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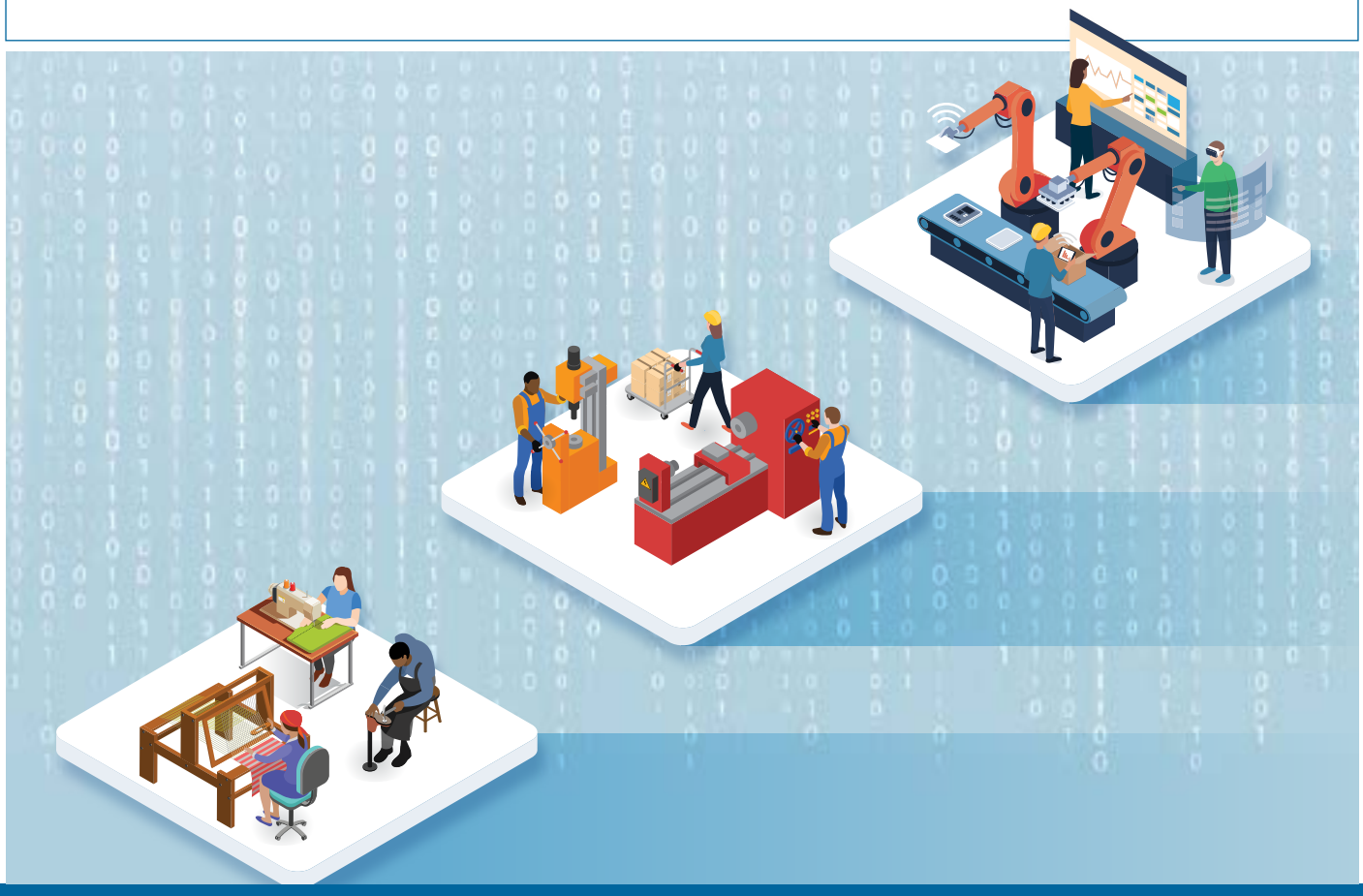
Industrialization in the digital age: more important than ever

