particular types of digital and other technologies. The activities that should be implemented under a strategy for digitalization or Industry 4.0 are described in box 4.9. Some business advisory services are oriented to the adoption of digital technologies in key management functions. Technology extension services aim at supporting implementation of specific technologies. Technology centers can be entirely dedicated to facilitating adoption of Industry 4.0 technological solutions, and also include most of the activities required under these strategies, as well as acting as an intermediary to facilitate access to other policy instruments such as equipment finance or procurement of digital technologies.

The discussion that follows describes each instrument in order from technology adoption to technology commercialization.

BOX 4.9

Designing Digital and Industry 4.0 Adoption Interventions

Digital technologies are increasingly ubiquitous and either underpin or form an essential element of most business innovation and technologies. Many countries are developing strategies to address the challenges and opportunities of digital technologies and Industry 4.0. A key focus is on how their industries and firms can both develop indigenous digital technologies but more importantly, how they identify, diffuse, adopt, and adapt existing technologies developed elsewhere. Arguably, the principles and main support mechanisms of technology diffusion do not change just because technology is digital. Firms need to be made aware of what digital technologies are available, assess the relevance and implications for their business, and decide which to invest in and how they should be acquired and implemented.

Information on which technologies will be most important to firms, how they can be sourced from public research organizations, and which can automatically be provided by the market (such as through equipment vendors) is critical. Public-private technology intermediaries can greatly facilitate this information transfer to firms. In some cases, such as technology extension services and technology centers, these intermediaries can play a key role in supporting the diffusion process.

In general, any good digital or Industry 4.0 should include the following activities:

- Awareness activities, such as events, workshops, roadshows, or industry visits.
- Skills and management training courses to manage digitally driven change, such as workforce assessments and training and training specific to digital business (like digital marketing/cloud computing).
- Advisory support activities diagnostics, such as readiness assessment or digital action plans, which can be supported with vouchers, grants, or direct technical assistance.
- Finance for digital upgrading, including equipment loans or guarantees.
- Infrastructure services to adapt technologies, provide specialized training, and offer accreditations to vendors and training and advisory providers.
- Technology foresight services for emerging digital technology applications.

All these activities can be integrated in several of the instruments reviewed in this profile. While business advisory services and technology extension services focus on a narrowly subset of these activities—primarily on awareness and advisory support, especially the latter—technology centers can include most of these activities and can act as intermediary to facilitate access to other government programs, such as equipment finance programs or government procurement of digital technologies, as well as provide their own technological solutions.

References

Cohen, W. M., and D. A. Levinthal. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly* 35: 128–52.

Shapira, P., and J. Youtie. 2017. "The Next Production Revolution and Institutions for Technology Diffusion." Chapter 7 in *The Next Production Revolution: Implications for Governments and Business.* Paris: OECD Publishing.

4.2.6.1 Business Advisory Services (BAS)

Business advisory services (BAS) focus on strengthening different business and management processes of the firm. Thus, they are often branded as part of SME or entrepreneurship policies. However, business advisory services are the building block of innovation and technology adoption processes. Hence, in this guide, they are placed in the family of technology adoption and generation instruments. They are the main instrument used to build the innovation and technological capabilities of firms. They are central to innovation because they result in the adoption of new and better management processes (process innovation) and can affect directly efficiency and productivity. They are also central to technology adoption because they strengthen knowledge management processes and the management processes needed to effectively adopt new technologies.

Business advisory services are common in many countries but are implemented using different business models and degrees of proactivity in getting firms to engage. Business advisory services can target very different areas—marketing, lean production, quality management—and the services provided have varying degrees of sophistication. Business advisory services were an essential policy instrument of some of the "Asian miracles" such as Japan and Singapore (Cirera and Maloney 2017). In addition, some impact evaluations suggest very high returns for this type of intervention in developing countries. In low-income countries, agencies may struggle to find high-quality consultants to implement these services effectively, and willingness to pay for these services is very low, which makes it difficult to attract large number of beneficiaries.

Definition

Business advisory services (or *management extension services*) consist of access to, or the direct provision of, specialist advice in areas such as financial and accounting services, human resource management, marketing and advertising, pricing strategies, supply chain management, quality management, and/or legal services. BAS address key absorptive capacity issues because adopting a new technology is not only about purchasing machinery, but also requires integrating the machinery into the full production and business processes of the firm. Thus, managerial practices are a key capability for innovation and technology adoption (Cirera and Maloney 2017).[26]

The delivery model for BAS tends to be more "demand" centered, and is often structured around physical centers that provide infrastructure to serve SMEs and entrepreneurs, which can find either a suite of available services or referrals to those services. These BAS models target smaller size firms, although their more demand-driven approach is probably better suited to medium and larger firms that may have more specific needs, such as ISO accreditation or marketing support.

Business advisory services usually include a broader range of topics than those directly linked to innovation; however, these noninnovation and innovation services are often bundled together in a "holistic" approach. In addition, the provision of business advisory services is meant to strengthen the underlying management capability and absorptive capacity of SMEs, without which more sophisticated innovation activities will probably fail—assuming an SME would embark on them.

A subset of business advisory services targets innovative entrepreneurs with services relevant to their challenges. These services may be bundled into an acceleration program or coordinated by an incubator, or may stand alone, and can include investment readiness, branding and distribution, team building and human resources, various R&D-related services (including intellectual property), and legal services.

Market and System Failures Addressed

Business advisory services attempt to address the following market and system failures:

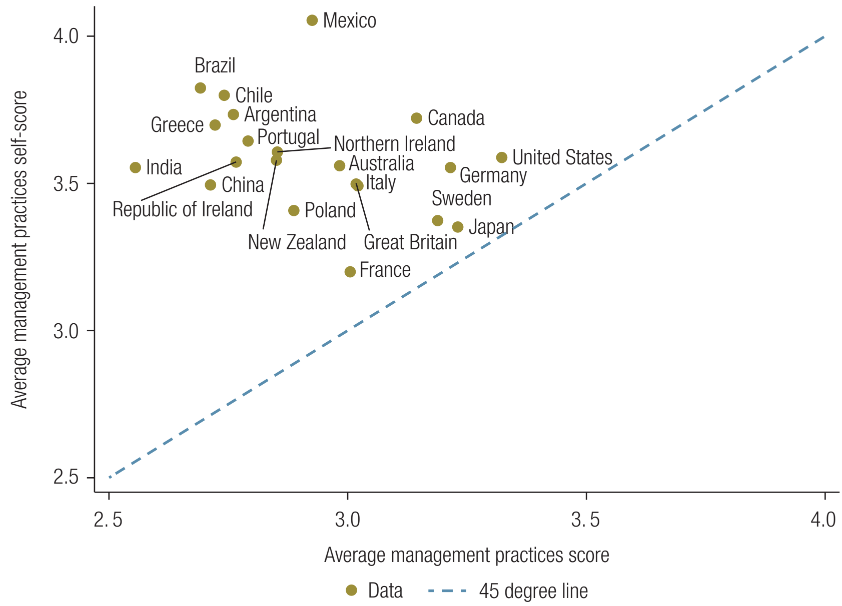
- *Information asymmetry.* SMEs do not have the same access as large firms to information on good managerial practices. They also have fewer resources to identify what assistance may be most beneficial, or how to judge the value and quality of the potential services provided or the new managerial practice to be adopted. This reduces their willingness to pay for these services. Business advisory services can signal what practices and what advisors are adequate for SMEs.
- *Coordination failures.* SMEs tend to operate in isolation and are often poorly networked. The perceived coordination costs to jointly procure advisory services are often too high. BAS programs can work with groups of SMEs and industry and trade associations to serve as an incentive for this coordination and provide the necessary advisory services.
- *Capability failures.* Many SME owners have trouble identifying what their constraints are and how to overcome them. Even if they recognize their problems, firms are unlikely to have the in-house expertise to work through the change process. One common problem is overconfidence in their management quality. Data from the World Management Survey suggests that managers tend to significantly overrate their true managerial abilities (figure 4.6). While the figure includes only medium and large firms, anecdotal evidence suggests that the problem may be greater in smaller firms, which is in line with the lack of take-up and willingness to pay observed in many BAS programs.

Target Group

The primary target group of advisory services is firms. Owners and/or managers of SMEs often have a relatively narrow set of skills and competencies, as well as limited networks, and therefore may not be knowledgeable about the skills required to implement new technologies in their business practices.

Another important target group is advisory service providers. This group comprises public, private, and nonprofit organizations involved in the provision of advisory and extension services, including regional business support centers, chambers of commerce, and small business associations and societies, in addition to large and small private consultancies. Various organizations focus on specific types of services, firms, and local areas.

FIGURE 4.6 Firms Overrate Their Own Managerial Abilities



Sources: World Management Survey; Bloom and Van Reenen 2007; Maloney 2017 (adapted from Cirera and Maloney 2017).
Note: Great Britain refers to England, Scotland, and Wales.

Strengths

The main strengths of business advisory services can be summarized as follows:

- *Offering BAS as a bundle of services can increase efficiency in delivery.* Given the suboptimal provision of advisory services in the private market, BAS interventions can provide an integrated suite of services to SMEs, which can be delivered conveniently through a one-stop shop approach.
- *Availability of diagnostics enables programs to be tailored to SME clients.* Business advisory services can include a diagnostic service that identifies the main barriers to growth and a roadmap to address them, including prioritized actions that can then be supported by focused BAS or technology-related services. This element makes it more likely that the advice is tailored to the business, and that change will both occur and be productive.
- *Costs of services are relatively lower.* Providing advisory services to SMEs through business advisory services, which are centralized and convenient, is inexpensive compared to the provision of separated services via different direct support instruments.
- *BAS often support the building blocks of SME innovation capability.* The management and operational competencies that effective business advisory services help build are essential for the more complex innovation activities in SMEs.

Potential Drawbacks and Risks

There are some drawbacks and risks associated with this category of instrument, summarized as follows:

- *Risk of overcrowding the market.* The provision of business advisory services should be considered carefully to avoid distorting the existing advisory market. To mitigate this risk, the services should target only those firms that could benefit the most from subsidized services, and when possible make beneficiaries pay full costs.
- *Lack of coordination among service providers.* There are typically several agencies and actors involved in the provision of these services. Therefore, the government must make sure there is a coordinated, systemic approach to the provision of support services that is integrated with the availability of other instruments.
- *Poor match between supply and demand for services.* Policy makers must ensure that the services provided are the ones that SMEs need. Ex ante market analysis is necessary to identify needs and tailor the provision of services to various types of SMEs. Problems can occur when a standardized set of business advisory services is offered regardless of SME needs, which can lead to products like generic business plans being delivered to SMEs regardless of whether they find them useful.
- *Weak demand, especially when it is totally demand driven.* SMEs' level of awareness of potential benefits tends to be low, reducing latent demand for business advisory services. Therefore, it is important to inform SMEs through targeted promotion and brokering, and proactively engaging with SMEs. Otherwise, uptake is likely to be limited to "early adopters" that tend to engage in many support initiatives.
- *Misguided focus of support if the diagnostic does not precede implementation.* Conducting diagnostics before deciding on the type of services needed is key to determine the appropriate set of services required. In BAS models where SMEs choose the service needed without prior analysis, the likelihood of failure is high because SMEs often do not identify or prioritize their critical constraints.
- *Capture by consultants.* If strong quality assessment mechanisms and services monitoring do not exist, consultants can capture BAS support initiatives that support standardized offerings by churning out business advisory services funded by the subsidy that are of little value to the client.
- *Measurement challenges.* There are significant challenges in measuring and monitoring the impact of business advisory services. SMEs' financial and productivity performance are affected by many variables. Ascribing particular results (such as revenue or employment changes) to specific advisory services is challenging, particularly given the length of time building capabilities can take. However, simply relying on client satisfaction as the main metric is equally flawed, particularly if the SME has no experience against which to compare the quality and usefulness of the advice received.

Elements for Good Policy Design

BAS programs are diverse, but there are a few key design elements that are likely to help achieve higher effectiveness. One approach that is frequently used is to have an *initial "diagnostic" stage*, where an assessment is made by an external expert either of an issue that the firm has identified as being an impediment, or of the whole firm and its performance. Then, an *action or improvement plan* is developed, and further advice can be provided to support the implementation of this plan. The advantage of this sequenced approach is that SMEs may misdiagnose their main problem, and an upfront assessment can promote the sensible prioritization of subsequent improvement activities. However, having a mandatory assessment as an entry criterion can sometimes be counter-productive, given that some SMEs can be suspicious of external advisors until they experience tangible benefits from interacting with them (particularly where the service is perceived to be linked to the government). Given these circumstances, a holistic assessment should be implemented once SMEs have engaged and are more trusting.[27]

A key design issue is *ensuring the quality and relevance of the business advice.* As discussed, one of the main market/system failures in this area is strong information asymmetry that can result in adverse selection, whereby SMEs cannot determine the value and quality of the consultancy services provider. One option to address this concern is to provide some signaling and develop a vetted list of service providers that are known to provide quality services, and to help SMEs negotiate the scope of any work from consultants if they are unfamiliar with the process.

Given the severe information asymmetry and lack of willingness to pay, *constant outreach and engagement* of the program is critical. BAS programs usually must be marketed extensively and continuously to induce most SMEs to utilize them. As a result, it is important to *partner with private sector intermediaries* (business associations, large customer companies, lawyers, and accountants) that interact regularly with SMEs and that can steer business to the initiative. Utilizing previous and current SME users of the initiative in the marketing and outreach process can provide important demonstration effects and increase take-up because SMEs are most likely to trust the experience of peers.

Given that the potential demand could be weak, it is also critical to have *agile application processes.* These initiatives should strive to be user-friendly and should ensure low-cost application processes. Reporting and payment processes should be simple and quick for the SMEs, particularly if the support involves relatively small amounts of money.

When more specialized business advisory services are needed, many governments either *subsidize part of the costs of the services and/or provide the services themselves.* When business advisory services are subsidized, the government usually provides the SMEs a voucher or grant[28] to purchase the services from a third party. When the government provides the service directly, they generally have centers with advisers at the regional and local levels that deliver the services to SMEs. In this direct provision model, it is critical that the advisors have knowledge and credibility and can quickly add value to SMEs; this is often the main failure in implementing this type of instrument in developing countries. These advisors generally need to have a business background and need to be recruited and remunerated accordingly, which is sometimes a challenge for government organizations. Therefore, *a realistic assessment of the quality and depth of the supply of these services* needs to be done before deciding on the scope of the delivery model.

This government delivery business model may also restrict the potential growth of the private market. Ideally, SME participants will continue to utilize business advisory services, in which case *having a viable private BAS market* is important. Thus, the optimal delivery model will involve private sector providers and may also involve capacity building (such as training) for those consultants if capability gaps are identified.

Evidence of Impact

Most governments have different BAS programs available to support SMEs, ranging from very basic services that respond to phone inquiries to intensive and personalized consulting services. In most countries, services are provided by decentralized centers and networks, but the government also maintains some schemes that are administered centrally.

The selected studies look at different dimensions of BAS programs, including issues related to the processes and performance of BAS programs (such as cost-efficiency), output additionality, and behavioral additionality. Evidence on effectiveness tends to be positive, although governments are constantly modifying the programs and launching new initiatives to improve the delivery of services, which makes evaluation problematic.

In recent years, randomized controlled trials have increasingly been used to assess the effectiveness of BAS interventions, especially in developing countries (see, for example, Iacovone et al. 2019; Bruhn, Karlan, and Schoar 2018). Some of this evidence, often regarding advisory services to informal firms and microentrepreneurs, is summarized in McKenzie and Woodruff (2013). Here the focus is primarily on programs that support innovation by formal, often manufacturing firms.

Processes and Performance of Business Advisory Services Programs

Table 4.19 summarizes key findings from the selected studies regarding the processes and performance of BAS programs. A range of issues have been found. The most important finding is limited uptake among SMEs in most programs. Also, there is ambiguity regarding the cost-effectiveness of BAS programs.

Behavioral and Input Additionality

A few studies look at behavioral changes of treated firms, such as how business advisory services have affected firm's organization routines in management, quality control, and planning, especially in the context of developing countries. Table 4.20 summarizes key findings from a few studies, which all suggest the effectiveness of business advisory services in generating behavioral additionality.

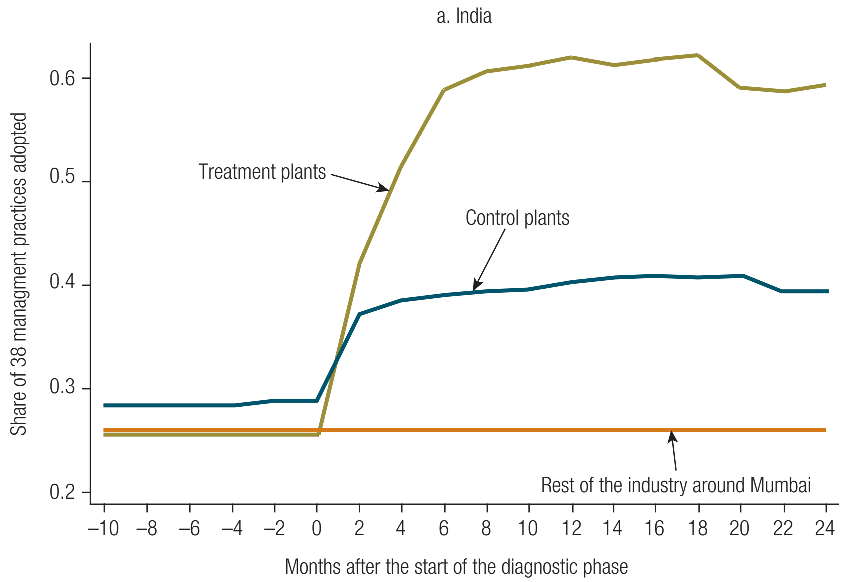
TABLE 4.19 Evidence on Processes and Performance of Business Advisory Services Programs: Key Findings

Study	Context	Finding
What Works Center (2014)	OECD countries	Most business advisory services (BAS) programs target multiple or vague objectives. Only three of the 23 evaluations considered find a clear link from program objectives to improved firm outcomes for that objective. Programs that used a hands-on, direct delivery performed better than those that used a more indirect and less intensive delivery model.
Hjalmarsson and Johansson (2003)	Multiple contexts	Public provision of BAS should be focused exclusively on strategic services, given that there is no mature market for these services. In contrast, there is a more mature market for operational services where SMEs managers can find suppliers on their own.
Dyer and Ross (2008); Hakimin (2010); Lewis et al. (2007)	Multiple contexts	Publicly provided BAS are not very popular among SMEs; uptake rates and take-up rates are low. The reasons for low participation include the lack of awareness and bureaucratic impediments.
Cumming and Fisher (2012)	Ontario, Canada	The program proved to be cost-effective. By June 2009, early-stage entrepreneurial firms had raised Can$6,545,000 in financing, while the program costs totaled Can$662,360, thus giving a ratio of financing raised per dollar of cost of only Can$0.10.
Iacovone et al. (2019)	Colombia	Both group consulting and individual consulting approaches lead to improvements in management practices of a similar magnitude (8 percentage points to 10 percentage points). The group treatment model dominates the individual consulting model on a cost-benefit basis and offers a promising approach to scaling management. Some delays by business owners in implementing business advice prevented the BAS intervention from being more effective. The delay, according to qualitative research results, was mainly because firm owners mistakenly did not consider the practices to be profitable (in 58 percent of the cases).

TABLE 4.20 Evidence on Behavioral Additionality of Business Advisory Services Programs: Key Findings

Study	Context	Finding
Bruhn, Karlan, and Schoar (2012)	Puebla, Mexico	Managerial inputs from business advisory services (BAS) had a large and significant impact on firm performance, mostly in marketing and financial controls. In addition, the advising services had an impact on helping firms set clear goals and define a strategy for how to achieve the goals.
Benavente and Crespi (2003)	Chile, PROFO program	Results of the treatment group suggested that participation in Proyectos Asociativos de Fomento/Programmes of Managerial Development (PROFO) led to improved production planning, marketing strategies, introduction of quality control and managerial training, and increased use of public extension services.
Tan and Lopez Acevedo (2005)	Mexico, enterprise support program	The program had a positive and significant effect on raising training investments per worker, and a higher proportion of treated firms (23 percent) adopted quality control systems as compared to the control group. The study finds evidence that some of the positive effects took several years to realize.
Bruhn, Karlan, and Schoar (2018)	Mexico	Owners had large increases in “entrepreneurial spirit”: that is, entrepreneurs’ confidence in their management skills and their ability to grow their firm and handle difficulties.
Bloom et al. (2018)	India	Nine years after the intervention, there is a significant gap in practices and performance between the treatment and control plants, suggesting lasting impacts of the BAS intervention. Many management practices had spread within firms, from the experimental plants to the nonexperimental plants, suggesting large spillovers within firms. Managerial turnover and the lack of director time were two of the most cited reasons for abandoning some management practices.

FIGURE 4.7 **Impact of Management Extension on Textile Plants in India**



Source: Bloom et al. 2018, adapted from Cirera and Maloney 2017.

Figure 4.7 illustrates the effect of business advisory services on Indian textile plants, suggesting significant impact on adoption of practices. Interestingly, some of these effects have persisted and spread to other firms (Bloom et al. 2018).

Output Additionality

The selected studies present mainly positive evidence on the output additionality of business advisory services, as summarized in table 4.21. The first five studies suggest, to a limited extent, a positive effect of business advisory services in generating output and outcome additionality measured through indicators such as sales, productivity, and employment. However, two studies in the context of Western European regions find no evidence of positive effects of the regional BAS programs. The other studies focusing on developing countries find a positive impact on sales and employment, or productivity, at least in the short term.

Main Requirements for Replicability

Successful implementation of business advisory services requires certain capabilities and capacity from agencies in charge of design and implementation, including:

- *Awareness building.* Implementing agencies need to build awareness of the program among target participants. While there is evidence that business advisory services are effective, there is also evidence of low uptake, which suggests that some programs do not invest sufficiently in generating demand.

TABLE 4.21 Evidence on Output Additionality of Business Advisory Services: Key Findings

Study	Context	Finding
Wren and Storey (2002)	United Kingdom, Enterprise Initiative	Consultancy advice services had a significant effect on SMEs performance, but only for firms that were neither too small nor too large.
Cumming and Fisher (2012)	Ontario, Canada, business advisory services	Services were positively associated with firms' sales growth, patents, angel equity finance, and alliances. The extent of advising a SME received was positively and significantly correlated with the firm's output.
Chrisman and Katrishen (1995)	United States, Small Business Development Centers (SBDC)	The program increased sales and employment significantly more than the firms would have done if no assistance had been received.
Sarder, Ghosh, and Rosa (1997)	Bangladesh	The treated firms showed significantly higher growth in employment, productivity and sales of between 5 percent to 16 percent; more extensive support (in terms of number of services received) was associated with higher sales and employment growth but not higher productivity.
Bruhn, Karlan, and Schoar (2012)	Puebla, Mexico	There were positive effects on return on assets and total factor productivity in the short term, and large increases in the number of employees and total wage bill several years after the program.
Tan and Lopez Acevedo (2005)	Mexico, enterprise support programs	There was a positive impact on productivity in the short term, but it disappears in the medium term.
What Works Center (2014)	OECD countries	BAS programs consistently presented better results for productivity and output than for employment.
Widerstedt and Månsson (2015)	Sweden, regional business development program	The distribution of private-sector consultancy vouchers had no significant impact on employment or productivity.
Lambrecht and Pirnay (2005)	Walloon region of Belgium	No evidence was found that advisory services had a significant impact on net job creation, sales, or financial indicators such as liquidity. Support to entrepreneurs and SMEs needs to be more customized and focused upon "the entrepreneur and his objectives."
Iacovone et al. (2019)	Colombia	The group treatment has positive treatment effects on sales of Col$63 million–Col$71 million per month (US$26,500–US$29,900) in levels, while the individual treatment effects have negative point estimates in level terms. The estimated impact of the group treatment corresponds to an increase of 3 to 7 workers after the intervention. Individual treatment has a positive impact on employment at the 10 percent level, but this result is not robust.
Bruhn, Karlan, and Schoar (2018)	Mexico	Access to management consulting led to better firm performance: one-year results show positive effects on return on assets and total factor productivity. Using Mexican social security data, the analysis finds a large increase in the number of employees and total wage bill several years after the program.

- *Technical abilities.* One of the main factors behind the success of BAS programs is the quality of the staff and the method of accrediting services providers. All advisers must have the technical and financial capacity to effectively provide advisory, training, information, or financial services to SMEs. Systems of professional ethical standards and quality assurance should be in place as well.
- *Funding capacity.* In many cases, firms may also need funding to make the necessary quality and/or capital improvements; therefore, it is important that

either the government can supply such funding or that they can help firms obtain it.

Certain competencies also are needed on the beneficiary side.

- *Awareness and absorptive capacity.* Potential beneficiaries need to have a certain degree of awareness of the value of business advisory services and of the challenges faced by their firms that could benefit from those services. Participants need to be able to frame their own problem, either through self-diagnostics or with help from external advisors. In addition, a certain minimum level of absorptive capacity is needed to take up new organizational routines and implement recommendations arising from the program.
- *Ability to cofinance.* Business advisory services are often partially funded by the government, but typically also have a cofinancing element. Therefore, many program beneficiaries should be capable of cofinancing advisory services through payment of program fees. Fees can help finance the system. Evidence has shown that firms value services much more when they are paying for them. However, SMEs might not be motivated to pay for services unknown to them. A common model is to heavily subsidize the initial service and/or use a sliding scale of pricing as the experience of the firm with advisory services and the specialization of the projects increases.

Dos and Don'ts of Business Advisory Services

Do	Don't
■ Ensure there is a clear picture of the supply and demand of business advisory services, and quantity and quality of BAS providers, so that clearly focused programs can be designed. ■ Ensure marketing and outreach effort to start the program, raise awareness of benefits among potential clients, and work with partner organizations in the private sector to crowd in demand. ■ Design a user-friendly and low-cost application process. ■ Make sure to recruit high-quality staff with the appropriate skills and capabilities needed to manage and render BAS. Systems of quality assurance and ethical standards are also highly desirable.	■ While decentralization is the right approach to ensure regional coverage of BAS, don't rely on ad hoc, local initiatives; a systematic, coordinated approach is still needed to ensure consistent quality effectiveness and cost efficiency. ■ Don't design schemes that just allow SMEs to subsidize business services they would use anyway (such as tax preparation services) and that do not build their capability. SMEs need to learn through the process.

Dos and Don’ts of Business Advisory Services

Do	Don’t
■ Ensure mechanisms to assess service provider quality and consider how to help reduce SME transaction costs in finding good quality providers (such as through accreditation schemes and rating schemes). If there are supply-side gaps, consider how to improve service provider capability and availability (such as through training and capacity building). ■ Design initiatives that build capacity of clients to find and effectively use BAS in the future.	

Checklist for Design and Implementation of Business Advisory Services

- Are firms’ management practices poor?
- Are firms using outdated technology?
- Is the problem with adoption related to lack of expertise and skills?
- Do you have other instruments that can support the finance of equipment?
- Do entrepreneurs have enough information on what the key technologies are in their sector? Do they know how to adopt them?
- Do existing diagnostics point toward key gaps in more general management processes?
- Do you have consultants that know the economic sectors well?
- Do you have a way to certify and ensure the quality of business services providers?

References

Benavente, J. M., and G. Crespi. 2003. “The Impact of an Associative Strategy (the PROFO Program) on Small and Medium Enterprises in Chile.” SPRU-Science Policy Research Unit, University of Sussex Business School.

Bloom, N., A. Mahajan, D. McKenzie and J. Roberts. 2018. “Do Management Interventions Last?” World Bank Other Operational Studies 29442, World Bank, Washington, DC.

Bloom, N., R. Sadun, and J. Van Reenen, 2016. “Management as a Technology?” NBER Working Paper 22327, National Bureau of Economic Research, Cambridge, MA.

Bloom, N., and J. Van Reenen. 2007. “Measuring and Explaining Management Practices across Firms and Countries.” *Quarterly Journal of Economics* 122 (4): 1351–1408.

Bruhn, M., D. Karlan, and A. Schoar. 2012. “The Impact of Offering Consulting Services to Small and Medium Enterprises.” World Bank, Washington, DC. Unpublished.

———-. 2018. “The Impact of Consulting Services on Small and Medium Enterprises—Evidence from a Randomized Trial in Mexico.” *Journal of Political Economy* 126 (2): 635–87.

Chrisman, J. J., and F. Katrishen. 1995. "The Small Business Development Centre Programme in the U.S.A: A Statistical Analysis of its Impact on Economic Development." *Entrepreneurship and Regional Development* 7: 143–55.

Cirera, X., and W. F. Maloney. 2017. *The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up.* Washington, DC: World Bank.

Cumming, D. J., and E. Fischer. 2012. "Publicly Funded Business Advisory Services and Entrepreneurial Outcomes." *Research Policy* 41 (2): 467–81.

Dyer, L. M., and C. A. Ross. 2008. "Seeking Advice in a Dynamic and Complex Business Environment: Impact on the Success of Small Firms." *Journal of Developmental Entrepreneurship* 13 (02): 133–49.

Hakimin, Y., ed. 2010. *The Utilisation of the Government Business Support Services: The Senior Adviser Perspectives* (Vol 1). Kelantan, Malaysia: Universiti Malaysia Kelantan.

Hjalmarsson, D., and A. W. Johansson. 2003. "Public Advisory Services—Theory and Practice." *Entrepreneurship & Regional Development* 15 (1): 83–98.

Iacovone, L., W. F. Maloney, D. McKenzie, and D. John. 2019. "Improving Management with Individual and Group-Based Consulting: Results from a Randomized Experiment in Colombia." Policy Research Working Paper 8854, World Bank, Washington, DC.

Lambrecht, J., and F. Pirnay. 2005. "An Evaluation of Public Support Measures for Private External Consultancies to SMEs in the Walloon Region of Belgium." *Entrepreneurship & Regional Development* 17 (2): 89–108.

Lewis, K., C. Massey, M. Ashby, A. Coetzer, and C. Harris. 2007. "Business Assistance for SMEs: New Zealand Owner-Managers Make their Assessment." *Journal of Small Business and Enterprise Development* 14 (4): 551–66.

Maloney, W. F. 2017. "Policies to Increase Firm Capabilities: Lessons from Japan and Singapore." Working Paper, November 28, World Bank, Washington, DC.

McKenzie, D., and C. Woodruff. 2013. "What Are We Learning from Business Training and Entrepreneurship Evaluations around the Developing World?" *The World Bank Research Observer* 29 (1): 48–82.

Sarder, J. H., D. Ghosh, and P. Rosa. 1997. "The Importance of Support Services to Small Enterprises in Bangladesh." *Journal of Small Business Management* 35 (2): 26.

Tan, H., and G. Lopez Acevedo. 2005. "Evaluating Training Programs for Small and Medium Enterprises: Lessons from Mexico." Policy Research Working Paper 3760, World Bank, Washington, DC.

What Works Center. 2014. *Evidence Review: Business Advice.* What Works Centre for Local Economic Growth. https://whatworksgrowth.org/public/files/Policy_Reviews/14-05-16-Business-Advice-Review.pdf.

Widerstedt, B., and J. Månsson. 2015. "Can Business Counselling Help SMEs Grow? Evidence from the Swedish Business Development Grant Programme." *Journal of Small Business and Enterprise Development* 22 (4): 652–65.

Wren, C., and D. Storey. 2002. "Evaluating the Effect of Soft Business Support upon Small Firm Performance." *Oxford Economic Papers* 54: 334–65.

4.2.6.2 Technology Extension Services (TES)

Technology extension services are a type of business advisory services oriented toward the implementation of technological solutions, such as digital technologies. Some extension centers offer both types of services—business advisory services and technology extension services—indistinguishably; often skills development services and training are also offered. Some public research organizations also offer this type of services to industry. Some of the delivery designs are very similar to business advisory services, although services are more likely to be provided "on site" than with business advisory services. Technology extension services are a key instrument to implement digitalization and Industry 4.0 strategies because they directly address the lack of technological capabilities. Unlike for business advisory services, evidence on the impact of this type of services is scarce, and more impact evaluations in this area are needed.

Definition

Technology extension services entail direct on-site assistance to SMEs through extension staff, field offices, or dispersed technology centers to foster technological and knowledge-based modernization to improve the competitiveness of firms. A key differentiation between technology extension services and business advisory services relates to the focus of services. Technology extension services tend to be more sophisticated and directly focused on supporting production technology and innovation capability and activity. However, there is a very large overlap in terms of the support provided because in some cases technology extension services also support the adoption of generic management practices. They are a long-established model in agriculture and in manufacturing. Technology extension services are less common in services sectors, although manufacturing extension services have often been utilized in sectors like health care (such as hospitals), where process efficiency is important.

Some of the most common technology extension services include: quality management and process efficiency (such as lean manufacturing); management of environmental impacts and energy use; advice on the purchase and installation of new technologies; advice on optimizing the use of existing technologies; development of new business models; R&D and commercialization; accreditation for ISO and technical standards; and more generally digitalization. Technology extension services can also involve longer-term and more systematic engagements with SMEs, for instance through formal continuous improvement programs. Given this focus, they are typically delivered by technical experts. Technology extension services can also offer skills development training, addressing both the demand for technology in the firm and the needed supply of adequate labor skills.

In the discussion that follows, the different aspects of technology extension services are discussed, but most of the factors are common to business advisory services. Some of the evidence also relates to both business advisory services and technology extension services.

Market and System Failures Addressed

Technology extension services addresses similar types of failures to those of business advisory services, with a greater focus on those aspects related to technology adoption.

Target Group

As with business advisory services, the primary target groups of extension support are SMEs and advisory service providers. Given that technology extension services involve more sophisticated advice, beneficiaries of technology extension services tend to be larger than in business advisory services. Also, technology extension services focus on a third target group, knowledge providers, such as research organizations, universities, and public laboratories.

Strengths

Technology extension services share similar strengths as business advisory services:

- *They provide a clear and centralized suite of services.* Given the suboptimal provision of advisory services in the private market in developing countries, technology extension services provide a clear suite of services for technology to many SMEs.
- *Technology extension services can offer tailored services based on diagnostics.* This category of instrument can provide firms with specific diagnostic advice plus support through the implementation process, which makes it more likely that the advice is tailored to the business, and that capability building will both occur and be productive. This is critical given that often the technology "problem" may center on how it can be integrated with other production and business functions. This "relationship-based" approach also provides policy makers with much better intelligence on what is happening "on the ground" in client SMEs and sectors.
- *Technology extension services tend to build core competencies.* The management and operational competencies that these services help build are essential for the more complex innovation activity in SMEs, and in some models sophisticated technology extension services are provided alongside innovation or R&D grant support. They can also provide quick financial wins to SMEs (such as by improving production efficiency) that provide the financial basis for further investments in innovation.
- *Technology extension services can help address the skills gaps for some technologies.* Some services can provide or refer to appropriate skills training for specific technologies, thereby narrowing the skills gap that many firms experience when trying to adopt more sophisticated technologies. In addition, by working on the frontline of technology adoption, they can play a role in shaping the suite of training courses for the workforce according to industry's needs.

Potential Drawbacks and Risks

Some of the drawbacks and risks associated with this category of instrument are similar to the ones presented for business advisory services.

- *Risk of overcrowding the market.* The provision of technology extension services needs to be considered carefully to avoid distorting the existing market, although less so than with business advisory services, given that these services are more specialized.

- *Lack of willingness to pay.* TES models that rely on SMEs paying upfront for services struggle, so some brokering and proactive engaging with SMEs is needed.
- *Risk of wrongly prioritizing services.* Providing a thorough and accurate diagnostic before deciding on the type of services needed is key to determine the optimal set of services required. This is more important with technology extension services, which are more sophisticated than business advisory services. Wrongly prioritized technology extension services could do more harm than good, particularly to businesses that lack the absorptive capability to select and utilize the knowledge and to companies that mistakenly prioritize investments in technology without addressing basic management weaknesses.

Other risks, such as the potential mismatch between supply and demand of services, tend to be addressed in the case of technology extension services by the role of advisors/client managers. These advisors, who may sit within a BAS firm, provide an initial diagnostic of the company, refer the SME for more technology extension services when needed, and seek to ensure SME satisfaction with these additional interventions.

Elements for Good Policy Design

Technology extension services and business advisory services can coexist with each other and with other policies aimed at supporting SMEs, with business advisory services generally relevant to a broader market (which includes noninnovative firms). These services often *take a sequential approach* that reflects the need for SMEs to develop and build their absorptive capacities. A company may first focus on improving its basic managerial skills or on simple production improvements before moving into product development or market expansion areas.

TES programs should be relationship-based and tailored to each SME. Ideally, these services are coordinated through a decentralized structure, which allows them to reflect local industry strengths and structures and provides policy makers with real-time information on local economic conditions. However, the programs should make sure there is *consistency in the quality of services* across the country.

TES interventions can be *delivered to groups of SMEs.* This allows SMEs to learn from and support each other in the change process; however, these should still involve some individual advice and coaching. Technology extension services also often provide "one-to-many" services like awareness-raising events (for instance, on new technological developments, business digitalization, or Industry 4.0).

Firm-level benchmarking can be a useful tool for SME performance assessment and behavior change. It provides an empirical mark of how an individual firm is performing relative to peers, as well as targets on which to base improvement strategies. In addition, good TES programs *strike a balance between providing tailored advice (which has a greater impact) and providing standardized packages of offerings (which is more* *cost effective)*. Most technology extension services develop standardized assessment and benchmarking tools, and standardized approaches to common SME problems (such as business planning, production efficiency/lean manufacturing), but tailor the implementation and sequencing of these to the specific circumstances of the client.

There is no agreed best practice on the *fee system* for technology extension services. However, most schemes have been heavily subsidized, particularly for initial services to show SMEs the value of such interventions. If there are extended engagements with clients, then SME contributions should be expected to rise. It is critical, however, to have effective monitoring and evaluation of different copayment schemes at each stage, to help determine the right subsidy level.

