The Innovation Paradox

Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up

Xavier Cirera and William F. Maloney
OVERVIEW

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Productivity growth is critical for accelerating development. Poverty around the globe cannot fall unless poorer countries raise their per capita incomes. Some of this income growth will come from investing in better physical and human capital. However, we know that a significant share of income growth derives from productivity growth, and specifically from innovations that render physical and human capital more productive.

Understanding how innovations arise and are adopted and which policies can support them is important for development policy design. It is even more important given the new wave of digitalization and automation that is rapidly altering economies around the world. One of the key findings of the research presented here is that the observed low level of technological adoption in developing countries is a rational response of firms to a range of conditions they face: barriers to accumulating physical and human capital, low firm capabilities, and weak government capacity. Unlocking the enormous growth potential of moving countries closer to the technological frontier thus is not as simple as, say, providing additional incentives for research and development. Moving countries closer to the frontier will require far-reaching policy changes that tackle multiple constraints to technological adoption.

The research presented here is part of a longer research project on productivity led by the Chief Economist’s Office of the World Bank’s Equitable Growth, Finance, and Institutions Vice Presidency. We are confident that researchers and development practitioners alike will highly value the new findings on innovation patterns and the directions for development policies this report contains.

Jan Walliser
Vice President
Equitable Growth, Finance, and Institutions
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Innovation—the invention of new ideas, and the introduction of new products, technologies, business processes, and ideas in the market—is central to the rise of advanced economies. It drives the process of creative destruction as new, productive firms enter the market and old, unproductive ones exit (Schumpeter 1942), underlies modern growth theory, and is the critical ingredient in historical accounts of how countries achieve prosperity. Its importance is captured by the classic metaphor of The Unbound Prometheus (Landes 1969), referring to the Greek god who released the power of fire to humankind.

Yet in developing countries, Prometheus remains bound. Despite the vast potential returns, developing countries encourage far less innovation, measured along a variety of dimensions, than advanced countries. Firms and governments appear to be leaving billions of dollars on the table in forgone productivity growth. This is the innovation paradox.

The standard policy advice to resolve this paradox—to move into areas of production thought to be more growth friendly—misses the critical point that countries that are unable to innovate and be competitive in their current industries are unlikely to do so in new industries. Moreover, discussions about innovation policy often omit the question of who actually implements it. The role public servants, ministries, and agencies play in ensuring or undermining the effectiveness of policy instruments is rarely considered. This public sector role is a key element in most developing countries with little implementation capacity.

Three factors help explain developing countries’ innovation paradox:

1. The critical complements to investments in innovation that are needed to achieve high potential returns are missing.
2. The key firm capabilities—managerial and organizational practices—required to pursue innovation and take it to market successfully are weak.
3. Government capabilities for implementing effective innovation policies are also weak and limited.

Innovation policy in developing countries is more challenging and complex than in advanced countries because the market failures and missing complementarities are likely to be more acute.
This volume analyzes these factors, with the goal of contributing to more coherent and effective policy making in developing countries to unleash the power of innovation. The analysis draws on two important traditions, the neoclassical and the national innovation system (NIS) literature, highlighting the common ground between them.

The Nature of Innovation in Developing Countries

New data allowed us to generate stylized facts about the nature of investments in innovation that firms have undertaken at various stages in the development process. Firms report innovating at all income levels and in all sectors. In developing countries, however, these investments often consist of marginal improvements in process or products, rather than significant technology adoption or new product imitation. They very rarely involve frontier research. Further, as a country’s per capita income rises, so too do its investments in a wide range of inputs related to innovation, such as use of technology licenses, purchase of equipment, and research and development (R&D), as well as investment in outputs, such as patents or products new to the national or international market (see figures O.1 and O.2).

These firm-level data reveal the innovation paradox: the coexistence of low levels of innovation-related investment in developing countries with the dramatically high returns that should accompany the adoption of more productive technology (technological adoption) and the catch-up of developing countries (Schumpeterian catch-up) to the levels of productivity of advanced countries (the productivity frontier). What explains this weaker effort in adopting technology, much less in introducing new products and services?

Explaining the Innovation Policy Paradox: The Importance of Complementarities

The increase in the use of the wide variety of inputs needed for the innovation process, as well as physical and human capital, as countries develop (as shown in figures O.1 and O.2), suggests a high degree of complementarity among the different factors necessary for innovation. This co-movement also helps explain the innovation paradox. If a firm (or country) invests in innovation but cannot also import the necessary technology, contract or hire trained workers and engineers, or draw on new organizational techniques, the returns to that investment will be low. That is, while it is true that the potential gains from Schumpeterian catch-up increase with distance from the frontier, the availability of the factors of production necessary to realize them decreases.

