MANUFACTURING JOBS: IMPLICATIONS FOR PRODUCTIVITY AND INEQUALITY

The declining share of manufacturing jobs in overall employment has been a concern for policymakers and the broader public alike in both advanced economies and some developing economies. This concern stems from the widely held belief that manufacturing plays a unique role as a catalyst for productivity growth and income convergence and a source of well-paid jobs for less-skilled workers. Against that backdrop, this chapter aims to provide new evidence on the role of manufacturing in the dynamics of output per worker and in the level and distribution of labor earnings. The two main takeaways from the analysis are that (1) a shift in employment from manufacturing to services need not hinder economy-wide productivity growth and the prospects for developing economies to gain ground toward advanced-economy income levels, and (2) while the displacement of workers from manufacturing to services in advanced economies has coincided with a rise in labor income inequality, this increase was mainly driven by larger disparities in earnings across all sectors. These findings imply that the goal of supporting equitable growth would be better served by policy efforts to raise productivity across all sectors and make the gains from higher productivity more inclusive. Facilitating the reallocation of labor to productively-dynamic sectors, including by removing barriers to entry and trade in the service sector and supporting the reskilling of workers affected by structural change, is crucial to raise productivity and combat inequality.

Introduction

 In many countries, manufacturing appears to have faded as a source of jobs (Figure 3.1). Its share in employment in advanced economies has been declining for nearly five decades. In developing economies, manufacturing employment has been more stable, but among more recent developers it seems to be peaking at relatively low shares of total employment and at levels of national income below those in market economies that emerged earlier.[1] The share of jobs in the service sector has risen almost everywhere, replacing jobs in either manufacturing (mostly in advanced economies) or agriculture (in developing economies; Figure 3.2). From a long-term economic perspective, the shift of capital and labor into different forms of economic activity is accepted as "structural transformation"—the natural consequence of changes in demand, technology, and tradability.

The implications of the reduced share of manufacturing in employment has been much debated, with researchers and policymakers focusing on two questions: (1) Does it hinder overall growth? (2) Does it raise inequality?

Regarding the first question, the growth of productivity and of income has historically appeared to slow once factors of production begin to shift from manufacturing to services (Baumol 1967; Imbs 2016). This phenomenon could be especially worrisome for developing economies where employment shares are shifting from agriculture to services, bypassing manufacturing, given that skipping a traditional industrialization phase could hinder their ability to narrow income gaps vis-à-vis advanced economies (Rodrik 2016). However, whether an expanding service sector necessarily weighs on economy-wide productivity growth is an open question. The service sector comprises subsectors with potentially varying productivity levels and growth rates; recent advances in technology and in the tradability of services may have accelerated the productivity gains in some of them. The impact of the shifts in employment shares on aggregate productivity would therefore depend on the exact mix of subsectors that are gaining or losing share.

[1]In this chapter, emerging market and developing economies, or developing economies for short, are an augmented group consisting of all emerging market and developing economies currently classified as such by the *World Economic Outlook* (WEO) plus those that have been reclassified as advanced economies since 1996 (the latter including, for instance, Hong Kong Special Administrative Region, Israel, Korea, and Singapore). See Annex 3.1 for data sources and sample coverage.

Figure 3.1. Share of Manufacturing in Aggregate Employment
(Percent)

Manufacturing employment has been in relative decline for nearly five decades in advanced economies, and it seems to be peaking at low shares of total employment among more recent developers.
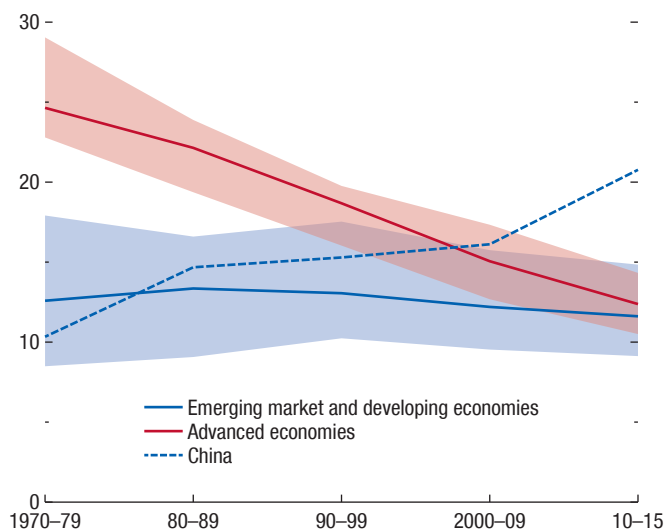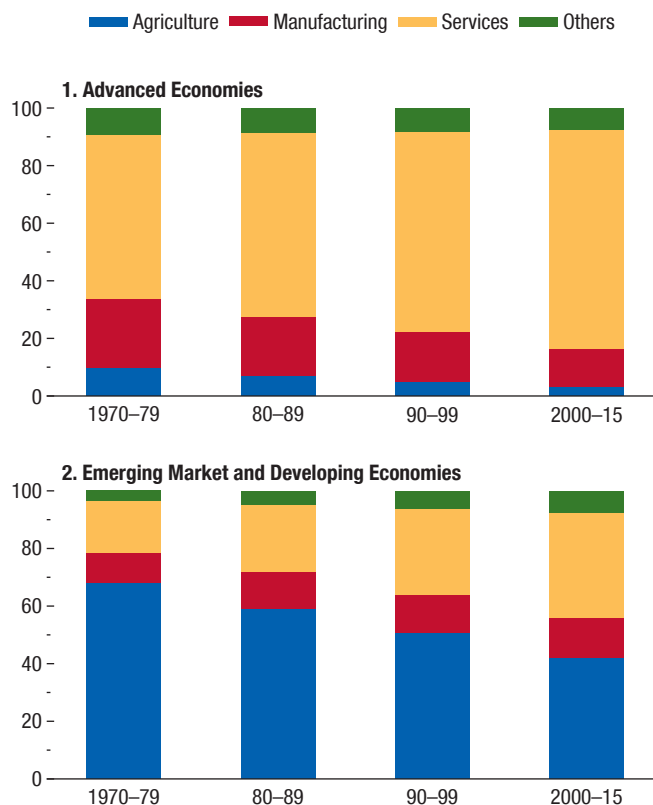

Source: IMF staff calculations.
Note: The solid lines and shaded areas denote the simple average and the interquartile range across economies, respectively. The sample comprises 21 advanced economies and 44 emerging market and developing economies with sectoral employment data since 1970. See Annex 3.1 for data sources and country coverage.

The second question arises because low- and middle-skilled workers have traditionally earned higher wages in manufacturing than in services (Helper, Krueger, and Wial 2012; Langdon and Lehrman 2012; Lawrence 2017); a reduced employment share for manufacturing would thus tend to worsen income inequality. Countries where inequality in labor earnings has risen since 1980 have typically experienced a decline in the share of manufacturing employment (Figure 3.3). But analysis of the mechanisms underlying that correlation has been sparse. Countries where the share of manufacturing employment has declined more may also have been more exposed to other inequality-enhancing trends (such as technological change and the automation of routine tasks), with a consequent rise in labor income inequality within all sectors. The significance of the latter explanation warrants review because it could mean that, to combat inequality, policy should focus on ensuring more inclusive gains from structural transformation rather than on supporting manufacturing employment.

Figure 3.2. Sectoral Employment Shares
(Percent)

The share of service sector jobs in overall employment has risen almost everywhere, reflecting a shift away from manufacturing employment in advanced economies and mostly a shift from agriculture in developing economies.

Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: The employment sectoral shares in each panel are computed as the weighted average across all economies in the group with weights given by total employment of each country. "Others" includes mining, construction, and utilities.

Changes in the share of manufacturing jobs in employment have been accompanied by even more diverse changes in the output share of manufacturing across countries.[2] Moreover, a few developing economies have experienced sizable increases in the share of manufacturing in both employment and output since the early 1970s, most notably China. This heterogeneous picture could reflect reallocation of production across countries or country variations in the demand for manufactures, or a mix of both.

Against that backdrop, this chapter has two related goals: (1) to contribute to a better understanding of the

[2]In this chapter, output is measured in constant prices (or equivalently, as value added in real terms).

Figure 3.3. Change in Manufacturing Employment Share and Inequality, 1980–2010
(Percentage points on x-axis; points on y-axis)

Inequality in labor earnings has tended to increase more in economies that have registered a steeper decline in the share of manufacturing employment.
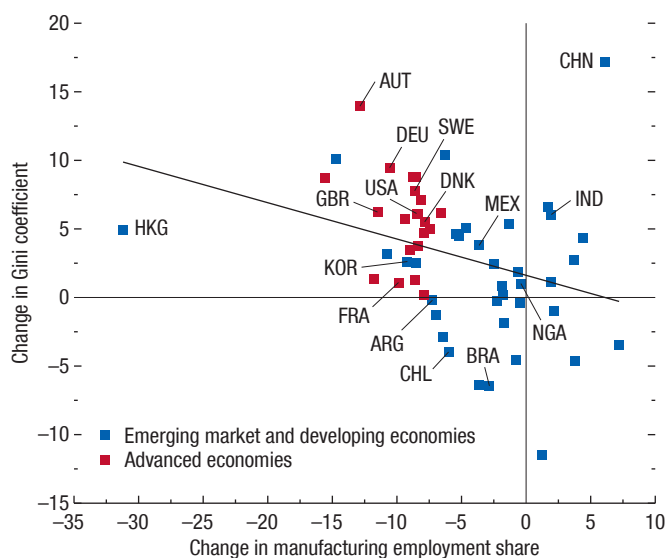
Sources: Standardized World Income Inequality Database (Solt 2016); and IMF staff calculations.
Note: The changes are calculated between the averages during 1980–89 and 2010–16. The Gini coefficient is based on income before taxes and transfers and ranges from 0 to 100. Data labels use International Organization for Standardization (ISO) country codes.

ongoing transformation of manufacturing activity within countries and at the global level, and (2) to examine whether manufacturing is indeed special in terms of output per worker and the level and distribution of labor earnings, so as to provide insight into how policies can help ensure strong and inclusive growth under structural transformation. In pursuit of these goals, the chapter seeks answers to the following questions:
- *Trends and drivers:* How have manufacturing employment and output shares evolved within countries and at the global level since the 1970s? What were the mechanisms behind these changes? Which service subsectors have expanded during the past five decades?
- *Per capita income growth:* How diverse are trends in output per worker (the main driver of income per capita) across the various service subsectors and how do they compare with those in manufacturing? Have shifts in employment shares between sectors weighed on economy-wide labor productivity growth? Does the relative expansion of service sector employment

pose a major challenge for developing economies in narrowing per capita income gaps vis-à-vis advanced economies?
- *Income inequality:* Does manufacturing uniquely offer higher incomes or a more uniform distribution of earnings across employees? How much of the increase in inequality observed in many countries over the past few decades are associated with changes in the relative size of the manufacturing sector?

The main findings of the chapter are as follows:
- The heterogenous evolution of manufacturing output and employment shares across countries reflects a mix of forces: diverse trends in domestic incomes and the associated variation in the demand for manufactures, varying productivity trends in manufacturing and other sectors, and specialization and reallocation of production based on comparative advantages, facilitated by international trade and financial integration. Even though output has out-paced employment in the manufacturing sector in most countries since the early 1970s, reflecting comparatively fast productivity growth in the sector, the same pattern has not held at the global level. The broadly parallel movement of global manufacturing output and employment shares reflects a change in the country composition of global manufacturing employment in favor of developing economies, where output per worker tends to be lower.
- The rise of services and the decline or leveling-off of manufacturing as a source of employment need not hinder economy-wide productivity growth. Some service industries have higher productivity levels and growth rates than manufacturing overall. Since the early 2000s, the rise in the service share of employment has contributed positively to economy-wide productivity growth in most developing economies. Moreover, productivity levels in services tend to converge to the global frontier (that is, to the productivity level in the most productive countries), just as in manufacturing. The rise in the employment share of those service sectors therefore can boost the growth of aggregate productivity and aid the convergence of income per worker across countries.
- While labor earnings in manufacturing are indeed somewhat higher and more uniformly distributed than in services, the main driver of the rise in labor income inequality in advanced economies since the 1980s has been an increase in inequality within all sectors.

Figure 3.4. Share of Manufacturing in Aggregate Employment and Output
(Percent)

At the global level, the share of manufacturing in employment and output (real value added) has changed little since 1970. However, that remarkable global stability masks pronounced changes in shares at the country level.

Employment —— Nominal value added —— Real value added
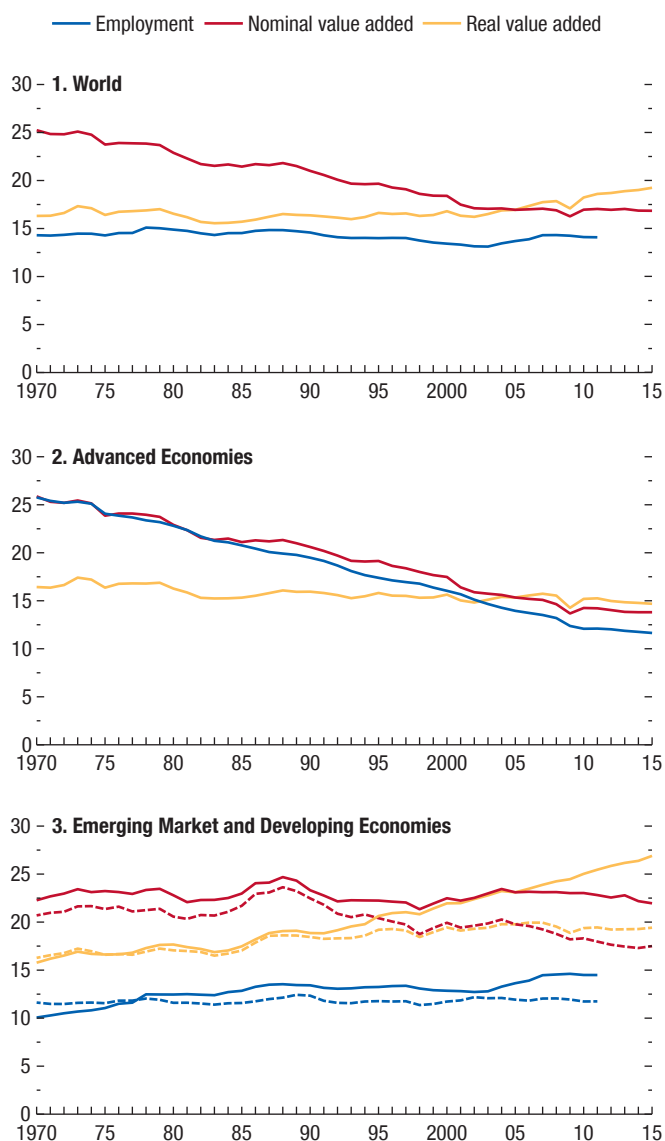
Source: IMF staff calculations.
Note: The employment (value added) manufacturing share in each panel is computed as the weighted average share across all economies in the group, with weights given by total employment (GDP in US dollars at market exchange rates) of each country. Dashed lines in panel 3 denote emerging market and developing economies excluding China.

A key question for policy is whether the service-led growth patterns observed in many developing countries since the early 2000s will continue to hold or whether they were a byproduct of a temporary boom in global demand. Higher commodity earnings and easy borrowing conditions, for instance, may have temporarily boosted the demand for nontraded services produced with less-skilled labor and facilitated the shift of labor out of agriculture—where productivity tends to be relatively low (Diao, McMillan, and Rodrik 2017). In many developing countries, less buoyant growth in domestic demand in the period ahead may restrain the expansion of nontraded services, while skill shortages may hold back the expansion of the traded, productively dynamic ones. The uncertainty surrounding future productivity trends and sizable gaps in output per worker among developing countries call for strong policy efforts to boost productivity in all sectors and help channel labor to the most dynamic and productive activities through skill development and the removal of barriers to entry and trade in service sectors. In countries where manufacturing jobs are disappearing outright, policymakers ought to facilitate the reskilling of former manufacturing workers and reduce the costs of their reallocation, while strengthening safety nets to alleviate the adverse consequences of joblessness and job transitions for the workers and their communities.

The rest of the chapter is structured as follows. The next section provides an overview of manufacturing trends at the country and global levels and discusses the mechanisms underlying changes in the relative share of manufacturing in economic activity. It also provides some statistics on the rise in service jobs. The subsequent two sections focus on the differences between manufacturing and services in terms of productivity trends and on the level and distribution of labor earnings. The concluding section discusses how policy can ensure strong and inclusive growth under ongoing structural transformation.

Structural Transformation: Key Trends and Drivers

The share of manufacturing jobs in global employment has been remarkably stable over nearly five decades (Figure 3.4, panel 1). The sector employs about the same share of the world workforce now—about one in seven workers—as it did in the 1970s. Its share in global output (value added measured at constant prices) remained broadly stable between the

Figure 3.5. Estimated Trends in Manufacturing Employment and Output Shares, 1960–2015
(Percentage points per year)

While the share of manufacturing jobs in aggregate employment has declined in all advanced economies and many developing economies since 1970, changes in the output share have been more diverse, and a few economies registered sizable increases in both their manufacturing employment and output shares.
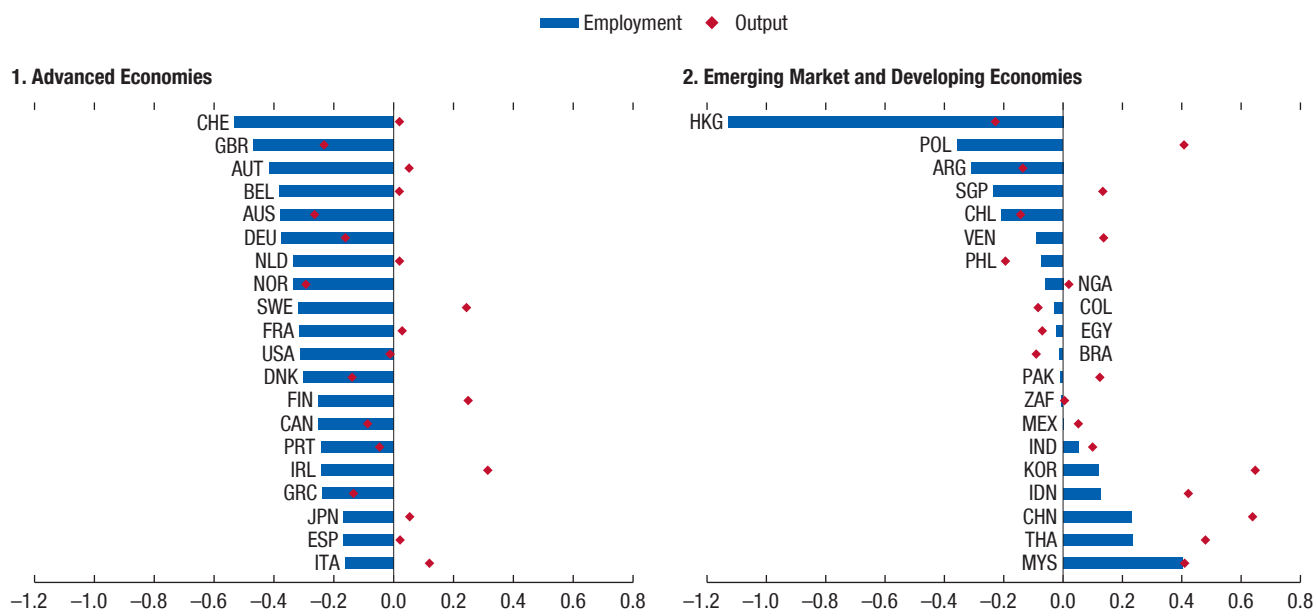
Source: IMF staff calculations.
Note: The figure shows the average annual growth rate in manufacturing employment and real-value-added shares during 1960–2015 (depending on data availability) for the 20 largest advanced and emerging market and developing economies ranked by 2015 GDP in US dollars at market exchange rates. Data labels use International Organization for Standardization (ISO) country codes.

1970s and the early 2000s and has been on a slight upward trend ever since.[3]

The global stability of manufacturing employment and output shares masks pronounced changes at the country level (Figure 3.5). The share of manufacturing in total advanced-economy output has remained unchanged since the 1970s, but with diverse (and offsetting) changes at the individual country level (Figure 3.4, panel 2; Figure 3.6, panel 3). At the same time, almost all advanced economies individually, and the advanced economy group at the aggregate, experienced steady declines in the share of manufacturing jobs in total employment over almost five decades (Figure 3.4, panel 2; Figure 3.6, panel 1), underscoring that labor productivity in manufacturing increased faster than in all the other sectors taken together.

[3]The share of manufacturing in global output measured at current prices shows a substantial decline over the past five decades as faster productivity gains in manufacturing have lowered the prices of manufactures relative to those of other products, such as services and agricultural goods.

Among developing economies, the median change in manufacturing employment and output shares since 1970 has been close to zero (Figure 3.6, panel 2 and 4). If China is excluded, the group at the aggregate has seen little change in the output and employment share of manufacturing (Figure 3.4, panel 3). China, Indonesia, Korea, Malaysia, and Thailand have seen sizable gains in shares since 1970 (Figure 3.5, panel 2), although in some of these economies the manufacturing sector still employs a relatively small fraction of the workforce (for instance, in Indonesia the manufacturing employment share has remained about 13 percent since the mid-1990s; in Thailand it was below 15 percent in 2010; in China, by contrast, the share was about one-fifth in 2013).