TES schemes can be an important instrument in an innovation policy mix. They can underpin broader enterprise improvement schemes, including those aiming to support exports, supply chain development, global value chain development, sectoral initiatives, clean production, and energy efficiency. Technology extension services and business advisory services schemes are used to support firm upgrading, driven by instruments that engage with firms and support firm-level improvement. There is evidence that TES schemes (as well as BAS schemes) are often more effective when they are combined with market development initiatives such as supplier linkages programs to large firms, multinational enterprises, or new export markets because these provide the motivation and incentives to invest in internal improvements. They can be accompanied by financial support for implementation—usually through matching grants. These address the financial risk of implementing new technologies and business models within SMEs.

Evidence of Impact

The limited number of studies that analyze the causal impact of TES policy interventions are primarily focused on OECD countries. The majority of the studies analyzed that directly evaluate technology extension services are from manufacturing extension services programs because these are the most common type of technology extension services. Table 4.22 summarizes key findings from the selected studies, which provide insight into the effectiveness of the US Manufacturing Extension Partnership (MEP) program, the UK Manufacturing Advisory Service (MAS) program, the UK Business Link (BL) program, and the Canadian Industrial Research Assistance Program (IRAP). The studies focus on issues such as productivity and output/outcome additionality (sales, employment, and so on), and softer dimensions such as enhancement of firms' knowledge and capabilities. Most studies find that technology extension services had a beneficial effect on business outcomes, but the effects vary from context to context, and might be conditional on the intensity and the combination of the services offered.

Overall, moderate but highly customized services in the product development and marketing areas led to greater benefits, while routine services focused on quality and

TABLE 4.22 Evidence on Effectiveness of Technology Extension Services Programs: Key Findings

Study	Context	Finding
Bloom, Sadun, and Van Reenen (2012)	India	Highly intensive extension support in adopting managerial, production, and organizational practices to a set of medium-sized textile companies led to raising average productivity by 11 percent through improved quality and efficiency and reduced inventory. The cost of interventions could be recovered in one year. (Caveat: The experiment fully subsidizes the intervention costs, which is not the case for most TES.)
Jarmin (1999)	United States, Manufacturing Extension Partnership (MEP)	MEP client plants moved up their industry productivity distributions over time. MEP participation caused an increase in labor productivity Value added per worker was 2.5 percent–5.9 percent higher for participating firms than for nonparticipating firms.
NIST (2011)	United States, MEP	For every $1 of federal investment, MEP generates $32 of return in economic growth. MEP centers create or retain one manufacturing job for every $1,570 of federal investment—one of the highest job growth returns of all federally funded programs.
Shapira and Youtie (1998)	State of Georgia, United States, MEP	Not all firms benefitted the same from the program; the services had a substantial impact on only a few firms.
Luria (1997)	State of Michigan, United States, MEP	Participating SMEs improved more than nonparticipating firms in sales growth, employment growth, and certain process improvements, but they did not improve in wage rates, profitability, and labor productivity.
Mole et al. (2008)	United Kingdom, Manufacturing Advisory Services (MAS)	A more intensive MAS program produced greater benefits in areas such as productive use of equipment and employment growth, and better stock holding, and delivery.
DTZ Consultancy (2007)	United Kingdom, MAS	The estimated rate of return of the program over a five-year period was 15 percent–17 percent.
Roper and Hart (2005)	United Kingdom, Business Links program (BL)	Recipients of the BL program support experienced a positive and statistically significant effect on productivity growth. However, no significant relationship between business advising and growth in either sales or employment is found.
Mole et al. (2008)	United Kingdom, BL	Firms that received intensive advising experienced significantly more growth in employment, but not in sales growth, than firms that received limited or no advising. Firms that received limited advising performed no better than those receiving no advising on the outcomes assessed.
NRC and Goss Gilroy (2007)	Canada, Industrial Research Assistance Program (IRAP)	The program generated benefits of more than 10 to 1 relative to public sector costs, based on multipliers derived from input-output models.
Goss Gilroy (2012)	Canada, IRAP	70 percent of the clients agreed that the program helped increase the firm's business skills and knowledge; 82 percent agreed that the program increased their scientific and technical knowledge; 90 percent agreed that it enhanced technical knowledge or capabilities; and 68 percent agreed that it enhanced business knowledge/capabilities.

process improvement achieved less significant benefits (Manrique et al. 2008; Shapira and Youtie 1998; Thompson 1998). In comparing TES practices across several countries (Argentina, Canada, Germany, Japan, Spain, the United States), Shapira, Youtie, and Kay (2011) observe that there has been a constant tension between pressure to increase coverage (serve more firms) and the demand to provide customized services (which usually requires more staff time and leads to less coverage).

Main Requirements for Replicability

There is some similarity in policy lessons between technology extension services and business advisory services, such as the necessity of implementing the initiative close to clients' programs but at the same time maintaining a level of consistency and quality across the nation. The studies also suggest some policy lessons that are specifically relevant to technology extension services.

- *Capability and capacity needs for the implementing agency.* Implementing agencies should have the capacity to conduct needs assessments to design and implement the program. The objective of TES schemes is to provide high-quality and tailored services to SMEs; therefore, these programs need to be run like a service business (given that they have many features of a consultancy service). They require high-quality staff who are managed and remunerated effectively, and they require a strong customer and service focus. Applications and other administrative processes need to be kept as simple as possible. These needs generally mean that technology extension services are best delivered through quasi-private agencies or structures and may involve close links to organizations focused on SMEs. If TES schemes are run as "standard" government programs, with a focus on transactional efficiency and utilizing civil servants and their culture, they are unlikely to deliver the results desired.
- *Technical expertise.* To deliver effective technology extension services, implementing agencies should engage a cohort of technical experts who can provide the needed assistance to clients in the various operational areas. These may be employed as staff or may reside in the market and be drawn on as needed; however, they need to be available and at a price the client SME and government are prepared to pay. There also needs to be a central cohort of "client or business advisors" who manage the main relationship (and often undertake the initial assessment) of the client. These can be trained if not immediately available, but this role is different from public service administration.
- *Capacity of SMEs.* Participants should be able to assess whether the TES proposition is relevant to their own needs, sometimes assisted by external consultants. They should show a commitment to undergo the process and the ability to absorb the assistance in the form of extension. Ability and willingness to modify their own processes to upgrade is critical. In addition, participants should be willing to cover some of the costs of technology extension services. The greater the subsidy, the more the number of clients or the length of services will be reduced. While increasing the amount of costs paid by firms allows additional leveraging and reduces the public funds spent, it can lead to the services to go "up market" to serve larger firms that can afford to pay higher fees. Many services use a model in which the initial service is free or heavily subsided, but ongoing services require copayment.
- *Policy coordination.* TES programs should be coordinated with other regional and national efforts that target SMEs, technology, and innovation. TES programs are

also potentially vital for the success of other initiatives aimed at SMEs because they help build the capacity of SMEs and enable them to be more effective users of other government programs (such as export initiatives) and of private providers (such as applying for bank financing), and to articulate their needs (such as for skills and training programs, or for infrastructure). Technology extension services should also play a critical role in the commercialization of technologies from universities and in bringing new technological solutions to SMEs, including the implementation of technology roadmaps and Industry 4.0 strategies.

- *Enhancing uptake.* TES programs need to be marketed proactively. Experience shows that just making free or heavily subsidized services available does not necessarily lead to uptake by SMEs because SMEs often do not understand the potential value of the service. Given this, linking with industry-focused organizations (such as industry/trade associations) or key intermediaries who interact with SMEs (such as commercial banks) can be important because these trusted intermediaries can vouch for the potential value of these interventions. In Japan, the banking sector is a major referrer of SMEs seeking upgrading support from the extensive business advisory services and technical extension services. Moreover, facilitating the exchange of experiences among SME owners might increase receptiveness to use of technology extension services. Providing opportunities for SMEs to learn and interact with one another within improvement programs can be very beneficial.

Dos and Don'ts of Technology Extension Services

Do	Don't
▪ Strongly consider public-private delivery models. ▪ Implement holistic management and production diagnostics. Try to gather knowledge about the management and production constraints of particular SMEs, so that targeted, intensive services can be provided, which is a precondition for effectiveness. ▪ Ensure that technology extension services incorporate delivery of face-to-face, on-site support to the recipients, so that a deeper understanding of local circumstances and better policy results can be achieved. ▪ Employ high-quality staff who have technical competencies and who will	▪ Don't design or deliver technology extension services in isolation from other programs also targeting SMEs. Technology extension services (together with business advisory services) can help enhance SMEs' absorptive capacity, which could improve the effectiveness of other SME policies. ▪ Don't assume a well-designed, favorable program can automatically attract SMEs. SMEs with low absorptive capacity might not understand the value of TES, and agencies need to actively reach out to promote the program, including through intermediary organizations (such as industrial associations).

Dos and Don’ts of Technology Extension Services

Do	Don’t
be respected and listened to by SME clients. Use performance-based indicators to monitor and incentivize staff. ▪ Utilize existing and past program participants to market and advocate for the program. ▪ Employ an integrated mix of services that raise awareness of traditional and new technologies, provide practical tools to diagnose current readiness and performance, and provide advisory support to implement upgrading and manage change. ▪ Build links with research institutions, technology centers, and technical training providers that can all contribute to awareness raising and technical upgrading in different ways. ▪ Try for a mix of individual and group activities, to capitalize on learning across the cohort, stimulating opportunities for uptake and experience exchange.	▪ Don’t run TES as a standard government bureaucracy. Partner with industry associations. This will encourage the appropriate service culture and will facilitate retaining the right kind of staff.

Checklist for Design and Implementation of Technology Extension Services

- Do technology road maps and other diagnostics indicate that firms are using outdated technology?
- Is the problem with technology adoption related to lack of expertise and skills? Do existing diagnostics point toward key gaps in more general management processes?
- Do you have other instruments that can support the finance of equipment and technologies?
- Do entrepreneurs have enough information about what the key technologies are in their sector? Do they know how to adopt them?
- Do you have “extensionists” and consultants that know the sectors well and the technologies that could be adopted?
- Do you have access to highly specialized sector technology consultants?
- Do you have direct links with public research organizations and universities to facilitate transfer of technologies?
- Can you design technology extension services as a public-private partnership?

References

Bloom, N., R. Sadun, and J. Van Reenen. 2012. "Does Management Really Work?" *Harvard Business Review* 90 (11): 76–82.

DTZ Consultancy. 2007. "Evaluation of the Manufacturing Advisory Service." DTZ, London.

Goss Gilroy, Inc. 2012. "Evaluation of the NRC Industrial Research Assistance Program (NRCIRAP)." Goss Gilroy, Inc., Ottawa.

Jarmin, R. S. 1999. "Evaluating the Impact of Manufacturing Extension on Productivity Growth." *Journal of Policy Analysis and Management* 18 (1): 99–119.

Luria, D. 1997. "Toward Lean or Rich? What Performance Benchmarking Tells Us About SME Performance, and Some Implications for Extension Center Services and Mission." In *Manufacturing Modernization: Learning from Evaluation Practices and Results: Evaluation of Regionally-Based S&T Programs,* Proceedings of Third Workshop on the Evaluation of Industrial Modernization Programs, edited by P. Shapira and J. Youtie, 6–29. Atlanta, Georgia: Georgia Institute of Technology.

Manrique, L., K. Bobb, D. Roessner, J. Youtie, and P. Shapira. 2008. "Eureka! Winning Ways: Analysis of Early Client Experiences." https://pdfs.semanticscholar.org/3859/012a4bed7ab381b072f4887107776232d619.pdf.

Mole, K., M. Hart, S. Roper, and D. Saal. 2008. "Differential Gains from Business Link Support and Advice: A Treatment Effects Approach." *Environment and Planning C: Government and Policy* 26 (2): 315–34.

NIST (National Institute of Standards and Technology). 2011. "The Manufacturing Extension Partnership: Partnering for Manufacturing Innovation and Growth." NIST.

NRC (National Research Council, Canada) and Goss Gilroy, Inc. 2007. "Impact Evaluation of the NRC Industrial Research Assistance Program (IRAP)." NRC and Goss Gilroy, Inc., Ottawa.

Roper, S., and M. Hart. 2005. "Small Firm Growth and Public Policy in the UK: What Exactly Are the Connections?" Aston University Business School.

Shapira, P., and J. Youtie. 1998. "Evaluating Industrial Modernization: Methods, Results, and Insights from the Georgia Manufacturing Extension Alliance." *Journal of Technology Transfer* 23 (1): 17–27.

Shapira, P., J. Youtie, and L. Kay. 2011. "Building Capabilities for Innovation in SMEs: A Cross-Country Comparison of Technology Extension Policies and Programs." *International Journal of Innovation and Regional Development* 3 (3–4): 254–72.

Thompson, C. 1998. "Local Politics, National Policy, and the Taxpayer-Payback of Manufacturing Extension." *Journal of Technology Transfer* 23 (1): 55–64.

4.2.6.3 Technology Centers (TC)

Technology centers are public or public-private infrastructure dedicated to providing technology extension services and skills training. They tend to be sector specific and accumulate considerable technology expertise in a sector, often helping to develop new technological solutions or adapting existing market technologies to the needs of the domestic sector. Technology centers are often an important part of a regional national innovation system, given their location and proximity to industry clusters. As in the case of technology extension services, the evidence on their effectiveness is highly qualitative and scarce. It is likely that their impact depends on the quality and capabilities of the sector and the strength of local clusters.

Definition

Technology centers are a broad category of government-supported institutions that provide a range of technological services to business,[29] from innovation and technological services to more sophisticated R&D projects and technological development. These centers tend to focus on a particular sector and are often implemented as public private-partnerships with industry or sector associations.

Technology centers can have very different functions in developing countries compared with those in developed countries. In developing countries, technology centers can serve as a policy vehicle to house support measures, such as provision of modern manufacturing equipment and related training, product testing and design, development, and demonstration. They might not have a strong R&D focus, but instead focus on the diffusion of technologies to SMEs. Typically, they provide the target group workforce training (and often charge a fee for this service). Technology centers intend to address cross-cutting issues such as design and fabrication, as well as address skills gaps in new production technologies and processes. Technology centers also frequently involve business advisory services and technology extension services, as well as certification services. In developed countries, technology centers tend to have less focus on mainstream workforce training and to have moved up the value chain, often providing practical advice on how to innovate and adopt new technologies, brokering applied R&D, and helping firms become more aware of available technology. In Japan, local public technology centers not only provide small local firms with various technological services, but also conduct their own research and patent inventions (Fukugawa 2009).

Technology centers may be stand alone or part of a larger network. One of the best-known networks globally is the Fraunhofer in Germany, a network of 72 applied research centers that work closely with industry and with other parts of the research sector. One relatively new initiative of Fraunhofer is the Industry 4.0 Competence Centers, which are intended to address cutting-edge technologies and to bring digitalization and networking technologies to German manufacturing SMEs. An example of network of technology centers in developing countries is the Indian Technology Centers Network, which is a World Bank-funded initiative running from 2015 to 2021. The stated objectives of this network are to provide access to advanced manufacturing technologies and to skilled manpower by offering opportunities for varying levels of technical skill development to youths.

Market and System Failures Addressed

Technology centers are an attempt to address the following market and system failures:

- *Coordination failures.* Firms, especially SMEs, tend to act in an uncoordinated fashion in adopting and generating new technological solutions, and often are reluctant or lack the expertise to jointly develop new technological solutions. Technology centers address the coordination problem and agglomerate the necessary skills and R&D effort to develop and diffuse more complex technologies.

- *Information asymmetry.* SMEs often do not have sufficient information about available technologies and are often reluctant to collaborate with universities and public research organizations in developing join projects. Technology centers provide a bridge between these actors and signal the most appropriate technological solutions.

Target Group

The target group of technology centers typically involves the following innovation actors:

- *SMEs.* The main target group of technology centers are SMEs that lack the funding or capability to build internal capacity in specialized technological areas or to purchase equipment that they may use only infrequently.
- *Larger companies with specific needs.* Larger companies may be involved as clients, for instance if they are seeking to upgrade their supply chains or if they are engaged in collaborative R&D.
- *Other stakeholders.* Because most centers have a sectoral or technology focus, they generally have a broader stakeholder base beyond individual firms or groups of firms, including industry organizations.

Strengths

Some key strengths of this instrument are:

- *Providing targeted training and services close to industry.* Technology centers provide a focus around which industry can start to upgrade their technologies and skill base. For individual firms and industries to develop deeper competencies, they will usually require specialized training, technology, and support services. These may not be provided through the mass training system or through existing applied science and technology and research organizations or through the private market, which can be weak in developing countries.
- *Supporting both the creation and diffusion of innovation.* Technology centers can act as both drivers of domestic innovation and mechanisms to diffuse new and existing technology. On the technology diffusion side, technology centers capture global industry-specific technologies and changes in business practice and make them available to domestic industry stakeholders through services. They can speed the technology adaption process technologies. On the technology creation side, technology centers support the development of indigenous processes and product innovation from local industry.
- *Creating new markets.* Technology centers can act as market developers that identify and provide services and training that are not addressed by private providers. When private providers come into the market, technology centers can move into newer areas of unaddressed needs.

Potential Drawbacks and Risks

Some of the potential drawbacks and risks associated with this instrument are:

- *Capture.* Establishing technology centers provides opportunities for corruption (for example, in the acquisition of land, building, and equipment acquisition). This can particularly be a problem for developing countries. Moreover, there is a need to avoid potential capture by one or two powerful industry players that can then skew the center's activities to their own advantage.
- *Difficulty in maintaining relevance to industry.* Technology centers that are government run, and that rely on government management approaches and pay-grades, can struggle to be sufficiently relevant to industry. There are various examples across emerging economies of "white elephant" centers that have poorly trained government employees and depreciating assets that become unused by industry.
- *Risk of being merely physical infrastructures.* In developing countries, staff capabilities and expertise can be insufficient to design and run technology centers as integral parts of the innovation policy mix; rather, there can be too much focus on the physical infrastructure during the design and establishment phase, and not enough on getting the right governance structure, leadership, staff, and combination of services.

Elements for Good Policy Design

Policy makers need to make appropriate decisions on a few crucial issues to lay the foundation of good policy design, including but not limited to the following:

- *Ownership of the program.* Technology centers can be entirely government owned and run or operate on a public-private partnership basis. Given their industry focus, technology centers need to have strong industry engagement, which usually includes industry representation on the board. Therefore, strong involvement or partnership with the private sector is recommended, rather than running the center as a fully government-owned scheme, which is likely to end up being not relevant to the target group.
- *Developing a sustainable business model.* Most technology centers operate with at least some level of government subsidy, which is often initially large but falls over time. For the longer term, however, technology centers need to maintain a sustainable business model. Typical revenue sources include fees charged for training services, testing, certification services, and use of equipment. However, many crucial services are difficult to make profitable. In such cases, centers need to find ways to cross-subsidize their activities, or such services will need to be fully subsidized for extended periods. The business model in many developed countries for technology centers is the one-third rule: one-third subsidy; one-third services revenue; and one-third technology royalties from licenses and intellectual property. While this is a desirable model because it provides incentives for the three key functions of a technology center—to address key failures, provide services and training, and generate new technological solutions—meeting all

three functions can be very difficult to achieve, especially in developing countries with low capacity to generate technology and intellectual property. In such cases, more subsidy will be needed. It is desirable that this subsidy be allocated in the form of competitive grants, to ensure the relevance of the technology center.

- *Deciding on the strategic focus.* Many centers focus on specific industry sectors or types of technology, such as subsectors of manufacturing. This may include housing modern production technology for demonstration purposes to showcase best practice to SMEs . In some cases, the required equipment is used in seasonal production (such as a processing plant) or in product development (such as CAD/CAM design tools or—increasingly—3D printers). Thus, SMEs only need access to the equipment infrequently, so they would not invest in it themselves. Other centers undertake product development but have a stronger focus on more sophisticated forms of applied R&D and engage in collaborative innovation projects with specific industry sectors. In any case, technology centers should have a clear strategic focus so that the limited resources can be directed toward the objectives of the intervention. Technology centers ideally form part of a broader strategic plan to upgrade a sector or industry that would typically be part of a national industry development or export strategy.
- *Location and proximity.* Technology centers are geographically specific, which requires their industry customers to be close by for many of their services. When designing this type of intervention, policy makers need to consider the locations of potential users of the centers and choose the optimal location closest to existing clusters.

Evidence of Impact

Evidence on the effectiveness of technology centers is extremely scarce. For this profile, five studies have been selected to shed light on various issues related to technology centers. Three of the studies consider local public technology centers in Japan, while the other two look at the centers in the United States and Mexico. The limited evidence covers several issues, including their patenting behavior (Fukugawa 2009), business models (Feller 1997), whether they fit into the regional innovation systems (Fukugawa 2008), and contributing factors to the self-sustainability of technology centers (Urbina, Samuel, and Molina Morejón 2016). Key findings are summarized in table 4.23.

Japan has a long history of utilizing technology centers as a policy instrument to boost regional innovation and competitiveness, dating back to the 1880s or so (Fukugawa, 2009). These technology centers have long served as the cornerstone of local technology service provision in Japan (Shapira 1992).

Main Requirements for Replicability

At least a few conditions need to be met to make technology centers work:

- *Existence of a relatively strong cluster of promising firms.* Some of the successful technology centers are the solution to the coordination failure found in strong

TABLE 4.23 Evidence on Effectiveness of Technology Centers: Key Findings

Study	Context	Finding
Feller (1997)	United States, manufacturing technology centers (MTCs)	Enough firm-specific accounts exist to indicate that MTC programs can contribute to the competitiveness of small- and medium-sized manufacturing firms. In terms of business model, MTCs are under increasing pressure from federal sponsors and external review panels to move in the direction of fee-based services. However, many MTCs view fees as an uncertain and volatile source of revenue until they have developed a larger and more stable client base, and fees are considered to be inconsistent with the national interests being served by the program.
Shapira (1992)	Japan, local public technology centers	With their intensive geographical coverage, broad range of technical services and nominal fees, local public technology centers offer small Japanese firms a readily available and effective source of assistance to improve their manufacturing operations, technologies, and products.
Fukugawa (2008)	Japan, local public technology centers	The strategy adopted by local public technology centers from 2000 to 2005 was irrelevant to the characteristics of regional knowledge transfer (data for 2000). This suggests that that small local firms lost an opportunity to improve their productivity by leveraging external knowledge due to the misallocation of resources of local public technology centers in the region. Unnecessary technological services may have been provided, while small local firms were unable to find the services they actually needed.
Fukugawa (2009)	Japan, local public technology centers	Employing more PhD scientists tends to promote the licensing of patents, while organizational efforts (on factors such as ownership structure, incentive mechanisms, and closing the cultural distance between universities and industry) that encourage scientists to better understand the technological needs of small local firms tend to increase royalty revenue.
Urbina Samuel, and Molina Morejón (2016)	Mexico, Technological Research and Development Centers (CTID)	Results show that most valuable key factors contributing to self-sustainability of Centros de Investigación y Desarrollo Tecnológico (CTID) are: customer focus (proactive and strategic management of client relationships); technology management model (technological intelligence); licensing strategies; project management (appropriate usage of structured approaches and software for budgeting and administration); and business culture (collaboration and spin-offs).

clusters of firms in specific sectors. Lack of these clusters calls into question the main purpose of technology centers: to serve industry with advanced and appropriate technological solutions. Thus, policy makers should invest in these technology centers only when some reasonably strong cluster already exists in an industry.

- *Sufficient initial investment.* Centers are generally capital-intensive. They need land, buildings, staff, and equipment while they are being established, and then need to capital to maintain equipment and update services. Significant amounts of capital from the very beginning are typically necessary to support such an initiative. Some support is also required over the medium to long term as centers seek to find a viable business model.
- *High levels of hard and soft assets (capabilities).* Capability needs to design and deploy technology centers are high, given that centers require infrastructure, organization building, and close engagement with end users. The management and staff of technology centers need to be good at maintaining both hard and soft assets, which means a high level of competences is needed.

- *Continuing relevance.* Technology centers need to maintain equipment and services to stay relevant. Failed centers have often either had the wrong equipment from the start or have failed to keep up with industry practice and have become irrelevant to potential users. Maintaining relevance also means there is a need for strong industry engagement and buy-in.

Dos and Don'ts of Technology Centers

Do	Don't
▪ Consider the development of technology centers as part of the bigger picture of sectoral/industrial development in the region/country and define a clear strategic focus for the intervention. ▪ Engage with the private sector in designing and delivering the intervention to make sure the technology centers are relevant to potential customers. ▪ Ensure sufficient funding for both the initial and the maintenance stages because technology centers tend to be capital-intensive and face difficulties in achieving financial sustainability in the short term. ▪ Seek strong buy-in from industrial stakeholders and a public-private delivery model to ensure the relevance of the intervention to potential users. ▪ Carefully balance a service mix of existing and new technologies.	▪ Don't treat technology centers as physical infrastructure (buildings and equipment) only; they are holistic packages of infrastructure and services, which combined serve as a policy mix. ▪ Don't ignore the importance of maintenance after the initial stage of intervention. Technology centers as a long-term intervention need to stay relevant as the needs of potential customers evolve and as the innovation landscape changes. ▪ Don't run technology centers as bureaucratic entities. Technology centers need to be strongly focused on and responsive to industry, and able to employ and retain staff with high levels of technical knowledge.

Checklist for Design and Implementation of Technology Centers

- Does some reasonably strong cluster already exist in a specific sector or industry?
- Are firms ready to the adoption of more sophisticated technologies? Are your technologies adequate for the level of maturity of the sector?
- Do you have access to highly specialized sector technology consultants?
- Do you have direct links with public research organizations and universities to facilitate transfer of technologies?
- Can you design the center as a public-private partnership?
- Do you have a clear business model for the center to avoid constant or full subsidization?

References

Feller, I. 1997. "Manufacturing Technology Centers as Components of Regional Technology Infrastructures." *Regional Science and Urban Economics* 27 (2): 181–97.

Fukugawa, N. 2008. "Evaluating the Strategy of Local Public Technology Centers in Regional Innovation Systems: Evidence from Japan." *Science and Public Policy* 35 (3): 159–70.

————-. 2009. "Determinants of Licensing Activities of Local Public Technology Centers in Japan." *Technovation* 29 (12): 885–92.

Shapira, P. 1992. "Modernizing Small Manufacturers in Japan: The Role of Local Public Technology Centers." *Journal of Technology Transfer* 17 (1): 40–57.

Urbina, C., A. Samuel, V. M. Molina Morejón, and M. D. C. Armenteros Acosta. 2016. "Determinant Factors for Success in Self-Sustaining Research & Development Technology Centers." *Global Journal of Business Research* 10 (4): 83–93.

4.2.6.4 Science and Technology Parks (STPs)

Science and technology parks (STPs) are often located near universities and public research organizations to attract R&D- and technology-intensive firms and to encourage university spin-offs[30] and the commercialization of research. They are designed to maximize the spillovers from agglomerating R&D activities. However, if poorly designed and/or run, science and technology parks can simply be real estate developments with few innovation spillovers. Science and technology parks are physical infrastructures, but their effectiveness depends on soft elements—on the services and activities that occur within them to induce innovation, on the initiatives (such as funding) they attract, and on the quality and intensity of innovation of tenant research organizations and businesses.

Definition

Science and technology parks typically feature physical spaces offering infrastructure and various support services to high-tech and R&D-intensive firms (box 4.10).[31] The primary objective of science and technology parks is to support the development of technology- and R&D-intensive sectors through the agglomeration of R&D activities via the attraction of R&D activities from multinational enterprises (MNEs) and the commercialization of research and the transfer of new technologies. Science and technology parks aim at exploiting the spillover benefits from the agglomeration of such activities. The parks typically have formal linkages with universities—often, they are located on university campuses—and public research organizations (PROs), whereby researchers engage in contract research with R&D-intensive firms, take part in university R&D activities with commercialization potential, and benefit from the physical proximity between business entities and public research organizations. While science and technology parks often attract large or established companies, they also aim to attract spin-offs from research groups in universities and public research organizations. From an ecosystem perspective, science and technology parks can serve as hubs to create and enhance local ecosystems of innovation and entrepreneurship, promoting collaboration between

BOX 4.10

Definition of a Science and Technology Park

A *science park* is an organization managed by specialized professionals whose main aim is to increase the wealth of their community by promoting the culture of innovation and the competitiveness of associated businesses and knowledge-based institutions.

To enable these goals to be met, a science park stimulates and manages the flow of knowledge and technology among universities, R&D institutions, companies, and markets; facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high-quality space and facilities

Source: Adapted from International Association of Science Parks and Areas of Innovation.

different stakeholder groups such as industry, academia, and the government and further catalyzing innovation-driven development of the local economy. The popularity of science and technology parks among policy makers was in part motivated by the successes of famous cases such as Stanford Research Park in Silicon Valley in the United States, and more recently TusPark in the Zhongguancun Innovation Zone in China.

With clearly defined target groups and geographical/technological/sectoral scopes, science and technology parks can also serve as vehicles to implement different innovation policy instruments (such as financial instruments like R&D grants), as well as non-financial instruments (such as advisory services). Increasingly, science and technology parks also incorporate incubation and acceleration programs to nurture and accelerate the development of new enterprises and spin-offs. This dimension was missing in early designs, resulting in a lack of early-stage activity. The combination of different support measures, in addition to the provision of sophisticated facilities and office space, offer businesses strong incentives to locate in science and technology parks. Some countries also offer STP tenants specific tax incentives (such as Turkey, which provides incentives to both tenant firms and employees) not enjoyed by firms outside the parks.

Science and technology parks vary greatly in terms of their business model, mission, geographical scope, sectoral focus, resources, and incentives package, among other dimensions. For example, in terms of business model, some parks host tenants for a defined period, some lease land/buildings, while others opt to sell real estate to enterprises. Locations of science and technology parks can be a well-defined space, often close to universities, or cover larger geographical areas (such as the Zhongguancun Innovation Zone in Beijing, which comprises several different campuses across the city).

Market/System Failures Addressed

Science and technology parks primarily address two key market/system failures that severely hinder university and industry collaboration and technology transfer, and as a result, innovation.

- *Agglomeration economies and knowledge spillovers.* The clustering of technology-intensive enterprises around university locations increases the possibility of significant spillovers (Wen-Jung et al. 2019) and lowers the costs of providing specialized services. Some of these cluster benefits are common to other business development support instruments, such as business parks or industrial parks, but what is specific to science and technology parks is the attempt to also match the demand and supply for knowledge. On the supply side, universities can benefit from learning and opportunities for contract research from technology/R&D companies. On the demand side, firms can benefit from easy access to university research.
- *Coordination failure.* The primary failure that science and technology parks target is coordination failure among different innovation actors in local innovation systems. Coordination failure is one of the main barriers that hinders innovation because innovation activities nowadays increasingly have a systemic and nonlinear nature. Fragmentation and poor communication among different actors, such as universities, large and small firms, and intermediaries, can severely limit the efficiency of innovation systems. Science and technology parks, through geographical proximity and provision of support mechanisms, can significantly enhance coordination among different actors. By tackling coordination failures, science and technology parks can also help address other market failures, such as information asymmetry by enhancing the information flow between actors.

Target Group

The primary target groups of science and technology parks are high-tech– and R&D–intensive enterprises on the one hand, and universities and public research organizations on the other. A key objective of science and technology parks is to bring the two sides together to stimulate research commercialization, R&D, and new technological start-ups arising from university spin-offs. Science and technology parks are also an instrument for attracting the R&D activities of multinational enterprises through MNE research centers and/or joint research activity.

For start-ups, science and technology parks typically offer incubation programs, advisory services on business and managerial skills, and support to gain access to financing. For more mature businesses investing in the science and technology parks, STPs can provide an environment where firms can develop close collaborations with research organizations and departments that suit their R&D needs. Science and technology parks can be particularly useful for multinational enterprises that launch R&D centers abroad because their settings and offerings significantly reduce the risks involved by locating centers (and key staff) in an R&D–friendly environment.

Science and technology parks offer support to research organizations (including both universities and public research organizations) to commercialize academic research or to promote technology transfer to business entities. Linkage with a science and technology park can provide indirect benefits to research organizations through interactions with end-users, such as contract research, and more patenting and publishing outputs. Moreover, association with a science and technology parks is in line with the mission of a modern university, which may involve contributing to the local economic development through knowledge transfer, commercialization, and production of research.

Strengths

Some of the key strengths of science and technology parks include the following:

- *Generating spillovers and network effects.* Science and technology parks maximize spillovers and network effects by agglomerating innovative activities, including research and extension, in a structured way and in a specific location. This agglomeration can make it easy to concentrate support (both physical infrastructure and other support) and can also attract investment.
- *Serving as vehicle to deliver various policy instruments.* Science and technology parks can serve as the venue to implement a mix of policy instruments, such as grants, vouchers, procurement, tax incentives, loans, and advisory services.

Potential Drawbacks and Risks

STP instruments have a high risk of becoming real estate development operations. Specifically:

- *STPs do not address the research quality problem directly* Often research commercialization and spin-offs do not happen because incentives for high-quality applied research are missing and/or there are problems with the ownership of intellectual property. STPs require some existing critical mass of good research that can be commercialized. Bringing high-tech/R&D companies to the park will do little to support more commercialization and transfer from universities if this critical mass is absent.
- *In practice, some STPs work more as property development operations*, providing inexpensive real estate and office services, but not providing much in the way of innovation-related value added or university linkages and often requiring local authorities to cover the costs of real estate infrastructure.
- *STPs are less suited for early-stage support.* Some of the spin-offs that could arise from universities would benefit more from the proximity to other start-ups in inner urban areas. Tenants in science and technology parks tend to be older and established companies, with different organizational cultures than young start-ups.

Elements for Good Instrument Design

There are some common characteristics shared by successful science and technology parks—as identified by practitioners and researchers (NRC 2009; European Commission 2017)—that can offer insight regarding good policy design.

- *Market, vision, and strategy.* The design of science and technology parks must be based on a thorough assessment of market and system failures and existing ecosystems in the region. This will allow the target group and their needs to be clearly identified, which can directly improve the design of a science and technology park and help it achieve its long-term goals and strategy If some of the preconditions outlined above are not met, strategies should also be in place to compensate for the missing conditions. It is critical that science and technology parks develop a business plan that includes a good diagnostic of local R&D capabilities and potential for commercialization—and more importantly, the sources of financial sustainability.

- *A strong urban planning and design concept.* There must be an overall urban planning concept and a coordinating urban planner who supervises the architecture of the individual buildings. Flexibility in the concept is of great importance to long-term planning and sustainability. In addition, the campus and individual buildings should be designed to encourage interaction/networking and collaboration.
- *Strong management.* Effective leadership and professional management are required to run several core activities of science and technology parks, including the supervision of facilities, such as laboratories, clean rooms, and testing facilities, and the facilitation of networking among entrepreneurs, researchers, investors, and others within and around the research park's innovation ecosystem. Committed champions who take initiative can play a powerful role in matching business demands with policy support and related resources.
- *Appropriate package of services.* To maximize effectiveness, it is important to have a comprehensive package of services that is well suited to the needs of tenants in science and technology parks. Driven by the profiles of businesses, the package can include access to sources of financing, management and marketing advisory services, incubators and accelerators, and networking support. Public services could be enhanced through intermediary organizations, such as industry associations and think tanks.
- *Facilitating role for government.* The local government's commitment is important and (in cooperation with other government agencies) can play a role in attracting businesses and improving national and international accessibility. Government subsidies are often necessary, certainly in the starting phase (government is often the source of the land). Government loans to set up science and technology parks are also attractive because the term of these loans is often longer than those provided by financial institutions. However, it is critical for the government to have an accreditation mechanism that establishes what projects can become science and technology parks based on R&D and research capabilities, and a business plan that makes science and technology parks financially sustainable.
- *Metrics, monitoring, and evaluation.* Well-defined metrics should be in place during the design of science and technology parks to help policy makers set clear goals and, over time, gauge the effectiveness of intervention. Evaluation of science and technology parks is very challenging due to their complex and systemic

nature, but at least a few key dimensions should be considered when designing the evaluation methodology, including performance of science and technology parks against stated goals that justified the intervention in the first place, the return on public investments, whether firm performance is enhanced, whether university performance is enhanced, and the (perceived) value of the park to tenants.

Evidence of Impact

Assessing the impact of science and technology parks is a challenging task due to two main issues.[32] First, there is a huge diversity of science and technology parks given their different goals, facilities, industry base, funding, and management structures, as well as the economic, political, and social environments surrounding them. This makes comparing one STP with another extremely complex. Second, the impacts of science and technology parks primarily come from the dynamics they stimulate, such as interactions between stakeholders and collaborations between organizations. Capturing these dynamics and tying them to the STP and its services is often a complex task and requires measuring outcomes years after the STP is in place.

In this context, qualitative methods have an important role to play in the assessment of science and technology parks, to uncover the underlying causal linkages that are not typically addressed through quantitative methods. Indeed, several of the studies reviewed in this profile utilize case study methods to investigate the processes and interactions that led to science and technology park performance, such as Ratinho and Henriques (2010) and Tsamis (2009), The body of literature on science and technology parks has been growing steadily over the past few decades. However, the geographical coverage is skewed toward a selected number of countries, such as the United States, United Kingdom, Spain, and China (Hobbes, Link, and Scott 2017). In particular, studies on China's science and technology parks tend to have employed case study methods due to the lack of extensive data, while studies on the United Kingdom and the United States have benefitted from more data availability.

This concentration of evidence in a few countries, most of which are high-income, is problematic when applying this evidence to developing economies. If necessary conditions (discussed later in this profile) for the success of an STP require some basic capabilities in applied research that can be commercialized, then the evidence presented is conditional on having these capabilities. None of the studies try to identify the necessary capabilities. As a result, the external validity of this evidence when thinking about setting science and technology parks in low- and middle-income countries is questionable.