Figure O.3 confirms the essential role of complementarities in realizing these returns. The returns from investment in R&D initially do rise as predicted with countries’ increasing distance from the frontier. However, the lack of complementary factors eventually becomes a binding constraint, causing the returns to innovation to decline, and possibly even become negative, as shown by the inverted U-shape.
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FIGURE O.1  As Countries Develop, Firms Introduce More Sophisticated New Products and Purchase More Licenses to Use Technology


FIGURE O.2  As Countries Converge to the Productivity Frontier, R&D Intensity Rises

a. Country level

(Figure continues on the following page.)
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This insight has two key implications for innovation policy. First, the concept of the national innovation system (NIS) must be expanded, as illustrated in figure O.4. The policy maker’s conception of the NIS must go beyond the usual institutions and policies designed to offset standard innovation-related market failures (as indicated in the left-hand side of figure). The scope of the NIS must include broader complementary factors and supporting institutions (as in the middle of the figure).

The second implication is that innovation cannot be supply driven; there must be demand from firms that have the capabilities to innovate. On this demand side—the firm and its decisions to innovate (shown on the right-hand side of figure O.4)—policy makers must be concerned with the incentives for firms to accumulate the necessary physical, human, and knowledge capital. Thus, policy makers must consider the overall macroeconomic and competitive contexts, the trade regime, and the barriers to the accumulation of all of these types of capital, such as credit markets, entry and exit barriers, the business and regulatory climate, or the strength of the rule of law. Hence, in

**FIGURE O.2** As Countries Converge to the Productivity Frontier, R&D Intensity Rises (continued)

What looks like an innovation problem, such as a low rate of investment in research and development, may not be one, but rather reflect barriers to accumulating other factors, including physical and human capital.
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In addition to the elements generally focused in the NIS (highlighted by the blue triangles in figure O.4), developing country innovation policy must address the failures or underdevelopment of a wider range of markets to realize the potential returns from catch-up (indicated by the green triangles). The innovation agenda is, therefore, much broader and more complex in these countries.

This complexity of the NIS has strong implications for conventional measures of benchmarking innovation performance—such as comparing raw levels of gross domestic expenditures on R&D across countries—since they are likely to be misleading if they do not consider the existing stock of other complementary factors. A low level of R&D may indicate unresolved problems in innovation per se, but may just as likely reflect constraints in the accumulation of other factors. That is, low-income developing countries that have weak education systems, or have capital markets or import restrictions that make it difficult to invest in physical capital, will not have high returns to R&D or innovation more generally, and hence should not be targeting advanced-country levels of R&D. Nonetheless, they may benefit from international scientific training, international collaborative projects, and links among universities that can transfer knowledge to domestic firms and universities.

FIGURE O.3 For Countries That Are Far from the Technological Frontier, the Returns to R&D Increase Until a Point Where the Lack of Complementary Factors Depresses Them

Source: Goñi and Maloney 2017.

Note: The figure uses quinquennials of cross-country data from 1960 to 2010 to estimate the rate of return to research and development (R&D) across the development process: 0.0 on the x axis is the frontier, and moving left represents progressively more distance from the frontier.
FIGURE O.4  The Expanded National Innovation System (NIS)

Government oversight, resolution of market and systemic failures, and coordination

SUPPLY

- Universities/think tanks/Technology extension centers
  - Human capital
  - Support to firm capability upgrading
    - productivity/quality extension services
    - dissemination of process/best practice
    - advanced consulting services
  - Domestic science and technology System
  - International linkages, such as scientific Training, collaborative projects, and University exchanges

ACCUMULATION/ALLOCATION

- Physical capital
- Human capital
- Knowledge

DEMAND

- Firm capabilities
  - Incentives to accumulate
    - macr oeconomic context
    - competitive structure
    - trade regime and international networks
  - Firm capabilities
    - core competencies (management)
    - production systems
    - technological absorption

- Barriers to all accumulation
  - Credit
  - Entry/exit barriers
  - Business/regulatory climate
  - Rule of law

- Barriers to knowledge accumulation
  - Rigidities (labor, etc.)
  - seed/venture capital
  - Innovation externalities

Wider factors that may also need attention
Factors usually focused upon in NIS

In order to innovate, firms need to acquire a range of capabilities, without which they cannot manage innovation projects effectively, as an extensive literature in the NIS tradition points out. The acquisition of these capabilities—specifically, managerial and organizational practices—is fundamental to the process of upgrading both productivity and quality (see Teece and Pisano 1994—and, more in the mainstream, Sutton 2012, Sutton and Trefler 2016, and Hallak 2006, among others). Accounts of the East Asian “miracles” place primary emphasis on the accelerated process of learning and raising the capabilities for innovation of firms, rather than on the particular sectors they were in (see Kim 1997; Hobday 2000; Dodgson 2000; Lee 2013).

