The Innovation Imperative for Developing East Asia

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WORLD BANK EAST ASIA AND PACIFIC
REGIONAL REPORT

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OVERVIEW

Overview

The Innovation Imperative for Developing East Asia

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World Bank East Asia and Pacific Regional Report

Overview

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Overview

Introduction

Countries in developing East Asia have undergone significant economic transformation, but the region now faces an array of challenges in sustaining growth

East Asia's economic success over the past 50 years has been transformative. High rates of growth have propelled countries in the region from low-income to middle-income, and even in a few cases, to high-income status. An approach that has become known as the "East Asian development model"—a combination of policies that fostered outward-oriented, labor-intensive sectors growth; investments in basic human capital; and sound economic governance—has been instrumental in moving hundreds of millions of people out of poverty and into economic security.

Despite their past successes, the region's middle-income countries now face an array of challenges as they strive to continue their economic progress: First, productivity growth has declined since the 2008–09 Global Financial Crisis. This, and rapid population aging in several countries, is putting pressure on the region's growth prospects, narrowing the opportunities for reaping demographic dividends. Second, the slowing of global goods trade, uncertainty about the future of the global trading system, and rapid changes in technology are all challenging a key engine of growth in the region: export-oriented manufacturing. Third, the COVID-19 pandemic, together with ongoing climate change, are increasing economic vulnerability and highlighting a pressing need for new modes of production in the region.

These forces, alone and together, raise questions about whether the model that has driven the region's economic success in the past can continue to deliver rapid growth and development in the future.

Innovation is increasingly important to future growth

Recent studies have highlighted the critical role that innovation must play in developing East Asia if the region's countries are to maintain or increase productivity growth in a rapidly changing and highly uncertain global economic environment (Mason and Shetty 2019; World Bank and DRC 2019). Reinforcing

the case for more innovation-led growth is a significant global literature showing strong links between innovation and productivity at the macro- and microeconomic levels (Cirera and Maloney 2017; Comin and Hobijn 2010; Griliches 1998; Hall 2011; Mohnen and Hall 2013; Solow 1957).

Against this background, this report seeks to deepen policy makers' understanding of the critical role for innovation in the future growth and development of developing East Asia.[1] To achieve this, the report examines the region's key innovation challenges, assesses its state of innovation, and analyzes the main constraints firms face in effectively pursuing innovation. The report then examines the policies and institutions needed to enable greater innovation and lays out an agenda for action aimed at spurring innovation-led growth in the region.

The report emphasizes the importance for the region of effectively using technologies that are already available in high-income economies as a means of raising productivity and addressing economic and societal challenges. For this reason, the report adopts a broad definition of innovation that encompasses *both* innovation as "invention" of new products and processes at the knowledge frontier *and* as "diffusion and adoption" of existing technologies and practices that enable firms to undertake new and more effective modes of production (box O.1).

BOX O.1 Defining innovation

The report adopts a broad view of innovation as the accumulation of knowledge and implementation of new ideas. Specifically, following the *Oslo Manual 2018*, a "business innovation" is defined as a "new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm" (OECD and Eurostat 2018, 20). The report considers innovation defined both as "invention" or "discovery" (that is, those developments that push the technological frontier) *and* as "diffusion" or "adoption" of existing technologies and practices that lead firms to novel ways of producing or acting. The latter definition is pertinent to most of the firms operating in developing East Asia.

An innovation may be either technological or nontechnological. Specifically, the *Oslo Manual 2018* defines the following two main types of innovations (OECD and Eurostat 2018, 21):

- A *product innovation* is "a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market." This includes the addition of either new functions or improvements to existing functions or user utility. "Relevant functional characteristics include quality, technical specifications, reliability, durability, economic efficiency during use, affordability, convenience, usability, and user friendliness" (OECD and Eurostat 2018, 71).
- A *business process innovation* is "a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm." The *Oslo Manual 2018* lists the six functional categories to identify and distinguish between types of business process innovations (OECD and Eurostat 2018, 73):
    - Innovative methods for manufacturing products or offering services
    - Innovations in distribution and logistics
    - Innovations in marketing and sales activities
    - Innovations in the provision and maintenance of information and communication systems
    - Innovations in administration and management
    - Innovations in product and business process development.

Source: Adapted from OECD and Eurostat 2018.

The innovation imperative for developing East Asia

Several economic forces are driving an imperative for a more innovation-led growth model in developing East Asia.

Productivity remains relatively low in developing East Asia—and productivity growth has declined since the Global Financial Crisis

Despite their remarkable growth performance, countries in developing East Asia still face important productivity challenges. Productivity—whether measured in terms of labor productivity (output per worker) or as total factor productivity (TFP, a measure of economic efficiency)—has been rising over time, although it remains well below the productivity frontier, defined as the productivity level in the United States. Even in Malaysia, whose productivity is the highest in developing East Asia, labor productivity was only about 42 percent, and TFP about 62 percent, of levels in the United States in 2017. Although productivity generally increases as countries develop, TFP in most developing East Asian countries is below what would be predicted on the basis of their gross domestic product (GDP) per capita (figure O.1).

Productivity growth has slowed worldwide since the Global Financial Crisis, and developing East Asia has not been immune. Indeed, the region has experienced the second steepest slowdown in labor productivity growth of all emerging market and developing regions since the Global Financial Crisis (World Bank 2020). While labor productivity growth has declined across the region, the decline has been particularly pronounced in China (figure O.2). A decomposition of labor productivity growth shows that the slowdown largely reflects weaker TFP growth.

Changes in global trade and technologies are challenging the region's main engine of growth: export-oriented manufacturing

The slowing of global goods trade and ambiguity about the future of the global trading system pose risks to a development model that has effectively used trade, foreign direct investment (FDI), and integration into global value chains (GVCs) as critical channels for growth. Furthermore, a new technological revolution—Industry 4.0—poses a risk of disrupting existing production structures as it moves toward more flexible manufacturing and customization and increases the importance of proximity to customers. These technological advances could potentially shorten GVCs or result in the reshoring of production systems that have been central in fueling growth in developing East Asian countries.

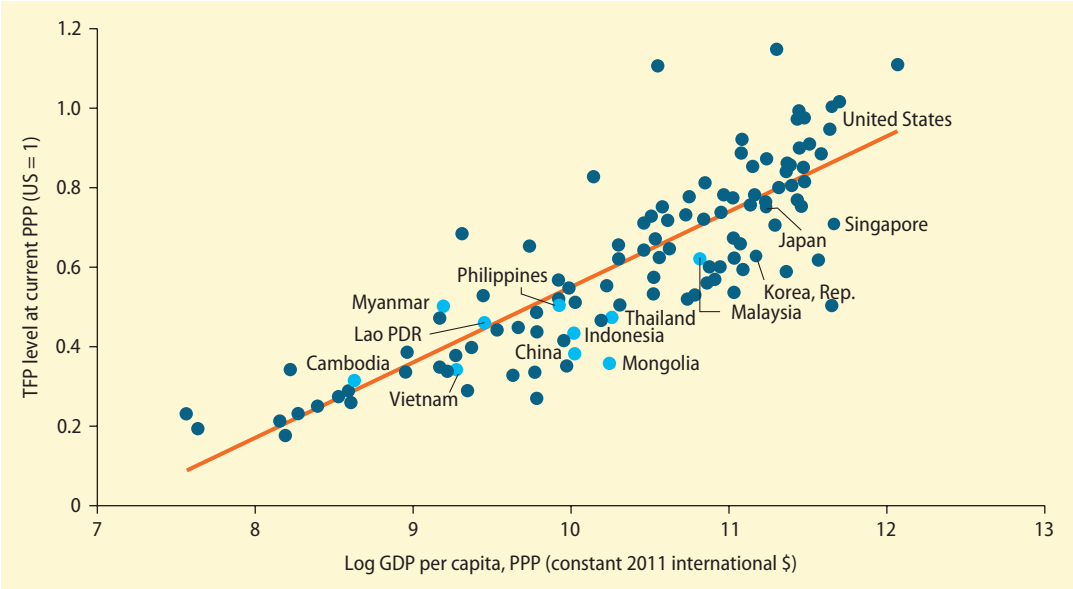
The COVID-19 pandemic and other shocks, including climate change, are accelerating the need for new modes of production

The COVID-19 pandemic

The COVID-19 pandemic has underscored the importance of innovation as policy makers and private firms have rushed to adopt or develop technologies to address both the health and the economic effects of the outbreak. This effort has included, among other things, the application of digital mobile technologies to provide real-time information about the spread of the virus and support social distancing; drone technologies for such applications as aerial disinfection, contactless transportation of medical supplies, and consumer deliveries; and advanced biomedical technologies and artificial intelligence (AI) to develop testing, vaccines, and treatments for the virus.[2]

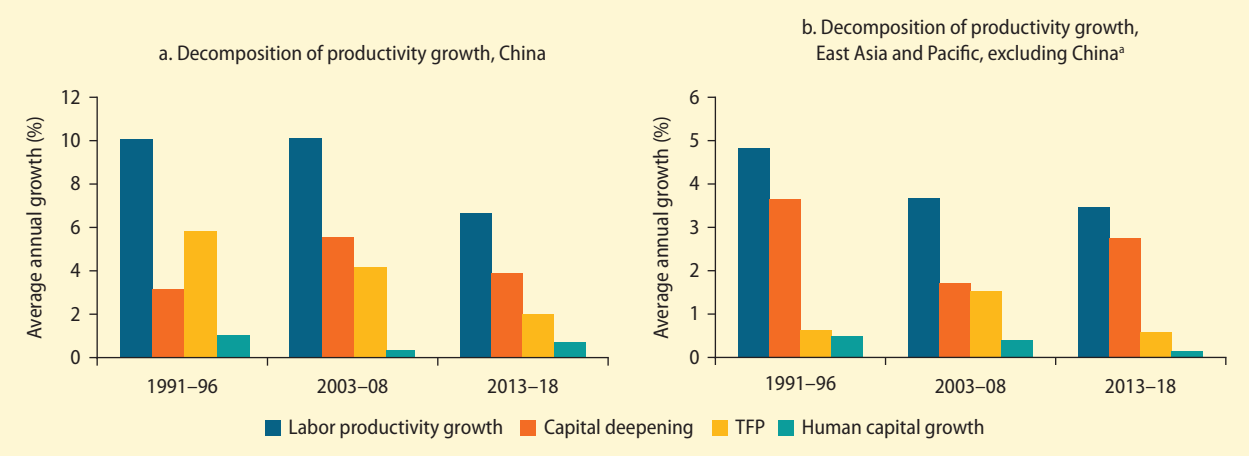
Importantly, the COVID-19 pandemic is a shock to GDP not seen for decades in the region—one that may have long-lasting

FIGURE O.1 Total factor productivity in most developing East Asian countries is below what would be predicted based on their GDP per capita



Source: World Bank elaboration, based on Penn World Table (PWT) version 9.1 and Asian Productivity Organization (APO) Database 2019, version 2 (https://www.apo-tokyo.org/wedo/productivity-measurement/).
Note: Data are from 2017. Countries in light blue designate the 10 "developing East Asia" countries studied in this report. Total factor productivity (TFP) is measured in purchasing power parity (PPP) terms relative to the United States (1.0). TFP series are calculated by the PWT team, except for Cambodia, Myanmar, and Vietnam, which are estimated through the methodology of Feenstra, Inklaar, and Timmer (2015), using data from PWT (version 9.1) and labor share estimates from the APO Database 2019 (version 2). GDP = gross domestic product; PPP = purchasing power parity; TFP = total factor productivity.

FIGURE O.2 Labor productivity and TFP growth have declined in developing East Asia since the Global Financial Crisis



Sources: Conference Board (CB), Asian Productivity Organization (APO) Database 2019, version 2 (https://www.apo-tokyo.org/wedo/productivity-measurement/); and Penn World Table (PWT) version 9.1 data; van der Eng (2009); World Development Indicators database; and World Bank calculations.
Note: Labor productivity is defined as GDP per worker. PWT data were used as the baseline. When PWT (version 9.1) data were not available, the APO Database 2019 (version 2) was used. Conference Board data were used for 2018. GDP = gross domestic product; TFP = total factor productivity.
a. Panel b shows weighted averages calculated using GDP weights at 2010 prices. Countries included are Cambodia, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam. For Indonesia, TFP growth was calculated by the World Bank, extending data from van der Eng (2009).

effects. So large a shock, affecting both demand and supply, has highlighted the need for more flexible management and production processes, both to accommodate restrictions due to social-distance measures and to prepare for what may be very different economies in the post–COVID-19 era. Production processes will be more automated, digitally integrated, and connected to consumers.

One challenge for policy makers, however, is that the pandemic may have conflicting effects on each of the two dimensions of innovation: invention and diffusion. Regarding *invention*, the pandemic is boosting research and development (R&D) on tests, vaccines, and treatment to combat the disease. This is likely to have positive spillovers for broader scientific and medical research in areas such as biotechnology. At the same time, the social distancing needed to contain the disease has impeded scientific research *not* related to COVID-19, by shutting down laboratories and durably disrupting experiments.

As for *diffusion*, adapting to social distancing has boosted firms' and households' demand for technologies supporting digital communication, conveyance, and commerce that will likely be used well beyond the pandemic. However, the crisis-induced economic contraction and uncertainty are inhibiting investments in both invention and diffusion in a variety of other areas by cutting resources and dampening expected returns. Policy makers will thus need to find ways to accelerate the technological transformation of their economies while managing these tensions.

