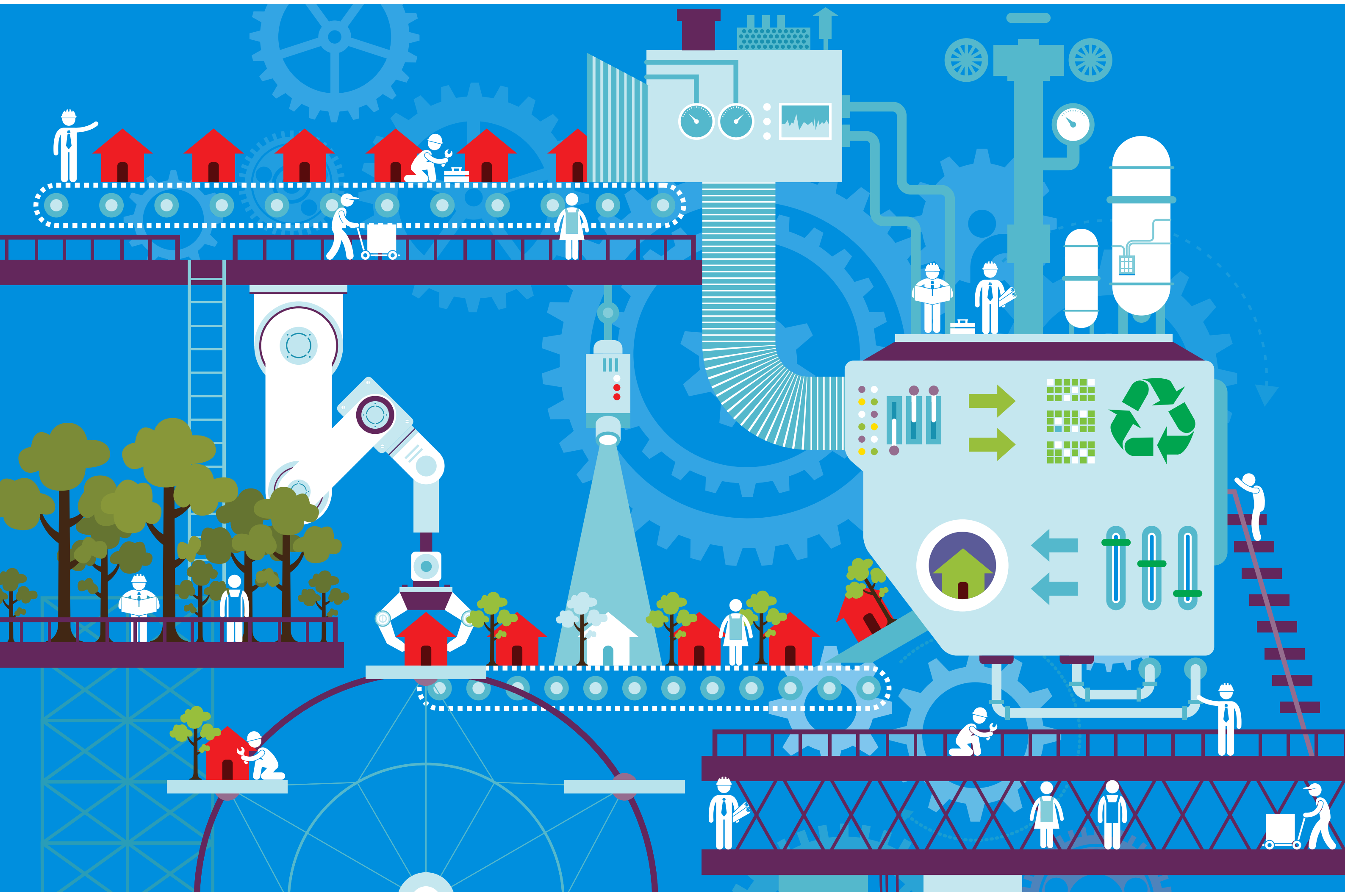
Industrial Development Report 2016

The Role of Technology and Innovation in Inclusive and Sustainable Industrial Development
Overview



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Foreword

Technological change is recognized as one of the main drivers of long-term growth. In the coming decades, radical innovations such as the mobile internet, the Internet of Things and cloud computing are likely to revolutionize production processes and enhance living standards, particularly in developing countries. The Sustainable Development Goal 9 *Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation* adopted on 26 September 2015 implies that without technology and innovation, industrialization will not happen, and without industrialization, development will not happen.

It is undebatable that technology makes production processes more efficient, thereby increasing the competitiveness of countries and reducing their vulnerability to market fluctuations. Structural change, i.e. the transition from a labour-intensive to a technology-intensive economy, drives economic upgrading. Low income countries thus acquire the necessary capabilities to catch up and reduce the gap with per capita incomes in high income countries.

Catching up, unfortunately, does not occur frequently. In the last 50 years, only a few countries were successful in rapidly industrializing and achieving sustained economic growth. Technology was always a key driver in these cases and they successfully developed an advanced technology-intensive industry. Though there is clear evidence that technological change contributes significantly to the prosperity of nations, the debate about the underlying factors deterring countries from promoting technology and innovation more intensively continues.

Though technology is linked to sustainable growth, it is uncertain whether it can simultaneously create social inclusiveness and environmental sustainability. The substitution of labour with capital induced by structural change may reduce employment. Technological change also requires the labour force to be prepared to use increasingly complex machinery and equipment, which widens the inequality between highly skilled and unskilled workers in terms of wage distribution. Industrialization has historically been accompanied by increasing pollution and the depletion of natural resources. Economic growth also entails a rise in the use of inputs, materials and fossil fuels, which generate environmental pollution and degradation, especially in low income countries.

The Lima Declaration approved during the 15th session of UNIDO's General Conference clearly states that "Poverty eradication remains the central imperative. This can only be achieved through strong, inclusive, sustainable and resilient economic and industrial growth, and the effective integration of the economic, social and environmental dimensions of sustainable development". UNIDO strongly promotes paths of economic growth and industrialization that reconcile all relevant dimensions of sustainability.

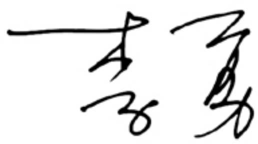
The *Industrial Development Report 2016* addresses a challenging question: under which conditions do technology and innovation achieve inclusive and sustainable industrial development (ISID)? The main finding of this report is that technology can simultaneously serve all three dimensions of sustainability. Rapid inclusive and sustainable industrialization can be achieved provided that policymakers resolutely facilitate and steer the industrialization process, which requires sound policies and avoiding the mistakes other countries have made in the past.

From an economic point of view, globalization and the fragmentation of production at international level have facilitated the diffusion of new technologies through the intensification of trade in sophisticated manufacturing goods. However, this diffusion of technology has in many cases not translated into concrete growth opportunities due to the lack of technological capabilities and the capacity of countries to promote innovation systems. Innovation needs to be supported by appropriate interventions that strengthen the process from technology invention to adoption by firms as was the case in benchmark countries such as China and the Republic of Korea.

From a social point of view, industrialization contributes to the improvement of many indicators such as the Human Development Index and the poverty rate. Even though technology and automation generally improve people's working conditions, the number of jobs may decrease as a result, with workers being replaced by machines. A key point highlighted in this report is that technological change itself can mitigate this effect. New technologies also generate new markets, for example the waste and recycling industry, reduce the prices of consumer goods and provide opportunities for new investments with higher levels of profitability. Most importantly, the expansion of new technologically-intensive industries absorbs those workers who have lost their jobs to machines.

From an environmental point of view, there is a natural tendency of firms to seek efficiency in the use of resources. Entrepreneurs tend to maximize profits by minimizing the use of inputs through process innovations. During the structural change process, the transition from medium tech industries towards high-tech industries is beneficial from a macro perspective, as it implies a lower level of environmental pollution. Despite these positive dynamics, the current trend of technological change does not guarantee that we will follow a sustainable path in the future. Global concerted action is indispensable to reduce greenhouse gases and to stimulate the creation and diffusion of environmentally friendly technological progress.

It gives me great pleasure to present this report as Director-General of UNIDO. I am particularly pleased that the *Industrial Development Report 2016* emphasizes the critical need for international cooperation to promote technological change and achieve ISID, and that it reaffirms the commitment of my Organization to fulfil its unique mandate in support of this effort. I am grateful to the UNIDO staff and the international experts who joined hands to produce this report, and look forward to seeing it become a key component in the development debate.



LI Yong
Director General, UNIDO

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Technical notes and abbreviations

References to dollars ($) are to United States dollars, unless otherwise indicated.

In this report, *industry* refers to the manufacturing industry and *sectors* refers to specific manufacturing sectors.

This report defines *developed countries* or *developed economies* as the group identified as "high-income OECD countries" by the World Bank and *developing countries* or *developing economies* as all other economies. See Annex B1 for a complete list of economies by region, income level, least developed countries and largest developing economy in each region.

Components in tables may not sum precisely to totals shown because of rounding.

CIP Competitive industrial performance
DEIE Developing and emerging industrial economies
FDI Foreign direct investment
GDP Gross domestic product
GHG Greenhouse gas
GVC Global value chain
ICT Information and communications technology
ILO International Labour Organization
IPR Intellectual property rights
ISIC International Standard Industrial Classification
ISID Inclusive and sustainable industrial development
LDC Least developed countries
MDG Millennium Development Goal
MNE Multinational enterprises
MVA Manufacturing value added
OECD Organisation for Economic Co-operation and Development
PPP Purchasing power parity
R&D Research and development
SEZ Special economic zones
SME Small and medium-size enterprise
STI Science, technology and innovation
TFP Total factor productivity
UN United Nations
UNCTAD United Nations Conference on Trade and Development
UNDESA United Nations Department of Economic and Social Affairs
UNDP United Nations Development Programme
UNEP United Nations Environment Programme
UNIDO United Nations Industrial Development Organization

Overview

The role of technology and innovation in inclusive and sustainable industrial development

Key messages

- Reaching advanced levels of inclusive and sustainable industrial development (ISID) requires not only increasing incomes but also conscious efforts to sustain growth, promote social inclusiveness and move towards greener structural transformation—as well as managing the trade-offs between them.
- Industrialization, a major force in structural change, shifts resources from labour-intensive activities to more capital- and technology-intensive activities. It will remain crucial to the future growth of developing countries.
- Manufacturing's share of gross domestic product (GDP) has remained stable over the last 40 years.
- Technology and capital equipment are the main drivers of both manufacturing growth and aggregate growth in developed and developing countries although in developing countries energy and natural resources use affects growth in middle and low tech industries.
- The choice of sector matters for economic growth and structural change since the technological opportunities between them vary significantly.
- Diversification into manufacturing can help to achieve rapid average growth rates, longer periods of growth and less volatility in growth—thus sustaining growth in the long run.
- Premature deindustrialization smothers economic development potential by limiting the application of technology to production and generating low productivity and informal services activities—while mature deindustrialization often leads to dynamic high-tech services.
- Technological capabilities are strengthened by investing in human capital, institutions, improving innovation systems and upgrading in industrial clusters and global value chains.
- Technological capabilities are developed in developed countries through tinkering with the frontiers of science and technology and in developing countries by acquiring and adapting technologies created elsewhere.
- Promoting social inclusiveness in manufacturing requires matching the choice of technologies to a country's resource and skill endowment.
- Improving the environmental sustainability of industry may sometimes require adopting production technologies that are not economically viable, although the profitability of these technologies is increasing over time.
- Hi-tech industries produce an environmental bonus since they are less polluting than other industries.
- The recycling industry exhibits the win-win-win properties of sustaining growth, generating employment and equity and being environmentally friendly—but the trade-offs are considerable in combining these aims.
- Policy instruments for industrial development depend on the type of technology and innovation being targeted and the country's level of development, ranging from protecting property rights at one extreme to providing grants for machinery imports at the other.
- Pooling financial and research resources internationally in a global knowledge base can contribute much to building technological capabilities for inclusive and sustainable industrialization.

Under what conditions can technological change trigger structural change in developing countries and lead to long-term, socially inclusive and environmentally sustainable industrial development? That is the central question addressed in this *Industrial Development Report 2016*. The Lima Declaration, adopted by the Member States of UNIDO in December 2013, set the foundation for a new vision of inclusive and sustainable industrial development (ISID). The ISID concept is part of the new Sustainable Development Goal 9 to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

ISID has three elements, which are the framework for this report. The first is long-term, sustained

> **For long-term structural change, manufacturing plays a key role**

industrialization as a driver for economic development. The second is socially inclusive industrial development and society, offering equal opportunities and an equitable distribution of benefits. And the third is environmental sustainability, decoupling the prosperity generated by industrial activities from excessive natural resource use and negative environmental impact. This three-dimensional structure feeds through to the policy recommendations for dealing with the many tradeoffs that countries face in sustaining economic growth, promoting social inclusiveness and moving towards greener economic transformations.

For long-term structural change, manufacturing plays a key role. It creates many productive, formal jobs at an early stage of development. It also drives technological development and innovation to sustain productivity growth in manufacturing and other sectors. And it has varying effects on employment, wages, technological upgrading and sustainability at different stages of development. The reason is that manufacturing changes economic structures, usually from labour-intensive activities to more capital- and technology-intensive activities. Each manufacturing subsector also changes products and production processes, with the increasing applications of capital and technology.

Premature deindustrialization can be a serious threat to growth in developing economies, smothering the growth potential of manufacturing when it sets in. The kind of informal service activities that emerge at this stage reduce rather than enhance growth. But when mature deindustrialization sets in at higher levels of per capita income, the kind of services that emerge—logistics, business services and information technology services—are much more dynamic and can take over and complement the growth-enhancing role of manufacturing.

How can developing countries catch up with the global economic and technological frontier? By promoting technological change through investing in human capital, improving innovation systems and upgrading global value chains (GVCs). Rather than build new technology themselves, developing countries can use technology transfers from abroad to grow. But this requires effort to adapt the knowledge that flows into the economy and greater absorptive capabilities —primarily education and skills. Living standards rise with gains in productivity, thanks to technological advances that, over the past decades, have taken place through globalization, notably GVCs.

To sustain economic growth, countries need growth-enhancing technological change. That requires understanding what sectors drive the growth process and how those sectors upgrade their technology. For example, process innovation has a different influence on productivity in the various sectors by changing the structure of output, employment and exports. Technological change also facilitates a new global organization of distributed production in GVCs, with positive and negative repercussions for countries—at all incomes—on their economic activities and sector structures. GVCs compel countries with low productivity to upgrade their production capabilities.

Structural change in manufacturing thus has significant implications for ISID. Countries at different incomes face different growth potentials within manufacturing. Shifts from labour-intensive to capital-intensive and technology-intensive industries alter the intensity of labour, technology and natural resources used in manufacturing activities. That changes a country's prospects for inclusive and sustainable industrial development.

How does technological change affect inclusiveness? Product innovations create new economic activities and sectors or increase the importance of existing sectors, drawing people into the labour market. If technological change is labour saving, it will promote economic sectors that are more capital intensive and affect the volume and structure of employment. If it is skill biased, it will increase the demand for skilled labour and reduce the demand for unskilled labour. Through skill premiums, technological change affects the income distribution. And technologies that upgrade previously marginalized low-tech activities can improve inclusiveness.

In similar fashion, structural change can prompt a shift to more environment-friendly sustainable sectors

“Once industrialization takes off, countries at low and lower middle incomes have opportunities to create a large number of formal manufacturing jobs

and activities—such as from heavy industry to light, to more recycling or to services, which tend to be less polluting than manufacturing. The direct effects of technological change can be positive or negative, affecting people's health, consumption-, and quality of employment. Innovation has direct effects, too, on the environmental footprints of economic activities, affecting the amount of non-renewable resources used and the pollution per unit of output, through improvements in energy efficiency, resource efficiency, pollution prevention, mitigation and recycling.

How, then, can countries at different stages of industrialization best pursue inclusive and sustainable industrial development? Developing countries, especially at an early stage of industrialization, have more opportunities to pursue inclusive industrial development with rapid growth and limited environmental damage. The take-off of labour-intensive industries exporting to major world markets could boost both output and employment, thus promoting sustained and inclusive growth. And the limited output and concentration on less polluting activities tend to make manufacturing less damaging for the environment than at a later stage.

As countries acquire skills and expand their infrastructure, the opportunities for growth and employment generation rise in other industries, but they usually proceed in an extensive manner by drawing in increasing amounts of production factors, as well as natural resources and energy. Most industries emerging at the middle-income stage are resource intensive with relatively poor emission performance. So countries emerging from the low-income stage have good prospects for continuing the path of inclusive and fast development, but they start facing sustainability challenges.

Entry into the high-income group at a mature level of industrialization comes with structural and technological changes in manufacturing. High-income countries tend to have slower growth in manufacturing, except for high-tech industries, and experience a reduction in employment. At this stage, productivity is the main driver for growth across manufacturing industries, leading to output growth without much increase in inputs—capital, labour and material. People employed in manufacturing might receive a relatively high wage, but the sector is not expanding or is often shedding employment. So the sector has limited opportunities for inclusive development in the sense of employment absorption, but it is more environmentally friendly.

Although employment prospects in manufacturing diminish as incomes grow beyond a certain level, high-tech industries could create a large number of manufacturing-related service jobs—with a wage often comparable to that in manufacturing—which could fully offset the reduction in manufacturing employment.

But there are trade-offs. Once industrialization takes off, countries at low and lower middle incomes have opportunities to create a large number of formal manufacturing jobs because their cheaper wages provide them with comparative advantage in labour-intensive industries, such as textiles and wearing apparel. The manufacturing wages in these activities might be much lower than those in capital-intensive industries, so the wage inequality across manufacturing industries can be high, which lowers the manufacturing wage equity part of the inclusiveness term in the ISID index. But what matters for countries in transition from an agrarian to a modern economy is generating many formal manufacturing jobs that pay more than agricultural and subsistence sectors. For this, the rapid growth of export-oriented labour-intensive industries is important.

At low incomes, countries' manufacturing industries are relatively clean because the labour-intensive industries, such as textiles, wearing apparel, and food and beverages, have high value-added performance per unit of carbon dioxide emission. Thus, from a structural change perspective, industrialization for low-income countries can be conducive to inclusive and sustainable growth, which is often more difficult at other stages of development. Even though labour-intensive industries are less emission-intensive than heavy industries, emissions for the economy as a whole might increase as countries shift from agricultural to

> **The foremost challenge for low-income countries is sustaining the process of industrialization**

more industrial economies. So, mitigation measures will remain important for low-income countries.

As countries move to middle incomes, their rising skills and capital accumulation often bring more capital-intensive, resource-processing industries, such as basic metals and chemicals industries. Inclusiveness is likely to improve due more to continued expansion of labour-intensive industries, increased employment in capital-intensive industries and gradually increased manufacturing wages. Although the share of the labour compensation in manufacturing value added (MVA) could stay constant since the value added is also increasing, increases in the equity-adjusted wage and employment are important as these contribute to inclusiveness. As capital-intensive, resource-based industries emerge, however, sustainability can be threatened as those industries tend to be less emission-efficient than labour-intensive industries, at least at an earlier stage of their development.

As countries develop further and move to upper-middle and high incomes, they tend to experience a decline of labour-intensive industries but an increase in opportunities to develop capital- and technology-intensive industries. These industries usually have high output-to-emission performance, so the manufacturing sustainability of countries usually improves. But these industries employ much less labour than labour-intensive industries to produce one unit of MVA. Besides, manufacturing as a whole intensifies the use of capital and technology relative to labour in production. So, even though manufacturing wages increase as GDP per capita rises, employment intensity steadily falls at higher incomes.

