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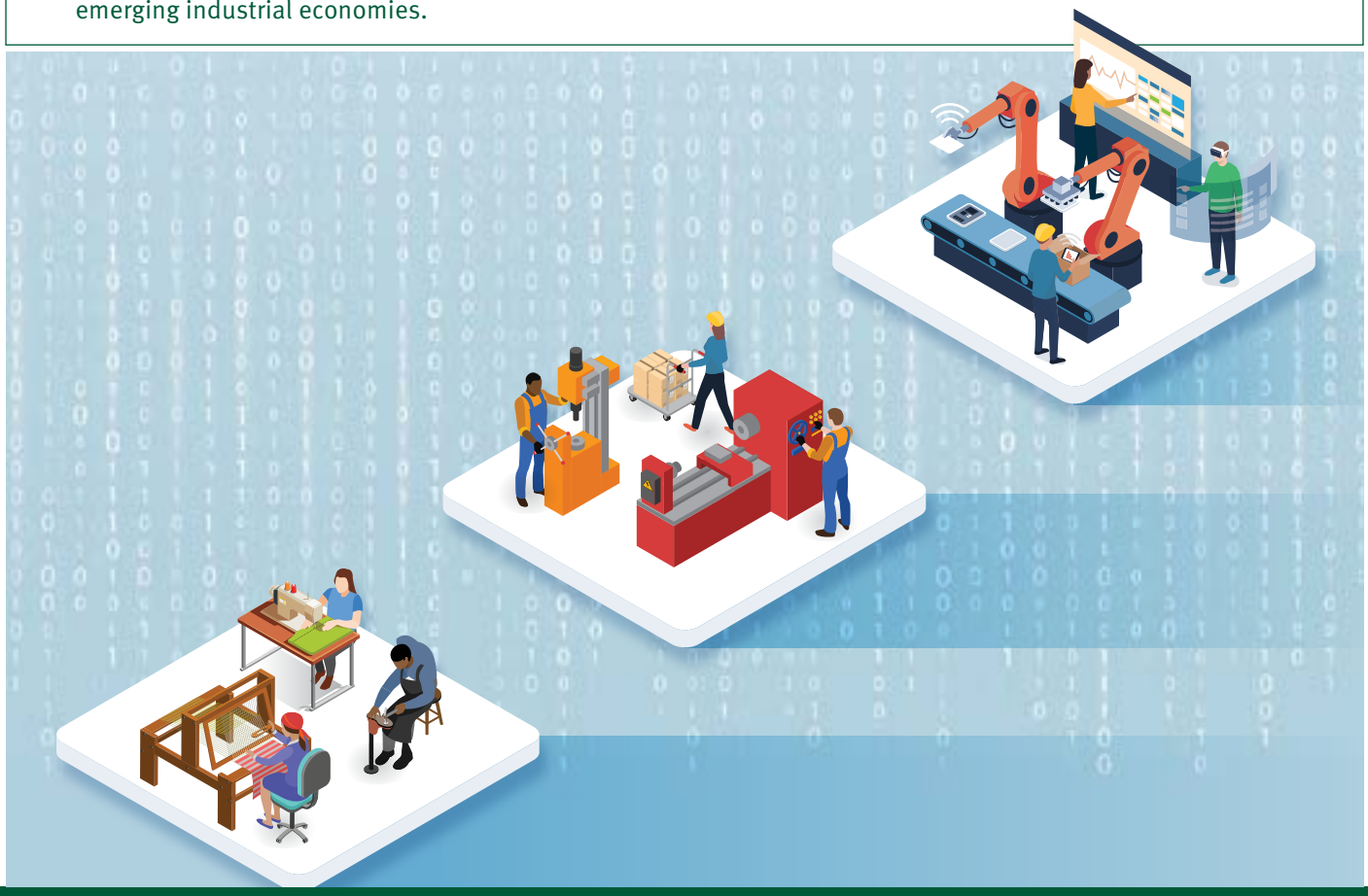
The diffusion of advanced digital production (ADP) technologies: a heterogeneous landscape

Executive summary

The scientific and production capabilities required to engage with ADP technologies are unevenly distributed across the globe. As a result, the diffusion of ADP technologies remains limited, particularly in developing and emerging industrial economies. Yet the use of ADP technologies remains concentrated in a niche of firms and high-technology industries, even in industrialized economies. Technology diffusion to developing and emerging industrial economies is, however, increasing. Participation in international trade and production networks is a key conduit for diffusion of such technologies.

Key findings

- Patenting and exporting activities in the field of ADP technologies are confined to a handful of frontrunner economies. This group accounts for over 90 per cent of the world's patents and 70 per cent of the world's exports in ADP technologies.
- ADP technologies remain the domain of a small niche of firms and industrial sectors, even in frontrunner economies.
- Developing and emerging industrial economies are increasing their adoption of ADP technologies, chiefly through the import of capital goods—such as robots—which embody the new technologies.
- Participation in global value chains (GVCs) is another important driver of technology diffusion in developing and emerging industrial economies.