With this caveat in mind, Hobbes, Link, and Scott (2017) provide a detailed review of the literature. The review reveals that most evidence is focused on processes and performance (such as how different factors influenced the dynamics within the science and technology parks), as well as output additionality (such as patenting and publishing activities).

This review has identified only one study shedding light on input additionality—Lamperti, Mavilia, and Castellini (2017), which compares the performance of firms located within a park with a control sample of off-park firms in the Italian context. The study finds a significant difference between on- and off-park firms with respect to their propensity to invest in R&D. In addition, the authors identify a positive role of science and technology parks in sustaining firms' research activities, especially during periods of economic and financial crisis.

Processes and Performance

A significant number of studies address evidence regarding processes of running science and technology parks, STP performance, and how STP characteristics relate to tenants' performance. The countries studied range from leading countries with well-established science and technology parks, such as the United States and Sweden, to less advanced economies that are actively implementing STP initiatives, such as China. Findings are diverse and inconclusive, and therefore should be interpreted with caution and with due consideration of the context. Specifically, Zou and Zhao (2014) look into how different factors contributed positively and negatively to the performance of TusPark in China; Fukugawa (2013) and Malairaja and Zawdie (2008) study how locating on or off science and technology parks might affect the collaboration behavior and growth patterns of firms; Díez-Vial and Fernández-Olmos (2014) take a closer look at what kind of firms might benefit the most from science and technology parks; and Link and Scott (2003) conduct extensive research on US science and technology parks, especially regarding how science and technology parks influence the mission and performance of associated universities and how science and technology parks with specific characteristics might outperform their peers (Link and Scott 2006). Key findings are summarized in table 4.24.

Output Additionality

Evidence on output additionality has been captured through a range of indicators, including patenting activities (such as the pace of patenting and number of applications) and business performance (such as sales, and share of sales resulted from new products). Some studies look at the impact of science and technology parks on aggregate outcomes, such as contributions of STPs to regional innovation performance (see, for example, Jongwanic, Kohpaiboon, and Yang, 2014). Generally speaking, the studies either report positive impacts or neutral effects of science and technology parks on firms' performance. Vásquez-Urriago et al. (2014) present a positive picture regarding the overall impacts of Spanish science and technology parks in enhancing innovation performance of on-park firms. Studies in other contexts such as China, Finland, and the United Kingdom, report more moderate impacts, and raise issues such as congestion (Zhang and Sonobe 2011) and mixed results of universities' involvement on science and technology parks (Albahari et al. 2017). Key findings are summarized in table 4.25.

TABLE 4.24 Evidence on Processes and Performance of Science and Technology Parks: Key Findings

Study	Context	Finding
Zou and Zhao (2014)	China, Tsinghua University Science Park (TusPark)	Having different types of stakeholders participate in the TusPark ecosystem enabled those participants to benefit from the interactions to suit their own business needs. For example, multinational enterprises can access academic resources and conduct tailored R&D to suit the Chinese market, while the university can gain more funding and job opportunities for graduates. The strengths of TusPark result from a strong commitment from different levels of government, proximity to the most prestigious universities and public research organizations, powerful alumni networks, and a dynamic entrepreneurial culture in the locality. Constraints compromising the performance of TusPark were tied to a rigid bureaucracy, moderate indigenous innovation capacity, and macro-level institutions that are unfriendly for innovators, such as the environment for intellectual property rights.
Fukugawa (2013)	Japan, focused specifically on STPs with incubators	Estimation results reveal that the number of cooperative research projects with universities is positively associated with the scope of the professional experiences of incubation managers, but not with the number of full-time incubation managers. The physical advantage, such as the geographical proximity to universities, is not conducive to the commencement of cooperative research with universities.
Malairaja and Zawdie (2008)	Malaysia, Technology Park Malaysia (TPM)	The study finds a reasonably high level of interactions among the science park (on-park) and off-park firms and local universities. Overall, science park firms have more links with universities than off-park firms, although the difference is not statistically significant. The hypothesis that science park firms are in a better position than off-park firms to establish links with local universities is duly rejected. The percentage of science park firms engaging in joint collaborative research identified by this study (31.81 percent) is higher than that found in other studies.
Díez-Vial and Fernández-Olmos (2014)	Spain, database from PITEC (Panel de Innovación Tecnológica/ Technological Innovation Panel)	Firms that have developed cooperation agreements with universities and other research institutions are more able to exploit on-park knowledge externalities, thus improving their innovative capacity. A mutual understanding among the actors based on shared routines and procedures can help firms identify and incorporate knowledge from the university, not only by formal mechanisms, but also by informal encounters and meetings, which are so important on-park.
Chan et al. (2010)	South Africa, the Innovation Hub	Results show that there are two groups of firms: on-park firms that network with other on-park firms (Group 1); and those that do not (Group 0). Compared with Group 0, Group 1 has more informal ties with off-park firms, is able to gain more useful knowledge from private knowledge sources, and has more access to unintended knowledge that flows in the park. However, the innovation performance of the groups (measured by patents, sales, new products, and so on) does not differ.
Ferguson and Olofsson (2004)	Sweden	Firms located in science parks have significantly higher survival rates than off-park firms but demonstrate no significant differences in sales and employment. The wider variation in the growth rates of firms located in parks together with the better survival suggests that the science parks are providing favorable locations for new technology-based firms (NTBFs) in a range of development phases. A location benefit associated with cooperation with universities is positively associated with growth.
Link and Scott (2003)	United States	There is a direct relationship between the proximity of the science park to the university and the probability that the academic curriculum will shift from basic research toward applied research.
Link and Scott (2006)	United States	Parks closer to the university, operated by a private organization, and with a specific technology focus (information technology in particular) grew faster than the average.

Source: Summary of key findings from the literature reviewed by Hobbs, Link, and Scott 2017.

TABLE 4.25 Evidence on Output Additionality of Science and Technology Parks: Key Findings

Study	Context	Finding
Zhang and Sonobe (2011)	China, national science and technology parks (STPs), 1988–2008	While on-park firms benefit from agglomeration economies, they are also faced with congestion problems—and the negative effect of congestion on productivity outweighs the positive effect of agglomeration economies. The paper also finds that the productivity of high-tech firms, whether within or outside the STPs, is positively associated with foreign direct investment and academic activities of local universities in the same city.
Jongwanic, Kohpaiboon, and Yang (2014)	China	Using a provincial-level panel dataset for 1997–2009, this study shows that STPs have significantly positive impacts on regional patenting performance. More importantly, STPs play a key role in coordinating R&D collaboration across various R&D performers within the region and indirectly contribute to upgrading the regional technological ladder.
Squicciarini (2008)	Finland	Firms slow down the pace at which they innovate (measured by patenting activities) in the second part of their lifetime, no matter where they are located; however, this trend seems to be stronger for off-park firms. The authors conclude that locating inside STPs can represent an asset because on-park firms demonstrate a higher patenting pace in the "after" phase of their lifetime than their matched off-park counterparts.
Siegel, Westhead, and Wright (2003)	United Kingdom, firm-level data back in late 1980s	New technology-based firms (NTBFs) located in university science parks have slightly higher research productivity than observationally equivalent firms not located in university science parks. These impacts are not as strong when controlling for endogeneity bias, or the possibility that location on a university science park and the generation of research output are jointly determined.
Liberati, Marinucci, and Tanzi (2016)	Italy	Although the business situation of firms located in STPs tends on average to be better than that of similar off-park firms, a difference-in-differences estimation shows that entering an STP did not generally improve firms' business performance (measured through sales, value added, patents, and so on) or their propensity to innovate (measured through investments), compared with external counterparts.
Albahari et al. (2017)	Spain	Higher involvement of a university in the STP is positively related to the number of patent applications, but negatively related to tenant's innovation sales. More specifically, science parks where the university is the major shareholder show the highest patenting performance and lowest product innovation levels, while technology parks in which the university has no formal involvement perform best for sales of new to the market products and worst for patenting.
Vásquez-Urriago et al. (2014)	Spain	Spanish STPs (representative dataset from 22 of 25 STPs in Spain) have a strong and positive impact on the probability and amount of product innovation achieved by STP located firms. These results hold when the endogeneity of STP location is considered. Specifically, the effect of locating in a park increases the probability of being an innovator by 10 percent to 20 percent and increases sales of new products by around 32 percent.

Source: Summary of key findings from the literature reviewed by Hobbs, Link, and Scott 2017.

Main Requirements for Replicability

Science and technology parks are meant to be fully embedded in regions and serve as drivers of R&D activities. Certain preconditions must be met at the regional level before the design of science and technology parks can proceed.

- *An already existing base of innovative businesses.* There is a strong interdependence between a science and technology park and related regional technology clusters. Strong, specializing economies with a good regional or local innovative ecosystem form a sound basis for successful STPs.

- *The presence of universities, public research organizations, and other knowledge institutions that already produce research with potential to be commercialized and with departments that can provide high-quality R&D services.* This is where the bulk of basic and applied research comes from; knowledge institutions could also be large innovative firms that would benefit from collaborating with smaller businesses.
- *A local labor market of highly qualified workers.* Technology and innovation companies are more dependent than other economic sectors on well-educated, creative workers. Therefore, it is essential for science and technology parks to locate in the areas where this condition can be met. Moreover, the region should be able to attract and retain these knowledge workers.
- *An attractive residential and living environment.* This is an essential condition for attracting highly educated people and retaining knowledge workers already living in the area.
- *Available sources of financing.* Small innovative companies often need a long development period for their products. This requires specific risk finance instruments.

Dos and Don'ts of Science and Technology Parks

Do	Don't
▪ Consider an accreditation system that carefully assesses whether the preconditions of setting up STPs in the region can be met, which include but are not limited to an existing local base of innovative businesses, the presence of strong research capabilities and high-quality commercial research, strong capabilities in university for contract research, highly skilled human capital, an attractive living environment, and available sources of financing. ▪ Make sure that the incentives in universities to participate in contract research, commercialize research, and create spin- offs are in place. Having effective technology transfer offices can be an important complement to strengthen the effectiveness of the park.	▪ Don't give STP status to any initiative arising from universities or local authorities without a strong assessment and the clarity of a business plan. ▪ Don't try to copy the successful experience from one region to another, especially when these are from high-income countries. STPs' performance is highly dependent on a wide range of factors and should be assessed only in the context of their specific settings. ▪ Don't focus merely on the quantifiable indicators of STP performance, such as sales and patenting. The benefits of locating in an STP can come from informal interactions. It is worth hearing from tenants about their experiences and perspectives to assess the effectiveness of STPs.

Dos and Don'ts of Science and Technology Parks

Do	Don't
■ Have a long-term vision from the perspective of urban planning as well as the regional innovation system. STPs in the longer term should perform as drivers of regional development and growth, and therefore should be fully embedded in the strategic planning of the region. ■ Set up strong and professional management mechanisms, and encourage the effort from champions, to design and deliver services according to the specific needs of different types of tenants. Where necessary, invest in upgrading/creating specialist science and technology management capability. ■ Set up metrics during the design of STPs, using mixed methods based on both quantitative and qualitative data, to gauge the effectiveness of intervention as closely as possible.	■ Don't design the instrument as a real estate development, which is a common feature of failed STPs.

Checklist for Design and Implementation of Science and Technology Parks

- Is there any good or applied research that can be commercialized?
- Is your region/city competitive in attracting R&D centers or technology-intensive firms?
- Are there groups of research excellence in the university that can commercialize research? Are there departments that can participate in contract research?
- Are advantages for foreign direct investment linked only to real estate and exemptions or is there potential for linkages?
- Do you have other instruments to support early-stage ventures and university spin-offs?
- Do you have a clear business model for the park to avoid constant or full subsidization?
- Do you have the resources and capabilities to develop a robust accreditation system for science and technology parks?

References

Albahari, A., S. Pérez-Canto, A. Barge-Gil, and A. Modrego. 2017. "Technology Parks versus Science Parks: Does the University Make the Difference?" *Technological Forecasting & Social Change* 116: 13–28.

Chan, K. A., L. A. G. Oerlemans, M. W. Pretorius, L. A. G. Oerlemans, and M. W. Pretorius. 2010. "Knowledge Exchange Behaviours of Science Park Firms: The Innovation Hub Case." *Technology Analysis & Strategic Management* 22 (2): 207–28.

Díez-Vial, I., and M. Fernández-Olmos. 2015. "Knowledge Spillovers in Science and Technology Parks: How Can Firms Benefit Most?" *Journal of Technology Transfer* 40 (1): 70–84.

European Commission. 2017. "Workshop on the Role of Science and Technology Parks and Incubators in Innovation Ecosystems." https://doi.org/10.2760/449384.

Ferguson, R., and C. Olofsson. 2004. "Science Parks and the Development of NTBFs—Location, Survival and Growth." *Journal of Technology Transfer* 29 (1): 5–17.

Fukugawa, N. 2013. "Heterogeneity among Science Parks with Incubators as Intermediaries of Research Collaborations between Startups and Universities in Japan." *International Journal of Technology Transfer and Commercialisation* 12 (4): 231–62.

Hobbs, K. G., A. N. Link, and J. T. Scott. 2017. "Science and Technology Parks: An Annotated and Analytical Literature Review." *Journal of Technology Transfer* 42 (4): 957–76. https://doi.org/10.1007/s10961-016-9522-3.

Jongwanich, J., A. Kohpaiboon, and C. Yang. 2014. "Science Park, Triple Helix , and Regional Innovative Capacity: Province-level Evidence from China." *Journal of the Asia Pacific Economy* 19 (2): 333–52. https://doi.org/10.1080/13547860.2014.880285.

Lamperti, F., R. Mavilia, and S. Castellini. 2017. "The Role of Science Parks: A Puzzle of Growth, Innovation and R&D Investments." *Journal of Technology Transfer* 42 (1): 158–83. https://doi.org/10.1007/s10961-015-9455-2.

Liberati, D., M. Marinucci, and G. M. Tanzi. 2016. "Science and Technology Parks in Italy: Main Features and Analysis of their Effects on the Firms Hosted." *Journal of Technology Transfer* 41: 694–729. https://doi.org/10.1007/s10961-015-9397-8.

Link, A. N., and J. T. Scott. 2003. "The Growth of Research Triangle Park." *Small Business Economics* 20 (2): 167–75.

————-. 2006. "U.S. University Research Parks." *Journal of Productivity Analysis* 25 (43): 44–55. https://doi.org/10.1007/s11123-006-7126-x.

Malairaja, C., and G. Zawdie. 2008. "Science Parks and University-Industry Collaboration in Malaysia." *Technology Analysis & Strategic Management* 20 (6): 727–39. https://doi.org/10.1080/09537320802426432.

NRC (National Research Council, United States). 2009. *Understanding Research, Science and Technology Parks: Global Best Practices.* Washington, DC: The National Academies Press. https://doi.org/10.17226/12546.

Ratinho, T., and E. Henriques. 2010. "The Role of Science Parks and Business Incubators in Converging Countries: Evidence from Portugal." *Technovation* 30 (4): 278–90. https://doi.org/10.1016/j.technovation.2009.09.002.

Siegel, D. S., P. Westhead, and M. Wright. 2003. "Assessing the Impact of University Science Parks on Research Productivity: Exploratory Firm-level Evidence from the United Kingdom." *International Journal of Industrial Organization* 21 (9): 1357–69. https://doi.org/10.1016/S0167-7187(03)00086-9.

Squicciarini, M. 2008. "Science Parks' Tenants versus Out-of-Park Firms: Who Innovates More? A Duration Model." *Journal of Technology Transfer* 33 (1): 45–71. https://doi.org/10.1007/s10961-007-9037-z.

Tsamis, A. 2009. "Science and Technology Parks in the Less Favoured Regions of Europe: An Evaluation of their Performance and the Parameters of Success." PhD thesis, London School of Economics and Political Science.

Vásquez-Urriago, A. R., A. Barge-Gil, A. M. Rico, and E. Paraskevopoulou. 2014. "The Impact of Science and Technology Parks on Firms' Product Innovation: Empirical Evidence from Spain." *Journal of Evolutionary Economics* 24: 835–73. https://doi.org/10.1007/s00191-013-0337-1.

Wen-Jung, L., C-C Mai, J-F Thisse, and P. Wang. 2019. "On the Economics of Science Parks." NBER Working Paper 25595, National Bureau of Economic Research, Cambridge, MA.

Zhang, H., and T. Sonobe. 2011. "Development of Science and Technology Parks in China, 1988–2008." *Economics E-Journal* 5: 1–27. https://doi.org/10.5018/economics-ejournal.ja.2011-6.

Zou, Y., and W. Zhao. 2014. "Anatomy of Tsinghua University Science Park in China: Institutional Evolution and Assessment." *Journal of Technology Transfer* 39 (5): 663–74.

4.2.6.5 Technology Transfer Offices (TTOs)

Technology transfer involves the transfer and diffusion of general purpose and specific technologies and knowledge to firms. Within the context of innovation policy instruments, some instruments focus on the transfer of technology from knowledge producers (often universities and public research organizations) to knowledge end-users (such as firms and the government). The goal is to maximize the contribution of public investments in research, development, and innovation for economic growth through the management and licensing of intellectual property rights (IPRs), and the diffusion to local businesses. Common formal transfer mechanisms include licenses or royalty agreements, although transfers can also occur via less formal consultancy or advisory processes, such as between an engineering faculty to consult and seek research support from private industry, or simply the open publication of research findings. Another potential role for technology transfer includes enabling the use of research facilities (such as testing labs) by industry.

The government has played an important role in supporting technology transfer through various means, including but not limited to: (1) supporting, both financially and operationally, technology transfer intermediaries; (2) setting IPR-related regulations and standards to facilitate or provide incentives for technology transfer;[33] (3) creating grants and technical assistance to help firms complete applications to file patents and pay renewal fees; (4) providing grants for commercialization and diffusion of technologies; and (5) attracting, facilitating, and regulating foreign direct investment, which holds great potential for technology transfer to local firms.

This guide focuses on supporting the creation and functioning of *technology transfer offices (TTOs)* as an instrument to support business innovation. Technology transfer offices are established in part because technology transfer faces a variety of impediments and knowledge barriers, and subsequently governments intervene by supporting or funding services to bridge the gaps. Technology transfer offices help (1) identify technologies ready for commercialization; (2) identify firms that could benefit from a certain technology; (3) provide IPR-related advisory services to researchers and to firms; and (4) manage the interaction between firms and knowledge-producing organizations.

The Need for TTOs

Knowledge created by public research organizations through publicly funded research and development (R&D) has the potential to benefit the local economy, society, and the environment. Roessner (2000) defines the technology transfer process as "the formal and informal movement of know-how, skills, technical knowledge or technology from one organization to another." However, transfer of tangible technology and tacit knowledge from a research organization does not happen spontaneously. Traditional, linear dissemination methods such as publication of peer-reviewed scientific papers often have limited economic impact, and researchers frequently lack incentives to engage in more complex transfer mechanisms that have wider impact on local economic development. The different forms of technology and knowledge exchange include *informal channels* (such as publications, education and training, and mobility of researchers) and *formal channels* (such as collaborative R&D, contract R&D, consulting, equipment hire and material testing, IPR licensing, and spin-offs). The technology transfer process is nonlinear (inventions do not necessarily translate into innovations) and, in some cases, unaccounted for—taking place in informal setting through personal contact and informal networks.

A clear gap between academia/research and industry often exists in countries and regions that have failed to modernize their innovation systems. In contrast, research delivers measurable benefits to a knowledge-based economy in countries that have aligned incentives for technology transfer; strengthened their IPR regimes; offered incentives to their public research organizations to embrace a "third stream mission" of promoting innovation alongside teaching and research; invested in culture change; supported technology transfer to intermediaries; and provided associated infrastructure.

Definition

Technology transfer offices (TTOs) are dedicated offices created by universities and public research organizations (often funded from national government programs) to support and facilitate different aspects of technology transfer. The name of these offices can vary—Centre for Technology Transfer, tech transfer office, Innovation Office, special purpose vehicle[34]—but this guide uses the term "technology transfer office." More important than the name is the mission and specific activities of these offices, which include managing IPR-related activities such as disclosures, patent filing, patent licensing, relationships with industry, and research contracts.

The discussion that follows describes the main characteristics of technology transfer offices. A more detailed analysis of this type of instrument can be found in Aridi and Cowey (2018).[35]

Market and System Failures Addressed

Technology transfer offices attempt to address the following market and system failures:

- *Information asymmetry.* The technology transfer process suffers from *uncertainty about the valuation of the scientific discovery*. Inventions at universities or public research organizations are usually at technology readiness levels (TRL) 1–2, while investors and industry are only interested in more advanced technology readiness levels (6–7). Thus, commercializing these inventions involves high risk.

- *Externalities and appropriation of knowledge.* In addition, there is *uncertainty about appropriation and ownership of the resulting intellectual property and the distribution of rights*. Clear and enforced intellectual property regimes help mitigate this asymmetry. However, sometimes national laws and institutional policies in developing countries do not unambiguously assign ownership of rights. In other cases, they do, but some of the provisions might be ambiguous, imperfect, or poorly enforced. Technology transfer offices play an important role in supporting the implementation of intellectual property rights at an early stage and in helping enforce these rights.
- *Coordination/network failures.* Such failures result from *the lack of linkages between firms and knowledge creation institutions in their markets, resulting in the loss of opportunities for learning/ complementarities*. Such failures could lead to *transition failures*, represented by the inability of firms to adapt to or adopt new technologies or solutions available within the local knowledge institutions.
- *Capabilities failure.* The technology transfer process requires access to a number of informational, financial, and human resources, which are usually scarce in developing countries. *Specialized providers* that offer information and advisory services related to matching of inventors and entrepreneurs with potential investors and firms, valuation of inventions, and market intelligence are crucial in supporting the technology transfer process. *Specialized technical staff* who combine legal and technical backgrounds with business acumen and market knowledge are usually in short supply even in developed economies. Finally, *access to early-stage financing* that supports prototyping, proof of concept, and patenting activities is usually scarce in developing countries.

Target Group

The primary targets of technology transfer offices are knowledge providers such as research centers, universities, and government laboratories, and the links with all kinds of businesses, such as big firms, SMEs, and small start-ups. Knowledge providers often lack the skills and specialized technical resources to support the technology transfer process and enable positive spillovers to the local economy. Similarly, owners and managers of big firms and SMEs in developing countries often have relatively limited resources and networks and may not be knowledgeable about the capabilities of local knowledge providers to collaborate with them. Hence, there is a need for advice and support by technology transfer offices to enable the technology transfer process and connect knowledge providers with businesses.

Strengths

The main strengths of technology transfer offices as a policy instrument can be summarized as follows:

- *TTOs can catalyze processes and relationships that are sustained over time.* This category of instrument can stimulate ongoing business improvement activities within SMEs and the development of further cooperation between firms and research centers, including training, skill sharing, and joint research, which enhances innovation.
- *TTOs can accelerate the commercialization of new products and processes.* TTOs help researchers disclose their inventions and think about their commercialization potentials through proof of concepts and prototyping. They offer the needed set of specialized skills that bring market intelligence into the realm of academia and research institutions. The cooperation among knowledge producers and firms enables higher quality and more effective, integrated, and robust outcomes, as each partner brings a differing perspective and experience to the process. This works both ways, as the research sector benefits from interaction with end-users.
- *Effective TTOs tend not only to facilitate the movement of knowledge, but also people.* This can include the placement of researchers within companies, company-sponsored Masters and PhD degrees, and the involvement of industry in teaching and designing courses. Through support for incubators and accelerators, TTOs can provide career alternatives for students and commercialization pathways for their knowledge. They can also help increase utilization of research infrastructure by industry, either directly or through services like testing and accreditation.
- *TTOs are an integral part of the third-stream mission of knowledge creation institutions.* In this context, TTOs enable knowledge exchange and cocreation of knowledge with private actors. They help capture the economic contributions of knowledge institutions for their local economy by monitoring a set of relevant indicators, such as the number and volume of patents, licenses, spin-offs, consulting services, and research contracts. This helps institutions set a baseline and allows for benchmarking against more economically active and entrepreneurial universities.

Potential Drawbacks and Risks

Potential drawbacks and risks associated with the use of technology transfer offices include the following:

- *TTOs may fail when knowledge creation (including R&D) is low.* In many developing countries, there is insufficient public and private investment in the generation of knowledge and R&D, and thus there is very little that can be transferred to industry, or the quality of infrastructure is low and of little use to industry.

Thus, sustainable and substantial funding for research and consequently high research quality are necessary conditions for any technology transfer activities.

- *TTOs may need to be supplemented by additional incentives to drive commercialization in knowledge organizations.* Too often, knowledge organizations—universities, research centers—in developing countries do not have the right incentives to support research and its commercialization. Incentives encourage staff to either teach or to conduct basic research, employment terms do not allow innovators to participate in private ventures, and the intellectual property generated is appropriated by academic institutions. In this context, the primary bottleneck for technology transfer lies in the absence of incentives to generate and commercialize industry relevant knowledge or technology.
- *TTOs can be subject to complicated government procedures.* Burdensome government administrative procedures or requirements can hinder the technology transfer process and can negate the activities of motivated and skilled technology transfer offices. For instance, in some countries, research institutions (and thus researchers) are not able to retain any revenues from knowledge they sell because revenues are mandated to be returned to the finance ministry. The incentive structures for researchers may not reward—or provide any benefit at all—for collaboration, particularly when there is lack of clarity about who owns formal intellectual property or intellectual property is also vested in the state.
- *Biased cost-benefit estimations and a scarcity of skills can result in low satisfaction.* The amount of resources required by technology transfer offices is often underestimated or underprovided, leaving the collaboration between TTOs, knowledge producers, and firms consuming more resources than their benefits warrant. Technology transfer offices fulfill a specialized function requiring knowledge of research and industry practice, plus intellectual property rights and often specific areas of technology. Finding, retaining, and remunerating staff for these positions is a challenge. Finally, technology transfer is a time-consuming process and requires cultural change at the institution and individual levels. TTOs are often expected to generate results within a short period after they are established and fail to do so.

Building a TTO will not automatically increase the quality and quantity of research and R&D and will fail if the incentives for research and commercialization are not aligned.

Elements for Good Instrument Design

The design and specific functions of technology transfer offices rely heavily on the local context. Policy makers need to consider several different aspects, including the underlying laws and regulations relating to publicly funded research, and the extent to which individual researchers, faculties, schools, and institutions are formally involved in knowledge exchange with industry and any revenues that accrue from it. Policy makers also need to assess whether the scope of technology transfer offices should cover a single organization or multiple organizations. In some models, TTOs covers more than one research body (either geographic or sectoral)[36]—although most typically cover one institution. Planning should secure a critical mass and specialization in staff, given that underscaled technology transfer offices achieve limited results. However, if a TTO is to cover multiple institutions, policy makers need to ensure uniformity in approach to intellectual property and revenues.

- *Appropriate business model for the context.* Different technology transfer offices have used different business models—including the ways by which they generate their own funding. For example, some technology transfer offices are directly funded by government or by their institutions; some charge a percentage of the value of transactions they generate; some charge a fixed percentage of external revenues generated by the institution(s); and some employ a mix of approaches. These models are highly context specific, so what works in one innovation system may not work in another.
- *Engagement with industry.* Technology transfer offices need to identify the best approach to engage with industry and decide whether they should feature specific SME outreach approaches. Dealing with larger companies is easier because they are more sophisticated, have more and better resources, and are more likely to be able to fund R&D and technology and to absorb and host graduates and researchers. By contrast, SMEs require more support, but they usually account for a greater share of industrial firms. However, there are challenges to servicing both, and companies usually present specific needs and maturity cycles that may not align with researchers. Moreover, in some cases policy makers will realize that there are no apparent users for the knowledge developed by researchers. In these cases, technology transfer offices may need to assist commercialization through venture "spin-offs"—new companies built around the intellectual property rights of the research organization, which would require a particular skillset in itself.
- *Choice of services provided.* Technology transfer offices can offer a variety of services, depending on their business model. They usually monitor all R&D activities for technology transfer opportunities that the researchers may not foresee. A key issue is to avoid publicizing results (such as in journals) of research that may have some commercial application in a way that could damage the commercialization opportunities of intellectual property later. Intermediaries can also help researchers in guiding their research strategies to understand both continuing fundamental research pathways and potential commercially relevant research and set up conditions appropriate for each. Technology transfer offices also typically provide training for researchers in commercialization and involvement and management of formal registration and protection of intellectual property rights for the institution. TTOs are increasingly involved in establishing and running internal incubators and accelerators for students, often including spin-off companies utilizing in-house knowledge. Technology transfer

offices have also been involved in running funding mechanisms (such as pre-seed or seed funding programs or funds) for individuals and spin-offs from their institutions. In addition, TTOs have played a "traditional" role in marketing and selling research intellectual property rights to external end-users, typically maintaining a bank of commercial technologies and seeking to find companies that could use them, while assisting in negotiating the terms of this use.

Technology transfer offices may also provide (or facilitate) a range of services directly to industry on behalf of their affiliated research institutions. They may play a coordinator role for inquiries related to innovation vouchers, run equipment- and laboratory-sharing services (making research infrastructure available to companies), coordinate the provision of testing and accreditation services, and provide "find-an-expert" services so that industry can access specialist expertise from within the research institution. Technology transfer offices can also choose to participate in technology extension service schemes (in some countries like the United States, universities house and run government technology extension service schemes), and place students or staff in specific businesses to promote knowledge sharing. In support of these services, they may offer simple legal templates for collaborative R&D, the sharing of intellectual property, research consultancies, and access to equipment to reduce the transaction costs faced by industry (and the research sector) in collaborating.

When the technology transfer function is weakly developed and policy makers are seeking to build capacity and activity, they will need to decide which mix of services is most needed and most appropriate, and what can be sensibly supported given existing resources—which are often scarce for this type of activity. For technology transfer offices to be able to provide good quality services to industry, they obviously need to achieve a high level of cooperation from their affiliated institutions, which are the actual service providers (and which need to see some benefit, particularly when their incentive structures may drive them to focus on basic research). Some of the new areas of activity (such as incubators) are specialist areas in themselves. Technology transfer offices need to be careful to establish and run them along sound commercial lines.

- *Adequate skills.* Technology transfer is a very specialized field, requiring people with knowledge both of research and industry and their respective cultures, and with the ability to understand potentially complex contractual issues.

Evidence of Impact

The evidence on the impacts of technology transfer-related policy initiatives (including technology transfer offices and other initiatives) is very limited. The selected studies look at the impacts of technology transfer offices and IPR-related legislation in the contexts of technologically advanced economies. Key findings of those studies are summarized in table 4.26. The main indicators used by the selected studies include the number of licenses issued and the income generated.

The methodology employed by the selected studies include randomized control studies, cost-benefit analyses, case studies, external reviews, and fiscal impact studies. Most studies come from developed countries, but recently, a few case studies on programs undertaken in developing nations have emerged. The main data source employed is administrative databases of field expert activities and customer interactions. Several of the studies use variations on ordinary least squares or matching techniques to control for all observable characteristics of firms or individuals.

TABLE 4.26 Evidence of Impacts of Technology Transfer-Related Policy Initiatives: Key Findings

Study	Context	Finding
Heher (2007)	United States, United Kingdom, Australia, Canada	For the United States, the licensing income as a percentage of research expenditure increased from 1.5 percent in 1991 to around 3.5 percent by 2003. The returns for United Kingdom, Australia, and Canada ranged between 1 percent and 1.5 percent over roughly the same period.
Conti and Gaule (2011)	Europe, United States	In terms of licensing, European TTOs performed comparably to their US counterparts but earned significantly less revenue from licensing activities.
Siegel et al. (2004)	United States	University-managed TTOs lose opportunities for technology commercialization due to a perceived unfavorable royalty distribution to the scientist.
Markman et al. (2005)	United States	A clear majority of mission statements of 128 university TTOs place emphasis on licensing over scientist start-ups and economic development.
Shane (2004)	United States	Many spin-off activities occur "through the back door." The reason is that measuring commercialization has relied solely upon data collected by TTOs. Many times, spin-offs are created without intellectual property being formally licensed from the institution in which it was created.
Aldridge and Audretsch (2010)	United States	The study emphasizes the value of building social capital for the technology transfer process. In addition to the characteristics of the TTO and the university, the levels of social capital (as measured by meaningful interactions and linkages with the private sector) increase the propensity of a scientist to become an entrepreneur.
Rothaermel, Agung, and Jiang (2007)	Generic (literature review)	The literature points to several factors contributing to the success of technology transfer, including university policies on strategy for intellectual property; investments in intellectual property protection; resource endowments, such as the quality of human resources; technology endowment; and funding from university, industry, and venture capitalists.
Mowery et al. (2001)	Generic (literature review)	The Bayh-Dole Act in the United States[a] was only one of several key influences behind the increase in university patenting and licensing activity. In fact, the patent growth trend started long before the Act.
Geuna and Rossi (2011)	Generic (literature review)	Policies at the national and regional levels had a significant impact in the growth of patenting activity, such as the federal subsidies for regional institutions to exploit/commercialize patents in Germany and Danish funding for the creation of technology transfer infrastructure following the introduction of institutional ownership.

Note: TTO = technology transfer office.

a. The Bayh–Dole Act or Patent and Trademark Law Amendments Act, adopted in 1980, is US legislation dealing with inventions arising from federal government-funded research.

In some of the studies, it is likely that unobservable characteristics are affecting the results. There is often an attribution problem resulting from the difficulties associated with isolating the effects of a specific relationship from the whole range of actions undertaken by a firm. Despite efforts in several studies to control for unobserved effects with comparison groups of similar firms that did not receive assistance, larger-scale economic and market forces can override the ability to distinguish impacts from these relatively small-scale programs.

In addition to the large concentration of studies in the Unites States, studies tend to focus on heterogenous outcomes and issues, so it is difficult to form a general conclusion on their impact. More empirical evidence is needed to evaluate the effectiveness of this type of instrument.

Main Requirements for Replicability

A precondition for any technology transfer instruments to work is a good research system. The system must be either producing applied and potentially usable research results or have physical assets and services that are valuable and relevant to the private sector. The research institutions themselves need to support the business model of any technology transfer office, and the TTO must be able to add value. The funding and support commitment must be long-term and stable. More concrete policy lessons include the following.

- *Successful implementation of technology transfer instruments requires demanding capabilities from agencies tasked with design and implementation of the policy program*—ideally staff who understand both science and industry.
- *The capability needs to deploy technology transfer policies are high*. Technology transfer offices need to have staff who represent diverse fields of expertise, to ensure technology disclosures from various fields are properly understood and to allow for further commercialization. TTOs also need to be effective negotiators with access to industrial input, market responsiveness, strong networking, links to policy makers, and links to universities. They need to develop a positive image with their potential users through endorsements and communication; researchers may avoid interactions if they are not perceived as adding value.

Other Policy Lessons

- *Technology transfer-related policies or programs must have clear objectives*, typically defined in terms of input metrics (R&D expenditure) or output metrics such as joint publications, patent registrations (or applications), or new products. Given the multiple functions that technology transfer offices can perform, it is important that they have a clear strategy and strong leadership.
- Besides using straightforward metrics based on inputs and outputs, *increasing collaboration between firms and knowledge producers should also be a priority*.

- *The presence of a transparent and well-articulated intellectual property rights regime, as well as an efficient court system, is necessary to encourage technology transfer.*
- *Technology transfer offices must be able to add value to the research sector*. If TTOs are just seen as entities that are entitled to collect a proportion of any external income earned without adding much value themselves, then researchers will avoid utilizing them.
- *Technology transfer offices also need to be able to educate researchers about the relative value of their research* (researchers usually significantly overvalue commercial research), provide sensible advice to research institutions on which intellectual property should they protect and how (patenting can be a very expensive process), and manage the cultural differences between researchers and industry representatives (such as time lines, working style, motivation, and incentives).
- *For industry, technology transfer offices need to be easy to navigate and the services that they offer on behalf of their institutions need to be convenient, responsive, good quality and cost effective*. As an example, technology transfer offices can help "sell" a portion of their institutions' research infrastructure time to firms by developing (1) a database of available instruments and machinery that are relevant to industry; (2) formulating a compelling offer with competitive pricing; (3) and undertaking an outreach campaign to inform firms of their institutions capabilities (*mainly testing and measurement*).
- *Technology transfer offices need to be part of a sensible and realistic view of publicly funded research and how it may assist industry (and society).* Research capacity has many valuable outcomes besides research commercialization, including public interest research, providing a wide "stock" of knowledge for society, and developing well-trained and knowledgeable people who may stay in research or use their research skills in industry or society.

Research commercialization is rarely a huge generator of income in most research institutions, even in developed countries. Policy makers should be realistic about expectations from such activities, and about the relative influence of technology transfer offices on research linkages with industry, compared to the underlying incentive structure for researchers to interact with end users.

Required capabilities from participants remain critical, as well. Participants should be able to assess whether the technology proposition is consistent with their own strategic needs and plans to upgrade. Participants need to show the capacity of engaging with not only providers of the technology, but also with intermediaries. The ability to manage licensing and to dealing with intellectual property procedures is also critical. Many of these technologies require adherence to specific conditions ruled by licensing agreements. The ability to finance technology absorption is also a necessary condition.

Dos and Don'ts of Technology Transfer Offices

Do	Don't
▪ Make sure to equip TTOs with capable staff who are knowledgeable in diverse technological fields and able to conduct sophisticated monitoring and commercialization and who can work both with the research and commercial sectors. ▪ Where necessary, be prepared to invest in building the capacity of TTO staff, given that this is an unusual skillset. ▪ Pay attention to the costs versus benefits of TTOs. TTOs require a high level of capabilities and resources and returns on investment are not always guaranteed. It may be sensible to have TTOs covering several institutions to provide scale; however, this requires additional coordination. ▪ The main focus of TTO policy should be to ensure that the research sector offers as much positive impact for business (and the wider community) as possible through as many channels as possible and does not focus narrowly on revenue generation for the research sector.	▪ Don't simply set up TTOs without assessing the supply side of knowledge production of the region, city or university. No matter how well designed the technology transfer policies are, a precondition for them to work is a strong research system with outputs that are relevant to industry. ▪ While technology transfer policies should be designed in a focused way with their impacts measured through input/output metrics, policy makers should not overlook the necessity of promoting academia-industry collaborations in general, which might lead to technology transfer in the longer term.