Climate change

Similarly, climate change is challenging traditional approaches to production and growth. Regarding mitigation, it is imperative to have cleaner, more energy-efficient production that reduces carbon emissions. As for adaptation, temperatures will increase significantly in developing East Asia. Warming is already causing severe weather events more frequently: heat waves, droughts, flooding, wildfires, and hurricanes. East and Southeast Asian countries are among those likely to be the hardest hit as the climate warms.

According to the Global Climate Risk Index 2020, four Southeast Asian countries—Myanmar, the Philippines, Thailand, and Vietnam—were among the 10 countries most affected by extreme weather events between 1999 and 2018 (Eckstein et al. 2019). Moreover, the continued reliance of Southeast Asian countries on agriculture and the concentration of populations in coastal regions exacerbate their vulnerability. Many major coastal cities are seriously imperiled, including Shanghai and Tianjin, China; Jakarta, Indonesia; Ho Chi Minh City, Vietnam; and Bangkok, Thailand. These changes demand urgent technological solutions, whether to ensure that agricultural production is sustainable or to enable safe and productive factory environments at higher temperatures.

To sustain high economic performance in the face of these challenges, the region's countries must move toward a more innovation-led growth model

To address all these challenges will demand that societies become more innovative. Countries in developing East Asia must find new and more effective ways to increase productivity growth as they seek to build on past economic success and move progressively from middle- to high-income status. Indeed, their high-income neighbors—Japan, the Republic of Korea, and Singapore—have all used innovation as a vehicle to improve efficiency and boost their incomes with great success.

The narrowing of productivity and technological gaps with high-income economies could help developing East Asian countries to address trade challenges, including threats of reshoring, by increasing their competitiveness and upgrading their participation in GVCs. Similarly, an effective response to the COVID-19 pandemic and the risk of other health shocks requires strong research and innovation fundamentals to address and monitor health impacts, as well as more innovative, automated, and digitally integrated business models. Finally, the risks and costs of climate change for the region's economies and societies demand more innovation and adoption of new technologies for both adaptation and mitigation.

The state of innovation in developing East Asia

Interest in innovation among the region's policy makers has peaked recently with the rise of digital technologies. Indeed, high-profile accomplishments by private sector actors—in e-commerce, digital financial technology (fintech), ridesharing, and mobile app-enabled service delivery—have captured the imaginations of policy makers, the media, and citizens alike. Enterprises in the digital space, like the Chinese multinational technology company Alibaba and the ride-hailing services Grab and Go-Jek in Southeast Asia, have become household names.

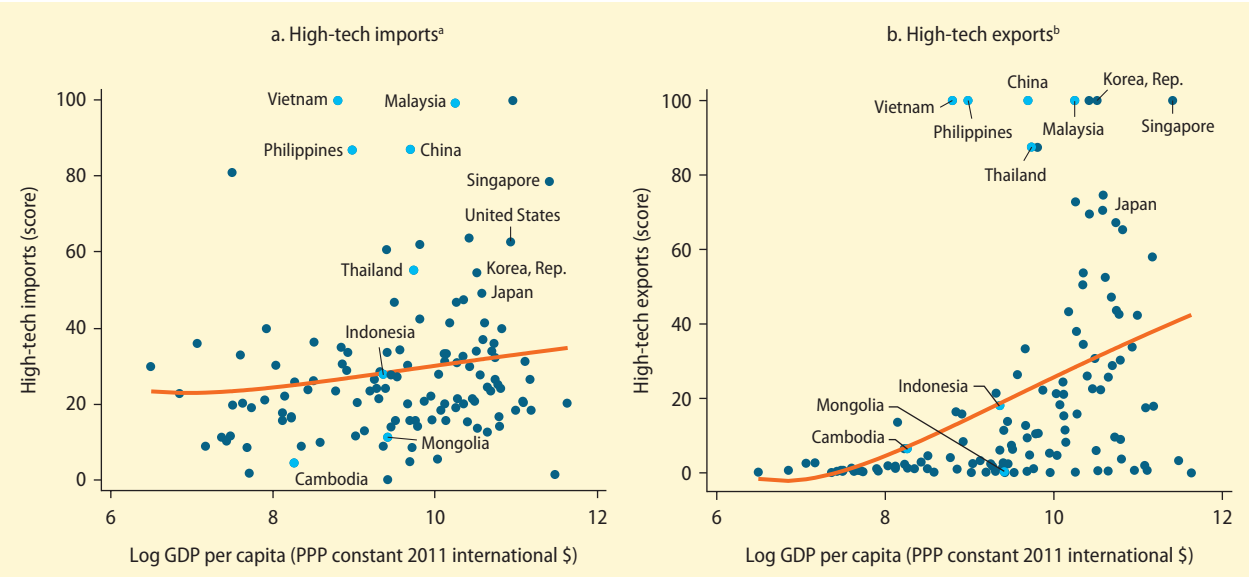
Although the achievements of high-performing "unicorns" are important and noteworthy, realizing the economic promise of innovation will require a broad swath of firms across different sectors of the region's economies to engage in innovation activities. But just how well are developing East Asian countries performing overall on innovation?

The region has experienced some important innovation-related successes

Data suggest that developing East Asia has registered some important successes with respect to innovation. Recent data on the spatial density of patents filed under the Patent Cooperation Treaty (PCT) of the World Intellectual Property Organization (WIPO) indicate a growing number of innovation clusters in the region, most notably in China (Bergquist, Fink, and Raffo 2017; Dutta, Lanvin, and Wunsch-Vincent 2019).

Looking more broadly across the region, data indicate that the region's export-oriented growth model has enabled most countries to participate in more sophisticated forms of manufacturing trade over time. Cross-country data show, for example, that most developing East Asian countries perform at or above what would be predicted from their per capita income levels with respect to both high-tech *imports* (figure O.3, panel a) and high-tech *exports* (figure O.3, panel b).

FIGURE O.3 Several developing East Asian countries are significant participants in the global value chains for high-tech products



Source: World Bank elaboration, using the Global Innovation Index database (https://www.globalinnovationindex.org/analysis-indicator).
Note: High-tech export and import indicators include technical products with high research and development (R&D) intensity, as defined and classified by Eurostat, the statistical office of the European Union. "Developing East Asia" refers to the 10 middle-income countries covered in this study (designated in light blue): Cambodia, China, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam. The figure excludes Lao PDR and Myanmar, for which no recent data exist. GDP = gross domestic product; PPP = purchasing power parity.
a. The high-tech imports indicator measures high-tech imports as a percentage of total trade.
b. The high-tech exports indicator is defined by high-tech exports minus re-exports as a percentage of total trade.

Although much of the region's participation in this trade began with less-sophisticated components and assembly, these measures reflect the increased adoption of global technologies and production processes over time through FDI, creation of joint ventures, and participation in trade and GVCs. For example, between 2000 and 2008, the share of the domestic content of exports in electronics grew significantly in Malaysia and Thailand, as well as in industrial machinery in Indonesia and the Philippines (WTO and IDE-JETRO 2011), probably as a result of FDI to produce locally and the participation of local suppliers. Central to the region's outward-oriented manufacturing and growth strategy, these forms of international engagement have represented important opportunities for technology transfer and knowledge diffusion over the past half century.

Most countries in the region perform below predicted levels on several key indicators of innovation, however

Despite the great promise of innovation in the region—and some high-profile successes—analysis of a range of key innovation indicators suggests that countries in developing East Asia still face important challenges to fostering innovation-led growth. Most of these countries appear to underperform on several standard indicators of innovation for both *diffusion* (the adoption of existing technologies) and *discovery* (the invention of new products, processes, and technologies).

One critical input for more-basic forms of innovation, such as improving the quality of products and processes, is international certification, which gives firms access to other countries' markets. International certification has been found to contribute to firm-level productivity in several middle-income countries, including China and four Southeast Asian countries (Cirera and Maloney 2017; Escribano and Guasch 2005). However, all countries in developing East Asia except China perform below their predicted values with respect to international certification (figure O.4, panel a).

Licensing of foreign technologies—another important input for the diffusion and adoption of new technologies—is associated with higher innovation output among firms in developing East Asian countries (Iootty 2019). The region's performance regarding foreign technology licensing is more mixed: in half of the countries, a smaller share of firms obtain licenses to foreign technologies than would be expected given their countries' per capita incomes (figure O.4, panel b).

Data on the main input of *discovery* of new products and technologies, research and development (R&D), and one key proxy of *invention*, patents, show similar patterns. Most countries in the region spend less on R&D than would be expected given their per capita incomes (figure O.5, panel a). Only three countries (China, Malaysia, and Vietnam) spend at or above expected levels.

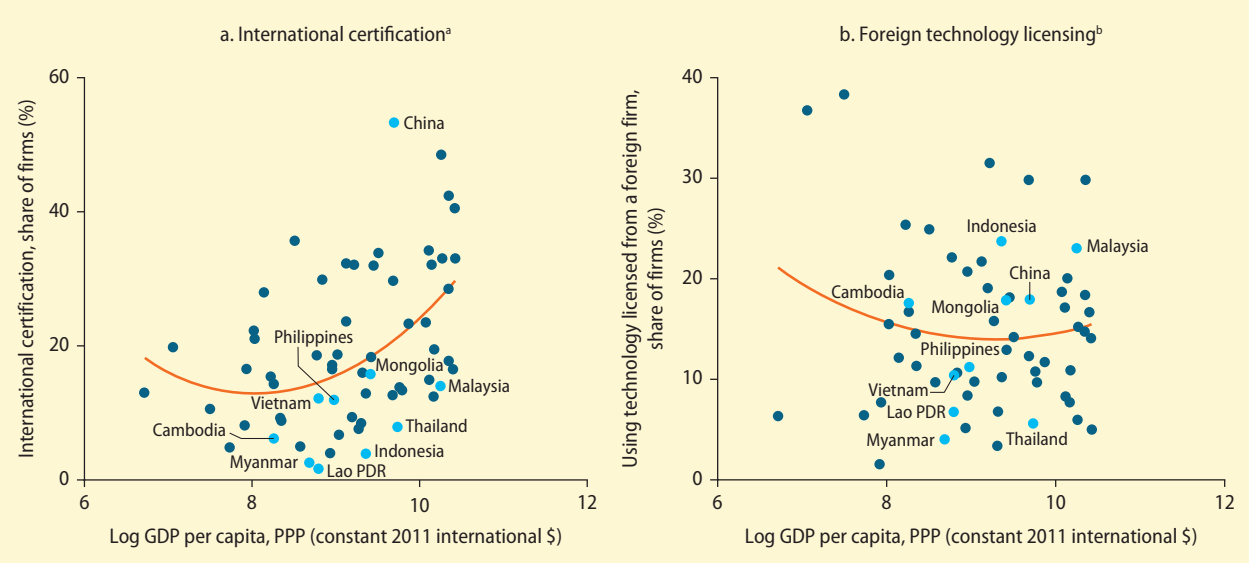
Similarly, most developing East Asian countries produce fewer patents than would be expected given their per capita incomes (figure O.5, panel b). Again, Malaysia, Vietnam, and in this case, Mongolia, perform at or near the predicted levels. China is noteworthy in that it performs significantly above expectations regarding both R&D spending and patents granted.

Similar patterns are seen with respect to the region's other innovation inputs and outputs, including several key areas related to innovation in services (despite some high-profile successes).

Developing East Asia is converging in adoption lags but diverging in intensity of technology use

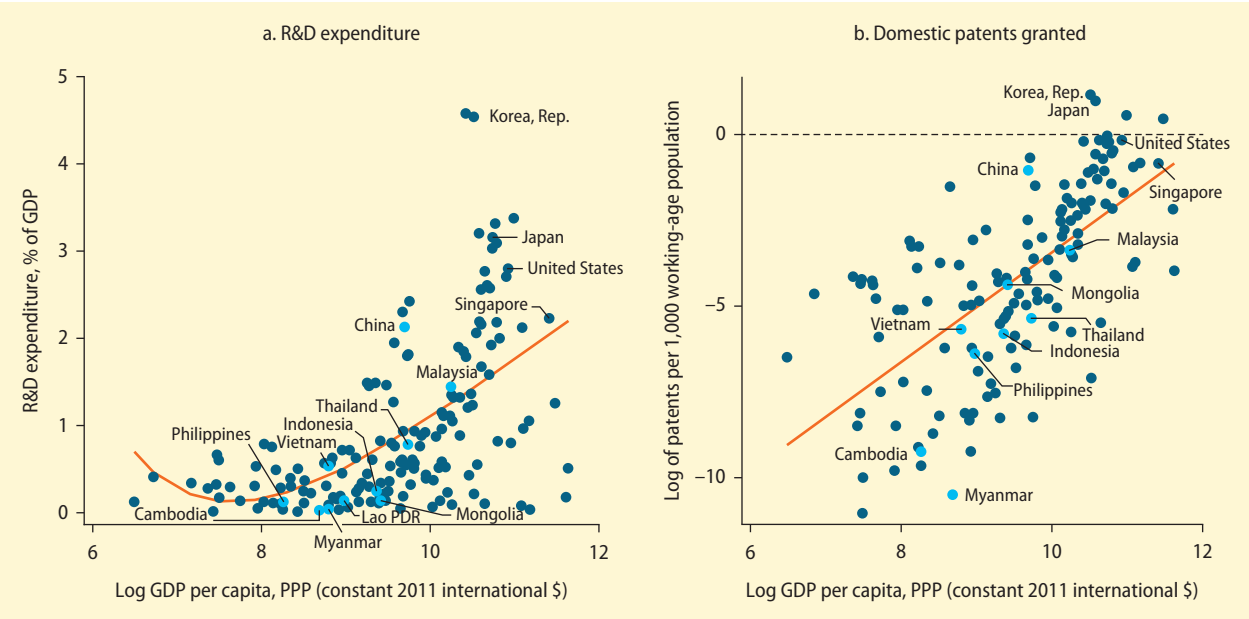
Despite countries' increasing participation in high-tech value chains, new technologies do not appear to be penetrating as deeply in developing East Asia's economies as they could. Analysis of the Cross-Country Historical Adoption of Technology (CHAT) dataset on adoption and use of primarily general purpose technologies (Comin and Mestieri 2018) indicates, on the one hand, that technology

FIGURE O.4 The share of firms with international certification is low in much of developing East Asia, and in half of the countries, fewer firms acquire licenses to foreign technology than expected given their countries' per capita incomes



Source: World Bank elaboration, using World Bank Enterprise Survey data (most recent available years).
Note: "Developing East Asia" refers to the 10 middle-income countries covered in this study (designated in light blue): Cambodia, China, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam. GDP = gross domestic product; PPP = purchasing power parity.
a. International certification provides independent assurance that products or services comply with certain mutually recognized standards.
b. Foreign technology licensing includes purchase or licensing of both patented and nonpatented technologies by firms as part of their production or organizational processes.