The recent introduction of the World Management Survey (WMS), initiated by Bloom and Van Reenen (2007, 2010), has permitted a quantum leap in the comparative quantitative analysis of management practices and their implications for productivity and innovation. Firms in developing countries are indeed lagging in a wide range of skills/abilities that are critical to the Schumpeterian catch-up process (figure O.5). Average scores in monitoring, employment of just-in-time processes, internal feedback mechanisms, long-run planning and goal stretching, and human resource policies in low- and middle-income countries are well below those of advanced economies. Firms that lack the capabilities required to respond to market conditions, identify new technological opportunities, develop a plan to exploit them, and then cultivate the necessary human resources will find it difficult to innovate and respond to government incentives to do so.

This report offers a novel empirical analysis that confirms the importance of advanced managerial and organizational practices for innovation, both directly and by facilitating investments related to innovation. Even after controlling for the usual innovation inputs such as R&D, managerial and organizational practices are important predictors of innovation and productivity across countries, firm size, and country income levels. Not only do they help explain the lower returns to R&D found in lower-income countries, but they also facilitate R&D and enhance its effectiveness. In sum, accumulating these managerial capabilities is of paramount importance for innovation policy, especially in countries and firms that are distant from the technological frontier.

What Drives Managerial Capabilities?

These findings beg the question of why managerial capabilities are so weak in developing countries. Figure O.6 shows that for four developing countries representative of
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their respective regions (East Asia, Latin America, South Asia, and Eastern Europe) their firms’ scores are lower than scores for firms in the frontier country (the United States) across the entire distribution. This implies that moving the average toward the frontier requires not only the exit of badly run firms, but also upgrading the managerial capabilities of the best firms.

Several factors have been identified as affecting managerial quality (Bloom and Van Reenen 2007, 2010; Maloney and Sarrias 2017). More educated managers tend to be better managers. Limits on product market competition enable inefficient firms to survive by failing to provide adequate incentives for firms to upgrade. Firms with diffuse ownership tend to be among the best, whereas government-owned companies and family-owned firms are weaker. The ubiquity of family-owned firms in developing countries is partly due to a weak rule of law, which triggers mistrust in delegating management to professional managers. Openness to trade provides incentives to upgrade and presents exposure to new ideas. Imports can increase access to technology and its embedded know-how, and exporting enables firms to learn about more sophisticated and contested markets. Similarly, exposure to better-managed multinational enterprises (MNEs) and participation in global value chains (GVCs) offer important opportunity for knowledge spillovers, although weak firm capabilities often impede participation in GVCs and learning.
The need for innovation policy in developing countries to address deficiencies or failures in a larger range of complementary factors and institutions that are required to promote innovation gives rise to the innovation policy dilemma. As the complexity of innovation policy increases with distance from the frontier, government capabilities to design, implement, and coordinate the appropriate combination and policy instruments—the policy mix—weakens. These limitations/constraints on government capabilities offer another key to resolving the innovation paradox.

Governments themselves must develop their own capabilities for innovation policy making across four pivotal dimensions:

1. **Policy design** demands the ability to identify market failures, design the appropriate policies to redress them, and establish clear metrics for success. Many failed experiments in developing countries result from naively importing institutional models and best practices from advanced economies.
that may not address the true failures or be politically viable. Many agencies, such as public research institutions, lack a clearly defined mission and incentives that would align them with identified clients and goals and shield them from capture.

2. **Efficacy of implementation** rests on strong public management practices, as well as processes for evaluating, adapting, and modifying or terminating policies when needed.

3. **Coherence of policy** across the NIS requires the ability to have an overview of the overall system and effectively coordinate across ministries and agencies. In developing countries, policy is often balkanized by ministry or administrative level, and there is little alignment between the stated goals of policies and actual budgets and impact.

4. **Policy consistency and predictability** require systems that cultivate innovation policies and institutions over time, overcoming fluctuations in the political economy and guaranteeing a predictable environment for long-term investments in innovation. Instead, there is often only partial high-level political commitment, and policy is subject to weak backing and frequent reversals.

None of these capabilities is easy to generate or maintain.