Checklist for Design and Implementation of Technology Transfer Offices

- Are there good incentives for research and commercialization? Is there good applied research that can be commercialized by universities or public research organizations?
- Do you have the technical staff who can understand both science and commercialization?
- Do you have links to business and industry associations to implement collaborative projects or to bring new technological solutions to the private sector?

References

Aldridge, T., and D. Audretsch. 2010. "University Entrepreneurship and Economic Growth." Working paper. Max Planck Institute of Economics & Indiana University, King-Saud University, Riyadh, Saudi Arabia, and WHU Otto Bresheim School of Management

Aridi, A., and L. Cowey. 2018. "Technology Transfer from Public Research Organizations. A Framework for Analysis." World Bank Group, Washington, DC.

Conti, A., and P. Gaule. 2011. "Is the US Outperforming Europe in University Technology Licensing? A New Perspective on the European Paradox." *Research Policy* 40 (1): 123–35.

Geuna, A., and F. Rossi. 2011. "Changes to University IPR Regulations in Europe and the Impact on Academic Patenting." *Research Policy* 40 (8): 1068–76.

Heher, A. D. 2007. "Benchmarking of Technology Transfer Offices and What It Means for Developing Countries." In *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices*, 207–28. MIHR, PIPRA, Oswaldo Cruz Foundation, and bioDevelopments-International Institute.

Markman, G. D., P. H. Phan, D. B. Balkin, and P. T. Gianiodis. 2005. "Entrepreneurship and University-based Technology Transfer." *Journal of Business Venturing* 20 (2): 241–63.

Mowery, D. C., R. R. Nelson, B. N. Sampat and A. A. Ziedonis. 2001. "The Growth of Patenting and Licensing by US Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980." *Research Policy* 30: 99–119.

Roessner, J. 2000. "Technology Transfer." In *Science and Technology Policy in the US. A Time of Change*, edited by D. Hill. London: Longman.

Rothaermel, F. T., S. D. Agung, and L. Jiang. 2007. "University Entrepreneurship: A Taxonomy of the Literature." *Industrial and Corporate Change* 16 (4): 691–791.

Shane, S. 2004. "Encouraging University Entrepreneurship? The Effect of the Bayh-Dole Act on University Patenting in the United States." *Journal of Business Venturing* 19 (1): 127–51.

Siegel, D. S., D. A. Waldman, L. E. Atwater, and A. N. Link. 2004. "Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies." *Journal of Engineering and Technology Management* 21 (1–2): 115–42.

4.2.7 Profile 7. Early-Stage Support for Innovative Ventures

Spurring innovation requires increasing innovation investments in incumbent firms as well as generating new innovative ventures. This profile discusses a family of instruments devoted to supporting the growth and acceleration of new innovative ventures. These are all instruments with a focus on the early stages of the firm life cycle: *incubators* and *accelerators,* and *equity finance* for early stages of the life cycle.

A popular set of innovation instruments focuses on the provision of physical infrastructure and different types of advisory services for early-stage enterprises in an integrated offering. This profile focuses on two instruments of this type—incubators and accelerators. These instruments typically target innovative companies and sectors, and in some cases are linked to public research organizations to support the commercialization of knowledge and the creation of university spin-offs. The interventions seek to exploit the benefits of networking and spillover effects arising from colocation but vary on the extent and duration of advisory services that may be provided as part of their suite of services.[37] Incubators and accelerators also vary in terms of their primary objectives. The main objective of incubators is entrepreneurship and the creation of new ventures, and therefore it has a focus on the number of firms, employment, and survival rates of the start-ups.

On the other hand, the main objective of accelerators is the rapid growth of a firm, often young, and therefore it targets rapid growth and investment. Table 4.27 shows some key elements and differences across incubators, accelerators, and science

TABLE 4.27 Comparison of Incubators, Accelerators, and Science and Technology Parks

Element	Incubator	Accelerator	Science and technology parks (STPs)
Target Group	Early-stage enterprises in specific sectors.	Early-stage enterprises with high growth potential that have a viable business that could be scaled up.	New and established technology-/ R&D–intensive enterprises and larger innovation-intensive enterprises.
Primary objectives	Support the creation of early-stage enterprises and build and strengthen the start-up ecosystem.	Grow and scale up enterprises with high growth/innovation potential or let them fail fast if needed.	Support the development of technology-intensive sectors via technology generation and transfer, and the commercialization of research; engage universities and researchers in commercial R&D activities.
Technology/ sector focus	Focuses on sectors with lower set-up costs and potential for fast scale-up. This can be sector-neutral, often within technology-intensive sectors.	Often specific to sectors that can scale up quickly, with dominating focus on ICT/digital technologies (web-based, mobile apps, social networking, gaming, cloud-based, software).	Narrow, although several tech sectors can coexist; often, the focus is on spin-offs from research groups in the university.
Infrastructure	Cowork spaces, rented office spaces, shared facilities and utilities.	Program-based, normally involving some dedicated shared facilities.	Provision of sophisticated real estate/ office space; can include research and testing facilities.

(Table continues on the following page.)

TABLE 4.27 Comparison of Incubators, Accelerators, and Science and Technology Parks *(continued)*

Element	Incubator	Accelerator	Science and technology parks (STPs)
Application process	On rolling basis, not selective in admissions.	Cohort-based, highly competitive, rigorous selection process.	On a rolling basis.
Advisory	Mix of support in various business areas (such as legal, accounting, marketing) and light-touch mentoring.	Intensive support in various business areas in a short period of time (usually 3–6 months); "fast-test" validation of ideas; assistance in preparing pitches.	Some advisory, business, or innovation services may be clustered together, and innovation programs may be delivered through the park.
Mentorships and networks	Varies, but often basic mentorship programs.	Strong focus on mentorship support and linking start-ups to external business networks and potential investors.	Varies; sometimes incorporate business incubators in the STP structure to provide business development services.
Access to finance	Varies, but often not a part of services offering.	Links to potential investors such as public pitch days to help entrepreneurs raise funding, often leading to investment in cohorts of start-up companies, in exchange for equity.	Varies; often offer access to public funds.
Time horizon	1 to 5 or more years (33 months, on average).	Typically, 3 to 6 months.	1 to 7 or more years (45 months, on average), although some parks sell their real estate.

Source: Elaborations from InfoDev 2015.

Note: ICT = information and communications technology; STP = science and technology parks.

and technology parks—described in the technology family of instruments in section 4.2.6.4, but which also offer support to early-stage ventures and spin-offs. Sometimes one type of scheme might evolve into another type: for example, an accelerator might later on pivot into an incubator (Hochberg 2016) or a science and technology parks may integrate features of incubators and accelerators.

The last instrument discussed in this profile, early-stage equity finance, focuses on ensuring that all necessary stages of the early-stage firm cycle—from business ideas to establishing ventures—are properly funded. The case that early-stage firms face significant barriers to obtaining finance is compelling (Hall and Lerner 2010), especially when related to more innovative ventures that present important risks for the financier. Support infrastructure and finance should be implemented jointly. In particular, finance should be merged with mentoring and opportunities for developing new ideas. So, despite their separate presentation in this profile, policy makers should consider both support infrastructure and financing as essential for supporting the establishment of new innovative ventures.

References

Hall, B. H., and J. Lerner. 2010. "The Financing of R&D and Innovation." Chapter 14 in *Handbook of the Economics of Innovation*, Vol. 1, edited by B. H. Hall and N. Rosenberg, 609–39. Elsevier.

Hochberg, Y. V. 2016. "Accelerating Entrepreneurs and Ecosystems: The Seed Accelerator Model." *Innovation Policy and the Economy* 16 (1): 25–51.

InfoDev. 2015. "InfoDev's Business Incubation Management Manual." World Bank, Washington, DC.

4.2.7.1 Incubators

Definition

Business incubation is a process aimed at supporting the development of new and early-stage enterprises. Incubators seek to provide entrepreneurs with an enabling environment at the start-up stage of entrepreneurial activity, to help reduce the cost of launching the enterprise, increase the confidence and capacity of the entrepreneur, and link the entrepreneur to the resources required to start and grow a business. Incubators usually combine physical space with advisory services. The most common goals of incubation programs are enhancing a community's entrepreneurial climate, commercializing new technologies, and creating wealth for local and national economies.

Incubators vary significantly in terms of the period of incubation, the type and intensity of support received, and the sector focus, but have several characteristics in common. Most of them provide workspace for new firms to benefit from shared facilities and a range of business support services on a preferential basis and flexible terms, which would otherwise be unavailable through the private sector. Such support tends to be limited in duration (typically up to three years) and is intended to back start-ups during the most vulnerable stages of their development. Incubators are sometimes attached to universities and public research organizations, playing the role of conduits of knowledge flows via start-ups from these institutions to the market. Clearly not all sectors can be accommodated in incubators, which tend to focus on those that do not need large physical premises or have very large set-up costs. As a result, incubators tend to be dominated by tech sectors and knowledge-intensive services sectors. Technology incubators aim at developing start-ups of complex technologies from universities, especially focusing on the commercialization of intellectual property and entrepreneurship training for the entrepreneurs of technological ventures.

From their start in the 1970s, business incubators have spread all over the world (Albert and Gaynor 2001). Today, there are an estimated 3,000 incubators, one-third of which are located in North America; 30 percent in Western Europe; and the rest dispersed across the Far East (20 percent), South America (7 percent), Eastern Europe (5 percent), and Africa, the Middle East, and other regions (5 percent) (InfoDev 2105).

Market and System Failures Addressed

Incubators aim to address a set of market and system failures associated with the early stage of the firm life cycle, when entrepreneurs and businesses lack the experience, networks, and social capital to easily grow their business.

- *Capabilities failure.* Large asymmetric information of business knowledge and experience upon entry can lead to difficulties in making informed decisions about market demand, sources of finance, or business models for early-stage enterprises.[38]

- *Network and infrastructure failures.* Start-ups often lack the social capital and networks that could facilitate their growth. Incubators provide the infrastructure, colocation space, and network services to generate the networking effects in terms of opportunities for peer-learning, complementarities, and access to technologies that can nourish these early-stage, highly innovative enterprises.

Target Group

Incubators target start-ups or early-stage entrepreneurs, often in technology sectors and technology-intensive sectors such as agribusiness and health care, as well as services. In some cases, incubators, especially ones affiliated with universities, also target idea-stage potential entrepreneurs, such as students and research groups, that can come up with new technologies or innovation-based business ideas to encourage commercialization.

Strengths

- *Network effects, technology transfer, and spillover effects.* Incubators exploit colocation and/or networks to maximize peer learning and spillovers among entrepreneurs. Knowledge exchange can occur through formal projects, informal interactions, or movement of people between organizations, all of which are made easier through agglomeration.
- *Economies of scale in fixed costs and service provision.* Tenants in a business incubator share a range of overhead costs, such as utilities, office equipment, computer services, conference rooms, and/or laboratories.
- *Signaling and enabling high-risk investment at early stages.* Incubated start-up businesses are provided with signaling and credibility with respect to other actors of the market and industry. The fact that a business has been accepted into/graduated from an incubation or acceleration program offers due diligence value to potential investors and makes it easier for the start-ups to attract further investment in their projects.

Potential Drawbacks and Risks

- *High cost of running programs and limited outreach.* Incubators are costly to set up and administer given the small number of firms that can be supported, compared to other instruments such as business development services. These high costs are even more of a problem given the uncertain returns that the evidence suggests in terms of survival, innovativeness, and growth. Due to these high costs, countries such as Chile have considered replacing some of these incubators with separate coworking spaces, which are more likely to be financially viable, and with mentoring programs.
- *Lack of a clear business model, internal management problems, and unclear selection criteria.* These can become important risks associated with putting incubation

programs in place. The heterogeneity of different types of incubators makes it difficult to issue general selection criteria for tenants.

- *Limited focus on scaling up and growth stages.* Incubators predominantly focus on a firm's birth, but scaling up and growth of businesses is the most challenging stage. As a result, when incubators are not complemented with a good business environment and complementary support to growth stages, the success in generating successful firms that scale up can be limited.
- *Risks of not achieving self-sustainability financially.* Self-sustainability, while a major aspiration for incubators around the world (and in some cases accelerators, especially in developing countries), is a big challenge. Incubators that are set up to be financially self-sustainable should be able to generate all of their own income. However, in most cases, financial sustainability means that they still need to rely upon ongoing financial support or in-kind subsidies (such as a free building), given that the time needed to break even can be very long.

Elements for Good Instrument Design

Incubators are effective only if they correctly address the key market/system failures and needs of early-stage entrepreneurs in a particular entrepreneurship ecosystem. Therefore, at the planning stage it is critical to select a business model based on market opportunities for entrepreneurs and their growth prospects, the core objectives of the incubator, and the realities of available funding, as well as the priorities and expectations of those providing funding, expected geographical scope and level of impact, and the availability of skills and resources that can be leveraged to operate the business incubator.

There is no one "golden standard" for an incubator model because each incubator operates in a unique entrepreneurial and social environment; each incubator must define the business model best suited to its purpose.

Variables that affect what business model an incubator should adopt include:

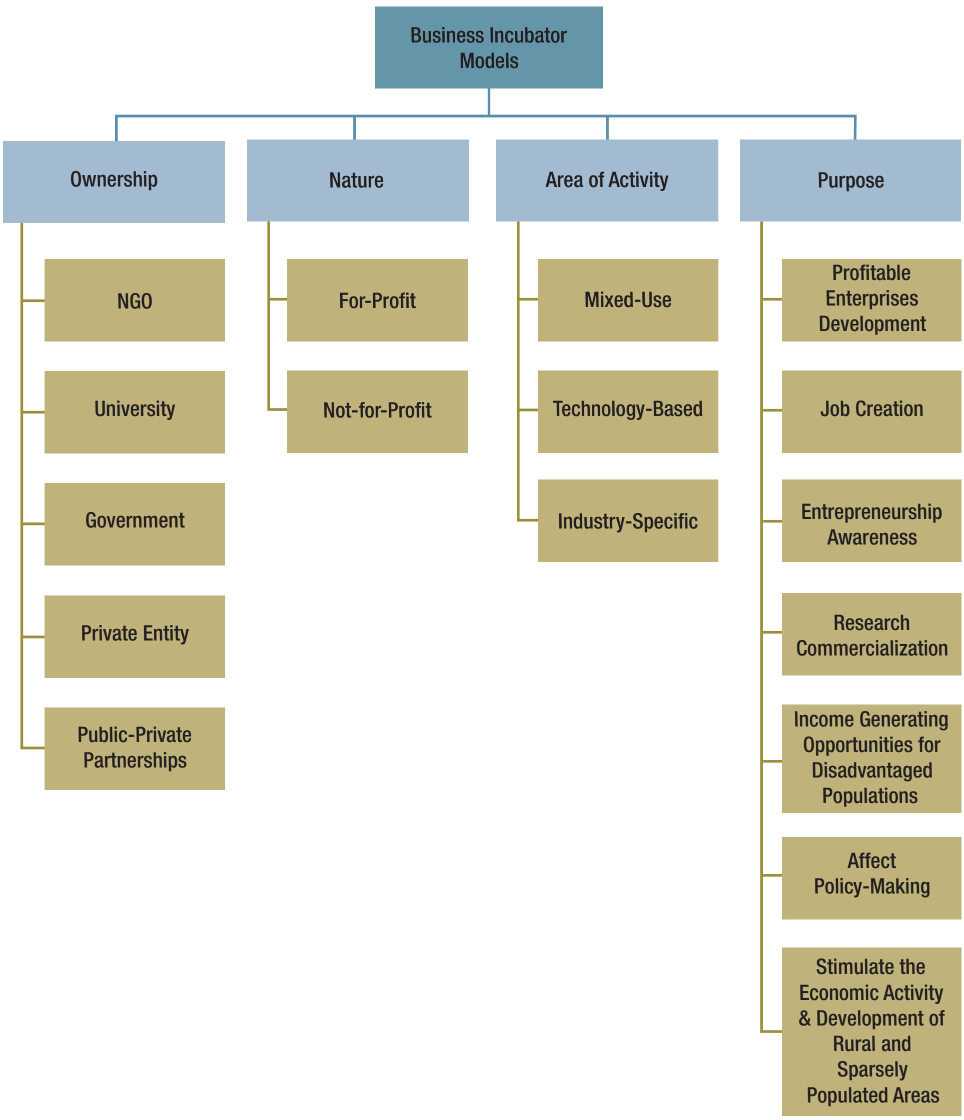
- *The ownership of the incubator*, which may produce differences in the advice offered and expertise, metrics, and reporting processes.
- *The nature of the incubator*, for example, whether for-profit or not-for-profit. For-profit incubators aim to maximize profitability, while not-for-profit incubators aim for sustainability but can still make a profit.
- *The area of activity of the incubator*, whether serving all or specific industry sectors, for example.
- *The incubator's main purpose*—whether job creation, technology commercialization, engaging youth in entrepreneurship, generating export revenues, stimulating the creation of a new sector of industry, stimulating the economy, or developing rural or sparsely populated areas.

Figure 4.8 provides a classification of the main types of incubators based on the variables discussed. In practice, there are different combinations of those dimensions that can translate into different models.

Evidence of Impact

Despite the extensive and still growing literature on business incubators, only a limited number of comprehensive evaluation studies have been undertaken to assess their

FIGURE 4.8 Typology of Business Incubation Models



Source: InfoDev 2015.

Note: NGO = nongovernmental organization.

impacts. A generally accepted set of instruments for analyzing the effectiveness of business incubators has yet to be developed. Moreover, there is a lack of homogeneity in definitions of business incubation processes, even within the research community. For example, some studies do not distinguish clearly between incubators and accelerators, or between incubators and science parks. Therefore, the evidence summarized next should be considered with caution. This synthesis analyzes those studies according to the subject they focus on.

The selected studies have adopted diverse indicators and methods to assess the effectiveness of incubators. One type of study adopts quantitative methods with a control group, typically using a sample of incubated businesses and a matched control group of unincubated businesses, such as Colombo and Delmastro (2002) and Amezcua (2010). Another type of study focuses on benchmarking across incubators using surveys and interviews, such as CSES (2002). A third method that is commonly used is in-depth case studies, such as Ratinho and Henriques (2010). Typical indicators to measure the performance/success of incubators include firm survival rates, jobs creation (both direct and indirect, such as additional jobs created in local supply chains), and sales/profit growth. Nevertheless, the lack of comprehensive and consistent databases dedicated to business incubators has made comparative analysis and systematic evaluation challenging tasks, as noted by Dee et al. (2011) and ANDE (2014).

Performance and Processes

Several studies shed light on the operational processes and overall performance of incubators rather than their impacts. Table 4.28 summarizes main findings from some of those studies. Important observations include that characteristics and performance of incubators are highly specific to context, that entrepreneurs selected by incubators tend to feature high-quality human capital, that affordable office space and business development programs were beneficial for tenants, and that the first three years after graduation is the toughest period for firms to survive.

Output and Outcome Additionality

A few studies assess the impacts of incubators in terms of outputs and outcomes, measured through indicators such as patenting activity, jobs creation, and revenues generated, as summarized in table 4.29. Some studies focus on describing the number of firms served and the employment associated with these firms. There were around 900 business incubators in the EU generating about 40,000 new (net) jobs per year, CSES (2002) suggests.

Evidence on output/outcomes is mostly derived from the context of developed countries; evidence about developing countries is scarce. The studies offer inconclusive findings about the effectiveness of incubators. While some find that incubators generate significant economic impacts (such as Chabin Concepts 2009), others report that the difference made by incubators has been marginal (such as Ratinho and Henriques 2010). In the extreme case, Schwartz (2013) finds statistically significant

TABLE 4.28 Evidence on Performance and Processes of Incubators: Key Findings

Study	Context	Finding
Vanderstraetena et al. (2016)	Brazil	Service customization is a significant mediator through which an incubator's industry focus can influence the survival and growth of incubated firms. Nevertheless, the authors fail to find any evidence for a significant direct relation between an incubator's industry segmentation and incubated firms' survival and growth.
Chandra and Fealey (2009)	Brazil, China, USA	Incubators in all three countries facilitated access to a range of financial services to their incubated firms by serving as an intermediary, but very few had the resources to make direct investments in their incubated firms.
Chan and Lau (2005)	Hong Kong SAR, China	Rental subsidies, especially free rental in the first year, greatly help start-up firms survive. Business-related training programs are particularly useful because the founders of tenant firms are all technology entrepreneurs who lack a business background.
Adegbite (2001)	Nigeria	Several issues must be addressed before the surveyed incubators can generate the desired impacts, including but not limited to inadequate quantity of existing incubators, firms' location after they leave the incubator, refusal of tenant firms to vacate the premises, and lack of private sector participation.
Colombo and Delmastro (2002)	Italy	The investigated Italian incubators have been playing a positive selection role, attracting entrepreneurs with high-quality human capital, such as a more extensive educational background and more explicit entrepreneurial orientation. Incubated firms outperformed unincubated firms in dimensions such as education of workforce, adoption of innovative information and communications technology, and participation in EU-funded research projects.
Abetti (2004)	Finland	Public policy leaders, in connection with the regional and local educational and industrial communities, can play a successful role in the development of new high-tech agglomerations of incubators and companies by being proactive (creating a learning environment and providing "seeding") rather than reacting to perceived market failures (subsidies and investments in "strategic" industries). But it is unclear if the same policy approaches would work in other countries with cultural dimensions different from Finland.

lower probabilities of survival within the incubator. The effectiveness of incubators seems to be highly specific to context and no universal conclusion can be drawn.

In terms of other output additionality, table 4.29 shows that the evidence from Italy does not support the premise that incubation leads to a significant increase in patenting activity. However, in the EU and the United States, evidence suggests that incubators have generated significant revenue and employment. In the Turkish context, Akçomak and Taymaz (2004) find greater sales and employment contribution from incubated firms than from unincubated firms. In the context of Colombia, India, and Mexico, ANDE (2014) suggests that incubators achieved stronger revenue-growth results for early-stage companies than for growth-stage ones.

Main Requirements for Replicability

Establishing an incubator is a significant, long-term investment for the community at stake. Therefore, effective planning is a key factor in ensuring the success of such an initiative and the return on investment for the principle stakeholders. The evidence strongly supports the notion that there is no one-size-fits-all solution in terms of successful incubation models for varying economic and social environments.

TABLE 4.29 Evidence on Output and Outcome Additionality of Incubators: Key Findings

Study	Context	Finding
Colombo and Delmastro (2002)	Italy	Incubated firms' performance does not differ significantly from the performance of their unincubated counterparts in terms of innovative output, measured by patenting activity.
Ratinho and Henriques (2010)	Portugal	In Portugal, the contribution of incubators and science parks to economic growth is modest. The impacts of company creation are minimal and could, at best, have a local impact. Most Portuguese incubators were not planned and are not working toward the creation and development of new ventures.
Akçomak and Taymaz (2004)	Turkey	In terms of employment generation (including R&D personnel) and sales growth, incubated firms significantly outperform unincubated firms. Nevertheless, in terms of innovative output (new intellectual property rights, new products), unincubated firms outperform incubated ones.
ANDE (2014)	Colombia, India, Mexico, and at the global level	Incubators appear to be creating more value for early-stage enterprises than for growth-stage enterprises; revenue growth (compound annual growth rate) in the two years following program participation was 86 percent for early-stage small and growing businesses versus 14 percent for growth-stage ones. The authors conclude that there should be greater distinction between "incubator" programs focused on early-stage enterprises and "accelerator" programs focused on later, growth-stage enterprises.
RTI International (2007)	State of Maryland, United States	Incubator firms employed 5,374 employees in 2006 and indirectly added another 8,670 jobs through economic interactions with other Maryland industries and households. They also generated approximately $1.2 billion in gross state product and $100 million in state and local taxes.
Amezcua (2010)	United States	Although incubated businesses have slightly higher employment growth and sales, they have slightly lower survival rates than the control group after they graduate. Overall, the difference in performance between incubated and unincubated businesses is marginal. Women-owned firms benefit more from incubation than men-owned firms.
Chabin Concepts (2009)	City of San Jose, California, United States	The four assessed incubators generated a combined economic impact of $515,782,349 million to the local economy in 2008, which corresponds to 1,900 directly and indirectly supported jobs and $196.6 million in annual payroll.
Schwartz (2009)	Germany	Within the first three years after leaving the incubators, about 20 percent of the graduates do not survive, and more than half of postgraduation closures occur within this time. Performance during the incubation period is an indicator of the propensity of business closure after graduation.
Schwartz (2013)	Germany	None of the five incubator locations demonstrated statistically significant higher survival probabilities for firms located in incubators compared to firms outside. Three locations demonstrate statistically significant lower chances of long-term survival (over 10 years) for those start-ups that received support from an incubator.

Required capabilities from implementing agencies are varied. Sponsors of incubators should identify the need for the program and assess whether there is a clearly identified demand for these types of intervention. In addition, implementing agencies need to clearly anticipate expected results, and whether the purpose of the program is job creation, technology commercialization, promotion of female entrepreneurship, or other outcomes.

Undertaking a feasibility study for setting up an incubator is strongly recommended to understand the current landscape of the entrepreneurial ecosystem, identify the right target market and strategic direction for the incubator, map potential stakeholders, and understand the type and scope of potential deal-flow of clients.

In addition, sponsors and implementing agency should have realistic expectations of the time required to attain results. A poor understanding of the time that business incubation takes to produce results often leads to unrealistic expectations and inadequate funding projections. Replication of these instruments should rely on the strong realization that the incubation takes time to achieve results and a robust portfolio of clients. Therefore, funding allocations for supporting these instruments should take into consideration long-term commitments (for example, at least five years for a business incubator).

Participation in incubator programs needs to be rigorous and performance based. A major criticism of incubators is often that they just provide cheap rent and occupants that are not growing can stay forever because there are neither performance criteria nor time-bound contracts.

A plan for financial sustainability should be addressed at the very beginning of setting up an incubator. Governments are a major source of seed funding for incubators, which can provide value to governments through job creation and industry development. For-profit incubators aim to maximize their return on investment, but they also still struggle with sustainability. Some, if not the majority, will never break even.

Dos and Don'ts of Business Incubators

Do	Don't
▪ Be demand-driven: Understand your potential market, the deal-flow of entrepreneurs, and their needs. ▪ Plan the governance structure carefully (this is a deal-breaker). A critical lesson learned is that business enablers are rarely effectively run and directly operated by government. Public-private partnerships are strongly encouraged. ▪ Ensure leadership with an entrepreneurial mindset, excellent market knowledge, and networking skills. ▪ If necessary, be prepared to invest in building the capability of incubator managers, given that this is a specialized skillset. ▪ Ensure that physical location is easily accessible for potential clients and close to other business infrastructure/university.	▪ Don't use accelerators and incubators interchangeably. They address innovation problems through different rationales. The theory of change needs to be clarified upfront when designing the instruments. ▪ Don't mix up incubators with cluster policies. Although cluster policies and early-stage support measures can mutually affect one another, they are different measures with different tools. ▪ Don't ignore developing a financial sustainability strategy, even if initial funding is secured for several years. ▪ Don't assume all successful growth companies inevitably come from incubators; most do not.

Dos and Don'ts of Business Incubators

Do	Don't
▪ Be strongly performance based. If tenant companies are not growing or showing much likelihood of doing so, they should be moved out and replaced with more deserving clients. ▪ Be careful about incubators that force tenants to use a narrow group of service providers tied to the incubator itself; this may be profitable for the incubator but not the best option for the companies.	

Checklist for Design and Implementation of Business Incubators

- Are you paying enough attention to other barriers to firm entry and firm growth?
- What is the goal that the incubator wants to achieve? Is it clearly defined and achievable?
- How do you provide incentives to participant firms and what incentives do you offer? How do you define the success rate in different early-stage support measures?
- Will you be able to identify/hire a strong entrepreneurial leadership team?
- Are the participation criteria sufficiently clear for all potential applicants?
- What growth stage of start-up development does your measure support? How do you want to deliver the support?
- What potential partners are you able to mobilize, such as seed funds, angel investors, or industrial clusters?
- What complementary instruments can you utilize to maximize the impacts of your scheme?
- Do you have resources that can produce sufficient quality entrepreneurs?

References

Abetti, P. 2004. "Government-Supported Incubators in the Helsinki Region, Finland: Infrastructure, Results, and Best Practices." *Journal of Technology Transfer* 29: 19–40.

Adegbite, O. 2001. "Business Incubators and Small Enterprise Development: The Nigerian Experience." *Small Business Economics* 17 (3): 157–66.

Akçomak, I. S., and E. Taymaz. 2004. "Assessing the Effectiveness of Incubators: The Case of Turkey." ERC (Economic Research Center), Middle East Technical University.

Albert, P. and L. Gaynor. 2001. "Incubators: Growing Up, Moving Out–A Review of the Literature." Cahier de recherché du CERAM, Sophia.

Amezcua, A. 2010. "Boon or Boondoggle? Business Incubation as Entrepreneurship Policy." PhD thesis, Syracuse University.

ANDE (Aspen Network of Development Entrepreneurs). 2014. "Measuring Value Created by Impact Incubators and Accelerators." ANDE, Agora Partnerships, & I-Dev International.

Chabin Concepts. 2009. "Assessment of Incubator Program–Operations, Tenant Surveys & Economic Analysis." Prepared for San Jose [California] Redevelopment Agency Downtown Management/Industrial Development. https://docplayer.net/9880979-Assessment-of-incubator-program.html.

Chan, K. F., and T. Lau. 2005. "Assessing Technology Incubator Programs in the Science Park: The Good, the Bad and the Ugly." *Technovation* 25 (10): 1215–28.

Chandra, A., and T. Fealy. 2009. "Business Incubation in the United States, China and Brazil: A Comparison of Role of Government, Incubator Funding and Financial Services." *International Journal of Entrepreneurship* 13 (January): 67–86.

Colombo, M. G., and M. Delmastro. 2002. "How Effective Are Technology Incubators? Evidence from Italy." *Research Policy* 31 (7): 1103–22.

CSES (Centre for Strategy and Evaluation Services). 2002. "Benchmarking of Business Incubators." European Commission Enterprise Directorate General.

Dee, N. J., F. Livesey, D. Gill, and T. Minshall. 2011. "Incubation for Growth, A Review of the Impact of Business Incubation on New Ventures with High Growth Potential." Research Summary. Nesta.

InfoDev. 2015. "InfoDev's Business Incubation Management Manual." World Bank, Washington, DC.

Ratinho, T., and E. Henriques. 2010. "The Role of Science Parks and Business Incubators in Converging Countries: Evidence from Portugal." *Technovation* 30 (4): 278–90.

RTI International. 2007. "Maryland Incubator Impact Analysis and Evaluation of Additional Incubator Capacity." International Center for Technology Applications.

Schwartz, M. 2009. "Beyond Incubation: An Analysis of Firm Survival and Exit Dynamics in the Post-Graduation Period." *Journal of Technology Transfer* 34 (4): 403–21.

———-. 2013. "A Control Group Study of Incubators' Impact to Promote Firm Survival." *Journal of Technology Transfer* 38: 302–31.

Vanderstraeten, J., A. van Witteloostuijn, P. Matthyssens, and T. Andreassi. 2016. "Being Flexible through Customization–The Impact of Incubator Focus and Customization Strategies on Incubatee Survival and Growth." *Journal of Engineering and Technology Management* 41: 45–64.

4.2.7.2 Accelerators

Definition

Acceleration programs target high growth-oriented firms in the process of scale up and entail an intensive mentoring program, usually accompanied by the possibility of an early-stage investment. The goal of acceleration program is to reduce the time it takes a firm to enter the growth stage, adapt its strategy according to market conditions, or close operations if scalability is not possible. In practice, a wide range of business acceleration models have emerged in both developed countries and increasingly in developing countries in the past decade. Some are physical and include infrastructures and facilities, while others are "virtual." Some provide funding or take equity, while others do not.

Although programs offering support to early-stage entrepreneurs are not a new phenomenon, these accelerators differ from other business support programs, such as incubators, in the sense that they:

- *Are time bound:* They offer short-term intense programs, typically between three to six months. They do not necessarily involve dedicated office space or infrastructure.
- *Are cohort-based:* They tend to be organized in cohorts, selecting and training/mentoring a group of enterprises over a given time; collaboration among enterprises in the same cohort is encouraged.
- *Have open intake:* Their application process is open to all businesses, yet very competitive.
- *Provide advisory services:* They provide intensive structured mentoring and coaching support, relying on the accelerator's business networks.
- *Offer access to finance:* They either provide participating enterprises with direct funding (normally, in exchange for equity) or with linkages to investors, often interacting in public pitch events or in a demo-day (as an accelerator graduation ceremony).

The first accelerator, Y Combinator, was founded by Paul Graham in 2005 in Cambridge, Massachusetts, and soon moved and established itself in Silicon Valley. Today, estimates of the number of accelerators range from 300+ to more than 2,000, spanning six continents and the number is growing rapidly (Cohen and Hochberg 2014). Initially, many accelerator programs were focused on information and communication technology or other technology. Today, accelerator programs have also diversified into different industry-based, vertically focused programs (such as energy, green technologies, and health care) or programs focusing on a given type of entrepreneurs (women or minority-owned start-ups, or university-affiliated start-ups).

Market and System Failures Addressed

- *Information asymmetry.* This can be pervasive in earlier stages and significantly constrain access to markets and suppliers, especially in riskier high-growth ventures. Accelerators try to bridge this information asymmetry and provide some screening and signaling to investors, suppliers, and customers. This can be especially important during the scaling up of potentially high-growth potential businesses, where accelerators can provide a very important signaling role to investors.

Target Group

A key difference between incubators and accelerators in terms of Target Group is that many incubators also service small young businesses that do not aspire to high growth. By contrast, accelerators exclusively target high-growth potential enterprises during the scale-up period and support them through a faster track to success, or failure, or pivoting them to other business trajectories.

Strengths

Key strengths of this type of instrument are:

- *Peer interaction and learning.* Accelerators allow group interaction and learning among entrepreneurs. Participants from the same cohort are motivated to collaborate with one another. Even if the result of acceleration is a "fast failure," the learning experience and the knowledge/skills gained throughout the acceleration process are invaluable for the participants.

- *Dedicated advisory assistance.* In accelerators, managers, staff members, and mentors often provide insightful and continued advice and/or information on a broad spectrum of business issues, from marketing to business expansion to access to finance.
- *Signaling and enabling high-risk investment at early stages.* Accelerated businesses are provided with signaling and credibility with regard to other actors of the market and industry. The fact that a business has been accepted into/graduated from an acceleration program provides due diligence value to potential investors and makes it easier for the start-ups to attract further investment into their projects.

Potential Drawbacks and Risks

This type of instrument also has some potential drawbacks and risks:

- *Risk of duplicate investment.* When there is insufficient coordination between different acceleration programs, some ventures might end up being accelerated multiple times, which severely compromises the efficiency of public resource allocation and can undermine the role of accelerators through churning rather than supporting scalable businesses.
- *Sector focus.* While there is a rationale for focusing on some tech sectors, given the lower fixed costs that firms in these sectors face compared to traditional sectors, it is not necessarily the case that only these sectors are characterized by a high concentration of firms with high growth potential (Grover, Medvedev, and Olafsen 2018) (see box 4.11). Moreover, in the context of developing countries, business incubators or accelerators can benefit more from being "neutral as to sector" to start with (to ensure sufficient deal-flow of the clients), and letting the real "deal-flow" of enterprises dictate whether they should focus on a sector, cluster, or value chain in the future.

Elements for Good Instrument Design

While there is no one-size-fits-all solution in terms of successful business acceleration models for varying economic and social environments, international best practices suggest several key success factors that contribute substantially to the efficiency of acceleration initiatives in different countries.

One of the critical lessons learned from the experience of infoDev[39] of working with clients across the globe is that the *early-stage entrepreneurship support instruments should not be run by government agencies, but rather operated with an entrepreneurial mindset, with proper private sector leadership and minimal government intervention*. Government can and should play a constructive role by, for example, providing financial support

BOX 4.11

Demystifying High-Growth Firms

It is commonly believed that young, small, and high-tech firms form the majority of high-growth firms. However, a recent study (Grover, Medvedev, and Olafsen 2018) finds that high-growth firms are:

- Not necessarily the youngest: While high-growth firms tend to be younger than the average firm, most will have been in business for at least two years before embarking on a high-growth trajectory.
- Not necessarily small: Many already are larger than the average firm at the beginning of a high-growth episode and, depending on the definition, the average high-growth firm is anywhere from 4 percent to 600 percent times as large as an average firm after three years of high growth.
- Not necessarily high-tech: High-growth firms also do not appear in the same sector across countries and are not necessarily more common in high-tech industries.
- Mostly likely to be "one-hit wonders": As many as 50 percent of firms that experienced a high-growth event in the previous three years are likely to exit the market altogether in the following three to six years, while less than 15 percent are likely to repeat a high-growth episode—illustrating the short-lived and episodic nature of firm growth.

This guide's findings therefore suggest an important reorientation of policies to support firm growth from searching for high-potential firms toward the **ABCs** of growth entrepreneurship: improving **A**llocative efficiency, encouraging **B**usiness-to-business spillovers, and strengthening firm **C**apabilities.

Source: Grover, Medvedev, and Olafsen 2018.

for the start-up phase of a business enabler and funding mechanisms for participating entrepreneurs, as well as performing an accreditation role. Thus, public-private partnerships can be an efficient way to launch a new early-stage entrepreneurship support instruments, especially in the context of developing countries. However, autonomy from the host or sponsoring institutions is an important factor.