FIGURE O.5 Most countries in developing East Asia spend less on R&D and produce fewer patents than would be predicted by their per capita incomes



Sources: World Bank elaboration, based on 2018 data from the World Intellectual Property Organization (WIPO) Statistics Database (https://www3.wipo.int/ipstats/index.htm) and the World Development Indicators database.
Note: "Developing East Asia" refers to the 10 middle-income countries covered in this study (designated in light blue): Cambodia, China, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam. GDP = gross domestic product; PPP = purchasing power parity; R&D = research and development. Panel b of the figure excludes Lao PDR, for which no 2019 patent data exist.

adoption lags between developing East Asia and Organisation for Economic Co-operation and Development (OECD) countries—that is, the time between introduction of a new technology and when it is first adopted—has narrowed over time (figure O.6, panel a). On the other hand, however, differences between the region and the OECD in the "intensity of use" of new technologies—that is, how widely new technologies have been used—have increased over time (figure O.6, panel b).

Heterogeneity of innovation capabilities within countries, sectors, and firms

The aggregate performance figures presented above mask significant heterogeneity. What matters most for a country's growth and productivity performance is how rapidly technology and innovation diffuse across enterprises within a country. Without positive spillovers from sectors that perform well relative to the rest of the economy, the contribution of innovation to overall growth is limited. Within sectors, the productivity and technological divide between the leading and lagging firms in developing East Asia reflects the slow diffusion of technology. Indeed, the region shows substantial heterogeneity in the pattern of technology adoption and innovation across and within countries, sectors, and in some cases, even within firms. This heterogeneity, if persistent over time, will significantly constrain growth in the region.

Countries across the region show significant differences in innovation performance

Firm-level measures of innovation, based on World Bank Enterprise Survey data, reveal significant heterogeneity in performance across the region's countries. Firms in Indonesia, the Lao People's Democratic Republic, Myanmar, and Thailand report little innovation activity; well under half of all firms in those countries indicate that they engage in any form of innovation-related activity (figure O.7). The data also show China as a positive outlier in the region. Close to 60 percent of Chinese firms report having a product or service innovation, and 20 percent license foreign technology. At the other end of the spectrum, less than 15 percent of firms in Myanmar and Thailand report having a product or service innovation, and a mere 5 percent have any technology licensed from foreign companies.

Innovation activity also varies widely across sectors, with less innovation in services

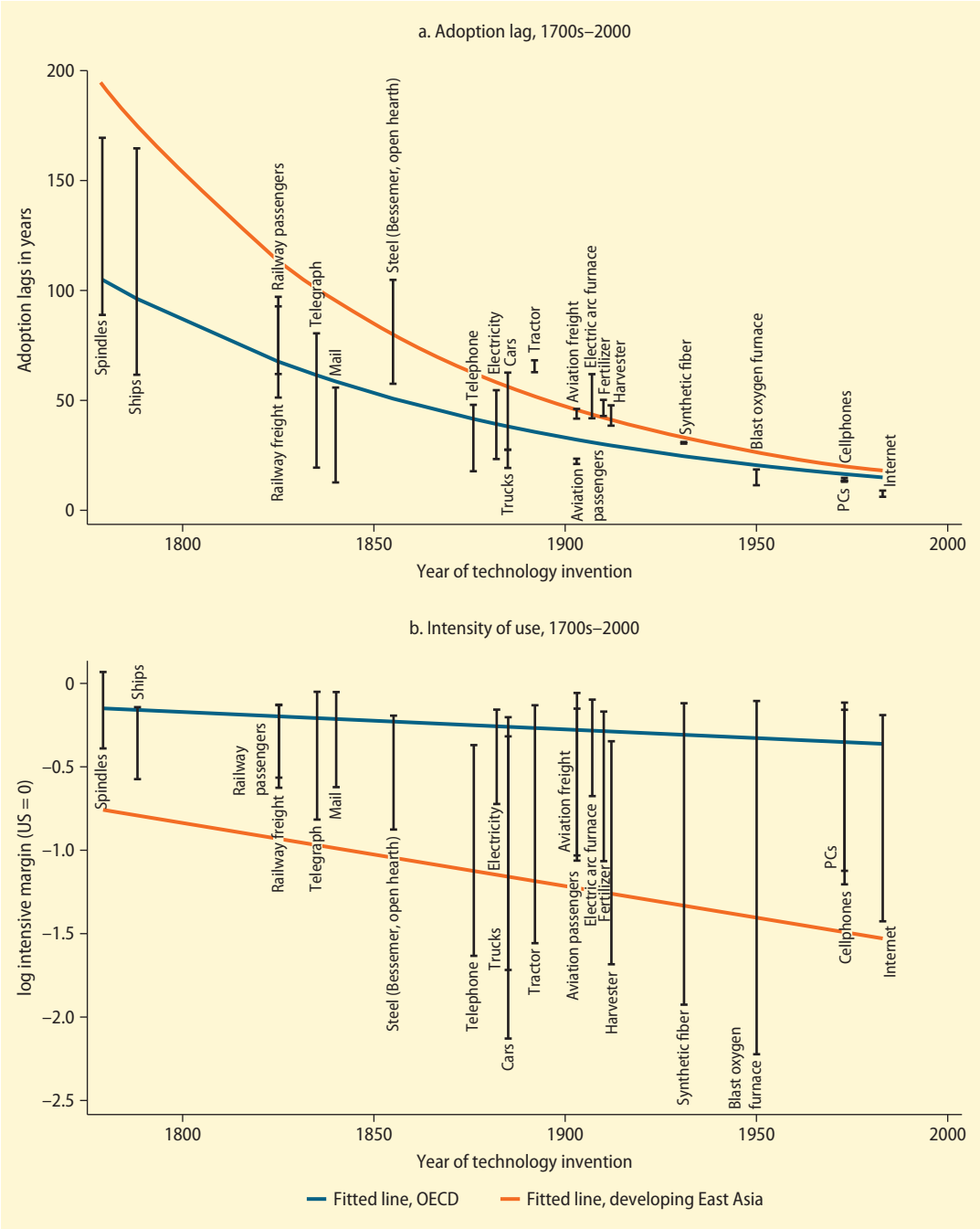
Although the most salient innovations portrayed in the region's popular press are examples from services sector companies (for example, Grab, Go-Jek, Alibaba, or Tencent), data from statistical sample surveys tell a different story. Measured as having implemented a product or process innovation, services sector firms in developing East Asia (and elsewhere) appear to be significantly less innovative than manufacturing firms (figure O.8). Innovation in services is key to enabling new business models and services required in the transition to Industry 4.0, but the region is lagging behind.

Most firms remain far from the technological frontier; even within firms, they vary in their use of technology across business functions

Micro evidence from the Firm-level Adoption of Technology (FAT) survey in Vietnam shows that most firms remain far from the frontier in their adoption and use of new technologies. Figure O.9 shows the most frequently used technology for different business functions, by sector, with the most sophisticated technology on top and the least sophisticated on the bottom, as follows:

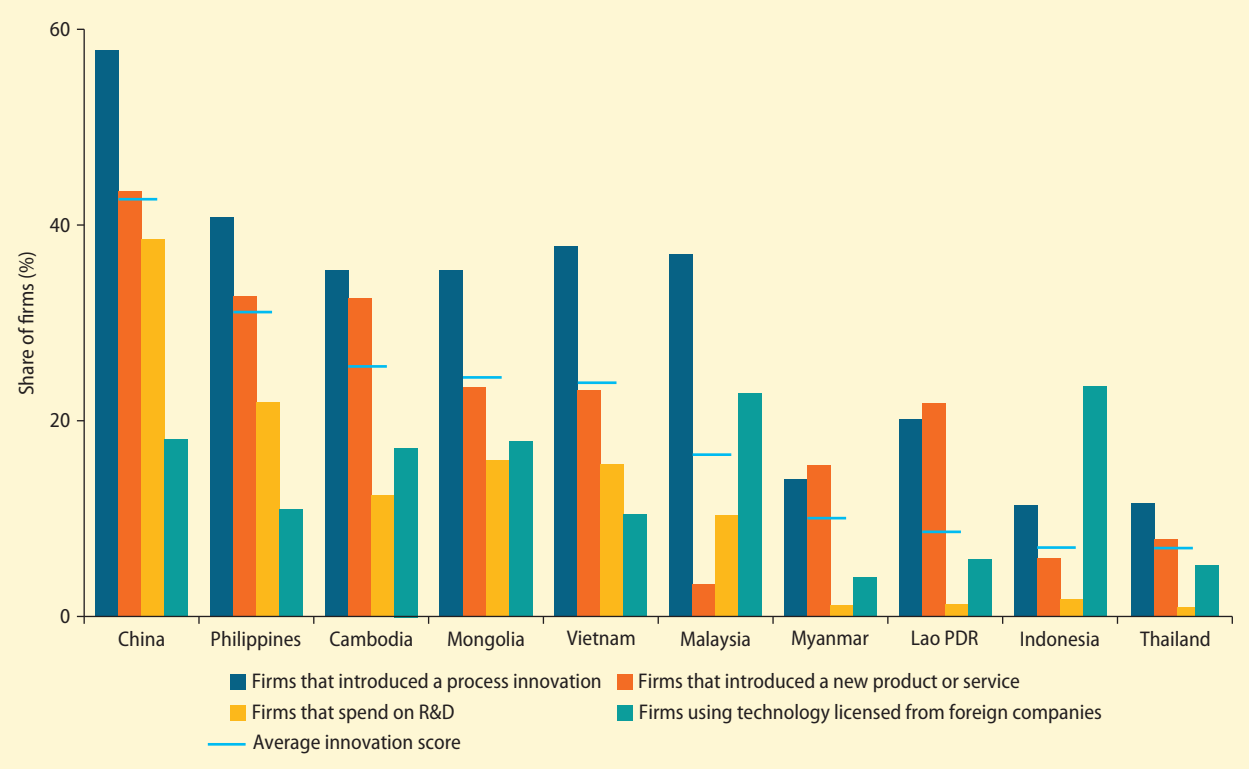
- *In manufacturing*, for fabrication, most Vietnamese firms (70 percent) use operator-controlled machines, only 9 percent use computer-controlled

FIGURE O.6 Technology adoption lags in developing East Asia are converging with those of OECD countries, but the intensity of technology use is diverging



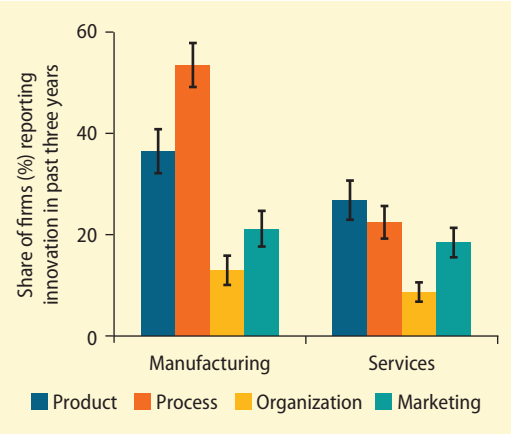
Source: World Bank, using country technology-level estimates from Comin and Mestieri 2018.
Note: Adoption lag (the number of years for a technology to arrive to a country after invention) and the intensive margin, or usage intensity (how widely new technologies are adopted), are both country-specific model parameters estimated structurally using the Cross-Country Historical Adoption of Technology (CHAT) database developed by Comin and Hobijn (2004). The blue and orange lines are fitted, respectively, to Organisation for Economic Co-operation and Development (OECD) and developing East Asian countries (the sample here including Cambodia, China, Indonesia, Malaysia, Mongolia, the Philippines, Thailand, and Vietnam). The bars show the median adoption lags (panel a) or intensive margins (panel b) of the two country groups for each labeled technology. PCs = personal computers.

FIGURE O.7 Developing East Asian countries vary widely in firm-level innovation activity



Source: World Bank calculations using latest World Bank Enterprise Survey data.
Note: The innovation score captures both innovation outputs and inputs. It is calculated as the average of the likelihood that firms have a product innovation, a process innovation, positive research and development (R&D) spending, or license technology from foreign companies.