For most developing economies, manufacturing shares peaked around the middle of the sample period: output and employment shares increased over the 1970s and 1980s in most countries but have declined in about two-thirds since the 1990s (Figure 3.6, panels 2 and 4). Very few countries have experienced rising manufactur-

Figure 3.6. Cross-Country Distribution of Estimated Trends in Manufacturing Shares, 1970–2015
(Percentage points per year)

The share of manufacturing jobs in total employment has declined steadily in most advanced economies since 1970, while in half of those economies the manufacturing output share increased until the 1990s. For most developing economies, manufacturing employment and output shares peaked around the middle of the sample period.
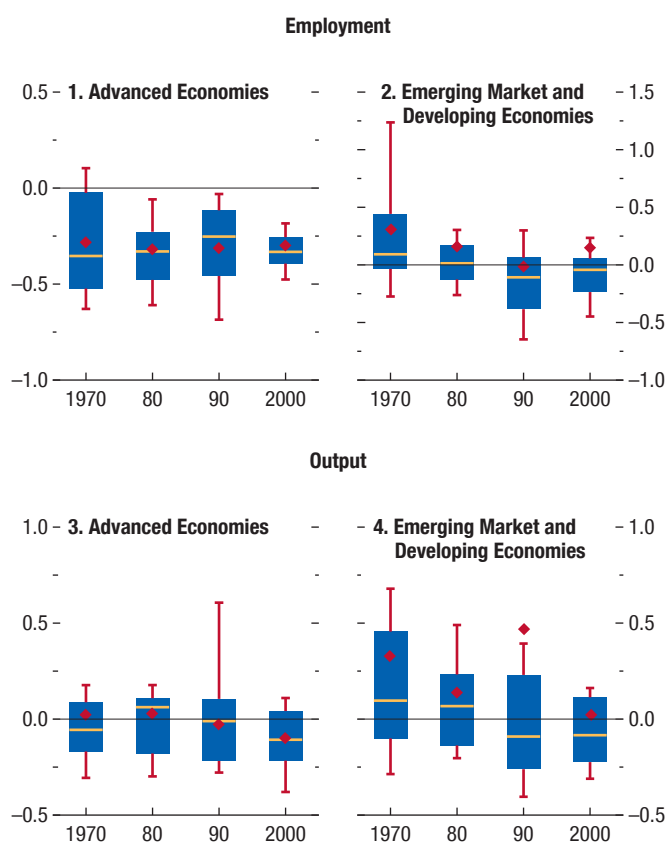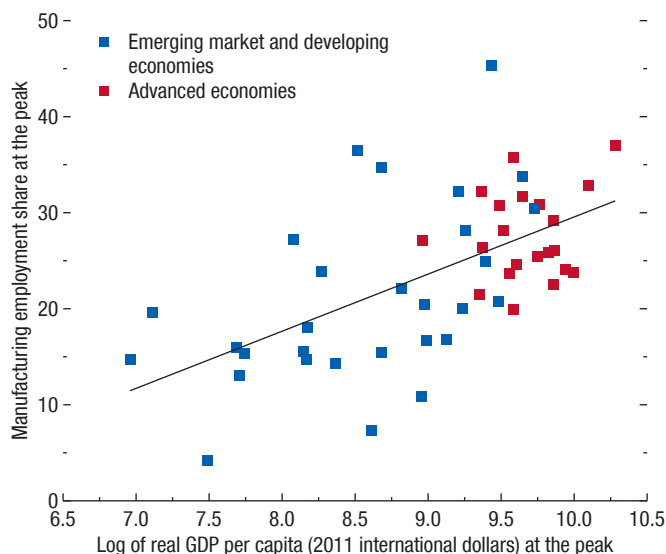

Source: IMF staff calculations.
Note: The figure shows the cross-country distribution of the average annual percent change in the employment and real-value-added manufacturing shares. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. The red diamond denotes the weighted average for the group. X-axis labels indicate the start of each decade. Boxes for 2000 represent data for 2000–15, whenever available.

ing employment and output shares in the 2000s (for instance, Bangladesh, China, Ethiopia, and Malawi). Moreover, many of the developing economies with declining manufacturing shares never experienced strong expansion of the shares to begin with, unlike most of the economies that developed earlier. As a result, compared with those of earlier developers, the manufacturing employment shares of many developing economies have typically peaked at lower shares and income

Figure 3.7. Peak of Manufacturing Employment Share
(Percent)

Compared with economies that developed earlier, the manufacturing employment shares of many developing economies have peaked at lower levels and lower income levels.

Source: IMF staff calculations.
Note: The sample is restricted to economies that show declining manufacturing employment shares since 1990 or earlier. The x-axis shows the income level when manufacturing employment shares peaked.

levels (Figure 3.7).[4] Only a few developing economies in which the manufacturing sector was already relatively large by 1980—Hong Kong Special Administrative Region, Korea, Mauritius, Poland, Romania, Singapore, and Taiwan Province of China—experienced a peak in the manufacturing employment share higher than in the average advanced economy. Accordingly, the services share of employment has started to rise at a lower level of per capita income in today's developing economies than it has in today's advanced economies.

Drivers of Manufacturing Output and Employment Shares

A spectrum of explanations can help reconcile the stable manufacturing output and employment shares at the global level with diverse changes across countries. At one extreme, shifts in manufacturing output and employment shares could reflect zero-sum reallocations in supply, with manufacturing production moving from locations where production costs are higher to

[4]Dasgupta and Singh (2006); Rodrik (2016) call this phenomenon "premature deindustrialization."

lower-cost economies (mostly developing economies) that have become increasingly integrated into the global trading system. At the other extreme, changes in output and employment shares could reflect trends in incomes and demand. Demand for manufactures increases faster than demand for food and services in the earlier stages of a country's development. In the later stages, the demand for services expands the fastest, but the decline in the relative price of manufactures could dampen the relative shift away from their consumption as income grows. Under a demand-based explanation, the global share of manufacturing output would initially be stable or even increase (as has been the case since 2000) as global incomes converge, with fast-growing developing economies consuming relatively more manufactured goods while the slower-growing advanced economies consume less. The global share of manufacturing output would be expected to decline in the long term as all economies increasingly need more services.

In reality, the explanation for a stable global picture amid country variations is probably somewhere between these two interpretations. The global performance likely reflects both some reallocation of manufacturing production toward countries with lower production costs and country variations in the demand for manufacturing.

Each of the potential drivers of changes in manufacturing output and employment shares—variations in demand for manufactures as incomes rise and their relative price falls, and cross-border integration—has been studied widely in the literature. Studies dating back to the 19th century (Engel 1895) as well as recent work (Kongsamut, Rebelo, and Xie 2001; Buera and Kaboski 2009, 2012; Herrendorf, Rogerson, and Valentinyi 2013; Boppart 2014) emphasize changing consumption patterns as real income per capita grows. The final consumption share of manufactured goods exhibits a hump-shaped relationship to real income per capita (Figure 3.8). As individuals' real income rise from low levels, the share they spend on food declines (Engel's law), and the share they spend on manufactured products rises. As incomes grow further, however, the proportion spent on services rises at the expense of manufactures.

A second factor is linked to the faster rise in productive efficiency in manufacturing than in other sectors (Kuznets 1966; Baumol 1967; Ngai and Pissarides 2007), which has lowered the amount of labor needed to produce a given amount of manufacturing output and made manufactures more affordable. Faster effi-

Figure 3.8. Share of Manufacturing in Final Consumption versus Income per Capita, 1980–2011
(Percent)

As real incomes rise from low levels, the share of manufactured goods in consumption increases. As incomes rise further, however, the proportion spent on services grows at the expense of manufactures.
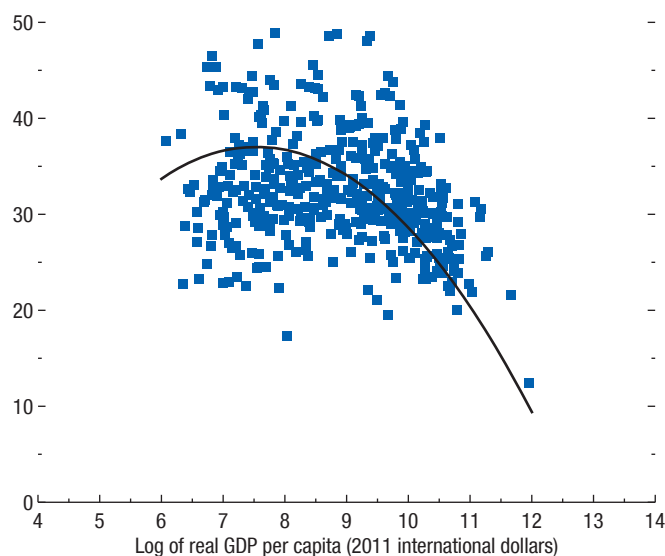
Sources: World Bank International Comparison Program (ICP) database; and IMF staff calculations.
Note: The black line shows the estimated relationship between the share of manufacturing in final consumption and income per capita based on a quadratic estimation using country fixed effects. Final consumption expenditure shares are based on ICP data (1980, 1985, 1996, 2005, and 2011 vintages) and include consumption by households and the government. Countries with population less than 1 million in 2014 are excluded.

ciency gains in production imply that a given increase in output requires smaller increases in labor and other inputs over time; a relatively faster rise of output per worker in manufacturing has thus come with slower employment growth in manufacturing than in other sectors. The faster rise of productivity has also led unit production costs in the manufacturing sector to fall more rapidly than in other sectors, lowering the relative price of manufactures in the vast majority of countries over the past five decades (Figure 3.9). The greater affordability of manufactured goods has tempered the decline in the relative demand for manufactures driven by higher incomes and shifts in preferences, but not to an extent that prevented the productivity-driven decline in the share of manufacturing in employment (Figure 3.10).[5]

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[5]The decline in the relative price of manufactures affects consumer behavior in two ways. First, it raises disposable incomes, allowing consumers to spend more on both goods and services (an income effect). Second, consumers may spend relatively more on the

Figure 3.9. Relative Price of Manufacturing, 1970–2015

The relative price of manufactures declined in most economies over the past five decades, reflecting faster productivity gains in manufacturing than in other sectors.

1. Total Factor Productivity in Manufacturing and Relative Price

2. Change in Log Relative Price
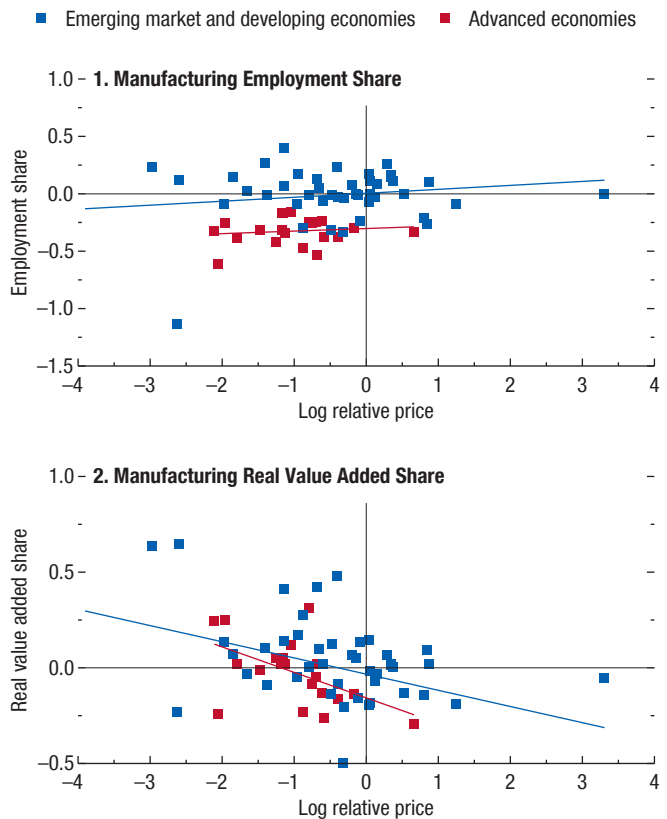(Percentage points per year)
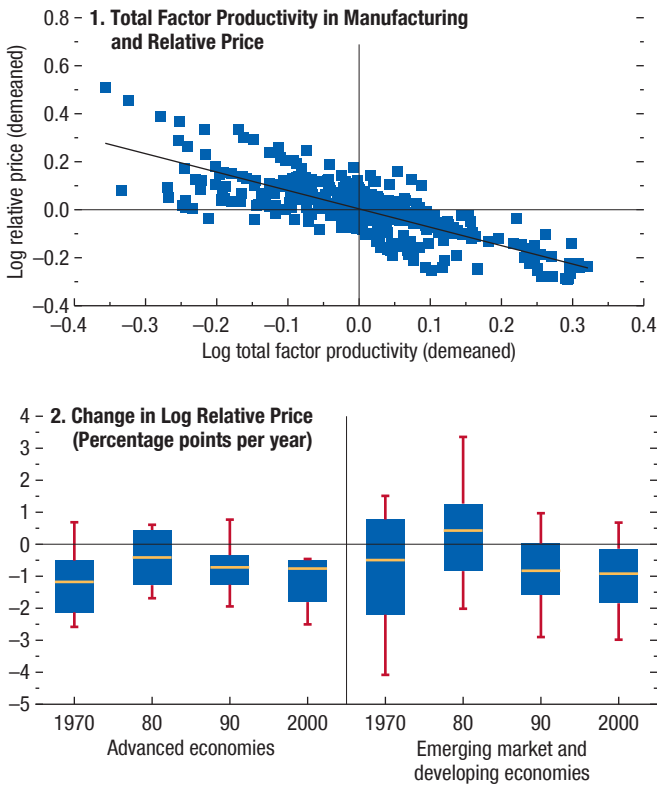
Sources: Groningen Growth and Development Centre database; United Nations database; World KLEMS database; and IMF staff calculations.
Note: Panel 1 shows the logarithm of the relative price of manufacturing value added (relative to that of the aggregate economy) in each country and year against the logarithm of the total factor productivity in manufacturing. Both variables are expressed as deviations from the country average across the sample period. Panel 2 shows the cross-country distribution of the average annual change in the logarithm of the relative price of manufacturing. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. X-axis labels indicate the start of each decade. Boxes for 2000 represent data for 2000–15, whenever available.

A third factor—trade and financial integration—can give rise to new influences on manufacturing shares. International trade allows the sectoral composition of domestic demand to differ from that of domestic supply as goods and some services can be traded across borders (Matsuyama 2009; Uy, Yi, and Zhang 2013;

now-more-affordable manufactured goods (a substitution effect). However, the second channel is not strong: consumers do not substitute services with manufactured goods to a great extent when the latter get cheaper (Buera and Kaboski 2009; Herrendorf, Rogerson, and Valentinyi 2013; Lawrence 2017).

Figure 3.10. Estimated Change in Manufacturing Shares and Relative Prices, 1960–2015
(Percentage points per year)

The decline in the relative price of manufactures boosted the relative demand for goods, but not to an extent that would prevent the shift of labor from manufacturing to services.

- ■ Emerging market and developing economies   ■ Advanced economies

1. Manufacturing Employment Share

2. Manufacturing Real Value Added Share

Sources: Groningen Growth and Development Centre database; United Nations database; and IMF staff calculations.
Note: The relative price denotes the price of manufacturing value added relative to that of the whole economy.

Swiecki 2017; Wood 2017). Declining trade costs affect the patterns of specialization across countries, increasing the share of manufacturing in output and employment in countries that have comparative advantage in that sector and lowering them in countries that do not.[6] Increased access to foreign finance that lowers

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[6]Trade also allows specialization within manufacturing: the manufacture of products requiring primarily low-skilled labor would shift to countries with an abundance of such workers, while the production of other types of manufacturing would shift to countries with an abundance of highly-skilled workers and lower user costs of capital. The share of manufacturing in output may remain unchanged in both groups, while the manufacturing share of employment would rise where low-skilled labor was most abundant and decline elsewhere.

the cost of capital can accentuate the specialization patterns in capital-scarce economies, especially where financial frictions and credit rationing are more prevalent. The reallocation of manufacturing to countries with comparative advantage also lowers the relative price of manufactures globally, raising the demand for manufactures.

Trade and financial integration also speed up the adoption of technological advancements and their diffusion across borders (Chapter 4). Faster diffusion of innovations allows countries to converge to the productivity frontier more quickly and shortens the period in which an increasing share of labor needs to be employed in the manufacturing sector (the so-called industrialization phase of development).[7] Faster diffusion also raises global competition among producers and puts downward pressure on manufacturing prices everywhere, which also tends to raise the final demand for manufactures.[8]

Global sectoral expenditure and production data can give a sense of the extent of production reallocation over the past two decades. Figure 3.11 compares the change in spending on manufactures with changes in the domestic gross output of manufactures.[9] Developing economies' shares in both global gross output and final expenditures of manufactures rose between 1995 and 2011, while those of advanced economies fell (Figure 3.11, panel 1). But the changes in gross output shares have not matched the changes in expenditure shares one-for-one. In advanced economies, gross output shares have declined more than spend-

ing shares (by about 5 percent of global spending on manufactures) as production has shifted to developing economies. In developing economies, the increase in manufacturing gross output has exceeded the rise in final expenditures on manufactures.

The difference between changes in manufacturing gross output and expenditure shares (that is, the extent of reallocation) in the 1995–2011 period has been large for some countries (Figure 3.11, panels 2 and 3).[10] Among large advanced economies, gross output declined more than final spending in France (by 4 percent of GDP), the United States (3 percent), and Japan (1.5 percent). The difference between the change in gross output and final spending is also negative in several developing economies in the sample, including India, Mexico, Russia, and Turkey. In contrast, in China, Germany, Ireland, and Korea, the rise in the manufacturing output share is larger than the rise in the expenditure share. The difference in the case of China (about 10 percent of GDP) stands out, as it represents about 2½ percent of global spending on manufactures. Not all of the reallocations of gross output have been met by equal shifts in domestic manufacturing value added, however. Some of the reallocation has fallen on the service-value-added component of manufacturing output as well (Box 3.1).

The broadly parallel movements of global manufacturing output and employment shares might seem puzzling given the relatively fast pace of productivity growth in the sector, which would be expected to drive a growing wedge between the global output and employment shares of manufacturing over time (as has happened in virtually all advanced economies and most developing economies). The explanation is a gradual shift in the composition of global manufacturing employment toward developing economies, where productivity tends to be lower but the demand for manufactures higher and the unit production costs lower.[11]

The bilateral relationships between manufacturing output and employment shares and their possible drivers are helpful in gaining a sense of the mechanisms underlying structural transformation. However, empirically estimating the relative importance of each of these

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[7]Huneeus and Rogerson (2016) argue that productivity growth in manufacturing (relative to other sectors) may be faster for current developing economies than for earlier developers due to catch-up effects, helping to explain why manufacturing employment shares are peaking at lower levels in developing economies.

[8]Rodrik (2016) argues that as developing economies "imported" deindustrialization as they opened to trade (including those that may not have experienced much technological progress), by becoming exposed to the downward pressure on the relative price of manufactures originating from productivity gains in advanced economies.
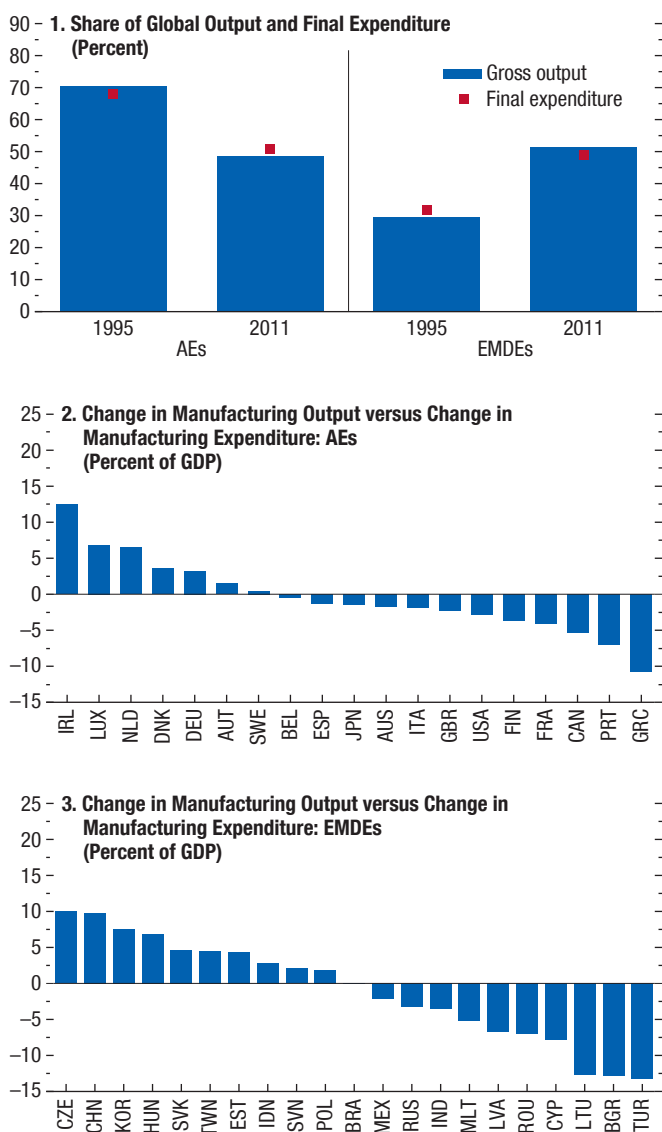
[9]A finished manufactured product embeds value added by both the domestic and foreign manufacturing and nonmanufacturing sectors. A vehicle purchased by a consumer, for instance, embeds domestically and foreign-produced manufactured parts as well as domestically and foreign-produced engineering and marketing services. The domestic gross output of the manufacturing sector is the sum of all the domestically produced content of its final output. Spending on manufactures in a given country equals the sum of the gross output of the domestic manufacturing sector, net imports of finished manufactured goods, and net imports of intermediate inputs by the manufacturing sector. Gross output and spending data used for this exercise are from the World Input-Output Database, which covers 1995–2011. See Annex 3.2 for details.

[10]The difference between changes in manufacturing gross output and spending on manufactured goods over time for individual countries can reflect a faster expansion of spending and not necessarily a decline in gross manufacturing output.