Another important factor is *careful selection of entrepreneurs*. Given the objective of accelerators in fast-forwarding growth of enterprises, growth potential is inevitably one of the criteria. In addition, given the cohort nature of accelerator programs, selection of entrepreneurs should try to maximize the synergy, collaboration, and peer-learning potential among participants of the same cohort.

Evidence of Impact

Accelerators are a relatively new type of instrument and have received little attention in the economics, finance, or management literature so far. While the proliferation of accelerator programs over the last few years has been rapid, very few have been analyzed to date regarding their efficacy as institutions and intermediaries in the entrepreneurial ecosystem. The selected studies typically adopt research methods based on surveys (of incubators, entrepreneurs, and investors) and interviews with stakeholders. Data analysis mostly remains descriptive. Key indicators used for performance assessments included survival rates, growth in revenues, number of employees, and follow-on funding/investment. Several studies involve comparison between beneficiary and nonbeneficiary groups, such as Roberts et al. (2016) and Yu (2015).

In addition to the heterogeneity in terms of support, one of the primary obstacles to research in this area has been the absence of large-scale representative datasets on accelerator programs that include program features and information about the companies that enter and graduate from the programs. Importantly, different types of accelerators have different objectives. Thus, their effectiveness should be assessed differently using dedicated metrics; this remains a gap in this field. Therefore, the evidence summarized next should be considered with caution. To address some of the challenges outlined, the Global Accelerator Learning Initiative (GALI) was launched in 2013 through collaboration between the Aspen Network of Development Entrepreneurs (ANDE) and Emory University (United States) with several other contributors. GALI builds on the work of the Entrepreneurship Database Program at Emory, which has been working with accelerator programs around the world to collect and analyze data describing the many entrepreneurs that they attract and support.

Processes and Performance

A few studies investigate factors affecting the processes and performance of accelerators. Core factors, as indicated by the key findings presented in table 4.30, include program selectivity, program age, and organizational characteristics such as emphasis on networking and branding. Table 4.30 shows that the best-performing accelerators tend to host a smaller number of applicants, and to focus on nurturing professional skills such as networking, communication, and organizational structure among residents. In developing countries, older accelerators have featured stronger enterprise success rates. In addition, accelerators that more carefully selected applicants have proved to increase both success and survival rates of resident firms.

Output/Outcome Additionality and Efficiency

Table 4.31 summarizes main findings from the few studies that shed light on the effectiveness of accelerators in generating output/outcome additionality and affecting investment efficiency. Two studies in the US context, Yu (2015) and Winston-Smith and Hannigan (2015) find that accelerators can enhance the efficiency of investment by speeding up exit, either through successful acquisition or through failure. The only study this guide found that looks at the impacts of accelerators on regional entrepreneurial ecosystems, Fehder and Hochberg (2014), reported positive impacts—again in the context of the United States.

Evidence found in table 4.31 from Europe and Israel reveals that accelerator programs have led to increased company survival rates (by around 15 percent). In Chile,

TABLE 4.30 Evidence on Processes and Performance of Accelerators: Key Findings

Study	Context	Finding
Roberts et al. (2016)	India, Kenya, Mexico, Netherlands, South Africa, and the United States, 15 Village Capital acceleration programs	High-performing programs typically feature smaller pools of applicants with stronger competencies. Better-performing acceleration programs focus on the quality and promise of the underlying idea rather than the venture itself. Networking among cohort members as well as emphasis on financial acumen improves program performance. High-performing programs spend less time working on finance, accounting, and formal business plan development and more time on networking, organization structure, and design, as well as presentation and communication skills.
ANDE and Village Capital (2013)	Global, 52 accelerators focused on social impact across developed and developing countries	Older accelerators perform better than younger ones in terms of their enterprise success rates (46 percent versus 25 percent);[a] nevertheless, no statistically significant differences are observed in terms of survival rates (80 percent versus 76 percent). Accelerators with higher selectivity appear to perform better than those with lower selectivity (success rate 39 percent versus 24 percent, and survival rate 91 percent versus 69 percent).
Birdsall et al. (2013)	United Kingdom, Eastern Europe, and Israel	Accelerator programs increase the level of company survivorship by 10 percent to 15 percent by the fifth year following exit. The authors identified several best practices for accelerator programs, including the development of a strong brand and a positive international reputation, as well as the use of key performance indicators and quantitative data to drive program development.
Gonzalez-Uribe and Leatherbee (2015)	Chile, Start-Up Chile (SUP)	Entrepreneurship education bundled with basic services (the building of entrepreneurial capital) can significantly improve the performance of new ventures. In contrast, no evidence was found that basic services affect performance on their own. This pattern is also consistent with the well-established findings on how interventions that combine finance (especially grants) and business training are more effective in supporting subsistence businesses than finance alone.
Hallen, Cohen, and Bingham (2017)	Top US and European accelerators and in major metropolitan areas or entrepreneurial hubs	Positive effects of accelerators are substantially driven by learning via consultation. Accelerator participation complements rather than substitutes for many forms of the founder experience before entering the program. If structured correctly, the practices of early accelerators represent a beneficial and likely replicable form of entrepreneurial intervention.

a. Success rate is defined as "percentage of graduate enterprises operating at a profitable level, and/or having raised major investment ($500,000 or more)" (ANDE and Village Capital 2013, 19).

participation in accelerator programs has led to additional fundraising by firms. Moreover, at the level of the city, the evidence suggests that the arrival of accelerators programs has been associated with increases in the number of deals.

Main Requirements for Replicability

Competent, innovative, and knowledgeable management is critical to success. Therefore, policy makers need to understand: (1) whether there is a pool of available local professionals to form and lead the core team to operate a business accelerator; and (2) whether it is possible to attract external expertise at the initial stage to build local institutional capacity.

TABLE 4.31 Evidence On Output/Outcome Additionality and Efficiency of Accelerators: Key Findings

Study	Context	Finding
Roberts et al. (2016)	28 acceleration programs in multiple countries	The 335 participating entrepreneurs reported an average increase in revenues of $32,965, while the 852 rejected entrepreneurs reported an average of $1,359. Nevertheless, the impact of acceleration on investment was modest, with participating entrepreneurs growing total investment by $34,528, compared to $11,255 for rejected entrepreneurs.
Gonzalez-Uribe and Leatherbee (2016)	Chile	Entrepreneurship education (bundled with the basic services of cash and coworking space) leads to significant increases in venture fundraising and scale. By contrast, the authors find no evidence that the basic accelerator services of cash and coworking space improve venture performance. Suggestive evidence was found that the program generates spillovers in the form of increased business creation.
Winston-Smith and Hannigan (2015)	United States	Participation in a top accelerator program increases the speed of exit, either through acquisition or failure. Participation in a top accelerator initially increases the speed of receiving follow-on funding from venture capital investors, particularly in the window surrounding the culminating "Demo Day" presentations. However, in the longer term, participation in a top accelerator relative to a top angel investor group—investors specialized in early-stage ventures—appears to decelerate the timing of follow-on funding from venture capital.
Yu (2015)	United States	There are efficiency gains from investing in accelerator companies because the quality of companies can be observed sooner, and the risk of investment is mitigated. Even though accelerator companies raise less money on average, investment in accelerator companies is 4.8 times more efficient than investment in nonaccelerator companies. On an aggregate level, accelerators' role as an intermediary resolving uncertainty seems beneficial.
Fehder and Hochberg (2014)	United States	Metropolitan Statistical Areas (MSA) that receive an accelerator program exhibit significant differences in seed and early-stage financing patterns compared to nontreated areas. The arrival of an accelerator is associated with a 104 percent increase in the number of seed and early-stage venture capital deals in the MSA each year; a 1,830 percent increase in the total amount of seed and early-stage funding provided in the region; and a 97 percent increase in the number of distinct investors investing in the region.
GALI (2017)	26 acceleration programs from high-income countries, and 17 programs from emerging markets	Compared to nonparticipants, participating ventures experienced 10.3 percent more revenue growth, 6.6 percent more employee growth, 8.3 percent more equity growth, and 8.6 percent more debt growth. Overall, participating ventures from high-income countries outperform those from emerging markets in terms of revenue growth (12.2 percent versus 9.4 percent), while participating ventures from low-income countries outperform those from high-income countries in terms of employee growth.

Specific technical capabilities to run a successful accelerator are also necessary. Those processes include the approach to selection of entrepreneurs, designing a strong mentorship/coaching or business development program, and creation of strong business networks, as well as the introduction of access to finance mechanisms, whether in-house or through collaboration with external early-stage financiers.

Some *basic competencies* are also needed to participate successfully in accelerator programs. First, and depending on the stage of the business cycle, participants should be able to fulfill basic eligibility requirements, such as legal registration. Many participants in very early stages may be exempt from this requirement, but registration normally becomes part of the support provided. Second, participants should not only be willing to invest their own time to absorb the assistance, but also should be able to articulate the novelty embodied in their business proposition and to absorb the assistance delivered through the services. Third, participants should show adaptiveness and willingness to modify their business proposition based on the processes of exploring business opportunities and refining solutions induced by the coaches and experts under the program.

Dos and Don'ts of Accelerators

Do	Don't
■ Implement an effective selection process to identify growth-oriented enterprises, as well as a performance management process to screen out no-growth tenants. ■ Implement an effective mentoring program harnessing the experience and networks of successful business professionals. ■ Develop a highly networked program that allows the accelerator to connect the entrepreneur with other relevant resources, including early-stage finance. ■ Think through what support structures are in place for graduates who wish to continue to grow.	■ Don't rely on public agencies; it is essential to get the private sector involved in running the program, either through partnership or delegation. It also is critical to engage with private sector partners with rich experience and knowledge to ensure quality. ■ Don't run accelerators in isolation from the local entrepreneurship ecosystem. Local networks and resources are the social capital upon which accelerators are built. ■ Don't distort the selection criteria and process with public sector preferences. The program should be kept fully commercial.
■ Be prepared to invest in capacity building for accelerator managers and advisors because this is a relatively new field with new approaches being developed.	■ Don't expect to always be able to identify unicorns,[a] but only growth potential. ■ Don't expect all high potential businesses to automatically be found in acceleration programs, many grow without involvement in such programs.

a. Unicorns are privately held start-up companies that often experience high-growth and are valued at more than $1 billion

Checklist for Design and Implementation of Accelerators

- Do you have good new ventures that require growth and scale up?
- How do you provide incentives to participant firms and what incentives do you offer? How do you define success rate in different early-stage support measures?

- Will you be able to identify/hire a strong entrepreneurial leadership team?
- Are the participation and exit criteria sufficiently clear for all potential applicants?
- How are you going to deliver the support?
- What potential partners are you able to mobilize, such as seed funds, angel investors, or clusters?
- What complementary instruments can you utilize to maximize the impacts of your scheme?
- Do you have sources that can produce enough numbers of quality entrepreneurs?
- Are you connected to angel investor networks and other investors that you can bring to startups?

References

ANDE (Aspen Network of Development Entrepreneurs) and Village Capital. 2013. "Bridging the 'Pioneer Gap': The Role of Accelerators in Launching High-Impact Enterprises." https://assets.aspeninstitute.org/content/uploads/files/content/docs/ande/Bridging%20the%20Pioneer%20Gap%20The%20Role%20of%20Accelerators%20in%20Launching%20High%20Impact%20Enterprises%20.pdf.

Birdsall, M., C. Jones, C. Lee, C. Somerset, and S. Takaki. 2013. "Business Accelerators–The Evolution of a Rapidly Growing Industry." Judge Business School, University of Cambridge.

Cohen, S. G., and Y. V. Hochberg. 2014. "Accelerating Startups: The Seed Accelerator Phenomenon." http://seedrankings.com/pdf/seed-accelerator-phenomenon.pdf.

Fehder, D. C., and Y. V. Hochberg. 2014. "Accelerators and the Regional Supply of Venture Capital Investment." Available at SSRN 2518668.

GALI (Global Accelerator Learning Initiative). 2017. "Accelerating Startups in Emerging Markets–Insights from 43 Programs." https://www.galidata.org/assets/report/pdf/Accelerating%20Startups%20in%20Emerging%20Markets.pdf.

Gonzalez-Uribe, J., and M. Leatherbee. 2015. "Business Accelerators: Evidence from Startup Chile." *SSRN Electronic Journal* (January). doi: 10.2139/ssrn.2651158.

————-. 2016. "The Effects of Business Accelerators on Venture Performance: Evidence from Startup Chile" (August). http://www.juanitagonzalez-uribe.net/wp-content/uploads/2016/10/Business_Accelerators_11_08_2016.pdf.

Grover, A., D. Medvedev, and E. Olafsen. 2018. "High-Growth Firms. Facts, Fiction, and Policy Options for Emerging Economies." World Bank Group, Washington, DC.

Hallen, B. L., S. Cohen, and C. B. Bingham. 2017. "Do Accelerators Accelerate? If So, How? The Impact of Intensive Learning from Others on New Venture Development." *Academy of Management Proceedings* 2014 (1): 12955.

Roberts, P. W., S. Lall, R. Baird, E. Eastman, A. Davidson, and A. Jacobson. 2016. "What's Working in Startup Acceleration–Insights from Fifteen Village Capital Programs." Emory University's Goizueta Business School, SEG, Aspen Network of Development Entrepreneurs (ANDE), and Village Capital.

Winston-Smith, S., and T. J. Hannigan. 2015. "Swinging for the Fences: How Do Top Accelerators Impact the Trajectories of New Ventures?" *Druid Conference Proceedings* 15: 15–17. https://conference.druid.dk/acc_papers/5ntuo6s1r5dvrpf032x24x5on5lq.pdf.

Yu, S. 2015. "The Impact of Accelerators on High-technology Ventures." PhD thesis, New York University. https://search.proquest.com/openview/db72758b63158227ad2016cc9ca0e132/1?cbl=18750&diss=y&pq-origsite=gscholar.

4.2.7.3 Equity Finance for Innovative Enterprises

Definition

Early-stage equity (ESE) finance is a relatively new category of financial capital. The government provides capital that is used by financial intermediaries to buy equity (shares) in small and young innovation-intensive companies, which use this capital to fund their growth. These intermediaries can be individuals, angel investor groups, organized funds, funds tied to service providers like accelerators, or larger companies. Investors usually achieve returns mainly in the form of capital gains when selling their shareholding (known as exiting) rather than from dividend income.

Early-stage equity aims to address a financial imperfection for a particular segment of the market: firms operating early in their life cycle, and in highly innovative, risky sectors. Such firms often have limited capacity to generate revenue and get access to other external sources of finance because of information asymmetries, which are more relevant at this stage than at more mature stages. Early-stage equity investors directly address this information asymmetry. Investors (or their representative) tend to be actively involved in the investee company (such as through a board position) so they can directly apply their knowledge and connections and assist the decision making and development of investees. In this way, early-stage equity finance is distinctive from debt capital.

Most of companies that receive early-stage equity do not achieve growth, so investors are encouraged to take a portfolio approach by investing in several businesses in the expectation that most of their gains will come from a minority of investees. Despite the growth of the industry, its coverage and maturity vary widely across regions and countries. Many of the investment skills and knowledge that are applicable for later-stage equity, traditional debt finance, and other types of investing do not apply in these markets. Investment of this kind is based more on judgment (of the entrepreneurs, the potential of the proposed business model, and the intellectual property/technology) than on financial analysis. This means early-stage equity investment is often an unfamiliar process for both entrepreneurs and investors. Entrepreneurs may be reluctant to rely on equity to finance firm growth because they are not willing to surrender control of the firm to investors. Issuing new equity dilutes an entrepreneur's control of the firm and can become a source of conflict if disagreements between shareholders emerge, even if it also increases risk sharing and gives the entrepreneur access to the investor's networks and expertise (Bravo-Biosca, Cusolito, and Hill 2014).

Governments can play a vital role in facilitating the investment process, both from the demand side and supply side of the market, for all relevant stakeholders, especially in developing economies. A range of direct and indirect policy programs has been employed to nurture a conducive environment for the seeding and growth of early-stage equity investing in the markets, and directly insert capital, as summarized in box 4.12.

BOX 4.12

Types of Government Programs to Support Early-Stage Equity in the Private Market

Direct supply of public capital

- *Direct investment funds.* The government creates and runs its own seed or venture capital (VC) fund(s). This is usually the practical option when there is no venture capital market available and no private investor community. Fund management may be completely internal or may be outsourced. This type of funding allows governments to pursue certain policy objectives, (such as the creation of regional and sectoral funds).
- *Coinvestment funds.* The government takes a passive role as a limited partner and seeks to "crowd in" private capital by matching private investments. This can be on a deal-by-deal basis (seed coinvestment funds) or through a more formal fund structure usually established for 10 years and managed by a general partner and team, which take full operational responsibility.
- *Fund-of-funds (FoF).* The government appoints an independent FoF manager who decides which private sector coinvestment funds to support. This is becoming a popular model because it offers governments the opportunity to invest in a few venture capital funds to reduce risks and provide the market with several alternative funding sources.

Tax and regulatory incentives

- *Tax incentives* include tax credits or deductions either to investors or investee companies that reduce/eliminate payable taxes; guarantees on loans taken out by firms or small start-ups; or guarantees on equity investments made by venture capital firms.
- *Regulations* include those easing the quantitative restrictions on institutional investors to diversify sources of venture capital funds; those improving accounting standards and performance benchmarks to reduce the opacity of venture capital funds and protect investors; and those removing barriers to inflows of foreign venture capital finance.

Support business angel activity

Some governments have supported the development of angel investing to increase the probability of funding for entrepreneurial ventures. This can be done by supporting education and awareness, establishing formal *business angel networks* (BANs). BANs are typically made up of high-net worth individuals who come together to jointly assess and fund new ventures (some models involve group/pooled investment; others involve individuals investing). Support measures include financial support for operation activities of BANs, national associations that connect BANs with other governmental or private organizations active in the field of risk capital, and training for business angels. BANs have become a mechanism to match investors who are seeking investments with entrepreneurs who are seeking financing, as well as serving as a space where entrepreneurs who have received angel investment can share experiences.

Market and System Failures Addressed

- *Information asymmetry.* Not only there is limited information about the likelihood of success of a particular innovative venture, but this information is also asymmetric. The entrepreneur (or firm) looking for finance has more accurate information both about how promising an innovation venture is as well as her effort and choices when developing it, although there is still considerable uncertainty. Further, for the private investor, there is a lack of motivation to fund early-stage ventures, given that it is hard (and time consuming) to conduct project appraisal and due diligence without reference benchmarks, and for relatively small amounts of money.
- *Coordination failure.* Innovation activity happens within a "system," drawing on different actors and networks, as well as underlying infrastructure and institutions. Entrepreneurs come up with ideas, investors back them with their funding, and these new firms try to attract talent, suppliers, partners, and customers. If successful, they expand, go through an initial public offering or are acquired in a profitable trade sale. Most (if not all) parts of the system need to be in place for it to function well, and missing parts may not emerge if some others are missing (Bravo-Biosca, Cusolito, and Hill 2014). Part of the fragmented nature of risk capital market is caused by the time and cost for investors of early-stage due diligence, and search costs for innovators looking for investment.

Target Group

ESE investment instruments target the following groups, at least:

- *Private investors* such as institutional investors (including pension funds, insurance companies, and banks) and individuals.
- *Venture capital fund managers,* such as former entrepreneurs and successful business managers, who put together prospective funds and marshal the private sector coinvestments. In an emerging venture capital market, government can play an active role in providing training and capacity building to venture capital managers.
- *Entrepreneurs,* as the ultimate beneficiaries.

Strengths

The different types of ESE investment instruments summarized in box 4.12 have different strengths:

- *Alignment of interests.* The general appeal of equity finance is the alignment of interests because both the investors and entrepreneurs are equally motivated to succeed via the achievements of the investee venture. Compared to grants and loans, direct investments can enable the entrepreneur to access the fund manager's or investors' advice, connections, and networks, making it so-called smart capital. Also, unlike grants, investment is not "free money." Investees are accountable for making their venture a success.

- *Risk sharing.* With coinvestment or fund-of-funds models, the government can outsource some (or all) of the critical skills to deploy this instrument successfully, such as investment appraisal decisions and advisory services, as well as mitigate some of the risks through the participation of private investors.
- *Bringing in investment and expertise from private sector.* Venture capital is often described as "smart capital" because it can benefit their investee companies in several ways beyond the provision of capital, such as assisting with business planning and strategy; mentoring the managers; providing strategic, technical, commercial, and legal advice; improving corporate governance; assisting in the recruitment process of key staff; and making connections (Gans, Hsu, and Stern 2002; Gorman and Sahlman 1989). Venture capital can also create networks of collaboration between investors, universities, R&D centers, large and technology-oriented firms, small entrepreneurs, and skilled workers (Florida and Kenney 1988). This can provide venture-backed companies an advantage over other firms, increasing their chance of success (Bravo-Biosca, Cusolito, and Hill 2014). The coinvestment or fund-of-funds models can crowd in private capital and its expertise.
- *Spillovers to the entrepreneurship ecosystem.* Incentives such as tax concessions for investors can attract a broad range of experienced investors to this market segment, and they bring both capital and knowledge. Angel investors will also often become part of the entrepreneurial ecosystem, investing locally (such as in regions) and providing nonfinancial support to the community.
- *Business angel networks as direct channel of communication between entrepreneurs and investors.* Business angel networks bring together a heterogeneous group of angels with different experience, know-how, and investment capacity, and offer opportunities to reduce transaction costs. In particular, BANs operate on a local or regional scale (EBAN 2008), reflecting the preferences of most investors to invest locally, so they provide a local investment market for potential investees. Projects that have been backed by business angels are more attractive to formal sources of funding than projects that are not backed because angels reduce informational asymmetries. Thus, angels play an accreditation role.

Potential Drawbacks and Risks

Some of the key drawbacks and risks include the following:

- *The complexity of the investment schemes demands scarce policy skills and ecosystem infrastructure.* Early-stage equity is a complex area of policy design, regardless of which modality is used. This is particularly the case in jurisdictions without well-established markets. Sophisticated instruments such as a fund-of-funds structure need a relatively developed venture capital ecosystem to function, and many countries do not have these ecosystems. Governments must balance the level of incentive to attract private funds, running the risk of being either too generous or too narrow, or just subsidizing investment that would have occurred anyway.

- *Investments run the risk of government failure.* There are several potential areas of government failure: lack of competence in running a fund; inappropriate decision criteria for choosing or supporting investments; and inability to manage the risk and performance profile of the model. Government might not have the capacity to successfully play the early-stage venture capital role, particularly if the fund is managed directly within government rather than being outsourced to a private manager. Venture capital is a "learn from experience" industry, and inexperienced governments can have adverse effects on market outcomes. If the investment decisions are not completely insulated from political interference, then investment returns will be suboptimal, and the reputation of the fund can quickly be lost. Many of these investments will also fail. Governments need to be able to justify why they are putting taxpayers' dollars into "failed" businesses.
- *The investments run the risk of opportunistic behavior.* Given the sophisticated nature of most investors and entrepreneurs, careful thought is needed as to whether the integrity of the tax system can be maintained with tax incentives. For tax and regulatory incentives aimed at entrepreneurs, care needs to be taken in designing the cut-off points for such initiatives to avoid companies artificially changing their behavior to keep the advantages.
- *Entrepreneurs and investors lack familiarity with early-stage equity investing.* In many countries, there is no familiarity with equity investment among entrepreneurs who do not wish to give up any shareholding or let "outsiders" into their business, while investors are more used to passive or more familiar types of investment (such as real estate).
- *Early-stage equity can crowd out private sector resources.* If interventions are not limited to cover the equity gap, there is a risk that public support of innovative start-ups and SMEs can crowd out private sector resources and jeopardize the ability to build a self-sustained venture capital ecosystem.
- *Alignment of interests is not perfect.* The alignment of interests between investors and entrepreneurs may separate in some instances, especially where investors are looking for a return and thus a sale. They may also diverge from the perceived "national" interest if investors are seeking to sell a successful investee to an overseas buyer, resulting in the investee being moved overseas. In this instance, governments generally do not want to lose this economic activity, especially if they have borne some of the investment risk.
- *Investments have long time frames.* These interventions do not typically provide quick impacts or results. They often take a long time to be established, and investments are often held for many years before being sold or liquidated.

Elements for Good Instrument Design

Elements to be considered include:

- *Design and delivery capacity.* These are complex instruments to design and administer. Many countries establish specialized agencies to deliver these types of initiatives or place them within organizations with extensive financial experience. Building capacity in the delivery agency should be part of program design, but equally important is building capacity in the investor and fund manager market, which is invariably inexperienced. To this end, new funds should be encouraged to partner with more experienced funds, and training/buddying should be offered.
- *Ability to crowd in private investment.* A core precept of all initiatives should be how to crowd in investments from the private sector. Although early-stage risk finance markets generally show signs of structural failure (that is a persistent lack of private sector funding—meaning government intervention is often warranted on an ongoing basis), efforts to bring in private smart capital should always be a priority. Incentives can be enhanced by making funding for the firm conditional, at least in part, on impacts. This can be done in a variety of ways, such as adding conditions to equity and loans.
- *Diversity.* It is important to encourage a competitive market for the supply of funding, so that entrepreneurs have options and that different investment models can be tried. Capital providers that do not face competition get lazy and arrogant. Thus, it is desirable, where possible, to establish a variety of groups/funds, and encourage other sources (such as overseas funds and corporate venture capital) to participate in the market.
- *Fund selection processes.* When supporting the establishment of new funds, selection processes should be as thorough and professional as possible. Selecting fund managers is extremely hard—early-stage equity investing is a new field, and potential managers will either have poor records or no records. However, given the amounts of capital involved and the prospective management fees, high-quality due diligence processes should be applied to any applicant and experienced early-stage experts should be involved in the selection process to assess individuals, teams, and proposed business models.
- *Investor incentives.* The ability to attract private coinvestors is highly sensitive to the incentive structure offered to them around both capital returns and profit (particularly whether capital protection or preferred treatment on capital returns is offered). Deciding on the exact rate is difficult, and policy makers need to be prepared to underwrite this risk using public funds—knowing that this can be characterized as "funding rich people."
- *Investment readiness.* The ability to have a good pipeline of projects to invest also depends on the investment readiness of some of these ventures. Often the structure and presentation of these projects deter potential investors, even in cases of good businesses and good business models. It is very important to include investment readiness programs in accelerators and other infrastructure support to maximize investments (see box 4.13).

BOX 4.13

Investment Readiness Programs

Investment readiness programs (IRPs) provide complementary support to the demand side (to increase the quality and quantity of deal flow). Innovative start-ups and SMEs in developing and transition countries often have innovative ideas, but do not have these ideas fine-tuned to the stage where they can attract outside funding to develop a viable product and commercialize their inventions. This is the case in the Western Balkans, where innovative start-ups often are not ready to compete for, and take on, outside equity (Karajkov 2009).

While much policy attention around the world has been given to efforts to expand the supply of equity finance for innovative start-ups and SMEs (through seed and venture capital coinvestment funds and other activities to attract capital), the effectiveness of these programs can be hampered by a lack of readiness of these firms to receive equity investment. Mason and Kwok (2010) highlight three main aspects of this lack of readiness. First, many entrepreneurs are unwilling to surrender ownership and control of their firms through equity investments. Second, many business that seek external finance are not considered "investible" by external investors because of deficiencies in their team structure, marketing strategy, financial accounts, intellectual property protection, and other business areas. Third, even if entrepreneurs are willing to consider equity and have investible projects, presentational failings mean that many firms are unable to pitch their ideas successfully to investors. Investment readiness programs, which provide individualized training, mentoring and coaching, are designed to overcome these constraints.

Investment readiness programs are intended to increase the effective demand for equity financing by helping firms overcome the factors that result in a lack of investment readiness, thereby enlarging the size and quality of the pipeline of potential funding opportunities for investors and increasing the likelihood that new equity investments will be made (Cusolito, Dautovic, and McKenzie 2018). While there is substantial heterogeneity in the content of these programs, the most comprehensive programs usually cover four dimensions, based on the core reasons that many investment deals do not materialize (Mason and Harrison 2001; Mason and Kwok 2010).

The first dimension aims at reducing the aversion to equity by explaining to entrepreneurs the potential advantages that equity can bring to the firm, both as a source of funding and also through the knowledge outside investors can bring to the firm. The second dimension addresses the investability of the business by helping train entrepreneurs to demonstrate that they have a viable revenue model, can measure market traction, have dealt appropriately with property right issues, have a competitive strategy, and so on. The third dimension works on presentational skills, teaching entrepreneurs how to effectively pitch their business ideas and provide the key information investors are looking for. Finally, some programs also offer a networking dimension, aiming to facilitate the matching process among entrepreneurs and investors through events such as venture forums (Cusolito, Dautovic, and McKenzie 2018).

These programs are offered in two modalities: "hard" and "soft" programs. Hard programs usually involve a package of support that combines online tools and training, customized and face-to-face mentoring, group training through master classes, and investor demonstration days or pitch events. Soft programs are self-learning online tools structured in modules that entrepreneurs can work through at their own (Cusolito, Dautovic, and McKenzie 2018).

- *Regional coverage.* Most funds and groups will be located in the main economic centers. Although much of the deal flow will be sourced from these centers, not all will be, so funds/investors need to be mandated to cover all regions.
- *Restrictive design.* Experience has shown that having an overly restrictive design will impair fund performance. Attempts to force funds to invest in particular regions, technologies/sectors, stages of development (only seed) or sources (only universities/research institutions) will generally degrade returns significantly. Notwithstanding the dangers of restrictive design, most funds will invariably seek to move to later-stage investing where the risks and transaction costs are lower. Program administrators need to be able to resist this trend and ensure that funds that were established—and received government capital—to operate in early-stage market do so.

Evidence of Impact

This synthesis focuses on the evidence of government ESE initiatives rather than evidence on venture capital in general, although some of the studies shed light on combined effects of both public and private venture capital. There is little empirical evidence available to establish the effectiveness of ESE policies, in both developed and developing countries. This may be, in part, because these policy instruments are still relatively new to government and there are not enough data and/or evaluation methodologies to conduct rigorous evaluations. Overall, the academic literature on government early-stage equity reveals a variety of patterns, implying that simplistic judgments about the effectiveness and appropriateness of government-funded schemes are inappropriate. The rest of this section looks at impacts of direct supply of capital, tax and regulatory incentives, and support for business angel networks.

Impact of Direct Supply of Capital and Investment

Access to financing and input additionality. Research findings on the effect of government funded venture capital on young firms' access to early-stage equity are mixed. Five of the eight studies listed in the table 4.32 reported positive impacts generated by government-funded venture capital, while three reported negative impacts. An important new study is Cusolito, Dautovic, and McKenzie (2018), which evaluated investment readiness and finds that this type of demand-side intervention increases the likelihood of investment.

Evidence presented in table 4.32 confirms that participants have been young firms but results of additionality remains mixed. Self-reported additionality for increased access to finance, and additional funding, was high, at 84 percent (32 percent for the ability to access). However, three out of the eight studies investigated reported either no or negative impact.

Output additionality. ESE investments can create direct returns from the companies in which they invest. A growing literature has examined the treatment effect of

TABLE 4.32 Evidence on the Impact of Direct Supply of Capital in Terms of Access to Financing and Input Additionality: Key Findings

Study	Context	Finding
Murray and Cowling (2014)	Denmark, Danish Growth Fund (DGF)	DGF plays an important role as "cornerstone investor" and DGF's investments in the market help attract institutional and private investors and additional funding.
National Audit Office (UK NAO) (2009)	United Kingdom, three government venture capital funds	84 percent of the businesses surveyed reported that the initial funding made it easier for them to obtain additional financing from other sources, and 32 percent reported they would have been unable to obtain any other financing without the government-backed funds.
Murray, Cowling, and Liu (2010)	Australia, Innovation Investment Fund (IIF)	IIF was significantly more likely to provide initial and follow-on funding to capital-constrained businesses than the two private sector equity providers that served as a comparison, thus addressing the equity gap faced by early-stage ventures.
Hood (2000)	Scotland, Scottish Development Finance (SDF)	The Scottish public venture capital program, SDF, was followed by the formation of new private venture capital funds, which increased the access to capital.
Cumming and MacIntosh (2006)	Canada, Labor-Sponsored Venture Capital Corporations (LSVCC)	Government intervention had a crowding-out effect sufficiently strong to lead to a reduction in the aggregate pool of private venture capital.
Baygan (2003)	United States, Small Business Investment Company (SBIC) program	Public venture capital investments did not address sectorial gaps or firms neglected by private venture capital; government venture capital may have contributed to the overfunding of particular sectors.
Qian and Zhan (2007)	China, Guidance Funds and the New Venture Capital Funds	The program was not very effective in providing capital to early-stage firms.
Cusolito, Dautovic, and McKenzie (2018)	Five countries in the Western Balkans, randomized control trial on investment readiness program	The investment readiness program resulted in a 0.3 standard deviation increase in the investment readiness score. Two follow-up surveys show that the judges' scores predicted investment readiness and investment outcomes over the subsequent two years. Treated firms attained significantly more media attention and were 5 percentage points more likely to have made a deal with an outside investor.

government-backed investments in portfolio firms, focusing on successful exit, innovation, and growth. Table 4.33 summarizes the main findings of selected studies regarding output additionality. Several studies, such as Grilli and Murtinu (2014) and Cumming and MacIntosh (2006), find that government venture capital schemes provide value creation only when combined with private investment. Although the studies of the United States, Australia, and United Kingdom report positive effects of government intervention, studies such as Brander, Egan, and Hellmann (2010) and Luukkonen, Deschryvere, and Bertoni (2013) find negative evidence on policy effectiveness.

Most studies find mixed results on output additionality, but when value is created, it is linked to private coparticipation in the scheme. Firms backed by the US SBIR program increased sales by 98 percent and increased employment by 56 percent, on average, compared to similar firms that were not backed by the program. However, most of the studies showing impact reported much more modest amounts.

TABLE 4.33 Evidence on the Impact of Direct Supply of Capital in Terms of Output Additionality: Key Findings

Study	Context	Finding
Lerner (1999)	United States, Small Business Innovation Research (SBIR) Program	SBIR-backed firms on average increased sales by 98 percent and experienced a 56 percent increase in employment compared to a matched control sample. But the performance of SBIR firms varied dramatically across locations.
Murray, Cowling, and Liu (2010)	Australia, Innovation Investment Fund (IIF)	IIF-supported firms were more likely to be start-ups in technology-based sectors, to attract multiple financing rounds, and to exit by either initial public offerings or liquidation than privately backed venture capital firms.
Nesta and BVCA (2009)	United Kingdom, six government-backed venture capital schemes	The schemes overall produced a positive yet modest impact on firm performance in terms of high-quality job creation compared to a matched control sample. But these programs are a relatively expensive mechanism for short-term job creation.
Grilli and Murtinu (2014)	Europe	Both types of investors had a positive and statistically significant impact on firm sales growth when they used cofinancing structures, but only when managed by private investors.
Brander, Du, and Hellmann (2015)	International	When there is a cofinancing structure, the firm is more likely to exit successfully than when only private venture capital financing or only government venture capital financing is present.
Cumming and MacIntosh (2006)	International	Compared to the positive contribution of independent venture capital funds on the likelihood to reach an exit though initial public offerings or mergers and acquisitions, government venture capital funds have a negligible impact. However, mixed independent-government syndicated venture capital investments lead to a higher likelihood of a positive exit than investments backed solely by independent venture capital.
Bertoni and Tykvová (2015)	Europe, biotechnology sector	Public venture capital boosted the impact of venture capital funds on both invention (measured by patent stock) and innovation (measured by passive citations of patents).
Brander, Egan, and Hellmann (2010)	Canada	Government-backed firms perform worse in terms of the frequency of successful exits, exit values, and survivorship than privately backed firms.
Luukkonen, Deschryvere, and Bertoni (2013)	Europe	The contributions of private funds prove to be significantly higher than those of government-sponsored funds in a number of areas, including the development of the business idea, professionalization, and the exit strategy.
Buzzacchi, Scellato, and Ughetto (2013)	Europe	While independent venture capital funds divest low-return investments as soon as possible, government-backed funds tend to postpone the exit from those ventures that might generate social returns or exert positive impacts on the economic system, even if their financial returns might not be satisfactory.

Performance and efficiency. Studies have also shown mixed results with regard to the efficiency of government-backed venture capital funds. While Lerner (1999) and Murray, Cowling, and Liu (2010) find evidence that government-sponsored venture capital funds perform better than private venture capital funds, other studies show negative results, as summarized in table 4.34. The underperformance of many government-backed firms may be due to their fund managers' lower engagement and value-adding activities. For example, Knockaert et al. (2006) and Knockaert and Vanacker (2013) show that the managers of public funds are less involved in value-adding activities than private venture capital fund managers. Further reasons for

TABLE 4.34 Evidence on the Performance and Efficiency of Direct Supply of Capital Programs: Key Findings

Study	Context	Finding
US SBA (2004)	United States, Small Business Investment Company (SBIC) fund	The composite internal return rates were -12.3 percent for government-backed venture capital funds in contrast to 20.4 percent for private venture capital funds. The estimated total value to capital ratio was 0.78 for government-backed venture capital funds, compared to 1.3 for the private venture capital funds.
Alperovych, Hübner, and Lobet (2015)	Belgium	Assessing a sample of 515 Belgian portfolio firms up to three years after the investment, the authors find that productivity dropped significantly for firms receiving government-backed venture capital.
Quan and Zhang (2007)	China	Returns of government-backed venture capital funds were lower than those of private venture capital funds; government programs have been ineffective in correcting the uneven concentration of venture capital investment activity.

underperformance include excessive capital under management relative to the number of managers (Cumming and MacIntosh 2006), lack of control and ability to effect changes in investees due to minority stakes (Cumming and MacIntosh 2006), and minimal time spent screening investments due to time limits to reinvest capital (Cumming and MacIntosh 2006).