As this trend continues, countries eventually reach the mature stage of industrialization (or deindustrialization). Due to higher wages and improved wage equity across manufacturing industries, inclusiveness within manufacturing may not deteriorate, but its contribution to the inclusiveness of the whole economy certainly declines at a very high income due to the sector's limited capacity to absorb a country's labour force.

Unless countries make conscious efforts on all three fronts—sustaining economic growth, promoting social inclusiveness and pursuing environmental sustainability—and on managing the trade-offs between them, they are unlikely, regardless of their development stage, to go much farther along the road to ISID. The foremost challenge for low-income countries is sustaining the process of industrialization. For middle-income countries, it is environmental sustainability. And for deindustrializing high-income countries, it is continued employment generation and inclusive industrial development. So, in different ways at different stages, technological change and innovation remain crucial for successful industrialization.

Manufacturing and structural change

Manufacturing employment's share in total employment and the absolute number of manufacturing jobs are generally falling in high-income countries. And on average, countries across all incomes now have a lower manufacturing share than before, and they reach their peak employment and value-added shares at a lower income than in previous decades. (Rodrik 2015; Ghani and O'Connell 2014) But declining manufacturing in developed economies does not necessarily mean the same in developing countries—or a decline in the sector's importance to developed economies on value added, productivity and linkages to other sectors. In a similar way, low manufacturing shares in many developing countries (relative to past trends) might be attributed to country-specific conditions rather than to systematic and long-term reduction in manufacturing's potential contribution to the economy from a structural shift in supply and demand conditions of different sectors.

Wanted: shifting shares of low, medium and high tech

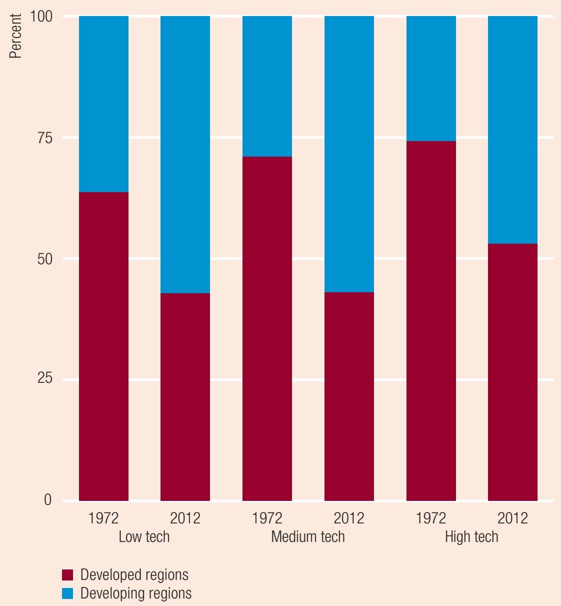
To illustrate the relationship between structural change and technological development—a key theme of this report—we look at structural change among manufacturing subsectors, grouped by technological category: low tech, medium tech, and high tech. The last 40 years have seen a relative shift in all three technological activities from developed to developing countries. In 2012, more than half of the world's value added in low- and

> **In different ways at different stages, technological change and innovation remain crucial for successful industrialization**

medium-tech industries was from developing countries, and even in high-tech industries, developing countries accounted for nearly half on that measure (Figure 1).

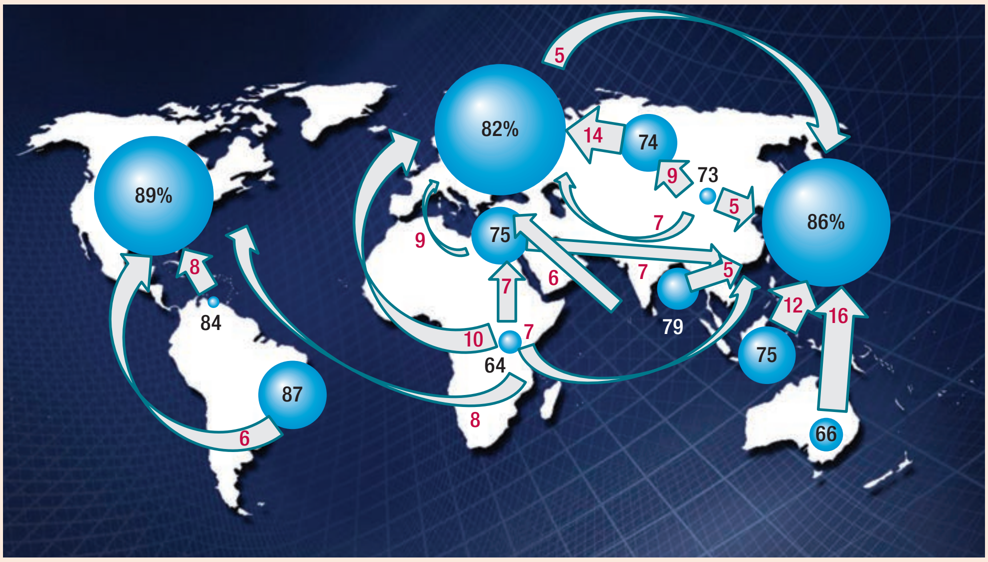
How has the technology structure in manufacturing changed in developing countries over those 40 years? In 1972, the low-tech share in Africa was higher than in the other two regions, which had a similar technology structure by proportion of the three technology groups. In 2012, Africa increased the share of the high-tech group and reached a structure similar to that of Latin America and Asia in 1972. In the same period, Latin America had very little change, with a slight decline in the share of the high-tech group, compensated by an increase in the medium-tech share. Asia experienced the most significant change in technology structure. Over the 40 years, its share of the high-tech group rose by 10 percentage points, at the expense of the low-tech share. Asia's economic success relative to other developing regions was thus accompanied not only by an increased manufacturing share in the economy but also by technological upgrading in manufacturing.

Figure 1
Shares of developing and developed regions in global value added of low-, medium-, and high-tech manufacturing industries, 1972 and 2012



Note: Tech classifications based on Annex A2, income classification based on Annex A1, Table A1.2.
Source: UNIDO elaboration based on Lavopa and Szirmai (2015).

Figure 2
Forward linkages—how regions generated manufacturing value added, 2011



Note: Arrows show the value added generated from the export of intermediate goods by the region of origin. The area covered by the bubbles represents the relative size of total value added (both generated within each region and from other regions) for a region's manufacturing output; the number in or next to a bubble (in black or white) indicates the share of manufacturing value added within the region for the production of final output, which can either be used within the region or exported to other regions. Arrows show the main sources of value-added contributions for manufacturing output in each region. Red numbers indicate the percentage of the value added that came from these transactions (that is, backward linkages with global value chains) in the region's total manufacturing value added. (Only transactions of 5 percent or more of the region's value added are shown.) Regional classification based on Annex A1, Table A1.2.
Source: UNIDO elaboration based on Eora MRIO Database (Lenzen et al. 2012; Lenzen et al. 2013).

> **The lower the GDP per capita at which a country begins to deindustrialize, the more the process is likely to negatively affect growth and growth prospects**

On the global trade in intermediate goods and value added generated by such trade, the importance of East Asia has shot up over the last 20 years (Figure 2). In 2011, a quarter of global MVA was generated by that region, whose value-added share was the third largest after North America in 1990 and became the second largest after Western Europe in 2011. Seven regions came to depend on generating their value added through intermediate exports to East Asia.

The world's manufacturing production increased its participation in GVCs and integration into supply chains led by North America, Western Europe and East Asia. Sub-Saharan Africa increased the share of value added coming from other regions in its manufacturing output (backward production linkages) and share in its total value added derived from intermediate exports to other regions (forward production linkages). But such integration did not see the region industrializing rapidly. It increased its global MVA share by a mere 0.13 percent from 1990 to 2011, one of the lowest increases in developing regions.

Are developing countries deindustrializing? In the main, No

Deindustrialization can describe a wide range of country experiences. For example, in one country, the share of manufacturing in employment may fall because very rapid technological progress in manufacturing leads to its productivity rising more than productivity in other sectors. So, employment is growing, but more slowly than it was previously. This can go hand in hand with healthy growth in manufacturing output, exports and sometimes even employment itself. In another country, the share of employment may be increasing, but due to slow productivity growth, the share of manufacturing in GDP is in decline. In a third country, manufacturing could be collapsing when a country experiences productivity declines, stagnant output growth and shrinking jobs in manufacturing.

If countries start deindustrializing prematurely (when their per capita income and degree of industrialization are too low), they are prone to growth-reducing structural change, involving the wrong kind of low-productivity informal services, which in many countries in Asia and Latin America are currently expanding their shares in value added and employment. They offer little potential for growth. Such premature deindustrialization is a threat to sustained economic growth in low- and middle-income countries on two counts.

First, such countries will have obtained fewer of the "growth-enhancing" benefits of manufacturing. Second, manufacturing tends to be replaced by the wrong kind of services. When "mature" deindustrialization sets in—in an advanced economy—subsectors of the expanding service sector have the dynamic characteristics attributed to manufacturing in the past: strong linkages, productivity increases and technological innovations. That kind of service sector can act as an engine of growth. In an economy characterized by premature deindustrialization, the service activities that emerge often are informal services lacking dynamism and growth potential.

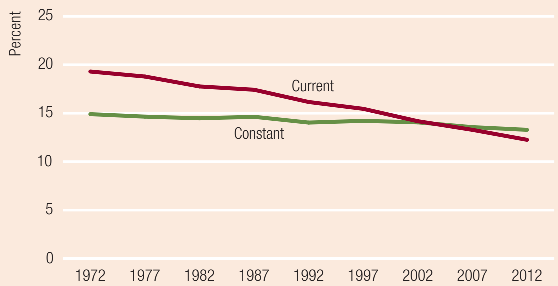
Very austere macroeconomic policies—especially high interest rates and overvalued exchange rates—are likely to have more pronounced negative effects on industry (and on the rest of the real economy) than on the financial sector. Such policies are likely to financialize and deindustrialize the economy. Similarly, trade liberalization affects tradables more than non-tradables, and has uneven effects among tradables, depending on their competitive position at the time the domestic market opens. Liberalizing tariffs too quickly without giving manufacturing the time to restructure is a major contributor to deindustrialization. Note, however, that manufacturing's share in global GDP has not changed much in constant purchasing power parity dollars ($PPP) using sector-specific converters (Figure 3).

The perils of premature deindustrialization—you have to have something to lose it

The lower the GDP per capita at which a country begins to deindustrialize, the more the process is likely to negatively affect growth and growth prospects. Similarly, the lower the share of manufacturing in value added when deindustrialization sets in, the more deindustrialization is likely to affect growth.

“With mature deindustrialization, certain advanced and dynamic services activities may have the kinds of growth-enhancing properties attributed to manufacturing

Figure 3
Manufacturing share in global GDP, current and constant prices, 1960–2009



Note: Calculations are five-year averages. Each series calculates the manufacturing value added–to-GDP ratio, using different valuations for the sectoral and aggregate value added. PPP (PPPsh) is the value added at current PPP using sector-specific converters; PPPk05 (PPPsh) is the value added at 2005 PPP using sector-specific converters.
Source: Lavopa and Szirmai (2015).

The extent to which deindustrialization is triggered or accelerated by a policy change, as opposed to just gradually taking place over time with economic development, also influences the likely effects of deindustrialization on growth. Policy-induced deindustrialization is more likely to kick in before the full benefits of industrialization have been obtained, before manufacturing has matured and before a dynamic and advanced service sector has developed.

The aggregate effects of deindustrialization depend on the characteristics both of the manufacturing activities in decline and of the service activities that are increasing their shares in employment and GDP. For instance, if the manufacturing activities have little scope for increasing returns to scale and limited scope for cumulative productivity increases while the activities are growing, negative effects on growth need not occur.

Still, the growth-enhancing role of manufacturing is especially important in the earlier stages of development —and it is more important for developing than for developed countries. When a country begins deindustrializing after manufacturing’s share has reached 30 percent of GDP, the benefits of manufacturing likely have diffused through the economy over an extended period. Those benefits include skill development through learning by doing, technological benefits to other sectors, foreign exchange relieving balance-of-payments constraints to growth, and stimulating other sectors through forward and backward linkages. But when a country fails to industrialize or when it prematurely (or very prematurely) deindustrializes before manufacturing accounts for even 5 percent of total jobs, those pro-growth economic benefits will not be realized.

Further, premature deindustrialization can jeopardize the potential of the service sector to act as an alternative growth engine. With mature deindustrialization, certain advanced and dynamic services activities may have the kinds of growth-enhancing properties attributed to manufacturing. But the types of services activities likely to replace manufacturing at premature deindustrialization are more likely to be low-skilled, low-productivity, non-tradable activities, such as retail or personal services, which do not have strong increasing returns or the potential for cumulative productivity increases. Although those activities may be important for job creation, they are not likely to drive growth. Nor are they likely to allow countries to leapfrog to dynamic growth-pulling services activities before they have industrialized. A partial developing-country exception may be India, the “office of the world,” which has enclaves of dynamic service activities but whose employment numbers are tiny relative to the country’s population.

Overall, however, with deindustrialization at low incomes per capita, a country is unlikely to have enough effective demand to support the sustainable development of dynamic services that can act as an alternative engine of growth. The non-tradable nature of many services makes domestic demand more of a constraint than it is with manufacturing. To the extent that services can be such an engine of growth, the situation is more likely to be feasible in advanced than in developing countries.

Manufacturing structural change and inclusive and sustainable development

Big differences in the way manufacturing drives economic growth

Developing and high-income countries display wide differences in the way manufacturing drives economic

> **In developing countries, contributions to output growth come mainly from capital investments, natural resources and energy**

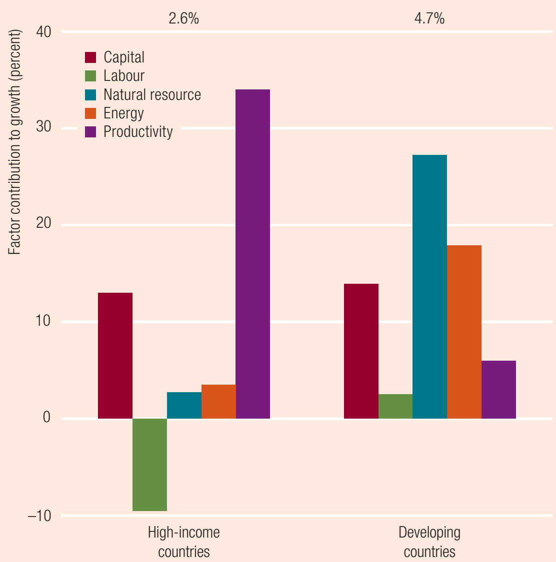
growth (Figure 4).[1] In developing countries, contributions to output growth come mainly from capital investments, natural resources and energy; in high-income countries, they come from productivity. High-income countries seem to use labour- and resource-saving technology, which allows them to increase output without significantly increasing factor inputs.

Consider three groupings of manufacturing industries—typical low tech, medium tech, and high tech—to assess how their production characteristics affect overall growth and factor contributions along country income lines.[2]

Low-tech industries

In these industries, high-income countries had negative output growth of 1.1 percent in textiles and textile products and in leather and footwear (Figure 5), particularly due to high negative shares of labour contribution or labour displacement. In developing countries, conversely, both industries grew: the largest contribution to output growth for both industries came from energy, less from capital investment and labour,[3] whereas productivity growth made a positive contribution only to textiles. Overall, productivity made a lower contribution to growth of labour-intensive industries in developing than in high-income countries.

Figure 4
Annual average manufacturing growth and factor contributions, high-income and developing countries, 1995–2007



Note: The analysis covers 40 countries. Based on income, eight are developing countries and the rest are high income. Income classification based on Annex A1, Table A1.2.
Source: UNIDO elaboration based on World Input-Output Database (Timmer and others 2015).

Medium-tech industries

These industries also show a difference between the two country income groups (Figure 6). Productivity was the largest source of growth for high-income countries in rubber and plastics and non-metallic mineral industries, but for developing countries in those industries—especially non-metallic minerals—the main contribution came from natural resources and energy, with productivity growth providing only a small contribution.

When countries industrialize further and move into this grouping, the pollution intensity of the manufacturing sector (here measured as carbon dioxide emissions per unit of value added) tends to rise. That does not, however, mean that the growth of medium-tech, resource-based industries must always be driven by heavy increases in energy and natural resource inputs, as evidenced by the relatively low contributions of energy and natural resources to the growth of these activities in high-income countries.

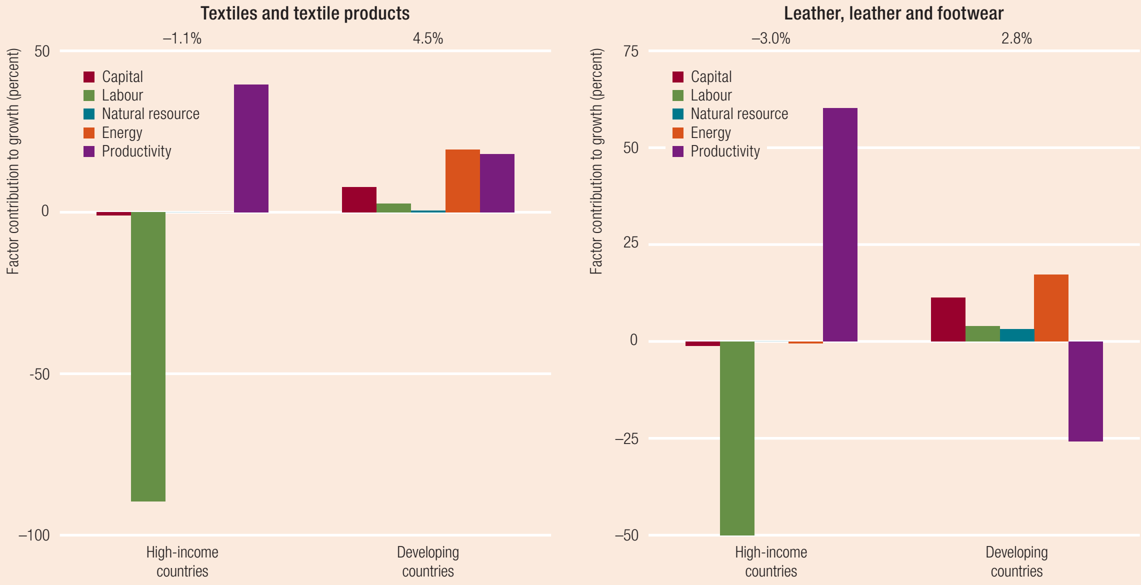
High-tech industries

High-income countries have an advantage in high-tech industries and clearly have the potential to achieve faster growth in those industries than in low- or medium-tech industries (Figure 7). That advantage drives structural change within manufacturing and shifts resources towards high-tech industries at higher income levels. Productivity is the dominant contributor to the growth of high-tech industries, and their growth does not depend significantly on an increase in the use of energy and natural resources.