Executive summary

Observers often question whether industrialization remains a viable development strategy in the digital age. Value is increasingly concentrated around intangible assets and—so the argument goes—manufacturing has become a thing of the past. The IDR 2020 finds that there is in fact a strong association between countries' industrial capabilities and the diffusion of new technologies. This finding holds both across and within income groups. The manufacturing sector remains the learning engine of any economy. It is thanks to the capabilities acquired in manufacturing production that countries successfully engage, either as producers or users, with advanced digital production (ADP) technologies.

Key findings

- The production and diffusion of ADP technologies is geographically concentrated in a few countries. Most developing economies have not yet entered the ongoing technology race.
- A major barrier for the productive adoption of ADP technologies is the lack of industrial capabilities.
- A clear positive relationship exists across countries between the level of engagement with ADP technologies and the level of industrial capabilities, as captured by UNIDO's CIP index.
- Across firms, production capabilities—those acquired through previous experience with manufacturing—are found to be more important than investment and technological capabilities for the adoption of new process technologies.
- Industrial development is crucial for countries to capture the digital dividend.



The production and diffusion of ADP technologies: a concentrated landscape

The production of ADP technologies (see Box 1) is geographically concentrated in a handful of industrialized and emerging industrial economies.[1] These include, among others, the China, Germany, Japan and the U.S. (Figure 1). Countries that are active in the production of ADP technologies are those where inventors patent new applications and where firms produce and export goods embodying ADP technologies, such as industrial robots or 3D printers. Producer countries are considered frontrunners in the 4IR race.

Box 1. What are ADP technologies?

ADP technologies combine hardware (advanced robots and 3D printers), software (big data analytics, cloud computing and artificial intelligence) and connectivity (the Internet of Things). Applying the latest evolution of digital technologies to manufacturing production gives rise to smart production, also referred to as Industry 4.0 – a key domain of the Fourth Industrial Revolution.

What is more, the diffusion of ADP technologies is also concentrated in a limited group of countries. Countries painted in a lighter shade of blue in Figure 1 represent followers. While they may not yet have the capability to produce goods embodying ADP technologies, these countries import—and use—tools, equipment and machines that are enabled by the new technologies. By contrast, the remaining developing economies are far from becoming players in the field of ADP technologies – either as producers or users.