In terms of performance, table 4.34 indicates that private funds attain higher rates of return than government-sponsored funds, at 20.4 percent and -12.3 percent, respectively, for the study of the US Small Business Investment Company (SBIC) fund (US SBA 2004).

Impact of Tax and Regulatory Incentives on Equity Finance

Input additionality. A very limited number of studies have reached robust conclusions regarding the input additionality of tax and regulatory incentives that affect equity finance. Gompers and Lerner (1998) use US state-level data to examine how a variety of government policies affect venture capital fundraising. Their results show that the regulation of public pension funds, and especially the relaxation of the "prudent man" rule in 1979, had a dramatic effect on the supply of venture capital. They also find that higher capital gains are likely to reduce entrepreneurial activity. Poterba (1989) uses an occupational choice model and finds that capital gains affect the incentives to becoming an entrepreneur because entrepreneurs tend to forego wage and salary income and accept compensation through corporate stock and options. Keuschnigg and Nielsen (2004) reach a similar conclusion.

Output additionality. Da Rin, Nicodano, and Sembenelli (2006) assess the effectiveness of different public policy instruments to support venture capital markets. Their results suggest that reductions in the capital gains tax rate increased the share of both high-tech and early-stage venture capital investments. A reduction in labor regulation also resulted in higher shares of high-tech investments. In a cross-country study, Jeng and Wells (2000) find that labor market rigidities are associated with less early-stage venture capital investing. Bozkaya and Kerr (2011) distinguish between two types of labor regulation: protecting workers from layoffs versus insuring workers in case of layoff. They show that labor protection (insurance) is associated with lower (higher) venture capital investment in more volatile sectors. In contrast, Lerner (2009), who studied a sample of private equity and venture capital investments worldwide between 1990 and 2008, does not find any relation between venture capital investments and labor market rigidities, barriers to entrepreneurship, or the tax rate for the highest bracket of corporate income. Lerner (2009) does find strong indications that equity market development and protection of minority shareholder rights matter for venture capital firms.

Public Support to Business Angel Networks

The empirical evidence regarding the public support of business angel networks is mixed, and most of the evidence comes from European countries. On the positive side, Mason and Harrison (1997) show that the result of the pilot program launched in the United Kingdom in 1992 was helpful in various ways, such as mobilization of resources; number of investments; education of entrepreneurs, investors, and intermediaries; and the generation of awareness of investment via equity. An assessment of the public support for Flemish BANs (Collewaert, Manigart, and Aernoudt 2010) provides evidence for the effectiveness of BANs in reducing information problems between business angels and entrepreneurs and stimulating economic development and employment growth. However, there are indications that business angel networks have a limited effect on business angels' investment (Mason 2008). One of the key conclusions from several evaluations of business angel networks in Europe is that they have not significantly improved the ability of business angels to invest because they have failed to provide business angels with superior investment opportunities. Also, there are issues regarding the sustainability of the business angel networks. Knyphausen-Aufseb, and Westphal (2008) find that even though many European networks have implemented different ways to generate income based on services offered, they have had serious problems in financing these services and have depended heavily on government subsidies.

Reflection on the Evidence

The scarcity of evidence about the role of government interventions with regard to early-stage equity investments and the lack of available data, especially in developing country settings, suggest that more research and data collection is needed in this field. While the two commonly used databases, ThomsonOne and VentureSource, are useful, they exclude an important portion of portfolio firms. To complement these databases, some researchers have collected data from surveys and interviews. While this approach allows access to interesting firm-specific data that would not be captured in commercial databases, it can also create bias, given that only a small percentage of venture capital funds or managers respond. Other data sources employed by the studies, such as data from national venture capital associations and data from initial public offering (IPO) prospectuses, remain limited in offering insight for the wide range of firms benefitting from venture capital support. Specific firm and investment details—such as employment growth, patents, revenues, profits, returns to venture capital funds, and measurements of entrepreneurial firm performance—are hard to obtain.

Main Requirements for Replicability

Support for government intervention in the early-stage equity market is conditional and cautionary. Investment in this area has been a trial-and-error exercise for policy makers. Numerous factors are country specific; thus, what works in one country might not work in another. Bearing this in mind, policy makers might find the following lessons/implications useful when designing ESE investment instruments.

Capability needs to design and implement early-stage equity instruments. ESE instruments feature a high degree of complexity, which requires policy makers to have high capabilities. While sometimes policy makers can leverage the expertise in the private venture capital market, this is not always the case in developing countries. In underdeveloped ecosystems, policy makers might consider the option of having overseas experts train fund managers and investors and bring the expertise needed.

General requirements for early-stage equity initiatives include the following:

- *Conducive policy framework.* The business environment in many developing countries is not supportive of the creation of an ESE market, given the lack of a well-established regulatory and legal system that reflects international best practices. Effective policy design should be built on an in-depth understanding of the size, development stage, and availability of a country's early-stage ecosystem and the actual deal-flow available to invest in.
- *Clear design.* ESE initiatives need to clearly define which stage the initiative is seeking to target (such as pre-seed, seed, start-up, scale-up) and identify the market failure that justifies public intervention in the selected segment of the market, which groups of firms are the main focus, which are the most prominent risk factors, and what type of leveraging effects on private capital can be achieved. Ideally companies should be able to access a range of finance providers at the different stages of growth. Particular care needs to be taken in designing tax incentives to avoid tax avoidance.
- *Staying within international norms.* ESE initiatives should be international in their perspective and execution, especially in small and developing economies. This includes conforming closely to internationally accepted legal, tax, financial, and operational norms of the venture capital industry; otherwise, it will be very difficult to attract overseas and diaspora investment.
- *Transparency.* The government should disseminate timely and accurate information about its policies and programs to all interested parties. The evaluation of the performance of government direct investment schemes, including metrics and methodologies, should be accessible to all relevant stakeholders. The evaluation process should be conducted by independent parties and be made public.

- *Evaluation and modification.* Successful program management should be characterized by a continued process of experimentation, evaluation, and modification. As these programs evolve, the needs of the market may change. Thus, the government should supply funding or support accordingly.

Policy requirements for the direct supply of capital include:

- *Neutrality to the political cycle and long-term commitment.* Early-stage venture investing is dynamic and prolonged, and program managers need to plan for long maturation cycles. During this period, the government needs to meet its commitment to provide sustained financial support to the funds (regardless of the structure used).
- *Avoiding imposing political pressure.* The decision-making process must be transparent and similar to the one used in the private sector and ideally, separate from government. Otherwise, in many countries, private investors will simply not engage with the program.

Other important lessons requirements include the following:

- *Support for angel investment capacity building should be designed carefully* to reflect on-the-ground realities (including business culture, levels of trust, existing investment habits, and underlying industry strengths) and be flexible, given that one-size-fits-all approaches generally fail. Stimulating angel investment activity has several benefits beyond the direct investment capital they inject, including their involvement in building local ecosystems, interest in investing locally, and ability to support many other investments.
- *Investment readiness components should be included to enhance the effectiveness of these programs.* Investment readiness programs will increase the effective demand for equity financing and improve the quality and size of the pipeline of potential funding opportunities for investors. This will narrow the information asymmetry between investors and investees, increasing the likelihood of investment.

Dos and Don'ts of Early-Stage Equity

Do	Don't
▪ Acknowledge that finance is an input to entrepreneurship, not an end in itself. ▪ Ensure there is a sound legal and investment climate environment for early-stage investors to operate within. ▪ Ensure there is reasonable and growing flow of investible business opportunities.	▪ Don't copy other countries blindly; design for the particular circumstances of your economy. ▪ Don't assume that professionals with a banking or private equity background can adjust to being effective early-stage fund managers. Early-stage investing is a specialized discipline, and professionals with a banking or private

Dos and Don'ts of Early-Stage Equity

Do	Don't
▪ Build funding options at the different stages of business growth (pre-seed, seed, growth, and so on). Otherwise, there is a risk of building financial "bridges to nowhere." ▪ Seek to ensure that initiatives are connected to overseas activity—and are accessing global knowledge. ▪ Design interventions taking an ecosystem approach—also looking at the supply of entrepreneurs and the support organizations that smooth the commercialization path. ▪ Be prepared to invest in capacity building (of program delivery staff, and of potential fund managers, and investors) because this is likely to be a new industry in most countries and one that demands a different skillset. ▪ Always look to crowd in private investment through whatever instrument is used.	equity background will often struggle to adjust, so there is usually a need to build a new cohort of professionals. ▪ Don't assume there will be quick wins. This is a long-term intervention. ▪ Don't assume there will be many commercial successes because most investments will fail. Don't assume this is a standard business support program; it a specialized type of finance requiring specialized program design and implementation skills. Thus, delivery is best managed by financial organizations.

Checklist for Design and Implementation of Early-Stage Equity

- Is the policy framework in the country conducive for investments in early-stage ventures?
- Do you have an ecosystem that is conducive to new ideas and new innovative ventures?
- Do you have good mentoring and early-stage infrastructure to complement investors?
- Do you have enough expertise to work in developing capacity of angel investors? Are you already working with investment networks?
- Is the pipeline of projects investment ready? Do you offer investment readiness training to your startups?
- Are you part of any interagency coordination mechanism to coordinate all the instruments supporting early-stage ventures?

References

Alperovych, Y., G. Hübner, and F. Lobet. 2015. "How Does Governmental versus Private Venture Capital Backing Affect a Firm's Efficiency? Evidence from Belgium." *Journal of Business Venturing* 30 (4): 508–25.

Baygan, G. 2003. "Venture Capital Policy Review: Israel." STI Working Paper 2003/12. Industry Issues. Directorate for Science, Technology and Industry, Organisation for Economic Co-operation and Development (OECD).

Bertoni, F., and T. Tykvová. 2015. "Does Governmental Venture Capital Spur Invention and Innovation? Evidence from Young European Biotech Companies." *Research Policy* 44 (4): 925–35.

Bozkaya, A., and W. R. Kerr. 2011. "Labor Regulations and European Venture Capital." Working paper, Harvard Business School.

Brander, J. A., Q. Du, and T. Hellmann. 2015. "The Effects of Government-sponsored Venture Capital: International Evidence." *Review of Finance* 19 (2): 571–618.

Brander, J. A., E. Egan, and T. Hellmann. 2010. "Government-sponsored versus Private Venture Capital: Canadian Evidence." In *International Differences in Entrepreneurship*, edited by J. Lerner and A. Schoar, 275–320. Chicago: University of Chicago Press for the National Bureau of Economic Research.

Bravo-Biosca, A., A. P. Cusolito, and J. Hill. 2014. "Financing Business Innovation—A Review of External Sources of Funding for Innovative Businesses and Public Policies to Support Them." Working Paper 91713, World Bank, Washington, DC.

Buzzacchi, L., G. Scellato, and E. Ughetto. 2013. "The Investment Strategies of Publicly Sponsored Venture Capital Funds." *Journal of Banking & Finance* 37: 707–16.

Collewaert, V., S. Manigart, and R. Aernoudt. 2010. "Assessment of Government Funding of Business Angel Networks in Flanders." *Regional Studies* 44 (1): 119–30.

Cumming, C., and J. MacIntosh. 2006. "Crowding Out Private Equity: Canadian Evidence." *Journal of Business Venturing* 21 (5): 569–609.

Cusolito, A. P., E. Dautovic, and D. J. McKenzie. 2018. "Can Government Intervention Make Firms More Investment-Ready? A Randomized Experiment in the Western Balkans." Policy Research Working Paper 8541, Impact Evaluation Series, World Bank Group, Washington, DC.

Da Rin, M., G. Nicodano, and A. Sembenelli. 2006. "Public Policy and Creation of Active Venture Capital Markets." *Journal of Public Economics* 90: 1699–1723.

EBAN (European Business Angel Networks). 2008. "The European Trade Association for Business Angels, Seed Funds and Early Stage Market Players." EBAN, Brussels.

Florida, R. L., and M. Kenney. 1988. "Venture Capital-Financed Innovation and Technological Change in the USA." *Research Policy* 17 (3): 119–37.

Gans, J. S., D. H. Hsu, and S. Stern. 2002. "When Does Startup Innovation Spur the Gale of Creative Destruction?" *RAND Journal of Econom*ics 33: 571–86.

Gompers, P., and J. Lerner. 1999. *The Venture Capital Cycle,* 2nd edition. Cambridge, MA: MIT Press.

Gorman, M., and W. A. Sahlman. 1989. "What Do Venture Capitalists Do?" *Journal of Business Venturing* 4: 231–48.

Grilli, L., and S. Murtinu. 2014. "Government, Venture Capital and the Growth of European High-Tech Entrepreneurial Firms." *Research Policy* 43 (9): 1523–43.

Hall, B. H., and J. Lerner. 2010. "The Financing of R&D and Innovation." Chapter 14 in *Handbook of the Economics of Innovation*, Vol. 1, edited by B. H. Hall and N. Rosenberg, 609–39. Elsevier.

Hood, N. 2000. "Public Venture Capital and Economic Development: The Scottish Experience." *Venture Capital* 2 (4): 313–41.

Jeng, L., and P. Wells. 2000. "The Determinants of Venture Capital Funding: Evidence across Countries." *Journal of Corporate Finance* 6: 241–89.

Karajkov, R. 2009. "Bridging the Gap: Access to Risk Finance for Early-Stage SMEs in Southeast Europe." http://www.incubat.ro/uploads/Publicatii_Investment_SMS_report.pdf.

Keuschnigg, C., and S. B. Nielsen. 2004. "Start-ups, Venture Capitalists and the Capital Gains Tax." *Journal of Public Economics* 88: 1011–42.

Knockaert, M. A. Lockett, B. Clarysse, and M. Wright. 2006. "Do Human Capital and Fund Characteristics Drive Follow-up Behavior of Early Stage High-Tech VCs?" Ghent University.

Knockaert, A., and T. Vanacker. 2013. "The Association between Venture Capitalists' Selection and Value Adding Behavior: Evidence from Early Stage High-Tech Venture Capitalists. *Small Business Economics* 40 (3): 493–509.

Knyphausen-Aufseb, D. Z., and R. Westphal. 2008. "Do Business Angel Networks Deliver Value to Business Angels?" *Venture Capital* 10 (2): 149–69.

Lerner J. 1999. "The Government as a Venture Capitalist: The Long-run Impact of the SBIR Program." *Journal of Business* 72 (3): 285–318.

————-. 2009. *The Boulevard of Broken Dreams: Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed—And What to Do About It*. Princeton, NJ: Princeton University Press.

Luukkonen, T., M. Deschryvere, and F. Bertoni. 2013. "The Value Added by Government Venture Capital Funds Compared with Independent Venture Capital Funds." *Technovation* 33 (4–5): 154–62.

Mason, C. 2008. "The Real Venture Capitalists. A Review of Research on Business Angels." Working paper.

Mason, C. M., and R. T. Harrison. 1997. "Business Angel Networks and the Development of the Informal Venture Capital Market in the U.K.: Is There Still a Role for the Public Sector?" *Small Business Economics* 9 (2): 111–23.

————-. 2001. "Investment Readiness: A Critique of Government Proposals to Increase the Demand for Venture Capital." *Regional Studies* 35 (7): 663–68.

Mason, C., and J. Kwok. 2010. "Investment Readiness Programmes and Access to Finance: A Critical Review of Design Issues." *Local Economy* 25 (4): 269–92.

Murray, G., and M. Cowling. 2014. "Evaluation of the Danish Growth Fund: Evaluation of Activities 2010–2012." Danish Agency for Science, Technology, and Innovation (Damvad), Copenhagen.

Murray, G., M. Cowling, and W. Liu. 2010. "An Independent Econometric Analysis of the Innovation Investment Fund Programme (IIF) of the Australian Commonwealth Government: Findings and Implications." Department of Innovation, Industry, Science and Research of Australia.

Nesta and BVCA (British Private Equity & Venture Capital Association). 2009. "From Funding Gaps to Thin Markets: The UK Support for Early Stage Venture Capital in the 21st Century." Nesta and BVCA, London.

Poterba, J. 1989. "Venture Capital and Capital Gains Taxation." NBER Working Paper 2832, National Bureau of Economic Research, Cambridge MA.

Qian, P. and W. Zhang. 2008. "Rate of Return on Venture Capital Investment in China." *China Economic Journal* 1 (2): 155–64.

United Kingdom, NAO (National Audit Office) 2009. "Venture Capital Support to Small Businesses." NAO, The Department for Business, Innovation and Skills.

United States, SBA (Small Business Administration). 2004. "Small Business Investment Company Program Financial Performance Report for Cohorts 1994–2004." US Small Business Administration, Washington, DC.

4.2.8 Profile 8. Inducement Instruments

Inducement instruments, including *prizes, competitions, crowdsourcing,* and *hackathons*, are relatively new mechanisms to incentivize innovation and the development of specific technological solutions. They tend to be relative low cost to administer and are underpinned by the framework of open innovation: promoting innovation by searching for ideas outside the firm and making different actors collaborate or even compete to find solutions to well-defined problems. While these instruments can be part of the innovation policy mix of any central or local government, they are also increasingly implemented by the private sector and, especially, some large companies. These instruments mostly consist of prizes and competitions, but corporate open innovation instruments—discussed in Profile 5 under demand-driven instruments—could be included. While there is very little evidence of impact, these instruments may sometimes be inefficient, in the sense of generating "too much" investment in developing solutions that fail or that will not be commercialized (although it is possible that more than one good innovative solution might be found in the same competition). More importantly, these instruments can often be a powerful tool for promoting an innovation and entrepreneurship culture, or innovation in particular sectors or social areas.

Definition

In recent years, there has been a surge of new ways of organizing and conducting collaborative innovation that try to maximize the use of external flows of information and ideas via open innovation and crowdsourcing approaches.[40] Correspondingly, public agencies have used policy instruments to support this trend in business innovation practices. The common elements of this type of instrument are the identification of a problem or potential new market and the search or crowdsourcing of potential solutions and their development. These innovation instruments have been traditionally implemented in the context of broad societal challenges or the development of innovative solutions to social problems because they are particularly well suited to address challenges that require unconventional, problem-oriented new solutions. In recent years, however, these instruments also have been used to support business innovation activities (see box 4.14 for a general typology).

This profile focuses on one type of these instruments that is closely linked to firm innovation: namely, inducement instruments,[41] primarily prizes. Agapitova and Ertekin (forthcoming) provide a general overview of crowdsourcing instruments, but some of the characteristics of inducement instruments discussed here apply to this entire family of instruments.[42] Corporate open innovation initiatives, although very much based on the open innovation framework, are discussed with the demand-pull instruments (section 4.2.5.4), given the link to supply development programs. All these instruments, however, have a link with both open innovation and procurement.

Inducement instruments—prizes, competitions, crowdsourcing, and hackathons—aim to trigger contestants' additional effort to address specific predefined problems/

BOX 4.14

A Typology of Open Innovation and Inducement Instruments

- *Prize challenge.* A monetary (or other) incentive is offered to the first one to solve a problem. The solution should be a fully achieved result, not an idea or early-stage plan.
- *Competition and competitive grants.* These are solutions-focused tournaments seeking solutions (new ideas, business models, or implementation plans) to a well-defined problem. Contestants with the best solutions get either recognition of their past effort (award) or an investment grant to implement solutions.
- *Crowd ideation.* This is a large engagement (generally online) to gather mass feedback on a set of issues. It is generally used by large organizations to engage their own staff or large external audiences for community mobilization/outreach needs.
- *Corporate open innovation initiatives.* The innovation agency acts as a broker to identify problems in large companies and search for potential solutions across small suppliers. Both the definition of the problem and the identification and development of the solution are supported with financial and nonfinancial support.
- *Hackathons.* Collaborative coding is undertaken by coders/developers, content experts and users, and others to create applications addressing predefined challenges. Hackathons are live and sometimes geographically distributed.

Source: Adapted from Agapitova and Ertekin (forthcoming).

challenges. Inducement prizes aim at encouraging external parties to develop an innovative solution. On the one hand, this type of prize can pose a risk to firms and entrepreneurs by generating effort from competitors in developing the innovative solution; on the other hand, it externalizes the risk of parties that are not able to develop a successful solution. Inducement competitive grants have characteristics similar to pre-commercial procurement (section 4.2.5.1), but less effort is required because only the best proposal is selected to be developed. At the same time, however, competitive grants internalize the risk that the suggested proposal cannot be successfully developed as an innovative solution.

Market and System Failures Addressed

Inducement prizes can address the following market and system failures:

- *Positive externalities.* Challenges hindering societal development nowadays can have very high spillover effects, and pure market mechanisms are not able to address them effectively. Inducement instruments can redirect and provide incentives to potential innovators to invest considerable effort in addressing particular challenges and thus can generate positive externalities.
- *Institutional failure.* Institutions often do not prioritize the development of certain technologies, especially nascent ones that possess high social value. Inducement instruments can selectively promote the development of certain technologies that possess high social value from the perspective of sponsors. Through dedicated

design that carefully addresses issues surrounding intellectual property rights, inducement schemes may bring certain technologies in the public domain and stimulate further R&D from wider stakeholders.

Target Group

Inducement schemes do not appear to have narrowly defined Target Groups. Nonetheless, there are a few types of stakeholders that can be incentivized and/or influenced.

Innovation providers. Any entity, including organizations and individuals, is in principle eligible for inducement prize schemes. Inducement schemes are expected to attract a diverse range of actors, and informal teams of actors might emerge while participating in the challenge.

Innovation seekers (sponsors). If the government is a partner in rather than the exclusive source of inducement schemes, sponsors from the private sector are one of the Target Groups and crowding them in may be a policy goal. For-profit enterprises that sponsor prizes are often motivated by the commercialization potential and the reputational effect. The power of not-for-profit organizations can be leveraged by policy makers as well, as evidenced in the cases of the UK government and Nesta, and the US government and the Gates Foundation.

The general public. The general public can play the role of innovation providers and actively participate in the generation of ideas and solutions. More broadly speaking, inducement schemes can raise public awareness of the particular issue(s) being targeted and the potential solutions and yield educational benefits. For instance, some prize schemes have had television programs built around them, with the general public voting for solutions.

Strengths

Some of the key strengths of inducement instruments are the following:

- *Openness.* Inducement instruments can attract innovative solutions from unconventional areas, which is one advantage over other types of instruments with preselected Target Groups. Grants, for instance, are subject to severe selection bias and are typically confined to traditional or professional actors. Procurement-based approaches are typically more restricted and prescriptive, with limited scope in terms of both technologies and Target Groups.
- *Distributing risks and leveraging public money.* With classic instruments such as grants, the program owners often bear most of the risks because they have "selected" the participants. In inducement schemes, the risks associated with R&D processes are borne by different participants. Agencies can effectively leverage public money, attracting additional funding from philanthropists and other organizations/individuals.
- *Publicity.* Prizes and competitions can stimulate public enthusiasm for technologies. Publicity might lead to venture capital, grants, and procurement contracts

supporting the follow-on development of solutions. Moreover, behind-the-science stories associated with prize winners can have invaluable impacts on young people, and on other industries.

Potential Drawbacks and Risks

There are also some important potential drawbacks:

- *Not a stable mechanism to support innovation.* Inducement schemes are often ad hoc in terms of their technological requirements and the resulting Target Group. Therefore, they do not provide stable support for the build-up of deep knowledge over time, which is especially important in basic research. Grants, in contrast, are a more stable mechanism.
- *Danger of serving the interests of the scheme setter rather than broader societal interests.* If the challenge to be addressed is identified solely by the scheme setter, there is a danger of demanding "innovations" that turn out to be not socially valuable.
- *Transfer of risk and inefficiencies.* Prizes can generate too much effort and risk taking by those developing innovative solutions, given that most teams will not reap the reward of the innovative solution produced. If the results are of no use for other projects or for commercialization, inducement instruments will generate too much investment.

Elements for Good Policy Design

These are novel instruments with a limited track record, but several elements for good policy design have emerged from experience and the literature:

- *Solid justification.* To ensure that the resources and energy expended by all parties are well spent in return for the unpredictable innovation outcomes, a solid justification is required before embarking on this type of instrument Policy makers might want to establish first whether or not the potential innovators are constrained by factors other than their technological competencies, such as financing to support initial R&D. If businesses struggle with resources already, they might not have the incentive to participate in those inducement schemes that require participants to make an upfront investment.
- *The proper role of the government agency.* Inducement schemes can be run by governments or can be purely private sector initiatives. Therefore, in designing an inducement scheme, the government agency first needs to assess its role in the prospective scheme, such as whether it is the sponsor and program owner or coordinator, or one of the contributors.
- *Appropriate size.* Setting the size of inducement prizes is a complicated exercise because the size of prizes should reflect the social value of the targeted solutions. However, the value is often manifested after the scheme is over. Prizes should be large enough to induce a sufficient number of contestants to invest effort in developing solutions, but should also be socially efficient.

- *Assessment criteria for developed solutions.* The literature suggests that the clearer the assessment criteria used in prizes schemes, the better. Nevertheless, it is often difficult to articulate criteria in a functional way without confining the imagination of potential contestants. One issue with basing reward payments solely on technical specifications set before contestants offer their solutions is that the solutions developed might not in fact be desirable to potential users (Kremer and Williams 2010). One approach to move the outputs of inducement schemes toward commercialization and scaling up is to experiment with different ways of incorporating market tests into reward payments (Kremer and Williams 2010). Moreover, a recent study, Reinecke (2018) indicates that the degree to which prize competitions specify the problem to be solved falls along a spectrum, from completely general competitions that permit submission of any innovations at one end to highly specific competitions that lay out the problem to be solved on the other. The assessment criteria should be adjusted to reflect this.
- *Adaptive mechanism for governance and management.* Inducement schemes, especially grand challenge prizes that involve a large amount of funding, often encounter difficulties in specifying ex ante all that can happen. Therefore, rule modifications and adaptations along the way are to be expected, and an adaptive mechanism for governance and management is needed (Murray et al. 2012).
- *Use of modern information and communication technology (ICT) to facilitate inducement schemes.* Modern IT can be very helpful in setting up platforms for launching and organizing inducement schemes, enhancing communication between the supply and demand of innovation, and creating communities of practices for government agencies. One example of this type of platform is Challenge.gov, which serves as a central hub for US government agencies to crowdsource innovative solutions to address the social or technical challenges they meet during their operations (Mergel et al. 2014).The official website of Challenge.gov reports that since 2010, the US government has run nearly 1,000 challenges and offered well over $250 million in cash prizes for the best ideas, awarded to diverse innovators ranging from students and hobbyists to small business owners and academic researchers.

Evidence of Impact

The evidence on inducement prizes is limited, but the contexts involved have been diverse in terms of the institutional settings of different jurisdictions, different historical times, the distinction between reality and laboratory settings, and differences across governmental initiatives, nongovernment initiatives, and joint initiatives. Studies on inducement prizes are often ex ante assessments, exploring design principles and elements, rather than reviews of ex post impacts. The studies do cite historical data that can provide descriptive evidence, but the explanatory power is low. Field and lab experiments are confined to analysis only at the level of individual contestants, as it is difficult to perform experiments at the organizational level. Intangible dimensions, such as public awareness, are hard to capture and quantify using existing methods. Another challenge to evaluating inducement schemes lies in the difficulty in establishing a counterfactual because treatment and nontreatment groups can hardly exist at the same time.

Performance and Processes

The literature provides moderate evidence on the performance of inducement schemes in terms of the uptake of participants and public awareness (Brook Lyndhurst 2010; Murray et al. 2012), and the implications of the role played by the government (Tong and Lakhani 2012). Most of the inducement schemes reviewed in this profile attracted a wide range of unconventional contestants, especially enthusiastic individuals and communities. In contrast, conventional players such as university departments or public research organizations have been reluctant to participate in some schemes.

Input Additionality

Only a few studies cite data that provide a rough idea of the leveraging power of prizes. Using historical data, Masters and Delbecq (2008) find that prize-seekers in history ". . . consistently invested as much as (or even more than) the prize itself in pursuit of the award" (page 3). Kay (2011) also notes that the $10 million Ansari X Prize attracted more than $100 million of investment from contestants. IPE Triple Line (2018) reports that the Challenge Funds by the Swedish International Development Cooperation Agency (Sida) have stimulated substantial amounts of additional funding through external partnerships.

Output Additionality

Many studies claim that prizes generate output additionalities such as new business start-ups and increased employment, but little data are available in this regard. Most evidence indicating output additionality is in terms of the new technologies/solutions developed. A few studies report some evidence on the ability of prizes to stimulate new technologies, solutions, or even new innovators, as summarized in table 4.36.

Spillover Effects

All studies note the spillover effects of inducement instruments, although no rigorous measurement of this intangible effect has been conducted. In particular, Liotard and Revest (2018) review the literature and secondary data on spillover effects generated by innovation contests run by US federal agencies and find: (1) a strong incentive effect before and during the contest; (2) favorable spillovers in innovation and economic terms in specified industry sectors after the contests; and (3) a beneficial social role, contributing to citizens' education and awareness. The other studies reported four types of spillover effects, summarized as follows:

- *Social benefits.* Brook Lyndhurst (2010) notes that finalists of the Nesta Big Green Challenge in aggregate achieved a cut in carbon dioxide emissions that ranged from 1,770 tons to 2,059 tons. Everett, Barnett, and Verma (2011) note a mass behavioral change caused by the Nirmal Gram Pursakar prize, which further generated significant effects toward improved sanitation coverage in

TABLE 4.35 Evidence on Processes and Performance of Inducement Instruments: Key Findings

Study	Context	Finding
Brook Lyndhurst (2010)	Nesta's Big Green Challenge	As many as 5,800 people were engaged in the work of the 10 finalist communities. The finalists acted as a beacon and focus for people who were already active in their communities but not necessarily on climate change issues, as well as individuals acting for the first time. Many finalists also mobilized a rich social capital base, revealing skills and expertise that were not previously evident or joined up.
Murray et al. (2012)	Progressive Insurance Automotive X Prize	Although the X Prize Foundation had attempted to attract mainstream players to compete in its Progressive Insurance Automotive X Prize, none of the large automotive companies participated, similar to the case of major aerospace corporations in the Ansari X Prize. The prizes committee learned from over 1,000 comments made by the crowd, which offered opportunities to define challenges that are meaningful to a wider group of stakeholders, and to understand what capabilities might exist in the crowd.
Tong and Lakhani (2012)	Generic	Different partnership mechanisms can be adopted to leverage power from nongovernmental sponsors and contributors. For instance, the US space agency, NASA, performs as a coordinator rather than host for the Harvard-NASA Tournament Lab. In this setting, administrative and operationalization roles are played by nongovernmental partners instead of NASA.
Nicholas (2013)	Japan in the Meiji era	Prize competitions generated considerable public awareness. In 1898, 1 million visitors (of a total population of 45.4 million) attended shows across prefectures.
Khan (2015)	Historical experience in United States and Europe	Industrial prizes faltered in part because of their lack of market orientation. Judges had to combine technical and industry-specific knowledge with impartiality, but even the most competent personnel could not ensure consistency; decision making among panels was complicated by differences in standards, interpretation, capture, and risk aversion. Such difficulties tended to lead to haphazard decisions.
Wooten and Ulrich (2017)	Experiments using online contest websites	The study compared the performance of three different feedback treatments in innovation contests: no feedback, random feedback, and directed feedback. Directed feedback is associated with greater agent participation. While directed feedback benefits the average quality of entries, the authors do not find that relationship for the best entries, which means no feedback or random feedback may produce better entry quality at the top end.

India, from 21.9 percent of the population in 2001 to 68.4 percent in 2011. All of the 10 global Challenge Funds financed by the Swedish development agency, Sida, achieved significant progress in addressing social needs such as water saving, clean energy generation, and food production (IPE Triple Line 2018).

- *Prestige for contestants and sponsors.* The selected studies invariably highlight the reputational, prestige, and advertising effects that prizes schemes can generate for their contestants and sponsors. This is especially the case for high-profile schemes such as X Prizes, as indicated by McKinsey & Company (2009), Kay (2011), and Murray et al. (2012).
- *Public awareness and education.* Nearly all studies consider the effects of prizes schemes in raising public awareness. For instance, DARPA (2006) finds that media coverage for Grand Challenge 2005 was an essential part of program

TABLE 4.36 Evidence on Output Additionality of Inducement Instruments: Key Findings

Study	Context	Finding
KEI (2008)	Innovation prize programs globally from 18th to 21st century	Inducement schemes have led to milestone inventions that advanced science and technology across sectors such as agriculture and food, automotive, space technology, energy, medicine, and architecture. Not all inducement schemes were successful, but they offer some advantages over grant schemes in terms of engaging unconventional innovators and overcoming the costs of monopolies.
Brunt, Lerner, and Nicholas (2012)	United Kingdom, competitions 1839–1939	Prizes stimulated patented innovations. Doubling the prize money in a given field resulted in 33 percent more patents being granted in that field in subsequent years. Prizes encouraged competition, and medals were more important than monetary awards.
Nicholas (2013)	Japan in the Meiji era	Prizes provided a strong boost to patents, especially in less developed prefectures, and they also induced large spillovers of technical knowledge in prefectures adjacent to those with prizes, relative to distant prefectures without prizes (the control group). Linking competition expenditures with the expected market value of patents induced by the prizes permits a cost-benefit assessment of the prize competitions to be made.
Zivin and Lyons (2018)	United States	The study differentiates between those participants (students) who self-select into innovative activities and those who are willing to undertake them only after receiving an additional incentive for doing so. The study finds that while induced participants have different observable characteristics than those who were "innately" drawn to the competition, on average, the success of induced participants was statistically indistinguishable from their self-selected counterparts.

impact. In the context of the X Prizes, Murray et al. (2012) find that this publicity effect—among the various intangible effects of prizes schemes other than technical success—justifies the resources invested by contestants even if they did not win.

- *Community building and social capital.* Prizes schemes have proven to be effective in building communities and networks tackling specific issues. For instance, Brook Lyndhurst (2010) finds that finalists acted as beacons and mobilized a rich social capital base to gather active and competent people to form communities around climate change issues.

Main Requirements for Replicability

The ambiguity concerning the effectiveness of inducement prizes points to the need for better evidence to inform policy making. Policy makers in developing countries should be particularly cautious in embarking on this instrument, given the uncertainty of its impact. A key principle is that this kind of scheme should make the best use of the power of stakeholders other than the government.

Capability needs for policy makers vary, primarily depending on what role the agency plays. If public agencies are simply contributors to prize schemes, they can adopt a very flexible approach, achieving some policy goals while avoiding expending too many resources. At minimum, the implementing agency should be able to define the challenge to be tackled and specify clearly what will constitute a responsive solution. If the agency is the implementer, then competencies to raise public awareness of the challenge, specify eligibility of solutions, and evaluate entries will be necessary.

Competency requirements from participants are high. For instance, inducement prizes schemes are in theory "open" to all innovators, but in practice, those innovators without resources or innovation capabilities are excluded from the process.

When designing inducement schemes, it is important to understand the social value/desirability of new solutions. A number of studies emphasize that prizes should only be used if the prize setters understand the social desirability of the demanded solutions. Some authors even argue that prize schemes should only be used when patent systems are not effective, such as in the domains where core technologies should be available to the public.

Engaging with stakeholders can benefit all stages of inducement prize schemes, from program sponsorship, challenge definition, to execution and administration, and further to prototype testing and dissemination. Self-organized interactions among stakeholders are also enabling conditions for prizes schemes, such as via communities of practices.

Prizes can be complementary to existing instruments: A few studies also imply that inducement prizes can be integrated with other policy instruments. For instance, some winners of X Prizes received follow-up grants from the US government. Technical assistance services can be useful mechanisms while solutions are being generated.

Dos and Don'ts of Inducement Instruments

Do	Don't
▪ Assess the appropriateness of launching inducement schemes in the first place; if businesses struggle with resources already, they might not have the incentives to participate in those inducement schemes that require participants to make an upfront investment. ▪ Consider carefully the various roles government could/should play in inducement prizes (program owner, coordinator, or contributor). ▪ Map the various stakeholders involved and their incentives and create win-win solutions. ▪ Consider how inducement prizes schemes might fit into the existing portfolio of innovation instruments.	▪ Don't merely focus on the potential leveraging effect and ignore issues of cost and quality control, given that results are often uncertain. ▪ Don't count on inducement prizes as the core instrument to support innovation. They cannot offer the stability required by long-term R&D development. When designing the scheme, consider whether the problem can be solved by more targeted R&D grants. ▪ Don't assume that inducement schemes require low investments, because participants' investments can be large and could be better used in other projects.

Checklist for Design and Implementation of Inducement Instruments

- What is the goal you want to achieve? Is it clearly defined and achievable?
- How socially desirable will the solutions be? Do you have a clear idea of the potential value?
- Do you foresee that there is a diversity of potential problem solvers?
- Are the potential problem solvers able and willing to take the risks of participating in prize contests?
- How can you use prize contests to raise awareness of innovation and engage with the community?
- What potential partners are you able to mobilize, such as peer agencies, non-government bodies, charities, and businesses?
- What complementary instruments can you utilize to maximize the impacts of your scheme?

References

Agapitova, N., and E. Ertekin. Forthcoming. "The Art of Crowdsourcing: A Planning Guide for Development Practitioners in the Use of Crowdsourcing Innovation Tools as Part of Operations." World Bank Group, Washington, DC.

Brook Lyndhurst. 2010. *The Big Green Challenge Final Evaluation Report*. Prepared for Nesta. http://www.nesta.org.uk/library/documents/BGC-Evaluation-Exec-Summary-FINAL.pdf.

Brunt, L., J. Lerner, and T. Nicholas. 2012. "Inducement Prizes and Innovation." *Journal of Industrial Economics* 60 (4): 657–96.

Chesbrough, H., W. Vanhaverbeke, and J. West, eds. 2006. *Open Innovation: Researching a New Paradigm*. Oxford University Press.