FIGURE O.8 Manufacturing and services firms differ in rates of innovation, especially of new products or processes



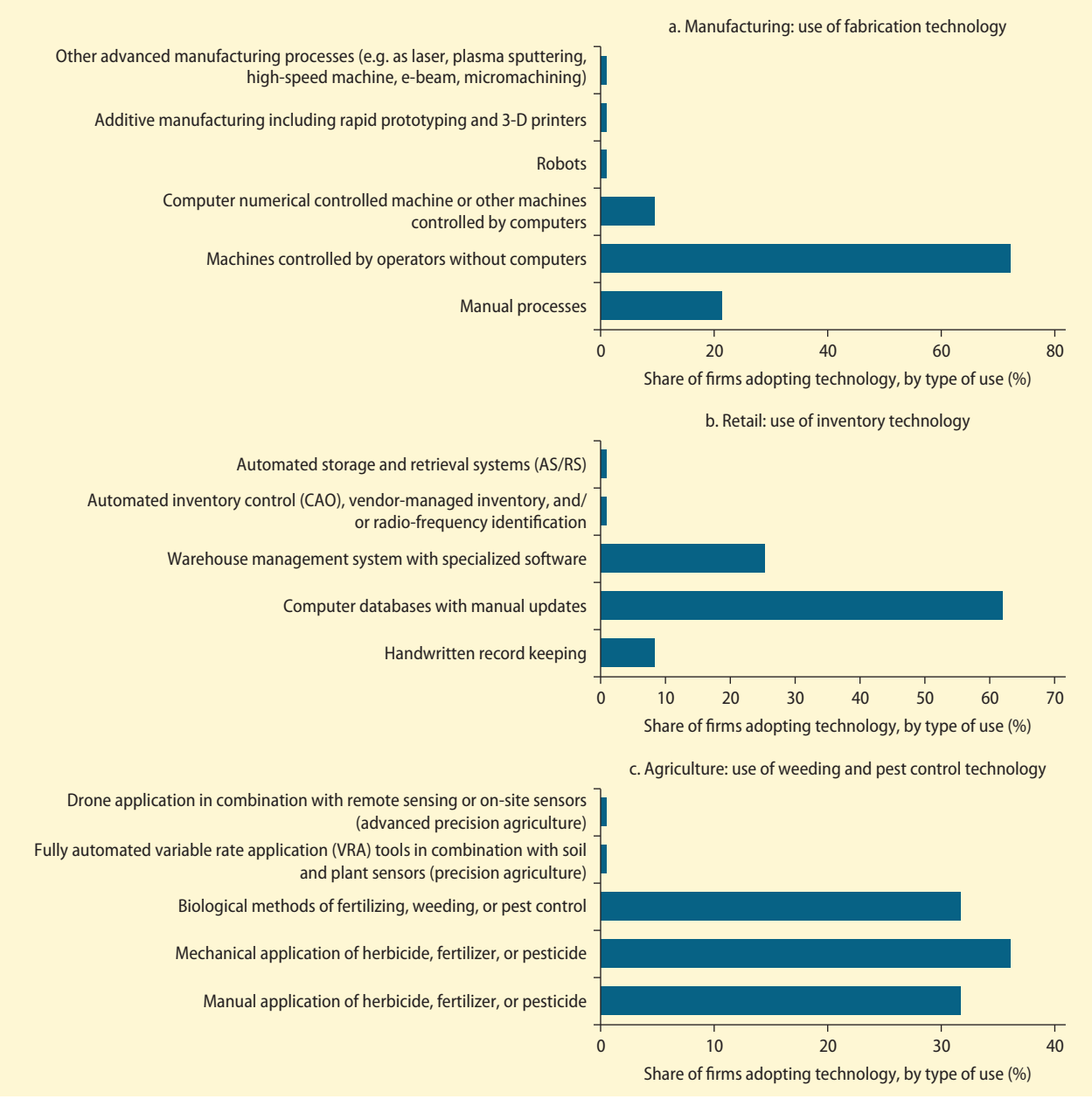
Source: World Bank Enterprise Survey data, latest round.
Note: The figure shows the average share and 95 percent confidence interval in the pooled sample, accounting for country fixed effects. Data include manufacturing and services sector firms covered by the Enterprise Surveys in all 10 middle-income countries covered in this study: Cambodia, China, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam.

machines, and less than 1 percent use more-advanced technologies like robots, 3-D printers, or additive manufacturing (figure O.9, panel a).

- *In retail,* for inventory management, 63 percent of firms use computer databases with manual updates, 25 percent use warehouse management systems with specialized software, and only 1 percent use advanced technologies such as automated storage and retrieval systems (figure O.9, panel b).
- *In agriculture,* for weeding and pest control, almost one-third of firms still rely largely on manual techniques, and another one-third use mechanical techniques, whereas the use of automated precision agricultural techniques is almost nonexistent (figure O.9, panel c).

The radar diagrams in figure O.10 reinforce the substantial heterogeneity in the use and sophistication of technology *across* firms but also highlight the often considerable

FIGURE O.9 The intensive use of cutting-edge technology for manufacturing, retail, and agriculture remains limited in Vietnam



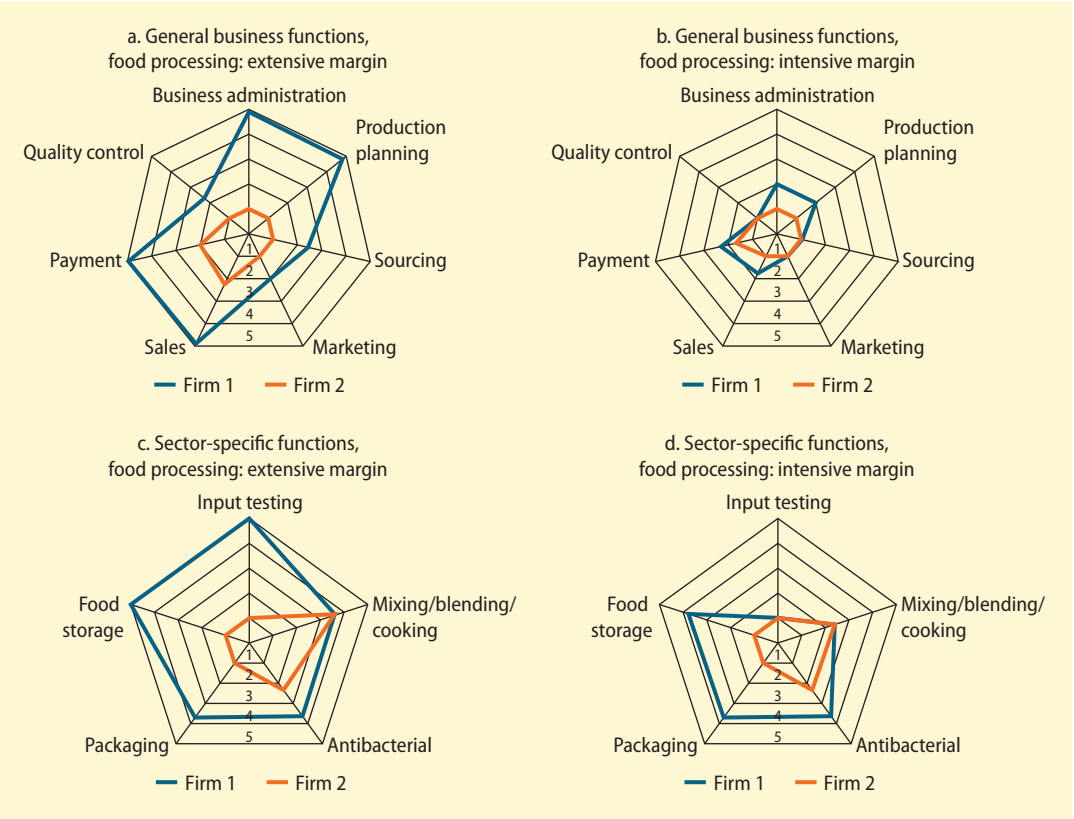
Source: World Bank estimates, using the 2020 Firm-level Adoption of Technology (FAT) survey of Vietnamese firms (Cirera, Comin, Cruz, Lee, and Martins-Neto 2020).

heterogeneity *within* firms. Using information on a typical large firm (Firm 1) and a medium-size firm (Firm 2) in the food processing sector, the figure shows that, for the same business functions, these two firms can be very different in the extensive margin of technology use (figure O.10, panel a), although the gap is smaller when use intensity (the intensive margin) is considered (figure O.10, panel b). It is noteworthy that the same firm (for example, Firm 1) can be near the technology frontier in its use of food storage technology but far from the frontier in its use of input testing technology (figure O.10, panel d).

Only a small share of firms engage in more sophisticated innovation activities such as R&D

There is similarly considerable heterogeneity between firms when it comes to the more sophisticated forms of innovation that could result in invention at the frontier, as evidenced by the high level of concentration in firms' R&D investments. Figure O.11 shows the distribution of R&D intensity (measured by R&D expenditure per full-time employee) in Cambodia, China, Malaysia, and the Philippines, using Israel as a benchmark.

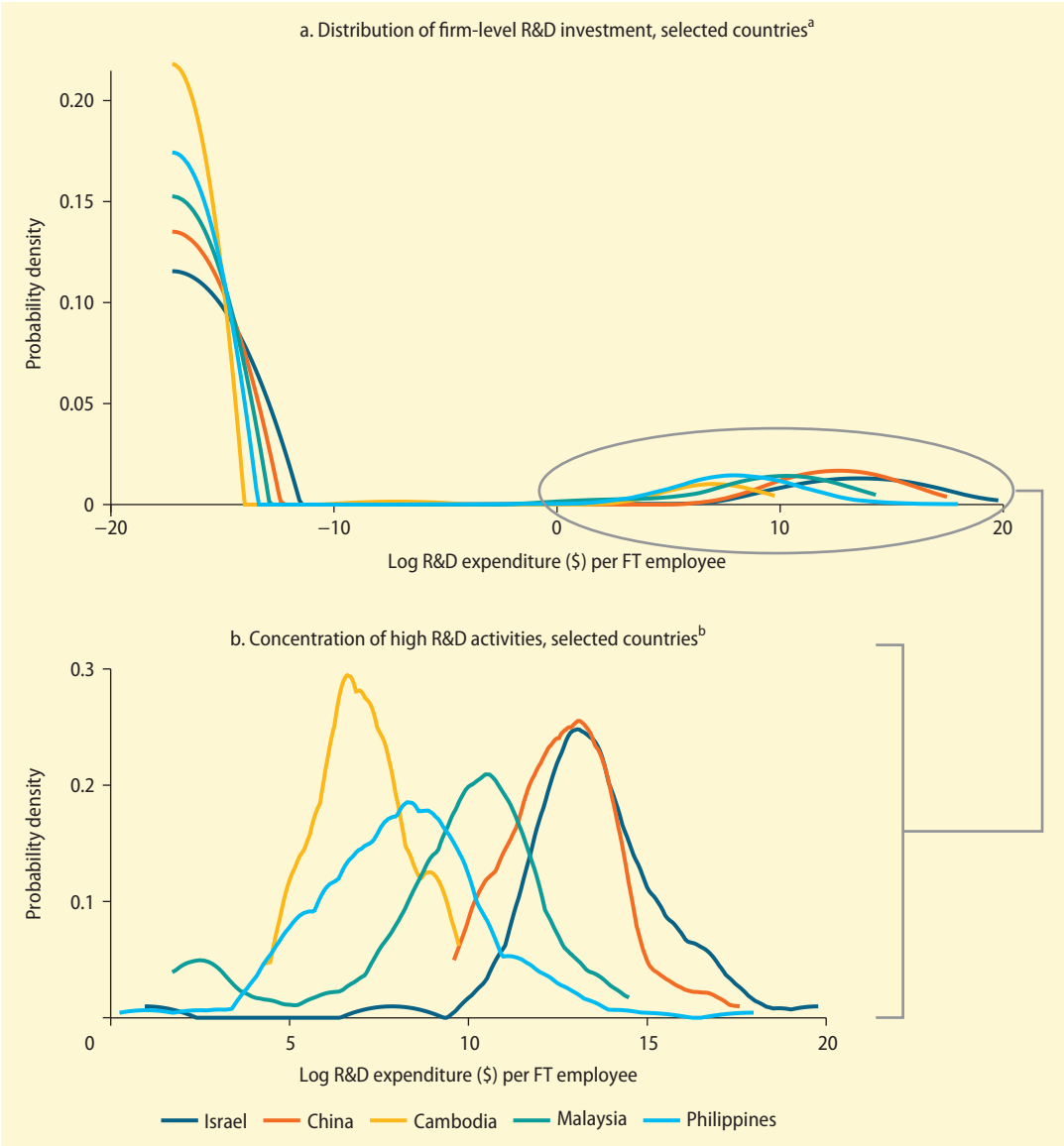
FIGURE O.10 Radar diagrams show substantial heterogeneity in technological sophistication within firms



Source: Cirera, Comin, Cruz, Lee, and Martins-Neto 2020.
Note: In each radar diagram, the values 1–5 indicate relative distance from the frontier in a firm's use of technology for a given business function (1 being the most distant and 5 representing the frontier). Firm 1 and Firm 2 are Vietnamese food-processing firms that provided data for the Firm-level Adoption of Technology (FAT) survey.

In all countries shown, the vast majority of firms perform no R&D whatsoever (figure O.11, panel a). Only a relatively small share engage intensively in R&D activities. Notably, among firms that do invest in R&D, the distribution of R&D intensity differs significantly across countries (figure O.11, panel b). The distribution of R&D intensity among firms in China most closely resembles the distribution found in Israel, whereas performance among the most R&D-intensive firms in Cambodia, Malaysia, and the Philippines still falls well below Israeli levels.

FIGURE O.11 There is significant duality in firm-level R&D investment



Source: World Bank Enterprise Survey data.
Note: In both panels, Israel (dark solid line) represents the benchmark. FT = full-time; R&D = research and development.
a. Panel a illustrates the distribution of R&D investment across all firms, by country.
b. Panel b (an enlarged portion of panel a) illustrates the distribution of R&D intensity (R&D expenditure per FT employee) among firms that *do* invest in R&D.

