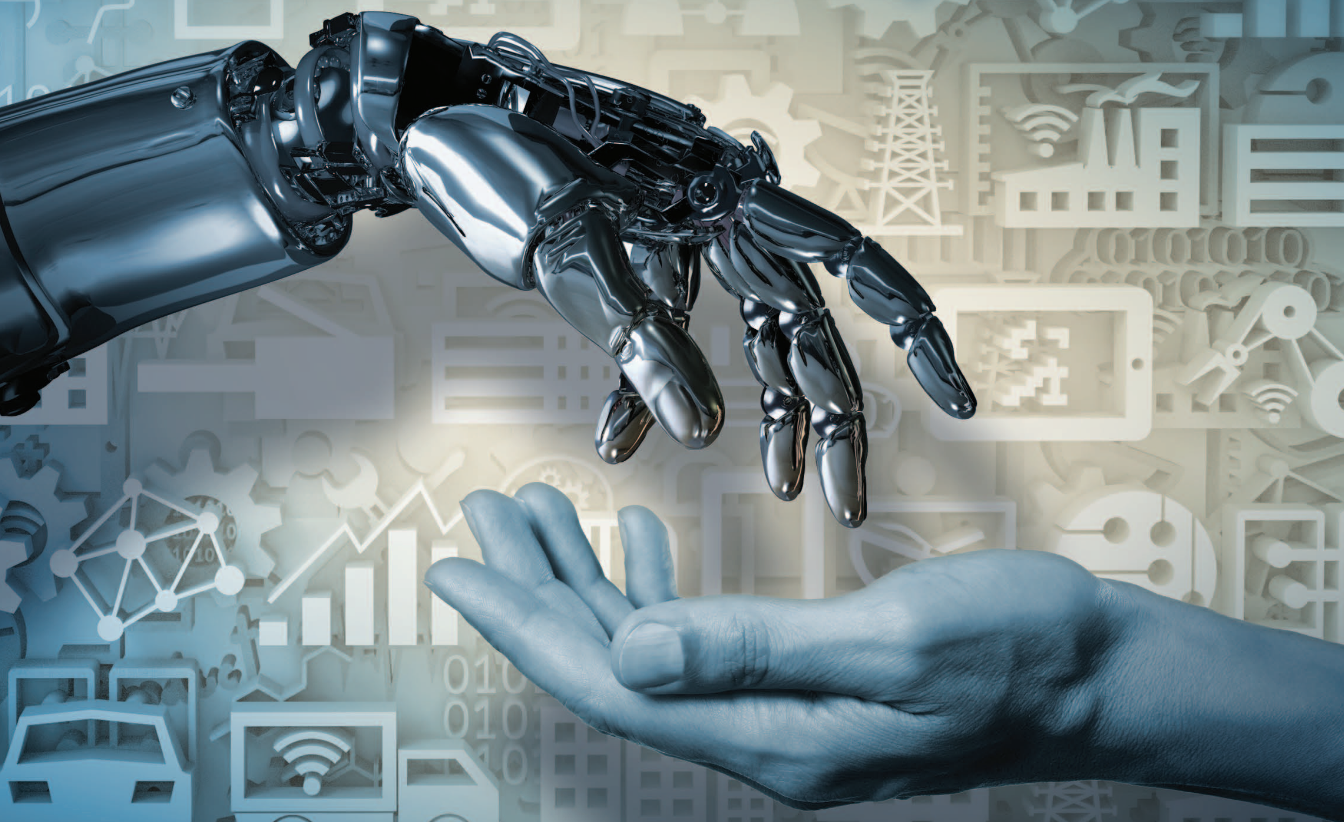
OVERVIEW

Trouble in the MAKING?

The Future of Manufacturing-Led Development



Mary Hallward-Driemeier
Gaurav Nayyar

WORLD BANK GROUP

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This booklet contains the overview, as well as partial front matter, from *Trouble in the Making? The Future of Manufacturing-Led Development,* doi: 10.1596/978-1-4648-1174-6. A PDF of the final, full-length book, once published, will be available at https://openknowledge.worldbank.org/ and print copies can be ordered at http://Amazon.com. Please use the final version of the book for citation, reproduction, and adaptation purposes.

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Foreword

With the global economy experiencing an era of profound change, building a prosperous society with an equitable distribution of income will require ever-greater ingenuity and stronger strategies. The creation of higher-skilled, higher-wage jobs is essential to achieving the twin goals of the World Bank Group—ending extreme poverty by the year 2030 and promoting shared prosperity—and will require investment and innovation across economic sectors, including agriculture, services, and manufacturing.

The surest way to raise workers' incomes is to create high-quality jobs. Historically, these have been found in manufacturing, but jump-starting job growth in manufacturing is no easy task for policymakers or the private sector. *Trouble in the Making? The Future of Manufacturing-Led Development* aims to help policymakers and business leaders envision new approaches to promoting manufacturing-led development.

Focusing on the impacts of new technologies and shifting patterns of globalization, the book recognizes that "business as usual" will not succeed in promoting manufacturing-led job growth in developing countries. However, it makes the case that wealth-generating, job-creating opportunities can indeed be seized. Success requires new approaches to promoting manufacturing that consider each economy's competitiveness, capabilities, and connectedness, within the context of ever-shifting international trade patterns, marketplace demands and financial strengths.

Society cannot afford to fail in confronting the challenges of the manufacturing sector. Any economy that misses opportunities for job creation—especially in the higher-skilled, higher-wage occupations that are concentrated in the manufacturing sector—is setting itself up for suboptimal growth rates and potentially an unstable society that suffers from a chronic concentration of wealth and poverty.

Designing effective strategies to broaden opportunities in production and related services will call for energetic economic thinking. Policies will be needed to raise education and skill levels, guide public- and private-sector finance to their most promising use, and reduce the barriers that have long hindered cross-border commerce and fair-minded development.

Government officials and private-sector leaders are seeking new ideas about strengthening productivity gains and bolstering job creation. This book offers a range of suggestions to help economic decision makers overcome these dilemmas.

Every economy will be affected by the accelerating change in global trends, and every policymaker and business leader who seeks practical solutions to the job-creation challenge can benefit from the imaginative ideas explored here.

Jan Walliser
Vice President, Equitable Growth, Finance and Institutions
The World Bank Group

Acknowledgments

This book has been led and written by Mary Hallward-Driemeier and Gaurav Nayyar, under the guidance of Anabel González. It has benefited enormously from the discussions and feedback of our advisory group—particularly Philip Schellekens, Marcio Cruz, José Guilherme Reis, and Jose Ernesto Lopez Cordova—and from the comments of our peer reviewers: James Emery, Michael Ferrantino, Alan Gelb, and William Maloney. The partnership with the World Bank's Development Economics Prospects Group and the contributions made by Philip Schellekens, S. Amer Ahmed, Marcio Cruz, and Bryce Quillin in helping conceptualize key issues to address and their roles in early discussions and consultations are gratefully acknowledged.

Background papers from Syud Amer Ahmed and Pinyi Chen[1]; Jean-Francois Arvis, Paul E. Kent, Ben Shepherd, and Rajiv Nair[2]; Penny Bamber, Olivier Cattaneo, Karina Fernandez-Stark, Gary Gereffi, Erik van der Marel, and Ben Shepherd[3]; and Marcio Cruz and Gaurav Nayyar[4] served as important inputs. Background notes from Arthur E. Appleton[5]; Xavier Cicera, Marcio Cruz, Natasha Kapil, and Denis Medvedev[6]; Jakob Engel and Daria Taglioni[7]; and Michele Ruta[8] also served as important inputs. Other contributions from Ileana Cristina Constantinescu, Arti Grover Goswami, Martha Martinez Licetti, and Sonia Plaza as well as comments from Wim Douw, Neil Gregory, Peter Kusek, Gladys C. Lopez-Acevedo, Andrei Mikhnev, José Ramón Perea, and Martin Rama are very much appreciated. Excellent research support has been provided by Kyun Suk Chang, Trisagni Sakya, and Linghui Zhu.

A number of external consultations also helped shape the messages of the book. Carl Dahlman (Organisation for Economic Co-operation and Development [OECD] Development Centre) and Shahid Yusuf (The Growth Dialogue, George Washington University) deserve special recognition for their extensive interactions with the team, particularly in the initial stages. The team also gratefully acknowledges the following: David Autor (MIT Economics), David Aitken (MIT Economics), Brian Anthony (MIT Mechanical Engineering), James Besson (Boston University Law), Asit Biswas (National University of Singapore), Jung-Hoon Chun (MIT Mechanical Engineering), Tyler Cowen (George Mason University Economics), Richard Freeman (Harvard Economics), Alan Gelb (Center for Global Development), Ricardo Hausmann (Harvard Kennedy School), César Hildago (MIT Media Lab), Brad Jensen (Georgetown McDonough School), Homi Kharas (Brookings Institution), Vu Minh Khuong (National University of Singapore), Jun Young Kim (National Research Council for Economics, Humanities and Social Sciences), Fukunari Kimura (Keio University), William Kirby (Harvard Business School), Fumio Kodama (Tokyo University), Josh Lerner (Harvard Business School), Justin Lin (Peking University), Antonio de Lecea (National University of Singapore), Danny Leipziger (George Washington University), Jeong-Dong Lee (Seoul National University), Donald Low (National University of Singapore), Andrew McAfee (MIT Initiative on the Digital Economy), Margaret McMillian (Tufts University), Danny Quah (National University of Singapore), John Page (Brookings), John Van Reenen (MIT Economics), John Richardson (National University of Singapore), Geunwoon Ryu (Keimyung University), and Jiang Yu (Chinese Academy of Sciences).

The team has also held consultations with a number of private sector firms working on the topic of manufacturing or research and development (R&D) in the areas of Industry 4.0 and the application of new technologies to improve labor productivity. These firms included AeroLion Technologies, Avetics, BASF Corporation, Bosch, Deloitte, DHL, Evonik, Fontainburg, Formlabs, Goldman Sachs, Hope Technik, Mitsubishi Electric, Mizuho Capital Markets Corporation, MJ Intelligent, NEC, NXP Semiconductors, Oxford Economics, POSCO, Samsung, SAP Software Solutions, Siemens, ST Microelectronics, Standard Chartered Bank, TE Connectivity, Toray, Toshiba, Tulip Interface, and UBS. The team has presented at the following events: an OECD workshop with members of the Directorates for Science, Technology and Innovation (STI), Trade and Agriculture, and Employment, Labour, and Social Affairs as well as the OECD Development Centre and Economics Department; the Korea Development Institute's (KDI) International Forum on the 4th Industrial Revolution and the Future of Industry; and a Center for Global Development roundtable on Africa's industrialization. It also had numerous consultations with think tanks and government agencies in China (Hong Kong SAR, Beijing, and Shanghai), Japan (Tokyo), and Singapore.

Notes

1. “Emerging Technologies, Manufacturing, and Development: Some Perspectives for Looking Forward.” 2017.
2. “Additive Manufacturing and the Diffusion of 3D Printing: Impact on International Trade.” 2017.
3. “Diversification through Servicification.” 2017.
4. “Manufacturing and Development: What Has Changed?” 2017.
5. “Role of Quality Infrastructure in Manufacturing-Led Development.” 2017.
6. “Technology Adoption in the Manufacturing Production Process and Innovation Policy Approach.” 2017.
7. “GVCs and the Future of Manufacturing-Led Development.” 2017.
8. “Trade, Trade Policy and the Future of Manufacturing.” 2017.

Abbreviations

GDP	gross domestic product
GVC	global value chain
IoT	Internet of Things
ICT	information and communication technology
LMICs	low- and middle-income countries
n.e.c.	not elsewhere classified
NTMs	nontariff measures
R&D	research and development
3Cs	competitiveness, capabilities, connectedness
WTO	World Trade Organization

Overview

Introduction

In the past, manufacturing-led development typically delivered both productivity gains and job creation for unskilled labor. Underpinning the productivity benefits of labor-intensive manufacturing was the sector's tradability in international markets, which not only reinforced scale economies and technology diffusion but importantly also provided greater opportunities to access demand beyond the domestic market and raised competition. The agricultural sector was also tradable but faced demand-side constraints owing to a low income elasticity of demand and productivity improvements that were closely linked to labor-saving technologies. Many low-end services could also absorb surplus labor from agriculture but provided little productivity growth.

Looking ahead, changing technologies and shifting globalization patterns bring manufacturing-led development strategies into question. Trade is slowing. Global value chains (GVCs) remain concentrated among a relatively small number of countries. The Internet of Things (IoT) advanced robotics, and 3-D printing are shifting what makes locations attractive for production and threaten significant disruptions in employment, particularly for low-skilled labor. These trends raise fears that manufacturing will no longer offer an accessible pathway for low-income countries to develop, and even if feasible, that it would no longer provide the same dual benefits of productivity gains and job creation for the unskilled. As a result, the potential risk of growing inequality across and within countries warrants closer attention to the implications of changing technology and globalization patterns.

This book looks at changing technology and globalization patterns across manufacturing subsectors, with a focus on creating opportunities in

low- and middle-income countries (LMICs). Much of the attention on these changing patterns treats "manufacturing" in the aggregate, highlights the downside risks, and focuses on high-income countries. This book, in contrast, looks at changing technology and globalization from the perspective of LMICs—emphasizing an analysis of differences across manufacturing subsectors and identifying policy priorities with an eye toward making the most of new opportunities. Any forward-looking discussion is inherently speculative; the aim here is to identify possible challenges and opportunities for LMICs to help them strengthen their position now. When analyzing shifts in technology and globalization patterns, the focus is on new manufacturing process technologies, trends in international trade and foreign direct investment (FDI), and the changing geography of production (defined both by aggregate manufacturing and by two-digit manufacturing subsectors at the country level).