[11]Felipe and Mehta (2016) also document the impact of changes in the country composition of manufacturing activity on the shares of manufacturing in output and employment at the global level.

Figure 3.11. Manufacturing Gross Output and Final Expenditure on Manufacturing Goods, 1995–2011

Developing economies exhibited a larger expansion in the share of global gross manufacturing output than in the share of global spending on manufactures, which suggests some production reallocation towards those economies as a group. But there is considerable variation across economies.

1. Share of Global Output and Final Expenditure
(Percent)

2. Change in Manufacturing Output versus Change in Manufacturing Expenditure: AEs
(Percent of GDP)

3. Change in Manufacturing Output versus Change in Manufacturing Expenditure: EMDEs
(Percent of GDP)

Sources: World Input-Output Database; and IMF staff calculations.
Note: Panel 1 shows the share of each group of economies in global manufacturing gross output (bars) and in global final expenditure on manufactures (squares). Panels 2 and 3 show the difference between the change in the domestic gross manufacturing output and in final expenditure on manufactures between 1995 and 2011, expressed as a share of average GDP during the period. Domestic gross manufacturing output includes value added from all domestic sectors embedded in manufacturing production (foreign value added is excluded). See Annex 3.2 for details. Data labels use International Organization for Standardization (ISO) country codes. AEs = advanced economies; EMDEs = emerging market and developing economies.

mechanisms for a broad set of countries is very challenging. The complexity of the underlying mechanisms aside, only the ex post outcomes of the causal drivers—production costs and relative prices, trade intensity, and income levels—are observed, not the exogenous forces driving structural change. The recent literature has therefore largely sought to explain structural transformation patterns using global general equilibrium models, typically focusing on one mechanism at a time.[12]

The Rise of Services

A striking feature of structural transformation is the expansion of the service sector. The share of services in global employment has increased by about 16 percentage points since the 1970s. While the increase in the share of service jobs in overall employment is largely the flip side of declining manufacturing employment in advanced economies (Figure 3.2, panel 1), in developing economies it mostly reflects a shift of labor from agriculture (Figure 3.2, panel 2).

Employment in nonmarket services (government, education, health) expanded rapidly in the group of advanced economies, contributing about one-third of the overall expansion in service employment since 1970 (Figure 3.12).[13] Within market services—which contributed the remaining two-thirds of the expansion in the share of services—financial intermediation, real estate, and business activity services were the subsectors with the fastest growth. In developing economies, employment in market services contributed the lion's share of the overall increase in services employment, with particularly large expansions in wholesale and retail trade, and hotels and restaurants.

Manufacturing output increasingly embeds inputs from services—the so-called servicification of manufacturing (National Board of Trade of Sweden 2010; Baldwin 2016; Hallward-Driemeier and Nayyar 2017). Using recently available data on global input-output

[12]Herrendorf, Rogerson, and Valentinyi (2014) survey recent contributions to the literature on structural transformation.

[13]The classification of service industries into market and non-market services follows the guidelines of the System of National Accounts. Market services consists of wholesale and retail trade and repair of goods; hotels and accommodation; transport, storage, and communications; financial intermediation; real estate, renting, and business activities; other community and personal activities; and activities of private households. Nonmarket services consist of government (public administration, defense, and social security); education; and health. See Annex 3.1 for a list of sectors, individual industries, and abbreviations.

linkages, analysis in Box 3.1 documents that the share of service inputs in manufacturing production has risen in most countries over the past two decades. However, the share of manufactures in final expenditure has been declining in most countries, and service inputs into manufactures still account for a small fraction of overall value added in the service sector, so the servicification of manufacturing has not contributed meaningfully to the increased share of services in overall output over the past two decades.

The changing service content of manufacturing output poses challenges to the measurement of structural change. Available statistics measure only imperfectly changes in the weight of different tasks and activities in the economy. The increasing fragmentation of manufacturing production implies that some activities formerly carried out within manufacturing firms (such as marketing, legal services, logistics) are unbundled and outsourced. The reclassification of these activities as services in official statistics could overstate the extent of structural transformation.[14] At the same time, firms in the manufacturing sector are increasingly producing and selling auxiliary services that are bundled with finished goods; including such service activities in manufacturing production may understate the true extent of structural transformation.[15] Available data do not permit reliable quantification of the relative magnitude of these two opposing effects, and partial evidence from existing studies suggests that their net effect on measures of sectoral employment and output shares is ambiguous.

Growth and Development beyond Manufacturing

Manufacturing has historically been considered more technologically progressive than the service sector, so the reallocation of production from the former to the latter has generally raised concern regarding the growth of aggregate productivity—the most important determinant of a country's standard of living (Baumol 1967; Kaldor 1967).[16] The countries that achieved

[14]Berlingieri (2014); and Bernard, Smeets, and Warzynski (2017).
[15]Pilat and Wölfl (2005); National Board of Trade of Sweden (2010); and Crozet and Milet (2017).
[16]Many of the key attributes of the manufacturing sector—relatively high levels of innovation, foreign direct investment (facilitating technological diffusion), economies of scale, high degrees of tradability, and strong interlinkages with other sectors—have traditionally been considered critical to long-term growth and development. Hallward-Driemeier and Nayyar (2017) note that these characteristics vary considerably across manufacturing subsectors and over time.

Figure 3.12. Change in Services Employment Share, 1970–2015
(Cumulative change, percentage points)

Market services account for about two-thirds of the overall expansion in service employment since 1970 in advanced economies, and more than 80 percent in developing economies.
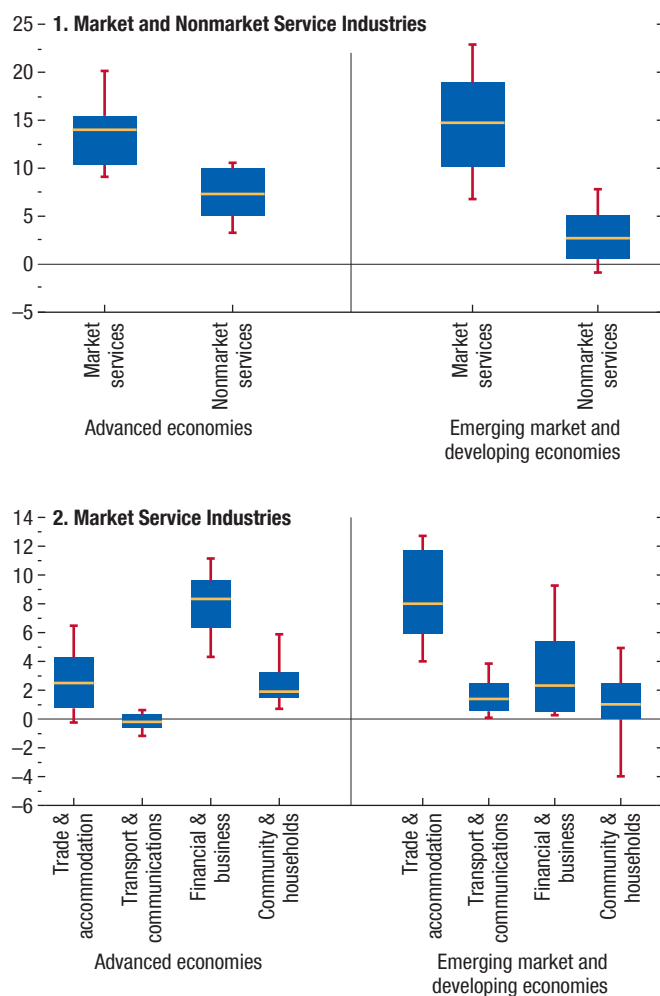
Source: IMF staff calculations.
Note: The figure shows the cross-country distribution of the cumulative change in the employment share of individual service industries between the average in the 1970s and the average during 2000–15. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. Nonmarket services consists of government; education; and health. All other service industries are market services. See Annex 3.1 for a list of sectors, individual industries, and abbreviations.

substantial income convergence toward more developed economies since the 1960s typically experienced strong increases in manufacturing employment and exports (Jones and Olken 2005; Johnson, Ostry, and Subramanian 2007). The observation that the industrialization phase among developing economies is not as vigorous as it was in countries that developed earlier has thus led some to doubt their ability to narrow income gaps with advanced economies. Rodrik (2013, 2016) provides compelling evidence in favor of these concerns, documenting that labor productivity in manufacturing in a sample of 130 economies has tended to converge to the frontier, regardless of policies, institutions, and other country characteristics (unconditional convergence), whereas labor productivity for the overall economy (and hence the nonmanufacturing sector) has not.[17] This unique attribute implies a pivotal role for manufacturing in the development process; a stagnant manufacturing sector could present a daunting obstacle for developing economies in catching up with advanced-economy per capita income levels. Consistent with this observation, McMillan and Rodrik (2011) document that structural transformation between 1990 and 2005 tended to be growth-reducing in developing countries that did not experience increases in the share of manufacturing employment.

Nonmanufacturing activities form a very diverse group, however.[18] Productivity dynamics vary substantially within services, and shifts of employment shares within the nonmanufacturing sector have been sizable, especially in developing economies (where activity has shifted from agriculture to services). These observations highlight the value of assessing the productivity effects of structural transformation using data at a more disaggregated sectoral level than for manufacturing and the rest of the economy. If productivity converges toward the international frontier for some types of services, and employment shares shift toward these subsectors, then structural transformation that bypasses manufacturing need not hinder economy-wide productivity growth.

In seeking to shed light on whether nonmanufacturing sectors can increasingly drive growth and help narrow income gaps across countries, the analysis follows McMillan and Rodrik (2011) and Rodrik (2013) and focuses on the growth of labor productivity as a normative benchmark. Labor productivity is defined as output at constant prices divided by the number of workers in the economy or a given sector. When cross-country comparisons of sectoral productivity levels are involved, output is expressed in "international dollars" using sector-specific purchasing power parity (PPP), which helps ensure that the comparisons are not affected by price differences across countries. The analysis also provides some evidence of differences in total factor productivity (TFP) growth rates by disaggregated sector, with TFP defined as the output for a given combination of labor and capital inputs, a measure of overall efficiency gains that (unlike labor productivity) does not vary with the amount of capital per worker but is available for a relatively limited set of countries.[19]

As a final word of caution regarding this analysis, productivity data by disaggregated sector are available only for a subset of the Rodrik (2013) database. Wherever possible, the analysis uses a variety of data sets to ascertain robustness. At the same time, the data sets used in the chapter include sector-specific PPPs that facilitate the comparison of sectoral productivity across countries, which was not possible in the Rodrik (2013) study.

The road map for the rest of the subsection is as follows. The discussion next turns to evidence on productivity levels and growth rates across disaggregated service and manufacturing subsectors. The subsequent section examines whether shifts in employment shares between sectors have tended to benefit or harm aggregate productivity. The final section looks at whether productivity convergence is unique to manufacturing or whether it is a feature of some service sectors as well.

Productivity in Services: Lagging Behind?

Many studies have stressed that productivity growth among the diverse set of market and nonmarket industries is likewise diverse, ranging from the slowest to the

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[17]Convergence requires productivity to grow faster in countries where its initial level is relatively low.

[18]Productivity dynamics vary substantially within manufacturing activities, as well as across firms within narrowly defined manufacturing and nonmanufacturing industries. Hsieh and Klenow (2009) document that that the "misallocation" of capital and labor across manufacturing firms in China and India hinder economy-wide total factor productivity. Dias, Marques, and Richmond (2016) find that the extent of resource misallocation in Portugal is larger in the service sector than in manufacturing.

[19]In addition to being available for a small set of countries on a sectoral basis, TFP measures (unlike labor productivity measures) do not lend themselves to straightforward decompositions of "within-sector" and "structural transformation" effects.

fastest in the economy.[20] Some service industries at the upper end of productivity growth are among the most intensive users of information and communication technologies (Stiroh 2002). Recent advances in those technologies are likely to have played an important role in boosting the productivity of the sectors that use them (Bosworth and Triplett 2003, 2007; Jorgenson and Timmer 2011).[21]

A first look at labor productivity by aggregated sector reveals that the manufacturing sector as a whole typically sees faster productivity gains than the service sector (most observations of the productivity growth differential between manufacturing and services are positive in Figure 3.13, both before and after 2000). However, the differential has shrunk since 2000 in most countries (that is, most observations lie below the 45-degree line in the same figure). Moreover, average productivity growth in services in many developing economies, including China, India, and some in sub-Saharan Africa, has recently exceeded that of manufacturing.
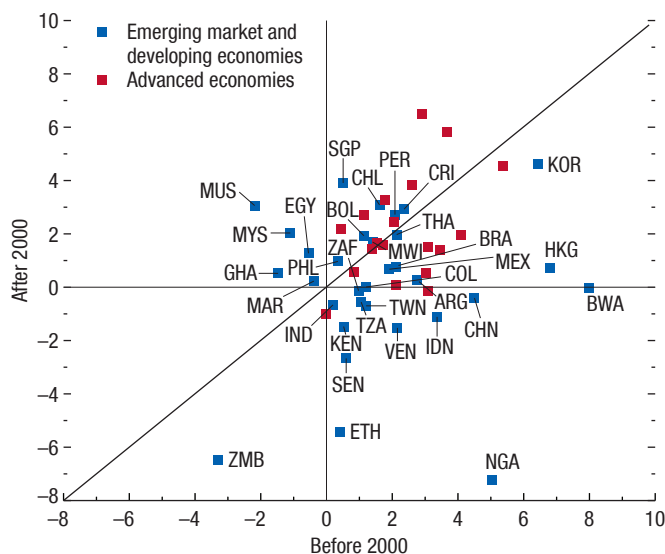
Disaggregated labor productivity data show that some service industries register as fast growth in output per worker as the top-performing manufacturing industries (Figure 3.14). The distribution of labor productivity growth in manufacturing industries over the past five decades is somewhat to the right of that of service industries. However, in a sample of 19 advanced and 43 developing economies during 1965–2010, labor productivity growth in some broad service industries is comparable to productivity growth in manufacturing as a whole (Figure 3.14, panel 1). A similar picture appears from data for 13 manufacturing industries and 13 service industries available for a smaller number of economies (Figure 3.14, panel 2). The data for the United States, which is available at a finer disaggregation level (20 manufacturing industries and 39 service industries), shows an even larger degree of overlap between labor productivity growth in manufacturing and service subsectors (Figure 3.14,

Figure 3.13. Difference in Labor Productivity Growth between Manufacturing and Services before and after 2000
(Percentage points)

The difference between productivity growth in manufacturing and services has shrunk since 2000 in most economies. The average productivity growth in the services sector has recently exceeded that of manufacturing in many developing economies.

Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: The figure shows the average annual growth differential between labor productivity growth in manufacturing and services during 2000–15 on the *y*-axis and during 1965–99 on the *x*-axis. Observations below the diagonal line denote a decline in the productivity growth differential. Labor productivity is defined as value added per worker at constant national prices. Data labels use International Organization for Standardization (ISO) country codes.

panel 3).[22] The main takeaway is that there is a sizable overlap between productivity growth among the service and the manufacturing subsectors.

Finally, the levels of labor productivity for a sample of 19 advanced and 43 developing economies in 2005 suggest that, within each country, workers in goods-producing sectors are not necessarily more productive than service sector workers (Figure 3.15). More precisely, labor productivity in two out of four market service industries (transport and communications; financial intermediation and business activities) is comparable to, or higher than, in manufacturing.

The finding of strong productivity growth among services is good news for developing economies where the share of manufacturing in overall activity has

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[20]See, for instance, Baumol, Blackman, and Wolff (1985); Jorgenson and Timmer (2011); Verma (2012); Young (2014); Duarte and Restuccia (2017); and Duernecker, Herrendorf, and Valentinyi (2017). Productivity in service industries is particularly difficult to measure (Triplett and Bosworth 2000), but previous work suggests that correction for mismeasurement of output in services would likely lead to higher productivity growth in services than recorded in official data (Gordon 1996).

[21]Communication and digital technologies may help increase productivity growth in some service industries by facilitating international trade in services (Heuser and Mattoo 2017; Loungani and others 2017; Box 3.2), which heightens competition, facilitates cross-border knowledge spillovers, and enhances economy of scale.

[22]TFP data also reveals substantial overlap between productivity growth in manufacturing and service subsectors (Annex Figure 3.3.1).

Figure 3.14. Distribution of Labor Productivity Growth of Individual Industries
(Kernel density)

There is a sizable overlap between labor productivity growth among the service and the manufacturing subsectors, with some service industries exhibiting productivity growth rates as high as the top-performing manufacturing industries.
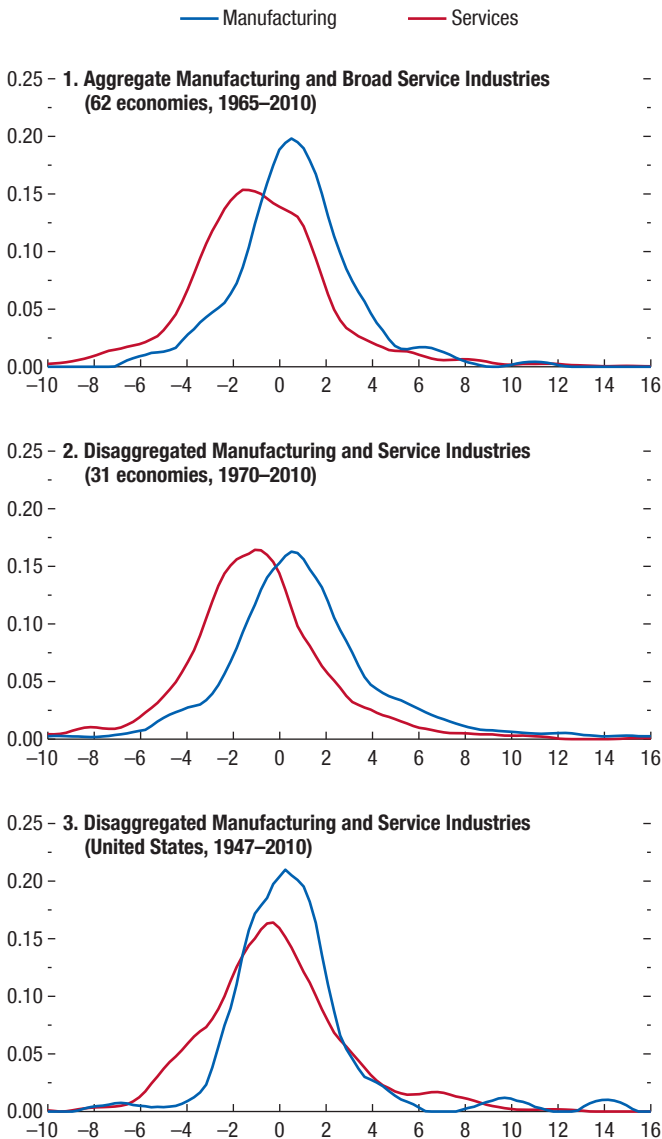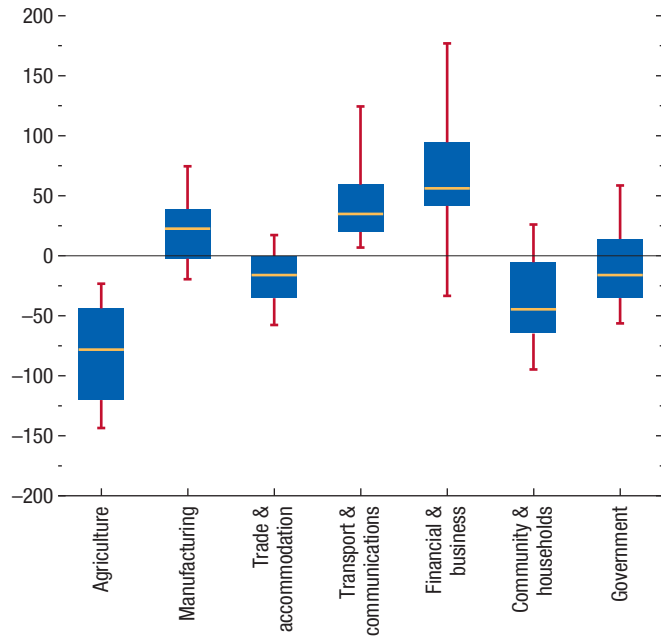

Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: The figure shows the distribution of average labor productivity growth per decade in individual manufacturing and service industries (expressed as deviations from the average labor productivity growth across sectors in each country and decade). Panel 1 is based on data for aggregate manufacturing and 5 service industries in 19 advanced economies and 43 emerging market and developing economies. Panel 2 is based on data for 13 manufacturing and 13 service industries in 19 advanced economies and 12 emerging market and developing economies. Panel 3 is based on data for 20 manufacturing and 39 service industries in the United States (Jorgenson, Ho, and Samuels 2012). See Annex 3.3 for details.

Figure 3.15. Sectoral Labor Productivity, 2005
(Difference with respect to economy-wide labor productivity; percentage points)

Within each economy, labor productivity is not necessarily lower in service industries than in goods-producing sectors. Labor productivity in two out of four market service industries is higher than the economy-wide average, and comparable or higher than in manufacturing.

Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: The figure shows the cross-country distribution across 62 economies of the percentage difference between labor productivity in each sector (value added per worker) and aggregate labor productivity in 2005. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles.

leveled off. However, these productively-dynamic service industries may not necessarily account for a large share of employment and thus may play a limited role in driving aggregate productivity. Moreover, their expansion in the future may be constrained by the availability of skilled workers or the pace of expansion in domestic demand. Ancillary evidence, however, suggests that these factors may not necessarily act as binding impediments to service-led productivity growth in the short term.