Why diffusion matters

Although inventions and new technologies offer the possibility for large increases in productivity, it is the diffusion of these new technologies rather than invention that ultimately determines the pace of economic and productivity growth (Hall and Khan 2003). The considerable heterogeneity observed in developing East Asia suggests that diffusion is not occurring at the pace and level that would be desirable. The approach of accelerating innovation through the acquisition of technologies embedded in imports and FDI, while an important part of the region's growth model to date, has not induced broad diffusion of new technologies and processes beyond export-linked firms. And it will be insufficient for propelling future productivity growth.

In light of the significant heterogeneity in firm innovation performance in the region, a broader innovation-based model is needed—one that still tries to maximize the absorption from FDI and participation in GVCs but that also supports a critical mass of firms in adopting new technologies and undertaking innovation. Although it remains important to enable more-sophisticated firms to undertake R&D projects and potentially to invent at the technological frontier, it is critical to support a large mass of firms to start innovating.

A large empirical literature links all types of innovation to higher firm productivity

The empirical literature that examines the relationship between innovation and productivity—focused mostly on high-income countries but also on China—indicates that innovation generally increases firm-level productivity. (For surveys of the evidence, see Hall [2011] and Mohnen and Hall [2013].) Productivity impacts tend to be strongest for product innovations, although this may partially reflect challenges associated with measuring other forms of innovation.

Recent analysis of Enterprise Survey data provides further evidence for developing East Asian countries. Consistent with the broader literature, innovation among firms in the region is associated with both higher labor productivity and higher revenue TFP (de Nicola 2019). The positive relationship between innovation and productivity holds both for firms that introduce new products and those that introduce new processes.

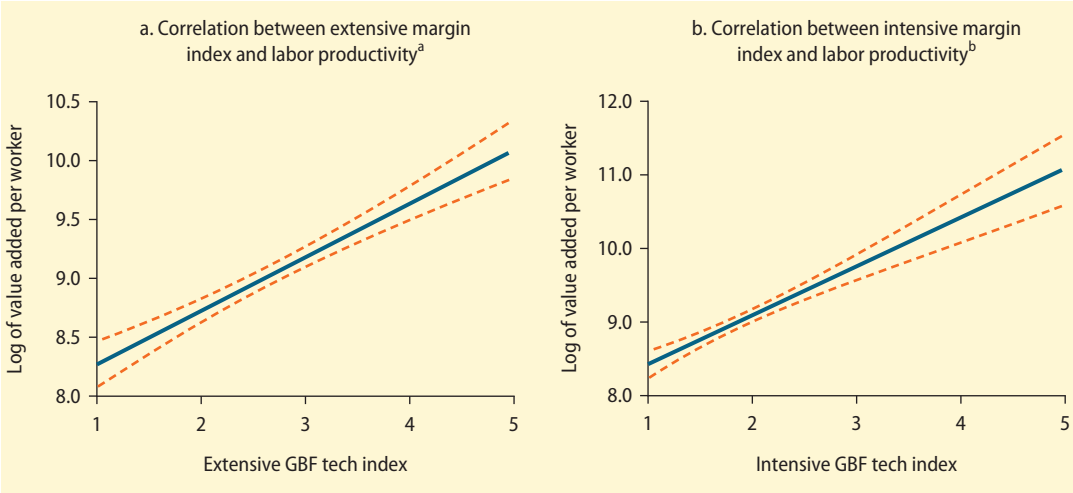
Although much of the literature focuses on invention, more-basic forms of innovation—increased diffusion and adoption—also pay off

Much of the literature has focused on innovation defined as invention, especially using patenting data. But it is important to emphasize that innovation in the form of imitation of products and processes, adoption of new technologies, or increased product quality is also important for productivity and growth. And policies that successfully encourage innovations that are new to the firm or new to the domestic market can have significant returns.

This advantage is clear from growth models, as in Madsen, Islam, and Ang (2010), but also from new microeconomic evidence. For example, in one of the few studies that specifically examines the impact of innovations that are only new to the firm or the local market (that is, that have been invented elsewhere), Fazlioğlu, Dalgiç, and Yereli (2019) find positive returns, based on a panel of Turkish firms. This less-sophisticated type of innovation, which helps firms to remain competitive, also pays off.

Data from the recent FAT survey in Vietnam also indicate a positive relationship between technology adoption and labor productivity at the firm level. Figure O.12 shows the results of regressing the logarithm of value added per worker on a technology index and sector dummies to control for different production functions, by sector. Firms that use more-sophisticated technologies for general business functions (GBF) such as human resource management, supply chain management, and sales (the extensive margin, shown in panel a) and that use

FIGURE O.12 Technology adoption brings labor productivity gains to Vietnamese firms



Source: Cirera, Comin, Cruz, and Lee 2020.
Note: The figures show the conditional predictions (solid lines) and 95 percent confidence levels (dashed lines) from regressing the log of labor value added per worker on a technology index and sector dummy variables. The index (from 1 to 5) measures the sophistication of technology—1 being the least sophisticated and 5 the most sophisticated technology for a set of general business functions (GBF) including business administration (human resources, accounting, and so on); production or service operations planning; sourcing, procurement, and supply chain management; marketing and product development; sales; payments; and quality control. The indexes were developed using data from the Firm-level Adoption of Technology (FAT) survey of Vietnamese firms in manufacturing, retail, and agriculture.
a. The "extensive" index refers to the most sophisticated use—here, as the average among all GBFs of the most sophisticated technology used in each business function, even if marginally used.
b. The "intensive" index refers to the most sophisticated use within the technologies that are used more intensively—here, as the average among all GBFs of the most sophisticated technology used more intensively for each business function (that is, the main technology used by the firm).

them more intensively (the intensive margin, shown in panel b) tend to have higher value added per worker.

Some caution is advised in interpreting these findings in terms of causality and the overall impact on TFP, because it is hard to distinguish empirically between the effects of technology adoption and capital deepening. Nonetheless, the analysis suggests that technology upgrading is likely associated with higher productivity. This is consistent with a broader micro literature that has found positive impacts from the adoption of information and communication technology (ICT) (Bloom, Sadun, and Van Reenan 2012; Brynjolfsson and Hitt 2003) and other technologies (Kwon and Stoneman 1995; Mcguckin, Streitwieser, and Doms 1998). The observed relationship is stronger for the intensive margin (the most intensively used technology), as expected.

What inhibits innovation?

Technology adoption and diffusion are determined not only by relative prices but also by factors such as differential returns to innovation, uncertainty about demand, and differences in firm-level capabilities

If returns to technology adoption, and to innovation more broadly, tend to be positive, what is constraining firm-level diffusion, adoption, and invention in the region? One prominent view of technology adoption and diffusion from a macro perspective focuses on the role of relative prices and factor abundance. The idea is that less-developed countries, because of differences in economic conditions and factor prices—including barriers to technology transfer, abundant labor, and a scarcity of skilled labor—will use different technologies than high-income countries

(Acemoglu and Zilibotti 2001). The implication is that countries in developing East Asia would be expected to use more labor-intensive and less capital-intensive technologies than do high-income countries. The extent of this will depend on how complementary technology and labor are (Acemoglu 2010) and how successful firm-level R&D is in generating new technologies.

Although it is unclear empirically how strongly some of these macro patterns of technology adoption based on factor prices affect diffusion, micro evidence suggests that other elements are at play in impeding successful technology adoption, diffusion, and invention in the region. These include uncertainty and lack of information, weak firm capabilities, inadequate workforce skills, lack of external financing, and weak or misaligned country innovation policies and institutions—each of which are discussed here, in turn.

First, firms face considerable uncertainty regarding investments in technology

Innovation is an inherently risky endeavor. Indeed, the process of technology adoption is often characterized by significant uncertainty—as to the future path of the technology and its benefits—and by limited information about the benefits, costs, and even the very existence of the technology's viability (Hall 2004).

Uncertainty about demand for new products or the efficiency of new technologies can lead to low initial adoption of new technologies among firms (as explained theoretically by Atkin et al. [2017]). Evidence of an increased investment in quality upgrading in response to new export demand provides empirical support for this argument (Atkin, Khandelwal, and Osman 2017).

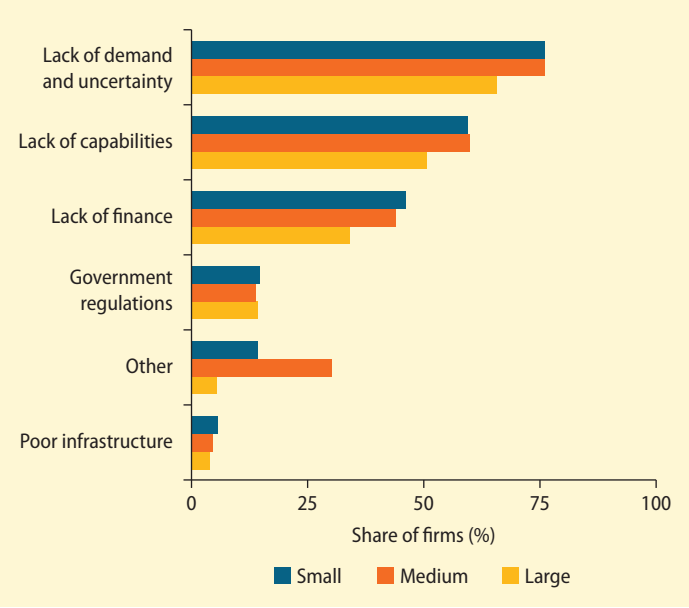
Data from the FAT survey in Vietnam confirm that firms consider uncertainty to be an important factor in the decision to adopt new technology. Over 75 percent of small and medium-size firms and two-thirds of large firms surveyed indicated that uncertainty about demand and doubts about the economic benefit of investing in a new technology are major obstacles to technology adoption (figure O.13).

In addition, more than 50 percent of firms, regardless of their size, report that lack of knowledge or related capabilities are a key barrier to investment in new technologies. Moreover, nearly half of small and medium-size firms and roughly one-third of large firms report difficulty in obtaining financing as a major barrier to technology adoption.[3] Costs of government regulations and lack of adequate infrastructure (such as electricity or internet) are also cited by firms as barriers to technology adoption, albeit to a lesser extent.

Second, firms' innovation capabilities, as reflected in management quality, is weak

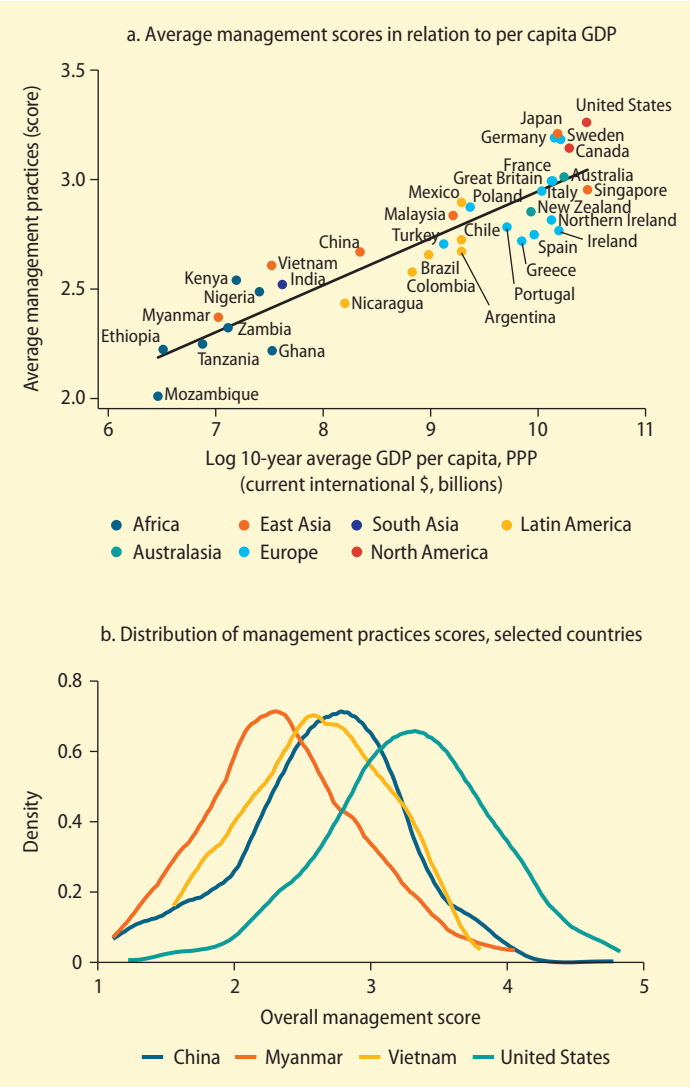
Innovation requires a range of capabilities that enable firms to respond to market conditions, identify new technological opportunities, develop a plan to exploit them, and

FIGURE O.13 Lack of demand and uncertainty is the top self-reported barrier to technology adoption among Vietnamese firms of all sizes



Source: Cirera, Comin, Cruz, Lee, and Martins-Neto 2020.
Note: Firm sizes small (5–19 employees), medium (20–99), and large (100+). Data were gathered from the Firm-level Adoption of Technology (FAT) survey of Vietnamese firms in manufacturing, retail, and agriculture.

FIGURE O.14 Firms in developing East Asian countries score lower on management capabilities than firms at the global frontier



Source: World Management Survey (WMS), Centre for Economic Performance.
Note: The WMS scores (collected over several years) range from 1 (worst practice) to 5 (best practice) across key management practices used by organizations in different sectors. These practices are grouped into five areas: Operations Management, Performance Monitoring, Target Setting, Leadership Management, and Talent Management. GDP = gross domestic product; PPP = purchasing power parity.

then cultivate the necessary resources to do so. The acquisition or the lack of these capabilities—and specifically, managerial capabilities—is fundamental to the process of upgrading (Sutton 2012).