The book will answer the following questions:

- How has the global manufacturing landscape changed, and why does this matter for development opportunities?
- How are emerging trends in technology and globalization likely to shape the feasibility and desirability of manufacturing-led development in the future?
- If low wages are going to be less important in determining competitiveness, how can less-industrialized countries make the most of new opportunities that the shifting technology and globalization patterns may bring?

Chapter 1: Why Manufacturing Has Been Important for Development

Some of the biggest development gains in history have been associated with the process of industrialization.[1] Until the early 19th century, annual growth in global gross domestic product (GDP) was below 0.1 percent. Then, between 1820 and 1870, the earliest industrializers in Western Europe and the United States registered rapid rates of per capita income growth of 1.0 and 1.3 percent, respectively, compared with close to zero in other regions such as East Asia and Latin America. It was industrialization again that drove other countries to catch up, starting in the late 19th century with Japan. More recently, the "economic takeoff" circa 1960 that resulted in East Asia's growth miracle coincided with the rapid export growth of manufactures (Leipziger 1997; Rodrik 1994; Stiglitz and Yusuf 2001; World Bank 1993).[2] Those few countries that have reached high-income levels through other means have done so through natural resource extraction[3] or the exploitation of specific locational or other advantages.[4]

Yet not all countries benefited equally from industrialization, which demonstrated the importance of the "how" rather than the "what" of production. Some countries that attempted industrialization were successful in climbing up the income ladder. Others saw progress stall after a transitory pickup of economic growth, such as in Latin America. Still other countries, including many in Sub-Saharan Africa and South Asia, never managed to break into manufacturing production to a significant extent. In many of these countries, efforts to industrialize without openness—for example, through import substitution—led to costly failures. Similarly, the adoption of capital-intensive techniques of production in heavy industries did not result in the large-scale absorption of unskilled labor. It is therefore not surprising that countries that have reached high income levels did so through manufacturing export–led strategies rather than import substitution approaches (Agénor and Canuto 2015).

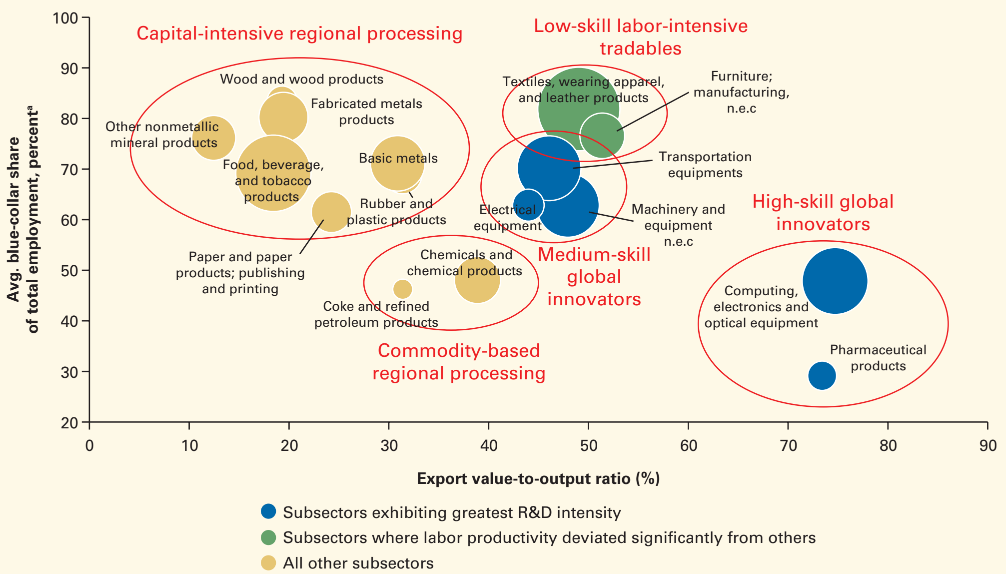
The manufacturing sector was different from other sectors because it absorbed large numbers of relatively unskilled workers at a substantial productivity premium, which was underpinned by the sector's tradability in international markets. Manufacturing has traditionally absorbed a substantial part of the economy's low-skilled labor from agriculture at higher levels of productivity (McMillan and Rodrik 2011). Further, labor productivity in low- and middle-income economies' manufacturing sectors tends to converge to the frontier over time because they produce tradable goods, thus facilitating scale economies, technology diffusion, greater competition, and other spillover effects (Rodrik 2013). Although the agricultural sector was also tradable, demand-side dynamics have played a constraining role: as per capita incomes rise, the share of agricultural products in total expenditure declines, while the share of manufactured goods increases in accordance with a hierarchy of needs.[5] Further, productivity improvements in agriculture were closely linked to labor-saving technologies.[6] As for the services sector, high-end professional services are skill-intensive and were typically not tradable before the information and communication technology (ICT) revolution, whereas many low-end services that could absorb surplus labor from agriculture provided little productivity growth.

Manufacturing's uniqueness can be summarized in the combination of five characteristics that identify potential sources for spillovers or are sought-after development outcomes in themselves. Among these characteristics, a sector's *tradedness in international markets* (its export-to-output ratio) indicates the potential for spillovers through learning-by-doing, scale economies, technology diffusion, and greater competition. Assessing tradedness alongside the sector's *extent of innovation* (ratio of research and development [R&D] spending to value added) can provide a more complete picture about the scope for knowledge spillovers. Expanding *employment* (total sector employment), particularly the *share of unskilled labor* (the share of blue collar workers within a sector), might itself be a goal for policy makers because it provides a means of livelihood to poorer households, beyond the spillovers associated with on-the-job learning-by-doing and a strengthened sense of social cohesion (World Bank 2012). Whether this unskilled labor is employed at a productivity premium can then be further assessed by also looking at the *level of value added per worker* (output per worker).

However, the manufacturing sector is not monolithic and there is heterogeneity in this employment-productivity-trade space across subsectors. The clustering of these pro-development characteristics delineates five groups: "high-skill global innovators," "medium-skill global innovators," "low-skill labor-intensive tradables," "capital-intensive regional processing," and "commodity-based regional processing" (figure O.1). These groups can be useful in comparing the evolving distribution of production across countries and the potential for different countries to realize these sources of gains.

The extent of these pro-development characteristics is not innate to a subsector but varies across countries, over time, and between firms. Pro-development characteristics associated with the same manufacturing subsector vary across countries, often reflecting its position in GVCs. For example, LMICs are typically engaged in the labor-intensive assembly of manufacturing industries classified as high-skill global innovators, medium-skill global innovators, and low-skill labor intensive tradables, all of which employ much larger shares of blue-collar workers in India, Mexico, and Vietnam than in high-income countries such as France, Spain,

Figure O.1 Manufacturing Subsectors, Grouped by Pro-Development Characteristics, 2013



Sources: Calculations based on United Nations Industrial Development Organization (UNIDO) Industrial Statistics (INDSTAT) database; UN Comtrade database; University of Minnesota's Integrated Public Use Microdata Series (IPUMS) International database.

Note: Bubbles colored blue indicate the five subsectors exhibiting the greatest R&D intensity. Bubbles colored green indicate subsectors that deviated significantly from others in terms of labor productivity. Bubble size indicates each manufacturing subsector's share of total manufacturing employment. n.e.c. = not elsewhere classified.

a. For blue-collar shares, occupations classified as International Standard Classification of Occupations (ISCO) groups 5, 7, 8, and 9 are labeled as blue-collar occupations. Total number of sector employees includes occupations classified as ISCO groups 1, 2, 3, 4, 5, 7, 8, and 9. Blue-collar shares are calculated at sector-by-country level for selected countries using census data harmonized by IPUMS International.

and the United States. The magnitude of pro-development characteristics across manufacturing subsectors has also changed over time, albeit not dramatically. Further, although there will likely be considerable heterogeneity in these pro-development characteristics between firms even within highly disaggregated industries, this analysis highlights broader activities that are likely to bring spillovers and contribute to growth and job creation as part of a country's development strategy.

The development impact of manufacturing comes not only from "production" per se but also increasingly from services involved in a product's broader value chain. The boundaries between sectors are blurring, and "manufacturing" increasingly represents the entire value chain of producing goods. Services are often embodied in goods (as part of the manufacturing process), and more services are being embedded in goods during postproduction (such as after-sales support and other add-on services)—a process called the "servicification" of manufacturing. Although this book purports to be about "manufacturing," a key message is that what matters is making and adding value at every stage of the production process—from raw materials to design and production, and all the way to sales and follow-on services.

Chapter 2: What Has Changed in the Manufacturing Landscape: Is Trouble Already Brewing?

Given the spillovers and dynamic gains associated with manufacturing and the heterogeneity within, relevant trends that describe the changing global manufacturing landscape provide an indication of benefits associated with production patterns. This chapter presents a set of 12 stylized facts to summarize changes in the global manufacturing landscape, particularly over the past two decades. In doing so, it looks at manufacturing both in the aggregate and across more disaggregated manufacturing sector groups. The stylized facts fall into three categories of change:

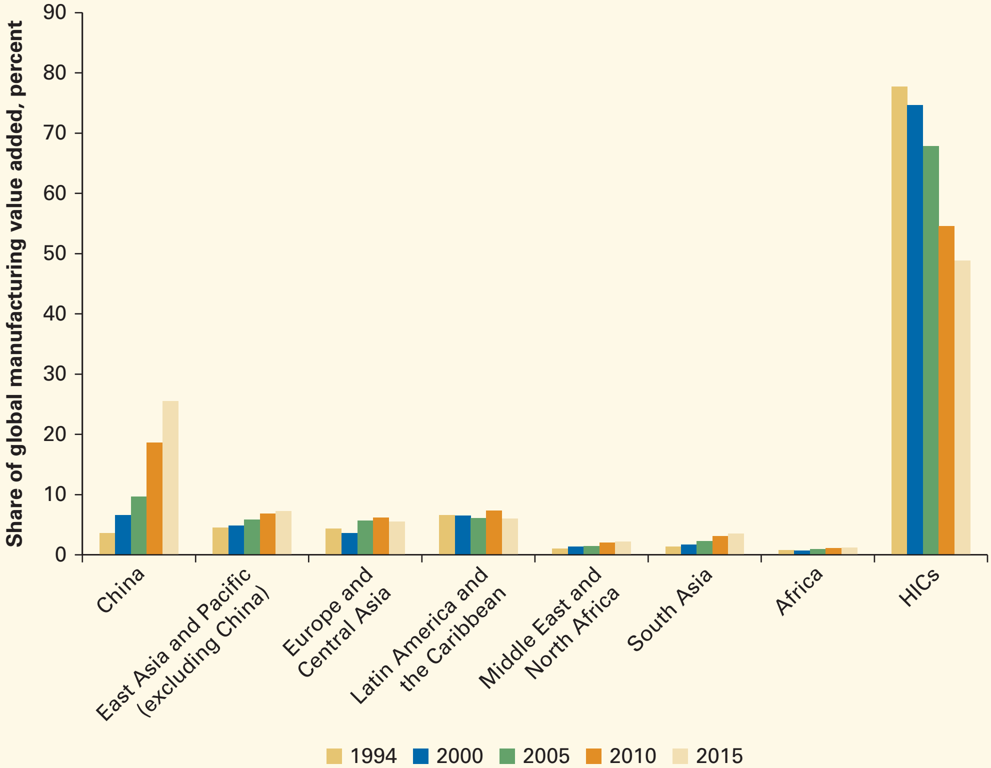
- *Distribution of global shares of manufacturing*. The first four stylized facts explore shifting patterns in manufacturing in terms of shares of global GDP, employment, productivity, and exports to shed light on the extent to which LMICs have emerged as global players.
- *Manufacturing as a share of GDP and employment*. Five stylized facts look at changes in manufacturing as a share of GDP and employment relative to other sectors in the economy as well as in absolute terms.
- *Composition of manufacturing subsectors across countries*. Using revealed comparative advantage and changing domestic production baskets, three stylized facts examine the extent to which there is evidence of the product cycle or "flying geese" paradigm.

Distribution of Global Shares of Manufacturing

Stylized Fact 1: High-income countries still account for most of global manufacturing value added, even as their shares decline and China has become the single largest producer of manufactured goods (figure O.2).

Figure O.2 Although Still Significant, High-Income Countries' Global Share of Manufacturing Value Added Has Been Declining, as China Stands Out as an Expanding Producer

Share of global manufacturing value added in China, global regions, and high-income countries, 1994–2015



Source: World Development Indicators database.
Note: High-income countries (HICs) as defined in 1994 are those whose gross national income per capita was at least US$8,955.

Stylized Fact 2: LMICs' shares in manufacturing employment are higher than their shares of value added, with China employing more than twice the workers of all high-income countries combined (figure O.3).

Stylized Fact 3: Productivity differences across countries remain substantial and have been rising over the past 20 years between the dominant and smaller producing countries (figure O.4).