Service industries with favorable productivity dynamics account for a meaningful share of employment and can play a key role in driving aggregate productivity growth. For instance, the service industries that rank in the top third of the labor-productivity growth distribution (Figure 3.14, panel 2) during 2000–10

accounted, on average, for almost half of total employment in market services, about 30 percent of total service employment, and close to 20 percent of overall employment.[23] Some service industries simultaneously registered above-average labor productivity growth and rising employment shares during the 2000s, thanks to strong demand (for example, financial intermediation in Hungary, Russia, and Slovenia; postal services and telecommunications in Korea and Lithuania; and wholesale trade in the Czech Republic and Latvia). And although employment in some of the tradable service industries—such as financial intermediation—are skill intensive, the skill intensity of other service industries with relatively high labor-productivity growth, including telecommunications, is comparable to that of manufacturing (Annex Figure 3.3.3).

The growth of nontraded service sectors could indeed be constrained by the pace of expansion in domestic demand. Notwithstanding the increased tradability of services in the recent past, especially among highly productive services, such as telecommunications, financial intermediation, and business activities, international trade in services is still rather limited (Box 3.2). That said, recent studies suggest that the domestic demand for services exhibiting strong productivity growth may increase in relative terms over time as they become more affordable.[24] And, given that barriers to international trade are higher for services than for goods (Miroudot, Sauvage, and Shepherd 2013), there is potential for service exports to gather speed if appropriate policy actions are taken.

Has Structural Transformation Weighed on Aggregate Productivity Growth?

To gauge the impact of shifts in employment shares across disaggregated sectors, this section follows a decomposition analysis put forth by McMillan and Rodrik (2011), and Diao, McMillan, and Rodrik (2017). The approach recognizes that economy-wide

labor productivity growth can be achieved in two ways.[25] First, productivity can increase within sectors through an increase in capital per worker, higher total-factor productivity, or a reallocation of labor and capital toward the more productive firms within the sectors. The so-called "within" component of the decomposition captures the contribution of productivity growth within sectors to economy-wide productivity growth. Second, economy-wide labor productivity can increase if workers shift from sectors where their productivity is low to sectors where it is high. This second part—the so-called "between" or "structural change" component—captures the effect of labor reallocations across sectors with varying productivity levels. When employment shares increase in high-productivity sectors, structural change will be beneficial for economy-wide labor productivity growth.

The results of the decomposition using data spanning 10 sectors in a sample of 62 economies covering 2000–10 confirm that productivity gains within sectors can account for the bulk of aggregate labor productivity growth in both advanced and developing economies (Figure 3.16, panel 1). Importantly, the results also show that structural change has not exerted a drag on aggregate productivity. In advanced economies, where employment shares have steadily shifted from manufacturing primarily to nonmarket service industries (Figure 3.16, panel 2) and intersectoral productivity gaps are relatively small, the contribution of structural change has been negative but quantitatively negligible. This finding is to be expected: as documented in McMillan and Rodrik (2011), gaps between productivity levels in sectors narrow over time as countries develop.

The contribution of structural change to aggregate productivity growth in developing economies has been positive in all regions since 2000—a period when labor has shifted from low-productivity agriculture to manufacturing in some cases, and to market services more prominently (Figure 3.16, panel 2). Consistent with the findings in McMillan, Rodrik, and Verduzco-Gallo (2014) and Diao, McMillan, and Rodrik (2017), the analysis shows that the positive contribution of structural change since 2000 has been particularly large in sub-Saharan Africa. This is explained by the strong labor shifts out of agriculture in the region during this period, combined with still-large productivity shortfalls in agriculture relative to manufacturing and market

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[23]The service industries that rank in the top third of the labor-productivity growth distribution during 2000–10 are postal services and telecommunications, financial intermediation, and wholesale and retail trade (Annex Figure 3.3.2).

[24]Duernecker, Herrendorf, and Valentinyi (2017) find that the elasticity of substitution between services with high and low productivity growth in the United States is larger than 1. This degree of substitutability implies that the demand for services with high productivity growth and declining relative prices can substitute for services with lower productivity growth, leading to an expansion of their employment share despite fast productivity gains.

[25]See Annex 3.3 for details.

Figure 3.16. Structural Transformation and Aggregate Labor Productivity Growth, 2000–10

The contribution of structural change in developing economies has been positive since 2000, when labor predominantly shifted from agriculture to market services.
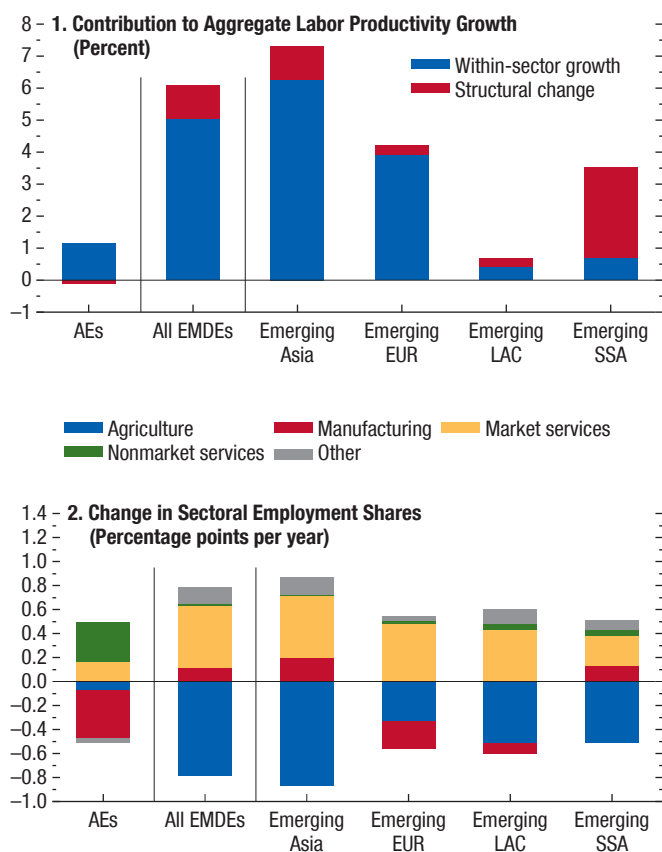
1. Contribution to Aggregate Labor Productivity Growth (Percent)

- ■ Within-sector growth
- ■ Structural change

- ■ Agriculture
- ■ Manufacturing
- ■ Market services
- ■ Nonmarket services
- ■ Other

2. Change in Sectoral Employment Shares (Percentage points per year)

Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: Panel 1 shows the contribution of within-sector labor productivity growth and changes in sectoral employment shares to the (weighted average) annual aggregate labor productivity growth in each group of economies (economies are weighted by total employment) based on data for 10 broad sectors. See Annex 3.3 for details. Panel 2 shows the change in sectoral employment shares for five groups of sectors. Nonmarket services consists of government; education; and health. All other service industries are market services. See Annex 3.1 for a list of sectors, individual industries, and abbreviations. AEs = advanced economies; EMDEs = emerging market and developing economies; EUR = Europe; LAC = Latin America and the Caribbean; SSA = sub-Saharan Africa.

services (Annex Figure 3.3.4).[26] One concern, stressed by Diao, McMillan, and Rodrik (2017), however, is that the recent growth-enhancing structural change

[26]In earlier work, McMillan and Rodrik (2011) find that structural change contributed negatively to economy-wide productivity growth in sub-Saharan Africa over 1990–2005, a period when the share of agriculture in employment declined by only 0.1 percentage points. In contrast, the share of agriculture within overall employment declined by 5 percentage points over 2000–10 and the bulk of this change occurred during the second half of the period.

appears to have been driven by the particularly strong growth of aggregate demand in the region (supported by external transfers or higher commodity-based revenues), suggesting that overall productivity growth may slow down as demand loses momentum, unless productivity growth picks up within sectors.

That said, the growth of productivity within sectors differs widely and accounts for the bulk of the variation in overall productivity growth across regions (Figure 3.16, panel 1). The contribution to aggregate productivity growth of both manufacturing and market services in 2000–10 was much larger in Asia (1.9 percent and 2.1 percent a year, respectively) than in sub-Saharan Africa (almost nil in manufacturing and 0.8 percent in market services) and in Latin America (about 0.2 percent in each). Therefore, the challenge for many developing economies is not only to facilitate the reallocation of labor to high-productivity sectors, but also to raise productivity growth in all sectors.

Implications for Income Gaps across Countries

Labor shifts into sectors with relatively high and fast-growing productivity (by the standards of the country) may not be enough to narrow the gap vis-à-vis the frontier if productivity grows even faster at the frontier. Rodrik's (2013) finding of unconditional convergence in manufacturing suggests that the lack of income convergence at the country level might be a result of the relatively small share of manufacturing employment in developing economies and that convergence would hasten if the share of manufacturing employment could be raised.

Even if the productivity of the nonmanufacturing sector as a whole does not converge to the world economy's highest levels, some of its subsectors might. This section tests this proposition.[27]

The empirical approach, following Bernard and Jones (1996) and Sorensen (2001), tests whether productivity growth in a sector is faster when the initial gap between its productivity level and productivity at the technological frontier is larger. This would imply that the greater the shortfall, the faster the convergence to the frontier

[27]Testing unconditional productivity convergence for individual sectors is challenging because it requires data on output per worker at comparable international prices across countries. This section uses new data on sector-specific PPP from the Groningen Growth and Development Centre database. Nonmarket service industries are excluded from the analysis because of lack of reliable sectoral PPP data. See Annex 3.3 for details.

Figure 3.17. Estimation Results, Beta-Convergence
(Coefficient)

There is strong evidence of unconditional productivity convergence to the global frontier (that is, to the productivity level in the most productive countries) for manufacturing as well as for several service industries.
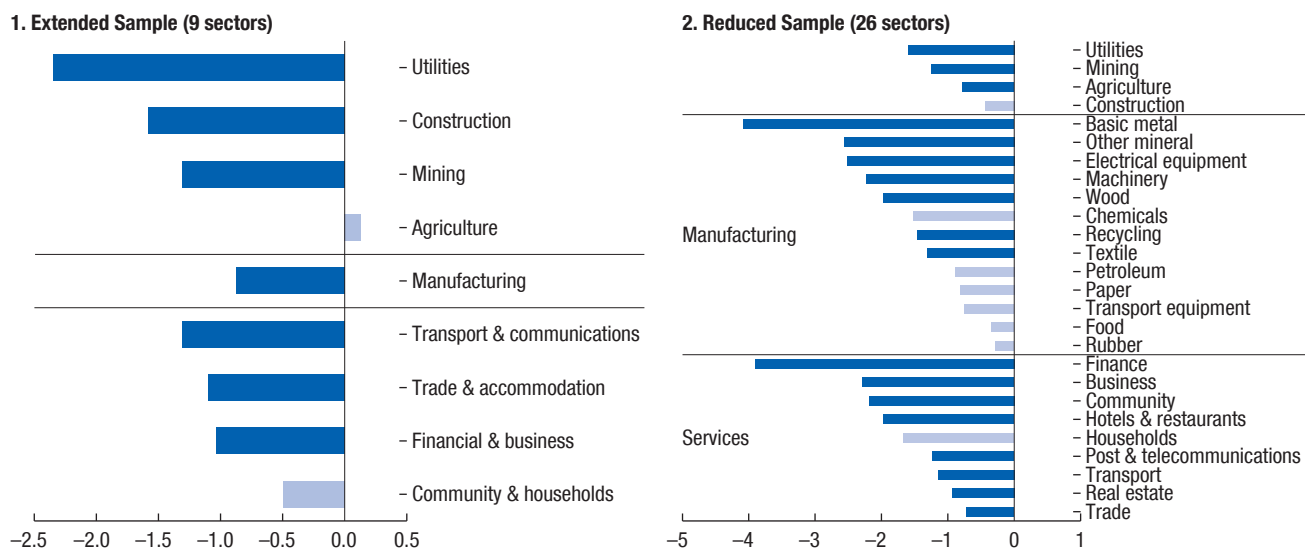
1. Extended Sample (9 sectors)

2. Reduced Sample (26 sectors)

Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: This figure shows the estimated coefficients from the unconditional convergence regression for each sector based on labor productivity. Solid bars denote that the coefficient is statistically significant at the 95 percent level. A negative and significant coefficient denotes evidence of productivity convergence across countries. Nonmarket service industries are excluded due to a lack of reliable sectoral purchasing-power-parity data. Panel 1 corresponds to an extended sample of 19 advanced economies and 20 emerging market and developing economies with data for 9 market sectors from 1965 to 2015. Panel 2 corresponds to a reduced sample of 19 advanced economies and 11 emerging market and developing economies with data for 26 market sectors during 1970–2010. See Annex 3.3 for details.

level of productivity—a concept of convergence known as beta-convergence (Barro and Sala-i-Martin 1992).

Starting with a sample of 19 advanced economies and 20 developing economies, the analysis provides strong evidence of unconditional convergence of productivity to the frontier for manufacturing, in line with Rodrik (2013), as well as for several nonmanufacturing sectors (Figure 3.17, panel 1). Importantly, the results suggest significant convergence in three of the four market service sectors under study: trade and accommodation, transport and communications, and financial and business services.

In addition, this sample exhibits no unconditional convergence for agriculture, which employed about two-thirds of the workforce in developing economies in the 1970s and almost half as recently as the first decade of the 21st century. The lack of unconditional convergence in agriculture is an important finding because it may explain the difficulty in finding evidence of unconditional convergence in aggregate income per worker in broader samples of countries, including lower-income countries where agriculture

still employs a large share of the workforce (see, for instance, the discussion in Chapter 2 of the April 2017 WEO and Box 1.3 of the October 2017 WEO).[28]

Another indicator of convergence describes whether the dispersion of sectoral productivity across countries has narrowed over time, a measure called sigma-convergence. Indeed, the dispersion of productivity across countries declined over time in all sectors that exhibited significant evidence of beta-convergence (Figure 3.18; Annex Figure 3.3.5).[29] In the case of the service sectors, the extent of convergence seems to have accelerated since the mid-1990s or early 2000s—a time when the trad-

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[28]Sectoral convergence, however, does not necessarily imply aggregate convergence. Even if sectoral productivity has converged to the frontier level of productivity in all sectors, there will still be differences in aggregate productivity levels if the relative size of sectors varies across countries (Bernard and Jones 1996).

[29]Given that examination of sigma-convergence requires a balanced sample, Figure 3.18 is based on a smaller sample than the beta-convergence, comprising 28 countries for the period 1971–2010 (excluding eastern European countries for which sectoral data are available only since 1995).

Figure 3.18. Sigma-Convergence
(Standard deviation of log labor productivity, PPP adjusted)

The dispersion of productivity levels across countries declined over time in several service industries, providing further evidence of convergence. The extent of productivity convergence in service industries has accelerated since the mid-1990s or early-2000s.
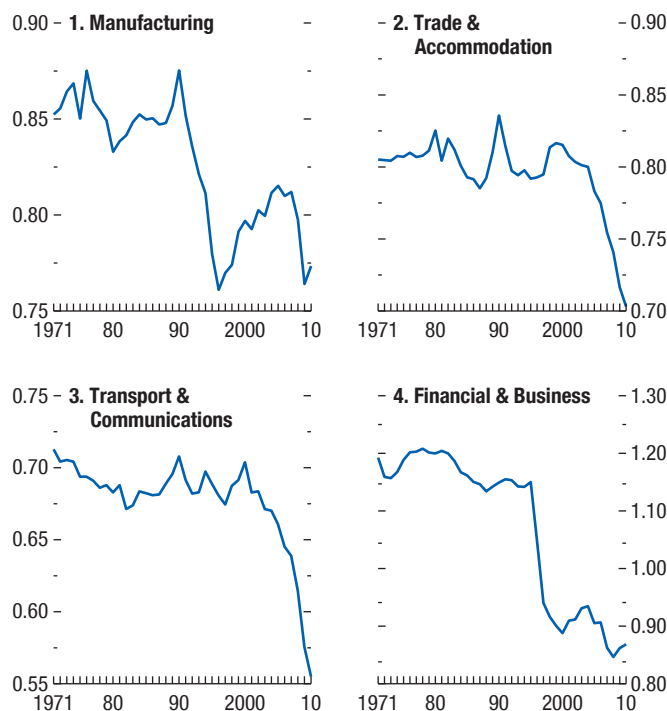
Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: See Annex 3.3 for details. PPP = purchasing power parity.

Figure 3.19. Productivity Gap in 2005
(Difference in productivity level with respect to the United States, percentage points)

The productivity gap vis-à-vis the United States in 2005 was larger for goods-producing sectors than for the service sector. Resource shifts from goods-producing sectors to the service sector need not harm convergence prospects.

Sources: Inklaar and Timmer (2014); and IMF staff calculations.
Note: Productivity gap is calculated as the log difference between sector-specific purchasing-power-parity-adjusted value added per worker in the United States and that in each country. The goods-producing sector includes agriculture, mining, manufacturing, utilities, and construction. The services sector includes the rest.
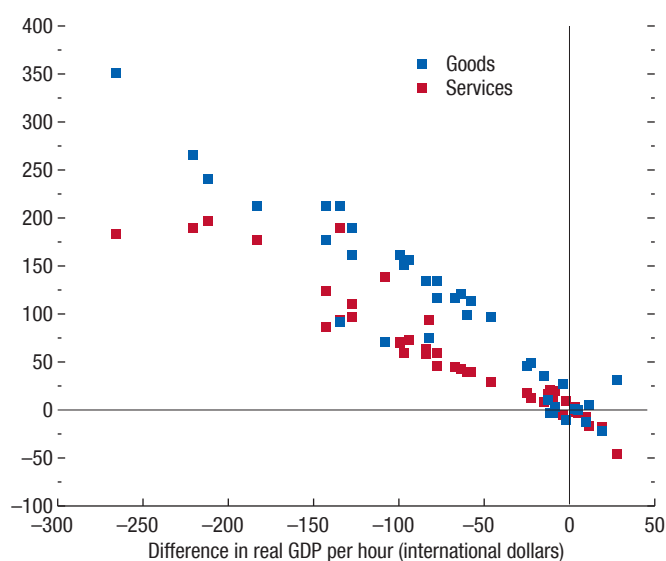
ability of services increased considerably (Heuser and Mattoo 2017; Box 3.2).

Further analysis using a reduced sample of 19 advanced economies and 11 developing economies with more granular sectoral detail reveals that almost half of the manufacturing industries (including chemicals, food, paper, and rubber) show no evidence of convergence (Figure 3.17, panel 2). Among services, eight out of nine market industries show evidence of unconditional convergence (including financial intermediation, postal services and telecommunications, and business services).[30]

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[30]There could be some concern that labor productivity convergence comes primarily from capital deepening. A robustness exercise on a reduced sample provides evidence of unconditional TFP convergence in some market service sectors (for example, financial intermediation, business services, and wholesale and retail trade; see Annex Table 3.3.2). See also the discussion in McMillan and Rodrik (2011).

The evidence of convergence in services productivity notwithstanding, the level of productivity in services may be further away from the technological frontier than in agriculture or manufacturing. In that case, the prospects for narrowing the gaps in income per worker as labor shifts from goods-producing sectors to services would be jeopardized, at least temporarily. However, in most countries, the productivity gap vis-à-vis the United States in 2005 was larger for goods-producing sectors than for the service sector (Figure 3.19), especially among lower-income countries.

The main message that emerges from the various parts of analysis in this section is that skipping a traditional industrialization phase need not be a drag on economy-wide productivity growth for developing economies. Some service industries have the potential to boost the growth of aggregate productivity and aid the convergence of income per worker across countries. But sustaining the recent improvements in living standards in many developing countries will require policy actions to strengthen productivity growth within all sectors.

Implications for Income Inequality

Historically, manufacturing industries are widely perceived to have been a major source of high-quality jobs. The decline in the share of manufacturing jobs in employment, especially among advanced economies, has thus fueled concern that the disappearance of what are thought to be relatively well-paying manufacturing jobs would hurt the living standards of affected workers and contribute to a variety of social ills.[31] Under this mechanism, the shift of workers from well-paying manufacturing to lower-paid jobs in the service sector contributes to the "hollowing out" of the income distribution by moving workers from the middle to the lower end of the income scale, leading to higher earnings inequality. A large body of research has investigated the causes of growing income inequality and polarization, focusing primarily on the roles of trade and automation.[32] Few studies, however, have sought to isolate the effects of structural transformation on the distribution of labor income.[33]

Against this backdrop, this section uses micro-level data for a set of advanced economies to examine if pay is systematically higher and more evenly distributed in the manufacturing sector, as is often assumed. It then gauges the extent to which changes in income inequality can be attributed to shifts in employment shares across sectors, exploiting the initial disparity of earnings within and across types of employment. The main takeaway of the analysis is that only a limited portion (less than one-fourth under an extreme assumption) of the rise in income inequality could have resulted from the shift between manufacturing and nonmanufacturing employment.

The micro-level data used for the analysis are from the Luxembourg Income Study database. Because of data limitations, the manufacturing sector is represented by the broader industrial sector.[34] The data used here cover labor income from household surveys in an unbalanced panel of 20 advanced economies since the 1980s.

Are earnings higher and more equal in industry than in services?

The data show that labor compensation in industry is indeed somewhat higher than in services for comparable skill levels (Figure 3.20).[35] For medium-skilled workers in the two sectors, earnings are practically indistinguishable. The median difference in labor earnings between industry and services for high- and low-skilled workers is about 6 percentage points and 9 percentage points, respectively. Nonetheless, the skill premium is more important in explaining the variation in earnings across workers than their sector of employment: the gap between earnings for middle- versus low-skilled workers within a sector is about twice as large as the gap between low-skilled workers in industry and services.