ADP technologies raise the capability threshold

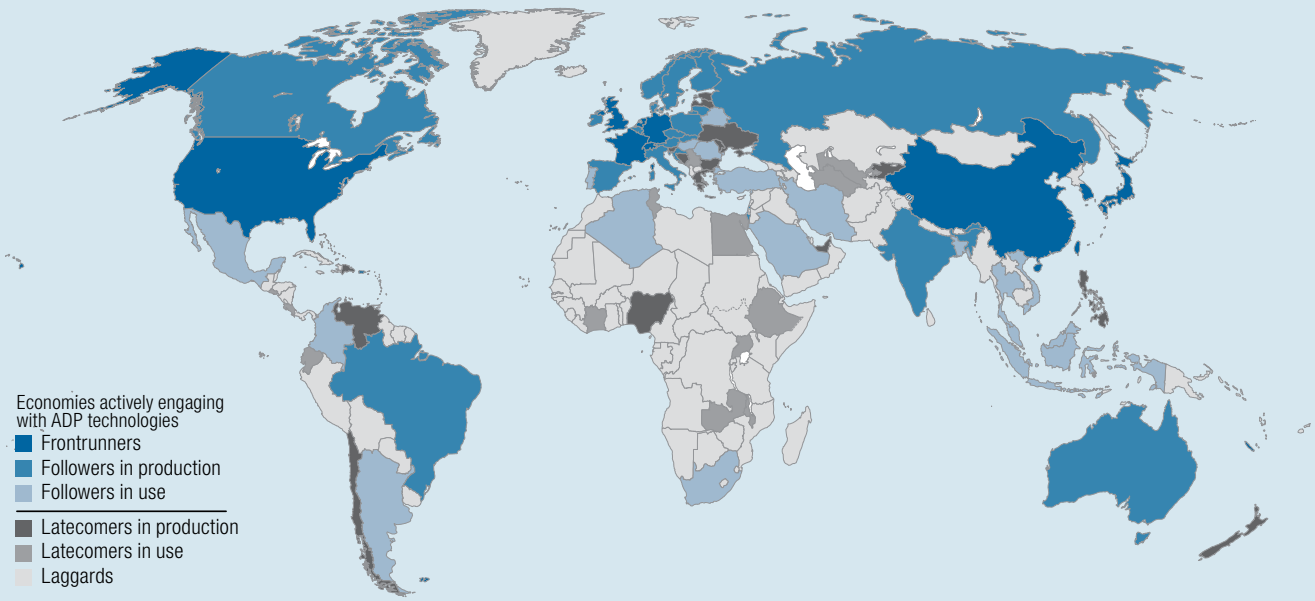
The emergence of ADP technologies creates a double challenge for developing economies. One relates to the availability of hard infrastructure. The diffusion of ADP technologies hinges on having access to fast, high-quality connectivity and reliable electricity supply. The infrastructure bottlenecks in many developing countries can act as a barrier to investment in new technologies by making the adoption of new technologies too risky and financially unviable for the individual firm.

Manufacturing and engineering skills also play an important role, however. Advanced digital production technologies raise the capability threshold. This is not so much because these technologies are entirely new. Rather, to function smoothly, ADP technologies require investment in a wide range of complementary applications and skills. Think, for instance, of new industrial robots and cobots, the operation of which may require some programming skills on the part of workers on the shop floor.

Moreover, firms must often integrate ADP technologies within pre-existing production facilities that are equipped with previous vintages of machinery. Particularly in developing and emerging industrial economies, where Fourth Industrial Revolution "islands" co-exist with a highly heterogeneous landscape of firms operating different generations of technology, retrofitting occurs more frequently than the establishment of new plants. Retrofitting requires a significant degree of engineering and manufacturing experience.

Figure 1

While only a few frontrunner economies are engaged in the production of ADP technologies and others begin importing and using them, the majority of developing economies have not yet entered the ongoing technological race



Note: The map is presented solely for graphical illustration and does not express any opinion on the part of the UNIDO Secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Source: UNIDO IDR 2020 Figure 1.14, p. 51

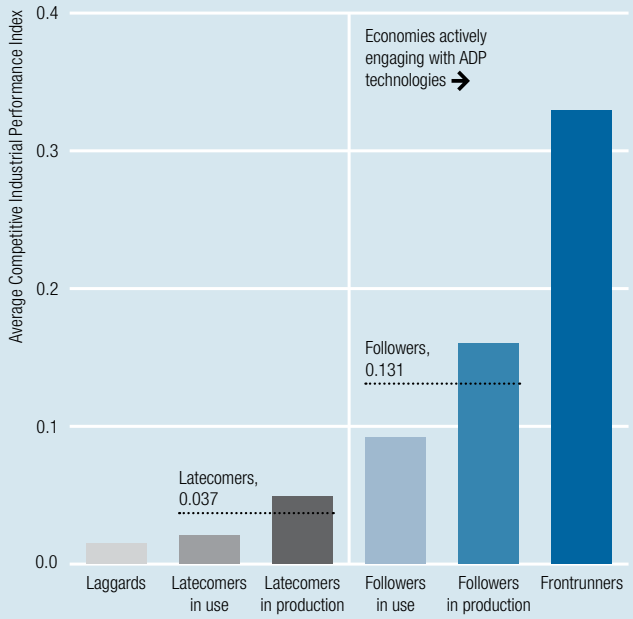
1 See Foster-McGregor et al. (2019) for a more comprehensive analysis of the geographical diffusion of ADP technologies.