In developing countries, productivity accounts for a significant share of the growth of high-tech

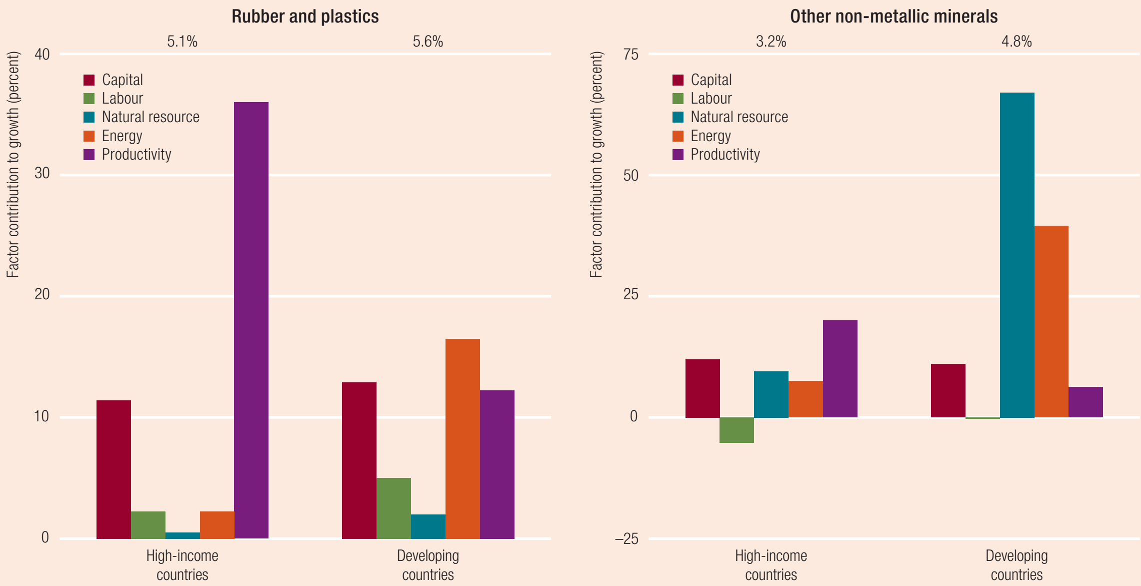
> **High-income countries seem to use labour- and resource-saving technology**

Figure 5
Selected low-tech, labour-intensive industries, 1995–2007



Note: Income classification based on Annex A1, Table A1.2
Source: UNIDO elaboration based on World Input-Output Database (Timmer and others 2015).

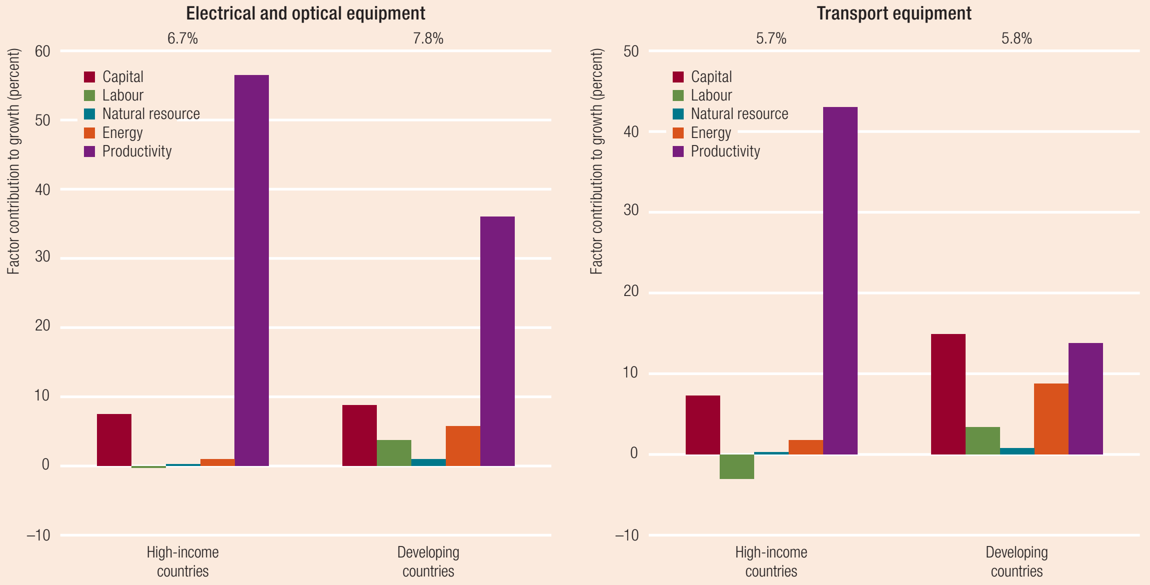
Figure 6
Selected medium-tech, resource-based industries, 1995–2007



Note: Income classification based on Annex A1, Table A1.2.
Source: UNIDO elaboration based on World Input-Output Database (Timmer and others 2015).

> **Differences in total factor productivity growth rates between sectors are the decisive factors in structural change**

Figure 7
Selected high-tech, technology-intensive industries, 1995–2007



Note: Income classification based on Annex A1, Table A1.2.
Source: UNIDO elaboration based on World Input-Output Database (Timmer and others 2015).

industries. But other factors, such as energy and capital investment, made a non-trivial contribution, too. So, although the importance of productivity for the growth of high-tech industries is common to developing and high-income countries, developing countries differ in that increased use of energy and labour accompanies growth—hence, the expansion of these activities is more inclusive in job terms, but it is less sustainable.

The main reason technological change is an important determinant of structural change is that its rate differs greatly between economic sectors, providing a stimulus to economic growth that favours some sectors over others. For structural change, the differences between sectors matter most, and those differences can be substantial both within a sector (between countries) and between sectors. By decomposing into two parts—one related to productivity change (indicating technological change or total factor productivity—TFP) and one to changes in the use of inputs (capital and labour)—makes it possible to assess which part of structural change is a direct result of technological change. Differences in TFP growth rates between sectors (within a country) are the decisive factors in structural change. High values of structural change are mostly achieved by a large contribution of technological change.

Linking inclusiveness and environmental sustainability

Industrialization was not factored into the Millennium Development Goals, but ISID features strongly in the 2030 Agenda for Sustainable Development. Sustainable Development Goal 9 promotes ISID with targets for sharply raising industry's share of employment and GDP by 2030, integrating small-scale industrial and other enterprises into value chains and markets, upgrading infrastructure and industries with greater resource-use efficiency, using clean and environmentally sound technologies and industrial processes, boosting scientific research, upgrading technological capabilities and encouraging innovation (UN 2015).

The ISID index allows analysing countries by industrial inclusiveness per unit of environmental impact

ISID can be conceptualized using the following equation:

$$\overbrace{\frac{(Mwage\_equality)^{*}\, Mwage \times Memp}{MVA}}^{\text{Inclusive industrial development}} \times \overbrace{\frac{MVA}{MCO_2\, emission}}^{\text{Sustainable industrial development}} = \overbrace{\frac{(Mwage\_equality)^{*}\, Mwage \times Memp}{MCO_2\, emission}}^{\text{Inclusive and sustainable industrial development}}$$

Note: M is manufacturing.

The equation essentially shows the extent of inclusive industrial development achieved per unit of environmental impact. The concept can be applied to available data to show the general trends in inclusiveness and sustainability across countries.

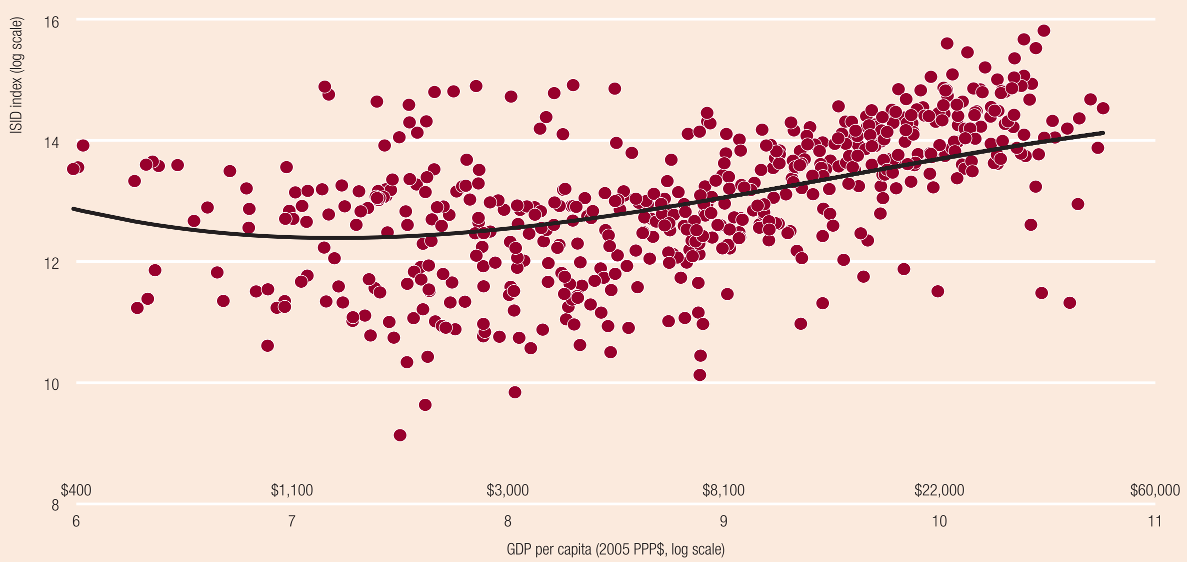
The ISID index thus allows analysing countries by industrial inclusiveness per unit of environmental impact. It is quite different from an index based on industrialization (MVA per capita) and economic development (GDP per capita). The top countries are not necessarily the ones with the richest economies—but their manufacturing industries have the highest inclusiveness per unit of environmental impact (Figure 8).

The U-shape of the ISID index is due to an improvement in manufacturing sustainability with a largely steady level of manufacturing inclusiveness. The inclusiveness component is neutral in relation to income, though this does not mean that countries have a similar level of inclusiveness: the differences across countries are significant (Figure 9).

The sustainability component exhibits an upward trend after deterioration at low income: the carbon dioxide efficiency of manufacturing output first decreases and then starts improving (Figure 10). Even though carbon dioxide inefficiency bottoms out at a fairly low income, the variance across countries is very high up to around $8,000 GDP per capita. Only then does the upward pattern become clearer.

Offsetting trends in wages and employment generate the largely flat trend observed in inclusiveness. As expected, the adjusted wage increases along a country's development (Figure 11), and a positive relationship becomes clearer after income reaches around $2,000–3,000 GDP (PPP) per capita. But employment intensity (manufacturing employment per unit of value

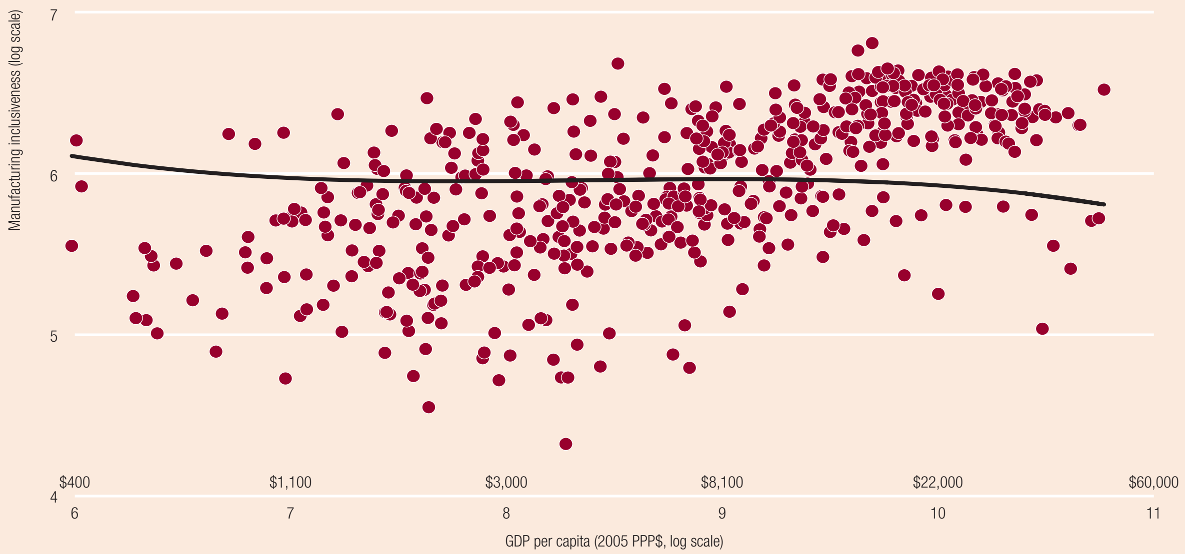
Figure 8
ISID index and GDP per capita—a shallow U shape



Note: ISID is inclusive and sustainable development; PPP is purchasing power parity. Calculations are five-year averages and cover 98 countries between 1970 and 2013. The ISID index is defined in the equation above.
Source: UNIDO elaboration based on INDSTAT2 (UNIDO 2014c), Penn World Tables (Feenstra and others 2015), UN National Accounts Statistics (UN 2014b), World Input-Output Database (Timmer and others 2015), Groningen Growth and Development Centre 10-Sector Database (Timmer, de Vries and de Vries 2014), ILOSTAT (ILO 2015a), KILM Database (ILO 2015b), EU KLEMS Database (O'Mahony and Timmer 2015), CAIT Climate Data (WRI 2015) and UTIP-UNIDO Industrial Pay Inequality Database (University of Texas and UNIDO 2015).

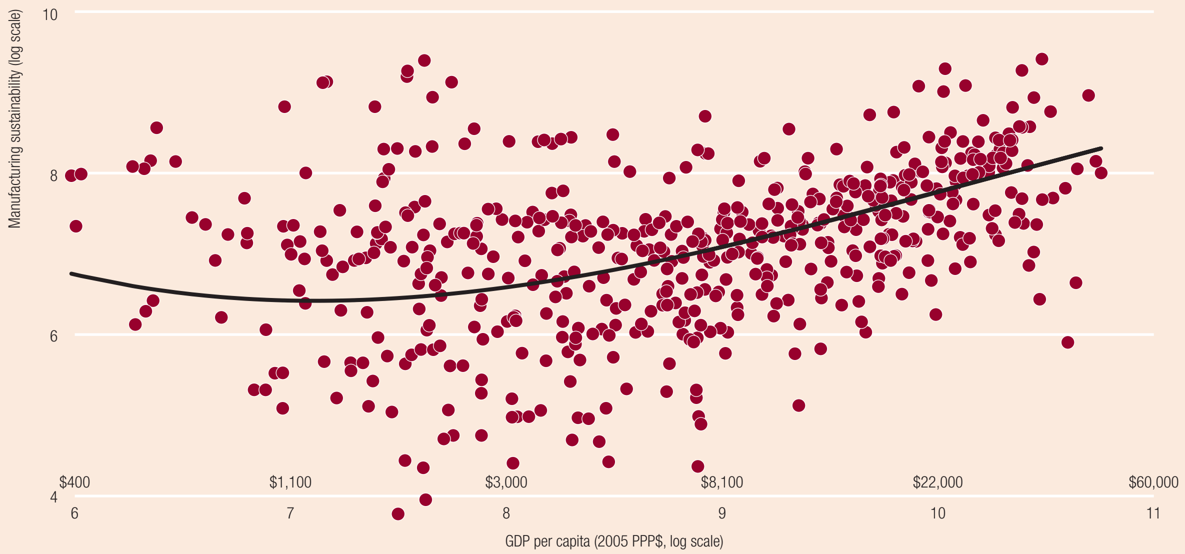
> **The decline in employment intensity in manufacturing stems from structural changes in manufacturing**

Figure 9
Manufacturing inclusiveness



Note: PPP is purchasing power parity. Calculations are five-year averages and cover 98 countries between 1970 and 2013. Manufacturing inclusiveness is defined in the equation (*M Inclusiveness*)/(*M Output*) = ((*Mwage_equality*) * *Mwage* × *Memp*)/*Manufacturing value added* (*MVA*), expressing equity adjusted total wage per unit of MVA.
Source: UNIDO elaboration based on INDSTAT2 (UNIDO 2014c), Penn World Tables (Feenstra and others 2015), United Nations National Accounts Statistics (UN 2014b), World Input-Output Database (Timmer and others 2015), Groningen Growth and Development Centre 10-Sector Database (Timmer, de Vries and de Vries 2014), ILOSTAT (ILO 2015a), KILM Database (ILO 2015b), EU KLEMS Database (O'Mahony and Timmer 2015), CAIT Climate Data (WRI 2015) and UTIP-UNIDO Industrial Pay Inequality Database (University of Texas and UNIDO 2015).

Figure 10
Manufacturing sustainability



Note: PPP is purchasing power parity. Calculations are five-year averages and cover 98 countries between 1970 and 2013. Manufacturing sustainability is defined in the equation (*M Output*)/(*M Environmental Impact*) = (*Manufacturing value added* (*MVA*))/(Manufacturing CO_2 (MCO_2) emission) as the MVA in constant 2005 $ per megaton of manufacturing CO_2 emissions.
Source: UNIDO elaboration based on Penn World Tables (Feenstra and others 2015), United Nations National Accounts Statistics (UN 2014b) and CAIT Climate Data (WRI 2015).

"As countries move to higher incomes, the capital and technology intensity of many manufacturing industries increases

added) first increases and then steadily declines as countries move towards higher incomes (Figure 12).

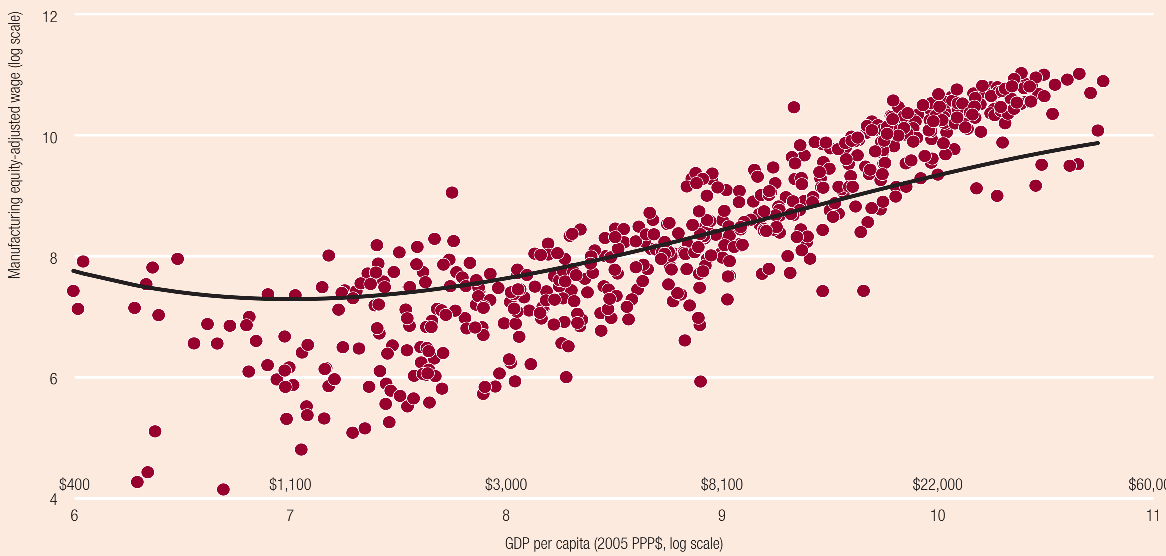
The decline in employment intensity in manufacturing stems from structural changes in manufacturing, reflecting a higher concentration in capital-intensive industries and an overall rise in capital intensity in manufacturing industries. The three major sources of manufacturing employment—food and beverages, textiles, and wearing apparel—are more labour intensive than the other industries, but textiles and wearing apparel generally cease to generate employment by the time countries graduate to upper middle-income status.