Similarly, there is somewhat less labor income inequality in the industrial sector than in the service sector (as indicated by the two leftmost boxes in Figure 3.21, panel 1). But the data also show that countries with a relatively high degree of earnings inequality within the service sector tend to have high inequality within the industrial sector as well (Figure 3.21, panel 2).[36]

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[31]For example, Helper, Krueger, and Wial (2012) document that average earnings in manufacturing jobs are about 8 percent higher than in nonmanufacturing jobs when differences in worker and job characteristics are controlled for. Lawrence (2017) stresses that manufacturing has historically provided the opportunity for relatively unskilled workers to earn relatively high wages; he notes that in the United States, the manufacturing sector employed more than one-third of men without a college degree in 1970 and 17 percent in 2015. Autor, Dorn, and Hanson (2017) highlight the effects of the loss in manufacturing jobs on family formation dynamics.

[32]The literature on job polarization and labor income inequality has focused mostly on occupations rather than industries. It indicates that, since the 1980s, employment and wages in several advanced economies tended to grow faster for high- and low-skill occupations than for middle-skill occupations (Autor, Katz, and Kearney 2006; Goos, Manning, and Salomons 2014). Autor, Dorn, and Hanson (2013, 2016) and Acemoglu and Restrepo (2017) argue that trade and technology are changing the manufacturing sector in the United States by lowering the demand for labor, especially for the middle-skill group.

[33]An exception is Bárány and Siegel (2018), who argue that employment shifts across industries in the United States have enhanced the polarization of the job market.

[34]The broad sectors considered for this analysis are agriculture, industry (which consists of manufacturing, construction, mining, and utilities), services, and a residual category. The Luxembourg Income Study database offers an alternative sectoral classification that distinguishes the manufacturing sector. However, using this classification would significantly reduce the sample size. Moreover, manufacturing accounts, on average, for about two-thirds of employment in the broad industrial sector, and distributional statistics on labor income for manufacturing and overall industry are comparable in countries where data is available for both sectors.

[35]Average labor earnings in services are higher than in manufacturing, but this is because the service sector as a whole employs more high-skilled workers than does manufacturing. Skill levels are determined according to the following classification of occupations in the International Standard Classification of Occupations (ISCO): managers and professionals (ISCO 1 and 2) are shown as high skill; laborers/elementary (ISCO 9) as low skill; and other skilled workers (ISCO 3–8, 10) as medium skill.

[36]While this section focuses on advanced economies, potentially lower earnings in expanding service sector jobs is also a concern for developing countries (Hallward-Driemeier and Nayyar 2017). Box 3.3 looks at the experience of individual workers in Brazil

Figure 3.20. Average Gross Wages in Industry and Services in the 2000s
(Difference with respect to average economy-wide gross wages, percentage points)

Labor earnings in industry are somewhat higher than in services for high- and low-skilled workers and broadly comparable for medium-skilled workers.
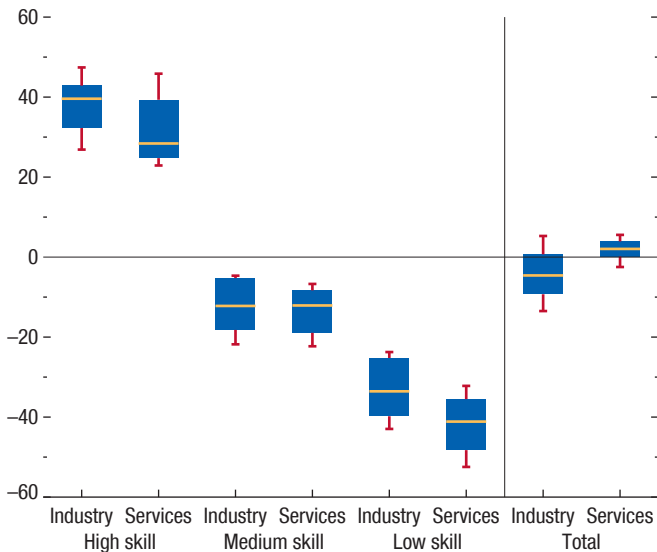
Sources: Luxembourg Income Study database; and IMF staff calculations.
Note: The figure shows the cross-country distribution of the difference between average (among individuals) gross wages by sector of employment and occupation and average economy-wide gross wages for full-time working household members for whom occupation data are available. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. The sample includes 12 countries; data correspond to the latest year available during 2000–09.

How did the shift in workers between industry and services affect the distribution of labor income?

To isolate the effects of shifts in sectoral employment shares on earnings inequality, the analysis offers a thought experiment. If the average pay differentials between sectors and the levels of inequality within them had stayed at their initial levels, how much would the shifts in sectoral employment shares have changed the inequality in earnings? A decomposition along these lines suggests that the shift in manufacturing workers to services would not have significantly worsened economy-wide income

between 1996 and 2013—a period during which the service sector was expanding while manufacturing employment remained broadly stable. Though the findings cannot be generalized, the analysis does not find significant wage gains for workers who move to manufacturing jobs from other sectors.

Figure 3.21. Labor Income Inequality in the 2000s
(Points)

Labor income inequality is somewhat lower in industry than in services, but country characteristics dominate in explaining within-sector inequality in both industry and services.
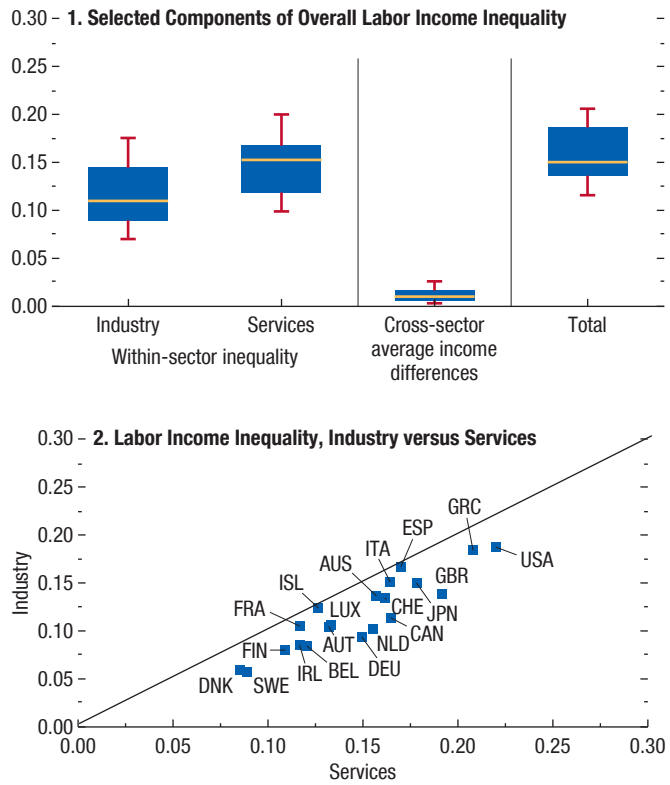
Sources: Luxembourg Income Study database; and IMF staff calculations.
Note: For each country, the analysis is based on data from the latest year available during 2000–09. The measure of inequality used is generalized entropy based on disposable income (see Annex 3.4 for details). Panel 1 shows the cross-country distribution of labor income inequality in industry and services; the contribution of differences in average earnings across sectors to aggregate inequality; and aggregate inequality. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. Data labels in panel 2 use International Organization for Standardization (ISO) country codes.

distribution if the level and distribution of earnings in each sector had remained at their initial levels. Shifts in employment shares between industry and services contributed only about 15 percent of the rise in economy-wide income inequality (keeping the dispersion and relative level of earnings constant at their initial values).[37] Instead, between the 1980s and

[37]A definitive test of whether the shift of middle-skilled workers from manufacturing to services implies erosion of their income would require data over time at the individual level, which are not available for a broad set of countries.

2000s, most of the rise in earnings inequality within countries came from the rise in pay inequality within services and industry (Figure 3.22).[38]

The increase in earnings dispersion within sectors could result, however, in part from the movement of workers across sectors for two reasons. First, the dislocation of manufacturing workers to low-skill (and low-wage) jobs in services would "mechanically" increase the share of workers at the lower portion of the income distribution and raise income polarization and inequality. With the average income of middle-skilled workers in the industry sector almost 30 percent higher than that of low-skilled service sector workers (Figure 3.20), the disappearance of middle-skill manufacturing jobs could imply a large pay cut for workers in that group who move to low-skill jobs in the service sector. Second, a spurt in the number of workers competing for lower-skill jobs can put downward pressure on wages at the lower end of the earnings distribution, widening the gap between incomes at the high and low ends of the spectrum.

To assess the quantitative relevance of the first channel, a stylized exercise assumes that, in the eight economies with available data since the 1980s and where manufacturing employment fell in absolute terms, all manufacturing jobs lost between the 1980s and 2000s were those of middle-skilled workers who moved to low-skill and low-wage jobs in services (set to the 25th percentile of wages in low-skill service jobs). In this scenario, overall labor inequality would have increased, on average, by about 9 percent of the actual increase in inequality between the 1980s and 2000s and up to one-fourth in any of the countries considered.

Testing whether the dislocation of manufacturing workers to low-skill jobs exerts downward pressure on wages for all workers at the lower end of the earnings distribution is beyond the scope of this chapter but could be a fruitful area for future research. Autor (2015) argues that the slow wage growth in low-skill jobs during 1999–2007 in the United States may have been related to middle-skilled workers—including those displaced from highly routinized jobs—taking low-skill jobs.

[38]The analysis is based on a decomposition of the overall change in labor income inequality between the 1980s and 2000s for a sample of 13 economies into the contribution of within-sector changes in inequality, changes in the relative size of each sector, and changes in average incomes across sectors. The year used for each country varies depending on survey data availability. See Annex 3.4 for details.

Figure 3.22. Contribution to Change in Overall Labor Income Inequality between the 1980s and 2000s
(Points)

Most of the increase in overall labor income inequality between the 1980s and 2000s is explained by rising inequality within sectors, rather than by shifts in the relative size of employment between industry and services.
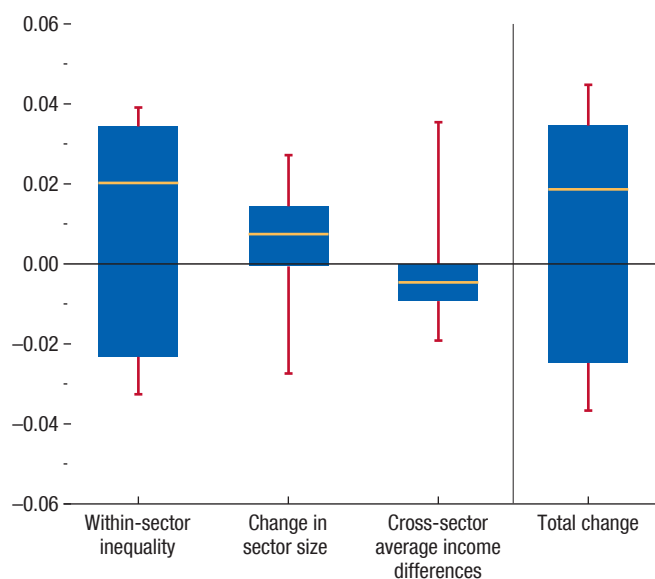
Sources: Luxembourg Income Study database; and IMF staff calculations.
Note: The figure shows the cross-country distribution of the change in aggregate labor income inequality between 1980–89 and 2000–09 and the contribution from changes in inequality within sectors, changes in the relative size of sectors, and changes in the difference of average income levels across sectors. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. The measure of inequality used is generalized entropy based on disposable income. The sample consists of 13 countries (see Annex 3.4 for details).

In summary, the findings in this section suggest that changes in aggregate labor income inequality are predominantly explained by rising labor income inequality within sectors. As analyzed widely in the literature, the key drivers behind greater pay inequality over time seem to be the dislocation of middle-skilled workers through technology and trade—and the resultant downward pressure on wages for medium- and low-skill jobs—rather than shifts in the relative size of employment between industry and services.

A word of caution regarding these findings is nonetheless warranted. First, displaced middle-skilled manufacturing workers may end up experiencing prolonged unemployment spells or dropping out of the labor force rather than taking low-wage jobs in services, leading to an increase in overall inequality that would not be captured in the analysis based on

workers' labor earnings. Indeed, the analysis in Chapter 2 shows that workers in routinizable occupations were more likely to involuntarily drop out of the labor force. Second, some valuable nonwage attributes of manufacturing jobs appear less widespread in other sectors. Manufacturing jobs tend to be characterized by formal employment arrangements with associated benefits for workers, such as access to retirement plans, paid holidays and sick leave, and health and life insurance. They also tend to provide relatively stable arrangements, relying less on part-time or temporary contracts than other sectors (Chapter 2 of the October 2017 WEO), and may offer collective bargaining via unions (Jaumotte and Osorio Buitron 2015). Finally, even if shifts in employment shares between sectors contributed little to aggregate inequality, the negative consequences of declining manufacturing jobs can be sizable for some groups. Transitional costs associated with sectoral reallocation can be substantial for individual workers, both due to prolonged unemployment spells and lower earnings in subsequent jobs (Walker 2013). These individual costs can have nonnegligible aggregate incidence in regions that had developed as manufacturing hubs.

Conclusion and Policy Implications

This chapter finds that the decline in the share of manufacturing jobs in overall employment need not hurt growth or raise inequality. Some service sectors can match the productivity levels and growth rates of manufacturing, so the relative expansion of those services could help national income approach advanced economy levels in economies that appear to be bypassing a traditional industrialization phase. Some service sectors exhibit signs of productivity convergence to the frontier, and the shift of employment shares from agriculture toward services since the 2000s has benefited economy-wide productivity in many developing countries.

However, these findings do not necessarily mean that income convergence is assured—whether manufacturing is expanding or not—or that recent favorable trends in output per worker can be extrapolated into the future. Strong policy efforts are needed to facilitate the reallocation of activity toward higher-productivity sectors and bolster productivity growth across all sectors.[39]

Shifts of employment shares toward services during the past two decades may have been enabled in part by strong domestic demand, which has lost momentum in many developing economies, especially among commodity exporters. To help maintain productivity-benefiting structural change, policymakers need to ensure that the growth of domestic demand and available workforce skills do not impede the expansion of highly-productive service activities. Reducing barriers to international trade and investment in services, which tend to be particularly high in developing economies (Miroudot, Sauvage, and Shepherd 2013; Koske and others 2015), would expand the service sector's opportunities for tradability, scale, and productivity growth. Adapting the rules in multilateral trade agreements to cover areas such as digital trade and e-commerce (as discussed in Chapter 1 and Box 2.2 of the October 2016 WEO) would also help in that regard. To facilitate the reallocation of workers to sectors where their efficiency is higher, policy should also ensure that workforce skills are aligned with those needed in highly-productive and expanding sectors of the economy.

The analysis in the chapter also indicates that within-sector productivity growth remains anemic in developing economies outside of East Asia. In many countries, raising productivity in agriculture—which remains the primary employer and still exhibits very low levels of productivity—is key to facilitate the transition of workers to dynamic industries in manufacturing and services. More generally, a comprehensive approach is needed to strengthen productivity across all sectors, including by bolstering human capital and physical infrastructure and improving the business and investment climate. Reforms aimed at removing obstacles to the efficient movement of factors of production between firms and promoting competition are also key, especially in services where barriers to entry tend to be higher and the extent of competition lower than in goods-producing sectors (Koske and others 2015; Chapter 3 of the April 2016 WEO). For example, the extent of government involvement in network sectors (such as electricity, gas, rail transportation, air transportation, postal services, and telecommunications) and barriers to entry in network sectors and other services (professional, freight transport, and retail distribution services) are still pervasive and partic-

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[39]Policies that do not respond to a specific market failure but focus solely on the relative size of the manufacturing sector could

be counterproductive as they might preserve low-productivity firms and postpone an efficient reallocation of resources (Fournier and Johansson 2016).

ularly large among developing economies. Services deregulation would facilitate the entry of new firms into the sector and promote competition (Koske and others 2015; Adler and others 2017). Moreover, the consequent productivity gains in services can generate positive spillovers for downstream and upstream industries, including in manufacturing (Fernandes and Paunov 2012; Bourlès and others 2013; Lanau and Topalova 2016).

The chapter also finds that changes in the inequality of labor income in advanced economies are predominantly explained by rising earnings inequality within all sectors. Higher pay inequality has nonetheless coincided with lower shares of employment in manufacturing and higher shares of service sector jobs, reflecting trends, such as automation, that have affected the demand for

the types of skills required in routinizable occupations. To ensure inclusive gains from technological progress, policy should help workers cope with its adverse side effects. A range of factors—including financial constraints, strong ties to their local area, and lack of needed skills—may have prevented workers displaced from manufacturing jobs from taking adequate employment in other sectors. Expanding access to training and education programs aligned with the needs of the evolving economy (including job-search assistance and training) as well as safety nets and redistribution policies targeted at displaced workers can help soften the blow imposed by structural transformation on workers and their communities. Regions with a heavy reliance on declining manufacturing jobs may require specifically targeted policy measures to facilitate the transition.

Box 3.1. The Changing Service Content of Manufactures

Services account for an increasing share of the total value of manufactured goods—an increase sometimes called the "servicification" of manufacturing.[1] The change in input-output linkages between the service and manufacturing sectors from 1995 to 2011 implies that the share of service inputs in the total production value of manufactures increased by about 6 percentage points, on average, across countries. This increase can reflect, for instance, rising consumer demand for goods that are more intensive in service inputs (for instance, design and software), or the fact that combining production inputs that are increasingly diffused geographically requires more service inputs (for instance, logistics and communications). However, service inputs in manufactured goods account for a small fraction (about 12 percent) of overall value added in the service sector, and the share of manufactures in total final expenditure has been steadily declining during this period (Figure 3.1.1). The lion's share of the expansion of services in aggregate value added—6 percentage points out of 7 percentage points, on average, between 1995 and 2011—corresponds to an increase in final expenditure on services—rather than to an increase in the share of service inputs used by other sectors.

Services can augment the value of finished manufactured goods in two ways: (1) as inputs in the manufacturing process, or (2) as auxiliary activities bundled with finished goods when sold to consumers. Examples of service inputs include design, research and development, and information technology; examples of auxiliary service activities include financing, logistics, and installation.
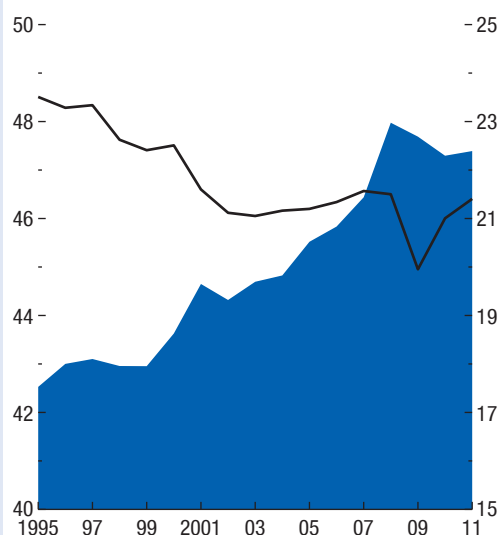
Input-output tables contain information on supply-use relations between industries within and across countries. To date, studies measuring the extent of servicification have been limited to individual countries or exports rather than overall output.[2] This

Figure 3.1.1. Nonmanufacturing Value-Added Content in Gross Manufacturing Output, 1995–2011
(Percent)

Sources: World Input-Output Database; and IMF staff calculations.
Note: The solid line (right scale) shows global spending on manufactures as a share of global total spending. The shaded area (left scale) depicts the share of nonmanufacturing value-added content in gross manufacturing output.

box uses worldwide input-output data to quantify the service content of manufacturing gross output.[3,4]

At the global level, the contribution to gross manufacturing output by nonmanufacturing activities—such as agriculture, mining, and services—increased from 42 percent of total gross manufacturing output in 1995 to 47 percent in 2011 (Figure 3.1.1). About two-thirds of the nonmanufacturing contribution to gross

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The author of this box is Wenjie Chen.
[1]This term is used in Baldwin, Forslid, and Ito (2015); Miroudot and Cadestin (2017); and Hallward-Driemeier and Nayyar (2017), among others.
[2]For instance, the National Board of Trade of Sweden (2010) and Lodefalk (2013) show that, in Sweden, the services share of total inputs used in manufacturing doubled over 1975–2005, with most of the gains reached by 1995. Baldwin, Forslid, and Ito (2015) use input-output data for a group of Asian economies and document a surge in the value-added share of services in manufactured exports. Heuser and Mattoo (2017) use the Organisation for Economic Co-operation and Development

Trade in Value-Added database to document the evolution of services trade in global value chains.
[3]The data used for this analysis come from the 2013 release of the World Input-Output Database, which covers the world economy over 1995–2011 (including data for 40 individual economies, accounting for more than 85 percent of world GDP) and from the corresponding socioeconomic accounts (Timmer and others 2015). The computations used for this box are described in Annex 3.2.
[4]The gross output of the manufacturing sector is the sum of the value added of the sector and the intermediate inputs it uses, whether produced domestically or abroad. Domestic gross output can be constructed by extracting the foreign value-added content of intermediate inputs.

Box 3.1 *(continued)*

Figure 3.1.2. Services Value-Added Content in Gross Manufacturing Output, 1995 and 2011
(Percent)
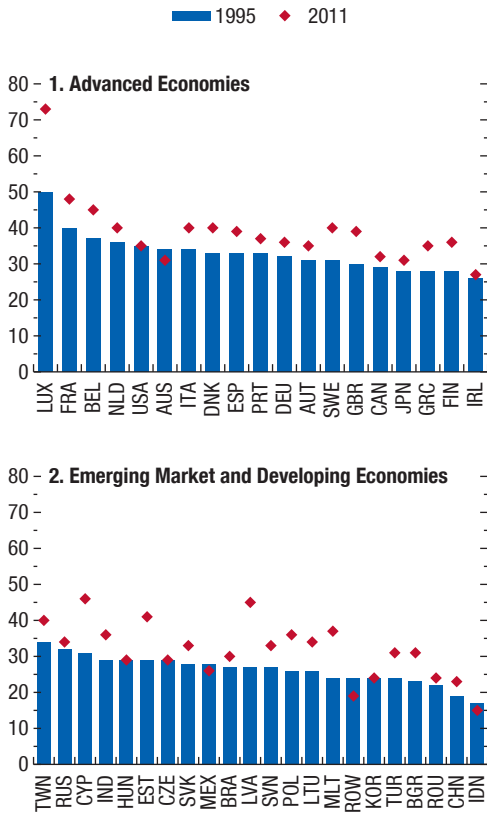
Sources: World Input-Output Database; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes. ROW = rest of the world.