Bridging the capability gap: the role of industrial capabilities at the macro and micro level

How can countries bridge the capability gap? For developing economies, catching up to the technology frontier requires making strides in industrial development. The geography of ADP technology diffusion reflects the uneven distribution of industrial capabilities across the globe: frontrunners tend to have larger industrial capabilities than followers; followers have higher capabilities than latecomers; and so on (Figure 2). The development of industrial capabilities can be proxied by the Competitive Industrial Performance (CIP) index (Box 2). A higher CIP score is associated with a higher level of industrial prowess.

Figure 2

Engaging with ADP technologies requires climbing a stairway of industrial capabilities



Note: ADP is advanced digital production. All values are average for the year 2017. Source: UNIDO IDR 2020 Figure 1.15, p. 52

Box 2. What is the CIP index?

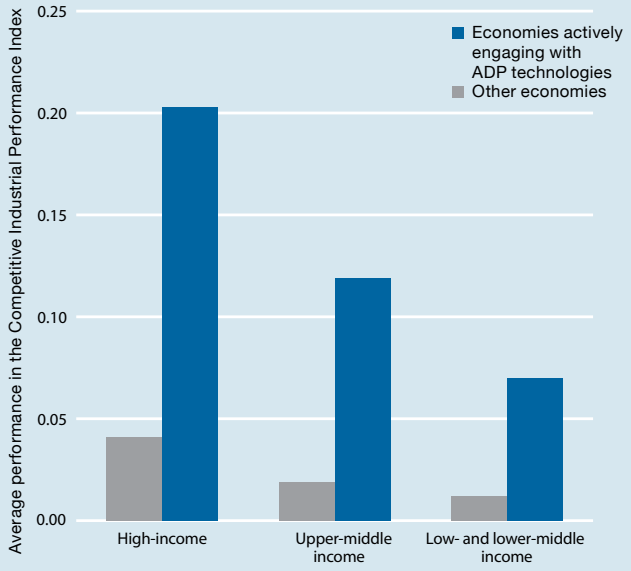
The CIP is an index developed by UNIDO to assess and benchmark countries' industrial competitiveness. It measures how much a country's manufacturing sector contributes to its economic development. The index captures three main dimensions. The higher the score on any dimension, the higher the country's level of industrial capabilities. The first dimension measures a country's capacity to produce and export manufactured goods. The second dimension refers to a country's technological deepening and upgrading. The last dimension captures the global impact of a country's production and export activities.

That frontrunners and followers are found to have greater industrial capabilities relative to the rest is not necessarily surprising. These countries tend to be richer than the rest, and richer countries tend to have more sophisticated industrial capabilities, which they accumulated over the years. But this is far from the whole story.

The IDR 2020 finds marked differences in industrial capabilities within income groups as well. These map neatly onto differences in technology diffusion between countries that belong to the same income group. Average CIP scores by group are always higher for countries that engage with ADP technologies relative to countries that do not (Figure 3). Within the three income groups, countries that actively engage with ADP technologies have a higher average CIP score relative to the corresponding average of the rest – up to five times higher. What is more, average CIP scores for developing countries that are active producers and users of new technologies are also higher than those of industrialized economies that are lagging behind in the adoption of new technologies.