After these labour-intensive industries start reducing employment, it is still possible to see employment increase in emerging capital-intensive industries such as chemicals and electrical machinery and apparatus. But while these industries contribute to MVA, they do not generate as much employment as the labour-intensive industries. As countries move to higher incomes, the capital and technology intensity of many manufacturing industries increases. And they greatly improve their emission performance, transforming from dirty to relatively clean industries such as machinery and equipment, chemicals, and motor vehicles.

Sustaining economic growth

In the long run, the ability of a country to use existing and to innovate new technology determines its economic performance through a process of structural change. But because developing the capabilities to use and assimilate technology is very hard when they are not present, the convergence of living standards between countries has generally been very slow or even absent. Only a few countries have moved from relative poverty to relative development. Rich developed countries have high levels of technological sophistication and account for the large majority of investment in science and technology (primarily research and development - R&D). Poor countries have much lower technological capabilities and invest much less in R&D.

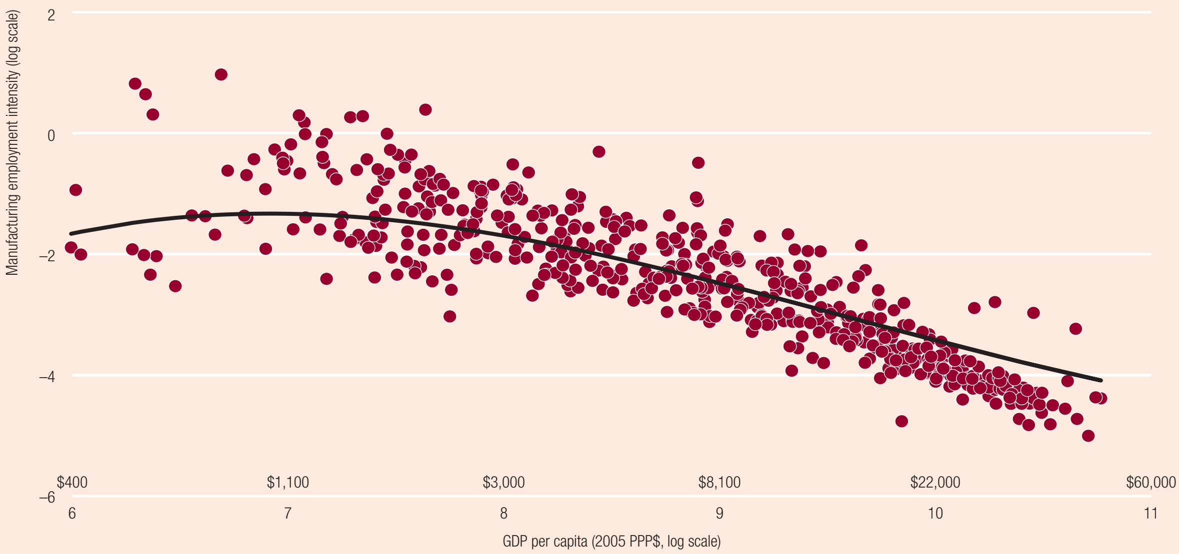
Figure 11
Equity-adjusted wage



Note: PPP is purchasing power parity. Calculations are five-year averages and cover 98 countries between 1970 and 2013. Manufacturing equity-adjusted wage is calculated as the average manufacturing wage level adjusted by the wage distribution within the manufacturing sector. Wages are defined as the yearly average compensation to employees in constant 2005 $ and are "weighted" by one minus the Theil index of wage inequality; see Industrial Pay Inequality Database (UTIP UNIDO 2015).
Source: UNIDO elaboration based on INDSTAT2 (UNIDO 2014a), Penn World Tables (Feenstra and others 2015), UN National Accounts Statistics (UN 2014), World Input-Output Database (Timmer and others 2015), EU KLEMS (O'Mahony and Timmer 2015) and Industrial Pay Inequality Database (UTIP UNIDO 2015).

> **How do countries move up the development ladder? The answer lies in the adoption and adaptation of knowledge from abroad**

Figure 12
Employment intensity



Note: PPP is purchasing power parity. Calculations are five-year averages and cover 98 countries between 1970 and 2013. Manufacturing employment intensity is defined as the number of manufacturing workers per unit of manufacturing value added in constant 2005 $.
Source: UNIDO elaboration based on Penn World Tables (Feenstra and others 2015), UN National Accounts Statistics (UN 2014b), Groningen Growth and Development Centre 10-Sector Databas (Timmer, de Vries and de Vries 2014), ILOSTAT (ILO 2015a), KILM Database (ILO 2015b), EU KLEMS Database (O'Mahony and Timmer 2015) and UTIP-UNIDO Industrial Pay Inequality Database (University of Texas and UNIDO 2015).

The concept—in theory, open to all

One of the three dimensions of sustainability is the ability of an economy to sustain growth over longer periods without serious interruption due perhaps to economic crises or slumps. The longer the duration of positive growth rates and the higher the rate of growth during positive growth episodes, the more likely a low- or middle-income country is to achieve sustained catch-up.

Sustained growth has three characteristics.

- *Average rates of GDP growth per capita.* Is growth rapid enough to achieve substantial increases in welfare in the foreseeable future? And is it faster than in advanced economies so that a country can catch up? Since 1950, catch-up has required growth of more than 5 percent a year, sustained over two or more decades (Szirmai 2012a). Such success is rare.
- *Duration of growth episodes.* The ability to sustain growth over longer uninterrupted periods is important, but growth often is not steady, and attempting to explain differences in average growth may be misleading. More promising is finding out what initiates or halts episodes of growth, or what influences the characteristics of growth episodes (Pritchett 1998).
- *Volatility of growth.* The lower the volatility, the more sustained the growth pattern. Volatility is often much higher in low- or middle-income countries than in high-income economies, and highest in countries that remain in the "development trap."

The global reality—in practice, very few succeed

How do countries move up the development ladder? The answer lies not in the creation of new knowledge, but in the adoption and adaptation of knowledge from abroad. Poor countries tend to have high potential for rapid growth, represented by the reservoir of global technological knowledge that is available for them to tap into. The evidence suggests, however, that the tendency to realize this potential varies greatly in the

“Not only are the growth episodes longer in catch-up countries, but they also tend on average to have much higher growth rates

group of poorer countries (Figure 13). In the large group of countries below, say, $15,000 GDP per capita, growth rates show a large variance. The regression line has a negative slope, indicating convergence (that poorer countries grow more rapidly), but this relationship is very weak. The regression line also divides the group of poor countries into two parts: one, below the regression line, growing slowly and tending to fall behind or stagnate, and one, above the line, showing some tendency for catch-up with richer countries.

On the duration of growth, countries that remain stuck in the bottom quintile have the shortest growth episodes (7 years on average). Countries that have maintained their position in the top quintile have much longer growth episodes (17 years on average). But there is not much difference in growth rates. By contrast, developing countries that have improved their relative position over the period tend to have much longer growth episodes than countries that remained in the same quintile or that even moved down: the three countries that moved to the top quintile have an average episode of no less than 26 years. So, not only are the growth episodes longer in catch-up countries, but they also tend on average to have much higher growth rates.

On the volatility of growth, two messages are clear. First, volatility is much higher in low-income than high-income countries. Second, the volatility of growth of countries that have improved their income ranking is much lower than for countries trapped in the same quintile. The upshot? In the long run, less volatile growth is a key ingredient to successful economic development.

Not only is the difference in average growth rate among developing countries much higher than among developed countries, but also the volatility of a country’s growth rate is higher in developing than developed countries. Thus the growth experiences of developing countries vary on the rate, duration and volatility of growth more than those of developed countries. But among developing countries, those catching up seem to have the common characteristics of higher growth rates, longer episodes of growth and lower volatility.

Figure 13
GDP per capita and growth rate, 1998–2013

Note: PPP is purchasing power parity. GDP is gross domestic product.
Source: Kaltenberg and Verspagen (2015).

> **Manufacturing can sustain growth by lengthening its episodes and reducing its volatility**

Interestingly, manufacturing can sustain growth by lengthening its episodes and reducing its volatility. The larger the share of the manufacturing sector at the start of a growth episode, the longer growth continues. The share of manufacturing within the modern sector yields similar results, and they have significant positive effects on duration. In line with the effects on duration, the chances of ending a growth spell are substantially reduced as the share of manufacturing at the start of the spell increases. Obviously, the longer an episode lasts, the greater the chances of it finally ending. But clearly the risk is much lower in every year in which the share of manufacturing at the start of the episode is higher.

Technology and innovation in manufacturing propel sustained growth

The rapid diffusion of new technologies based on broad areas of scientific research such as information technologies, biological sciences, material sciences and energy are examples of technological breakthroughs. These new technologies will likely fuel the next wave of global economic growth. A dozen new economically disrupting technologies might have a huge impact in years to come: mobile internet, cloud technology, advanced robotics, autonomous vehicles, energy storage, 3-D printing, advanced materials and renewable energy. These technologies have the potential to affect billions of consumers, hundreds of millions of workers and trillions of dollars of economic activity across different industries (Manyika and others 2013).

These "radical" technological advances, however, represent only a fraction of what the economic literature typically identifies with innovation and technological change. At the extreme, radical innovations can lead to what Joseph Schumpeter called "technological revolutions," consisting of a cluster of innovations that together may have a far-reaching impact in a whole range of industries or the economy as a whole. These technologies are also sometimes called "general purpose technologies." They affect the entire economy, transforming both household life and the way firms conduct business. Examples include the steam engine, electricity, internal combustion and information technologies.

Yet incremental innovations also drive economic growth. Their cumulative impact on long-run economic and social change may be even greater than that of radical innovations. In fact, the realization of the economic benefits from radical innovations typically requires a series of incremental improvements. This type of innovation enters the world in a very primitive condition and goes through a long process of technical improvement and cost reduction. Some of today's most extended electronic devices, such as televisions, mobile phones or even computers are examples. When first introduced, their commercial uses were restricted and the costs of production were so high that only a small portion of society could afford them. Their massive diffusion later was enabled by a series of widespread incremental innovations.

One incremental innovation that deserves special attention, particularly in the context of developing countries, relates to the absorption and imitation of foreign technologies. Introducing something in a new context is an innovation by definition and often requires considerable effort and capability to adapt it to the local context. The imitation and adaptation of technologies streaming in from the industrially advanced economies is one of the major sources of economic growth and catch-up in developing economies.

Enhancing technological capabilities

How can absorptive and technological capabilities reduce technological gaps?

Technological capabilities are mainly related to the education of the population and the allocation of human capital and other resources to undertake R&D. The relative importance of each of these elements depends on a country's development. At early stages of development, technological gaps create the potential for fast structural change through global technological knowledge, but the extent to which such change will be realized depends on the absorptive capacities of countries, sectors and firms (Lall 2000 and 2002). Among the most important determinants of absorptive

The conditions for technological upgrading are closely tied to the various channels through which firms can acquire technological knowledge

capacity are sustained investments in human capital. Strong basic and secondary education and specialized human capital are fundamental to absorb new technologies. Basic education and new skills are needed to use new technologies, and a more educated population tends to adopt new technologies faster.

But basic literacy is not enough. Certain technology-specific skills are typically needed to absorb new technologies. In some cases, skills can be provided by an improved basic education curriculum. In other cases, they have to be provided through specialized training at vocational centres. At middle ranges of development, the creation of new indigenous knowledge becomes very important. A strong tertiary education system in science and engineering and larger formal R&D efforts play a key role at this stage. In fact, the transition towards more technology-intensive manufacturing and service activities depends on a "hi-tech infrastructure," which includes—among other elements—universities and polytechnics capable of generating skilled technicians, engineers and scientists.

Ultimately, technological capabilities are embedded in domestic firms. So, the conditions for technological upgrading are also closely tied to the various channels through which firms can acquire technological knowledge to upgrade their capabilities: informal learning, learning from foreign direct investment (FDI) partners, licensing, strategic alliance and co-development, among others. At early stages of development, technological knowledge is mainly embodied in imported machinery, and the main channel for capacity building relates to learning by doing. At an intermediate stage, domestic firms recognize the need for more systemic learning and technological development and tend to resort to technological licensing, or looking for knowledge transfers from FDI partners. This tends to be complemented with greater in-house R&D capacity. At a later stage, once the channels of licensing and learning from foreign partners have reached their limit, domestic firms rely on public-private R&D consortia, existing literature, overseas R&D outposts, co-development contracts with foreign R&D firms and international mergers and acquisitions.

While learning and technological absorption take place at the firm level, the success or failure of individual firms occurs within a system (Lall and Narula 2004). Thus, the scope to which countries can upgrade their technological capabilities also depends on the functioning of so-called national innovation systems. In this perspective, learning and innovation involve complex interactions between firms and their environment—not just the firms' network of customers and suppliers but also the technological infrastructure, institutional and organizational framework, and knowledge-creating and diffusing institutions. As innovation systems improve, countries tap into international sources of technological knowledge, which is not limited to a few modern firms but circulates rapidly among different firms and actors.

Technological upgrading needs a broad dissemination of knowledge throughout the whole economy. Such dissemination requires strong public policies to diffuse new technologies with an institutional infrastructure that includes, among other things, extension services, industrial clusters, metrology standards, productivity standards, technical information services, and quality control institutions. Upgrading technological capabilities also requires a technological commercialization infrastructure that can put into practice the new knowledge created, for example, in government research labs and universities. This infrastructure includes adequate intellectual property rights (IPR) protection systems, technology-transfer offices at universities and research institutes, science and industrial parks, business incubators, and early-stage technology finance and venture capital.

The development of domestic technological capabilities, one of the most important elements of sustained growth, requires a solid education system (basic, secondary and tertiary), strong domestic R&D efforts (especially in middle-income or emerging economies), an appropriate technological commercialization system and a strong infrastructure for technological knowledge dissemination.

❝ Clustering economic activity is important for economies of scale and scope

Upgrading technology in industrial clusters

Clustering economic activity is important for economies of scale and scope, whether oriented to domestic markets or to exports. Domestically oriented clusters are important because a focus on globalization masks the fact that large segments of economic and industrial activity in low- and middle-income developing countries are still directed at domestic markets. But as clusters upgrade, they will also become more export oriented.

Lessons from upgrading in clusters in advanced economies

The emergence of clusters—the film industry (Hollywood, Bollywood and Nollywood), high-tech firms (Silicon Valley), specialist software firms and firms specializing in new materials (Seattle, near Microsoft and Boeing), metalworking and machine tools (Baden Würtenberg)—was originally due to external economies and market forces. But in an increasingly global economy, successful and dynamic clusters have to engage in purposive collective action.

Important as inter-firm cooperation and trust might be, they are generally not enough to ensure a cluster's survival in the modern world. So clusters often also require support from governments. As the clusters increasingly participate in global markets and as technology becomes increasingly challenging, local governments help sectorally specialized service centres provide training and technological support. But many of the clusters that once dominated global trade in sectors such as footwear, ceramics, clothing and furniture have failed to make the required transitions. The latest challenge—dancing to the tunes of global buyers of final and intermediate products and services since the last quarter of the 20th century—is even more daunting. Unless producers can meet these GVCs' needs, they are out.

Industrial clusters in low-income countries

Industrial clusters in low-income countries have features that distinguish them from clusters in advanced economies. First, many clusters, particularly in the least developed economies or in localities of great poverty in middle-income economies, are essentially "survivalist." They can remain static for many years, showing little signs of upgrading or firm development. Second, their markets are overwhelmingly local. The entrepreneurs essentially make the kind of products that they themselves consume, and there is little incentive for product upgrading or for the more extended division of labour owing to the small size of the market.

Third—and a potential source of strength for some low-income clusters—they have the advantage of providing small steps for improvement. In theory, this provides the capacity for small and medium-sized enterprises (SMEs) in these economies to fill the missing middle between the myriad small firms and the large, often foreign-owned enterprises that dominate industry. This then raises the possibility of shifting policy from support for SMEs (a widely used policy lever) to support for the industrial clusters in which SMEs participate.

The cluster upgrading agenda in developing countries

The African experience shows that clusters are a natural outcome of economic activity, and some Chinese, Mauritian, and Mexican special economic zones (SEZs) aside, they have arisen spontaneously from the external economies of geographical clustering. Although many clusters in low- and many middle-income economies are predominantly static and survivalist in nature, many of these economies have built successful and dynamic clusters. The more dynamic clusters are associated with sales beyond the immediate area to national, regional and foreign markets. They also display a range of external economies, particularly in skills, supplier clustering (which provides for specialization among firms), being a magnet for buyers, developing trust to support collective action and having the capacity to upgrade their operations. Numerous types of institutional support also accompany dynamic cluster development. But a major obstacle to their development is poor infrastructure.

Cluster upgrading faces challenges in four main areas—in final markets, process technology,

Global value chains offer new opportunities for industrialization and industrial policy

organizational technology and the inter-firm division of labour, which includes positioning in the value chain.

Expanding final markets. Meeting new demands from consumers and overcoming the offerings of competitors are often the prime drivers for cluster upgrading, whether the extended market is at home or abroad. Strengthening user-producer interactions and extending markets are routes to upgrading.

Upgrading processes. Most clusters—survivalist or dynamic—are small and use basic technologies, often second-hand. Small final markets do not allow for the purchase of large and scale-intensive technologies, but the acquisition costs of more sophisticated equipment may be too high. The upgrading challenges in these clusters, particularly in the informal sector, are complex. In some cases the solution to process upgrading lies in buying new equipment or improving equipment. Another solution could be to search for new sources of capital goods, for an improvement in what they use but not the quality of equipment from more established capital goods suppliers. Here, the prospects are good for South-South technology transfers.

Organizational upgrading. Many informal sector clusters offer wide scope for upgrading workflow, quality procedures, material storage, machine maintenance and business strategy. These "soft" elements of process technology can involve writing business plans and securing finance from governments and NGOs. But while important, they meet only a restricted part of the organizational technology-upgrading agenda. In East African clusters using Chinese and Indian equipment, there is no evidence of structured attempts to facilitate cluster upgrading by addressing workflow, skill development, or machine maintenance and repair. Each of these arenas was the sole responsibility of the individual entrepreneurs, and in most cases, there has been very little change in any of these clusters.

Interfirm divisions of labour and functional upgrading. One of the major drivers of productivity growth is specialization within firms and the division of labour between firms. This is often a natural outcome of cluster dynamics. An increase in the inter-firm division of labour poses multiple upgrading challenges for clusters. It reflects a drive towards the specialization of components manufacture and their dissociation from assembly. But it also involves specialized business services providers, for example, in the extension of standards in value chains and in the provision of support for finance and marketing.

Once enterprises begin to participate in GVCs, they also need to upgrade functionally. That is, an upgrading strategy may involve the capacity to change position in the chain, perhaps moving from low-skilled assembly to more skill-intensive component manufacturing, or beginning to design, brand and market products independently. The drive towards functional upgrading may have broader economic benefits only if the cluster as a whole changes its position in the value chain. If individual firms merely swap their position in the chain, they may gain or lose as separate economic agents, but there may be little cluster upgrading in the chain as a whole.