Figure 3.1.3. Change in Services Value-Added Content in Manufacturing Gross Output, 1995–2011
(Percentage points)
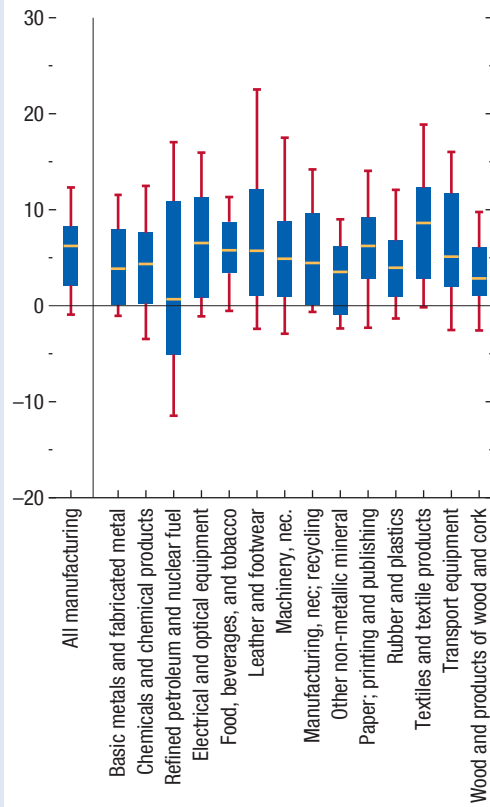

Sources: World Input-Output Database; and IMF staff calculations.
Note: The figure shows the cross-country distribution of changes in the service value-added content in gross manufacturing output between 1995 and 2011 for each of the 14 manufacturing industries. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. nec = not elsewhere classified.

manufacturing output come specifically from service industries. For the median economy in the sample, the contribution of services to gross manufacturing output was about one-third of manufacturing gross output in 2011 (Figure 3.1.2), albeit with considerable variation, ranging from about 15 percent in Indonesia to 50 percent in France and 70 percent in Luxembourg. Across all economies in the sample, the services value-added share in gross manufacturing output increased by an average of about 6 percentage points, or about 0.4 percentage point a year between 1995 and 2011. The services contribution increased across the whole spectrum of manufacturing industries (Figure 3.1.3).

As documented in the main text, the prices of manufactures relative to services have been declining in most economies. The increase in the share of services in the total production value of manufactures could thus reflect that the price of services value-added has outpaced that of manufacturing. Indeed, when calculated at constant (real) prices, the rise in the services share of gross manufacturing output is smaller than it is at current prices, and even declined in many

Box 3.1 *(continued)*

Figure 3.1.4. Change in Services Nominal and Real Value-Added Content in Manufacturing Gross Output, 1995–2009
(Percentage points)
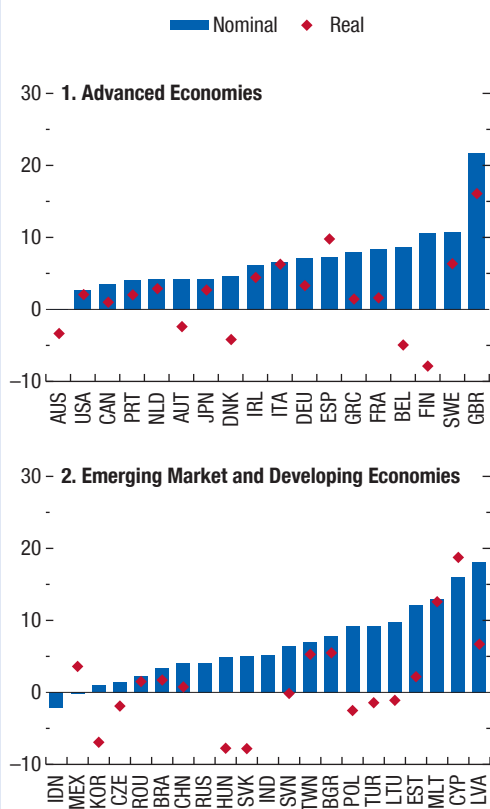
Sources: World Input-Output Database; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes.

economies over the 1995–2009 period (Figure 3.1.4).[5] Nonetheless, the share measured in real prices increased in about two-thirds of the sample economies.

Finally, despite the higher service content of manufactures documented above, the increase in the share of service inputs in the total production value of manufactures during 1995–2009 did not play an important role in the overall expansion of services in the economy. The expansion of services value-added as a share of total value-added (by almost 7 percentage points, on average, between 1995 and 2011) was mostly due to an increase in final demand for services (about 6 percentage points, on average), rather than due to an increase in the use of services as intermediate inputs by other sectors.

[5]Data limitations restrict the comparison to the 1995–2009 period. The results for 1995–2007 are similar.

Box 3.2. The Rise of Services Trade

Cross-border trade in services has been growing steadily over the past four decades, and now accounts for about one-fifth of global exports (Figure 3.2.1). The service share of exports has expanded in most advanced and developing economies (Figure 3.2.2, panel 1), with the expansion being particularly pronounced in the latter group. In one-fourth of these economies, the service share of exports increased by more than 20 percentage points since the early 1980s.

Much of the rise in the share of service exports comes from the decline in trading costs, in turn resulting from advances in information and communication technologies.[1] The rise of global value chains (GVCs) has also been intricately linked to the rise of services trade. As in the case of goods, the emergence of GVCs has allowed for international specialization in service tasks, and services have been increasingly traded as components within GVCs.[2] Indeed, many services have become as tradable as manufactured goods (see Gervais and Jensen 2014). As a result, cross-border trade as a share of global services output has risen from about 3 percent in 1970

to 10 percent in 2014 (Figure 3.2.1). The increase in the tradability of services is widespread across countries (Figure 3.2.2, panel 2).

In terms of industries, the increase in service exports has been particularly large in "modern" services that can be delivered at a distance, such as telecommunications, computer and information services, intellectual property, financial intermediation, and other business activities, including research and development and professional services (Figure 3.2.3).[3] The share of modern services exports in total services

[3]Following Loungani and others (2017), modern services typically refer to those that do not require the physical proximity of buyer and seller. All other services are classified as traditional, although the boundaries between traditional and modern are becoming increasingly blurred as technology evolves.

The author of this box is Ke Wang.
[1]Copeland and Mattoo (2007) and Francois and Hoekman (2010) review the growing literature on trade in services.
[2]Heuser and Mattoo (2017) provide a comprehensive overview of the role of services trade within global value chains.

Figure 3.2.1. Exports of Services
(Percent)
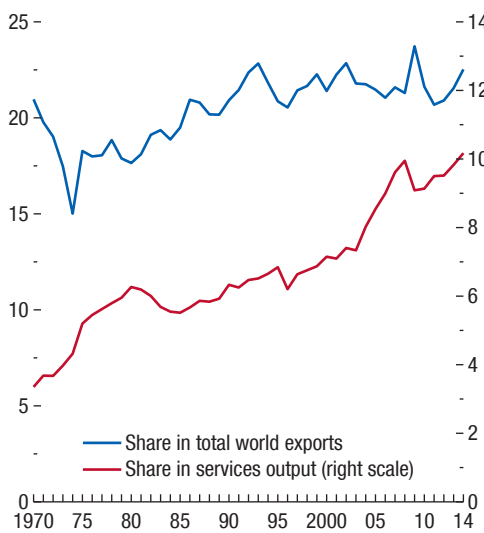
Sources: Loungani and others (2017); and IMF staff calculations.

Figure 3.2.2. Increase in Service Trade, 1980–2014
(Percentage points)
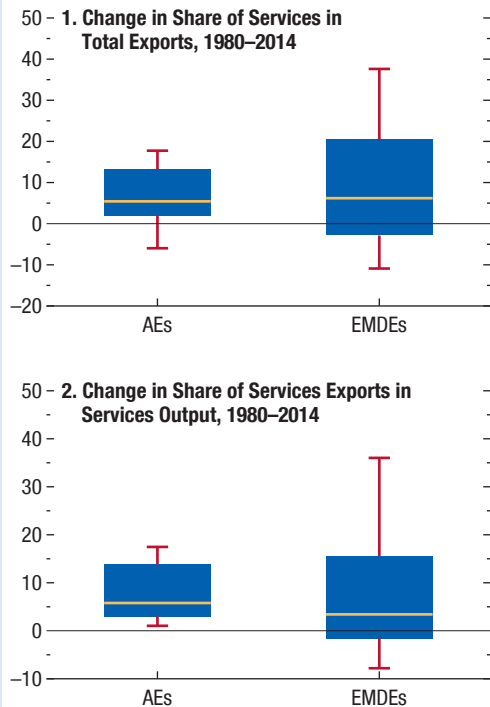
Sources: Loungani and others (2017); and IMF staff calculations.
Note: The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. AEs = advanced economies; EMDEs = emerging market and developing economies.

Box 3.2 *(continued)*

Figure 3.2.3. Services Exports by Industry, 1990–2014
(Percent)

Legend:
- Business services
- Financial services
- Intellectual property
- Insurance and pension
- Telecommunications, computer, and info.
- Travel
- Transport
- Other traditional services
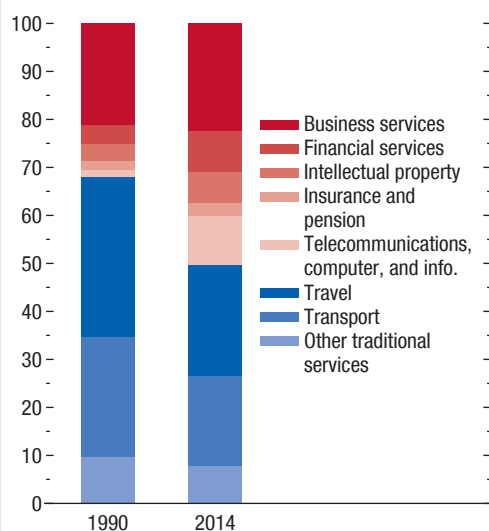
Sources: Loungani and others (2017); and IMF staff calculations.
Note: Blue (red) shades represent traditional (modern) services.

exports increased from about 32 percent in 1990 to 50 percent in 2014. The fastest growing segment was telecommunications and computer and information services industries, whose exports in 2014 reached 10 percent of total services exports, up from 1 percent in 1990. The travel industry accounts for a sizable fraction of the services exports of developing economies, although its relative importance has diminished over time.

Barriers to international trade are larger for service exports than for goods, and particularly large in developing countries (Miroudot, Sauvage, and Shepherd 2013; Koske and others 2015; Heuser and Mattoo 2017). Moreover, service sectors facing lower trade costs tend to be more productive and exhibit higher productivity growth (Miroudot, Sauvage, and Shepherd 2013). Policy action to reduce barriers to trade in the service sector would enhance its tradability and help boost productivity growth in services.

Box 3.3. Are Manufacturing Jobs Better Paid? Worker-Level Evidence from Brazil

Jobs in the service sector, rather than in manufacturing, are increasingly replacing agricultural employment in developing economies. This box uses a rich micro-level dataset from Brazil to answer the following questions: Are wages higher in manufacturing than in services for workers with comparable skills? Do workers who switch to manufacturing jobs from jobs in agriculture or services obtain initial wage gains and faster wage growth? Are labor earnings more uniformly distributed in manufacturing than in services?

About 10 percent of Brazil's workforce moved from agriculture to service activities between 1996 and 2013, while the share of manufacturing jobs remained broadly stable (Figure 3.3.1). Wage inequality fell during that period. A panel dataset that tracks the wages of Brazilian workers and their sector of employ-

The author of this box is Jorge Alvarez.

ment allows for an examination of the relationship between the rising role of service employment and wage inequality.[1]

Wages in manufacturing are not much higher than in services (Figure 3.3.2). After controlling for age, education, and labor market regions of workers, the wage gap across sectors at the outset of the period was only about 6 percentage points, and by 2013 it was close to zero.

In line with a moderate differential between wages in manufacturing and elsewhere, workers who switched from agriculture or services to the manufacturing sector during the sample period did not obtain much of an initial wage gain. The average boost was no larger than

[1]The data are from household surveys and a large matched set of employer-employee records on workers' income, hours, education, and other demographic characteristics.

Figure 3.3.1. Sectoral Employment Shares and Wage Inequality
(Percent, unless noted otherwise)
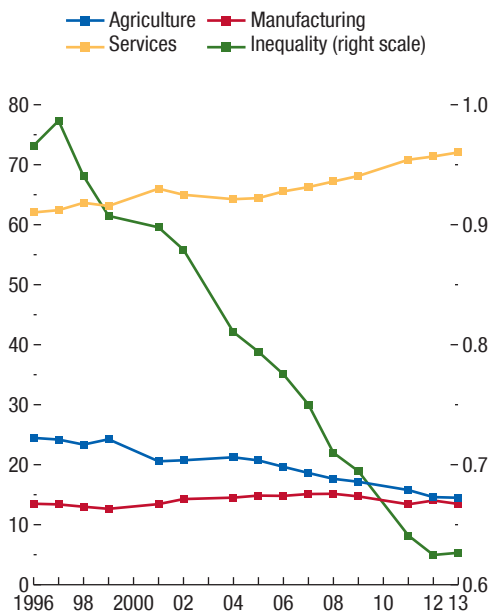
Sources: Alvarez (2017); and IMF staff calculations.
Note: The measure of inequality is the variance of log wages based on the the Pesquisa Nacional por Amostra de Domicílios household survey data. Survey data are not available for 2000, 2003, and 2010.

Figure 3.3.2. Wage Gap between Manufacturing and Services
(Percentage points)
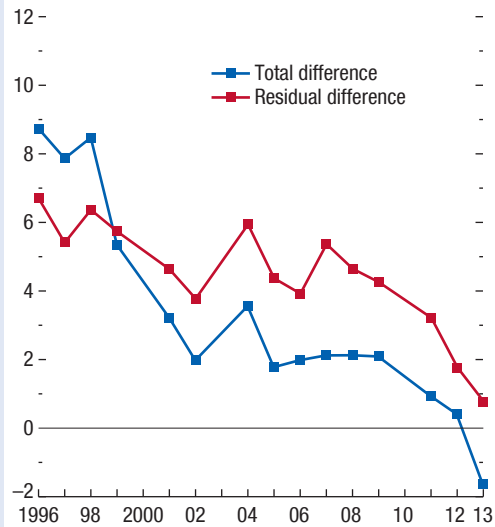
Sources: Alvarez (2017); and IMF staff calculations.
Note: The figure shows the average difference in mean log wages between workers in manufacturing and those in services based on household surveys from the Pesquisa Nacional por Amostra de Domicílios. The residual difference is the average difference after controlling for the age, education, gender, race, and region of individual workers. Survey data are not available for 2000, 2003, and 2010.

Box 3.3 *(continued)*

Figure 3.3.3. Wages of Workers Switching to Manufacturing Jobs
(Wage relative to level at time of switching sectors, percentage points)
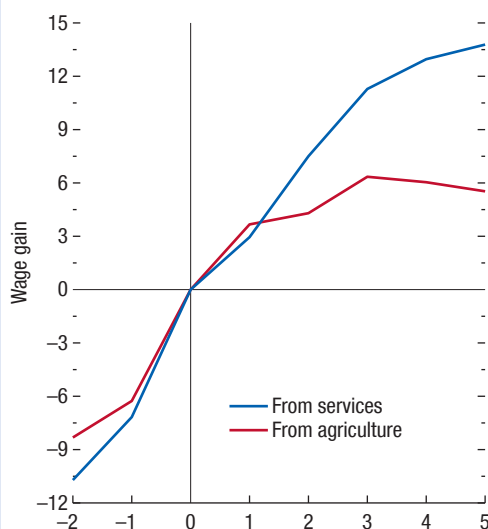
Source: Calculations from Alvarez (2017) using Relação Anual de Informações Sociais panel data on formal workers.
Note: The figure shows the average relative wage of individual workers who shifted to manufacturing jobs (relative to their wage level at the time of the transition), controlling for time and worker fixed effects. *X*-axis labels indicate the number of years before and after switching sectors (1 = first year in new sector).

Figure 3.3.4. Inequality in Manufacturing and Services
(Variance of log labor earnings)

Sources: Alvarez and others (2018); and IMF staff calculations.
Note: The measure of inequality used is the variance of log labor earnings and is computed using Relação Anual de Informações Sociais panel data on formal workers.

the expected gain from an additional year of experience in the original sector (Figure 3.3.3).[2]

Moreover, wage gains for workers who switched to a manufacturing job were no faster in the subsequent years than they were before the switch, once the common trend in wages across all workers and worker characteristics are accounted for.

At least in the formal sector, wage inequality is not higher in services than in manufacturing, and the decline of inequality in the two sectors over the past few decades is very similar (Figure 3.3.4). The analysis also shows that the dispersion of wages across firms within the two sectors plays an important role in

explaining the overall level of inequality in each sector and the decline since the mid-1990s. Less important is inequality within service sector firms versus that within manufacturing firms.

In sum, differences between the services and manufacturing sectors in terms of the level and dispersion of wages have remained small in Brazil over two decades that saw an expansion of the services share of employment and a decline in overall inequality. Changes that affect all sectors, such as the increase in the minimum wage (Engbom and Moser 2018), and other firm-level factors (Alvarez and others 2018), appear to have played a more prominent role in driving overall labor income inequality than changes in the relative size of manufacturing versus service jobs in overall employment.

[2]The analysis shows gains from transitioning after controlling for time effects. As discussed in Alvarez (2017), these expected gains are equivalent to the sectoral premiums after controlling for differences in both observable and unobservable characteristics of workers in the two sectors. Similar trends are seen when using wages or earnings.

Annex 3.1. Data Sources and Country Coverage

All data sources used in the chapter are listed in Annex Table 3.1.1. The country coverage for the different sections is presented in Annex Table 3.1.2. In this chapter, advanced economies are those that are classified as such by the *World Economic Outlook* in 1996. All other economies are considered emerging market and developing economies (developing economies for short).

Annex Table 3.1.3 provides a summary of the main sectoral compositions used throughout the chapter and the correspondence with United Nations International Standard Industrial Classification (Revision 3.1) sectors.

Data from multiple sources are used to enhance the coverage of sectoral employment and output series (Annex Table 3.3.1): Groningen Growth and Development Centre (GGDC), Organisation for Economic

Annex Table 3.1.1. Data Sources

Indicator	Source
Final Expenditure on Manufacturing Goods	IMF staff calculations based on World Input-Output Database
Generalized Entropy	IMF staff calculations based on Luxembourg Income Study database
Gross Hourly Wage	IMF staff calculations based on Luxembourg Income Study database
Manufacturing Consumption Share	IMF staff calculations based on World Bank, International Comparison Program database
Manufacturing Gross Output	IMF staff calculations based on World Input-Output Database
Purchasing Power Parity	Penn World Table 9.0
Real GDP per Capita	IMF, World Economic Outlook database
Relative Price of Manufactured Goods	IMF staff calculations based on GGDC; UN National Accounts Official Country Data database
Sectoral Employment	Felipe and Mehta (2016); GGDC; ILO; national sources; OECD; UNIDO; World KLEMS database
Sectoral Labor Productivity	GGDC; World KLEMS database
Sectoral Purchasing Power Parity	GGDC; Inklaar and Timmer (2009); World KLEMS database
Sectoral TFP	Jorgenson, Ho, and Samuels (2013); World KLEMS database
Sectoral Value Added (at current and constant prices)	GGDC; UN National Accounts Official Country Data database; World KLEMS database

Source: IMF staff compilation.
Note: GGDC = Groningen Growth and Development Centre; ILO = International Labour Organization; TFP = total factor productivity; UN = United Nations; UNCTAD = United Nations Conference on Trade and Development; WTO = World Trade Organization.

Annex Table 3.1.2. Sample of Economies Included in the Analytical Exercises

Group[1]	Economies[2]	Exercise[3] I	II	III	IV	V	VI
A	Argentina,* Australia, Austria, Belgium, Brazil,* Canada, Chile,* China,* Denmark, Finland, France, Germany, Greece, India,* Indonesia,* Ireland, Italy, Japan, Korea,* Luxembourg, Mexico,* Netherlands, Poland,* Portugal, South Africa,* Spain, Sweden, United Kingdom, United States	X	X	X			
B	Bolivia,* Botswana,* Colombia,* Costa Rica,* Egypt,* Ethiopia,* Ghana,* Hong Kong SAR,* Kenya,* Malawi,* Malaysia,* Mauritius,* Morocco,* Nigeria,* Peru,* Philippines,* Senegal,* Singapore,* Taiwan Province of China,* Tanzania,* Thailand,* Venezuela,* Zambia*	X	X				
C	Bangladesh,* El Salvador,* Guatemala,* Honduras,* Norway, Pakistan,* Panama,* Puerto Rico,* Romania,* Suriname,* Switzerland, Syria,* Trinidad and Tobago*	X					
D	Cyprus,* Czech Republic,* Estonia,* Hungary,* Latvia,* Lithuania,* Malta,* Russia,* Slovak Republic,* Slovenia*		X	X			
E	Austria, Finland, Germany, Ireland, Netherlands, United States				X	X	X
F	Australia, Canada, Denmark, France, Italy, Sweden, United Kingdom				X	X	
G	Belgium, Greece, Iceland, Luxembourg, Spain, Switzerland				X		X
H	Japan				X		

[1] Group of economies according to their use in different analytical exercises.
[2] Asterisk (*) denotes emerging market and developing economies as classified by the IMF, World Economic Outlook, plus economies used in the exercises that have been reclassified as advanced economies since 1996 (Cyprus, Czech Republic, Estonia, Hong Kong SAR, Korea, Latvia, Lithuania, Malta, Puerto Rico, Singapore, Slovak Republic, Slovenia, Taiwan Province of China).
[3] Analytical exercises performed in the chapter: I = stylized facts (Figures 3.1, 3.4–3.7, 3.9, 3.10); II = sectoral employment (Figure 3.2) and productivity (Figures 3.12–3.16); III = beta convergence (Figure 3.17); IV = inequality decomposition, 2000s (Figure 3.21); V = inequality decomposition over time (Figure 3.22); VI = wages (Figure 3.20).