New survey evidence from China supports this view. The degree of a firm's innovativeness (as measured by the firm's incidence of having a product, process innovation, R&D project, or patent) is significantly associated with the firm's management quality (Park and Xuan 2020).

Data from the World Management Survey (WMS) indicate that firms' management quality in selected East Asian countries is roughly on par with what would be expected, given their per capita income levels.[4] However, their management quality remains far from the global frontier (proxied by the United States). Compared with US firms, firms in developing East Asia are less well-managed, on average and across the whole distribution (figure O.14).

Moreover, poor overall performance is driven by quality gaps that are generally larger for the best firms.[5] That is, the frontier firms in developing East Asia perform disproportionally worse than the frontier firms in the United States. This gap in management capabilities likely contributes to the innovation gaps between the region and the global frontier while also helping to explain some of the firm heterogeneity within countries described earlier.

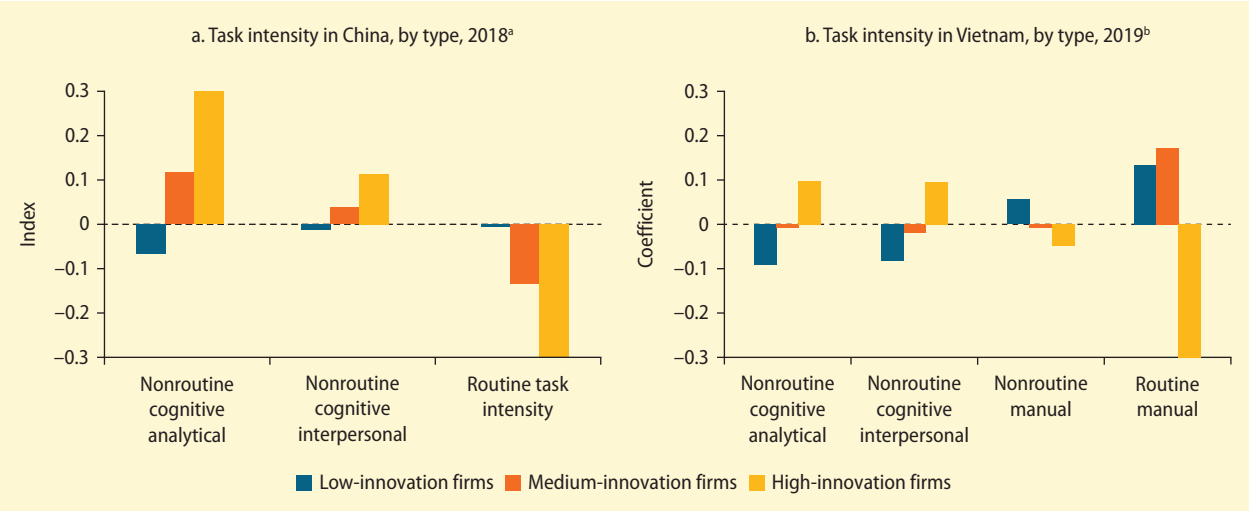
Third, inadequate workforce skills impede innovation in the region

A range of advanced skills are important in enabling innovation at the firm and country levels, including advanced cognitive, socioemotional, and technical skills. Such advanced skills become increasingly important as firms move from diffusion and technology adoption toward the technological frontier.

New analysis carried out for this study highlights that employees in highly innovative firms carry out more nonroutine cognitive and interpersonal tasks and fewer manual tasks than those in less-innovative firms (figure O.15). For this reason, highly innovative firms in developing East Asia employ more (college) educated employees, with advanced technical training, greater cognitive abilities, and stronger socioemotional skills.

Firms in the region consistently report skills gaps as serious impediments to their operations. This is true of firms whether or not they innovate. Nonetheless, the

FIGURE O.15 Employees in more-innovative firms in China and Vietnam have jobs that are more intensive in nonroutine cognitive analytical and interpersonal tasks



Sources: World Bank elaboration, based on Park and Xuan 2020 and Miyamoto and Sarzosa 2020, using, respectively, the 2018 China Employer-Employee Survey (CEES) and the 2019 Enterprise Survey on Innovation and Skills (ESIS) for Vietnam.
Note: Firms are categorized by "innovation intensity," measured by the number of innovation activities undertaken, as captured in the respective surveys. Scaled from 0–5, low-, medium-, and high-innovation are defined, respectively, as those undertaking 0–1, 2–3, and 4–5 innovation activities. The Vietnam analysis does not include an aggregated measure of "routine task intensity"; therefore, panel b shows instead an individual measure of "routine manual" tasks. No information was included in either panel on routine cognitive tasks because none of the related regression coefficients was statistically significant.
a. The CEES collected responses of 2,001 manufacturing firms and 16,379 workers from five Chinese provinces: Guangdong, Jiangsu, Jilin, Hubei, and Sichuan.
b. The ESIS collected responses from 201 manufacturing and information and communication technology services firms and 849 staff in five Vietnamese provinces: Hanoi, Bac Ninh, Da Nang, Ho Chi Minh City, and Binh Duong.

challenges that innovative firms face in finding suitably skilled staff are considerable. Over 50 percent of innovating firms in Indonesia, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam cite a lack of managerial and leadership skills as a challenge when hiring new workers (figure O.16). And more than half of all innovative firms in at least three of those six countries cite the scarcity of interpersonal and communication skills, foreign language skills, computer and information technology (IT) skills, or technical (non-IT) skills as critical challenges when it comes to hiring.

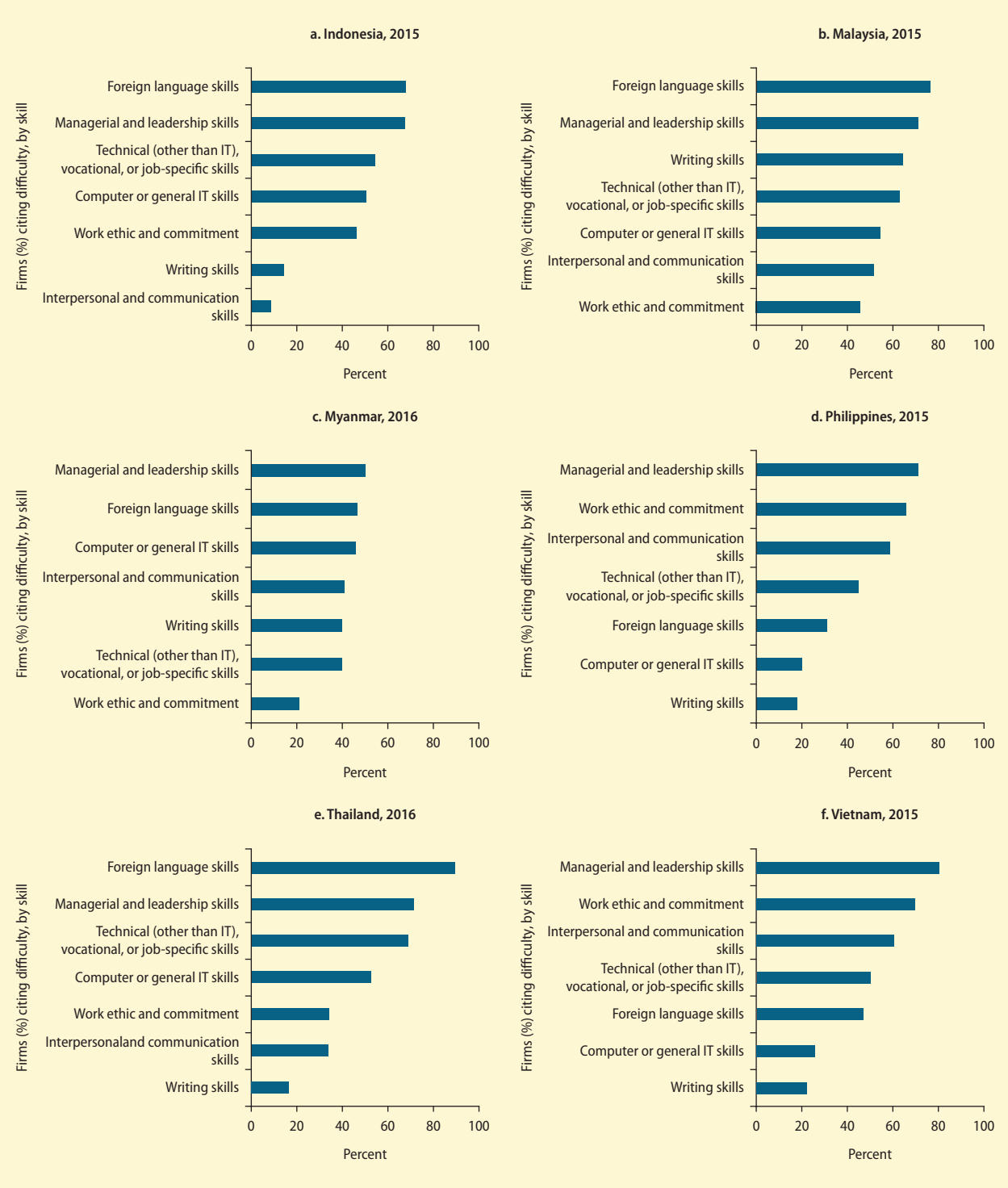
A fundamental challenge in this context is that most of the region's countries are still struggling to ensure that their students develop basic reading, math, and science skills. Indeed, students in several countries (Indonesia, Malaysia, the Philippines, and Thailand) score poorly on international education assessment tests given to eighth graders (the Programme for International Student Assessment, or PISA)—considerably below what would be predicted based on their countries' income levels.

Weak development of reading, math, and science capabilities—the "foundational skills"—represents an important impediment to the development of the more advanced cognitive, technical, and socioemotional skills needed to support innovation. These skills-related constraints are relevant to the process of diffusion and adoption of existing technologies, but they are all the more severe when it comes to invention.

Fourth, a lack of diversified sources of external finance constrains firm innovation

Access to external finance—and to a suitable range of financial instruments—is critical to enabling firm innovation. How firms finance their investments and operations influences both the decision to innovate and the quality of that innovation.

FIGURE O.16 Most innovative firms in developing East Asia report difficulties in hiring workers with adequate skills



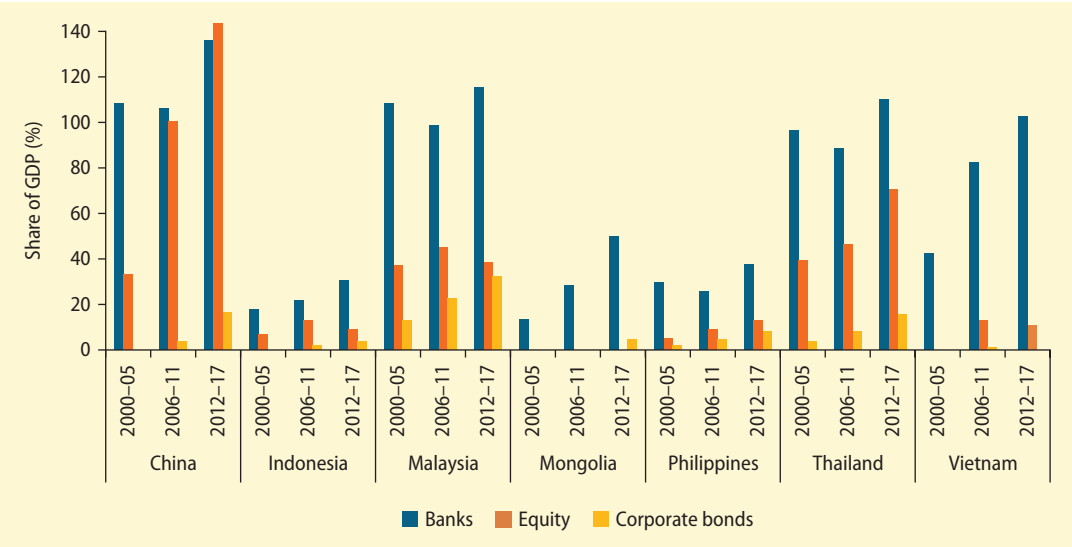
Source: World Bank calculations, based on World Bank Enterprise Surveys.
Note: "Innovative" firms are defined as those that introduced new or significantly improved products or services (product), or adopted new production methods (process), during the past three fiscal years. IT = information technology.

As noted earlier, about 16 percent of Vietnamese firms surveyed report difficulty in obtaining loans as the primary barrier to new technology adoption. More broadly, an analysis of Enterprise Survey data from developing East Asian countries shows that firms that make use of external finance, other than from banks, are more likely to innovate and to engage in more innovation activities (Mare, de Nicola, and Liriano forthcoming). A recent study of innovation in China also shows that financial constraints affect innovation quality. Firms that are financially constrained are less likely to invest in large innovation projects with the potential to transform productivity, focusing rather on making marginal improvements to existing products (Cao 2020).

Well-developed, deep financial markets allow firms to take advantage of diverse financial instruments, supporting both increased quantity and quality of innovation. A diversity of sources is important because different financial instruments have different characteristics regarding maturity, cost, and ancillary services. And these characteristics, in turn, help reduce market frictions associated with asymmetric information, cash flow uncertainty, and an extended time lag between investment and returns. Such frictions are especially serious among firms undertaking long-gestation R&D projects commonly associated with invention.

Although financial sectors in developing East Asia have become more diversified in recent years, most remain heavily banking based, having neither the depth nor the breadth to effectively support innovation-led growth (figure O.17). Moreover, financial markets remain accessible mostly to large firms (Abraham, Cortina, and Schmukler 2019). Key challenges, therefore, involve the continued deepening of countries' financial markets to ensure greater diversity of sources of finance for innovation—especially invention—and the enabling of greater access to small and medium-size enterprises.