Upgrading technology in global value chains

From developing countries' perspective, GVCs offer new opportunities for industrialization and industrial policy. Rather than having to build up capabilities over the complete range of industrial activities, countries can focus on entering given slices of GVCs. But if their activities remain limited to thin slices, they may become too specialized, with concomitant dangers of a lack of diversification and an adverse impact on growth.

Many countries have deliberately followed policies to enter GVCs by establishing SEZs with special facilities and incentives to attract foreign investment. Among the best known are China's SEZs. For firms that are newly incorporated into the chain or that are new entrants into the sector, the strategy is "thinning in." That is, they enter the chain by contributing a low proportion of the value added embodied in the final

> **During structural transformation, societies become more technologically complex and economically productive, improving incomes, wealth and subjective well-being**

product. Examples of this are the firms that are newly established to assemble apparel on a cut-make-and-trim basis. Other supplier firms have long operated in a sector, and for them GVC entry involves a "thinning out" of activities, cutting the range of activities they have historically undertaken. Keeping the apparel sector as an example, this would represent a firm that gives up its own designs and brand names to assemble apparel for an outsourcing lead buyer.

In some value chains, the lead firm limits opportunities for upgrading in others. Thus a key objective in GVC upgrading is for firms to enter chains that provide such scope. Different markets have different requirements and vary in their scope for entry-profit margins. Environmental and health standards in advanced-country markets provide serious barriers to entry, but also provide challenges (and incentives) for quality improvement and technological upgrading. The increasing concentration of buyers and final retailers (power asymmetry) reduces the bargaining power of entrants and the conditions for upgrading. But the more deeply embedded foreign firms are in the local economy, the more they can help upgrade their local suppliers.

There is broad-ranging agreement around policies addressing market failures in public goods. Foremost among them is to strengthen human resource development. Closely allied is to build institutions such as a national system of innovation to support R&D. Other dimensions are more controversial but widely in evidence. There is ongoing debate about the relative importance of horizontal policies that affect all firms in the economy versus selective (discretionary, vertical) policies that target specific sectors, technologies or even firms. Although there is a widespread and generalized commitment to an open trading environment, in reality many countries continue to craft their trade policies to support the particular needs of their productive sectors.

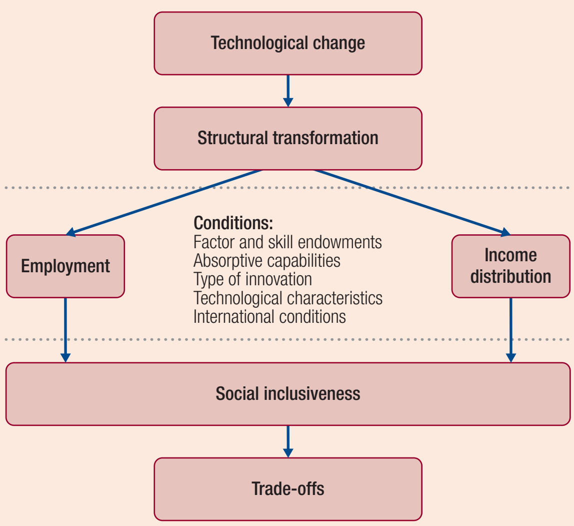
Promoting social inclusiveness

During structural transformation, societies become more technologically complex and economically productive, improving incomes, wealth and subjective well-being. Demographic shifts, facilitated by rising incomes and the uptake of modern technologies, help improve outcomes in health, education and urbanization. Manufacturing is fundamental to this process. It provides productive employment in the early stages and is a catalyst for technological innovation. Over time a country's manufacturing typically evolves from being labour-intensive to being more capital- and technology-intensive, creating demand for more skilled labour. And a better skilled workforce provides incentives for technological innovation, which can enable a virtuous circle of education, innovation and productivity growth. But not everyone can access the opportunities that arise. Only with domestic capabilities and technologies better suited to match these conditions can socially inclusive industrial development distribute the fruits of economic growth more evenly.

Creating employment, distributing income

The channels for technological change to affect social inclusiveness through the transformation of the economic structure can be broadly divided into two major areas: employment creation and income distribution (Figure 14). On the first, the relevant question

Figure 14
Conceptual framework: Technological change for inclusive structural transformation



Source: UNIDO elaboration.

> **Product innovations create new jobs while process innovations eliminate them**

is whether new technologies will lead to the creation or destruction of jobs. On the second, the interest is in whether innovations will improve or impair the distribution of incomes within society.

In industrially advanced high-income countries, technological change is typically related to the generation of new technologies; in developing countries, to the absorption of foreign technologies. Some technologies are better suited to a country's factor and skill endowments, thus creating new jobs without hurting income distribution. But if the conditions of the country do not match the requirements of the technology implemented, the outcome can be negative.

By the same token, the net effect of a particular innovation on job creation depends on the type of innovation. Broadly, product innovations create new jobs while process innovations eliminate them. The conditions in a country (market structure, investment behaviour and degree of substitution between factors) determine how well compensation mechanisms alleviate the negative impact of labour-saving process innovations. And new technologies and structural change may introduce important trade-offs between objectives. In particular, new technologies that promote social inclusiveness might achieve that at the expense of environmental deterioration. Or new technologies that improve environmental sustainability might hurt job creation and income distribution.

With the right capabilities, technology-driven structural change expands the modern, formal industrial sector and industry-related services, absorbing labour from the pool of underemployed workers in agriculture or informal services. Manufacturing plays a key role in generating and diffusing new technologies. Moreover, backward and forward linkages and spillover effects from manufacturing promote regional and country development, creating feedback loops of accumulating human capital and improving institutions. So generating direct and indirect jobs in manufacturing and manufacturing-related sectors not only brings more people into the growth process—it also increases average productivity, wages and family incomes. Higher family incomes, in turn, help reduce poverty.

This process can temporarily lead to income inequality. An example is the invention of the internal combustion engine, which caused substantial job losses in the horse-drawn carriage industry but eventually resulted in substantial new employment in the automobile industry. Technological innovation therefore has not only static effects in the once-off reallocation of labour, but also dynamic effects, such as facilitating the growth of productivity and output in modern urban industries.

The expansion of the modern formal sector gives the government a tax base and more revenue in the public sector that might enable the government to improve economic, administrative and political institutions and widen social protection measures. It also helps more women participate in the labour market. With better earning opportunities, parents want their children to receive more education. And with a quantity–quality trade-off for the number of children, the expanding modern sector may reduce fertility, further allowing a shift of resources towards better education of children and enhancing human capital formation and labour productivity. Thus, a growing modern sector is also a major determinant of fertility and the demographic transition.

From this perspective, even if new technologies hurt income distribution and employment creation, it is often temporary. Persistent rising inequality ultimately reflects institutional and policy failures that perpetuate technological gaps between sectors, regions, and countries or that fail to provide adequate social buffers in times of rapid change.

Getting the right technological mix

What, then, are the conditions for getting technology to drive social inclusiveness? Regulations and incentives help steer the direction of technological change, and more can be done to guide innovation to complement rather than replace humans. It may also be necessary to support technological innovations with organizational change, helping to flatten hierarchies and decentralize management responsibilities.

Countries should try to use technologies that are better suited for their characteristics, reflecting their

Even if new technologies hurt income distribution and employment creation, it is often temporary

factors, skills and endowments. Innovation and industrial policies are therefore fundamental in shifting the innovation path towards a more inclusive trajectory—determining the structure of prices, factor costs, infrastructure and the availability of alternative technologies (and the knowledge that firms have about these technologies).

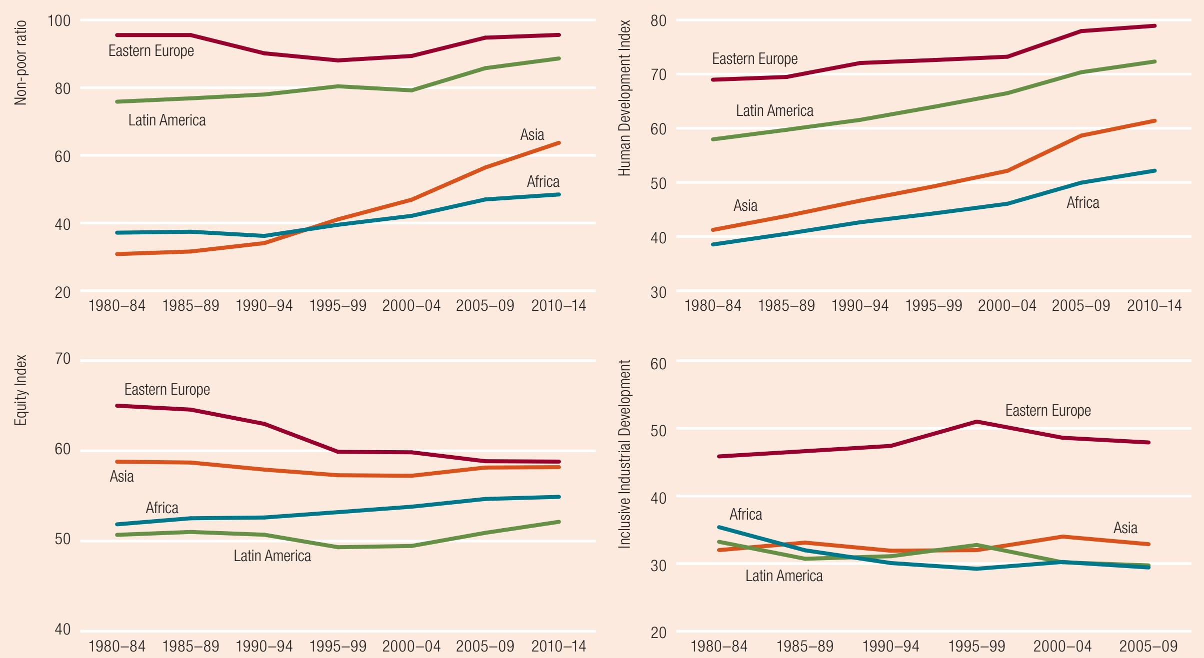
How social inclusiveness is changing

Trends in social inclusiveness over the last few decades can be observed in four indicators. The Non-Poor Ratio (NPR) is one minus the poverty headcount ratio. The Human Development Index (HDI) is the standard United Nations Development Programme (UNDP) index presented in each year's Human Development Report. The Equity Index (EI) is one minus the Gini index. And the Inclusive Industrialization Development (IID) index is the inequality-adjusted wage rate in manufacturing industries (Figure 15).

The indicators vary widely among developing regions. On poverty and human development, Eastern Europe and Latin America perform far better than Asia and Africa. On distribution, Latin America ranks as the worst both on the overall economy and on manufacturing. Eastern Europe still ranks as the most equal region.

Most indicators and regions show positive trends, again varying. As expected, Asia shows the best performance on poverty and human development, with an impressive increase of the NPR and the HDI, especially after 1995. Its outcome on income distribution is not so positive. Africa also shows solid gains in poverty, human development and overall income distribution, though the IID index has dropped sharply. Latin America shows good achievements on poverty reduction and improved income distribution, especially since 2000. Its HDI has increased steadily.

Figure 15
Main trends in social inclusiveness indicators, by developing region, 1980–2014



Note: Regional values are calculated as unweighted averages over countries with available data for the whole period. Developing countries are countries that in 1990 were not high income according to the World Bank's definition (see Annex A1, Table A1.2). Within these countries are four groups based on location: Africa (including the Middle East), Asia (excluding the former Union of Soviet Socialist Republics [USSR] and the Middle East), Eastern Europe (including the former USSR) and Latin America. Five-year averages are used to maximize the number of observations and minimize the potential effects of extreme years.
Source: Lavopa (2015).

“The relationship between structural change and social inclusiveness is positive

The relationship between structural change (broadly defined as the expansion of manufacturing in total employment) and social inclusiveness is also positive on basic correlations for the social inclusiveness indicators (Figure 16).

In all cases except the Equity Index this relationship seems to be increasing with the share of manufacturing, but only in the case of Human Development Index does it reach a turning point within the relevant ranges of manufacturing share. Industrialization is thus associated with lower levels of poverty, better income distribution, and better Human Development Index rankings.

These basic correlations provide some preliminary evidence on the positive role of manufacturing in driving social inclusiveness. They might, however, also be indicative of other factors. One would be income: rich countries tend to have larger shares of manufacturing than very poor countries, and their social inclusiveness indicators are, at the same time, much better than those in poor countries.

Moving towards greener structural transformation

Countries with the highest GDP per capita are those showing the lowest energy intensity (defined as an emissions/GDP ratio). Over 1960–2011 world GDP per capita increased monotonically whereas emissions intensity decreased (Figure 17). But although the period saw environment-friendly technological change, that change was not enough to decouple pollution from economic growth. Even though existing market pull forces stimulated environmental improvements, this pulling effect was not sufficient to stabilize or even reduce emissions and in general environmental pollution.

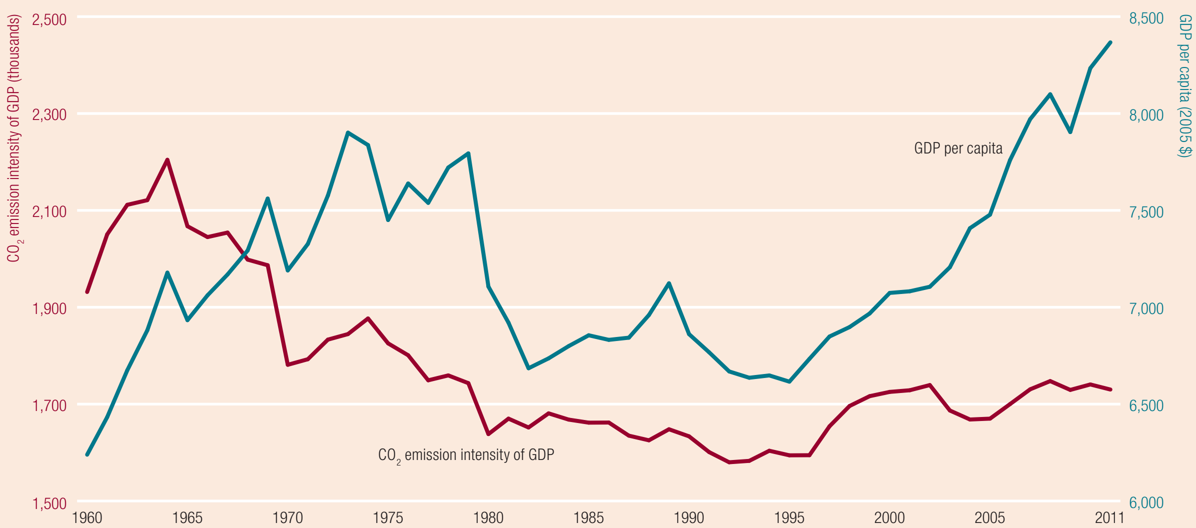
Technological change for environmental sustainability operates mainly through two channels—the

Figure 16
Inclusiveness indices by share of manufacturing in total employment, 1970–2010

Note: Sample of almost 100 countries. Each dot represents the average values of each country for a 5-year subperiod. In all cases, a quadratic trend is also included in the figures to indicate the general trend of inclusiveness.
Source: Lavopa (2015).

> **Global emissions increased over 1995–2009 by 29 percent but only 16 percent in manufacturing**

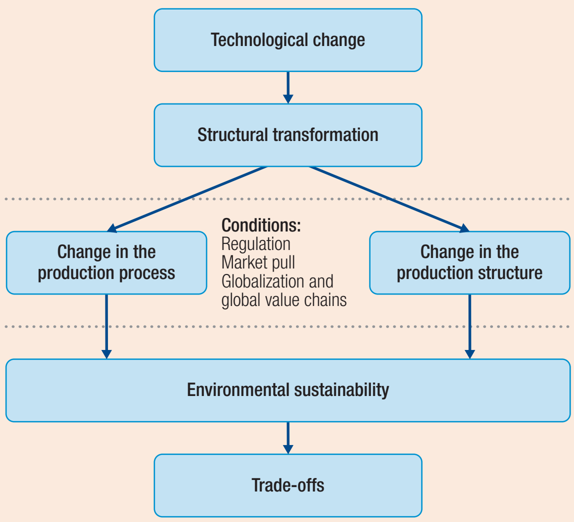
Figure 17
CO_2 emission intensity and GDP per capita, worldwide, 1960–2011



Note: GDP is gross domestic product. Carbon dioxide emission intensity is calculated as emissions over GDP.
Source: Adapted from Mazzanti and others (2015) based on World Development Indicators (World Bank 2015).

production process and the production structure—involving environmental, economic and social trade-offs (Figure 18).

Figure 18
Conceptual framework: Technological change for environmental sustainability



Source: UNIDO elaboration.

Changes in production processes

The changes in production processes happen through more efficient use of natural resources, such as non-renewable energy and materials, helping firms to be more cost-competitive. Under ideal conditions, costs of renewable inputs are comparable to fossil fuel energy. Some pollution abatement technologies that reduce any incurring pollution are affordable, and production processes are re-engineered to minimize resource use. Waste, normally considered a bad outcome of the production process, becomes a key input to be re-used directly as inputs through materials recovery or waste-to-energy technologies. But such transformations are possible only if the environmental technologies exist and the conditions, including the relative prices faced by producers, enable environmentally positive change in production. Some transformations such as a global transition to the use of renewable energy or a drastic reduction of costs for pollution abatement technologies are still far from materializing but evidence shows that firms tend to use more efficient energy inputs even if not necessarily driven by policies.

An increase in energy prices is an important vehicle for environmentally friendly innovation in the

Countries tend to industrialize by transitioning towards more emissions-reducing sectors

medium- to long-term, as rising energy costs stimulate firms to invest in energy-efficient technologies. Firms tend to maximize output by minimizing input costs. The more innovative sectors, such as manufacturing, are more exposed to profit-driven measures. But a short-term increase of energy prices generates a reduction of real GDP, especially for energy-importing countries.

Global emissions increased over 1995–2009 by 29 percent but only 16 percent in manufacturing. The sector had the lowest increase on four metrics in the period, including energy intensity and emissions intensity, representing efficiency in energy consumption. Energy efficiency can also be explained by the usual tendency of firms to replace depreciated capital. When firms replace old machinery, they tend to purchase more advanced capital, usually more productive and without an extra energy burden.

Efficiency also pushes firms to invest in technologies that recycle waste or materials. There is increasing awareness of technologies that re-use materials as inputs in the production process. Sharp price increases in primary materials in the last decade indicate that resources are scarce and need to be managed more sustainably. So, recycling becomes more economically viable than the discharge of materials and waste, and production is transformed into a circular process whereby economic "bads" acquire a value.

Renewable energy is not yet cost competitive, and it will take a steep fall in the cost of generation to make it so. Energy efficiency needs to accomplish very ambitious emission reductions, which are likely to be greater than those induced naturally by the market. Moreover, even when energy efficiency is profitable, market failures, particularly a lack of information or incomplete pricing of inputs, may affect adoption. In these cases, policy can stimulate firms to use fossil fuel inputs more efficiently or to adopt more costly renewable energy.

Changes in production structures

Countries tend to industrialize by transitioning towards more emissions-reducing sectors. Low-income countries generally show the highest share of value added in low-tech sectors, but since the 1970s, this share has been decreasing. Medium-income countries show the highest share of medium-tech sectors, and high-income countries have the highest share of high-tech sectors. The share of high-tech sectors tends to rise across all income categories.