Everett, B., C. Barnett, and R. Verma. 2011. *Evidence Review–Environmental Innovation Prizes for Development*. DEW Point Enquiry No. A0405. DEW Point, the DFID Resource Centre for Environment, Water and Sanitation, UK.

Howe, J. 2008. *Crowdsourcing*. New York: Crown Publishing Group.

IPE Triple Line. 2018. Evaluation of Sida's Global Challenge Funds. https://www.sida.se/contentassets/eb4c7e1c459a4ccbb8c3e6dbd1843219/2018_1_evaluation_of_sidas_global_challenge_funds.pdf.

Kay, L. 2011. "The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrop Grumman Lunar Lander Challenge." *R&D Management* 41 (4): 360–77.

KEI (Knowledge Ecology International). 2008. "Selected Innovation Prizes and Reward Programs." KEI Research Note 2008:1. https://keionline.org/misc-docs/research_notes/kei_rn_2008_1.pdf.

Khan, B. Z. 2015. "Inventing Prizes: A Historical Perspective on Innovation Awards and Technology Policy." *Business History Review* 89 (4): 631–60.

Kremer, M., and H. Williams. 2010. "Incentivizing Innovation: Adding to the Tool Kit." *Innovation Policy and the Economy* 10 (February): 1–17. https://doi.org/10.1086/605851.

Liotard, I., and V. Revest. 2018. "Contests as Innovation Policy Instruments: Lessons from the US Federal Agencies' Experience." *Technological Forecasting and Social Change* 127 (February 2018): 57–69.

Masters, W., and B. Delbecq. 2008. "Accelerating Innovation with Prize Rewards: History and Typology of Technology Prizes and a New Contest Design for Innovation in African Agriculture." International Food Policy Research Institute (IFPRI).

McKinsey & Company. 2009. "And the Winner Is . . . –Capturing the Promise of Philanthropic Prizes." McKinsey & Company.

Mergel, I., S. I. Bretschneider, C. Louis, and J. Smith. 2014. "The Challenges of Challenge.Gov: Adopting Private Sector Business Innovations in the Federal Government." 2014 47th Hawaii International Conference on System Sciences, Waikoloa, HI, 2073–82.

Moser, P., and T. Nicholas. 2013. "Prizes, Publicity and Patents: Non-Monetary Awards as a Mechanism to Encourage Innovation." *The Journal of Industrial Economics* LXI (3): 763–88.

Murray, F., S. Stern, G. Campbell, and A. MacCormack. 2012. "Grand Innovation Prizes: A Theoretical, Normative, and Empirical Evaluation." *Research Policy* 41 (10): 1779–92.

Nicholas, T. 2013. "Hybrid Innovation in Meiji, Japan." *International Economic Review* 54 (2): 575–600.

Reinecke, J. 2018. "General Innovation Competitions." *Stanford Technology Law Review* 21 (1): 128–66.

Tong, R., and K. R. Lakhani. 2012. "Public-Private Partnerships for Organizing and Executing Prize-based Competitions." Berkman Center for Internet & Society, Harvard University.

United States, DARPA (Defense Advanced Research Projects Agency). 2006. Report to Congress–Fiscal Year 2005 Report in Accordance with 10 U.S.C. § 2374a. DARPA, US Department of Defense.

Wooten, J. O., and K. T. Ulrich. 2017. "Idea Generation and the Role of Feedback: Evidence from Field Experiments with Innovation Tournaments." *Production and Operations Management* 26 (1): 80–99.

Zivin, J. S. G., and E. Lyons. 2018. "Can Innovators Be Created? Experimental Evidence from an Innovation Contest." NBER Working Paper 24339, National Bureau of Economic Research, Cambridge, MA.

4.2.9 Profile 9. Quality Infrastructure, Standards, Metrology, and Testing

This typology of instruments provides services and technical assistance to support quality, testing, and standardization. Despite their clear link to innovation policy, sometimes these instruments are presented under the umbrella of export support programs and services, or more generally SME policy. Regardless, these are key instruments for the implementation of product and process innovation (upgrading).

Definition

National quality infrastructure (NQI) provides the basic facilities and services for quality assurance and standardization, and thus is part of a country's framework conditions for innovation. National quality infrastructure is comprised of public and private parties that deliver specific functions to determine whether a product, process, or service meets a defined set of requirements. These functions are delivered through a group of services that support standardization, including metrology (the science of measurement), inspection, certification, accreditation, and conformity assessments. These services are often delivered through technology extension services (TES) (see section 4.2.6.2).

The government can play three main roles. The first is developing national quality infrastructure and guaranteeing a minimum and basic level of functionality and service provision of the interrelated institutions that facilitate the diffusion of standards in the economy. The second is supporting the development of local standards and/or participating in the development of international standards. The third is supporting the uptake of and compliance with standards, through both financial instruments and nonfinancial instruments such as advisory services and training.

The discussion that follows highlights the use of standards, metrology, and conformity assessment for innovation as central elements of the NQI system.

Standards specify characteristics or performance, convey information, or provide means of communication. In their most general definition, they can be regarded as a reference that has been established by some form of authority, custom, or general consent (Guasch et al. 2007). Standards codify know-how and market requirements, enable interoperability among products and processes, set a minimum level of quality, and reduce variety, enabling economies of learning and scale (Guasch et al. 2007). Standards serve as a classic mechanism to transfer technology; their adoption often drives process and organizational innovation, as firms seek accreditation for cross-industry standards (such as ISO 9000 and ISO 14000),[43] or industry-specific standards. Standards may apply to all the operations of an organization or may be specific to manufacturing or R&D. Government initiatives to support the uptake of standards are relatively common—although they may not be labeled as innovation instruments. They generally involve subsidizing the accreditation process and the firm-level innovation that occurs as a consequence of accreditation (organizational change, process improvements, training and retraining, upgrading of production and ICT equipment, and so on). This type of support may be found in various policy initiatives that target exporting, sectoral or regional development, or value/supply chain upgrading, but they all target firm-level innovation by supporting standards and accreditation. The main mechanisms for this support are vouchers or grants, combined with business advisory services or technology extension services.

Metrology is the science of measurement or the study of a system of measures (Guasch et al. 2007). Measurements play an important role in people's daily lives, as well as in the broader economy and global trade. Metrology therefore provides a basis for commercial exchanges as well as technological advancement. It not only supports quality consistency across different industries, but also enables the testing of new solutions and prototypes. The function of metrology is typically performed by public institutions, such as a national agency of metrology, public research organizations, or universities. These organizations typically possess advanced equipment and facilities to perform metrology, which is supported by large amounts of investment from the government. Metrology and testing are key services in support of firms' innovation process. In order for firms to improve their quality, they often must prove the quality either of inputs (for example, that raw materials meet particular environmental standards in order to be sold in developed markets) or of the product itself (such as CE mark in Europe). In some cases, particular R&D projects will also require specialist testing services. Without the availability of these services at affordable levels, firms in emerging economies may simply not invest in upgrading their product quality through innovation.

Conformity assessment (testing) is the group of procedures used to evaluate whether a product, process, or service fulfils certain standards, linking the standards with the product, processes, and services themselves. These procedures include some—and sometimes all—of the following activities: (1) *testing and inspection* evaluates a product, process, or service, according to a specified procedure; (2) *calibration* measures the relationship between the inputs to an instrument and the magnitude of response in its outputs; and (3) *certification* provides independent assurance that a certain product or service complies with a certain standard, and can help manufacturing and service firms differentiate themselves from less reputable suppliers.

Market and System Failures Addressed

The policy justification for the application of national quality infrastructure and standards for innovation rests on the following issues:[44]

- *Coordination failures.* Many of these standards do not emerge spontaneously. The government can play a catalytic role in developing voluntary standardization and disseminating standards. Many functions of the NQI system, such as metrology, are not commercially viable and are not likely to be provided by the market (Robertson and Swanepoel 2015). In addition, qualification requirements of personnel are high, and for-profit providers may have a conflict of interest if they are too close to clients. Moreover, the development of standards involves a negotiation process in which competing interests must agree on a common framework. Thus, in developing countries with weak capacities, governments may need to lead coordination efforts by setting up technical committees, establishing testing facilities, and adopting standards into technical regulations to ensure consumer and/or environmental protection.

- *Public goods for market specifications.* Information regarding market requirements can be thought of as a public good. Dissemination may be costly for producers. The government can play a role in disseminating this information. In addition, the impact of standards depends on network effects, given that the value of adopting the standard increases with the number of adopters.
- *Information asymmetry.* The private sector has an intrinsic interest in allowing consumers to make informed decisions regarding product quality, particularly among market leaders offering superior quality, branded products, and labels. The availability of known standards and firms' use of them can inhibit unscrupulous providers from supplying substandard products to unaware consumers, which can smear the industry's reputation. National quality infrastructure can help address those barriers by offering platforms of communication and standardization, and therefore build trust between actors and reduce transaction costs by serving as channels to transfer knowledge. Standards can also reduce search costs by enabling buyers to confirm that either the product or technology possesses has the traits it claims to have, without the need for independent testing.

Target Group

National quality infrastructure and standards for innovation primarily target firms and industry stakeholders to affect the behavior of players within the industry, especially in terms of enhancing innovation and productivity of firms adopting these standards and using related services. Another important group of stakeholders are providers and intermediaries, such as R&D practitioners, research labs, and scientific associations. Moreover, this policy instrument has links to the national measurement institutes, which disseminate measurement standards by providing calibration services to independent calibration laboratories and other organizations responsible for regulations and standards (secondary providers). Finally, national quality infrastructure and standards for innovation require the participation of standard setting organizations (SSOs), comprised of industry groups that set common standards in a variety of significant areas. SSOs are a common feature of systems-based industries, where firms supply interoperable components for a shared technology platform. Standard setting organizations promote coordinated innovation by providing a forum for collective decision making and a potential solution to the problem of fragmented and overlapping intellectual property rights.

Strengths

National quality infrastructure and standards have the following strengths:

- *Providing network effects.* Compatibility standards can facilitate the way products work within a system or a network, allowing participants to benefit from interacting with other participants operating in the same network, and using a system with complementary components. Network externalities between industry, consumers, ministries, academics, laboratories, regulators, and other quality infrastructure institutes decrease the transaction costs associated with innovation processes by helping national quality infrastructure establish norms and regulations and measure the quality of people, processes, and products against the devised criteria.

- *Increasing competition.* Open dissemination of market preferences that had previously been codified in technical specifications gives producers more equitable access to market information, promoting a level playing field. In addition, the interchangeability coming from standardization can reduce entry barriers in markets, promoting informed choices for consumers, lower prices, and increased quality. However, under specific circumstances, standards can instead reduce competition (see discussion on potential drawbacks and risks).
- *Supporting internationalization of innovation processes.* By diffusing market and technological information across borders, standards allow countries and firms to compete in new international markets. They enhance transparency and allow foreign producers to incorporate national preferences and technical specifications and adapt their products and services accordingly. In particular, standards can help SMEs upgrade their capabilities in the context of their participation in global value chains. Advanced technologies and best practices are usually adopted as standards in developed countries, and thus can represent a significant aspiration for firms in developing countries.
- *Improving innovation efficiency.* Standards that reduce variability promote economies of scale and learning, with suppliers saving costs while reducing product variation, and enable the introduction of new processes in short time frames without having to modify an entire system. Moreover, standards lower the investment requirements in R&D by mitigating the risks associated with the acquisition of a new technology, particularly when technology suppliers can demonstrate to the market of adopters that these technologies can perform as they claim to do.
- *Serving as a building block of innovation capability.* The introduction of standards at the firm level can be an important step in building the capability for more complex innovation because the systems and processes not only involve organizational and process innovation but underpin other forms of innovation.

Potential Drawbacks and Risks

National quality infrastructure and standards also have a few potential weaknesses. A poor legal framework and a weak governance structure may result in a set of supply-driven institutions, operating with limited funding and providing mediocre services. Some of the common problems and risks include the following:

- *Conflict of interest and weak governance structures.* Centralized NQI structures with shared responsibilities for accreditation and conformity assessments pose challenges for governance. For example, a centralized structure can lead to conflicts of interest where discretion from the accreditation agency can distort the playing field for certifying operators outside of the government system, or where credentials of operators lose credibility in the eyes of users. Moreover, if the agency issuing technical regulations also benefits from servicing fees, then it is likely to impose additional accreditation requirements that involve private testing and inspection.

- *Imposition of obstructive requirements and technology lock-in.* When technical regulations are imposed on the market system from the top, they are likely to create barriers for private businesses. This is often the case when policy makers are not fully aware of the regulatory burden already imposed on firms, and when the regulations are conceived with little or no private consultation. In addition, dominant interests may promote lock-ins in the long term for inferior, outdated standards. Obsolete standards can slow the pace of technical progress by preventing the adoption of superior innovation and embedding path dependence. For example, standards have created situations in which consumers were locked into a network or a product using less efficient technology, such as the QWERTY keyboard.
- *Compliance and conformity costs.* The high costs of standardization processes may discourage researchers, their organizations, and industry from participating. Standardization processes are time consuming, which may create some delay in knowledge transfer.
- *Risk of private capture and constrained competition.* The combination of intellectual property rights and standard-based network externalities may lead to monopolies lasting longer than the maximum length of patent protection, which creates inefficiencies, such as a market with a low level of competition and high prices for consumers. Companies can abuse standards to extend their market power over competitors. For example, owners of a particular interface technology can control the use of compatibility standards to extract higher market rents, as in the case of Microsoft with API interface in 1998.

Elements for Good Policy Design

Critical issues related to the design of standards include the following:

- *Deciding on the right modality.* There are two basic types of standards: market standards and formal standards (Guasch et al. 2007). Private firms usually set market standards in motion, under an iterative design process based on uncoordinated collective innovation. These market standards can be either unsponsored or sponsored by private firms, depending on the presence of proprietary rights to a set of technical specifications. One example of the latter is the Adobe Portable Document Format (pdf). Industry consortiums can also establish market standards. Formal standards do not arise spontaneously or in an uncoordinated fashion. They usually result from coordination among various parties through a negotiation process, followed by agreement and accreditation. Formal standards include voluntary standards and technical regulations (mandatory standards). Voluntary standards are usually open, and any party can join. Mandatory standards are developed by the government and adherence by firms is mandatory. Mandatory standards ensure a minimum level of performance of products and processes, which usually mitigates environmental risks and promotes safety and consumer protection.

- *Keeping the requirements balanced and relevant.* The review of the potential impact of standards should be systematic to ensure that anticipated benefits of quality upgrading and innovation are realistic, and to avoid a high proportion of constraining standards that could stifle the industry and result in overregulation.
- *Assigning a single agency and engaging with the private sector.* Policy makers should assign a single agency with the task of coordinating and providing oversight over national quality infrastructure. If the responsibilities over NQI tasks and functions remain embedded in various agencies, the creation of a new agency may require mergers and restructuring of these distinct units. The standardization process should be open and transparent. The private sector should have a balanced presence in governance mechanisms for standards—for example, through a general assembly or consultative committees—to ensure that the standards serve industry as a whole and promote competition.
- *Providing adequate resources.* Effective systems require funding for consultative and consensus building activities as well as negotiations. Because industry may not see the immediate value in subsidizing this activity, there is a role for government to play to provide funding. Similarly, the proper application and dissemination of standards requires resources for coordinating technical supervision, engaging with local and international partners, and undertaking awareness raising activities. Standardization agencies can recover costs through membership fees, as well as through certification and testing activities.

Evidence of Impact

Most of the studies reviewed in this section have been conducted in countries, such as the United States, the United Kingdom, and Germany, with well-established national quality infrastructure, although there is some evidence from developing countries with less mature NQI infrastructure. Most of the studies look at industries with strong network effects such as electro-technology and space technologies, where forums are available for collective decision making and coordination.

The effect of standards on providing incentives for business innovation depends on the specific content of the standards, as well as product and market characteristics. Empirical evidence suggests that standards have a positive, albeit nonlinear, impact on innovation (Blind 2016). As the age of standards increases, firms may find standards informative, but there comes a point when they become obsolete and lose their information value. In addition, when the number of standards becomes relatively high, they can constrain innovation if firms become focused on meeting the various standards rather than developing new approaches (Guasch et al. 2007).

Output Additionality

The effectiveness of standards in generating output additionality has mostly been measured through their contribution to the growth of GDP and productivity. Largely

TABLE 4.37 Evidence on the Output Additionality of Standards: Key Findings

Study	Context	Main finding
Jungmittag, Blind, and Grupp (1999)	Germany	Standards were at least as important to technical innovation as patents and second only to capital accumulation in their contribution to growth. For the 1960–90 period, the analysis finds that standards contributed about 0.9 percentage points out of an average overall growth rate of 3.3 percent. However, from 1990 to 1996, after German reunification, the contribution of standards decreased to 0.3 percentage points out of an overall growth of 1.5 percent per year.
UK DTI (2005)	United Kingdom	From 1948 to 2002, standards contributed 13 percent of the growth in labor productivity in the United Kingdom. The long-term elasticity of labor productivity with respect to the stock of standards was on the order of 0.05.
Blind and Jungmittag (2008)	United Kingdom, Germany, France, Italy	Both the stock of patents and the stock of technical standards contributed significantly to economic growth in the 1990s. Whereas the results of the country models are rather similar, significant differences are observed between the sector models, which indicate that standards are more important for growth in less R&D-intensive industries, while patents are more important in R&D-intensive industries.
Escribano and Guasch (2005a, 2005b)	Nine developing countries	Using ISO certification as a proxy to measure the effect of standards in developing countries, the authors find that productivity increases on the order of 2.4 percent to17.6 percent were observed in four Central American countries (El Salvador, Guatemala, Honduras, and Nicaragua); less than 1 percent in four Southeast Asian countries (Indonesia, Malaysia, the Philippines, and Thailand); and 4.5 percent in China.

based on economic modelling and estimation, the selected studies all find that standards have a positive impact on innovation and growth, although their effectiveness differs across different types of industries (for example, as demonstrated by Blind and Jungmittag 2008).

Impacts on the Innovation Process

A few studies look at the impacts of standards on processes of innovation, in various contexts in terms of sectors, levels of market certainty, and level of innovation intensity. Main findings are summarized in table 4.38.

Main Requirements for Replicability

Critical considerations when designing and implementing national quality infrastructure in developing country settings include the following:

- *Good governance and independence from political influence.* National quality infrastructure, including standards, accreditation, metrology, are all deeply embedded in the modes and styles of innovation practice across industry, commerce, and the public sector. One fundamental condition for the NQI system to work is a sound institutional framework that has good governance and that is free of conflicts of interest. Experience from developing countries, particularly from Central Asia, suggests that accreditation agencies should be independent from metrology and standardization bodies, to avoid

TABLE 4.38 Evidence on the Impact of Standards on the Innovation Process: Key Findings

Study	Context	Main Finding
Blind and Gauch (2009)	Germany	Standards, which lead to interoperability, compatibility, and common terminology, can enhance the dissemination and commercialization of research results. In addition, standardization is a major motivation of researchers from both public and private sectors to conduct research.
Blind, Petersen, and Riillo (2017)	Germany	Formal standards lead to lower innovation efficiency in markets with low uncertainty, while regulations have the opposite effect. In cases of high market uncertainty, regulation leads to lower innovation efficiency, while formal standards have the reverse effect. Regulations can be helpful in more mature markets by creating transparent and nondiscriminatory rules, while standardization can be more effective as a coordination instrument in uncertain or emerging markets.
Swann (2010)	United Kingdom	Sixty percent of the companies stated that standards were a source of information for their innovation activities. The majority of respondents also confirmed that regulations (not standards) were a constraint on their innovation activities. In addition, the authors find that those that say standards inform their innovation are more innovative than those who say standards do not inform their innovation, though "innovative" is not clearly defined in the study.
Mangiarotti and Riillo (2014)	Luxemburg	ISO 9000 certification increases the propensity for innovation in manufacturing when the focus is on technological innovation and formalized innovation expenditures, while the impact of certification on services is clearer when nontechnological aspects and wider innovation activities are considered. Specifically, the role of certification in promoting innovation success is stronger in the manufacturing sector than in services sector.

perverse incentives and loss of credibility. In addition, metrology, accreditation, and standardization bodies must refrain from participating in the issuance of technical regulations and be free from potential political interference, to promote competition between public and private conformity assessment operators.

- *Provision and training of highly qualified human capital.* It is essential to ensure that service providers in the NQI system, especially those with technical responsibilities for testing and conformity assessment services, are highly qualified. This, together with qualified facilities, forms the technical foundation of national quality infrastructure. Developing countries might need to engage proactively in knowledge transfer and learning processes from developed countries to fulfill this precondition.
- *Legitimizing the use of standards, accreditation, and measurement system to increase users' trust of national quality infrastructure.* Two prerequisites are especially important to legitimize and build trust in national quality infrastructure. First, political commitment is required to overcome obstacles, ensure the level of budgetary support and resource allocation, and designate the right type of institutional arrangements. Second, systematic efforts are required to raise awareness among prospective users; this may include information and advocacy programs to show the need for and benefits of adopting standards.
- *Incorporating national quality infrastructure as part of the national innovation system.* National quality infrastructure, especially metrology and standards for

innovation, is complementary to and supportive of other drivers of innovation, such as new technology, knowledge from the research base, organizational and managerial changes, and marketing strategies. Policy makers should ensure the availability of national registries of quality management professionals, including auditors. A competent network of quality service providers is a necessary condition for supporting firms in acquiring certification and adopting new technologies. In early stages, when quality infrastructure is incipient, government may need to provide the services directly through universities and public laboratories in coordination with consortiums of firms and industry associations to build these services.

- *Engaging with the private sector.* Policy makers should engage the private sector at the outset of the process and clearly delineate the division between private and public sector roles. Ideally, an advisory council on quality should be established. The council should have representation from the main intended beneficiaries: that is, industry and consumer organizations that utilize NQI outputs. In addition, the NQI institution should allow space for inputs from key stakeholders, such as importers, academia, industry, consumer organizations, and technical agencies from government.
- *Supporting SMEs to benefit from national quality infrastructure.* SMEs usually face financial barriers to invest in quality management systems and tend to have lower levels of awareness of quality issues. Policy makers can enable participation of SMEs by providing advisory services (such as technology extension services) and training, and by providing grants or subsidized loans to cover the costs of registration, certification, equipment, and facilities. Standards and quality requirements can provide the basis for cooperation between the private and public sectors to help upgrade SMEs. Policy makers should enable access to certification, particularly when the upgrading gap for SMEs is significant. Moreover, global value chains bring increased revenue opportunities for SMEs in developing countries. For example, when lead firms operating in buyer-driven value chains organize decentralized production networks, they provide supporting mechanisms to upgrade suppliers, such as guidance for performance improvements; technical assistance through capacity building, training, and supervision; and technology transfer through inputs and equipment.
- *Integrating local national quality infrastructure with international standards.* Policy makers should facilitate recognition of local standards by the international community and should consider further integration and compatibility of NQIs with other global systems. To project the local system internationally, policy makers should ensure that national procedures for the accreditation and certification of providers comply with international norms. Policy makers should particularly focus on promoting upgrading toward international standards in trade sectors with high potential and in economic activities in which the country possesses a competitive advantage.

Dos and Don’ts of National Quality Infrastructure and Standards for Innovation

Do	Don’t
▪ Make special efforts to engage SMEs in quality standards, given that they face increased challenges for adopting these. ▪ Ensure political commitment to the development of national quality infrastructure and the adoption of standards, with appropriate institutional mandates and resources. ▪ Engage private stakeholders from the very beginning, particularly through mechanisms such as advisory councils on quality. ▪ Try to engage a wide range of stakeholders (such as SMEs and public procurers) in the standardization processes, so that diverse interests and objectives are considered, and innovation potential is better exploited. ▪ Strike a balance between breaking technological lock-in through open standardizations and avoiding duplicate efforts that lead to competing standard schemes. ▪ Ensure that the use of standards is not captured by dominant market players and facilitate competition among domestic and foreign firms in the adoption of standards.	▪ Don’t establish parallel organizations or flat structures in setting up and implementing national quality infrastructure. This will lead to confusion, conflicts of interest, and delays in the set-up and operationalization of new standards. Instead, assign a single agency with the task of coordination, but avoid excessive centralization of services delivery. An approach that brings service provision closer to the beneficiaries is likely to be more effective. ▪ Don’t impose restrictive or mandatory technical regulations that might affect the flow of trade. Restrictive measures also stifle innovation and make it difficult for firms to develop or import new products that do not meet existing and often outdated standards. ▪ Don’t rely excessively on the public sector, particularly in situations in which the private sector can take over, such as service provision in a system that has matured enough.

Checklist for Design and Implementation of National Quality Infrastructure and Standards for Innovation

- Does the country have the political commitment to take a long-term view to invest and develop national quality infrastructure and standards for innovation?
- How receptive are industry players to working in alliance with policy makers to participate and codevelop the national quality infrastructure and standards framework?
- What should be the policy maker’s role in facilitating the emergence of market standards to deal with regulatory specifications?
- What evidence can justify the need to develop new standards, update existing standards, and eliminate obsolete standards to promote innovation?

- How likely is it that the benefits from increasing access to information and dissemination of technology associated with these standards will offset the risks of hindering competition and technology lock-in?
- How developed are the NQI components—standards, metrology, accreditation, and testing—in your country, and what is the evidence of unmet demand or potential demand for further developing these components?
- What level of capacity exists in firms to benefit from the NQI system and to meet the standards for innovation?
- How can policy makers enhance participation of SMEs in national quality infrastructure and standardization?
- How can policy makers integrate standards with the use of direct financial instruments, public procurement, and the framework for intellectual property rights, if applicable?
- How can policy makers leverage international experience and existing organizations (such as ISO) to develop national quality infrastructure?

References

Blind, K. 2016. "The Impact of Standardisation and Standards on Innovation." Chapter 14 in *Handbook of Innovation Policy Impact*, 423–49. Edward Elgar Publishing

Blind, K., and S. Gauch. 2009. "Research and Standardization in Nanotechnology: Evidence from Germany." *Journal of Technology Transfer* 34 (3): 320–42.

Blind, K., and A. Jungmittag. 2008. "The Impact of Standards and Patents on Macroeconomic Growth: A Panel Approach Covering Four Countries and Twelve Sectors." *Journal of Productivity Analysis* 29: 51–60.

Blind, K., S. S. Petersen, and C. A. F. Riillo. 2017. "The Impact of Standards and Regulation on Innovation in Uncertain Markets." *Research Policy* 46 (1): 249–64.

Escribano, A., and J. L. Guasch. 2005a. "Assessing the Impact of the Investment Climate on Productivity Using Firm-Level Data: Methodology and the Cases of Guatemala, Honduras, and Nicaragua." Policy Research Working Paper 3621, World Bank, Washington, DC.

———. 2005b. "Investment Climate Assessment on Productivity and Wages: Analysis Based on Firm- Level Data from Selected South East Asian Countries." Finance, Private Sector, and Infrastructure Group, Latin American and the Caribbean Region, World Bank, Washington, DC.

Guasch, J. L., J-L Racine, I. Sánchez, and M. Diop. 2007. *Quality Systems and Standards for a Competitive Edge*. Washington, DC: World Bank.

Jungmittag, A., K. Blind, and H. Grupp. 1999. "Innovation, Standardization and the Long-term Production Function: A Cointegration Analysis for Germany 1960–1996." *Zeitschrift für Wirtschaftsund Sozialwissenschaften* 119 (2): 205–22

Mangiarotti, G., and C. Riillo. 2014. "Standards and Innovation in Manufacturing and Services: The Case of ISO 9000." *International Journal of Quality & Reliability Management* 31 (4): 435–54.

Robertson, K., and J. A. Swanepoel. 2015. "The Economics of Metrology." Research Paper 6/201, Office of the Chief Economist, Department of Industry, Innovation and Science, Australian Government.

Swann, G. P. 2010. "International Standards and Trade: A Review of the Empirical Literature." OECD Trade Policy Working Paper No. 97, OECD Publishing, Paris.

United Kingdom, DTI (Department of Trade and Industry). 2005. "The Empirical Economics of Standards." DTI Economics Paper 12, UK Department of Trade and Industry, London.

4.2.10 Profile 10. Clusters and Networks for Innovation

There is increasing evidence that innovation occurs or is enhanced through interactions among firms and users or specialized partners, and that innovative activity agglomerates. As a result, policy makers in both developed and developing countries have encouraged and supported the creation of structures that enable interactions between groups of firms (and related stakeholders). Those structures might target firms that are in certain sectors and geographically proximate (clusters), and/or that have dynamic relationships and linkages (networks), in the hope of further boosting innovation and competitiveness.[45] While most clusters and networks develop organically in the absence of any policies to support them, they can serve as a valuable organizing structure to implement policies to support business innovation and encourage member companies to raise their capabilities.

A classic definition of a *cluster* is a "geographical concentrations of interconnected companies and institutions in a particular field" (Porter 1998), while *innovation network* refers to formal or informal collaborations of different parties with a common aim to generate innovations by enhancing competencies and innovativeness (Cunningham and Ramlogan 2016).

There are at least two differences between clusters and networks. First, while clusters entail a high degree of geographical proximity, networks do not necessarily involve geographically co-located entities. Clusters as a colocation of related activities happen automatically in the market process; clustering lies at the heart of differences in regional specialization patterns. In contrast, many networks are virtual initiatives without physical infrastructure, often facilitated by the development of internet-related technologies.

Second, in terms of the level of governance, clusters frequently operate at the industry level, serving as vehicles for industrial policies, while networks typically operate at the organizational level. Clusters feature intensive local linkages (which networks cannot match). At the same time, clusters can be highly globalized with dynamic international linkages.

Rather than being artificially created by policy mandates, clusters and networks often emerge naturally in response to different circumstances and needs. The role played by the government in these instruments is thus often supporting and complementary, rather than inducing. Cluster organizations, which are a specific type of network, can be used by governments to provide structures for actual collaboration, focusing on "a specific geography, oriented toward a set of related industries" (Ketels 2012).

In practice, supporting clusters and networks is often not an innovation policy in itself, but increasingly serves as a channel for innovation policy implementation, including funding. Clusters and networks also serve as intermediaries that engage private and public actors to promote and drive collaborative innovation.

4.2.10.1 Clusters

Definition

Various typologies of *clusters* have been proposed by different authors. The typology popularized by Gordon and McCann (2000) groups clusters in three models: a pure agglomeration model based on localization externalities; a "social network model" emphasizing exchange of information and collective learning; and an "industrial complex model" around the formation of local production systems. The exact designs of clusters policies are driven by the different underlying models, the policy objectives, and other circumstances related to context.

Innovation policy initiatives targeting clusters typically have two elements. The first is support for the cluster ecosystem/organization to undertake innovation awareness activities and to encourage cluster firms and other members to collaborate and develop joint innovation projects. The second is direct financial and advisory support to these firms and other members (such as technology centers and technology transfer offices) to undertake innovation activities, such as through innovation grants.

For instance, Germany's Leading-Edge Cluster Competition (LECC) initiative has provided funding of up to €40 million to firms and their partners in 15 leading technology-based clusters (with this funding mostly for R&D). Germany's Go-Cluster initiative supports capacity building within the organizations managing the cluster and the leads of national cluster organizations, promoting learning and connections within the network and providing an assessment and labelling scheme for clusters.

Market and System Failures Addressed

Several issues justify the use of cluster and networks, but primarily:

- *Coordination failures.* Innovation processes are often hindered by a lack of interactions and collaborations. Individual firms within clusters may underinvest in the coordination mechanisms that underpin joint activity. Cluster policies, by encouraging concentrations of different innovation actors, can effectively address coordination failures. In addition, stakeholder dialogues enabled by clusters can reveal problems, thus serving a diagnostic purpose for policy makers to identify further gaps to be addressed.

Target Group

Cluster policies target a diverse group of organizations, including firms and related organizations within the cluster, such as research organizations, technology centers, finance institutions, public agencies, NGOs, third sector organizations (voluntary and community organizations, social enterprises, mutuals, and cooperatives), associations, and local agencies. Firms and especially SMEs often depend on external sources of information, knowledge, know-how, and technologies in order to build their own innovative capabilities. Research organizations often serve as knowledge providers in clusters to transfer knowledge to, and across, business sectors. Nonprofit associations and local governments often manage clusters or fund organizations that manage clusters.

Strengths

Some strengths of this type of instrument include the following:

- *Enhanced policy effectiveness through economies of scale.* Using clusters for innovation policy can enhance policy effectiveness by taking advantage of preexisting linkages with upstream and downstream firms, and preexisting concentrations of economic activity, to develop innovative projects. Cluster members tend to be interested in collaboration, or actually experienced in collaboration and innovation projects.
- *Higher efficiency enabled by proximity.* Using clusters for innovation policy offers a high potential for efficient policy implementation because the geographical proximity of clusters can overcome fragmentation caused by distance, and innovation spillovers can be easily captured by firms in the cluster. Policy makers can also leverage the investment, using clusters to build a specialized skills base with low search and training costs, to support activities to gain and maintain market access (such as supply chain development/export development) and to identify needs and gaps in policy and infrastructure.
- *Low program costs.* Clusters can lead to lower transaction costs and more direct involvement of the private sector in policy design and implementation.
- *Cross-cutting support.* Clusters can stimulate innovation projects that are more likely to cut across technologies and firm-level activities. Clusters can also support related development activities at the industry level, such as specialized skills development, or market access (supply chain development/export development) that enhance the likelihood that innovation can be sustained and will find a market.

Potential Drawbacks and Risks

Clusters can also have some drawbacks and risks, including:

- *Difficulty in establishing effectiveness.* Clusters can be highly complex, given that they often involve a wide diversity of motivations, rationales, activities, outputs, outcomes, and associated effects. As a result, innovation policies acting through clusters are also highly diverse, making the evaluation of their effectiveness very challenging.
- *Risks of lock-in.* Implementing innovation policies through clusters is subject to the risks of policy lock-in and short-termism. Many clusters that perform well are the outcomes of natural evolution through a long period of time, and members may already be very experienced in both collaboration and innovation. In

these circumstances, spillovers from support may be limited. Members in such clusters may also be very effective at accessing support for innovation, regardless of whether their growth prospects are good, so there is a risk of lock-in into clusters that have lost dynamism and competitiveness.

- *Institution building.* In some cluster policies, too much focus (and too many resources) accrue to cluster management organizations that may not add much value, but once established may be difficult to eradicate when underperforming. These organizations need to be strongly focused on creating value. If interventions in a particular cluster are not proving effective, policy makers need to be able to quickly move onto another cluster.
- *Complexity.* Cluster interventions that generate real spillovers are inherently complex because they involve building collaboration and mutual activity across a range of actors. They rely on cluster managers with a particular set of coordination and marketing skills, and industry leaders prepared to commit to joint activity, but these are often not easy to find.

Elements for Good Instrument Design

Many issues need to be considered when designing cluster policies, including:[46]

- *Identifying which clusters to support*. Both top-down and bottom-up approaches can be utilized: the former refer to using macro-level data, expert knowledge, and firm surveys to select candidates; while the latter utilize knowledge of subnational agencies to identify candidates and embed regional development objectives into clusters. The final selection among candidates might further involve approaches either based on competitions or not.
- *Deciding about resourcing and timing*, such as whether or not to provide direct funding. Typically, cluster policies target only the engagement of actors, and rely on modest budgets and undefined timelines, aiming to leverage additional matching funds (such as from collaborative R&D programs, or export support initiatives). However, some intensive cluster policies feature heavy investment for longer periods of time (such as the Go Cluster discussed earlier). Policy makers will need to reflect on the specific policy objectives to be pursued and make design choices according to the context.
- *Being prepared to stop supporting clusters whose collaborative activities do not appear to have traction*. Even though cluster-related activity can take some time to have an impact, there are leading indicators (such as the degree of engagement from key potential participants and agreed and coherent strategies) that can be monitored and acted upon.
- *Utilizing the right instruments.* Possibilities include those summarized in table 4.39.

Evidence of Impact

There is a considerable body of literature on clusters. However, evidence on the effectiveness of deliberate cluster policy initiatives remains very limited,[47] largely

TABLE 4.39 Policy Instruments to Support Clusters

Cluster identification/support	Collective services and business services	Collaborative R&D
■ Identify clusters (for example, mapping studies) ■ Support networks/clusters (awareness raising, networking, and so on)	■ Improve capability and productivity of business (especially SMEs) ■ Increase external linkages (FDI and exports) ■ Skilled labor force development ■ Input on infrastructure and regulation	■ Increase links between research and industry and within industrial partners ■ Commercialization of research (IPRs, tech transfer support) ■ Access to finance and spin-offs

Source: Adapted from Uyarra and Ramlogan 2016.

Note: FDI = foreign direct investment; IPRs = intellectual property rights; R&D = research and development; SMEs = small and medium enterprises.

because of methodological barriers resulting from the complexity and diversity of cluster modalities. Unlike evaluations of direct financial instruments such as vouchers and grants, input additionality is not sufficiently addressed by evaluations of cluster policies. The synthesis here follows Uyarra and Ramlogan (2016), who have categorized the impact of clusters covered by the existing evidence into "processes and performance", "collaborations and 'soft' impacts," and "longer-term outcomes."

Ten studies from both developing and developed countries (Argentina, Brazil, Canada, Germany, Norway, Spain, the United Kingdom) have been selected for synthesis. Overall, all the studies suggest some degree of positive impact of cluster policies on the targeted firms, at least in the short term, but not all cluster policies analyzed have generated long-lasting effects. The studies evaluate a range of issues, such as program operation, effects on innovation and longer-term performance. All the studies acknowledge limitations of their methodologies: for example, due to data deficiency and selection bias. Most of these studies lack a robust control group based on random selection, which limits their validity. Therefore, caution should be taken when extrapolating the findings because the evaluation results are highly context-specific.