FIGURE O.17 Banks remain the dominant source of finance to firms in most of developing East Asia (except China)



Sources: The World Bank's Global Financial Development and FinDebt databases.
Note: The graph reports averages over the three periods. "Equity" refers to stock market capitalization, "corporate bonds" to the amount outstanding of domestic bonds issued by private entities in industries other than finance, and "banks" to the outstanding amount of private credit granted by domestic banks. "Developing East Asia" refers to the 10 middle-income countries covered in this study: Cambodia, China, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam. The figure excludes Cambodia, Lao PDR, and Myanmar because of unavailability of data. For Mongolia, data on the corporate bond issuance are not available before 2011.

Fifth, countries' innovation policies and institutions are often not fit for purpose

Policies and agencies in developing East Asia are not well positioned to enable the process of increasing innovation and technological catch-up. Among the factors that dull the impact of policies on innovation, countries' current policy mixes are not well oriented toward building firms' capabilities for innovation or accelerating technology diffusion and adoption; nor are they set up to enable innovation in services. In addition, weak governance and institutional capacity among innovation agencies and public research organizations (PROs) often impede their ability to address countries' most pressing innovation challenges.

Innovation policies in the region neither focus on key bottlenecks nor prioritize technology adoption or building innovation capabilities

Given the lagging innovation performance of most countries in the region, it would make sense for their policies to emphasize building firms' basic capabilities and to prioritize support for technology adoption and diffusion. An in-depth review of the mix of innovation policies in Indonesia, the Philippines, and Vietnam suggests that their policies do not support these objectives, however. To different degrees across these countries, innovation policies are poorly aligned with the most pressing innovation challenges.

Two important policy gaps stand out: (a) the lack of support for technology adoption and diffusion, and (b) a virtual absence of support for innovation in services sectors. This misalignment of policies suggests, among other things, that many countries in the region have been poorly equipped to respond quickly to the technological challenges that the COVID-19 crisis has created, whether in terms of digitalization or the creation of more flexible production systems.

Most countries' capacity to implement innovation policies remains relatively weak

Detailed benchmarking exercises carried out in Indonesia, the Philippines, and Vietnam reveal numerous shortcomings in the design and implementation of innovation policies. Among the most important design shortcomings are:

- A lack of adequate economic justification for public policy;
- The absence of a logical framework to guide the design and implementation of policy interventions; and
- A lack of monitoring and evaluation (M&E) mechanisms for most policy instruments.

The outcome of this lack of good practices is that both the design and implementation of policies fall below potential. The overall quality of the policy mix was also found to be hampered by a lack of coordination across government agencies involved in innovation. Such coordination is critical because innovation needs and challenges cut across sectors, ministries, and agencies.

Innovation policy making is also hampered by weak institutions

Agencies supporting innovation in the region use outdated governance models, and together with the lack of coordination, this undermines the coherence of policies across countries' innovation systems. Some salient features of high-income countries' experience underline the importance of (a) having a clear strategy addressing market failures, (b) hiring capable staff, (c) instituting effective governance structures, and (d) instituting robust M&E frameworks.

Adopting these good practices in innovation agencies in the region would help improve both policy design and implementation and should be a top priority. Creating and empowering a dedicated innovation agency to take a high-level view of policy and to coordinate could be one way of improving and professionalizing policy making—although without due care and an appropriate mandate, there is a risk that such an agency could fail in its mission, resulting in continued lack of coordination along with additional fragmentation and competition for resources.

Inadequate governance structures and a lack of mission orientation constrain the contribution of public research to innovation

A new survey of PROs and research centers in Malaysia, the Philippines, and Vietnam shows that those governments have strengthened their national research capacity, increasing their investments in supporting PROs to create opportunities for new knowledge generation and innovation-based competencies. In Malaysia and to a lesser extent in the Philippines and Vietnam, the number of researchers in the public sector has grown rapidly during the past decade. This has been accompanied by a significant increase in publication activity, especially in Malaysia, and an upsurge in patenting by universities and PROs.

However, the results of these efforts and the impact of PROs on innovation and the economy are still far from clear. The surveys showed that, with a few noteworthy exceptions, PROs and university research departments develop few industry-science links (including knowledge links and human capital interactions). Indeed, technology transfer activities are still embryonic and mainly concentrated among a few organizations.

The impact of PROs and research centers could be leveraged by addressing governance and funding issues, along with inconsistencies in national regulatory frameworks governing public research systems. Specifically, inadequate governance is related to:

- Low levels of autonomy;
- A lack of links between institutional funding policies and performance measurements; and
- Inadequacy of academic incentives, which deters technology transfer activities, with often unclear mechanisms for sharing intellectual property.

The main factor that dissuades researchers from engaging in technology transfer and entrepreneurial activities, however, is the heavy weight that scientific publication (that is, the number of published articles) still receives among the criteria for researchers' career advancement and salary enhancement.

Spurring innovation in developing East Asia: Directions for policy

To spur innovation more effectively in developing East Asia—both diffusion of existing technologies and invention at the frontier—and to better keep pace with the wave of new technologies, policy makers in the region need to invest in building firms' innovation capabilities. This approach was effectively used by now high-income countries in East Asia, such as Japan, Korea, and Singapore, which accomplished rapid technological convergence by focusing on policies that addressed their innovation capabilities gaps (Cirera and Maloney 2017).

But what does such an approach look like in practice? How should policy makers deal with the substantial heterogeneity in their countries' innovation capabilities? To strengthen innovation policies and spur innovation-led growth by addressing the innovation inhibitors described above, countries can take several key steps:

- *Reorient policy objectives* in a graduated manner (the "capabilities escalator") to reduce uncertainty and information problems by removing current biases against diffusion; building management and innovation capabilities; and including a focus on services sector innovation
- *Strengthen complementary factors*—skills and finance—for innovation
- *Reform innovation institutions* and agencies and strengthen their capacity.

Reorient policy objectives and remove policy biases against adoption and services sector innovation

Effectively fostering innovation, both diffusion and invention, requires a graduated approach of moving firms toward the frontier—one that recognizes heterogeneity in the capacity to innovate

Cirera and Maloney (2017) propose assessing the adequacy of policies and institutions through the lens of the "capabilities escalator"—to reflect the capacity of firms

and country systems to absorb and use knowledge (figure O.18).

Production capabilities. On the lowest step of the escalator, firms have productive, but few technological, capabilities. Policies should focus on building technological capabilities by addressing the uncertainty and critical information required for adoption (for example, through management extension and national quality infrastructure), improving skills, and supporting improvements in management quality. Where the business climate and competition are weak, policies should focus on creating an environment conducive to investment and knowledge diffusion, where firms compete, have access to competitive inputs, and can maximize knowledge spillovers through FDI and trade.

Technology adoption capabilities. In countries where some firms have technological capabilities, but few have R&D and invention capabilities—the next step on the escalator—policies should focus on expanding and strengthening technological capabilities while also supporting more firms in implementing R&D projects oriented toward invention.

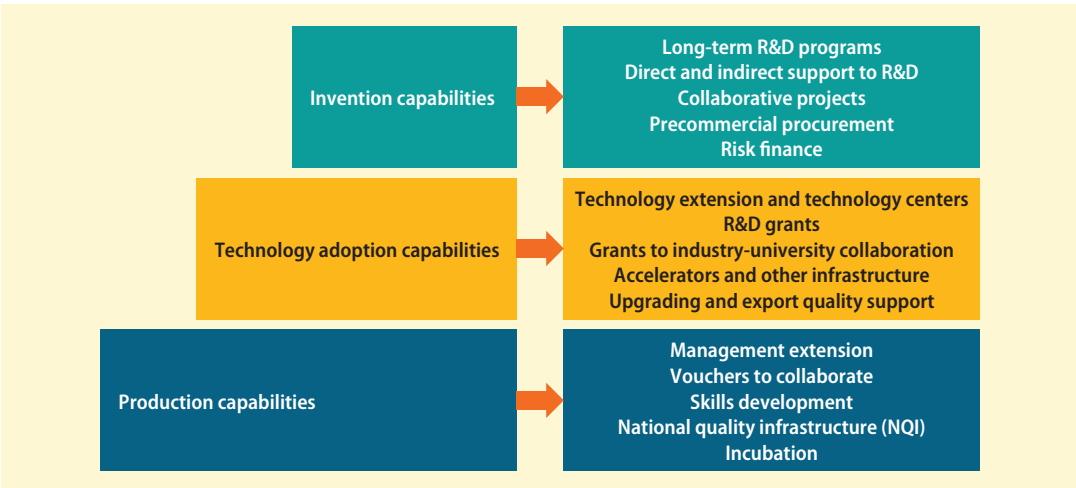
Invention capabilities. In countries where firms have more sophisticated capabilities, the goal of policy should be to enable invention by supporting more-complex, long-term R&D projects. At this stage, countries also require adequate intellectual property protection and will benefit from significant collaboration between industry and universities or other knowledge providers.

Figure O.18 illustrates several sets of policy instruments, each corresponding to a different level of the capabilities escalator.

Addressing heterogeneity in innovation capabilities requires that governments support diffusion and adoption as well as invention, prioritizing policies and allocating resources consistent with capabilities

The framework presented here does not imply that only one type of policy applies to each country. It does mean, however, that the policies and public resources for innovation should be well aligned with the capacities and needs of the private sector. Thus, countries with relatively low innovation capabilities—typically the region's lower-middle-income countries—are best advised to prioritize the adoption and diffusion of existing technologies. As innovation capabilities rise, the mix of policies can

FIGURE O.18 Appropriate policy instruments to foster innovation differ depending on the level of innovation capabilities



Source: Adapted from Cirera and Maloney 2017. ©World Bank. Further permission required for reuse.
Note: R&D = research and development.

shift, progressively focusing on the more technically advanced needs of leading firms.

Notably, even East Asia's high-income, high-capacity countries such as Japan, Korea, and Singapore—as well as Canada and the United States—offer support for technology adoption as well as invention, with different sets of policies to encourage both dimensions of innovation. At any level of capabilities, the point is not to focus policies only on either adoption or invention but rather to allocate more resources in a way commensurate with innovation capabilities.

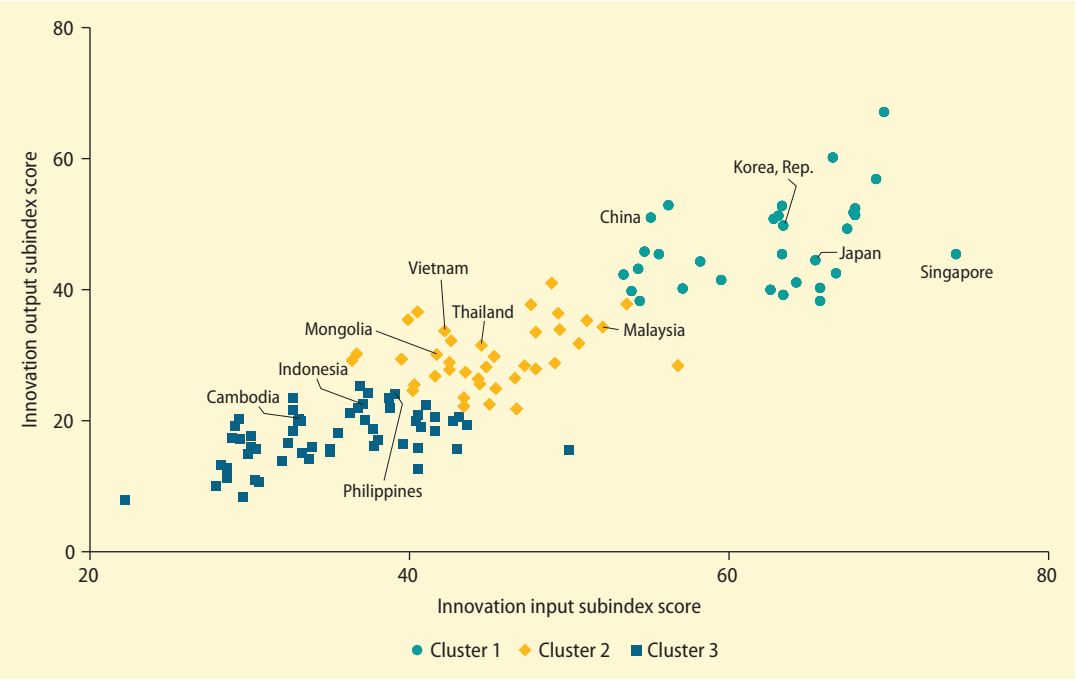
Figure O.19 provides an approximation of where the countries of developing East Asia may be in terms of innovation capabilities. The scatterplot uses Global Innovation Index data on innovation *inputs* (measuring infrastructure, institutions, R&D, research, and human capital quality) and an innovation *outputs* index that captures the quality of knowledge, technology, and creative outputs of the economy.

As expected, the relationship is positive. Most countries in the upper-right portion of the figure, with the exception of China, are high-income countries, whereas the countries in the lower-left portion of the figure are low- and middle-income countries. The figure shows three clusters that, with a few exceptions, correspond to the levels of capabilities depicted in the "capabilities escalator" (figure O.18).