**Supporting the “Capabilities Escalator”**

The final step in addressing the innovation policy dilemma requires choosing the appropriate *policy mix* in the context of scarce government capabilities. The report offers a heuristic framework, the “capabilities escalator” (see figure O.7). Policies to support firm upgrading are sequenced in keeping with the level of capabilities of the private sector, policy makers, and institutions, and ratchet up through progressively higher stages of sophistication:

1. Stage 1 primarily supports production and management capabilities in incipient NISs.
2. Stage 2 increases the focus on supporting technology adoption and imitation capabilities in maturing NISs.
3. Stage 3 expands the support to invention and technology-generation capabilities in more mature NISs.

Given the wide variation in the innovation potential of firms found at all development stages, the framework is not meant to be deterministic. For example, many
advanced countries—such as Italy, Japan, Singapore, and the United States—have invested and continue to invest heavily and profitably in the first stage of the escalator. Rather, the capabilities escalator provides guidance on where to prioritize and allocate existing public resources. Evidence from India, Italy, and the United States, among others, suggests that programs supporting managerial upgrading can yield high returns and increase tax revenue by multiples of the cost of the program. For instance, textile firms in India that received consulting services almost doubled the share of management practices they adopt and enjoyed a rise in productivity of more than 10 percent after one year (Bloom et al. 2003) (see figure O.8).

Figure O.9 depicts the three stages of the capabilities escalator and presents the implications for the policy mix. The important message of the figure is that the policy mix is cumulative. As firms move up the capabilities escalator, the policy mix also advances from less sophisticated instruments to more sophisticated ones.

The first stage starts by building basic managerial and organizational capabilities through management extension. It provides incentives for collaboration among firms, such as through vouchers for innovation. It also focuses on developing key complementary factors, such as science, technology, engineering, and mathematics (STEM) skills and early-stage infrastructure. More important, it makes sure that there is an enabling environment for firms to invest in innovation.

The second stage focuses on strengthening technological capabilities via technological extension or technology centers. It provides direct and indirect support to R&D projects, while continuing to strengthen existing complementary factors and
FIGURE 0.8  Management Extension Improved Management Practices in India

![Graph showing management extension improved management practices in India.](image)

**Source:** Bloom et al. 2013.

FIGURE 0.9  The Capabilities Escalator: The Policy Mix Evolves from Less to More Sophistication

![Diagram illustrating the capabilities escalator showing policy mix evolution.](image)

**Note:** NQI = national quality infrastructure; R&D = research and development; STEM = science, technology, engineering, and mathematics.
infrastructure for innovation. It is important to highlight that the institutions appropriate to this stage take decades to build. Although capability building remains the priority, laying the groundwork for an advanced science and technology capability must also begin at this stage.

The final stage facilitates advanced technological development capabilities and invention, while supporting the strengthening of basic innovation capabilities in laggard firms. Establishing stage 3 capabilities is a long-term process, so it must be started at the same time as efforts in the earlier stages. Nonetheless, it cannot be considered a substitute for the policies to support stage 1 capabilities—firms need to walk before they can run.

Table O.1 presents some illustrative combinations of instruments that could be used at each stage.

**TABLE 0.1 The Policy Mix at Different Stages of the National Innovation System**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Illustrative policy mix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage 1: Incipient NIS</strong>&lt;br&gt;Prevalent in low- and lower-middle-income countries&lt;br&gt;• Build managerial and organizational practices</td>
<td>Focus on employing instruments that improve absorptive capacity and strengthen management and production capabilities:&lt;br&gt;• Support management extension programs&lt;br&gt;• Provide early-stage infrastructure and advisory services (incubators)&lt;br&gt;• Foster collaboration and simple innovation projects through, for example, vouchers and direct grants (accompanied by advisory services)&lt;br&gt;• Establish standards and basic national quality infrastructure&lt;br&gt;• Strengthen research quality</td>
</tr>
<tr>
<td><strong>Stage 2: Maturing NIS</strong>&lt;br&gt;Prevalent in middle- and upper-middle-income countries&lt;br&gt;• Focus on building innovation capacities and accelerating technology transfer</td>
<td>Continue to build absorptive capacity.&lt;br&gt;Support technology extension projects.&lt;br&gt;Start university-industry collaboration in some clusters.&lt;br&gt;Focus on research quality and STEM.&lt;br&gt;• Technology extension and business advisory programs&lt;br&gt;• Development of local supply chains and export programs&lt;br&gt;• Grants for innovative projects to finance prototyping, testing, and commercialization activities&lt;br&gt;• Early-stage infrastructure and advisory programs (incubators), and some accelerators&lt;br&gt;• Innovation vouchers and grants</td>
</tr>
<tr>
<td><strong>Stage 3: Mature NIS</strong>&lt;br&gt;Prevalent in higher-income countries&lt;br&gt;• Concentrate on generating technology and supporting capabilities.&lt;br&gt;• Focus on bringing along laggard firms.</td>
<td>Combine instruments to support frontier technology generation and projects that are highly R&amp;D intensive with a variety of instruments to help SMEs ignite innovation:&lt;br&gt;• Tax incentives for R&amp;D&lt;br&gt;• Grants to large, complex, long-term, and collaborative R&amp;D projects&lt;br&gt;• Procurement for innovation&lt;br&gt;• Equity finance and early-stage capital&lt;br&gt;• Loan guarantees accompanied by firm-level capacity building and advisory programs&lt;br&gt;• Technology extension and business advisory services&lt;br&gt;• Systemic policies for innovation</td>
</tr>
</tbody>
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Note: NIS = national innovation system; STEM = science, technology, engineering, and mathematics.
Rethinking Innovation Policies