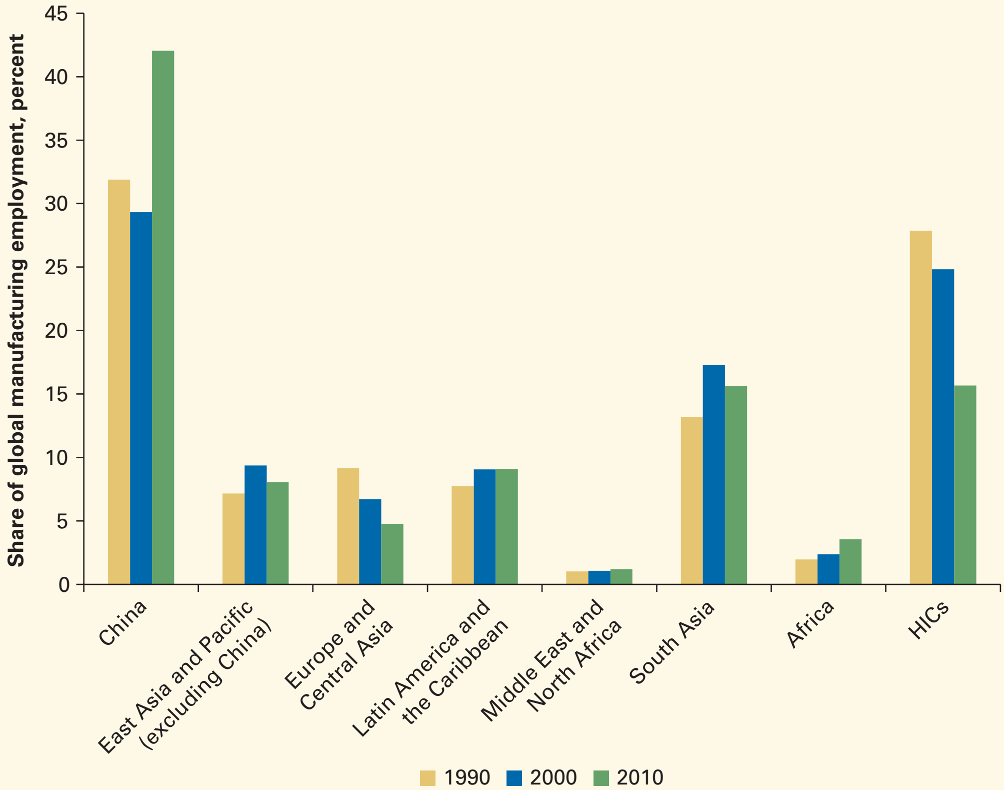
Stylized Fact 4: High-income countries remain dominant players in terms of exports, too—and across all five manufacturing sector groups—with China joining their ranks in four of the five.

Manufacturing as a Share of GDP and Employment

Stylized Fact 5: The share of manufacturing value added in global GDP has been declining for decades as services have grown relatively faster (figure O.5).

Figure O.3 Shares of Global Manufacturing Employment Are Significantly Higher in Low- and Middle-Income Countries than Their Shares of Global Manufacturing Value Added

Share of global manufacturing employment in China, global regions, and high-income countries, 1990–2010



Sources: ILOSTAT database, International Labour Organization (ILO); Key Indicators of the Labour Market (KILM) database, ILO; Groningen Growth and Development Centre (GGDC) 10-sector database, University of Groningen, Netherlands.

Note: Figure includes only 67 economies for which data were available for 1995, 2000, and 2010. (Germany's missing 1990 data were replaced by data for 1995.) High-income countries (HICs) as defined in 1990 are those whose gross national income per capita was at least US$7,620. Europe and Central Asia includes only five countries (Azerbaijan, Poland, the Russian Federation, Slovenia, and Ukraine). South Asia includes only India. Middle East and North Africa includes only the Arab Republic of Egypt and Morocco. Latin America and the Caribbean includes 20 countries.

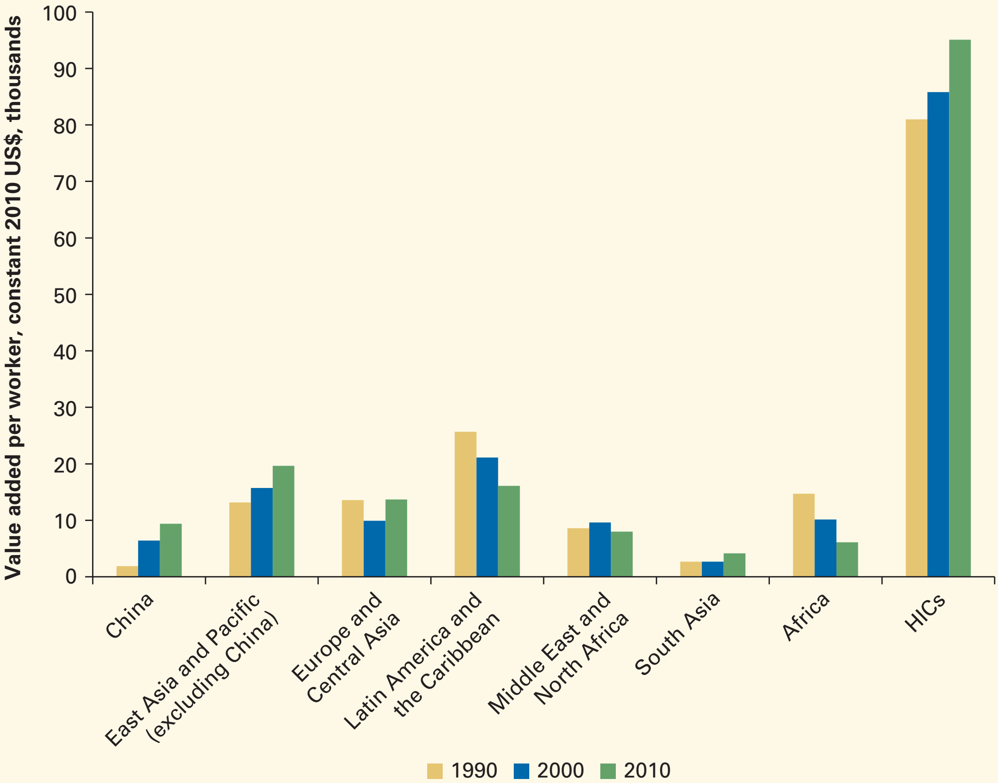
Stylized Fact 6: Three-quarters of countries—including China—are experiencing a decline in the share of manufacturing in GDP (figures O.6 and O.7).

Stylized Fact 7: Changes in the manufacturing share of total employment overlap with those of value added in most countries—but often are bigger (figure O.8).

Stylized Fact 8: In only a few cases did these relative declines of the manufacturing sector in GDP or employment translate into absolute declines.

Figure O.4 Labor Productivity Is Rising among the Dominant Manufacturing Countries—As Is the Productivity Gap with Smaller Producing Countries

Manufacturing labor productivity in China, global regions, and high-income countries, 1990–2010



Sources: ILOSTAT database, International Labour Organization (ILO); Key Indicators of the Labour Market (KILM) database, ILO; Groningen Growth and Development Centre (GGDC) 10-sector database, University of Groningen, Netherlands; United Nations (UN) National Accounts database.
Note: Figure includes only 66 economies (instead of the 67 included in figure O.3) owing to the lack of data on value added for Taiwan, China. (Germany's missing 1990 data were replaced by data for 1995). High-income countries (HICs) as defined in 1990 are those whose gross national income per capita was at least US$7,620. "Europe and Central Asia" includes only five countries (Azerbaijan, Poland, the Russian Federation, Slovenia, and Ukraine). "South Asia" includes only India. "Middle East and North Africa" includes only the Arab Republic of Egypt and Morocco. "Latin America and the Caribbean" includes 20 countries.

Stylized Fact 9: The manufacturing shares of both total value added and employment are peaking at lower levels and at lower levels of per capita income than in the past.

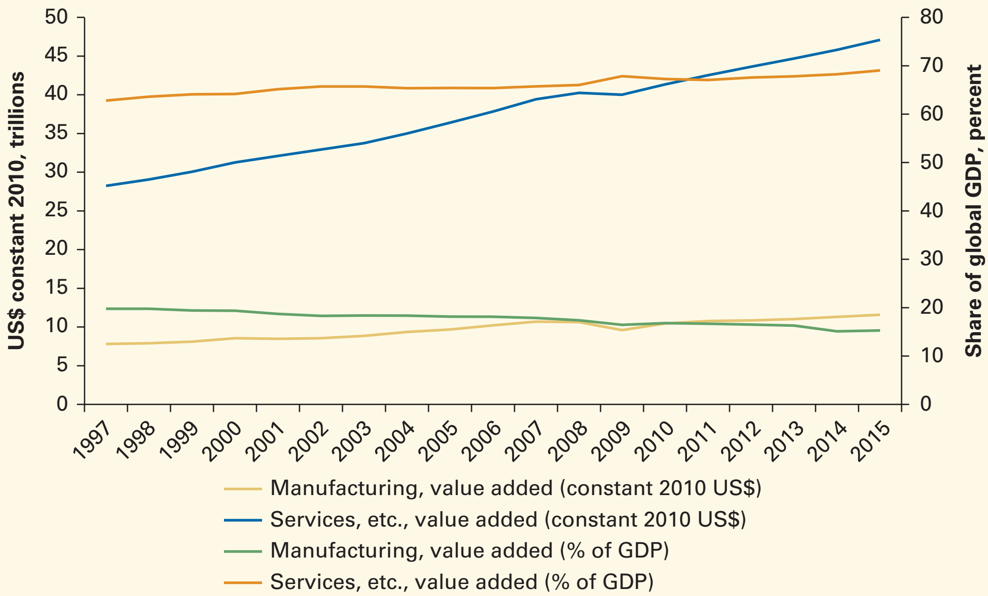
Patterns of Subsector Specialization across Countries

Stylized Fact 10: Almost all high-income countries are deindustrializing across the five sector groupings.

Stylized Fact 11: Among the upper-middle-income industrializers, the changing composition of production and export baskets shows evidence of

Figure O.5 Real Global Manufacturing Value Added Is Growing, but not as Fast as Services, so Its Share of GDP Is Falling

Global manufacturing share of GDP and absolute value relative to services, 1997–2015



Source: World Development Indicators database.

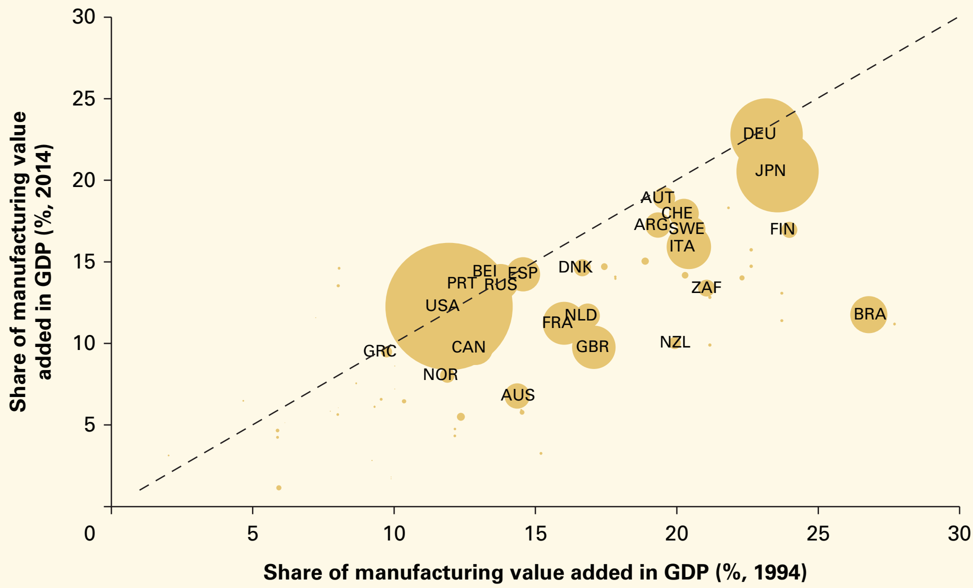
the "flying geese" paradigm—moving from labor-intensive to higher-skill manufactured goods—except for China, which remains a big player in the labor-intensive sectors, too.

Stylized Fact 12: Few lower-income countries outside of Asia have a revealed comparative advantage in anything but labor-intensive tradables or commodity-based regional processing—although not all even have passed these thresholds.

These specialization patterns in the manufacturing sector across low- and lower-middle-income economies have implications for potential spillovers and dynamic growth and development gains. Overall, greater opportunities for lower-income countries are being realized in labor- and commodity-intensive manufactures. For those with a presence in the global market for labor-intensive tradables, the sector brings together the benefits of international trade—scale, technology diffusion, and competition—with large-scale employment creation for unskilled workers. Although commodity-based regional processing comprises industries that are less traded internationally and therefore benefit less from related productivity spillovers, there is still scope for job creation for unskilled labor. The lack of presence in GVCs for high-skill global innovators and medium-skill global innovators means that few lower-income countries have successfully combined unskilled jobs in labor-intensive assembly with the

Figure O.6 Countries with *Shrinking Global Shares* in Manufacturing Value Added Include Almost All Countries That Were High Income in 1994, and Almost All Are Deindustrializing Domestically

Change in manufacturing value added as a share of domestic GDP among countries with contracting global shares, 1994–2014



Sources: World Development Indicators database; United Nations Industrial Development Organization (UNIDO) Manufacturing Value Added (MVA) 2017 database; U.S. Bureau of Economic Analysis National Economic Accounts database.