Annex Table 3.1.3. Sectors, Individual Industries, and Abbreviations Used in the Chapter

Sector Group	10-Sector Name	Sectors Included (ISIC Revision 3.1)	Examples of Industries Included
Agriculture	Agriculture	Agriculture; fishing	
Manufacturing	Manufacturing	Manufacturing	Food, tobacco, textiles, apparel, leather, wood, paper, coke, chemicals, rubber, other non-metallic products, basic metals, electrical equipment, machinery, transport equipment, recycling, petroleum
Market Services	Trade & accommodation	Wholesale and retail trade; repair of goods; hotels and restaurants	Wholesale and retail trade; sale, maintenance and repair of motor vehicles
	Transport & communications	Transport, storage and communications	Land, water, and air transport; post and telecommunications
	Financial & business	Financial intermediation; real estate and business activities	Financial intermediation, insurance and pensions, real estate, renting of machinery and equipment, computer (including hardware consulting, production of software, and data processing), research and development, other business activities (including professional services)
	Community & households	Community and personal services; activities of private households	Sewage and sanitation; recreational and other service activities; activities of private household as employers of domestic staff
Nonmarket Services	Government	Public administration and defense; education; health	Public administration and defense; education; health
Other	Utilities	Electricity, gas and water supply	
	Construction	Construction	
	Mining	Mining and quarrying	

Source: IMF staff compilation.
Note: ISIC = International Standard Industrial Classification.

Co-operation and Development (OECD), World KLEMS, International Labour Organization (ILO), United Nations Industrial Development Organization database (UNIDO), and Felipe and Mehta (2016). The main source for sectoral employment data is the GGDC 10-sector database. The country and time coverage are extended using, in order of preference, World KLEMS, OECD, UNIDO and ILO, as well as national sources for individual countries.[40] Data from Felipe and Mehta (2016) provide manufacturing employment data for additional countries. Sectoral value-added data are from the GGDC 10-sector database, World KLEMS, UN National Accounts Official Country Data database, and national authorities.

The analysis on inequality relies on the Luxembourg Income Study database and the Standardized World Income Inequality database.

Annex 3.2. Value-Added Decomposition

Data from the World Input-Output Database (WIOD) is used for the analysis underlying Figure 3.11 and Box 3.1. The WIOD provides data on global input-output linkages across countries and industries for each year between 1995 and 2011. It covers 40 economies (19 advanced and 21 developing economies, representing more than 85 percent of world GDP), along with a residual for the noncovered part of the world economy, and 35 industries. The data also contain final expenditure and value added by industry for each country.[41]

The analysis follows the consumption value-added procedure described in Herrendorf, Rogerson, and Valentinyi (2013) to decompose a given value of final expenditure into its underlying value-added components. Using this approach on global input-output data allows to decompose the value of global final spending on finished manufactured products into the value added from each country and sector (that is, both manufacturing and nonmanufacturing) that is embedded in those manufactures. Summing the resulting decomposed value added across sectors for a given country gives the measure of domestic gross output of manufactures underlying the calculations in Figure 3.11. Summing the resulting value added across nonmanufacturing sectors in all countries gives the measure reported in Figure 3.1.1 (Box 3.1). The results reported in Figure 3.1.2 are

[40]National sources are used for Australia, Canada, China, Brazil, Costa Rica, El Salvador, Guatemala, India, Korea, Malaysia, Philippines, Thailand, and Trinidad and Tobago.

[41]Timmer and others (2015) provide more details about the construction of the database and discuss additional features.

obtained by summing the decomposed value added across service industries in each country while those in Figure 3.1.3 correspond to the decomposed value added in each service industry. The calculation of value added in constant (real) prices in Figure 3.1.4 requires the use of the sector specific value-added price indices in the WIOD Socio Economic Accounts data.

Annex 3.3. Sectoral Productivity, Aggregate Growth, and Convergence

This annex provides additional details on the analysis shown in the section "Growth and Development Beyond Manufacturing." Annex Table 3.1.2 presents the sample of economies included in the analyses in this section.

Sectoral Productivity Analysis

Data

Sectoral labor productivity is constructed as value added at constant prices in a given sector divided by the number of workers in that sector (Figure 3.14, panel 1), or divided by total hours worked in the sector (Figure 3.14, panels 2 and 3), using data from the Groningen Growth and Development Centre (GGDC) 10-sector database; World KLEMS; Jorgenson, Ho, and Samuels (2013); and national sources (see Annex Table 3.1.1). The data reported in Figure 3.14, panel 1, are available for a sample of 62 economies (19 advanced and 43 developing economies) spanning 10 broad sectors during 1965–2015. Data at a more disaggregated sectoral level are available for fewer countries: a sample of 31 economies (19 advanced and 12 developing economies) for 1970–2010 spanning 13 manufacturing and 13 service industries (Figure 3.14, panel 2), and data for the United States for 1947–2010 spanning 20 manufacturing and 39 service industries (Figure 3.14, panel 3). Total factor productivity (TFP) data based on sectoral value added (reported in Annex Figure 3.3.1) are available for a reduced set of 20 economies (16 advanced and 4 developing economies).[42,43]

[42]The source of sectoral TFP data is World KLEMS *Growth and Productivity Accounts* (ISIC Rev. 3, 2011 release, and Rev. 4, 2017 release).

[43]Under the assumptions of perfect competition, full capacity utilization, and constant return to scale, TFP growth for each sector is calculated based on the standard growth accounting methodology:

$$\Delta \ln TFP_t^i = \Delta \ln Y_t^i - \bar{v}_t^{k,i} \Delta \ln K_t^i - \bar{v}_t^{L,i} \Delta \ln L_t^i - \left(1 - \bar{v}_t^{k,i} - \bar{v}_t^{L,i}\right) \Delta \ln M_t^i$$

in which i denotes country, $\bar{v}_t^{k,i}$ and $\bar{v}_t^{L,i}$ denote the two-period average (t and t − 1) share of capital and labor input in nominal gross

Annex Figure 3.3.1. Distribution of Total Factor Productivity Growth of Individual Industries
(Kernel density)
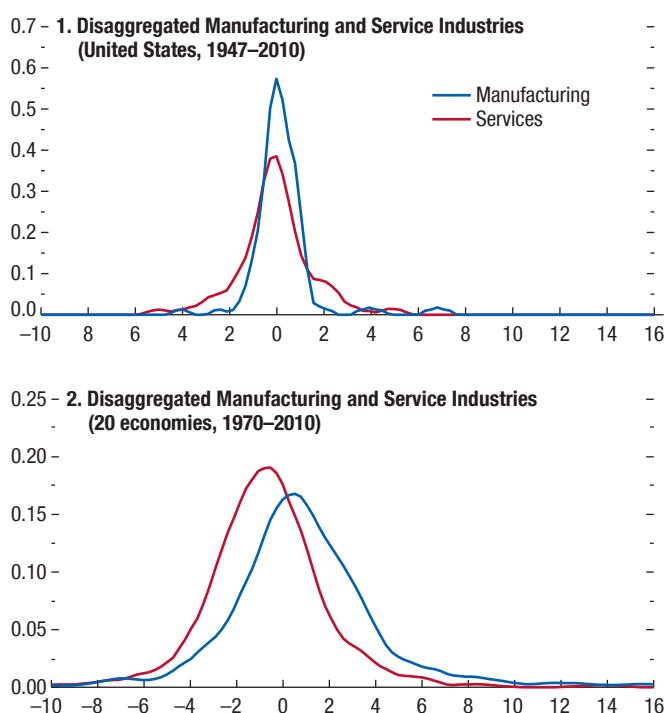
Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: The figure shows the distribution of average total factor productivity growth per decade in individual manufacturing and service industries (expressed as deviations from the average total factor productivity growth across sectors in each country and decade). Panel 1 is based on total factor productivity growth data for 20 manufacturing and 39 service industries in the United States (Jorgenson, Ho, and Samuels 2013). Panel 2 is based on total factor productivity growth data for 13 manufacturing and 13 service industries in 16 advanced economies (including the United States) and 4 emerging market and developing economies.

Annex Figure 3.3.2 is based on the same sample of countries and industries as Figure 3.14, panel 2, but shows the cross-country distribution of the average relative sectoral labor productivity growth (relative to economy-wide labor productivity growth) over 2000–10 for 13 individual service industries and manufacturing as a whole. The average sectoral labor productivity growth across countries during that period is then used to split service industries into two groups: a high-productivity-growth group, corresponding to the four industries that have on average the highest labor productivity growth (postal services and telecommunications, financial intermediation, wholesale trade, and retail trade); and a low-productivity-growth group,

output. Y_t^i denotes the (constant-price-based) gross output, K_t^i measures capital service, L_t^i is labor input, and M_t^i is intermediate input.

Annex Figure 3.3.2. Sectoral Labor Productivity Growth, 2000–10
(Difference with respect to economy-wide labor productivity growth, percentage points)
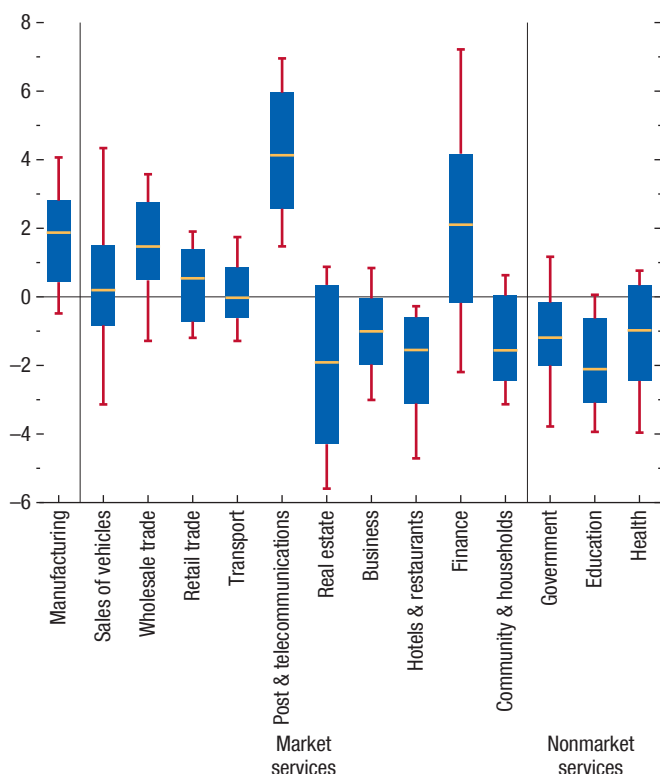
Source: IMF staff calculations.
Note: The figure shows the cross-country distribution across 19 advanced economies and 12 emerging market and developing economies of the percentage difference between average labor productivity growth in each sector and aggregate labor productivity growth over 2000–10. The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. Nonmarket services consist of government, education, and health. All other service industries are market services.

which includes the remaining service industries. Annex Figure 3.3.3 shows the skill intensity of employment in these two groups of service industries, as well as in manufacturing as a whole, based on industry-level data on educational attainment from the World Input-Output Database for 40 economies (19 advanced and 21 developing economies) over 2000–07.

Decomposition of Aggregate Labor Productivity

This section describes the decomposition exercise conducted to gauge the contribution of structural change reported in Figure 3.16. Aggregate value added per worker can be expressed as the (employment-share-weighted) average of value added per worker in each individual industry:

Annex Figure 3.3.3. Skill Composition of Workers by Sector, 2000–07
(Share of workers by skill level, percent)
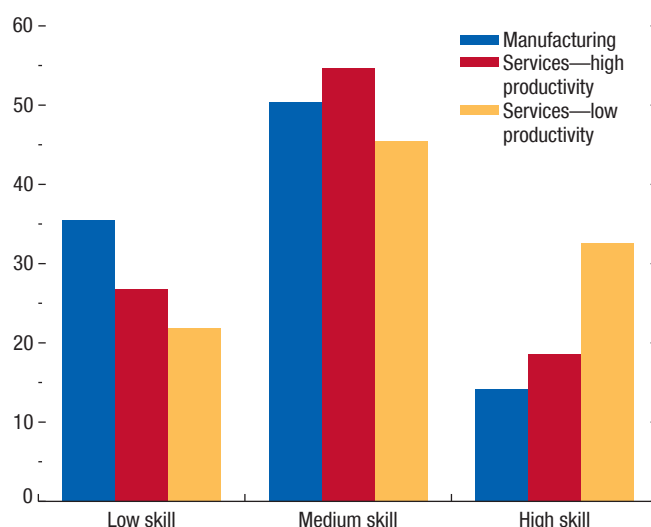
Source: IMF staff calculations.
Note: High (low) productivity services correspond to the service industries that rank in the top third (bottom two-thirds) of the labor-productivity growth distribution during 2000–10 for the sample used in Figure 3.14, panel 2. The share of low, medium, and high skilled-workers corresponds to the average in each group of industries over 2000–07 and across the 40 economies included in the World Input-Output Database. Skill categories are based on the level of education (see Timmer and others 2015).

$$y_t = \sum_i y_t^i \theta_t^i, \tag{3.1}$$

in which y_t denotes the aggregate value added per worker (at constant prices); y_t^i is value added per worker in sector i; and θ_t^i is the employment share of sector i. The economy-wide growth rate of labor productivity can then be decomposed in two components:

$$g_{t-k,t} = \underbrace{\sum_i \theta_{t-k}^i \frac{y_{t-k}^i}{y_{t-k}} g_{t-k,t}^i}_{\text{within-sector growth}}$$
$$+ \underbrace{\sum_i \frac{y_{t-k}^i}{y_{t-k}} \left(1 + g_{t-k,t}^i\right)\left(\theta_t^i - \theta_{t-k}^i\right)}_{\text{structural change}} \tag{3.2}$$

where $g_{t-k,t} = \frac{y_t}{y_{t-k}} - 1$ is aggregate productivity growth from period $t-k$ to t; $g_{t-k,t}^i = \frac{y_t^i}{y_{t-k}^i} - 1$ is productivity growth in sector i; and $\frac{y_{t-k}^i}{y_{t-k}}$ is the relative productivity level in sector i.

The first component measures the "within" effect— the growth contribution of sector i holding the shares and the level of productivity as in the initial period. The second component measures the aggregate contribution of the movement of workers across sectors with different levels and growth rates of productivity. Following Timmer and others (2015); and Diao, McMillan,

Annex Figure 3.3.4. Sectoral Labor Productivity, 2010
(Ratio with respect to economy-wide labor productivity)
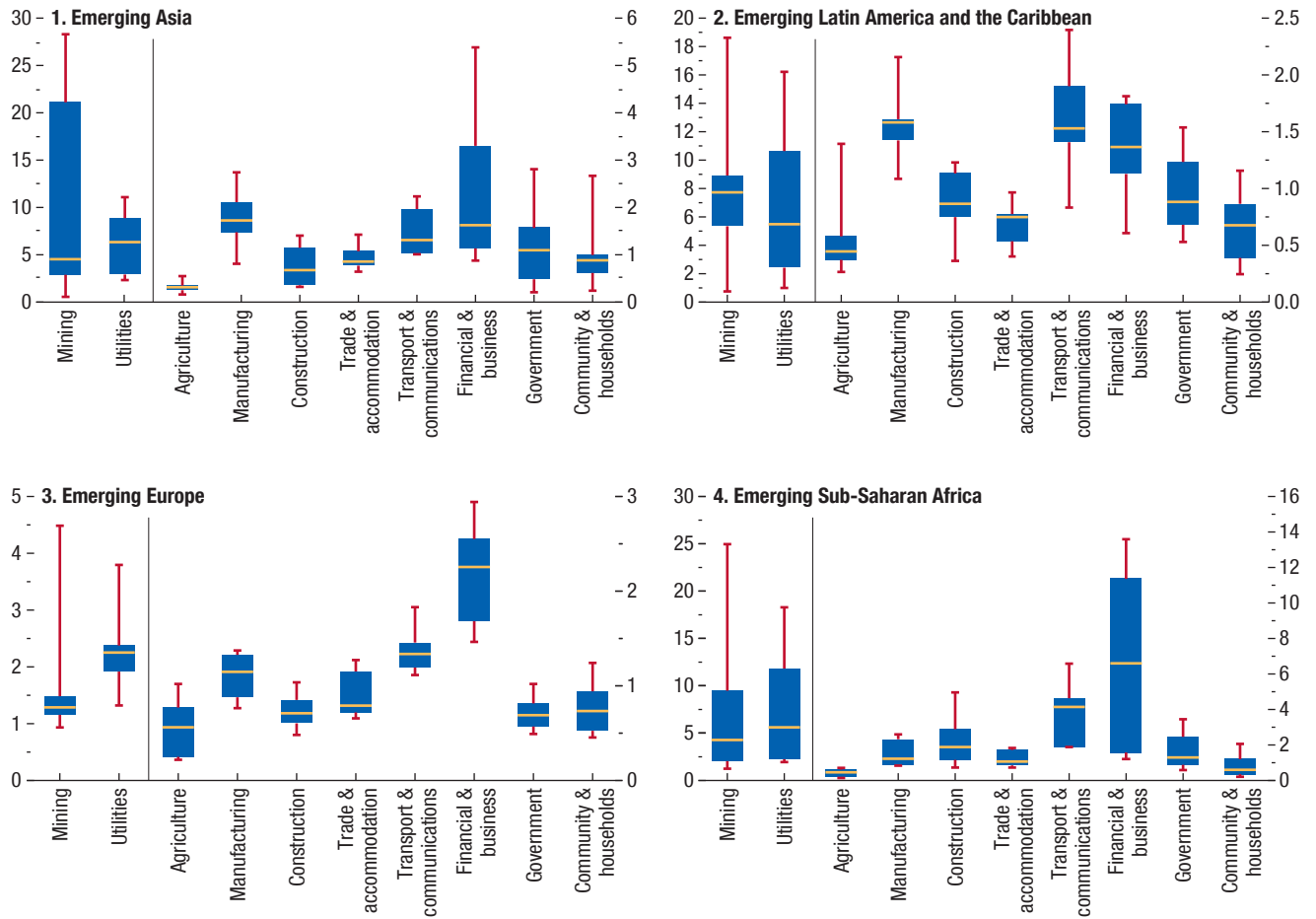
Sources: Groningen Growth and Development Centre database; World KLEMS database; and IMF staff calculations.
Note: The figure shows the distribution across economies in each region of the ratio of labor productivity (value added per worker) in each sector with respect to economy-wide labor productivity in 2010 (at 2005 prices). The horizontal line inside each box represents the median; the upper and lower edges of each box show the top and bottom quartiles; and the red markers denote the top and bottom deciles. Values for mining and utilities are reported on the left scale.

and Rodrik (2017), a year-by-year growth rate is first calculated (that is, k is set to 1), and then the average annual growth rates for the within and between terms in a given period T (that is, 2000–10) for each sector are reported by taking the simple average:

$$g_T^{within} = \frac{1}{T}\sum_{t\in T}\sum_i \theta_{t-1}^i \frac{y_{t-1}^i}{y_{t-1}} g_t^i, \qquad (3.3)$$

$$g_T^{structural} = \frac{1}{T}\sum_{t\in T}\sum_i \frac{y_{t-1}^i}{y_{t-1}}(1+g_t^i)(\theta_t^i - \theta_{t-1}^i). \qquad (3.4)$$

Cross-Country Productivity Convergence Analysis
Data

Testing for productivity convergence across countries requires a cross-comparison of their sectoral productivity. Sectoral purchasing-power-parity (PPP) conver-

sion rates are needed to convert sectoral value added expressed in national currencies to units that are comparable across countries. Using PPP rates for aggregate output would be problematic as they fail to capture the systematic differences in sectoral relative prices across countries (Sorensen 2001; Rogerson 2008). Following Rodrik (2013), the baseline analysis is based on sectoral labor productivity data. TFP data based on sectoral value added are used in robustness exercises. Nonmarket service industries, such as government, health, and education are excluded from the convergence exercise because public funding and provision make output prices hard to measure (Heston 2013).

The analysis is conducted using two samples that offer different country and sectoral coverage:

Annex Table 3.3.1. Estimation Results, Beta-Convergence—Extended Sample (9 Sectors)

Sector	A. Baseline Specification Full Sample				B1. Baseline Specification Balanced Panel				B2. Cross-Section Regression Balanced Panel			
	Beta	S.E.	t	R^2	Beta	S.E.	t	R^2	Beta	S.E.	t	R^2
Agriculture	0.13	0.18	0.73	0.34	0.27	0.19	1.41	0.44	0.01	0.23	0.04	0.00
Mining	−1.31	0.30	−4.39	0.37	−1.00	0.33	−3.03	0.35	−0.67	0.31	−2.16	0.15
Manufacturing	−0.87	0.26	−3.37	0.27	−0.58	0.28	−2.07	0.28	−1.16	0.49	−2.39	0.23
Utilities	−2.35	0.50	−4.67	0.29	−1.77	0.42	−4.21	0.38	−1.39	0.27	−5.18	0.48
Construction	−1.58	0.40	−3.94	0.46	−1.49	0.44	−3.36	0.49	−0.20	0.63	−0.32	0.01
Trade and Accommodation	−1.10	0.33	−3.35	0.40	−0.94	0.33	−2.87	0.45	−0.78	0.26	−3.06	0.18
Transport and Communications	−1.31	0.45	−2.94	0.19	−1.19	0.47	−2.55	0.18	−0.95	0.40	−2.39	0.24
Financial and Business	−1.04	0.35	−2.95	0.13	−0.99	0.36	−2.79	0.13	−1.62	0.42	−3.87	0.50
Community and Households	−0.50	0.37	−1.33	0.16	−0.64	0.33	−1.91	0.21	−0.46	0.22	−2.12	0.16

Sources: Groningen Growth and Development Center database; World KLEMS database; and IMF staff calculations.
Note: Robust standard errors are reported. Panel A shows the estimation results based on 10-year nonoverlapping windows with decade dummies and an unbalanced panel of 39 countries. Panel B1 shows the results for a balanced panel of 28 countries. Panel B2 is based on a cross-section regression over the same sample than Panel B1. S.E. = standard errors.