Policy priorities require adjustment over time as innovation capabilities are developed

Climbing the capabilities escalator is a dynamic process and hence requires adjusting priorities over time. High-innovation

FIGURE O.19 Developing East Asian countries occupy three distinct clusters with respect to innovation capabilities



Source: World Bank elaboration from Global Innovation Index (GII) data (https://www.globalinnovationindex.org/).
Note: The "innovation input" subindex scores aspects such as infrastructure, institutions, research and development (R&D), and human capital quality. The "innovation output" subindex scores the quality of knowledge, technology, and creative outputs of the economy. Among the 10 developing East Asia countries in this study (Cambodia, China, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam), Lao PDR and Myanmar are excluded for lack of data.

countries in East Asia, such as Korea and Singapore, periodically adjusted their policy mixes over time to achieve convergence to the technological frontier.

Korea's journey has two important lessons for developing East Asia: First, the country has pursued an overarching objective and focus throughout the period on the importance of developing technological capabilities. Second, it has had an evolving prioritization of policies grounded in its evolving innovation and technological capabilities. Policy priorities were updated over time, reflecting changing challenges—from prioritizing the building of basic innovation capabilities in the 1960s and 1970s; to maximizing links to GVCs, FDI, and entry into export markets in the 1980s; to a significant focus on R&D and patenting in the 2000s; and to technological leadership in selected sectors in the 2000s.

A current priority includes removing policy biases against services

Traditionally, innovation and technology development have been seen as primarily processes driven by the manufacturing and agriculture sectors. Networks of PROs performing R&D have been established throughout the region and globally in narrowly defined areas of manufacturing and agriculture.

The reality, however, is that innovation in services is increasingly important for competitiveness in manufacturing, for the strengthening of GVCs, and also for services themselves, which employ the largest share of people in all countries. For example, business internationalization depends on transport, logistics, and communication networks. Innovations in these services are thus critical to facilitating integration of local firms into global networks. Improvements in digital infrastructure, digital networks, and platforms are also enabling the proliferation of innovative services firms in the region. Yet, innovation policy rarely supports innovation in services.

Removing this bias requires action on two fronts. First, it is important to go beyond instruments that traditionally support services firms, such as accelerators, and to reach out to services and retail firms with other innovation instruments such as matching grants for innovation projects or digitalization. Second, it is necessary to expand the scope of innovation activities to include design—a significant component of R&D (Kox and Rubalcaba 2007) in manufacturing but also in services—and to strengthen firms' digital capabilities. Services sectors are extremely diverse, and innovation takes different forms with different priorities across subsectors. For example, digital and AI elements are more important in routine services, whereas design, business models, and delivery are more important in knowledge-intensive services (Salter and Tether 2006).

Recognizing these differences and designing adequate policies will thus be critical to enabling innovation in this increasingly important sector of the economy. This can be seen in the United Kingdom, for example, where the government's innovation policy has supported the growth of the creative industry, a sector that contributes £90 billion and 2 million jobs to the UK economy.

Develop key complementary factors: skills and finance

The ability of firms to innovate depends on multiple factors that fall outside the realm of innovation policy, strictly defined. These factors include the availability of a sufficiently skilled workforce and adequate financing to support firms'—often risky—innovation activities.

Building strong workforce skills is critical to fostering innovation

As noted earlier, policy makers face a *dual challenge* of ensuring that their populations develop the necessary foundational skills while also building the types of advanced skills needed to enable innovation. To meet this dual challenge, it will be important for

policy makers to act on several fronts, as described below.

Strengthen students' foundational skills by improving basic education. Lessons from high-performing education systems in East Asia and beyond suggest that building stronger basic skills will require strengthening the conditions for learning; improving teacher preparation and the quality of teaching; ensuring adequate public spending for basic education; increasing children's readiness to learn, including through early childhood education and development services; and undertaking regular learning assessments to diagnose challenges and inform improvements (World Bank 2018).

Lay the foundation for advanced cognitive and socioemotional skills early in the education life cycle. Even where countries have recognized the importance of cultivating more critical thinking, creativity, problem solving, and the ability to work effectively in teams, there remains a need to institutionalize the development of advanced cognitive and socioemotional skills into standard school curricula and extracurricular programs. Strong innovation performers in the region—Japan, Korea, and Singapore—have all revised their curricula to include an emphasis on higher-order cognitive and socioemotional skills development (Kataoka and Alejo 2019). Recent studies of skills formation emphasize that building strong cognitive and socioemotional skills is best begun early in the learning life cycle (Arias, Evans, and Santos 2019; Cunningham and Villaseñor 2016).

Strengthen technical skills through improved access to and quality of science, technology, engineering, and mathematics (STEM) education. The demand for technical skills to innovate is quite diverse across firms. For firms focused on diffusion and adoption of existing technologies, basic digital literacy and the capacity to use general purpose technologies and existing software applications may be sufficient. As firms move toward the technical frontier, more sophisticated technical skills are required. Efforts are needed to improve access to and the quality of technical education in much of the region. Establishing opportunities for continuous skills development will support skills upgrading in the current workforce.

Continuous skills development—or lifelong learning—systems for adult workers are necessary to support skills upgrading in the face of rapid technological change. There may be scope for incentivizing on-the-job training, which, evidence suggests, contributes to firm-level innovation activity. Singapore, for example, has instituted a promising system of individual training accounts to promote upgrading of people's workforce skills (Kataoka and Alejo 2019). Technical and vocational education and training (TVET) programs can also play a role—although, to be effective, such programs must closely reflect private sector demand to ensure their market relevance.

Strengthening finance can enable innovation

As discussed above, access to both external finance and a suitable range of financial instruments are critical to enabling innovation at the firm level. To strengthen finance for innovation, the region's countries should implement policies in three different areas: (a) developing well-functioning capital markets, (b) promoting venture capital markets, and (c) broadening the range of financial instruments available to innovating firms through the banking sector.

Developing deep, well-functioning capital markets. The development of deep capital markets is critical to ensuring alternative sources of external capital to innovative firms at different stages of a firm's life cycle. Some countries in the region have already moved in this direction by introducing capital market reforms targeted to increasing the investor base; improving financial market infrastructure (for example, introducing a capital market data warehouse system); and enhancing investor protection (Abraham, Cortina, and Schmukler 2019). Where countries have made progress in deepening capital markets, the main beneficiaries to date have been

relatively larger firms. Innovative instruments are still required to improve capital market access to small and medium-size firms, however (Mason and Shetty 2019).

Promoting the development of venture capital markets. Three broad, complementary sets of measures are important for the development of successful venture capital markets: First, the supply side of the market can be enhanced by enabling domestic investment and attracting foreign capital, such as through clear bankruptcy rules and transparent accounting standards. Second, the demand for risk finance can be stimulated by fostering an active entrepreneurial and innovation ecosystem. And third, governments can provide support for all market players by strengthening the institutional and regulatory framework for venture capital, as well as by investing directly or through public-private partnerships (for example, the successful Yozma program in Israel). Careful design of public intervention is important to ensure that programs are effectively addressing market failures and do not crowd out investment from the private sector.

Leveraging existing bank-firm relationships. Governments in the region could also channel financing to firms through the banking sector, exploiting existing bank-firm relationships. Well-designed government lending programs can help to align debtors' and creditors' incentives, lessening moral hazard problems (Cirera, Frias, Hill, and Li 2020; SQW 2019). This approach is not without risk, however, because identifying, targeting, and monitoring potential innovation projects may be difficult and costly for government agencies. Credit guarantee schemes may be more efficient because they make use of existing lending products, allowing banks to select projects and maintain the incentives to monitor borrowers' behavior. An example of such a scheme is the Korea Technology Finance Corporation (KOTEC), which has been successfully providing loan guarantees to small and young firms in high-tech sectors.

Reform innovation institutions and agencies and strengthen their capacity

Investing in institutional capacity is critical for more effective innovation policies

To date, discussions of innovation and technology policies have commonly ignored countries' capacities to effectively design and implement innovation policy, but these capacities are critical for the effectiveness of interventions. An initial review of innovation agencies indicates that some developing East Asian countries lag in the use of best practices in public management for innovation policy.

Going forward, it will be critical to invest more in policy-making capacity. Countries need to recruit capable staff and provide adequate training on innovation policy and public management, and to ensure that managers have adequate digital infrastructure to monitor beneficiaries and register innovation project outcomes.

More professionalized innovation agencies and increased interagency coordination are essential

Agencies supporting innovation policy in the region use outdated governance models and lack coordination across entities, which undermines policy alignment. Innovation policy requires coordination among agencies or ministries because of its cross-cutting nature. The current lack of coordination results in significant fragmentation in effort, along with policies that are poorly designed and executed.

In addition to improving the innovation agencies' public management capabilities, governments in the region need to (a) ensure better coordination of the different ministries and institutions in charge of innovation policy, and (b) adopt new agency models that enable recruitment of sufficient talent and professionalized services. There is no single model for coordination, and each country needs to find its own approach. Nonetheless, coordination is needed to ensure more integrated, focused, and effective innovation policy.

Strengthening the governance and incentive structures of PROs and research centers would help to maximize their contribution to innovation and technology diffusion

The impacts of government efforts to strengthen the national research capacity and of investments in science and technology in public research institutions are still unclear. Public institutions and university research departments engage little in industry-science collaboration (including knowledge links and personnel exchanges). Moreover, technology transfer activities remain embryonic and concentrated among a small number of organizations. Maximizing the contributions of these research institutions to innovation will require reforms in four key areas:

- *Improving governance,* for example, increasing autonomy, clarifying legal mandates for technology transfer, and strengthening links between institutional funding and performance; and disseminating good public management practices and strategic planning
- *Improving academic incentives* for research-industry collaboration and technology transfer
- *Adopting mission-oriented policies* to address specific innovation challenges facing the region (such as COVID-19 and climate change)
- *Incentivizing PROs* to enhance their impact on firm innovation and productivity through technology extension; upgrading of support services (including for new technology-based entrepreneurship); licensing of new technologies to small and medium enterprises (SMEs); and support to start-ups.

Final remarks

Developing East Asia has achieved unprecedented growth in the past several decades that has raised incomes broadly and lifted hundreds of millions of people out of poverty. This report has argued that the region's growth performance is under threat if countries do not transform their development model to one in which innovation is at the forefront. The impacts of the COVID-19 pandemic have been severe, and as the region focuses on the recovery, it is an opportune moment to accelerate pending reforms to accelerate the process of technological catch-up.

Although this transformation would be important under all circumstances, the COVID-19 pandemic has served to highlight the urgency of reform. The pandemic is likely to tighten the constraints on innovation identified in this report: limited capabilities of firms, scarcity of human capital and finance, and uncertainty about demand and returns to innovation. Moreover, the pandemic is raising uncertainty and may deepen the international divisions that were already simmering before the outbreak. Restrictions on trade, investment, and the mobility of people can hurt not just the flow of existing knowledge but also the creation of new knowledge through international collaboration. Similarly, mutual suspicion can divide the digital infrastructure and curb the digital flows that are vital for all creative activity today.

To accelerate progress in the face of challenges, countries in developing East Asia must update their objectives and give greater priority to better innovation policies. It is critical to focus on technological diffusion and to incentivize more firms to undertake innovation. This process requires stronger regulatory frameworks as well as policies that are aligned with the technological capabilities of the private sector in each country. Beyond domestic policy, East Asia must continue to deepen its tradition of international openness, which could also induce openness in other parts of the world, and help sustain the flows of ideas, trade, investment, and people that facilitate the creation and diffusion of knowledge. The time for action is now.

Notes

1. The terms "East Asia" and "developing East Asia" will be used throughout the report. For convenience, unless otherwise specified, these terms refer to the 10 middle-income countries covered in this study: Cambodia, China, Indonesia, the Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, the Philippines, Thailand, and Vietnam.
2. For more information on innovative responses to COVID-19, see the Coronavirus Innovation Map (https://coronavirus.startupblink.com/); the World Economic Forum COVID Action Platform (for example, Chandran [2020], at https://www.weforum.org/agenda/2020/03/asia-technology-coronavirus-covid19-solutions/); and Huang, Sun, and Sui (2020).
3. Challenges associated with obtaining external finance for innovation are discussed in more detail later in this Overview.
4. The WMS (https://worldmanagementsurvey.org/), operated by the Centre for Economic Performance of the London School of Economics and Political Science, is conducted through in-depth interviews of over 20,000 firms in 35 countries. Management practices, as measured in the WMS, capture several dimensions, including firms' practices in target setting, monitoring, and human resource management. The WMS is not specific to innovation, but it is a proxy for firms' overall capabilities.
5. These differences are statistically significant at 95% confidence level and hold true for different quantiles of the overall WMS management score distribution.

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After a half century of transformative economic progress that moved hundreds of millions of people out of poverty, countries in developing East Asia are facing an array of challenges to their future development. Slowed productivity growth, increased fragility of the global trading system, and rapid changes in technology are all threatening export-oriented, labor-intensive manufacturing—the region's engine of growth. Significant global challenges—such as climate change and the COVID-19 pandemic—are exacerbating economic vulnerability. These developments raise questions about whether the region's past model of development can continue to deliver rapid growth and poverty reduction.

Against this background, *The Innovation Imperative in Developing East Asia* aims to deepen understanding of the role of innovation in future development. The report examines the state of innovation in the region and analyzes the main constraints that firms and countries face to innovating. It assesses current policies and institutions, and lays out an agenda for action to spur more innovation-led growth.

A key finding of the report is that countries' current innovation policies are not aligned with their capabilities and needs. Policies need to strengthen the capacity of firms to innovate and support technological diffusion rather than just invention. Policy makers also need to eliminate policy biases against innovation in services, a sector that is growing in economic importance. Moreover, countries need to strengthen key complementary factors for innovation, including firms' managerial quality, workers' skills, and finance for innovation.

Countries in developing East Asia would also do well to deepen their tradition of international openness, which could foster openness in other parts of the world. Doing so would help sustain the flows of ideas, trade, investment, and people that facilitate the creation and diffusion of knowledge for innovation.

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