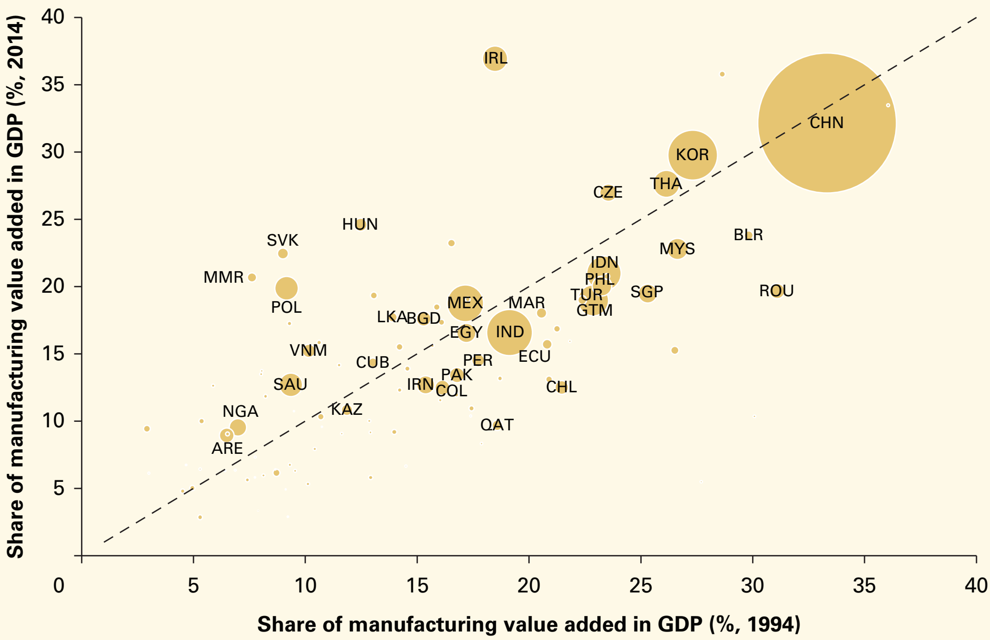
Note: The dotted 45-degree line separates countries that are industrializing (above the line) from those that are deindustrializing (below the line) over time. Bubble size represents a country's global share of manufacturing value added in 2014.

highest scope for technology diffusion, owing to R&D being carried out in high-income economies.

Looking ahead, a concern is whether new technologies and shifting patterns of globalization will make it harder for LMICs to have a significant role in manufacturing, including in sectors that define their current production baskets. Historically, changes at the intersection of technology and globalization (figure O.9)—from the first Industrial Revolution in the 18th century to the ICT revolution in the 1990s—have had an important association with evolving comparative advantage and therefore patterns of specialization in the manufacturing sector. Not all countries have benefited equally, but there has been a pattern over time of additional lower-income countries using manufacturing as a central driver of their development. To the extent that big global players continue to account for large shares of manufacturing, agglomeration economies might make hitherto less-industrialized countries less competitive in export markets. Further, to the degree that the most-emphasized process technologies associated with

Figure O.7 Among Countries with *Expanding Global Shares* in Manufacturing Value Added, Half Are Still Deindustrializing Domestically

Change in manufacturing value added as a share of domestic GDP among countries with expanding global shares, 1994–2014



Sources: World Development Indicators database; United Nations Industrial Development Organization (UNIDO) Manufacturing Value Added (MVA) 2017 database; U.S. Bureau of Economic Analysis National Economic Accounts database.
Note: The dotted 45-degree line separates countries that are industrializing (above the line) from those that are deindustrializing (below the line) over time. Bubble size represents a country's global share of manufacturing value added in 2014. Ireland's outlier position reflects in part tax advantages it offers to multinational corporations that locate headquarters there.

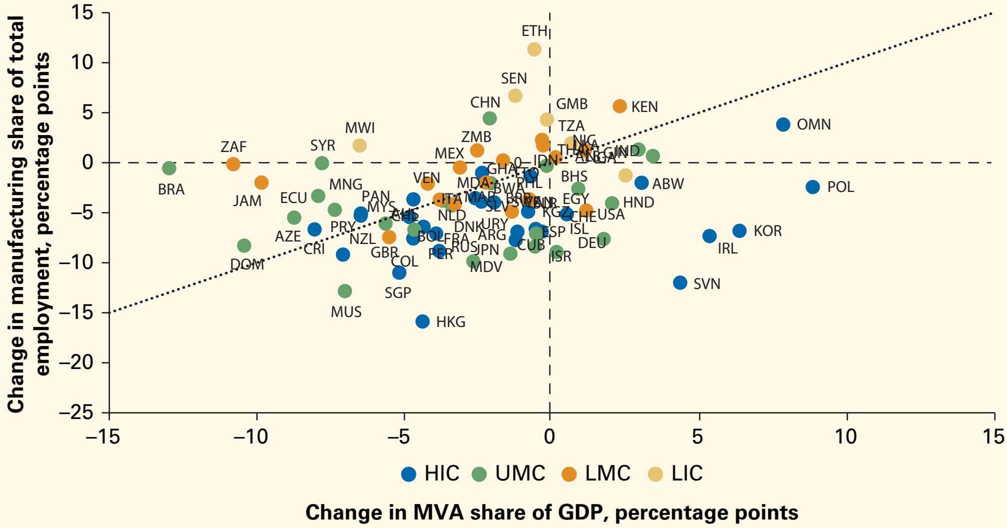
Industry 4.0[7] (a new production paradigm widely defined as the fourth industrial revolution)—such as the IoT, advanced robotics, and 3-D printing—may be labor-saving, they potentially narrow the paths for less-developed countries to realize the pro-development characteristics that manufacturing has traditionally offered. Chapters 3 and 4 explore these questions even if definitive answers cannot be provided, as many of the new technologies being discussed are only starting to spread.

Chapter 3: Trends Shaping Opportunities for Future Production

While the future manufacturing landscape will be influenced by many megatrends—including demographic change, urbanization, and climate change—new technologies and changing globalization patterns will remain

Figure O.8 The Changes in Manufacturing Employment Are Often Greater than Those in Value Added, 1994–2011

Change in manufacturing shares of employment and GDP, by country income level, 1994–2011



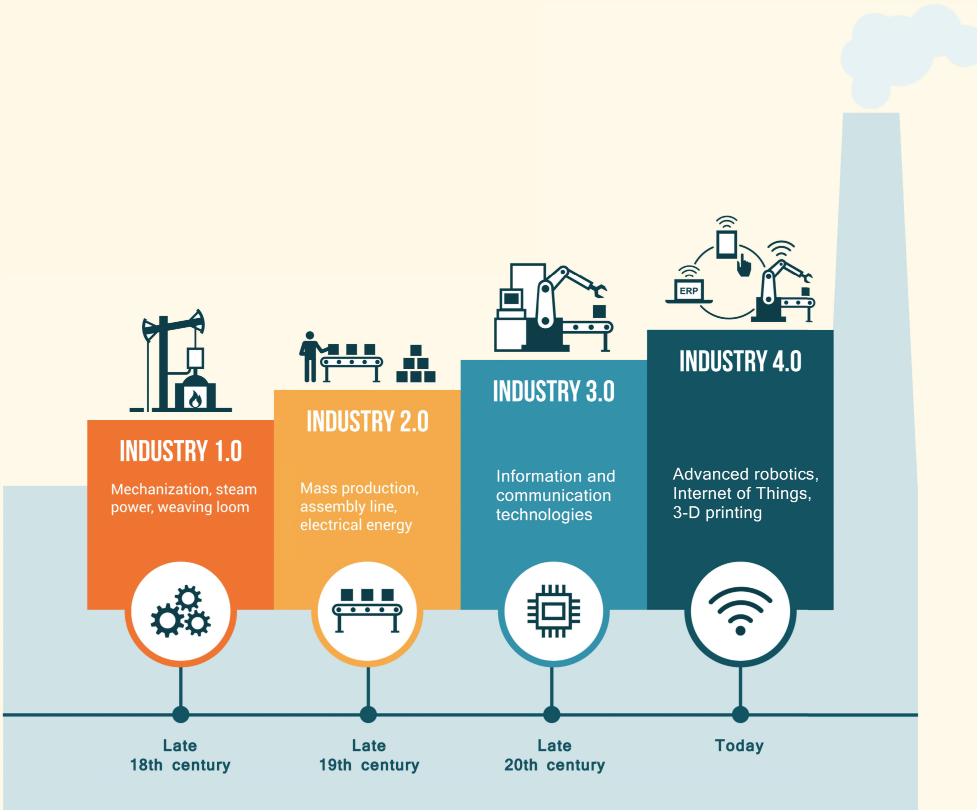
Sources: ILOSTAT database, International Labour Organization (ILO); Key Indicators of the Labour Market (KILM) database, ILO; Groningen Growth and Development Centre (GGDC) 10-sector database, University of Groningen, Netherlands; World Development Indicators database; United Nations Industrial Development Organization (UNIDO) Manufacturing Value Added (MVA) database 2017.
Note: HIC = high-income country; LIC = lower-income country; LMC = lower-middle-income country; UMC = upper-middle-income country.

central to the changing geography of production. The growth in demand for manufactures might be dampened by the higher income elasticity of demand for services and the dematerialization of consumption owing to climate change concerns, the sharing economy, more efficient production processes, and bundling of features in a single good. However, as the populations of LMICs expand and urbanize, incomes rise, and material standards of living continue to converge (Kharas 2010; WEF 2012), strong global demand for manufactured goods is likely to continue. And given their past importance, changes at the intersection of technology and globalization will remain the most relevant forces shaping the geography of manufacturing production. A key question will be whether new trends will weaken the industrialization prospects across a broad range of LMICs or whether they will create new potential to boost manufacturing output and exports and leverage them for growth.

Changes in the global trade environment itself may affect opportunities for countries less involved in global manufacturing, but these prospects will be further influenced by emerging technologies that are creating new product lines and transforming production processes. The end of the

Figure O.9 Each Industrial Revolution Shifts Manufacturing Opportunities and Patterns of Specialization

Industrial revolutions and shifts in manufacturing specialization, late 18th-century–present



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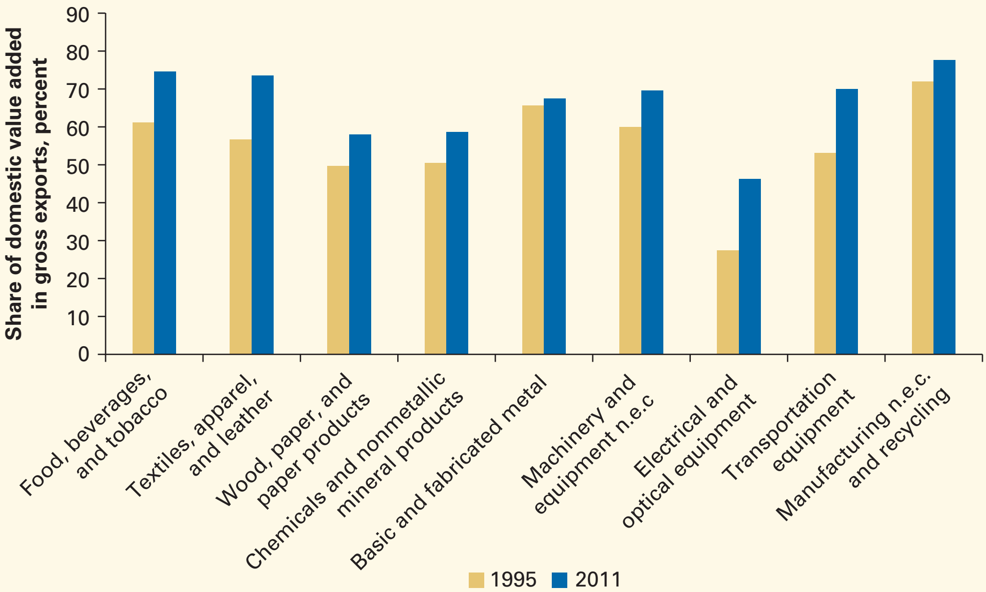
commodities super-cycle and China's production upgrading provide new opportunities for export-led manufacturing in countries hitherto less involved in GVCs. Presenting new challenges, at the same time, are weak import demand resulting from the trade slowdown following the 2008 financial crisis, the declining trade in parts and components, and China's continued expansion at even the lower end of GVCs (figure O.10). The potential for low- and middle-income economies already in GVCs to boost their manufacturing exports in the future, and leverage them for growth, is also affected by how emerging technologies change globalization patterns—the effects of which could vary substantially across countries with different levels of manufacturing sector development.

For most LMICs, the impact of new technologies is likely to be felt most through new manufacturing process technologies—primarily the IoT, advanced robotics, and 3-D printing—that can change globalization

Figure O.10 China Increased Its Domestic Value Added in Gross Exports across All Manufacturing Sectors between 1995 and 2011

Change in domestic value added of manufacturing sectors in China, 1995–2011



Source: Calculations based on Trade in Value Added (TiVA) database of the Organisation for Economic Co-operation and Development and World Trade Organization.
Note: n.e.c. = not elsewhere classified.

patterns. Although new technologies encompass a wide range of advanced goods, what holds the potential to be disruptive for low- and middle-income economies is the use of new process technologies to produce traditional manufactured goods, which can change coventional patterns of comparative advantage. The focus here is on robotics (particularly artificial intelligence [AI]-enabled); digitalization and IoT, including sensor-using "smart factories" (that may also be AI-enabled); and 3-D printing. These are among the most emphasized technologies in the Industry 4.0 literature (Cirera et al. 2017). Moreover, while not all of these technologies are new (robots and 3-D printing have been around for decades, and IoT builds on ICT legacy technologies), cost innovation, software advances, and evolving business formats and consumer preferences are fueling adoption.