This report explains why the low levels of innovation observed in developing countries are not due to some irrationality on the part of firms and governments. Nor is the solution simply providing more training or extension or promoting R&D to remedy well-known knowledge-related market failures. Rather, policy makers in the developing world face barriers that are orders of magnitude more challenging than those found in the advanced world. Thus, fostering innovation requires a rethinking of innovation policies along three key dimensions.

First, the importance of a wide range of innovation complementarities implies that the scope of the NIS that policy makers must pursue is much larger than in advanced countries. It must include everything that affects the accumulation of all types of capital—physical, human, and knowledge—and their supporting markets. What looks like an innovation problem, such as a low rate of investment in R&D, may actually reflect barriers to accumulating other factors, including physical and human capital.

Second, the cultivation of firm managerial and technological capabilities is critical to encouraging a continual process of technological adaptation and quality upgrading. This implies a rebalancing of policy priorities toward management and technology extension instruments and away from a focus mostly or exclusively on promoting R&D. Although R&D is an important input for innovation, it requires a set of capabilities that are unlikely to be met by many developing countries. Its promotion cannot be at the expense of the other, and more fundamental, investments on the capabilities escalator.

Finally, while the complexity and problems of constructing a functional NIS and building private sector capability are greater in developing countries, government capabilities to manage them are weaker. Innovation policy thus needs an honest balancing of capabilities with tasks. This requires working on a selective set of issues rather than trying to import a full set of institutions and policies from elsewhere.

Better data and better analytical frameworks are necessary as developing countries face the dramatic and unpredictable evolution of the world economy. The rate of technological change is accelerating. We cannot know with assurance which sectors or industries will offer rapid routes to prosperity, or what technologies will drive them. However, Pasteur’s counsel that “fortune favors the prepared mind” remains as vitally relevant for countries as for people. Policy makers need to ensure that they, and their countries, are ready.

Overall, the issue of capabilities in innovation policy making and how to improve them is one of the most pressing yet unacknowledged aspects of innovation policy in developing countries.
Raising the capabilities of firms to manage uncertainty, ensuring that the innovation system provides necessary complementary inputs and flows of knowledge, and strengthening government capabilities to manage a large and expanding set of challenges are all keys to resolving the innovation paradox and preparing countries for the opportunities ahead.

References


Since Schumpeter, economists have argued that vast productivity gains can be achieved by investing in innovation and technological catch-up. Yet, as this volume documents, developing-country firms and governments invest little to realize this potential, which dwarfs international aid flows. Using new data and original analytics, the authors uncover the key to this innovation paradox in the lack of complementary physical and human capital factors, particularly firm managerial capabilities, that are needed to reap the returns to innovation investments. Hence, countries need to rebalance policy away from R&D-centered initiatives—which are likely to fail in the absence of sophisticated private sector partners—and toward building firm capabilities; and they need to embrace an expanded concept of the national innovation system that incorporates a broader range of market and systemic failures. The authors offer guidance on how to navigate the resulting innovation policy dilemma: as the need to redress these additional failures increases with distance from the frontier, government capabilities to formulate and implement the policy mix become weaker.

This book is the first volume of the World Bank Productivity Project, which seeks to bring frontier thinking on the measurement and determinants of productivity to global policy makers.

“Too often we see companies and countries paying huge costs trying to invent shiny new things and push out the technological frontier when, for a fraction of the price, they can harvest the low-hanging fruit of processes and products already found in frontier firms. This book highlights the critical importance of such untapped technological adoption for development and explores the reasons countries, counterintuitively, invest so little to effect it. In particular, it brings empirical discipline and economic rigor to the concept of learning to “walk before they run,” that is, the process of developing firm and country capabilities, and in particular, sophisticated management practices. If CEOs and governments followed this advice they could save themselves billions of dollars while rapidly accelerating growth.”

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