Processes and Performance

Table 4.40 summarizes some lessons regarding processes and performance in clusters. These studies suggest three main lessons: (1) a flexible approach to policy support is needed because businesses in different sectors have different needs; (2) engagement from participants is important to ensure program effectiveness; and (3) it can take a few years before impact can be observed and accurately measured. Other lessons are that successful cluster initiatives should consider long-term resource allocation (for example, more than five years); the higher the investment of companies in time and financial resources, the stronger the results for the cluster; and the quality of the cluster facilitator is an essential factor for the success of cluster projects.

TABLE 4.40 Evidence on Processes and Performance of Clusters: Key Findings

Study	Context	Finding
DTZ (2008)	Yorkshire, United Kingdom, Yorkshire Forward clusters development initiative	Businesses in different industries possess different opinions about the various elements of the clusters initiative. Businesses within the advanced engineering and metals cluster consider access to new technology and machinery and consultancy expertise to be most beneficial. Food and drink cluster companies highly rate the advice and knowledge available, as well as the marketing and business support.
Canadian NRC (2012)	Canada, National Research Council (NRC)	Most of the technology areas at the heart of the cluster initiatives were found to be consistent with stakeholder needs and their vision for their region. Nevertheless, the short time frame for funding (five years) hindered the achievement of optimal results in the longer term.
Jakobsen and Røtnes (2012)	Norway, Norwegian Centres of Expertise (NCE) and Arena programs	It is primarily in those cases in which participants in individual projects invest some of their own time and resources that they manage to achieve effects from participating. There is a close correlation between how the project manager was evaluated and how satisfied the respondents are with the project as a whole. The personal characteristics of the cluster facilitator are seen as being very important for the success of cluster projects.
Esmaeilpoorarabi, Yigicanlar, and Guaralda (2018)	One-North (Singapore); Arabianranta (Helsinki); DUMBO Incubator (New York); Macquarie Park Innovation District (MPID) (Sydney)	The study confirms the significant role of "place quality" in shaping and enhancing the competitive advantages of innovation clusters. Good practice includes choosing locations that are well connected to central business districts and universities; respecting natural and artificial surroundings; avoiding urban sprawl; forming a people-centered urban structure; providing a unique, diverse, and high-quality urban and architectural design; and following a public-private development plan.

Collaboration and Innovation Outcomes

Table 4.41 summarizes findings regarding evidence on collaboration and innovation outcomes. These findings suggest that that networks in clusters feature increasing centrality and influence by dominant players as time goes by. More importantly, the effectiveness of cluster policies in generating R&D input additionality is questionable, although innovation outcomes may increase as a result of R&D spillovers. The evidence, however, is too thin to show how robust these findings are.

Longer-Term Outcomes

The evidence regarding medium-term outcomes is mixed (table 4.42). In some cases, there was a positive impact on employment and sales, while the impact on exports was mixed. There is evidence of spillover effects in some cases. The evidence suggests that genuine motivations of firms are important to ensure program effectiveness. Also, short-term performance does not guarantee long-term benefits, and spillover effects take time to materialize.

Main Requirements for Replicability

A few issues need to be considered when adopting cluster policies.

- *Tailoring policies to the context.* The reviewed studies suggest that cluster policies must be tailored to the level of sophistication of the sector. Highly successful

TABLE 4.41 Evidence on Collaboration and Soft Outcomes of Clusters: Key Findings

Study	Context	Finding
Giulani, Matta, and Pietrobelli (2016)	Córdoba, Argentina, Córdoba Technology Cluster (CTC) (electronics cluster)	Two years into the program, significant interorganizational networks had been formed aiming for knowledge exchange and collaboration. Nevertheless, the study detects a decrease in the density of linkages between 2005 and 2012. Networks have become more centralized, with emerging dominant players that are vital to guaranteeing network connectivity. The program led to strengthening and creating new technology-transfer ties between the electronics firms in Córdoba and other local, provincial, and national institutions, but had no impact on promoting new ties aimed at export-oriented activities. However, networking-oriented activities do not stimulate networking. Instead, networks are formed when there is a real need, not when actors are invited to do so in a set of networking activities.
Falck, Heblich, and Kipar (2010)	Bavaria, Germany, High-Tech Offensive	Introduction of the program increased the likelihood of an innovation by a firm in the target industries by 4.6 percent to 5.7 percent, and decreased R&D spending in the target industries by 19.4 percent, on average.[a] There were increased opportunities for obtaining access to external know-how, cooperating with public scientific institutes, and accessing suitable R&D personnel.
Jakobsen and Røtnes (2012)	Norway, Norwegian Centres of Expertise (NCE) and Arena program	Most of the participating enterprises felt that the Arena project led to increased mutual trust and a greater sense of community. Two-thirds of the actors agreed or partially agreed that the project helped discover synergies between the actors.

a. The authors argue, "However, this does not necessarily point toward a negative effect of the policy; to the contrary, it suggests that firms are now able to develop innovations at lower costs" (Falck, Heblich, and Kipar 2010, 579).

TABLE 4.42 Evidence on Longer-Term Outcomes of Clusters: Key Findings

Study	Context	Finding
Boneu et al. (2016)	Córdoba, Argentina, Córdoba Technology Cluster (CTC) (ICT cluster)	The program increased the participants' employment levels by 20.7 percent, sales by 15 percent, and wages by 4.6 percent, on average, between 2003 and 2011. The authors also find that the longer the time after the firms received the support, the higher the increase in sales. There is strong evidence of positive spillover effects due to geographical proximity. Nevertheless, the program did not effectively increase exports.
Aranguren et al. (2014)	Basque country, Spain	If firms act proactively based on genuine motivations to join the cluster, their membership is more likely to have an impact on competitiveness. Those members that had no clear motivations for membership had lower levels of social capital and perceptions on impacts on competitiveness.
Engel et al. (2012)	Germany, BioRegio contest, BioProfile contest	Winners of policy support outperform nonwinning participants during the treatment period (that is, in the short term). Nevertheless, the authors do not find significant outcome effects of the program in the posttreatment period.
Garone et al. (2015)	Brazil, Local Productive Arrangements (Arranjos Produtivo Local, APLs)	Relative to the control group, beneficiary firms increased their value of total exports by 90 percent and their likelihood of exporting about 8 percent, while the indirect beneficiaries experienced only modest increases that are not statistically significant. However, spillover effects took some time to materialize. After the fourth year of treatment, spillover effects show an almost constant trend, reaching values of around 15 percent for total exports and 2 percent for the likelihood of exporting.
DTZ (2008)	Yorkshire, United Kingdom, Yorkshire Forward clusters development initiative	The annual final net impact increased steadily over the period 2005/06 to 2007/08, from 3,359 to 3,932 jobs created per year and £195 million–£371 million additional turnover. The average final net impact over the three-year period is 3,615 jobs created and £284 million additional turnover.

clusters such as Silicon Valley are typically the result of natural evolution rather than policy intervention. There are inherent risks in trying to "copy" the successes through deliberate policies to generate clusters. Therefore, an important prerequisite to the use of cluster policies for innovation is that a functioning cluster has already been formed. Various conditions, such as the level of commitment from private players or the underlying economic circumstances of the industry, can be strong determinants of success or failure.

- *Competencies and characteristics of cluster managers.* A few studies point to the strong correlation between the competencies and characteristics of cluster managers and cluster performance. Whether or not the managers (or facilitators) can proactively act as brokers and serve as a unifying force to a large extent shapes the effectiveness of program implementation. The studies also highlight that cluster management must initiate early engagement of private sector actors to embed market orientation into cluster policies. This orientation is important to improve the chance of leveraging private funding, as well as developing cluster activities that can organically evolve in the longer term.
- *Competencies of beneficiaries.* As mentioned, the motivation and contribution from potential beneficiaries are important preconditions for cluster policies to be effective. Willingness to invest in conducting the necessary assessment of the initial situation, in planning activities, and in committing to evaluating them after implementation are important preconditions for success
- *Using clusters as vehicles for broader policymaking and implementation.* Policy makers need to appreciate that clusters can perform as platforms for the implementation of a diverse range of policy instruments, crossing the domains of regional, sectoral, industrial, and innovation policies, although some of the outcomes may take time to materialize. For countries/areas facing resource constraints, there might also be an issue of using cluster-based efforts to concentrate scarce resources or engage in upgrading and regulatory changes at a more concentrated level. Interactions stimulated by cluster policies are a means, not an end. Policy makers should be clear about the real problems and challenges they are targeting, rather than merely promoting interactions.

Dos and Don'ts of Clusters

Do	Don't
▪ When identifying cluster candidates, conduct a thorough assessment based on solid methodologies and reliable data sources, coupled with expert knowledge and insight from local stakeholders to assess their strengths. ▪ Engage private sector actors early to reduce the risks of government failures, enhance the chance of lever	▪ Don't follow the crowd and simply copy cluster policies and sectors that have been successful elsewhere. Successful clusters emerge naturally, and public interventions should be used to enhance them. The distinct capabilities and circumstances of each context require different cluster policy approaches.

Dos and Don'ts of Clusters

Do	Don't
aging private funding, and ensure a market orientation in the longer run. ▪ Be prepared to stop cluster interventions if stakeholders are simply not engaging. ▪ Take policy evaluation issues into account at the design stage and create a central database of businesses to facilitate monitoring and evaluation. ▪ Keep cluster management organizations lean and strongly focused on creating value. ▪ Identify the key private sector leaders who are committed to making the cluster work, and who can draw others into the process. ▪ Recognize that this cluster management role is crucial for creating dynamism within clusters and requires a specific skillset, so recruiting the right managers is vital. Provide capacity building if necessary.	▪ Don't try to engineer clusters; the record of government orchestrating clusters is poor. ▪ Don't try to apply clusters policies to all industries; rather, select only the ones with potential to maximize competitive advantage.

Checklist for Design and Implementation of Clusters

- Have functioning clusters already been formed?
- Why have some of these clusters you are targeting not been created endogenously?
- Are there clusters that represent local specialization and strengths?
- Have you identified suitable candidates for clusters?
- What is the governance model for the clusters?
- Are experienced cluster managers and industry leaders committed to making the cluster work available?
- What are the incentives planned for participants in these clusters?
- What are the instruments that you are planning to implement via clusters?
- What are the performance management arrangements that will ensure that funding is withdrawn from ineffective clusters and resources are allocated to better clusters?

References

Aranguren, M. J., X. de la Maza, M. Davide Parrilli, F. Vendrell-Herrero, and J. R. Wilson. 2014. “Nested Methodological Approaches for Cluster Policy Evaluation: An Application to the Basque Country.” *Regional Studies* 48 (9): 1–16.

Boneu, F., V. Castillo, D. Giuliodori, A. Maffioli, A. Rodríguez, S. Rojo, and R. Stucchi. 2016. “Impact of Support to the Information and Communication Technology Cluster: Córdoba, Argentina.” In *The Impact Evaluation of Cluster Development Programs.* Washington, DC: Inter-American Development Bank.

Canada, NRC (National Research Council). 2012. “Portfolio Evaluation of the NRC Technology Cluster Initiatives.” http://archives.enap.ca/bibliotheques/2012/10/030315425.pdf.

Cunningham, P., and R. Ramlogan. 2016. “The Impact of Innovation Networks.” In *Handbook of Innovation Policy Impact,* edited by J. Edler, P. Cunningham, A. Gök, and P. Shapira. Edward Elgar Publishing.

DTZ. 2008. *Evaluation of Yorkshire Forward’s Investment in Cluster Initiatives Final Report (Revised).* London: DTZ.

Engel, D., T. Mitze, R. Patuelli, and J. Reinkowski. 2012. “Does Cluster Policy Trigger R&D Activity? Evidence from German Biotech Contests.” Ruhr Economic Papers 311, RWI-Leibniz-Institut für Wirtschaftsforschung, Ruhr-University Bochum, TU Dortmund University, University of Duisburg-Essen.

Esmaeilpoorarabi, N., T. Yigitcanlar, and M. Guaralda. 2018. “Place Quality in Innovation Clusters: An Empirical Analysis of Global Best Practices from Singapore, Helsinki, New York, and Sydney.” *Cities* 74: 156–68.

Falck, O., S. Heblich, and S. Kipar. 2010. “Industrial Innovation: Direct Evidence from a Cluster-oriented Policy.” *Regional Science and Urban Economics* 40 (6): 574–82.

Garone, L., A. Maffioli, J. A. de Negri, C. M. Rodriguez, and G. Vázquez-Baré. 2015. “Cluster Development Policy, SMEs’ Performance, and Spillovers: Evidence from Brazil.” *Small Business Economics* 44 (4): 925–48.

Giuliani, E., A. Matta, and C. Pietrobelli. 2016. “Networks, Cluster Development Programs, and Performance: The Electronics Cluster in Córdoba, Argentina.” Inter-American Development Bank.

Gordon, I., and P. McCann. 2000. “Industrial Clusters: Complexes, Agglomeration and/or Social Networks?” *Urban Studies* 37 (3): 513–32.

Jakobsen, E. W., and R. Røtnes. 2012. “Cluster Programs in Norway–Evaluation of the NCE and Arena Programs.” Menon Publication Number 1/2012, Menon.

Ketels, C. 2012. “The Impact of Clusters and Networks of Firms on EU Competitiveness. Final Report.” DG Enterprise and Industry, Brussels.

Maffioli, A., C. Pietrobelli, and R. Stucchi, eds. 2016. *The Impact Evaluation of Cluster Development Programs–Methods and Practices.* Washington, DC: Inter-American Development Bank.

Porter, M. 1998. “Clusters and the New Economics of Competition.” *Harvard Business Review* November/December: 77–90.

Uyarra, E., and R. Ramlogan. 2016. “The Impact of Cluster Policy on Innovation.” In *Handbook of Innovation Policy Impact,* edited by J. Edler, P. Cunningham, A. Gök, and P. Shapira, 196–238. Edward Elgar Publishing.

4.2.10.2 Innovation Networks

Definition

Network support policies—as defined by Cunningham and Ramlogan (2016, 444)—are “measures aimed at promoting or sustaining the linkage of firms and/or knowledge producers where the activities concerned are centered on a specific technological or problem-oriented topic for the primary purpose of knowledge and information sharing." Some network programs with particular features can complement cluster policies, including but not limited to (1) networks with a broader geographic and industry scope, especially those involving work with emerging industries; (2) networks that can provide shared services and connect individual firms across geographical boundaries; (3) networks that specifically target SMEs; and (4) networks that can embed more comprehensive efforts to enhance regional competitiveness (Ketels 2012).

Networks can focus on different aspects of innovation. Some involve fairly simple forms of innovation: for instance, groups of SMEs that engage in "learning groups" when implementing process change (like kaizen)[48] sharing knowledge and experiences and providing mutual encouragement. Other networks are much more focused on frontier technologies, sharing information about technological breakthroughs in particular sectors or technologies, and encouraging linkages. The Knowledge Transfer Network (KTN) in the United Kingdom is an example.

Innovation policy initiatives targeting networks generally focus on supporting the networks themselves and enabling them to undertake innovation/technology awareness and diffusion efforts and collaborative innovation activity. They can be particularly relevant for SMEs that do not have large internal management teams or extensive formal external business relationships to learn from and discuss innovation challenges.

Market and System Failures Addressed

The market and system failures discussed in the preceding section on clusters apply to innovation networks. Coordination failures occur mainly because the coordination and administration required to run collaborative networks are beyond the resources or capacity of any single network member or because the geographical spread of the cluster enhances the challenges involved in coordination. Public support can effectively address this barrier.

Target Group

A network can be comprised of only firms or can include private and public actors (used to foster industry-academia collaboration). The so-called "complete innovation networks" comprise a range of industry actors, universities, and government laboratories. In general, the Target Groups of network policies are similar to that of cluster policies but tend to concentrate less in specific geographies and/or sectors.

Strengths

- *Risks and costs sharing.* Networks, by combining the strengths and competencies of different partners, can effectively reduce the risks and costs involved in investing in novelty by distributing these risks across all participants.

- *Effective communication and information/knowledge flows.* Networks with wider stakeholder groups facilitate communication between the demand and supply sides of the market, create new opportunities for innovation, and serve as sources of value added and flexibility.
- *Tackling challenging issues.* Networks may be able to create innovations that one single enterprise is not able to address alone due to a lack of resources, capabilities. or personnel.
- *Inexpensive.* Networks are typically not a costly intervention, especially when built upon existing communication infrastructures and personnel.

Potential Drawbacks and Risks

- *Risk of high cost for organizers.* If not designed properly, the maintenance costs in terms of time and personnel may be borne by the network organizer, while all firms in the network benefit. This "free-rider" effect can impair the sustainability of the network and impose high costs on other participants.
- *Low predictability of outcomes.* It can be very difficult to predict the development path of a network, given that this path can be influenced by unpredictable circumstances experienced by network participants, and it can be difficult to track outcomes directly tied to the network.
- *Potential conflicts regarding intellectual property rights.* Mutual trust among partners is crucial in networks. Clear arrangements regarding intellectual property in advance are important to prevent conflicts. This requires the presence of a well-established intellectual property system.

Evidence of Impact

The evaluations of network policies overwhelmingly focus on the preconditions, operations, and processes of networking activities per se, rather than the impacts on innovation and economic performance. This is in part because networks overlap significantly with other policy instruments and seldom function alone. While there are quite a number of evaluations of research-based networks—such as the set of evaluations looking at the implementation and impacts of the Networks of Centers of Excellence (NCE)—evidence on the effectiveness of business innovation networks is extremely scarce. This synthesis covers four studies that shed light on both implementation and impact of network policies.

The selected studies use different methodologies to investigate the workings and impacts of networks. The two quantitative studies, Nishimura and Okamuro (2011) and Damvad (2011), use econometrics with a control group. Damvad (2011) claims to be the first quantitative impact assessment of innovation networks, employing longitudinal data from 2002 to 2008. In terms of timing for the evaluations, Eickelpasch, Kauffeld, and Pfeiffer (2002) and Kaashoek and Holland (2011) were commissioned early on in the program implementation process and fall short on assessing program effectiveness.

TABLE 4.43 Evidence of the Impact of Innovation Networks: Key Findings

Study	Context	Finding
Damvad (2011)	Denmark, Innovation Network	Participation in the Innovation Network increases the probability of innovating by more than 4.5 times and increases the probability of R&D collaboration by 4 times after the first year. Compared to 1.7 percent of firms outside the network, 8.3 percent of network participants had an innovation outcome measured by new products or new processes.
Eickelpasch, Kauffeld, and Pfeiffer (2002)	Germany, InnoRegio	The larger the number of participants, the more extensive the network's total sphere of competencies tends to be, but this also raises additional problems of organization and communication. Another factor is the degree of homogeneity. A uniformly high performance by participating enterprises tends to be advantageous, while a more heterogeneous performance could potentially cause problems for network cohesiveness.
Kaashoek and Holland (2011)	Belgium, Flemish Innovation Network (Vlamms Innovatienet-werk)	Interview respondents were divided on how well the network worked. The most positive felt that the network worked well and had great potential for further development. Others did not view the network as one single network; rather they looked at the clusters as boundaries and the network as one approach to better support clusters. A third group felt that the network made no difference for firm activities.
Nishimura and Okamuro (2011)	Japan, Industrial Cluster Project	The utilization of indirect networking/coordination support programs (especially research meetings, business matching, and management consultation) is positively related to the development of industry-university-government collaboration. In contrast, R&D support does not always promote network formation.
Najafi-Tavani et al. (2018)	Iran	The effects of collaborative innovation networks on either product or process innovation capability are significant only for firms with sufficient absorptive capacity. This finding suggests that the level of collaboration with different partners can enhance firms' innovation capabilities only if the firm's managers have developed the capacity to gather and acquire external knowledge.

Only one of the studies, Damvad (2011), has concrete findings about the innovation impact of a network program. This study suggests a positive impact of networks on innovation and R&D collaboration. The other studies find that networks sometimes increase collaboration in innovation projects, but do not measure the impact on outcomes.

Main Requirements for Replicability

The literature suggests several important elements for design:

- *Required management capacity and leadership.* Networks might appear low-cost to launch, but management can be complicated and there is a strong need for highly competent management by individuals or teams. The reviewed studies point out that proactive network leadership is a powerful contributing factor to program success.
- *Strong political support and long-term commitment.* These are necessary, particularly as the impacts on innovation materialize only after a certain period of implementation. It is very hard to measure the impact of the intervention in the short term, making it more difficult for politicians to justify the intervention in comparison to more tangible interventions like physical innovation infrastructure.

- *Required characteristics of beneficiaries.* The reviewed studies suggest that firms are not equally able to benefit from network policies. Firms with clear motivations, proactive attitudes, and a certain level of capacity to absorb new technologies and ideas are more capable of benefiting than firms that lack these elements. Some targeting and assessment of the willingness to effectively participate is warranted.
- *Proactive involvement of all parties, including both the management of the network and its members*. Proactive involvement is built upon trust, common interests, and a real demand for networking. Continued financial support is a necessary but not sufficient condition for network success.
- *Clear intellectual property arrangements.* Networks involving commercialization require clear intellectual property arrangements to reduce investment risks for participants and contribute to trust building among members.
- *Independence.* The reviewed studies point out that independence contributes to network sustainability. Policy makers, while facilitating the setup and maintenance of networks, should give enough space and autonomy to participants.
- *Maintenance of policy consistency and predictability of support and effort*. These are also important to sustain the network and promote innovation.

Dos and Don'ts of Innovation Networks

Do	Don't
■ Position networks around an issue that is important to firms and requires collaboration to address. Networks are a means to an end (innovation) rather than an end in themselves. ■ Consider the competencies of participants when structuring networks, and make sure there are complementary characteristics to create collaborative opportunities (such as the need for both dominant and periphery players). ■ Recognize that the tangible outputs of networks can be difficult to identify, but inducing firms to be more outwardly linked is inherently important. ■ Utilize the potential of cluster organizations or network structures to aggregate needs and coordinate the delivery of policies to industry groups, including competitiveness policies (such as export promotion, value chain development, and skills development).	■ Don't intervene too much or micromanage the dynamics of networks. Support for networks needs to be financial but indirect and be both continuing (to allow impacts to materialize) and "soft" (to give enough space and autonomy to participants). ■ Don't assume the network experience is equal among participants; assessment of network effectiveness needs to consider the potentially highly varied experience of all parties.

Checklist for Design and Implementation of Innovation Networks

- Why have some of these networks not been created endogenously?
- What is the governance model for the networks?
- What are the incentives to participate in the network?
- What instruments are more suitable to be implemented using these networks?

References

Cunningham, P., and R. Ramlogan. 2016. "The Impact of Innovation Networks." In *Handbook of Innovation Policy Impact,* edited by J. Edler, P. Cunningham, A. Gök, and P. Shapira. Edward Elgar Publishing.

Denmark, Damvad (Danish Agency for Science, Technology, and Innovation). 2011. "The Impacts of Cluster Policy in Denmark–An Impact Study on Behaviour and Economical Effects of Innovation Network Denmark." Damvad, Copenhagen.

Eickelpasch, A., M. Kauffeld, and I. Pfeiffer. 2002. "The InnoRegio Program: A New Way to Promote Regional Innovation Networks–Empirical Results of the Complementary Research." In 42nd Conference of the European Regional Science Association, ERSA Conference Papers ersa02p262 (1–22).

Kaashoek, B., and C. Holland. 2011. "The Flemish Innovation Network–Structure, Workings and Future Set-Up." http://www.iwt.be/sites/default/files/varia/iwt_studie67_eng.pdf.

Ketels, C. 2012. "The Impact of Clusters and Networks of Firms on EU Competitiveness. Final Report." DG Enterprise and Industry, Brussels.

Najafi-Tavani, S., Z. Najafi-Tavani, P. Naudé, P. Oghazi, and E. Zeynaloo. 2018. "How Collaborative Innovation Networks Affect New Product Performance: Product Innovation Capability, Process Innovation Capability, and Absorptive Capacity." *Industrial Marketing Management* 73: 193–205.

Nishimura, J., and H. Okamuro. 2011. "Subsidy and Networking: The Effects of Direct and Indirect Support Programs of the Cluster Policy." *Research Policy* 40 (5): 714–27.

Notes

1. Some standards related to quality are covered in Profile 9 on quality infrastructure.
2. Nine studies look at middle-income countries (Argentina, Chile, China, Turkey, and a number of Eastern Europe and Central Asia countries); more than thirty studies look at developed countries (Australia, Austria, Belgium—especially Flanders, Canada, Finland, Germany—especially eastern versus western, Ireland, Italy, Korea, Norway, Spain, the United Kingdom, the United States); two studies look at multiple countries across the developed and developing world; and nine studies are syntheses or meta-analyses and thus not country-specific.
3. Methodologies adopted are mostly econometric techniques, including (parametric) regression, difference-in- differences estimation, (nonparametric) matching techniques, and, more recently, matching combined with difference-in-differences.
4. These typically involve ex post evaluations using existing data, but without prior evaluation design or randomization.
5. It is also possible to evaluate the impact of grants on project additionality (that is, the project would not have been conducted without public funding) and scale additionality (that is, the project is conducted on a larger scale than it would have been without public funding).
6. There are some exceptions, such as Chile, where vouchers have also been used with larger firms for amounts up to US$10,000 and use application processes similar to those of matching grants.

7. For instance, the Dutch national scheme allocates vouchers on a first-come, first-served basis if the number of available vouchers is larger than the number of applicants. When the number of applications exceeds the number of available vouchers, the vouchers are allocated randomly through a lottery conducted by a civil law notary (Cornet, Vroomen, and van der Steeg 2006).
8. In practice, boundaries between financial instruments can be blurred. For example, equity financing has elements of debt, such as venture debt instruments, while convertible loans has elements of equity financing. In addition, other forms of debt financing exist, such as leasing (for example, of equipment) and intangible asset (or intellectual property) financing (for an overview, see Bravo-Biosca, Cusolito, and Hill 2014).
9. For a recent review of credit guarantee schemes for SMEs, see Calice (2016).
10. The selected studies employed different estimation strategies. The evaluation of the Spanish CDTI program estimates the equations as a Probit model with sample selection by maximum likelihood. The KOTEC program evaluation instead relies on an econometric model using two regressions: one to estimate determinants of participation in the credit guarantee and the other to estimate determinants of firms' R&D investments, including participation in the credit guarantee. The evaluations of both CDTI and KOTEC use panel data. In the case of Chile's FOGAPE (Fondo de Garantía para Pequeños Empresarios), the phased introduction of the program allowed researchers to employ a quasi-experimental strategy to build a counterfactual, assuming that firms that participated in the program only later on would have participated earlier had their bank offered guarantees earlier.
11. For details, see http://www.oecd.org/sti/rd-tax-stats.htm.
12. This includes current expenditures (labor and other current expenditures, including overhead) and capital expenditures (acquisition cost for machinery and equipment, buildings, and land; intangibles; and depreciation costs).
13. R&D demand equations are estimated using a dummy variable for the tax credit or a measure of the user cost of R&D. Data sources are typically firm-level panel data.
14. Government officials in Colombia suggested that only 15 percent of firms knew about the existence of tax incentives.
15. European Commission (multi-country) (Czarnitzki, Hansel, and Rosa 2011); Netherlands, Dutch Payroll Tax Withholding Scheme (Lokshin and Mohnen 2013); Norway, Norwegian SkatteFUNN (tax deduction scheme for R&D in business and industry) (Cappelen et al. 2017); and Italy (Caiumi 2011).
16. Pre-commercial procurement in practice can overlap with other policy instruments such as competitive grants (where proposals are assessed on a competition basis with predefined criteria) and corporate open innovation instruments (where multinational enterprises can purchase R&D services from their suppliers).
17. Pre-commercial procurement lies beyond the scope of the World Trade Organization (WTO) Agreement on Government Procurement (GPA) or similar legislation on commercial procurement.
18. Alternatively, agencies can commission the main innovation support institution to run PCP schemes on their behalf, or innovation agencies can run multiagency schemes, as occurs in the United States with the whole-of-government Small Business Innovation Research (SBIR) scheme run by the US National Institute of Standards and Technology (NIST).
19. An example of this type of one-stop platform is the Smart PCP platform in the EU. See http://www.smart-pcp.eu/ for more details (accessed November 24, 2016).
20. Evaluations of the Dutch SBIR have been conducted, but the final reports are not available. There is a study that compares the Pesquisa Inovativa em Pequenas Empresas (PIPE) in the Brazilian state of São Paulo and the US SBIR. There is no conclusive evidence on the effectiveness of European initiatives.

21. See, for example, Edquist, Hommen, and Tsipouri (2000) for a collection of PPI cases.
22. Competitive dialogue is a tendering arrangement that allows procurers to negotiate proposed solutions with bidders. It is typically used for highly complex and risky projects where bidders will have a major role in defining the solution or where flexibility is much needed.
23. In addition, the other standard market failures that SMEs face in investing to upgrade innovation all apply.
24. ISO 9000 is a set of international standards on quality management and quality assurance.
25. For an overview of technology adoption institutions and instruments, see Shapira and Youtie (2017).
26. In addition, managerial practices can be considered a technology because they can explain around 30 percent of productivity differences across countries (Bloom, Sadun, and Van Reenen 2016).
27. This may also mean that any initial interaction should not seek to involve a full financial assessment of the SME, given that SME owners may be wary about providing access to this data without trusting the advisor fully.
28. In the case of vouchers or grants, SMEs may not know how to best utilize external advisors, so assistance can be provided both to make the engagement process easy (such as through standardized contracts and scopes of work) and also through third-party checks and assessments of the consultant's work.
29. A similar term, innovation centers, is also used to label innovation facilities often located in university campuses. These are, however, more cross-sectoral initiatives and closer in function to science and technology parks.
30. For a description and comparison of science and technology parks in early-stage instruments, see table 4.27.
31. In many instances, science and technology parks are referred to by other terms, including science park, science city, science town, technology park, technopark, technopole, Technopolis, hi tech (industrial) park, research and technology park, R&D park, university research park, innovation center, and cyber park.
32. This section has primarily drawn upon the extensive literature review conducted by Hobbs, Link, and Scott (2017) to trace the studies that look into the effectiveness of STPs.
33. An example is the Bayh-Dole Act in the United States, followed by similar initiatives in many developed and developing countries.
34. Special purpose vehicles (SPVs) are established legal mechanisms that allow universities to own equity in university spin-offs.
35. In addition, some case studies on best practices in technology transfer are available at http://www.progresstt.eu/best-practice-library/.
36. The Podkarpackie Center for Innovation (PCI) in Poland is one such technology transfer office. It centralizes resources and is designed to support tech transfer from the regions' three local universities.
37. Other interventions that are similar to incubators include innovation hubs, which focus mainly on the colocation element for innovative ventures, and one-stop shops, which are more oriented toward supporting entrepreneurship.
38. This can also be addressed in different models, such as more traditional business development services. Incubators and accelerators exploit these support services, using a more clustered and networking approach.
39. infoDev is a World Bank Group multidonor program that supports entrepreneurs in developing economies. It oversees a global network of business incubators and innovation hubs for climate technology, agribusiness, and digital entrepreneurs (Source: http://www.infodev.org/about).

40. *Open innovation* is "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough, Vanhaverbeke, and West 2006). *Crowdsourcing* is "the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call" (Howe 2008).

41. Inducement instruments run by government can sometimes be very similar to government procurement, in the sense that the process typically starts with government signaling unmet innovation needs to the market, followed by proposals and the development of innovative solutions by suppliers that might win government contracts through procurement procedures. Procurement of innovation and R&D are covered in section 4.2.5; this section focuses on other types of inducement instruments.

42. Another type of instrument closely linked to inducement prizes is ex post recognition awards: that is, awards that are given retrospectively to outstanding performers after the intended outcomes take place. Recognition awards can generate significant reputational effect, bringing attention to achievements by researchers and/or entrepreneurs and potentially publicizing (and justifying) government expenditure on innovation. They can also send signals to private sector investors so that the development of awarded solutions can be further supported by more resources. There is limited literature dedicated to this type of instrument; one example is Moser and Nicholas (2013).

43. ISO 9000 is a set of international standards on quality management and quality assurance. The ISO 14000 family of standards aims to promote effective environmental management systems in organizations. They are established by the International Organization for Standardization (ISO).

44. See also the business advisory services (BAS) (section 4.2.6.1) and technology extension services (TES) section (section 4.2.6.2) for the justification of firm-level support for the uptake of standards and provision of testing services.

45. Clusters and networks are widely used in many domains of public policy. This profile focuses on those aiming (at least in part) to support business innovation. Policy instruments supporting collaboration are dealt with in three different sections in this guide, including Profile 1 on vouchers (fostering innovation in noninnovative firms) and matching grants (expanding R&D and non-R&D innovation activities), and this profile on networks and clusters.

46. As noted, network policies are often part of cluster policy package; the design of networks is addressed in the next section. This discussion draws mainly upon Uyarra and Ramlogan (2016).

47. The selected studies employ a range of methodologies, including descriptive statistics, econometrics, case studies, and participatory evaluation methods based on interviews and surveys. Methods such as social network analysis have also been introduced to explore networking relationships (see, for example, Giuliani, Matta, and Pietrobelli 2016). Driven by the wide diversity of modalities of cluster policies, diverse indicators have been employed, including number of new firms or patent applications, and indicators of soft impacts, such as increased collaborations. Limitations of the studies include the reliance on self-reported data and the lack of robust control groups. Moreover, clusters naturally evolve, and related policies are also intertwined with regional and industrial policies. Thus, it is difficult to distinguish which elements of the intervention actually led to the observed outcomes. Maffioli, Pietrobelli, and Stucchi (2016) note that a possible way to move forward is to design the evaluation and data collection at the same time as the program design.

48. Kaizen is the Sino-Japanese word for "improvement." In the business context, kaizen refers continuing improvement involving everyone—managers and workers alike.

5. Four Final Messages

This practitioner's guide aims at filling an important gap in innovation policy making, especially in developing countries. The document synthesizes a large amount of accumulated knowledge about innovation policy making, building on previous efforts from Manchester Institute of Innovation Research (commissioned by Nesta), the Organisation for Economic Co-operation and Development (OECD), and other agencies, as well as the accumulated expertise obtained through innovation-related operations financed by the World Bank. This knowledge, we hope, will provide important information to improve the effectiveness of innovation policy in developing countries. This guide is, however, a living document. Innovation policy needs to change and adapt to cope with the changes in the nature of innovation and technology.

This guide concludes by emphasizing a few key messages, especially for those readers who skipped chapters 2 and 3 but have read some of the instrument profiles in chapter 4. There are four key final messages that we hope the reader will retain.

1. *Innovation is a broad concept that includes not only R&D activities, invention, patents, and new technologies, but also more incremental activities to upgrade processes and quality, adopt new business models, and undertake product imitation*. The latter type of innovation is especially prevalent in developing countries, where innovation capabilities are less developed than in developed countries. Fortunately, this more incremental type of innovation can yield great payoffs in terms of boosting productivity and employment. Thus, it is critical that policy makers keep this broader concept in mind when designing and implementing innovation policies. Moreover, firms are rarely born with world-leading innovation capabilities; rather, they steadily learn how to be more effective in innovation by building their own capabilities and utilizing simple types of innovation, and through trial and error. *Thus, innovation policy must prioritize and facilitate this incremental process of learning and accumulation of innovation capabilities.*
2. *Innovation policy often tries to solve many complex problems; this requires good diagnostics and careful design. Thus, policies need to be implemented with caution to avoid failure.* Effective innovation policies require adequate diagnostics of the innovation problems, appropriate design, sound implementation, and adaptation and learning through good monitoring and evaluation. These features are often difficult to be achieved in contexts where there are large gaps in the national innovation system and limited human and financial resources. Innovation ministries and agencies, like firms, need to build their capabilities for good design and implementation; accumulating knowledge and competencies to implement

gradually more complex policies. *Thus, this guide advocates a gradual approach to innovation policy that also prioritizes building the required government competencies.*

3. *Don't try to address all innovation problems at the same time.* This message is a direct corollary to the first and second messages. Innovation agencies and ministries tend to push toward increasing their budgets and the set of instruments to support innovation, *but it is critical that policy makers be realistic about what can be effectively delivered and accomplished. It is better to have a narrow but more aligned policy mix (with fewer instruments) than a broad but fragmented and ineffective policy mix (with many instruments) that wastes taxpayers' money*. This is especially important in countries with low capabilities, in both the private and public sectors, and where the necessary conditions to implement some of these instruments cannot be met. Agencies should prioritize working with the private sector to address key bottlenecks—including the cost of doing business or regulations that undermine innovative investments—because if markets do not reward firms that invest in innovation, then no innovation policy intervention will be effective, regardless of how well designed it is.
4. *There is an urgent need to measure, evaluate, and adapt innovation policies.* It is striking that policies that have the potential to have such a large impact on income and human well-being, but that also can be both expensive and ineffective, are so rarely evaluated. Innovation can provide high private and social returns and transform livelihoods by providing critical solutions to societal problems, but their effectiveness can be heavily influenced by local design and delivery factors; what has worked elsewhere may not work in a local context. Given this, there is a need for policy makers to carefully watch whether their initiatives are working and what impact they may be having. In this regard, innovation policies lag behind social or education policies in their evaluation and the establishment of a solid body of empirical evidence that can improve design. Given the potential impact these policies have, it is imperative to increase the number of robust impact evaluations and improve our understanding of the impact of these policies across developing countries to better design and implement innovation policy.

Rapid technological change is increasing the pressure on policy makers to improve the effectiveness of innovation policies needed to reap the benefits of innovation and technological catch-up. However, there is little information about what works when it comes to innovation policy, particularly for developing countries. Moreover, market and systemic failures that hamper innovation are pervasive in developing countries, but the institutions tasked to design and deliver innovation policies often lack the capabilities to design and implement policies that successfully address them. This practitioner's guide aims to fill this gap and support policy makers in developing countries in their quest to design more effective policies to foster innovation. It does so by rigorously describing the range of innovation policy instruments available, the evidence of impact, and more importantly, the conditions and institutional capabilities necessary to successfully implement these policy instruments in developing countries.

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