Figure 3

Within income groups, economies actively engaging with ADP technologies have stronger capabilities relative to the rest

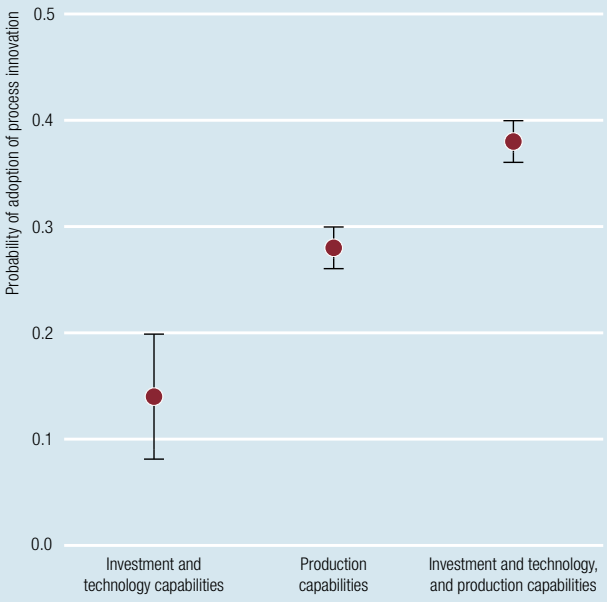


Note: ADP is advanced digital production. All values are averages for the year 2017. The analysis includes 140 economies, of which 50 actively engage with advanced digital production (ADP) technologies). By World Bank income group definitions for 2017: 53 are low- and lower middle-income economies (of which 4 are active), 38 are upper middle-income economies (of which 13 are active) and 49 are high-income economies (of which 33 are active). Source: UNIDO IDR 2020 Figure 1.16, p. 53

Industrial capabilities do not only matter at the aggregate level. They are also crucial at firm level. Broadly speaking, firms need three sets of capabilities to adopt new technologies: investment, technology and production capabilities. Investment and technology capabilities enable firms to deal with technological change. They include the knowledge, resources and skills firms need to identify the equipment and technologies they need and to integrate them within their business activities. Production capabilities, instead, relate to experience, learning by doing and entrepreneurial behaviour. They are developed by actively engaging in industrial production and by devoting time and resources to learning how to do things better.

Analysing firm-level data from the World Bank Enterprise Surveys, the IDR 2020 confirms that production capabilities are the most important determinant of the uptake of new process technologies, such as ADP technologies (Figure 4).[2]

Figure 4
Capabilities acquired in industrial production matter for the adoption of new technologies at the firm level too



Note: The analysis includes 13 African economies and 4 Asian economies. The graph depicts coefficients and confidence intervals (at 95 per cent) for the average marginal effects of the variables of interest on the probability of adopting a process innovation. Source: UNIDO IDR 2020 Figure 3.17, p. 111

Firms that get their hands dirty by exporting and looking out for new markets, for instance, or by innovating and launching new products, tend to accumulate greater levels of industrial capabilities. This group of firms is almost twice as likely to adopt new process technologies relative to firms that opt to acquire new competences "off the shelf" by investing in R&D, among other activities, rather than to develop them in-house by learning from experience.

The special role of manufacturing

Why are capabilities acquired in manufacturing production so important for the successful diffusion of new technologies? Both economic theory and history offer some insights. First, manufacturing processes are highly complex and require widespread use of interdependent sets of machinery, tools and skills. As such, learning opportunities for firms are primarily located within manufacturing.

Moreover, the Fourth Industrial Revolution builds on technologies and organizational principles that evolved in previous revolutions. Looking at technological change through an evolutionary lens suggests that there is significant value in taking part in the industrialization process, even if that might mean starting out without the latest vintage of machinery: industrial development pushes firms to learn, thereby serving as a springboard for the diffusion of newer technologies.

Conclusions

- To fully engage with ADP technologies and move from being users to becoming producers of these technologies, developing and emerging industrial countries need to continually invest in the upgrading of their industrial capabilities.
- Any strategy that aims at integrating into the global economy by skipping the manufacturing stage is likely to deter the widespread diffusion of new technologies than to facilitate it.
- At the micro level, policymakers should pay greater attention to production-related aspects of firms' capabilities. While supporting investment in R&D or training are important, so are other activities, such as exporting, introducing new products and processes or changing managerial practices.

Bibliography and/or suggestions for further reading

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2 See Bogliacino and Codagnone (2019) for the details of this analysis.