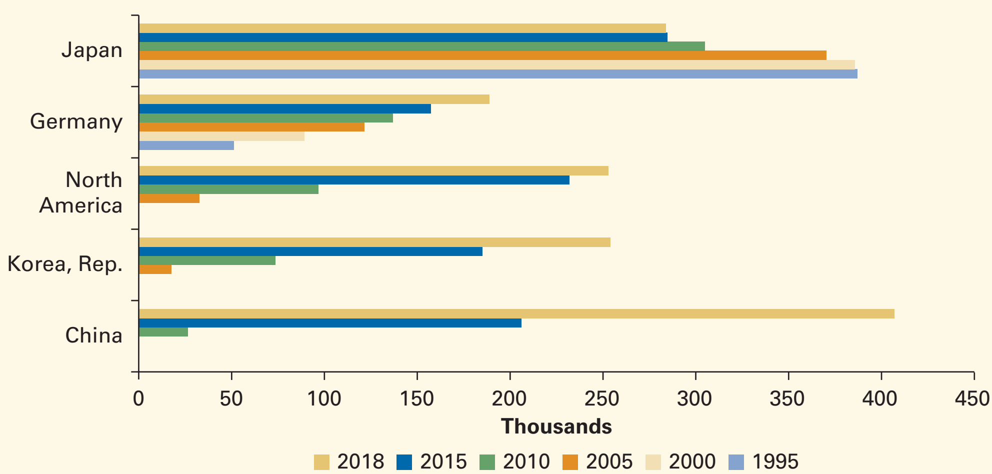
The greater diffusion of existing ICT technologies and newer IoT developments can reduce trade and coordination costs and strengthen globally fragmented production. New technologies in the IoT space, some of which are already in use, can further reduce the costs of coordinating globally fragmented production by making it easier to track and monitor components as they move through the supply chain. Cloud computing, for example, can change the landscape of information storage and exchange while also enabling better, more cost-effective coordination of globally fragmented production. Similarly, the analysis of large, fast-moving, and varied streams of "big data" has received much attention because it can enable firms in GVCs to optimize complex distribution, logistics, and production networks.

At the same time, greater digitalization through IoT and advanced robotics may challenge established patterns of comparative advantage if it becomes more efficient to rebundle activities in "smart" factories. By reducing the relative importance of wage competitiveness, increased automation under Industry 4.0 may make it feasible for some leading firms to reshore labor-intensive activities back to high-income economies and closer to final consumers. But reports about the advent of reshoring and resulting changes in globally fragmented production at present appear to be greatly exaggerated. At the same time, evidence suggests that Chinese manufacturers are increasingly turning to automation to deal with labor market pressures, with the country projected to have the largest number of installed industrial robots in the world by 2018 (figure O.11). Such a development potentially becomes all the more important given recent expectations of an en masse migration of light manufacturing activities to poorer economies with lower labor costs, such as those in Sub-Saharan Africa.

3-D printing, which is still too costly to be widely used, can be either scale-reducing or scale-enhancing, with mixed implications for the

Figure O.11 High-Income Countries Were the Largest Users of Industrial Robots in Manufacturing between 1995 and 2015, but China Is Expected to Have the Largest Operational Stock by 2018

Operational stock of industrial robots in manufacturing, selected countries and regions, 1995–2018



Source: Calculations based on Industrial Robots Statistics, International Federation of Robotics.
Note: Industrial robots are also used in agriculture, mining, utilities, and construction. The stock of industrial robots in China, for example, is projected at around 600,000 in 2018 when these sectors are included.

geography of global production. Scale is expected to matter less with 3-D printers than with other new manufacturing process technologies, and the demand for customized, quickly delivered goods could lead to geographically dispersed manufacturing activity—that is, a "micromanufacturing" model whereby even small businesses in a wide range of LMICs can access international designs and print them locally. However, this scenario might be constrained by the scarcity of trained technicians and engineers or by unreliable electricity supply. The weak protection of intellectual property rights is another factor: firms will be unlikely to send designs to places where they can easily be printed without limit for customers not paying license fees or royalties. Further, countries that are not open to trade in services risk being left behind because the 3-D printing model effectively substitutes trade in services (through the payment of license fees and royalties for designs) for goods trade. Therefore, either given these limitations on the widespread use of 3-D printing or if scale economies in 3-D printing itself turn out to be strong, printing activity could cluster in hub locations close to major markets (Arvis et al. 2017).

Chapter 4: Likely Impacts of Trends on the Feasibility and Desirability of Manufacturing-Led Development

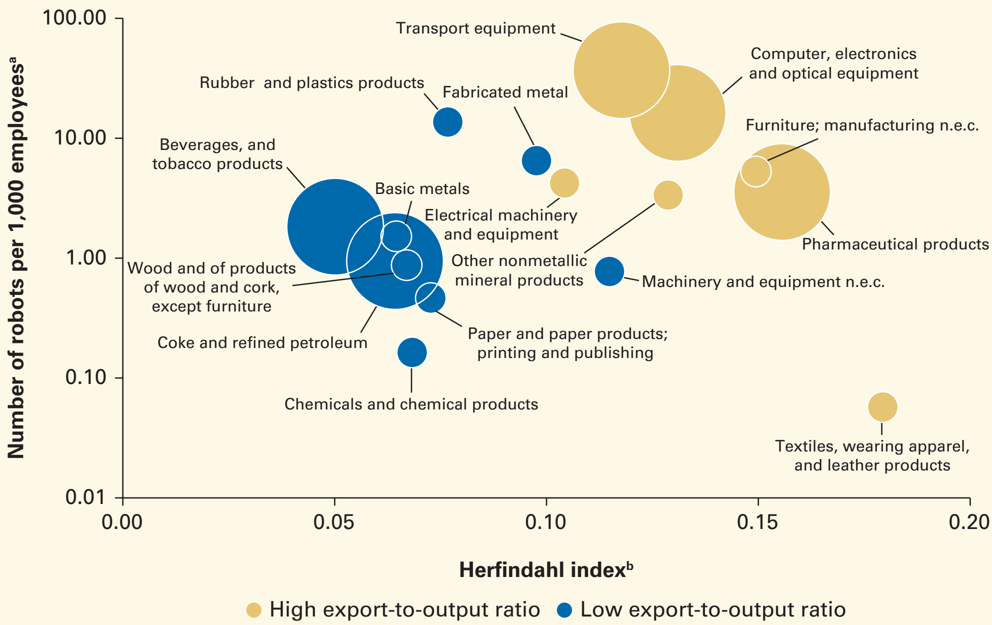
The feasibility of manufacturing-led development may decline because cheap labor as a source of competitive advantage is increasingly giving way to more demanding ecosystem requirements for countries still using Industry 2.0 technologies. Less-industrialized countries, where firms are using processes associated with Industry 2.0 (such as assembly line production), will be competing on price, with low labor costs a key factor determining success. However, these production processes may be less viable in the future if processes based on Industry 4.0 in high-income economies (such as robotics and 3-D printing) deliver higher quality at lower prices. To break into the low-end, unskilled-labor-intensive segments of GVCs, firms in lower-income countries would need to meet more demanding ecosystem requirements in terms of infrastructure, logistics and other backbone services, regulatory requirements, density of the supplier base, and so on to reduce unit labor costs if low wages are no longer sufficient. The increasing "servicification" of manufacturing will particularly raise the bar on what is feasible, thereby placing a premium on increasing the productivity of services embodied and embedded in manufacturing.

The alternative—using Industry 4.0 technologies to produce traditional manufactured goods—has a higher bar, too. The second way that the feasibility of manufacturing-led development may decline is that the requirements to support the adoption of new technologies are rising. New technologies place higher demands on the availability and reliability of ICT services, the data ecosystem, skills, and intellectual property rights. And if the time to market matters that much more and links with suppliers need to be that much more seamless, then the feasibility of using these new production processes depends on the ecosystem as well as the technical requirements. It may be particularly challenging for firms in countries with a less-established manufacturing base to leapfrog into using new technologies, not having already established certain processes, skills, and networks using more-accessible technologies.

The changing feasibility of manufacturing subsectors can be assessed on the relative magnitude of automation, export concentration, and services intensity, conditional on the extent to which they are internationally traded. These dimensions represent key ways in which new technologies and changing globalization patterns are raising the bar for countries to be competitive locations for manufacturing (figure O.12). Several manufacturing

Figure O.12 The Bar Is Rising for Some Manufacturing Subsectors More than Others Owing to the Relative Magnitude of Automation, Export Concentration, and Services Intensity, Conditional on the Extent to Which They Are Internationally Traded

Manufacturing subsectors, grouped by export concentration, degree of automation, services intensity, and tradedness, circa 2011–15



Sources: Calculations based on United Nations Industrial Development Organization (UNIDO) Industrial Statistics INDSTAT database; International Federation of Robotics (IFR) World Robotics database; and UN Comtrade database.

Note: Bubble colors indicate the subsectors' export-to-output ratios as reflected in two categories: above and below 40 percent, using combined 2011 UN INDSTAT and Comtrade data. Bubble size reflects the share of professional, scientific, and technical service inputs in value added and is defined by two categories: those above and those below 10 percent, using 2014 World Input-Output Database (WIOD) data.

a. The number of robots per 1,000 employees uses the 2015 stock of operational robots from IFR data and the number of 2013 employees from 2015 UN INDSTAT observation.

b. The Herfindahl index is a commonly accepted measure of market concentration based on market share of each firm competing in a market. Here it is adapted to the share of countries in the total exports of a particular sector or good, using 2013 UN Comtrade data.

subsectors combine a relatively high Herfindahl-Hirschman index of export concentration[8] with a relatively high number of robots per 1,000 workers currently in use, and therefore these subsectors are likely to be the most competitive to break into or maintain: electronics, computer, and optical instruments; pharmaceutical products; transportation equipment; other machinery and equipment; electrical machinery and apparatus; and manufacturing not elsewhere classified (n.e.c.).[9] Among the other subsectors, textiles, apparel, and footwear are the least automated but are characterized by a high degree of export concentration,[10] while fabricated metal products and rubber and plastic products are quite automated but with less export concentration and a lower overall trade intensity. A range of commodity-based manufactures are both less automated and have the lowest trade concentration ratios, and global competition will likely be the lowest in these subsectors. Food processing and coke and refined petroleum, however, are among the manufacturing subsectors that are relatively more intensive in the use of professional services.

Some manufacturing industries will remain entry points for development and critical drivers of employment, especially for lower-skilled workers, but the range is shrinking. In less-industrialized countries, the manufacturing sector's job creation capacity is of increasing concern. But manufacturing industries that are less traded and currently less automated—commodity-based processing manufactures, for example—will remain an entry point for hitherto less-industrialized countries and a driver of low-skill employment. This group includes a range of subsectors including food processing, wood products, paper products, basic metals, nonmetallic mineral products, coke and refined petroleum, and chemical products. Countries that combine low wage costs with a sound business environment could maintain the cost-effectiveness of labor-intensive production over greater robotization in highly traded subsectors such as textiles, garments, and footwear. Domestic or regional markets for lower-quality, lower-price manufactures will also likely be viable. Therefore, manufacturing will remain in most countries' futures—just not necessarily as the same source of dramatic growth that the East Asian manufacturing powerhouses experienced.

Just how many current jobs are put at risk by labor-saving technologies is at the heart of concerns about the desirability of manufacturing in the future, but recent evidence reveals that many of these concerns are exaggerated, especially in LMICs. Some studies estimate that half or more of current occupations across all sectors could be automated away by new technologies (Bowles 2014; Frey and Osborne 2013; Manyika 2016; World Bank 2016). However, breaking down occupations into tasks with varying levels of automatability, Arntz, Gregory, and Zierahn (2016) find a much lower share of jobs that could be automated away in a set of Organisation for Economic Co-operation and Development (OECD) economies, with 6–12 percent of current jobs at high risk of automation. When this approach is extended to cover a broader set of economies, the threat of automation to jobs is found to be relatively modest, at 2–8 percent for LMICs (Ahmed and Chen 2017). There is similarly little evidence thus far of polarization due to new technologies in LMIC labor markets (Maloney and Molina 2016).

These estimates do not include the additional "potential jobs" that could be lost by never being created, and they also overlook the possibility that new technologies could lead to creation of more jobs or new occupations in the future. "Potential jobs" could be lost in LMICs as high-income countries adopt new technologies and keep more manufacturing within their own borders. Further, if the only way LMICs can compete in manufacturing GVCs is by adopting labor-saving processes (that is, automation), this, too, will eliminate a set of potential additional jobs. Taken together, these effects could be much bigger than the direct substitution of machines or software for current jobs and may erode the unique desirability of the manufacturing sector, which earlier combined productivity increase with large-scale unskilled labor absorption. At the same time, although concerns about technological unemployment date back as far as the Industrial Revolution (Acemoglu and Restrepo 2016; Bessen 2016; Mokyr, Vickers, and Ziebarth 2015), the faster growth and job-creating effect of technological change has proven to be greater than any labor displacement effect (Bessen 2015, 2016). These effects, whereby new technologies lead to creation of more jobs or new occupations, are also not captured by studies that estimate potential labor displacement.

New technologies and changing globalization patterns may also erode the desirability of manufacturing if they reduce international trade and its associated spillover effects. Much of the discussion has been on the employment impacts, but the trade dimension may change, too, because of the technologies associated with Industry 4.0. If labor-saving technologies such as advanced robotics result in reshoring of unskilled-labor-intensive tasks to high-income economies or enable China to retain low-value-added manufacturing segments as they move up the value chain, GVCs might shorten. Further, 3D printing might substitute trade in services for trade in physical parts and components. Therefore, if GVCs shorten as a result of Industry 4.0, the productivity benefits associated with international trade in manufactured goods will likely diminish, too, thereby reducing the sector's desirability.