This natural tendency to shift from low- to high-tech sectors comes with a natural tendency to pollute. The lowest environmental productivity (expressed as the value added/pollution ratio) is associated with medium-tech sectors. The medium-tech sector also shows the highest pollution intensity for other pollutants beyond carbon dioxide emissions, such as particulates, sulphur dioxide (SO2) and nitrogen dioxide (NO2) though with lower abatement costs than other sectors. Low- and high-tech sectors have higher environmental productivity—in other words, they generate fewer emissions when producing $1 of value added. Sectoral specialization towards high-tech sectors reduces emissions intensity. In short, a natural economic tendency contributes to ISID.

But environmental protection improvements deriving from the low- to high-tech transition may not be sufficient to decouple economic growth from pollution. Countries need to enforce actions to curtail environmental harm, even if they are not strictly related to the production process (environment-friendly pollution abatement technologies). Yet this non-profit-driven technological change is often expensive.

This steep cost of abatement is one of the main factors deterring firms from pursuing aggressive pollution reduction beyond a "natural tendency" and countries from adopting emissions caps policies. Low- and middle-income countries are especially reluctant to adopt environment-friendly technologies since adoption costs can hamper growth, though changing how emissions are measured changes the relative picture regarding the contribution of different country groups to global emissions. The problem is particularly complex for global pollutants such as greenhouse gas (GHG) emissions, which require massive and urgent action internationally, because the changes required

> **Technology and industrial policies for innovation should be complemented with a more radical macroeconomic approach and strategic investment policies**

go far beyond what the market can induce through profit-maximizing firms.

Industrializing countries have not committed to reducing atmospheric carbon concentration, which was mainly generated by high-income countries. Moreover there is an asymmetry across countries in terms of the emissions abatement effort through the adoption of new environment-friendly technologies. Countries that already committed to emissions reduction policies with the Kyoto Protocol have already used the low-cost emissions reduction options and further emissions abatement actions would be much more expensive. The problem of equality and responsibility now deters countries from reaching a global agreement for emission reductions. Thus, every effort at pollution abatement should be tailored to a country's stage of structural change.

Greater attention has recently been paid to supply chains in cooperative approaches based on learning and knowledge transfers. Such greening of these chains has the potential to create opportunities for collaborative approaches to eco-innovation that permeate and benefit all actors involved. An increasing number of companies are committed to stricter and more stringent ways to identify material sources and committing to certification schemes to ensure the sustainable supply of different materials. Regional national support systems that provide access to specific knowledge and help (especially smaller) companies in introducing and adopting new technologies, or even developing them, may be of special importance.

Facilitating the adoption of environmentally friendly technologies

Market conditions and the way markets are organized play a role in driving—or deterring—eco-innovation. The demand for new products and the progressive incorporation of environmental features in existing products have driven the adoption and diffusion of eco-innovations. Market demand has also been shaped by developments in the policy agenda that define what consumers expect from the environmental impact of products and services. Firms may be interested in polluting reduction actions simply because they are profitable, but market externalities may prevent them from exploiting market opportunities. In those cases, policy-makers need to correct biases to create the right market environment.

Different types of regulatory approaches may trigger different types of innovations. While regulatory standards may trigger pollution abatement solutions, environmental management systems or integrated regulatory systems can incentivize cleaner and more resource-efficient technologies. And for resource-efficient eco-innovations and cleaner technologies, both regulatory pressure and cost savings seem to be pivotal. Whereas standards may set minimums for recycled or recyclable content in products, packaging and other eco-design considerations, economic instruments tackle market failures such as externalities of environmental impacts linked to resource use.

International agreements can also drive technological change. In a post-Kyoto world, the main problem is to reach coordinated agreement for cutting emissions globally. Emissions-abatement efforts through the adoption of new environment-friendly technologies are asymmetrical across countries. Countries that already committed to emissions-reduction policies under the Kyoto Protocol have already used the low-cost emissions-reduction options, and further emissions-abatement actions would be much more expensive. The problem of equality and responsibility now deters countries from reaching a global agreement for emissions reduction. Thus, every effort at pollution abatement should be tailored to a country's stage of structural change.

Designing and implementing inclusive and sustainable industrial development policies

To support a country's competitiveness, technology and industrial policies for innovation need to be complemented by infrastructure policies, industry representation, and business-enabling trade and investment. These policies are prerequisites for integrating into GVCs, but they should be complemented with a more radical macroeconomic approach and strategic

> **Policymakers have to weigh economic pros and environmental cons, social pros and environmental cons, and environmental pros and economic cons**

investment policies. Complementary policies should address possible trade-offs and ensure a balance between environmental and social objectives.

Managing tradeoffs and seeking complementarities

Between sustained growth and inclusive development are possible complementarities and possible trade-offs. One important trade-off is that the kind of productivity growth associated with rapid upgrading tends to reduce the demand for labour (Massa 2015). But this trade-off is not inevitable because, at lower levels of per capita income, manufacturing tends to be more labour-intensive. And if productivity growth goes hand in hand with accelerated growth of output, the net effects on employment can be positive. So, if structural change and industrialization promote rapid growth in the whole economy due to linkages and spillovers, this can increase total employment and labour absorption. In poverty reduction, synergies between sustained growth and inclusive development are most prominent.

Trade-offs between sustained growth and income inequality can be very pronounced. In almost all countries experiencing sustained growth and catch-up, there have been increases in inequality as measured by the Gini coefficient. This has to do with the balance between the supply and demand for skilled labour. Where technological change is skill-biased and the labour supply fails to keep up with the demand for skilled labour, inequality will tend to increase. This is not an inevitable outcome, but it does seem to characterize growth experiences in the past decades.

The final trade-off is between sustained growth and environmental sustainability. Here the record so far has been disappointing, and the negative environmental impacts of growth on CO_2 emissions and global warming have been larger than the positive impacts of technological advance.

Social pros vs. environmental cons

Biotechnology. In developing economies biotechnology is a good example of technological innovations bringing social benefits but environmental harm. Biotech crops can alleviate poverty of small farmers by increasing their incomes, but the adoption of genetically modified crops may also have adverse impacts on the environment. First, the presence of living modified organisms may pose serious challenges to biodiversity (Kaphengst and Smith 2013). Second, transgenic crops may negatively affect the soil and soil organisms (Kaphengst and Smith 2013). Third, the development of an increasing resistance to pesticides and herbicides targeted to biotech crops may lead to an even higher use of pesticides. For example, Wang and others (2009) argue that in China the use of biotech cotton and the associated lower level of insecticide spraying have led to secondary insect infestations and therefore to an increased use of pesticides.

Biofuel production. Similarly, biofuel production can lead to rural employment, even though the magnitude of this effect depends on the type of feedstock grown as well as on the degree of agricultural mechanization (Diop and others 2013). The replacement of fossil fuels with biofuels may also lead to important public health benefits by improving the quality of air (USAID 2009). Still, biofuels may lead to a series of adverse environmental impacts, as reported by Timilsina and Shrestha (2010). The conversion of natural landscapes into biofuel plantations and processing plants may have severe effects on biodiversity. In Indonesia and Malaysia, palm oil plantations have replaced natural forests (Koh and Wilcove 2008) In Brazil, increasing parts of the Mata Atlantica region (a biodiversity hotspot) and the Cerrado (the world's most biodiverse savannah) are being converted into sugarcane and soybean plantations (Timilsina and Shrestha 2010).

Biotechnology innovation. This can also increase the vulnerability of the poorest smallholder farmers who are encouraged to move from growing a wide variety of crops to growing monocultures of biotech crops, thus increasing the risk of worsening their already precarious socio-economic situation in the case of a failed harvest. This was the case in South Africa, where

Policy-makers should keep in mind that the same measure may affect the various types of innovation differently

the introduction of biotech cotton has contributed to the vulnerability of poor farmers as well as to socio-economic inequality (Witt, Patel and Schnurr 2006). Nevertheless, biotechnology may contribute to a better environment as it allows a reduction in pesticides. There is evidence, for example, that in Argentina, China, and India, among other countries, the introduction of biotech cotton has led to decreases of up to 75 percent in the amount of insecticides applied (Carpenter 2011).

Environmental protection and growth are in many cases in conflict, although "natural" environment-friendly technological change is a fact and "artificial" or policy-induced technological change can become a business opportunity.

Environmental pros vs. economic cons

Biofuel technologies. As with trade-offs between social and environmental impacts, biofuel technologies exemplify environmental and economic trade-offs. Biofuels can yield significant reductions in GHG emissions against fossil fuels, possibly 90 percent (OECD 2008) relative to petrol. But their production often exerts upward pressure on food prices (FAO and others 2011).

Textiles and clothing. These two industries are huge exporters and employers in some developing economies, but they are also linked to serious environmental issues, including the use of harmful chemicals; high consumption of water and energy; generation of large quantities of solid, liquid, and gaseous wastes; air emissions; and animal exploitation. Huge volumes of water and energy are consumed not only in textile production but also in subsequent laundering by consumers (Sherburne 2009).

Steel. The steel industry supplies basic products to other industries and can be an important sector at the middle stage of development. Yet its production technologies have considerable adverse environmental impacts, such as massive quantities of wastewater and air emissions from blast, open-hearth, or basic oxygen furnaces. Direct-reduction furnaces and electric arc furnaces are less polluting, but they still produce substantial emissions of dust and carbon monoxide and are highly electricity-intensive.

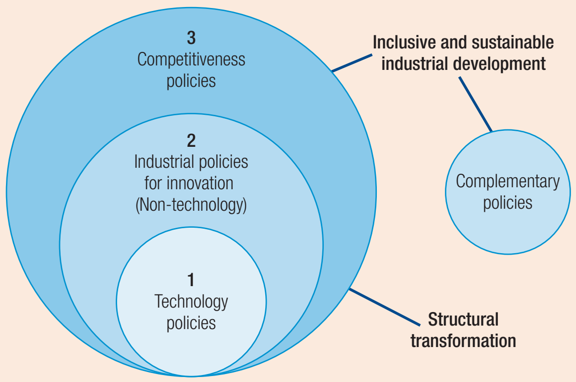
Clusters of policies

Policymakers thus have to weigh economic pros and environmental cons, social pros and environmental cons, and environmental pros and economic cons. The technology policies need to be complemented by macroeconomic, business-enabling, trade and investment, industry institutionalization as well as infrastructure policies to support a country's competitiveness (Figure 19). These policies are prerequisites for integrating into GVCs but should be complemented with a more radical macroeconomic approach and strategic investment policies. Complementary policies are also needed to address possible trade-offs and ensure an environmental and social equilibrium.

Technology policies

Technology policies vary by an economy's development stage: early, middle and late. Each stage is characterized by some regularity in factors, such as the complexity of market structures, technological content, productivity and degrees of specialization and qualification of the labour force. In each stage, there is

Figure 19
Policies targeting inclusive and sustainable industrial development



Source: UNIDO elaboration.

A sound policy mix of innovation and competitiveness policies is crucial

a choice between general horizontal measures available to all firms and selective vertical ones applied selectively to priority targets, whether subsectors or specific firms. In addition are market-based interventions and public inputs. The former affect prices and taxes and thus operate through pricing links. The latter reflect the provision of goods or services, which firms themselves would not supply adequately either because they cannot be marketed or because significant external benefits are involved.

Industrial policies

Industrial policies for innovation are a broad concept for combining technological and non-technological policies for different kinds of innovations at different stages of development. One crucial element determining the emergence, development and expansion of innovation activities is government intervention. Governments in developed and developing countries are increasingly making innovation a key issue, recognizing its potential to promote economic growth and address social and environmental challenges.

The main argument for government support is that a market economy cannot generate by itself the optimal levels of investment in innovation because of market failures and information asymmetries that lead to serious funding gaps. These market failures inhibit private firms from investing the optimal amount of resource (in fact they do not invest enough) in innovation activities, thus depriving the economy from one of the key levers of sustained growth. To counter this, governments aim to restore optimality by providing different forms of support to firms' investment in innovation, often through (sometimes overlapping) policy instruments (Table 1).

To identify the optimal intervention, the first step is to understand the type of innovation that has to be targeted, since product and process innovations differ in their impacts on firm or economy-wide performance. Objectives such as introducing new products or increasing the range of exported goods are more likely to require technological innovations than non-technological innovations. Innovation policy traditionally tends to favour technological innovation, yet evidence suggests that success often also depends on accompanying non-technological innovation. Policy-making should therefore be broadened to take into account non-technological innovation.

Policy-makers should also keep in mind that the same measure may affect the various types of innovation differently. For example, those aiming at increasing demand for innovation are more likely to favour

Table 1
Taxonomy for innovation policy (including technology and non-technological industrial policies)

Policy domain	Market-based	Public goods/direct provision
Technology market	R&D subsidies, grants	Technology transfer support, technology extension programme, public-private research consortia, public research institutes
Product market	Tax exemptions for innovation investments, attraction of foreign direct investment, R&D tax incentives, import tariffs, duty drawbacks, tax credits, investment/foreign direct investment incentives	Use of public procurement for innovation, protection of intellectual property rights, procurement policy, export market information/ trade fairs, linkage programmes, foreign direct investment country marketing, one-stop shops, investment promotion agencies
Labour market	Wage tax credits/ subsidies, training grants	Training institutes, skills council
Capital market	Subsided credit for innovative firms, directed credit, interest rate subsidies	Loan guarantees, skills council
Land market	Subsidized rental	Promotion of technology and production clusters, creation of technology parks, establishment of special economic zones, export processing zones, factory shells, infrastructure, legislative change, incubator programmes

Source: Adapted from Weiss (2015) and Warwick (2013).

> **Industrial policy-makers might gradually shift their attention to identifying and reproducing national success stories**

the generation of incremental rather than radical innovation, which often stems from large public-funded projects and supply-push policies.

The barriers to innovation also differ by type and stage of innovation. For instance, cost factors can be relevant for all types of innovations, while market factors, such as uncertain demand for innovative goods or the weakness of property rights, may affect mainly product innovation, not process, innovation. In contrast, weak engineering and technical skills are often associated with lack of process innovation, especially in developing countries. Proactive and comprehensive government policies are a prerequisite to establish an overall innovation policy framework as well as the need for interaction among the actors and government institutions involved, especially at local level, as innovation primarily takes place in local milieus with a concentration of knowledge, talents and entrepreneurs.

Competitiveness policies

The innovation toolbox has to be extended to competitiveness policies in order to achieve structural transformation. A sound policy mix of innovation and competitiveness policies is crucial, and the orthodox competitiveness approach is too timid.

GVC lead firms might require their local suppliers to adopt international standards, if they are skilled and fully competent or when the product is a commodity. Lead firms can also require them to adjust to specific technical and quality standards and to take full responsibility for the process technology. As lead firms do not become directly involved in the learning process but impose pressure on their suppliers for innovating and keeping abreast of technological advancements, they can be seen rather as a crucial stimulus for inducing learning and innovation but not as participants in the process. Nor do lead firms always enrich local firms with knowledge transfer and support upgrading processes. So, it is crucial to understand the structure of the value chains, the processes of structural change and the power asymmetries between firms that determine how entry barriers are created and how gains and risks are distributed.

Complementary policies

Technological change can lead to enormous advantages for economy and society, but it can also result in awkward trade-offs, often in manufacturing and in three main dimensions: economic vs. social, social vs. environmental and environmental vs. economic. Understanding these trade-offs is a precondition for developing the right complementary policies. To achieve gains on all three dimensions, integrative policy approaches are needed, which consider the full range of positive and negative consequences of innovation and promote interactions between all actors and sectors of the economy.

Another important key is to provide incentives to innovate and diffuse technologies. National policies have failed to achieve this objective so far because governments have been unable to develop integrative approaches to the full range of consequences of technological change, partly because of knowledge and implementation gaps (Box 1).

There is no single, correct recipe; nor can all governments privatize, stabilize and liberalize in similar ways. Industrial policy-makers, especially in developing countries, might gradually shift their attention from investigating and imitating international best practices to identifying and reproducing national success stories. This approach underlines the need for sound measuring, monitoring and evaluation, especially in the context of serious budget constraints, since it is essential to know whether a policy intervention is effective (or not) and whether the benefits outweigh the associated public costs.

International cooperation can help in all this. Technology and innovation policy-making is usually conducted nationally. As suggested by the subsidiarity principle, interventions should be accomplished where results are expected to be best. International collaboration is needed with trans-border and global problems driving collaboration in this area. Globalized technology (and innovation in general), the rise of emerging and developing economies as champions of globalization, and the growing role of individuals, small firms and open modes are further

> **Manufacturing exports by industrialized economies expanded by an annual average 4.3 percent over 2005–2013, reaching $11,998 billion in 2013**

Box 1
Good practices in formulating policies

As UNIDO's *Industrial Development Report 2013* highlighted, a one-size-fits-all approach to economic policy has not succeeded in the last decades and is unlikely to bring structural changes in the future, especially because country heterogeneity demands a flexible approach to policy design. Realistic, evidence-based, and country-tailored industrial policy conducted consensually is key for policy effectiveness and requires the following preconditions to be met.

First, use—do not fight—the political system. A fact of political life is that no policy will be underwritten unless those in power agree to it. Good economic policies must be proposed in a way that those with political power will choose them.

Second, strengthen political leadership. This will set a national transformation agenda that aims, in low-income countries, to create and nurture productive activities or, in middle-income countries, to advance technologically. Political leadership at the top is crucial for raising the profile of industrial policies and for ensuring the required coordination, oversight and monitoring.

Third, encourage public–private dialogue. Governments should join forces with their industrial private sector to design interventions based on their combined expert knowledge and to ensure that decisions are supported by key stakeholders. Especially in developing countries with low public sector capacity, the private sector input can contribute to successful policies. The new industrial policy needs to be based on such dialogue and not on top-down planning.

Fourth, boost industrial policy management capabilities. These capabilities can ideally be fostered through learning by doing, especially in developing countries with capacity gaps. Each step of the policy cycle requires strong analytical and implementation capacities. Special emphasis (again, often in low- and lower-middle-income countries) is needed in defining priorities and building a broad consensus; establishing clear rules for market-based competition conducted transparently and efficiently; delivering services effectively; and avoiding political capture.

reasons for the need of international technology and innovation policy cooperation. The Organization for Economic Co-operation and Development (OECD) emphasizes the need for effective international cooperation and sharing of burdens and benefits to protect the global commons and the world's public goods (including technology and innovation). This implies not only pooling financial resources and sharing a large research infrastructure but also improving the global knowledge base.

Trends in manufacturing value added, manufactured exports and industrial competitiveness

Key messages

- Global MVA reached an all-time high of $9,228 billion in 2014. By 2014, the MVA of developing and emerging industrial economies (DEIEs) increased 2.4 times from 2000, while their GDP doubled.
- World export growth rates averaged 7.7 percent over 2005–2013, and in 2013 world trade reached a peak of more than $18 trillion, with 84 percent comprising manufacturing products.
- Manufacturing exports by industrialized economies expanded by an annual average 4.3 percent over 2005–2013, reaching $11,998 billion in 2013. In the same period, DEIEs expanded their manufactured exports by an average 11.5 percent, to peak at $6,327 billion, 2.4 times more than in 2005.
- Around 58 percent of the world's manufactured exports consists of medium- and high-tech products such as chemical machinery and equipment, communication equipment, and motor vehicles.