- *Extended sample*, based on GGDC and World KLEMS data—an unbalanced panel of value added per worker for nine market sectors for 39 countries during 1965–2015. Data on sectoral PPP in 2005 are obtained from the GGDC productivity level database.[44]
- *Reduced sample*, based on World KLEMS—an unbalanced panel covering 26 market sectors during 1970–2007 with data on value added per hour for 30 countries and data on TFP for 20 countries. Internationally comparable data on sectoral TFP and labor productivity levels are from the 1997 benchmark World KLEMS database (for details, see Inklaar and Timmer 2009).[45]

Following Sorensen (2001), the industry-specific productivity growth series for each country are used to extrapolate the productivity level of 2005 or 1997 over the whole sample period.

Methodology and Baseline Results

The baseline specification for testing unconditional productivity convergence in each sector follows the specification in Bernard and Jones (1996) and Sorensen (2001):

$$\hat{P}_{i,t} = \alpha + \beta \ln P_{i,t} + D_t + \varepsilon_{i,t}, \qquad (3.5)$$

in which $\hat{P}_{i,t}$ denotes the trend growth rate of productivity (labor productivity or TFP) for a given sector in country i relative to the United States over the time period t; $P_{i,t}$ is the sector-specific PPP-adjusted productivity level in country i relative to the United States in the initial year of the period; D_t is the period dummy that controls for common factors; and $\varepsilon_{i,t}$ indicates an average relative productivity shock between the two countries.[46] Each period corresponds to a 10-year nonoverlapping window.

A negative estimate of β for a given sector indicates evidence of productivity convergence across countries: the larger the initial gap in productivity between two countries, the higher the rate of productivity growth in the country with lower sectoral productivity (relative to growth in the higher-productivity country). This concept of convergence is known as beta-convergence.

The estimation results using the extended sample covering nine market sectors are shown in Annex Table 3.3.1. The results in panel A are based on the baseline regression on labor productivity based on 10-year nonoverlapping periods and a broad sample of 39 countries during 1965–2015 as shown in Figure 3.17 (panel 1).[47] The estimation results using a reduced sample covering 26 sectors are reported in Annex Table 3.3.2, in which panel A corresponds to

[44]The internationally comparable level of industry productivity is computed as the nominal value added in 2005 per worker in a given industry-country deflated by the output PPP in the same industry-country. See Inklaar and Timmer (2014) for details.
[45]The measures of industry productivity from World KLEMS are adjusted not only by PPPs for gross output but also by PPPs for intermediate input (a so-called double deflation method). Double deflation is preferable but is not possible in the GGDC 10-sector sample due to data limitations.

[46]$\hat{P}_{i,t}$ is constructed as the trend coefficient from a regression of the log level on a constant and a linear trend to minimize the problems associated with measurement error, business cycles and end-sample issues, as in Bernard and Jones (1996).
[47]Excluding observations from 2008 onwards, which could reflect developments associated with the global financial crisis, does not change the results.

Annex Table 3.3.2. Estimation Results, Beta-Convergence—Reduced Sample (26 Sectors)

Sector	A. Baseline Specification Labor Productivity				B1. Baseline Specification Labor Productivity, Balanced Panel				B2. Cross-Section Regression Labor Productivity, Balanced Panel				C1. Baseline Specification Labor Productivity, Sample as C2				C2. Baseline Specification Total Factor Productivity			
	Beta	S.E.	t	R^2	Beta	S.E.	t	R^2	Beta	S.E.	t	R^2	Beta	S.E.	t	R^2	Beta	S.E.	t	R^2
Agriculture	−0.78	0.38	−2.04	0.37	−0.49	0.35	−1.41	0.47	−0.36	0.32	−1.10	0.08	−0.51	0.46	−1.12	0.57	−0.24	0.49	−0.48	0.58
Mining	−1.26	0.52	−2.40	0.52	−0.92	0.63	−1.46	0.53	−0.94	0.62	−1.52	0.16	−1.31	0.82	−1.60	0.49	−2.40	0.95	−2.54	0.47
Utilities	−1.60	0.50	−3.21	0.32	−2.09	0.48	−4.38	0.48	−1.78	0.28	−6.32	0.69	−2.10	0.87	−2.42	0.56	−2.99	0.57	−5.23	0.46
Construction	−0.44	0.37	−1.18	0.54	−0.49	0.42	−1.18	0.50	−0.94	0.58	−1.61	0.11	0.15	0.56	0.26	0.60	0.10	0.67	0.15	0.57
Manufacturing																				
Food	−0.34	0.42	−0.81	0.15	−0.36	0.36	−1.01	0.21	−1.03	0.59	−1.74	0.15	0.33	0.68	0.48	0.26	−0.11	0.80	−0.14	0.28
Textiles	−1.31	0.60	−2.18	0.21	−1.71	0.74	−2.30	0.25	−0.98	0.57	−1.72	0.11	−0.55	0.76	−0.72	0.26	−0.84	0.73	−1.16	0.15
Wood	−1.97	0.63	−3.12	0.37	−1.51	0.75	−2.02	0.43	−1.38	0.71	−1.93	0.27	−0.40	0.50	−0.79	0.48	−0.99	0.58	−1.73	0.48
Paper	−0.82	0.49	−1.68	0.31	−0.87	0.63	−1.37	0.39	−1.59	0.41	−3.92	0.30	0.50	0.78	0.64	0.36	0.17	0.72	0.24	0.15
Petroleum	−0.90	1.40	−0.64	0.63	−2.99	1.04	−2.88	0.82	−3.22	0.52	−6.25	0.64	−1.12	1.29	−0.87	0.72	−0.82	1.11	−0.74	0.72
Chemicals	−1.52	0.83	−1.84	0.19	−0.81	0.86	−0.94	0.33	−1.08	0.70	−1.54	0.09	−1.08	0.68	−1.59	0.42	−1.47	1.05	−1.40	0.55
Rubber	−0.28	0.65	−0.43	0.25	−0.45	0.46	−0.98	0.39	−0.61	0.53	−1.15	0.07	−0.30	0.67	−0.45	0.38	0.66	0.55	1.21	0.41
Other Mineral	−2.57	0.52	−4.93	0.35	−1.67	0.59	−2.80	0.28	−1.23	0.37	−3.31	0.25	−1.24	0.61	−2.04	0.38	−0.99	0.59	−1.67	0.42
Basic Metal	−4.08	0.61	−6.69	0.64	−3.22	0.58	−5.58	0.49	−2.32	0.32	−7.16	0.73	−2.97	0.81	−3.65	0.57	−3.40	0.83	−4.08	0.55
Machinery	−2.22	0.61	−3.65	0.31	−1.95	0.45	−4.30	0.38	−2.06	0.47	−4.34	0.48	−1.61	0.91	−1.77	0.25	−1.03	1.12	−0.92	0.37
Electrical Equipment	−2.52	0.78	−3.22	0.55	−2.96	0.79	−3.75	0.59	−3.82	0.54	−7.02	0.71	−0.04	1.40	−0.03	0.62	0.55	1.72	0.32	0.60
Transport Equipment	−0.75	0.57	−1.32	0.17	−0.77	0.41	−1.87	0.30	−0.88	0.23	−3.85	0.25	−0.78	0.46	−1.70	0.45	−0.86	0.53	−1.62	0.40
Recycling	−1.46	0.39	−3.79	0.41	−1.03	0.40	−2.60	0.53	−0.86	0.32	−2.66	0.26	−1.02	0.40	−2.57	0.67	−1.19	0.41	−2.89	0.63
Market Services																				
Trade	−0.72	0.31	−2.36	0.49	−0.19	0.29	−0.67	0.54	−0.25	0.32	−0.77	0.02	−1.10	0.46	−2.39	0.59	−1.23	0.45	−2.73	0.59
Hotels and Restaurants	−1.97	0.57	−3.49	0.30	−1.43	0.51	−2.77	0.38	−1.05	0.22	−4.82	0.58	−0.41	0.51	−0.81	0.28	−0.46	0.56	−0.82	0.23
Transport	−1.15	0.34	−3.41	0.30	−0.86	0.34	−2.50	0.41	−0.92	0.38	−2.41	0.27	−0.50	0.32	−1.57	0.35	−0.32	0.33	−0.95	0.37
Post and Telecomm.	−1.23	0.37	−3.36	0.59	−1.41	0.46	−3.05	0.63	−1.22	0.54	−2.25	0.42	−1.13	0.69	−1.63	0.61	−1.45	0.87	−1.67	0.57
Finance	−3.90	0.81	−4.81	0.48	−4.64	0.61	−7.60	0.58	−2.46	0.24	−10.15	0.79	−4.59	0.67	−6.90	0.62	−3.95	1.23	−3.22	0.49
Real Estate	−0.94	0.47	−2.00	0.33	−0.67	0.48	−1.41	0.36	−0.84	0.26	−3.24	0.18	−0.75	0.46	−1.63	0.56	−1.07	0.66	−1.61	0.45
Business	−2.29	0.62	−3.71	0.22	−2.83	0.59	−4.83	0.31	−1.94	0.40	−4.86	0.51	−2.57	0.57	−4.50	0.37	−3.25	0.71	−4.56	0.39
Community	−2.19	0.73	−3.02	0.22	−1.69	0.58	−2.92	0.34	−1.31	0.25	−5.19	0.60	−2.03	0.93	−2.18	0.35	−3.81	0.90	−4.23	0.42
Households	−1.67	1.58	−1.06	0.11	−3.51	0.65	−5.38	0.33	−2.34	0.31	−7.44	0.81	−4.56	0.75	−6.08	0.38	−5.92	1.19	−4.98	0.61

Sources: Inklaar and Timmer (2009); World KLEMS database; and IMF staff calculations.
Note: Robust standard errors are reported. Panel A is shows the estimation results from the baseline specification (using 10-year nonoverlapping windows with decade dummies) over an unbalanced panel of 30 countries. Panel B1 shows the results from the baseline specification using a balanced panel of 20 countries over 1973–2007, and Panel B2 the results based on a cross-section regression over the same sample. Panel C1 shows the results from the baseline specification using a unbalanced panel of 20 countries over 1970–2007 and Panel C2 shows the results from the baseline specification over the same sample but using total factor productivity instead of labor productivity. See Annex Table 3.1.2 for countries used in each regression. S.E. = standard errors.

Annex Figure 3.3.5. Sigma-Convergence
(Log standard deviation of PPP-adjusted labor productivity)
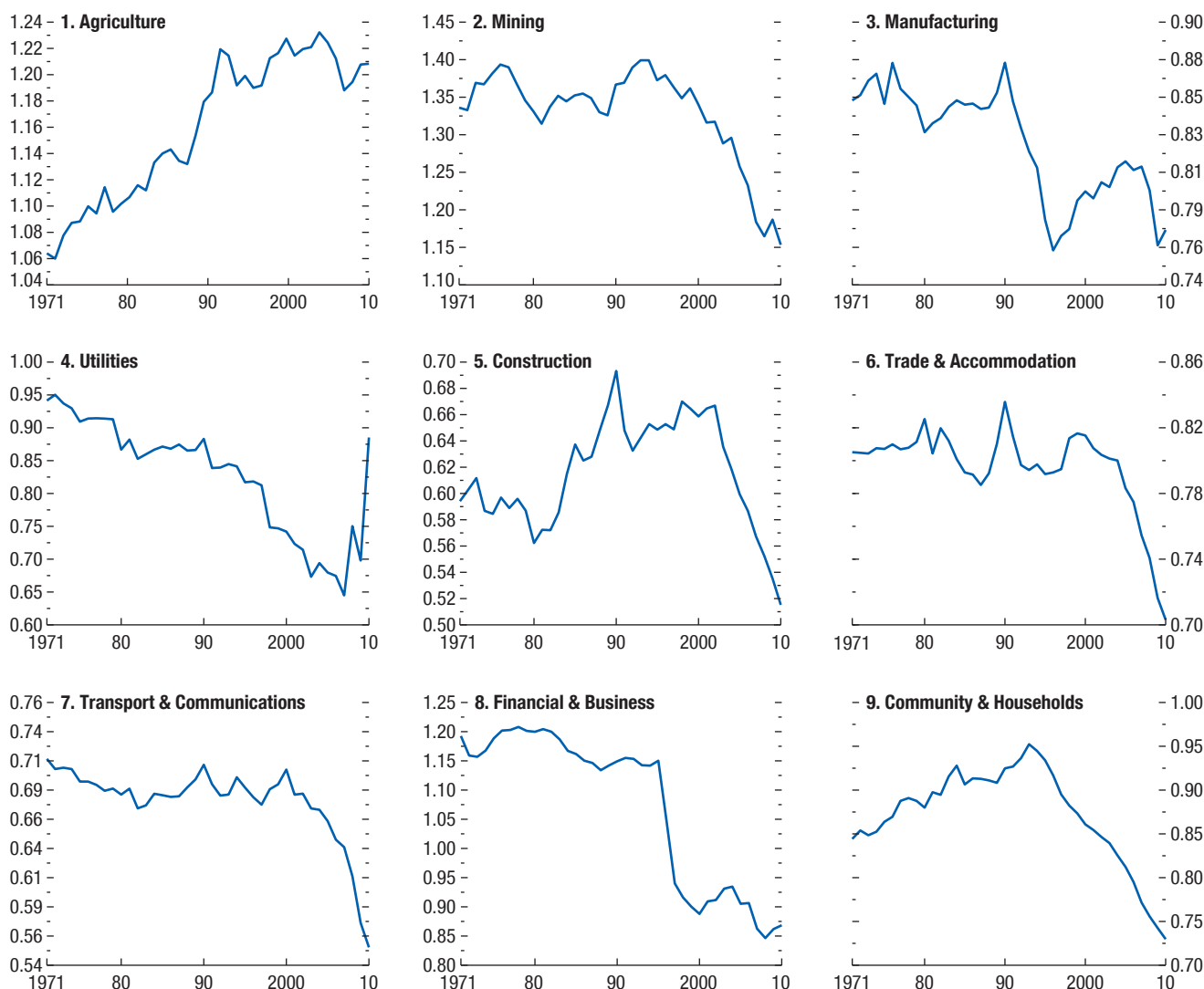
Sources: World KLEMS database; and IMF staff calculations.
Note: Each graph shows the cross-country log standard deviation of purchasing-power-parity-adjusted labor productivity (sigma-convergence) for each of the nine market sectors available in the Groningen Growth and Development Centre 10-sector database. PPP = purchasing power parity.

the results based on labor productivity on 10-year nonoverlapping periods during 1970–2010, as shown in Figure 3.17 (panel 2).[48]

Beta-convergence across sectors is a necessary but not sufficient condition for convergence in productivity levels. Even if beta-convergence holds, if

shocks to the growth process are relatively large, sigma-convergence may not be achieved (Young, Higgins, and Levy 2008). Annex Figure 3.3.5 shows the standard deviation of log labor productivity across countries for each of the nine market sectors in the GGDC 10-sector database.

Robustness Exercises

Mean Reversion. One concern with using 10-year nonoverlapping windows is that the evidence on con-

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[48]Annex Tables 3.3.1 and 3.3.2 report robust standard errors. Clustering standard errors at the country level does not change the results of the analysis.

vergence may reflect mean reversion over the business cycle. Panel C of Annex Table 3.3.1 shows the results from a robustness exercise using a cross-section analysis over a balanced panel. For each sector, the trend growth rate of labor productivity over the period 1965–2010 is regressed on its level in 1965 and a constant. The results reported in panel B2 confirm that the baseline results are not due to mean reversion (panel B1 shows for comparability purposes the results from the baseline specification but using the same balanced sample).

The robustness exercise for the reduced (26 sectors) sample is shown in Annex Table 3.3.2, panel B2 (panel B1 shows for comparability purposes the results from the baseline specification but using the same balanced sample). For each sector, the trend growth rate of labor productivity over the period 1973–2007 is regressed on its level in 1973 and a constant.[49] The results are broadly unchanged.

Total Factor Productivity. Given that changes in labor productivity may reflect capital deepening rather than actual productivity, an additional robustness exercise uses the standard TFP instead of labor productivity. The results are reported in Annex Table 3.3.2, panel C2 (panel C1 shows for comparability purposes the results using labor productivity over the same sample). The results are similar to those based on labor productivity in a comparable sample: (1) several manufacturing industries show no evidence of beta-convergence, and (2) several service sectors show significant evidence of beta-convergence.

Annex 3.4. Manufacturing and Inequality

This annex provides additional details on the analysis carried out in the section "Implications for Income Inequality."

The analysis in the section on income inequality uses micro data from the Luxembourg Income Study (LIS) to compute labor earnings inequality at the sectoral and the aggregate level. The LIS offers survey-based data at the household and personal level on labor income, employment sector, and occupation for a broad set of countries, including a set of advanced economies since the early 1980s. Given

that surveys are conducted at irregular time intervals that differ across countries, the cross-country statistics reported in the chapter correspond to the latest survey year available for each country within a specific range, as noted in the analysis. Because of data limitations, three broad sectors are considered: agriculture, industry (which consists of manufacturing, mining, electricity and construction), and services.[50]

The analysis on labor earnings across sectors and skills reported in Figure 3.20 uses LIS data on gross hourly wage of full-time working household members for whom skill data is available.[51] The skill levels—high, medium, and low—are based on the International Standard Classification of Occupations (ISCO) classification of occupations into managers and professionals (ISCO 1 and 2), other skilled workers (ISCO 3–8, 10), and laborers/elementary (ISCO 9), respectively. Average gross hourly wages for each sector-skill are expressed relative to average economy-wide wages.

The measure of inequality used is the Generalized Entropy (*GE*[0]) index, or mean log deviation, which has the advantage of being decomposable, unlike the Gini coefficient (Shorrocks 1980; Mookherjee and Shorrocks 1982). The mean log deviation, or *GE*(0), is given by:[52]

$$GE(0) \ = \ -\tfrac{1}{n}\sum_i \ln\left(\tfrac{y_i}{\bar{y}}\right), \tag{3.6}$$

in which n is the number of households, y_i is income of household i, and $\bar{y}$ is the mean of y_i.

The economy-wide GE(0) index can be decomposed as a weighted sum of the extent of inequality in each sector (within-sector inequality) and the contribution arising from differences between average incomes across sectors (between-sector inequality):

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[49]1973 is chosen as the initial year to maximize the country coverage, as data for Japan only starts from 1973. Given that data for countries in Central and Eastern Europe are not available before 1995, this cross-sectional analysis includes fewer country observations (20 countries).

[50]The information on the sector of employment might not be available if the household head is unemployed, out of the labor force, or the data is missing. In those cases, the household is assigned to a separate "missing data" sector to ensure that the aggregate inequality measure is calculated for the entire population, and the sum of the components equals the economy-wide level of inequality.

[51]The hourly wages are top and bottom coded to address extreme values. At the bottom, negative or zero wages are set to "missing." At the top, wages greater than 10 times the median for a given country-year are set to 10 times the median.

[52]The general formula for Generalized Entropy is

$$GE(\alpha) \ = \ \frac{1}{n\alpha(\alpha \ - \ 1)}\sum_i \left[\left(\tfrac{y_i}{\bar{y}}\right)^{\alpha} - \ 1\right],$$

when $\alpha \ \neq \ 0,1$. When $\alpha = 0$, GE is defined as in equation 3.6.

$$GE(0) = \underbrace{\sum_k v_k \, GE(0)_k}_{within} + \underbrace{\sum_k v_k \ln\left(\frac{1}{\lambda_k}\right)}_{between}, \qquad (3.7)$$

in which $v_k = \frac{n_k}{n}$ is the population share of sector k, and $\lambda_k = \frac{\bar{y}_k}{\bar{y}}$ is the relative mean income of sector k. The sector of employment of the household head is used to calculate inequality at the sector level. The cross-sector average income differences reported in Figure 3.21 correspond to the between-sector inequality term.

Changes in inequality over time can be analyzed by applying the difference operator to both sides of the equation 3.7:

$$
\begin{aligned}
GE(0)_{t+1} - GE(0)_t = {} & \sum_k v_{k,t} \Delta GE(0)_k \\
& + \sum_k GE(0)_{k,t+1} \Delta v_k \\
& - \sum_k \ln(\lambda_{k,t+1}) \Delta v_k \\
& - \sum_k v_{k,t} \Delta \ln(\lambda_k). \qquad (3.8)
\end{aligned}
$$

Equation 3.8 is an exact decomposition of the change in generalized entropy over time into four terms that can be interpreted as: (1) the effect of intertemporal changes in within-sector inequality, (2) the effect of changes in sectoral employment shares on the "within" component, (3) the effect of changes in sectoral employment shares on the "between" component, and (4) the effect of changes in the relative average sectoral income levels (Mookherjee and Shorrocks 1982). In the analysis reported in Figure 3.22, the second and third terms are added and referred to as "changes in sector size."

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