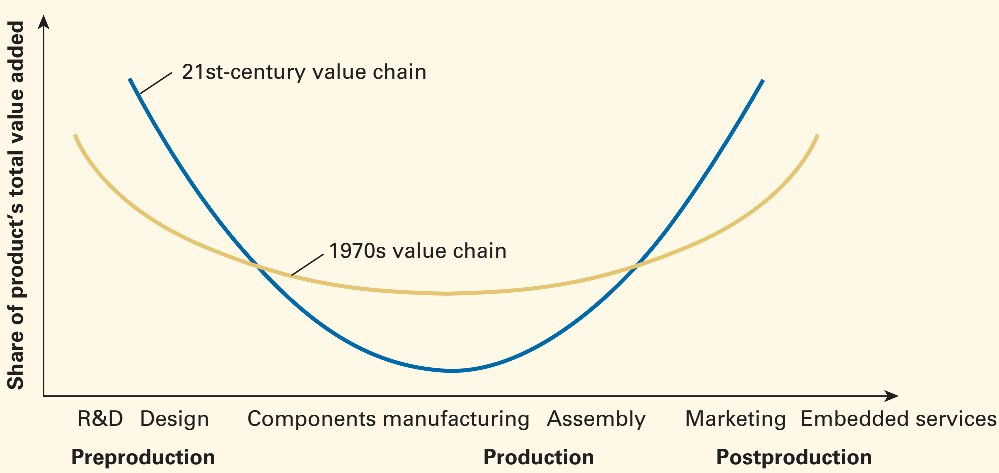
Chapter 5: Beyond Production: The Role of Services

Services that are either embodied or embedded in goods increasingly matter for manufacturing competitiveness and account for much of the value added in a product's supply chain. Some service sectors are embodied in manufacturing production either as inputs (for example, design, marketing, or distribution costs included in the value of a good) or as enablers for trade to take place (such as logistics services or e-commerce platforms). Globally, more than one-third of the value of gross manufactures' exports comes from the value added of embodied services (Bamber at al. 2017).[11]

Evidence from the Czech Republic, India, and Sub-Saharan Africa shows that this "servicification" of manufacturing has improved manufacturing productivity (Arnold et al. 2010; Arnold, Javorcik, and Mattoo 2011; Arnold, Mattoo, and Narciso 2008).[12] The expansion of embedded services in the manufacturing process has further underscored the complementary nature of services in adding value to goods postproduction. These are services that are increasingly bundled with (or added to) manufactured goods (for example, apps for mobile phone or "smart" solutions for "smart" factories). Furthermore, these embodied and embedded services constitute a larger share of value added than component manufacturing and final assembly in a product's supply chain, as encapsulated in the "smile curve" (coined by Acer Chief Executive Officer Stan Shih in the early 1990s) (figure O.13).

The servicification of manufacturing is further enabled by using data that will play an increasingly important role in "smart" manufacturing. Interconnected manufacturing—or the IoT, where networks, machines, and computers are connected to the Internet—requires the sending and receiving of data across the entire production chain. ICT services such as custom computer programming services, software publisher services, telecommunications services, Internet publishing, and data processing services such as cloud computing produce data for technology-intensive "smart" factories. At the same time, telecommunications, publishing services, office support and business services, computer programming services, engineering services, advanced data analytics, advertising, and R&D services use real-time

Figure O.13 Value Added of Services in Manufacturing, 1970s vs. the 21st Century



Note: Figure adapts the "smile curve" depiction of the changes in value added across different stages of bringing a manufactured product to market, as first proposed circa 1992 by Acer Inc. founder Stan Shih; for a more detailed discussion, see Baldwin (2012). R&D = research and development. "Embedded services" refers to services delivered through the manufactured good (for example, apps on a mobile phone).

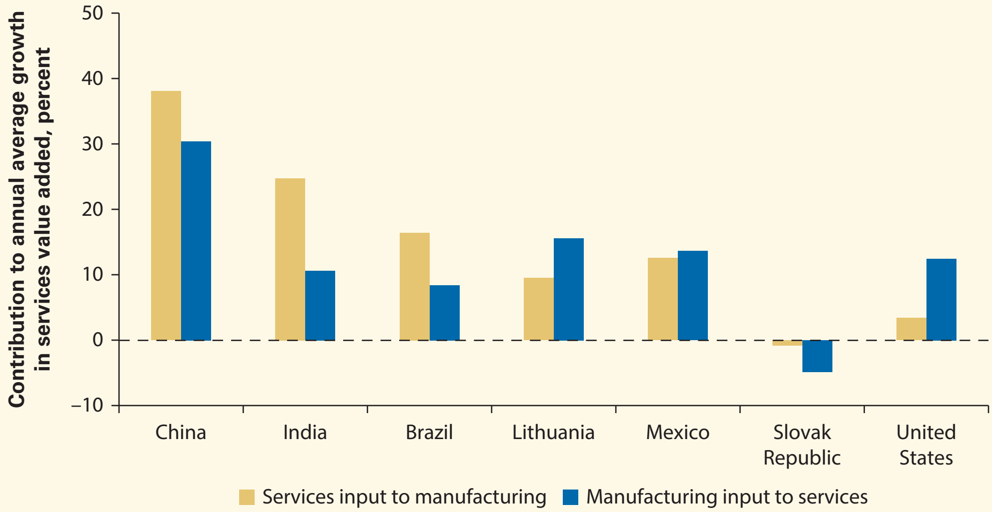
information through equipment logs, smart meters, or manufacturing sensors to optimize production processes (Dijcks 2013; Opresnik and Taisch 2015; Van der Marel 2016). ICT service sectors, as the predominant producers and users of data, can therefore play a crucial role in boosting manufacturing competitiveness through the IoT.

Further, the features of manufacturing once thought of as uniquely special for productivity growth might be increasingly shared by some services, but these are unlikely to create jobs for unskilled labor. Some service industries—financial, telecommunication, and business services—are now internationally tradable through ICT advances and yield the benefits of demand beyond the domestic market, competition, and technology diffusion. Scale economies have also become important in ICT-enabled service sectors as the marginal cost of providing an additional unit approaches zero (Fontagné, Mohnen, and Wolff 2014). Further, R&D expenditure in business services increased from an annual average of 6.7 percent of total business R&D during 1990–95 to nearly 17 percent during 2005–10 (WTO 2013). As a result, ICT and trade-intensive services are offering expanding opportunities for productivity gains (Enache, Ghani, and O'Connell 2016; Fagerberg and Verspagen 2002; Jorgenson and Timmer 2011; Kinfemichael and Morshed 2015; Timmer and de Vries 2009). However, most service sectors that exhibit productivity-enhancing characteristics are less likely to be associated with large-scale employment creation for unskilled labor, while those that *will* create jobs for unskilled labor are less likely to provide much by way of productivity gains (Cruz and Nayyar 2017).

Whether services "need" a manufacturing core to develop depends on the extent to which they either are embodied and embedded in goods or stand alone. The increasing servicification of manufacturing underscores the growing interdependence of the two sectors and therefore may limit the extent to which services can grow independently of a manufacturing core—and not just whether manufacturing can grow without a vibrant service sector. In China, for example, services inputs into manufacturing accounted for 38 percent of the annual average growth in services value added between 2000 and 2014, while manufacturing input into services accounted for 30 percent (figure O.14). This reflects the symbiotic relationship between the two sectors, as manifested by a range of services that are either embodied or embedded in manufactured goods. There is the possibility for certain embedded services to provide growth opportunities independent of a country's manufacturing base, particularly those services offering opportunities to develop content that tailors global business solutions to local needs. Take the example of mobile phone applications, where the design and marketing must take local language and cultural considerations into account. There are also stand-alone services, where the transaction takes place directly between a service provider and the final consumer (such as in tourism, health, business process outsourcing [BPO], and other professional services), that do not need links to manufacturing to flourish.

Figure O.14 Net Intermediate Demand from the Manufacturing Sector Accounted for a Fraction of Annual Growth in Services Value Added between 2000 and 2014, but This Hides the Fact That These Sectors Buy and Sell from Each Other

Contribution of (net) intermediate inputs from manufacturing to average annual growth in services value added, selected countries, 2000–14



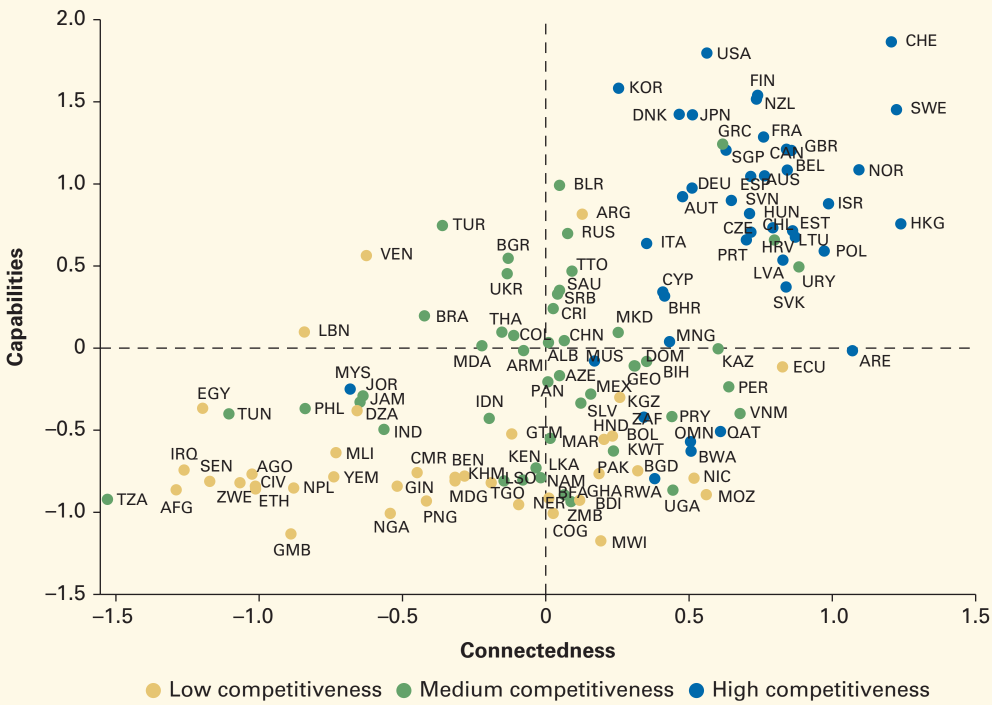
Source: Cruz and Nayyar 2017.

Chapter 6: Policy Recommendations for Future Manufacturing-Led Development

With heightened global competition, competitiveness, capabilities, and connectedness (the 3Cs) represent three broad challenges to manufacturing-led development strategies—each with a twist to address new dimensions. As the importance of low wages in determining low unit labor costs increasingly gives way to more demanding ecosystem requirements, catch-up strategies for countries hitherto less involved in global manufacturing will place greater urgency on reforms that improve the *competitiveness* of the business environment. Further, if LMICs need to adopt new technologies in manufacturing processes, it is critical to expand their *capabilities* by developing the right sets of worker and managerial skills and putting in place the supporting infrastructure and regulatory frameworks to be able to use new technologies. Finally, new connections between firms, growing needs to get goods to market quickly, and the increasing role of embodied and embedded services also put more emphasis on *connectedness* to markets. This connectedness highlights not only shifts in the trade agenda but also the growing synergies across the manufacturing and service sectors. Therefore, these dimensions of reform need to be reconceptualized, both to highlight those traditional reforms where there is greater urgency and to capture new reforms in line with the coming demands of new technology and heightened international competition.

An illustration of how countries perform across these three dimensions provides a typology that highlights how relative reform priorities may vary. Figure O.15—in which the axes represent countries' *capabilities* and *connectedness* and the color of their markers indicates their levels of *competitiveness*[13]—highlights how these 3Cs vary across countries. All but one in the high capabilities–high connectedness (upper right) quadrant are also in

Figure O.15 Country Distribution in Space of Competitiveness, Capabilities, and Connectedness, 2012–14 (or Latest Available Year)



Sources: Calculations based on Kee, Nicita, and Olarreaga 2009; International Telecommunications Union's ICT Indicators Database; and the following World Bank databases: World Development Indicators, Worldwide Governance Indicators, Global Findex, Logistics Performance Index, and Services Trade Restrictiveness Index.
Note: Each of the 3Cs is described by a summary measure that aggregates relevant dimensions. "Competitiveness" consists of the ease of doing business, the rule of law, and the use of mobile technologies to complete financial transactions. "Capabilities" comprises information and communication technology (ICT) use, tertiary school enrollment rates, and the share of royalty payments and receipts in trade. (The use of royalty payments [receipts] reflects the extent to which the firms in a country are accessing [generating] technology, but it does not capture the intrafirm transfer of technology among multinational corporations and their affiliates.) "Connectedness" combines the dimensions of logistics performance, restrictions on trade in manufactured goods, and the restrictions on trade in professional services. Countries are categorized on the "capabilities" and "connected" indexes on the basis of on their median z-score value. They are categorized as high, medium, or low in competitiveness on the basis of partitioning the z-scores into terciles. Note that Ireland and the Netherlands, because of tax treatments, have extreme values on the royalty payments (further boosting the "capabilities" measure) and thus are not shown as outliers in the upper right quadrant.

the high or medium tercile for competitiveness and thus are likely to be better placed to address the higher requirements that changes in technology, trade, and increased servicification may bring. On the flip side, only one country is in the top tercile for competitiveness in the low capabilities–limited connectedness (lower left) quadrant, and the rising bar will be particularly challenging here. Few countries have high capabilities but low connectedness, while many more have low capabilities but high connectedness.[14]