> **An increasingly export-oriented manufacturing sector is part of a normal pattern of structural change in the growth process**

Key messages (continued)

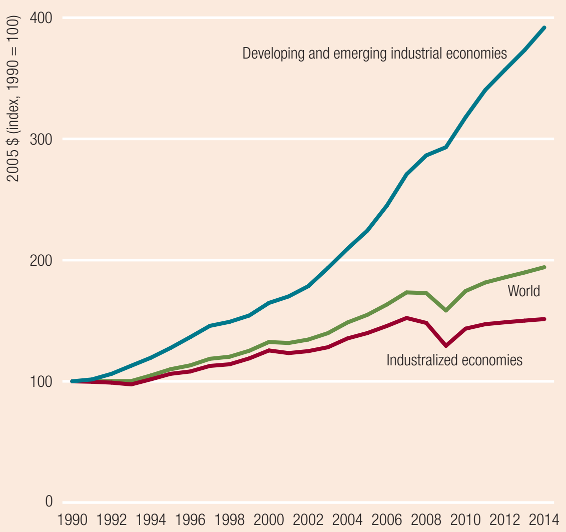
- On UNIDO's industrial competitiveness index, most industrialized countries lost ground in the last three years. Among the five most competitive are four high-income countries (Germany, Japan, the Republic of Korea and the United States), along with China ranking fifth. The four are among the world's most industrialized countries and, with China, account for 59 percent of world MVA.

Over the last few decades, global manufacturing has shifted from West to East, and from North to South. Since the beginning of the century, rapid growth in MVA has been a major source of poverty reduction in many DEIEs through employment creation and income generation. Those economies still have considerable capacity for manufacturing growth and technological progress in the coming decades.

Manufacturing value added

World MVA climbed strongly until the 2008–09 global financial crisis. Industrialized countries contributed the highest share of world MVA, but along with DEIEs experienced a slowdown in MVA growth. Since 2010, MVA has recovered in both groups but has so far not reached the pre-crisis level within the industrialized country group (Figure 20).

Figure 20
World manufacturing value added, by country group and worldwide, 1990–2014



Note: Development level classification based on Annex B1, Table B1.2.
Source: UNIDO elaboration based on Manufacturing Value Added Database (UNIDO 2015b).

Global MVA reached an all-time high of $9,228 billion (at 2005 constant prices) in 2014. The MVA share of industrialized countries in GDP fell from 15.4 percent in 1990 to 14.5 percent in 2014; in DEIEs it increased from 16.2 percent in 1990 to 20.5 percent in 2014. The share of MVA in world GDP increased from 15.6 percent to 16.2 percent over the period. Since 1990, MVA growth has remained consistently higher in DEIEs. By 2014, the MVA of DEIEs had expanded almost four times compared with 1990. Higher MVA growth has led to sustained economic growth in many developing countries.

Manufacturing remains a key driving force of overall economic growth of DEIEs. From 1990 to 2014, global MVA doubled from $4,753 billion to $9,228 billion at 2005 constant prices (Table 2). In DEIEs since 1992, MVA growth has stayed consistently higher than GDP growth (aggregate economic output). By 2014, the MVA of DEIEs had increased 2.4 times from 2000 at constant 2005 prices, while their GDP doubled; industrialized countries saw their MVA increase overall by only 51.3 percent.

DEIEs as a whole improved their share in total MVA but performance varied widely. Among the top five, China's share in world MVA increased by 6.5 times over 1990–2014. China's manufacturing industry has become the largest sector in the country and accounted in 2012 for more than 30 percent of GDP and more than 18 percent of global MVA, second only to the United States. Although China—and India—improved their group share, the other three of the five faltered, particularly Brazil.

“The fast-growing share of developing and emerging industrial economies in world manufacturing exports reflects their dynamism

Table 2
Manufacturing value added in developing and emerging industrial economies by development group and region, 1990, 2000 and 2014

	Manufacturing value added (billions, constant $ 2005)			Percentage of manufacturing value added		
	1990	2000	2014	1990	2000	2014
World	4,753	6,295	9,228	100	100	100
Industrialized countries	3,907	4,902	5,914	82	78	64
Developing and emerging industrial economies	846	1,393	3,314	18	22	36
By development group						
Emerging industrial countries	708	1,222	2,994	84	88	90
Least developed countries	20	22	54	2	2	2
Other developing countries	118	148	266	14	11	8
By region						
Africa	79	92	144	9	7	4
Asia and Pacific	315	746	2,362	37	54	71
Europe	151	164	300	18	12	9
Latin America	301	391	508	36	28	15

Note: Regional and development level classification based on Annex B1, Tables B1.1 and B1.2.
Source: UNIDO elaboration based on Manufacturing Value Added Database (UNIDO 2015b).

Manufactured exports

An increasingly export-oriented manufacturing sector, accompanied by a rising share of manufacturing in total exports, is part of a normal pattern of structural change in the growth process of DEIEs. Following this pattern, developing countries today have increased their presence in the export of manufactured goods. More developing economies are now benefiting from integration into the global economy through manufactured export growth and diversification. In most of these instances, export promotion has played a critical role in long-run growth by supporting a virtuous circle of investment, innovation and poverty reduction.

It is widely recognized that the benefits of exporting manufactured goods are greater than those from exporting primary commodities, largely due to the higher value added. Successful DEIEs have pursued export-led economic growth policies, diversifying from primary commodities to manufactured goods. As with their industrialized peers, the success of these economies stems from concentrating on manufactured exports.

Table 3
World exports by product category, 2005–2013

	Exports (billions, current $)									Average growth rate 2005–2013 (percent)
Category	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Manufacturing	8,130	9,367	10,772	12,050	9,421	11,409	13,422	13,363	13,866	6.9
Primary	1,146	1,411	1,543	2,197	1,422	1,939	2,511	2,442	2,620	10.9
Other	102	137	163	193	141	185	224	214	196	8.5
Total trade	9,378	10,915	12,478	14,440	10,984	13,533	16,157	16,018	16,682	7.5

Note: Product category classification based on ISIC Rev. 3, ITC (2015).
Source: UNIDO elaboration based on United Nations Comtrade database (UNSD 2015).

"Around 58 percent of the world's manufactured exports consists of medium- and high-tech products

World export growth rates averaged 7.7 percent over 2005–2013, and in 2013 world trade reached a peak of more than $18 trillion, with 84 percent comprising manufacturing products (Table 3). Over the period world output expanded at an average 2.3 percent a year, though many countries saw a decline during the crisis. Global manufacturing trade recovered fully after a sharp decline during 2007–2009, largely due to the fast-expanding DEIEs. Indeed, their relative weight has grown enormously, mainly due to China's meteoric rise as an exporter. Exports of primary products surged, but still only account for 1.6 percent of world trade.

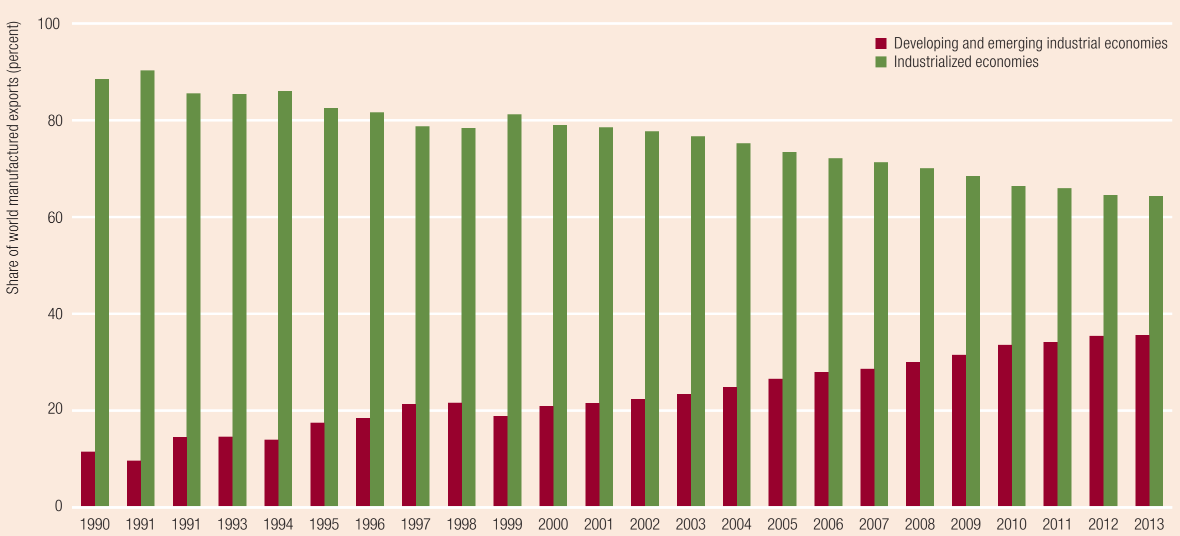
Manufacturing exports by industrialized economies expanded by an annual average 4.3 percent over 2005–2013, reaching $11,998 billion in 2013. In the same period, DEIEs expanded their manufactured exports by an average 11.5 percent, to peak at $6,327 billion, 2.4 times more than in 2005. The three largest manufacturing exporters in the DEIE group—China, Mexico and India—accounted for 62.1 percent of the total of the country group in 2013, up from 55.3 percent in 2000, indicating the rapid growth of larger economies and the increasing gap with smaller economies.

The fast-growing share of DEIEs in world manufacturing exports reflects their dynamism. The group accounted for 6.1 percent of world manufacturing trade in 1990, 17.6 percent in 2000 and 34.5 percent in 2013 (Figure 21). The EIEs contributed most to the DEIE growth path by increasing their share in global manufactured exports to 15.2 percent and 31.7 percent in 2000 and 2013, respectively, from 5.6 percent in 1990. It is expected that the role of DEIEs as exporters will increase significantly over the next years, reflecting their high growth rate and the development of the middle class. In addition, their dependence on developed-country markets is expected to decline as they move towards more advanced manufacturing sectors.

Led by China, Asia and the Pacific recorded a new peak of $7,145 billion in manufacturing exports in 2013, with an average growth of 11.6 percent a year over 2009–2013 (Table 4). Lower prices with the high competitiveness of China's market caused many manufacturing firms to move production there from more expensive, industrialized countries.

Europe as a whole contributed to a higher share in global manufacturing exports, though its pace of recovery was more moderate, with average growth

Figure 21
Share in world manufactured exports by country group, 1990–2013



Note: Development level classification based on Annex B1, Table B1.2.
Source: UNIDO elaboration based on United Nations Comtrade database (UNSD 2015a).

Countries can become more industrially competitive if they develop their technological capabilities, expand their production capacity and invest in their infrastructure

Table 4
World manufacturing exports by development group, region and income, selected years, 1995–2013 (billions, current $)

	1995	2000	2005	2010	2013
World	3,901	5,079	8,130	11,409	13,866
Industrialized countries	3,218	4,015	5,967	7,579	8,929
Developing and emerging industrial economies	683	1,064	2,163	3,831	4,937
By development group					
Emerging industrial countries	653	938	1,944	3,451	4,526
Least developed countries	7	14	24	49	39
Other developing countries	24	113	195	330	372
By region					
Asia and Pacific	346	566	1,291	2,509	3,371
Europe	83	127	302	483	620
Latin America	213	309	460	632	733
Africa	41	62	110	207	212
By income (world)					
High income	3,407	4,221	6,225	7,914	9,269
Upper middle income	417	669	1,570	2,872	3,771
Lower middle income	72	178	313	578	794
Low income	6	12	22	45	33

Note: Regional, development level and income classification based on Annex B1, Tables B1.1–B1.3.
Source: UNIDO elaboration based on United Nations Comtrade database (UNSD 2015).

of 7 percent a year over 2009–2013. Manufacturing exports in Latin America grew at a high 11.1 percent a year during the period, but the region failed to maintain its share of world manufacturing exports, contributing a low of 5 percent in 2013.

Africa followed a similar pattern to Latin America but with less strong growth of 10.4 percent, taking its share to a low of 1.4 percent in 2013. The region concentrates on resource-based manufacturing exports, which are the key factor in the overall growth as product prices and demand from industrializing countries have increased. High-tech products account for only 3.8 percent of manufacturing exports.

Despite some signs of progress, LDCs remain highly vulnerable to geopolitical tensions and political instabilities. Lack of proper infrastructure to support manufacturing adds to the problem. In 2013, LDCs accounted for 0.2 percent of world manufacturing exports. The group traditionally concentrated on low-tech manufactured products, but in the past few years that share has dropped dramatically due to lack of support in industry and the struggle of some countries with war. LDCs' manufacturing exports slumped by an average 19.3 percent a year.

Around 58 percent of the world's manufactured exports consists of medium- and high-tech products such as chemical machinery and equipment, communication equipment, and motor vehicles. The high-tech sector reached its peak, 25 percent, in 2000, and fell to 20 percent in 2013. This could be due to the high investment risk in the sector, which can hold markets back. While the export share of low- and medium-tech products fell during 2000–2013, the share of resource-based manufacturing increased from 17.8 percent to 23.7 percent. The increasing size of the middle classes in industrialized and developing countries has generated higher demand for processed food.

Most industrialized countries have lost ground from the 2010 CIP ranking

Industrial competitiveness

UNIDO assesses and benchmarks industrial competitiveness through its Competitive Industrial Performance (CIP) index, building on a concept of competitiveness that emphasizes countries' manufacturing development, implying that industrial competitiveness is multidimensional. *Industrial competitiveness* is defined as the capacity of countries to increase their presence in international and domestic markets while developing industrial sectors and activities with higher value added and technological content.

Countries can learn in international markets and become more industrially competitive if they develop their technological capabilities, expand their production capacity and invest in their infrastructure. Hence, increasing industrial competitiveness requires selective policy interventions, through which comparative advantages are exploited while new competitive advantages are created.

The CIP Index is a performance (or "outcome") indicator rather than a potential (or "process") indicator. It consists of output indicators only. Given its focus on industrial competitiveness and structural economic variables, it provides country rankings that tend to remain relatively stable over short periods of time. The reason is that processes of technological learning are cumulative and take time. The effects of learning are reflected in industrial statistics and structural economic variables only in the medium to long term, and those effects can be captured through detailed longitudinal studies, in particular by tracking changes of key dimensions over time. The CIP Index allows us to observe not only the absolute level of key indicators at any particular time, but also their rate of change.

Based on their CIP values, countries are divided into five, colour-highlighted quintiles: top, upper middle, middle, lower middle and bottom.

Countries in the top quintile account for nearly 83 percent of world MVA and more than 85 percent of global manufactured trade. Among the five most competitive are four high-income countries (Germany, Japan, the Republic of Korea and the United States), along with China ranking fifth. The four are among the world's most industrialized countries and, with China, account for 59 percent of world MVA.

Germany's manufacturing sector is a key factor in its macroeconomic performance, with a strong industrial core and an ability to control complex industrial value creation chains. Its medium- and high-tech exports account for 73 percent of its total manufactured exports, and it has maintained its technological lead against newcomers in the global economy. Germany thus has strong technological upgrading and deepening, on both the production and trade sides.

Japan's industrial competitiveness is supported by its large manufacturing base, high-tech exports and high manufacturing per capita. The United States' industrial competitiveness arises from its large manufacturing base, although it is more aimed at the domestic market than Japan or any other developed country. The United States alone accounts for nearly 20 percent of world MVA. The Republic of Korea has a competitive manufacturing sector based on a high share of medium- and high-tech industries.

In the top quintile, given the population size and stage of development, China has the lowest per capita values on both trade and production sides. China's position in the ranking is attributable to its high share in global trade (though low per capita values indicate that manufacturing still has the potential to grow further). China has increased its share of manufacturing exports to 17 percent of global manufacturing trade in 2013, and is the largest exporter in the world today. It has also started positioning itself as a high-tech manufacturing exporter: the export share of medium- and high-tech products almost doubled over 1995–2013. China's manufacturing industry has become the largest sector in the economy and accounted for more than one third of GDP and 18 percent of global MVA in 2013, second only to the United States.

Others in the top quintile include Switzerland, Singapore and the Netherlands thanks to their very high exports per capita in general and high-tech exports in particular. Other top-quintile members include major European Union transition economies, such as the Czech Republic, Poland, Slovakia and Hungary—due to their export orientation, more focused on the European market. Completing the list are Mexico, Malaysia and Thailand, whose competitiveness arises from their participation in global value chains.

The upper-middle quintile includes some of the most populous countries in the world, such as Turkey, the Russian Federation, Brazil, Indonesia, South Africa, India and the Philippines. The production and export performance of high-tech products in the Philippines and Indonesia is strong, while the Russian Federation and South Africa have higher MVAs per capita but low manufacturing exports due to their dependence on foreign sales of natural resources. India and Brazil accounted for 2.2 percent and 1.7 percent, respectively, of global MVA in 2013.

The middle quintile has populous countries, such as Iran, Egypt and Bangladesh and some less populous nations, such as Costa Rica, Iceland, Oman and Uruguay. Countries in the lower-middle and bottom quintiles include less developed countries by income, accounting for roughly 0.8 percent of world MVA in 2013. Their level of industrialization is on average less than one third that in countries in the middle quintile.

The CIP ranking for 2013 shows that most industrialized countries have lost ground from the 2010 ranking. Denmark and Finland have been replaced by Mexico and Poland during the past three years. Germany, Japan, the Republic of Korea and the United States, although not among the winners, show very stable and enduring industrial competitiveness that relies on long-term advantages such as high technology, good education and advanced infrastructure.

Notes

1. The analysis is based on the World Input-Output Database (Timmer and others 2015), which covers 40 countries. Based on income, eight are developing countries and the rest are high income. To focus on inclusiveness, sustainability and productivity aspects, the analysis assesses for intermediate inputs, for example, only the contributions of energy and mining (from domestic as well as foreign sources) to output growth; other intermediate inputs are excluded. us, the shares of each factor contribution do not add up to 100 percent. The natural resource data come from "Mining and Quarrying" in the World Input-Output Database.
2. For classification, refer to Annex A2.
3. None of the eight developing countries are from the low-income group, and only one country, India, is from the lower-middle-income group. The rest of the developing countries belong to the upper-middle-income category. So the results may not reflect the conditions of countries in the early stage of development. That might be the reason why the labour contribution to the growth of labour-intensive industries in the developing countries group is relatively low.