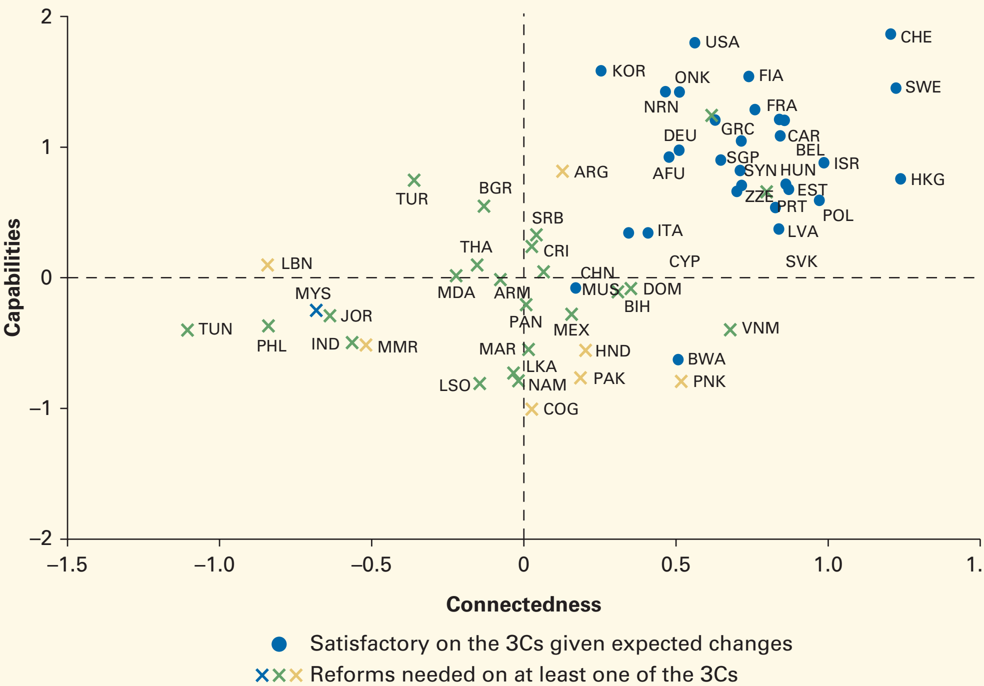
Further, countries' current position in the 3Cs space may or may not be compatible with the expected impacts of technology, export concentration and servicification on the future feasibility of producing those manufactured goods already in their current export baskets. As chapter 4 describes, three sets of trends are affecting the feasibility of being competitive in different manufacturing subsectors: the use of labor-saving technologies, the level of concentration in global trade, and the rise of services as a necessary complement to manufacturing. Depending on the combination of trends a sector is expected to face, the demands across the 3Cs will vary. Thus countries, depending on what they make, will then also face different pressures to reform to maintain their current comparative advantages. Consider the manufacturing subsectors that are characterized by high trade concentration, exposure to new technology, and services intensity: transportation equipment, electronics, pharmaceuticals, electrical machinery, machinery and equipment n.e.c., and other manufacturing n.e.c.[15] Countries with a revealed comparative advantage in any of these six subsectors will need to be strong on each of the 3Cs to compete, but there is one exception: if countries are not going to develop "high" capabilities, they would need "high" connectedness and "high" competitiveness (in the top tercile) to make competing with traditional technologies viable, at least in the short to medium run. Countries that do not match these criteria in the 3Cs space are designated by an "X" in figure O.16. The book develops five such scenarios to indicate country–sector pairs that could be at risk in the future.[16]

However, there are three caveats to keep in mind in interpreting how much at risk countries are if their current export baskets are incompatible with their performance on the 3Cs:

- First, the mapping of expected changes to these 3Cs is not exact. For example, that a sector is expected to use more-advanced processes does not necessarily mean countries must be in the top half of the capabilities distribution to be successful in the sector (the threshold could be lower—or higher).
- Second, the chart uses quadrant boundaries as cutoffs; in reality, many countries are close to the middle and so are not far from being above the threshold. For example, Mexico is close to being in the upper right quadrant, which would then match its revealed comparative advantages in electronics and transportation equipment.
- Third, that the country has a revealed comparative advantage in certain sectors that does not match their performance on the 3Cs perhaps

Figure O.16 How Well Do the Technology Trade and Servicification Requirements of Manufacturing Subsectors in Which Countries Have RCAs Match Those Countries' Readiness in Competitiveness Capabilities and Connectedness?

Country distribution in competitiveness, capabilities, and connectedness of six manufacturing subsectors expected to be affected most by automation, export concentration, and servicification, 2012–14 (or latest available year)



Sources: Calculations based on Kee, Nicita, and Olarreaga 2009; International Telecommunications Union's ICT Indicators Database; and the following World Bank databases: World Development Indicators, Worldwide Governance Indicators, Global Findex, Logistics Performance Index, and Services Trade Restrictiveness Index.
Note: Figure displays the countries that have RCA (revealed comparative advantage) in at least one of the following six manufacturing subsectors: transportation equipment, electronics, pharmaceuticals, electrical machinery, machinery and equipment not elsewhere classified (n.e.c.), and manufacturing n.e.c. Countries designated by circles generally satisfy high capability, high connectivity, and high competitiveness. Some countries that are highly competitive and connected but low in capability are also designated by circles. All other countries are designated by Xs: Blue refers to high competitiveness, green refers to medium competitiveness, and yellow refers to low competitiveness. Ireland and the Netherlands, because of tax treatments, have extreme values on the royalty payments measure (further boosting the "capabilities" measure) and thus are not shown as outliers in the upper right quadrant.

reflects the country's ability to come up with solutions in particular sectors and locations even if not on average across the country. This could be particularly true in large economies such as India.

If figures O.15 and O.16 illustrate the priority policy dimensions for countries, table O.1 provides more specific examples of what the recommendations would be—differentiating between countries starting with lower and higher strengths in each of the 3Cs. New technologies and changing globalization patterns do not change all of the policy recommendations. Many of the fundamental building blocks remain as important as ever. What changes

Table O.1 New Technologies Shift the Policy Areas to Prioritize—With Sequencing Appropriate to a Country's Current Position

Policy priorities to strengthen manufacturing-led development, by country's level of competitiveness, capabilities, and connectedness

Dimension	Priorities for countries currently "lower" on this dimension	Priorities for countries currently, or aiming soon to be, "higher" on this dimension
Competitiveness	Strengthen the business environment Promote flexible labor markets Liberalize backbone services critical to supporting manufacturing	Facilitate firm entry and exit, and the reallocation of capital and workers; improve bankruptcy procedures and universal coverage of social protection to facilitate worker mobility and to lower costs of disruption
	Develop mobile finance to facilitate use of embodied and embedded services	*Set competition policy framework for network platforms; adjust regulations for new business forms* *Facilitate contracting, to enable greater use of sharing economy on production side*
Capabilities	Prioritize literacy, numeracy, basic ICT, and socioeconomic skills, but also invest in the development of advanced skills for people with access to higher education	*Develop programs to strengthen more-advanced skills, creativity*
	Improve basic management skills and processes	*Emphasize the use of data and data processes within production*
	Develop certification of quality standards	*Support the development of a data ecosystem (access to ICT, policies on localization, network security, IPR)*
Connectedness	Reduce restrictions on trade in goods, particularly inputs (lower tariffs and NTBs, support trade facilitation)	Further facilitate trade in services, including removing restrictions on FDI
	Strengthen basic logistics	*Support IoT logistics systems* *Develop regulatory frameworks to support cross-border data flow*

Note: Traditional agenda items of rising urgency are set in roman. Items that relate more specifically to new technologies are set in italics within blue shading. ICT = information and communication technology. IoT = Internet of Things. IPR = intellectual property rights. FDI = foreign direct investment. NTB = nontariff barriers.

is the relative urgency of addressing some of them—with some new elements being added that directly address the ability to absorb and support the use of new technologies, adapt to new business models, and address greater ways that connectedness matters.

Reform Priorities for Competitiveness

The business environment agenda has greater urgency in countries currently less involved in export-led manufacturing, while the emphasis in those more connected to GVCs shifts to resource reallocation and new issues in competition policy. Many low-income economies fare poorly on the business environment agenda, and the resulting lack of scale and time-to-market advantages erodes their competitiveness, particularly as new technologies make labor a smaller share of overall costs. Regulatory reform that increases the efficiency of key input markets (especially backbone services) in countries with weaker competitiveness frameworks also assumes greater urgency because it supports backward and forward links in a product's value chain. For countries involved in global manufacturing, regulations that improve allocative efficiency—such as those governing entry and exit—will need greater emphasis considering the changing economic landscape. Supporting workers during employment transitions will be an important complement to facilitating the adjustment process. With large firms taking the lead in setting standards for advanced manufactures and with significant network effects in new platforms, emerging technologies raise new issues around competition policy in higher-income countries with implications for export-led manufacturing opportunities.

Furthermore, the business environment architecture will need to incorporate new technology-based services that improve production processes, and regulations will need to adjust to new business forms. New technologies can improve access to financial services in ways that expand opportunities for manufacturing, including in countries with a relatively weak business environment. Mobile payment systems are an increasingly intricate part of ensuring that services can be embedded in goods—and that trade in digital services can be embodied in the making of goods. New technologies are also being used to develop new business forms. For example, the prospect for expanding the sharing economy to warehousing, production facilities, and vehicles could significantly reduce the costs needed to set up a business. Such arrangements, however, will rely on contract enforcement, more sophisticated payment systems, and competition policies overseeing platform production systems. As such, they will likely be more relevant in countries with stronger competitiveness frameworks.

Reform Priorities for Capabilities

Education and training policies will need to be redesigned to deliver more of the new skills needed for countries to take advantage of emerging opportunities, including in countries with "low" capabilities. As countries become increasingly connected and engaged in more complex production processes, meeting the changing need for skills will be important to ensure that more people can access jobs, which are likely to become increasingly nonroutine and cognitive. This might involve greater investment in the development of advanced ICT-related skills such as software programming and coding, or complementary skills in engineering. While countries with "low" capabilities will need to emphasize basic numeracy, literacy, and ICT skills with greater urgency, this effort can be complemented with a focus on advanced skills for a subset of the population that has access to higher-quality tertiary education. Skills programs will need to be inclusive; e.g., training programs should be gender-informed in whom they target and how they are implemented.

These programs should also be more responsive to changing industry demands if firms are to be able to find the employees they need. In addition, given rapid and unexpected changes in the global economic landscape, the importance of "soft" skills that foster creativity, problem solving, and initiative cannot be emphasized enough.

In ensuring access to new technologies, the priority for low- and middle-income economies should be the diffusion of improved production processes through strengthening firm capabilities, differentiating across firms and countries including over time as capabilities expand. While innovations on the frontier grab headlines and the imagination of policy makers, far more impact in improving firm productivity and employment outcomes can be achieved by helping firms catch up and move closer to the frontier. There is a need to start with improvement of more basic managerial and organizational practices,[17] which will allow firms to use and adapt new processes, and to proceed to more sophisticated technological knowledge associated with Industry 4.0 further along (Cirera and Maloney, forthcoming). Therefore, rather than trying to jump straight to R&D subsidies for Industry 4.0 technologies, the mix of policy instruments should reflect this capabilities escalator (Cirera and Maloney, forthcoming): in stage 1, dedicated field services to support broader managerial and organization practices that can help in the adoption of basic technologies; in stage 2, technology-oriented services and technology centers for the adoption of more-complex technologies; and in stage 3, targeted R&D centers to support the generation of new technologies. Importantly, the nature of some of the new technologies should reinforce good managerial practices—if the capabilities are there. For example, the IoT changes the availability of real-time information dramatically, thereby providing an incentive for stronger organizational and managerial practices to use systems integration across multiple locations to improve efficiency.

To realize the promise of Industry 4.0, the system of certifying quality standards will be central in countries with lower capabilities, while the data ecosystem will become increasingly important in those with higher capabilities. With more complex products and processes, improving quality infrastructure (QI) systems can facilitate opportunities for export-led manufacturing to the extent that certification of internationally recognized standards enables firms in countries with lower capabilities to sell in major markets. New technologies may also change the content of some standards and increase the pressures to meet them. For example, QI is increasingly embedded in the physical and software components of deeply interconnected manufacturing processes associated with Industry 4.0: sensor-based applications, control systems, and continuous monitoring devices. Further, issues relating to intellectual property rights, data security, and privacy must be addressed for firms to adopt these data-driven technologies, and they might be particularly relevant in countries with higher capabilities. New regulations can ensure security, create acceptance, and encourage innovation, but they need to keep up with the development of new business models.

Reform Priorities for Connectedness

For countries that are less "connected" to the global economy, the reciprocal opening of markets and trade facilitation need to be tackled with greater urgency, and new technologies do not dilute the importance of this trade agenda. Although significant progress has been made in addressing trade restrictions on manufactures, lower-income economies seeking new opportunities for export-led manufacturing will still benefit from reducing restrictions on the import of intermediate inputs and from secure market access in their destination markets. Tariffs remain high in some sectors or are not subject to stringent commitments, and several nontariff measures (NTMs) also affect trade flows. Similarly, trade facilitation that aims at better logistics and easing border clearance merits even greater emphasis given heightened global competition and the increasing importance of delivery time, especially in higher-income markets. The World Trade Organization (WTO) 2013 Trade Facilitation Agreement (which entered into force in February 2017) represents an important step forward in facilitating the movement of goods across borders, especially for lower-income countries. Market access restrictions, the connectivity agenda, and regulatory cooperation remain indispensable for new forms of trade as well, such as e-commerce.

At the same time, the trade reform agenda for the range of services embodied in goods will become more pressing, and new rules on cross-border data flows will deserve emphasis, particularly for more "connected" countries. Services sector reforms are relevant in their own right, but their importance is magnified by changing technologies whereby services are increasingly embodied in the production and sale of goods—through banking, transport, and telecommunications, for example. In this context, restrictions on services trade that are more common in LMICs than in high-income countries will become even more costly. As new technologies create forms of international trade, new rules will also need to emerge in response to changing regulatory needs. With "smart" production processes enabled by the IoT, restrictions on cross-border data flows will affect the ability of firms to use many of these technologies associated with Industry 4.0. This might be as relevant for the trade of services embedded in goods (for example, mobile-phone applications or after-sale services for electrical goods). At the same time, the agenda on intellectual property rights and privacy concerns will likely be emphasized more, given the risks for firms and consumers with these cross-border data flows.

Regional and bilateral trade agreements will remain central in driving connectedness to markets through the old and new reform agendas. As the trend of customization intensifies, larger markets, or countries near larger markets, will become more attractive as centers of production. But "deep" trade agreements could make geography matter less by enabling firms in smaller economies to experience scale economies through access to these markets. Such agreements can also provide the institutional framework that governments in LMICs need to coordinate and commit their policies to exploit new trade opportunities in a changing environment. The number of preferential trade agreements (PTAs) notified to the WTO has risen from about 50 in 1990 to about 280 in 2015, and many of them include LMICs. These trade agreements are capturing the wider agenda, too, by increasingly covering a range of NTMs including "deep" provisions in policy areas (data protection and e-commerce, for example) beyond the current mandate of the WTO (Hofmann, Osnago, and Ruta 2017).

Targeted and Horizontal Approaches

The merit in policies that target the expansion of a manufacturing sector per se will depend on the sector's shifting desirability as measured by spillovers and dynamic growth gains or in meeting other public objectives, such as employment for specific groups. Identifying market failures or spillovers as justification for government intervention remains a relevant disciplining device. However, new considerations might be relevant to identify the desirability of targeted approaches. First, if dynamic gains are associated with certain manufacturing sectors and if countries face a limited window to industrialize with technologies and processes associated with Industry 2.0, there is the question of whether targeted interventions to develop manufacturing are necessary to support more sophisticated processes associated with Industry 4.0 in the future.[18] Second, new labor-saving technologies are raising the stakes in the debate over targeting sectors on the basis of their job creation potential. Ensuring means of livelihood is a social objective, and job creation may have positive spillovers, too—learning-by-doing and deepening social cohesion, for example. However, trying to develop a sector using labor-intensive production processes when new technologies are more efficient is not likely to be sustainable or viable for very long. Continued progress on the 3Cs will be needed over time. Third, the rapid pace of technological change and uncertainty in the global economic landscape might make sector-specific approaches riskier than before.

Successfully targeting manufacturing sectors will also increasingly depend on the shifting feasibility of a country's competitiveness given changing technologies and globalization patterns. Given the uncertainty, grounding assessments of feasibility in market signals on comparative advantage and quality of capabilities will help diversify the risks of targeting. In many lower-income countries, that will mean focusing on labor- or commodity-intensive manufactures—sectors where they have a revealed comparative advantage.[19] These are also the sectors that are currently less automated, and it might be more feasible for countries to target them and achieve success in the global market. Because reforms in the 3Cs will inevitably have disproportionate impacts across sectors, it is important to take this into account when choosing reform priorities. Similarly, policies that target improvements in competitiveness, capabilities, and connectedness in specific locations may be more feasible than trying to improve all of these conditions countrywide. At the same time, given the higher premium on technology diffusion as well as on interfirm and intersectoral spillovers, establishing linkages that reduce the risk of enclaves deserves emphasis.

Institutional frameworks will need to adapt to minimize the risks of government failure—and new technologies themselves can provide additional tools. In a rapidly changing global economic environment, an institutional framework that streamlines government-industry information flows in an inclusive and transparent way will become increasingly important to assess the desirability and feasibility dimensions of policies. Further, policy experimentation—whereby inducements are given to firms for investment and risk taking—should go hand in hand with iterative evaluation processes whereby governments allow nonproductive firms to fail and exit the market. And this holds true for targeted and horizontal policies alike (Maloney and Nayyar 2017). Going forward, new technology itself could help reinforce institutional frameworks that minimize the risks of government failure. For example, using ICT and web-based platforms can improve the inclusivity, transparency, and communication strategies with the private sector (World Bank 2016). Similarly, the IoT as a means of disseminating information, coordinating market players, and potentially collecting data during the production process of participating firms can help provide needed feedback loops for monitoring and evaluation purposes.

Although countries can learn from the industrial upgrading trajectories of similar countries at earlier levels of development, replicating what was successful in the past may be neither feasible nor desirable. The combination of countries already producing certain products, the changing mix of conditions needed (including on the 3Cs) to support different manufacturing activities, and the potential for disruptive new technologies that shift the basis of comparative advantage mean that what was an effective strategy in the past may not be in the future. Further, focusing on goods that others successfully made rather than on providing the right conditions for their production may miss what really mattered for development. For example, both the Republic of Korea and Mexico began assembling electronics in the early 1980s, yet only Korea has produced a truly indigenous electronic device in the Samsung Galaxy. Hence, expanding a sector with potential externalities does not necessarily imply that they will automatically occur if the sector is not organized appropriately (Lederman and Maloney 2012; Rodríguez Clare 2007). Further, policy makers should consider that new technologies and changes in globalization may have changed manufacturing's relative desirability—that is, its dual promise of productivity growth and unskilled-job creation is unlikely to hold going forward; indeed, many services are also associated with these spillovers. In addition, the growing interdependence between sectors means that sectoral policies that target specific products or activities will be less likely to work in isolation.

With reform priorities becoming more demanding, one key lesson is that new technologies and changing globalization patterns increase the complementarities between economywide and targeted approaches. On the one hand, it may be more feasible, at least in the immediate future, to meet the requirements to be competitive by targeting locations and sectors rather than attempting to reform and provide public investments throughout the whole economy and country. And in practical terms, horizontal policies still involve choices, because their rollout or focus will inevitably have differential effects across sectors. On the other hand, for growth to be more inclusive over the long run, establishing the building blocks of competitiveness, capabilities, and connectedness across the economy would be necessary to exploit linkages across firms, sectors, and regions. Similarly, given the growing uncertainty about the pace of technological change, horizontal policies that develop transferable skills would reduce risks in the future. Hence, the debate is not so much over targeted *or* horizontal policies than about the right mix between them, a mix that depends on what is feasible and what the underlying case for market failures and spillovers would be—not only in the immediate run but over time.

Conclusion

New technologies and changing globalization patterns do not spell the end of manufacturing export-led development, but they do make it a less powerful strategy than before. Manufacturing will remain a part of development strategies, but it will likely contribute less to inclusive growth than it did in the past "miracles" of many current high-income industrialized economies, particularly those in East Asia. Manufacturing's dual promise of productivity growth and job creation is unlikely to hold as widely in the future, given the increasing importance of labor-saving technologies. However, many services now promise productivity gains as well, and job gains will also likely come as demand for services rises.

Some manufacturing industries will remain feasible entry points for hitherto less-industrialized countries and drivers of low-skill employment. For example, a range of commodity-based manufactures are less automated and less concentrated in terms of export locations. Further, despite a rising bar to be globally competitive, countries with low unit labor costs could remain cost-effective in the production of labor-intensive tradables such as textiles, garments, and footwear given the limited automation thus far. Domestic or regional markets for lower price, low-quality manufactures as a source of productivity increase and job creation will also likely remain.

Opportunities to benefit from productivity growth and job creation will also be associated with the broader manufacturing process. Looking at the manufacturing process as a value chain of activities involved in designing, making, selling, and supporting the use of goods will deliver more opportunities than focusing narrowly on production per se. The increasing synergies between manufacturing and services also mean that, rather than focus on sectors per se, countries should pursue productivity improvements throughout a product's value chain to best exploit the potential for spillovers.

The attention on downside risks needs to be balanced with efforts to enable new opportunities through policies that strengthen the competitiveness, capabilities, and connectedness of countries. Countries certainly need to address the disruptions that come with change, but more attention is needed on positioning firms and workers to take advantage of new opportunities. Countries should tailor their approaches on the basis of their competitiveness, capabilities, and connectedness—and, based on what they do (or aim to) make, the extent of changes they can expect to face. For countries with a significant manufacturing base, expanding their performance on the 3Cs should help them maintain and expand their position within value chains. For those seeking to expand their manufacturing base from a low level, addressing the fundamentals remains important even as the agenda becomes more complex. With reform priorities becoming more demanding, targeting sectors in isolation will not be successful; new technologies and changing globalization patterns increase the complementarities between economywide and targeted approaches.

There may be opportunities to leapfrog, but in many cases the need for improvements will be a continual process. Seeking to be on the frontier of new technologies attracts attention, but catching up also has considerable development impact. Enabling new technologies to diffuse will be central to avoiding greater polarization across countries. Leapfrogging also raises the question of how feasible it is to develop the high-productivity, high-value-added services without a manufacturing base as a driver. In theory, some stand-alone professional services can be developed in support of other services. However, these services are generally skill-intensive, and given the paucity of high-skilled workers to draw upon in LMICs, this will likely be a gradual process; therefore, what an appropriate timetable is likely to be should be kept in mind.

As countries adjust to the changing global economic and technological environment, the policy agenda is challenging but urgent given the potential economic, social, and political costs. The manufacturing process, encompassing both the production activity and the related services, will remain a source of productivity gains and of employment, but not necessarily in a win-win combination. This means productivity and employment gains can be achieved, just not necessarily together; the risk of rising inequality is real. Being unprepared for disruption or for new opportunities will be costly—socially, economically, and politically. Complacency on this reform agenda is not an option.

Notes

1. Throughout the book, the term "industrialization" refers to manufacturing only.
2. The "East Asia growth miracle" here refers to the following economies: Hong Kong SAR, China; the Republic of Korea; Singapore; and Taiwan, China.

3. Norway, for example, has created an innovative oil and gas industry with substantial links and become one of the richest countries of the world (Cappelen, Eika, and Holm 2000; Fagerberg, Mowery, and Verspagen 2009).
4. For example, Singapore's location in key shipping lanes and its deep natural port have made it an important transshipment point. A few small economies have adopted specific tax or financial regulations to attract large numbers of multinationals, but much of the wealth reflects accounting practices rather than wealth-generating activities in the country.
5. This pattern of shifting expenditure shares with income is traditionally referred to in the literature as Engel's law. Engel's law refers to the empirical observation that as income rises, the proportion of income spent on food or agricultural products falls (even if the absolute expenditure on food rises). The share of expenditures on manufactured goods is expected to rise and then fall as incomes rise further and the share spent on services is expected to rise with income.
6. The introduction of high-yield seed varieties, irrigation infrastructure, and agricultural education, among other factors, also played an important role.
7. The Industry 4.0 technological paradigm involves a different set of specific technologies, which Cirera et al. (2017) categorize in terms of emphasis: (a) most emphasized, such as Internet of Things, big data, 3-D printing, and advanced (autonomous) robotics; (b) moderately emphasized, such as augmented reality, smart sensors, cloud computing, artificial intelligence (AI) and machine learning, nanotechnology, synthetic biology, and simulation; and (c) less emphasized, such as human-machine interface, mobile devices, cybersecurity, quantum computing, and horizontal and vertical integration.
8. The Herfindahl-Hirschman index is a commonly accepted measure of market concentration based on market share of each firm competing in a market. Here it is adapted to the share of countries in the total exports of a particular sector or good.
9. In addition, the electronics, computer, and optical instruments; pharmaceutical products; and transportation equipment subsectors have a relatively high share of professional services input in total value added.
10. "Other nonmetallic products" are also relatively more concentrated in terms of exporting countries, but this means little given that they are the most nontraded manufacturing sector.
11. These estimates of embodied services' value added in the export of manufactured goods are based on input-output tables and therefore only capture services provision related to economic transactions outside the boundaries of the firm. In practice, many firms provide some services in-house, too.

12. Similarly, there is scope for the greater use of services, such as engineering and marketing, to improve the efficiency of agricultural production. In Australia, for example, agricultural exports are nearly one-third embodied services. By contrast, in Thailand, services' value added is only about 17 percent of gross exports of agricultural products.
13. On the "capabilities" and "connectedness" indexes, countries are categorized as "high" or "low" on the basis of the median Z-score value. On the "competitiveness" index, countries are categorized "high," "medium," or "low" (as reflected in the color shading of the markers) by partitioning the Z-scores into terciles.
14. Although each of the 3Cs is represented by a summary measure, how countries perform across the different constituent indicators can illuminate specific policy challenges in a country. For example, India is a country where significant restrictions on services trade lower its connectedness measure.
15. Three of the six sectors are not characterized by high services intensity, but, because they are traded and concentration is high, the need for competitiveness in the business environment is likely to be high over time as well.
16. The five scenarios are developed for countries that have a revealed comparative advantage in these sector groups, but the exercise will be just as meaningful for countries that do not but are seeking to develop one.
17. Firms in LMICs tend to have weaker management practices overall.
18. Even if leapfrogging technology may not be possible, it still does not necessarily follow that targeting manufacturing sectors, rather than the adoption and adaptation of technologies more directly, is the right choice.
19. Comparative advantage must also be looked at in terms of tasks. For example, it would be easier to move from labor-intensive garments to electronics assembly than from electronics assembly to manufacturing electronic components.

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Technology and globalization are threatening manufacturing's traditional ability to deliver both productivity and jobs at a large scale for unskilled workers. Concerns about widening inequality within and across countries are raising questions about whether interventions are needed and how effective they could be.

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