Annexes

Annex A1 World Bank country and economy classification

Table A1.1
World Bank countries and economies by income classification (gross national income per capita)

High income ($12,746 or more)				
Andorra	Curaçao	Ireland	New Zealand	St. Kitts and Nevis
Antigua and Barbuda	Cyprus	Isle of Man	Northern Mariana Islands	St. Martin (French)
Aruba	Czech Rep.	Israel	Norway	Sweden
Australia	Denmark	Italy	Oman	Switzerland
Austria	Equatorial Guinea	Japan	Poland	Taiwan Province of China
Bahamas	Estonia	Korea, Rep. of	Portugal	Trinidad and Tobago
Bahrain	Faeroe Islands	Kuwait	Puerto Rico	Turks and Caicos Islands
Barbados	Finland	Latvia	Qatar	United Arab Emirates
Belgium	France	Liechtenstein	Russian Federation	United Kingdom
Bermuda	French Polynesia	Lithuania	San Marino	United States
Brunei Darussalam	Germany	Luxembourg	Saudi Arabia	Uruguay
Canada	Greece	Macao SAR, China	Singapore	Virgin Islands (United States)
Cayman Islands	Greenland	Malta	Sint Maarten (Dutch)	
Channel Islands	Guam	Monaco	Slovakia	
Chile	Hong Kong SAR, China	Netherlands	Slovenia	
Croatia	Iceland	New Caledonia	Spain	
Upper middle income ($12,475–$4,126)				
Albania	Bulgaria	Hungary	Marshall Islands	South Africa
Algeria	China	Iran, Islamic Rep. of	Mauritius	St. Lucia
American Samoa	Colombia	Iraq	Mexico	St. Vincent and the Grenadines
Angola	Costa Rica	Jamaica	Montenegro	Suriname
Argentina	Cuba	Jordan	Namibia	Thailand
Azerbaijan	Dominica	Kazakhstan, Rep. of	Palau	Tonga
Belarus	Dominican Rep.	Lebanon	Panama	Tunisia
Belize	Ecuador	Libya	Peru	Turkey
Bosnia and Herzegovina	Fiji	Macedonia, Former Yugoslav Rep. of	Romania	Turkmenistan
Botswana	Gabon	Malaysia	Serbia	Tuvalu
Brazil	Grenada	Maldives	Seychelles	Venezuela, Bolivarian Rep. of

Lower middle income ($4,125–$1,046)				
Armenia	Ghana	Mauritania	Samoa	Uzbekistan
Bhutan	Guatemala	Micronesia, Federated States of	São Tomé and Principe	Vanuatu
Bolivia, Plurinational State of	Guyana	Moldova, Rep. of	Senegal	Viet Nam
Cabo Verde	Honduras	Mongolia	Solomon Islands	West Bank and Gaza
Cameroon	India	Morocco	South Sudan	Yemen
Congo, Rep. of the	Indonesia	Nicaragua	Sri Lanka	Zambia
Côte d'Ivoire	Kiribati	Nigeria	Sudan	
Djibouti	Kosovo	Pakistan	Swaziland	
Egypt	Kyrzygzstan	Papua New Guinea	Syrian Arab Rep.	
El Salvador	Lao People's Dem. Rep.	Paraguay	Timor-Leste	
Georgia	Lesotho	Philippines	Ukraine	
Low income ($1,045 or less)				
Afghanistan	Comoros	Kenya	Nepal	Uganda
Bangladesh	Congo, Dem. Rep. of the	Korea, Dem. People's Rep. of	Niger	Zimbabwe
Benin	Eritrea	Liberia	Rwanda	
Burkina Faso	Ethiopia	Madagascar	Sierra Leone	
Burundi	Gambia	Malawi	Somalia	
Cambodia	Guinea	Mali	Tajikistan	
Central African Rep.	Guinea-Bissau	Mozambique	Tanzania, United Rep. of	
Chad	Haiti	Myanmar	Togo	

Table A1.2
World Bank countries and economies by region classification

Industrialized countries and economies				
Americas				
Aruba	Bermuda	Canada	United States	
Bahamas	British Virgin Islands	Greenland		
Asia				
Brunei Darussalam	Hong Kong SAR, China	New Zealand	Taiwan Province of China	
French Polynesia	Japan	Singapore		
Europe				
Andorra	Finland	Ireland	Monaco	Spain
Austria	France	Italy	Netherlands	Sweden
Belgium	Germany	Liechtenstein	Norway	Switzerland
Denmark	Iceland	Luxembourg	San Marino	United Kingdom
North Africa and Middle East				
Cyprus	Israel	Kuwait	Qatar	United Arab Emirates
Oceania				
Australia	New Zealand			
Industrializing countries and economies				
Central America and Caribbean				
Antigua and Barbuda	Cuba	Grenada	Jamaica	Saint Kitts and Nevis
Barbados	Dominica	Guatemala	Nicaragua	Saint Lucia
Belize	Dominican Rep.	Haiti	Panama	St. Vincent and the Grenadines
Costa Rica	El Salvador	Honduras	Puerto Rico	Trinidad and Tobago
East Asia				
China	Macao SAR, China	Korea, Dem. People's Rep. of	Korea, Rep. of	Mongolia
Eastern Europe (excluding USSR)				
Albania	Czech Rep.	Kosovo	Poland	Slovakia
Bosnia and Herzegovina	Czechoslovakia, Former	Macedonia, Former Yugoslav Rep. of	Romania	Slovenia
Bulgaria	Hungary	Montenegro	Serbia	Yugoslavia, Former
Croatia				
Former Union of Soviet Socialist Republics (USSR)				
Armenia	Georgia	Latvia	Russian Federation	Ukraine
Azerbaijan	Kazakhstan	Lithuania	Tajikistan	USSR, Former
Belarus	Kyrgyzstan	Moldova, Rep. of	Turkmenistan	Uzbekistan
Estonia				
North America				
Mexico				

North Africa and Middle East				
Algeria	Iraq	Libya	Saudi Arabia	Tunisia
Bahrain	Jordan	Morocco	Sudan	Turkey
Egypt	Lebanon	Oman	Syrian Arab Rep.	Yemen
Oceania				
Fiji	New Caledonia	Samoa	Tonga	
Kiribati	Papua New Guinea	Solomon Islands	Vanuatu	
South Asia				
Afghanistan	Bhutan	Iran, Islamic Rep. of	Nepal	Sri Lanka
Bangladesh	India	Maldives	Pakistan	
South America				
Argentina	Chile	Guyana	Suriname	
Bolivia, Plurinational State of	Colombia	Paraguay	Uruguay	
Brazil	Ecuador	Peru	Venezuela, Bolivarian Rep. of	
South-East Asia				
Cambodia	Lao People's Dem. Rep.	Myanmar	Thailand	
Indonesia	Malaysia	Philippines	Viet Nam	
Sub-Saharan Africa				
Angola	Congo, Rep. of the	Guinea-Bissau	Namibia	Swaziland
Benin	Congo, Dem. Rep. of the	Kenya	Niger	Tanzania, United Rep. of
Botswana	Côte d'Ivoire	Lesotho	Nigeria	Togo
Burkina Faso	Djibouti	Liberia	Rwanda	Uganda
Burundi	Equatorial Guinea	Madagascar	São Tomé and Principe	Zambia
Cabo Verde	Ethiopia	Malawi	Senegal	Zimbabwe
Cameroon	Gabon	Mali	Seychelles	
Central African Rep.	Gambia	Mauritania	Sierra Leone	
Chad	Ghana	Mauritius	Somalia	
Comoros	Guinea	Mozambique	South Africa	
Western Europe				
Greece	Malta	Portugal		

Source: UNIDO's elaboration based on World Bank (2015b).
Note: World Bank GNI per capita operational guidelines and analytical classifications as per 1990.

Annex A2 Classification of manufacturing industries by technology group

ISIC full description	Abbreviation used in this report	ISIC code rev. 3	Technology group
Food and beverages	Food and beverages	15	Low tech
Tobacco products	Tobacco	16	Low tech
Textiles	Textiles	17	Low tech
Wearing apparel, fur and leather products and footwear	Wearing apparel	18 and 19	Low tech
Wood products (excluding furniture)	Wood products	20	Low tech
Paper and paper products	Paper	21	Low tech
Printing and publishing	Printing and publishing	22	Low tech
Furniture, manufacturing n.e.c.	Furniture, n.e.c.	36	Low tech
Coke, refined petroleum products and nuclear fuel	Coke and refined petroleum	23	Medium tech
Rubber and plastic products	Rubber and plastic	25	Medium tech
Non-metallic mineral products	Non-metallic minerals	26	Medium tech
Basic metals	Basic metals	27	Medium tech
Fabricated metal products	Fabricated metals	28	Medium tech
Chemicals and chemical products	Chemicals	24	High tech
Machinery and equipment n.e.c. and office, accounting, computing machinery	Machinery and equipment	29 and 30	High tech
Electrical machinery and apparatus and radio, television and communication equipment	Electrical machinery and apparatus	31 and 32	High tech
Medical, precision and optical instruments	Precision instruments	33	High tech
Motor vehicles, trailers, semi-trailers and other transport equipment	Motor vehicles	34 and 35	High tech

Note: ISIC is International Standard Industrial Classification; n.e.c. is not elsewhere classified. The three technology groups follow OECD (2005) technology classification based on R&D intensity relative to value added and gross production statistics.
Source: UNIDO's elaboration based on INDSTAT2 (UNIDO 2012).

Annex B1 Country and economy groups

Table B1.1
Countries and economies by region

Industrialized countries and economies				
Asia and the Pacific				
Bahrain	Taiwan Province of China	Korea, Rep. of	Malaysia	Singapore
Hong Kong SAR, China	Japan	Kuwait	Qatar	United Arab Emirates
Macao SAR, China				
Europe				
Austria	France	Iceland	Portugal	Switzerland
Belgium	Germany	Lithuania	Russian Federation	United Kingdom
Czech Rep.	Hungary	Luxembourg	Slovakia	Liechtenstein
Denmark	Andorra	Malta	Slovenia	Monaco
Estonia	Ireland	Netherlands	Spain	San Marino
Finland	Italy	Norway	Sweden	
North America				
Bermuda	Canada	Greenland	United States	
Others				
Aruba	Cayman Islands	Guam	New Zealand	
Australia	French Guiana	Israel	Puerto Rico	
British Virgin Islands	French Polynesia	New Caledonia	Virgin Islands (United States)	
Industrializing countries and economies				
Africa				
Algeria	Côte d'Ivoire	Kenya	Niger	Swaziland
Angola	Djibouti	Lesotho	Nigeria	Tanzania, United Rep. of
Benin	Egypt	Liberia	Réunion	Togo
Botswana	Equatorial Guinea	Libya	Rwanda	Tunisia
Burkina Faso	Eritrea	Madagascar	Sao Tome and Principe	Uganda
Burundi	Ethiopia	Malawi	Senegal	Zambia
Cabo Verde	Gabon	Mali	Seychelles	Zimbabwe
Cameroon	Gambia	Mauritania	Sierra Leone	
Central African Rep.	Ghana	Mauritius	Somalia	
Chad	Guinea	Morocco	South Africa	
Comoros	Guinea-Bissau	Mozambique	South Sudan	
Congo, Rep. of the	Kazakhstan	Namibia	Sudan	
Asia and the Pacific				
Afghanistan	Fiji	Lebanon	Papua New Guinea	Timor-Leste
Armenia	India	Maldives	Philippines	Tonga
Azerbaijan	Indonesia	Marshall Islands	Samoa	Turkmenistan
Bangladesh	Iran, Islamic Rep. of	Micronesia, Federated States of	Saudi Arabia	Tuvalu
Bhutan	Iraq	Mongolia	Solomon Islands	Uzbekistan
Brunei Darussalam	Jordan	Myanmar	Sri Lanka	Vanuatu

Cambodia	Kiribati	Nepal	State of Palestine	Viet Nam
China	Korea, Dem. People's Rep. of	Oman	Syrian Arab Rep.	Yemen
Cook Islands	Kyrgyzstan	Pakistan	Tajikistan	
Congo, Dem. Rep. of the	Lao People's Dem. Rep.	Palau	Thailand	
Europe				
Albania	Croatia	Latvia	Romania	Ukraine
Belarus	Cyprus	Montenegro	Serbia	
Bosnia and Herzegovina	Georgia	Poland	Macedonia, Former Yugoslav Rep. of	
Bulgaria	Greece	Moldova, Rep. of	Turkey	
Latin America and the Caribbean				
Anguilla	Chile	Grenada	Mexico	Saint Vincent and the Grenadines
Antigua and Barbuda	Colombia	Guadeloupe	Montserrat	Suriname
Argentina	Costa Rica	Guatemala	Nicaragua	Trinidad and Tobago
Bahamas	Cuba	Guyana	Panama	Uruguay
Barbados	Dominica	Haiti	Paraguay	Venezuela, Bolivarian Rep. of
Belize	Dominican Rep.	Honduras	Peru	
Bolivia, Plurinational State of	Ecuador	Jamaica	Saint Kitts and Nevis	
Brazil	El Salvador	Martinique	Saint Lucia	

Table B1.2
Countries and economies by industrialization level

Industrialized countries and economies				
Andorra	Taiwan Province of China	Iceland	Monaco	Slovenia
Aruba	Czech Rep.	Ireland	Netherlands	Spain
Australia	Denmark	Israel	New Caledonia	Sweden
Austria	Estonia	Italy	New Zealand	Switzerland
Bahrain	Finland	Japan	Norway	United Arab Emirates
Belgium	France	Korea, Rep. of	Portugal	United Kingdom
Bermuda	French Guiana	Kuwait	Puerto Rico	United States
British Virgin Islands	French Polynesia	Liechtenstein	Qatar	Virgin Islands (United States)
Canada	Germany	Lithuania	Russian Federation	
Cayman Islands	Greenland	Luxembourg	San Marino	
Hong Kong SAR, China	Guam	Malaysia	Singapore	
Macao SAR, China	Hungary	Malta	Slovakia	
Industrializing countries and economies				
Emerging industrial countries and economies				
Argentina	Colombia	Kazakhstan	Saudi Arabia	Turkey
Belarus	Costa Rica	Latvia	Serbia	Ukraine
Brazil	Croatia	Mauritius	South Africa	Uruguay
Brunei Darussalam	Cyprus	Mexico	Suriname	Venezuela, Bolivarian Rep. of

Bulgaria	Greece	Oman	Thailand	
Chile	India	Poland	Macedonia, Former Yugoslav Rep. of	
China	Indonesia	Romania	Tunisia	
Other developing countries and economies				
Albania	Cook Islands	Guatemala	Montenegro	Saint Lucia
Algeria	Cuba	Guyana	Montserrat	Saint Vincent and the Grenadines
Angola	Côte d'Ivoire	Iran, Islamic Rep. of	Morocco	Seychelles
Anguilla	Dominica	Iraq	Namibia	Sri Lanka
Antigua and Barbuda	Dominican Rep.	Jamaica	Nicaragua	State of Palestine
Armenia	Ecuador	Jordan	Nigeria	Swaziland
Azerbaijan	Egypt	Kenya	Pakistan	Syrian Arab Rep.
Bahamas	El Salvador	Korea, Dem. People's Rep. of	Palau	Tajikistan
Barbados	Equatorial Guinea	Kyrgyzstan	Panama	Tonga
Belize	Fiji	Lebanon	Papua New Guinea	Trinidad and Tobago
Bolivia, Plurinational State of	Gabon	Libya	Paraguay	Turkmenistan
Bosnia and Herzegovina	Georgia	Maldives	Peru	Uzbekistan
Botswana	Ghana	Marshall Islands	Philippines	Viet Nam
Cameroon	Grenada	Martinique	Moldova, Rep. of	Zimbabwe
Cape Verde	Guadeloupe	Micronesia, Federated States of	Réunion	
Congo, Rep. of the	Honduras	Mongolia	Saint Kitts and Nevis	
Least developed countries and economies				
Afghanistan	Congo, Dem. Rep. of the	Lesotho	Rwanda	Timor-Leste
Bangladesh	Djibouti	Liberia	Samoa	Togo
Benin	Eritrea	Madagascar	Sao Tome and Principe	Tuvalu
Bhutan	Ethiopia	Malawi	Senegal	Uganda
Burkina Faso	Gambia	Mali	Sierra Leone	Vanuatu
Burundi	Guinea	Mauritania	Solomon Islands	Yemen
Cambodia	Guinea-Bissau	Mozambique	Somalia	Zambia
Central African Rep.	Haiti	Myanmar	South Sudan	
Chad	Kiribati	Nepal	Sudan	
Comoros	Lao People's Dem. Rep.	Niger	Tanzania, United Rep. of	

Table B1.3
Countries and economies by income

High income				
Andorra	Curacao	Hong Kong SAR, China	Netherlands	Slovenia
Anguilla	Cyprus	Hungary	New Caledonia	Spain
Aruba	Czech Rep.	Iceland	New Zealand	Sweden
Australia	Denmark	Ireland	Norway	Switzerland
Austria	Equatorial Guinea	Israel	Oman	Taiwan Province of China
Bahamas	Estonia	Italy	Poland	Trinidad and Tobago

Bahrain	Finland	Japan	Portugal	United Arab Emirates
Barbados	France	Korea, Rep. of	Puerto Rico	United Kingdom
Belgium	French Polynesia	Kuwait	Qatar	United States
Bermuda	Germany	Liechtenstein	Saint Kitts and Nevis	Virgin Islands (United States)
Brunei Darussalam	Greece	Luxembourg	Saudi Arabia	
Canada	Greenland	Macao SAR, China	Singapore	
Croatia	Guam	Malta	Slovakia	
Upper middle income				
Algeria	Chile	Jamaica	Mexico	Seychelles
American Samoa	China	Jordan	Montenegro	South Africa
Angola	Colombia	Kazakhstan	Namibia	Suriname
Antigua and Barbuda	Costa Rica	Latvia	Palau	Thailand
Argentina	Cuba	Lebanon	Panama	Tunisia
Azerbaijan	Dominica	Libya	Peru	Turkey
Belarus	Dominican Rep.	Lithuania	Romania	Turkmenistan
Bosnia and Herzegovina	Ecuador	Macedonia, Former Yugoslav Rep. of	Russian Federation	Uruguay
Botswana	Gabon	Malaysia	Saint Lucia	Venezuela, Bolivarian Rep. of
Brazil	Grenada	Maldives	Saint Vincent and the Grenadines	
Bulgaria	Iran, Islamic Rep. of	Mauritius	Serbia	
Lower middle income				
Albania	El Salvador	Lao People’s Dem. Rep.	Paraguay	Syrian Arab Rep.
Armenia	Fiji	Lesotho	Philippines	Timor-Leste
Belize	Georgia	Marshall Islands	Samoa	Tonga
Bhutan	Ghana	Micronesia, Federated States of	São Tomé and Principe	Tuvalu
Bolivia, Plurinational State of	Guatemala	Moldova, Rep. of	Senegal	Ukraine
Cabo Verde	Guyana	Mongolia	Solomon Islands	Uzbekistan
Cameroon	Honduras	Morocco	South Sudan	Vanuatu
Congo, Rep. of the	India	Nicaragua	Sri Lanka	Viet Nam
Côte d’Ivoire	Indonesia	Nigeria	State of Palestine	Yemen
Djibouti	Iraq	Pakistan	Sudan	Zambia
Egypt	Kiribati	Papua New Guinea	Swaziland	
Low income				
Afghanistan	Comoros	Haiti	Mali	Sierra Leone
Bangladesh	Congo, Dem. Rep. of the	Kenya	Mauritania	Somalia
Benin	Eritrea	Korea, Dem. People’s Rep. of	Mozambique	Tajikistan
Burkina Faso	Ethiopia	Kyrgyzstan	Myanmar	Tanzania, United Rep. of
Burundi	Gambia	Liberia	Nepal	Togo
Cambodia	Guinea	Madagascar	Niger	Uganda
Central African Rep.	Guinea-Bissau	Malawi	Rwanda	Zimbabwe
Chad				

Source: UNIDO (2015a)

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"The year 2015 marks the launch of the United Nations 2030 Sustainable Development Goal 9 (SDG 9), an important step forward to address global development by highlighting sustainable and inclusive industrialization and economic growth. UNIDO's *Industrial Development Report 2016* provides a comprehensive and timely analysis of the path to achieve this goal through sustainable and inclusive industrial development based on insightful discussion, solid empirical evidence and valuable policy advice. It points to innovative new thinking about industrialization, which is key for the implementation of SDG 9 and the progress of global development. I strongly recommend it."

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1) 26026-0, Fax: (+43-1) 26926-69
E-mail: unido@unido.org, Internet: www.unido.org