Scientific and industrial capabilities are unevenly distributed across the globe

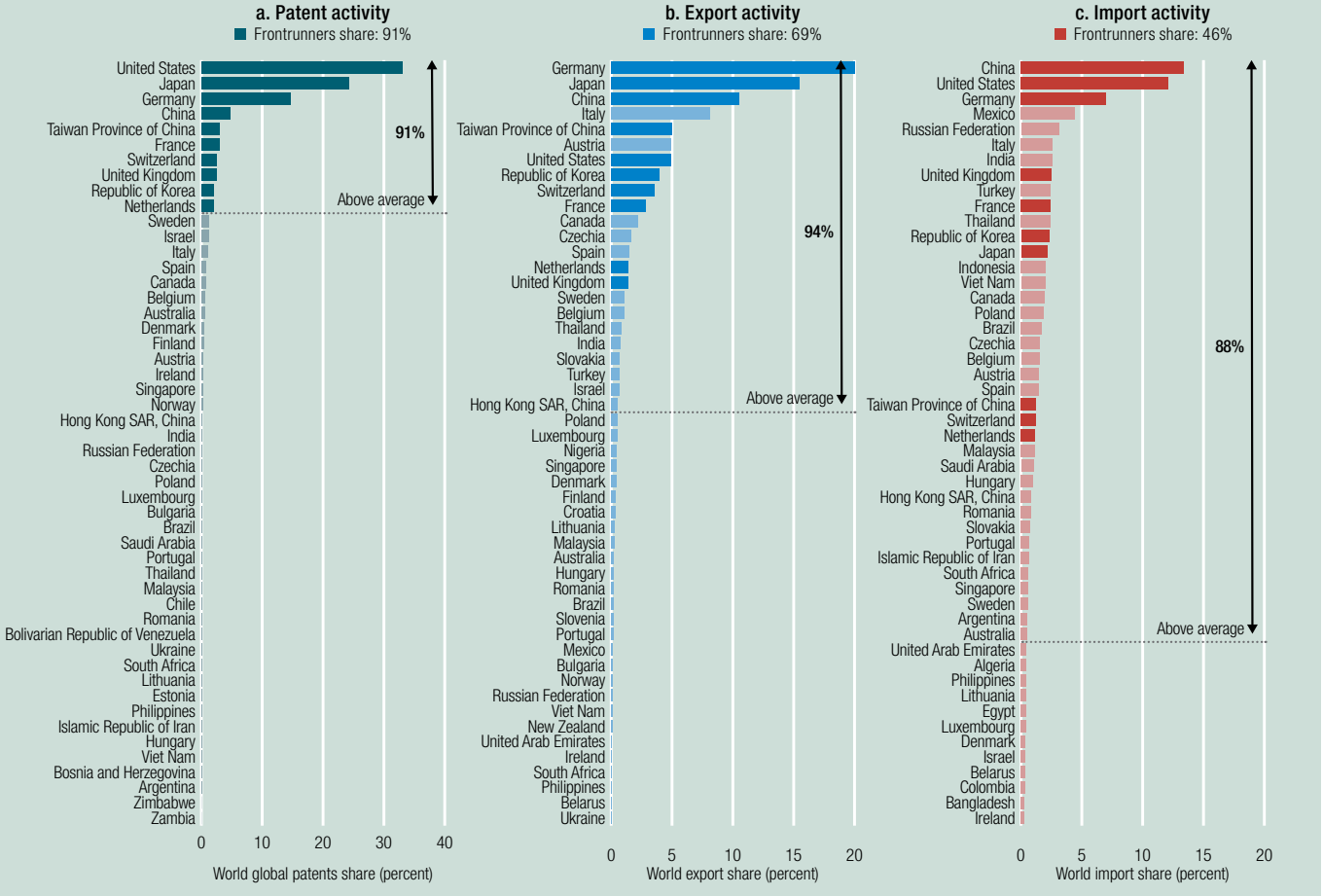
Under the appropriate conditions, the diffusion of advanced digital production (ADP) technologies can generate significant economic, social and environmental benefits in both industrialized and developing economies alike. Yet as has been the case with past technological and industrial revolutions, the emergence of the Fourth Industrial Revolution has witnessed a division of the world economy into frontrunner and follower economies. This is because the scientific and industrial capabilities required to actively engage with ADP technologies are highly concentrated globally.

We can proxy a country's scientific capabilities by looking at the types and number of patents linked to ADP technologies its firms and inventors hold. The IDR 2020 dubs economies whose share of global ADP patents is higher than the average as the frontrunners of the Fourth Industrial Revolution. Above average shares in the world's ADP patents imply that these economies tend to be at the scientific and technological frontier in the development of ADP technologies. Of the 50 economies that hold at least one patent in an ADP technology, only 10 appear to have above average market shares (Figure 1, Panel a).

The exports of capital goods embodying ADP technologies—such as industrial robots or 3D printers—serve as a proxy for countries' production capabilities. Economies whose shares of world exports are above the average possess the capabilities to produce ADP-enabled goods efficiently and competitively and can even sell these goods abroad. The IDR 2020 finds that frontrunners account for over 90 per cent of the world's patents and 70 per cent of global exports in ADP technologies (Figure 1). This means that ADP technologies are almost exclusively patented by frontrunners, and that most global sales of goods associated with these technologies are concentrated in the same group.

While frontrunner economies dominate the invention of ADP technologies and production of capital goods embodying them, their share in global imports is somewhat lower—46 per cent. This implies that developing and emerging industrial economies—many of which are active importers—are increasingly integrating capital goods embodying the new technologies within their manufacturing operations. These economies are followers in the race to the Fourth Industrial Revolution. The rest of the developing countries, however, are lagging far behind in the field of ADP technologies.

Figure 1
The diffusion of ADP technologies remains limited: evidence from patent and trade data



Note: Panel (a) refers to the cumulative number of global patent families in the last 20 years. Global patents are defined as those simultaneously applied for in at least two of the following patent offices: the EPO, the USPTO, the Japan Patent Office and/or the China National Intellectual Property Administration Office. Panels (b) and (c) refer to the average export and import values of capital goods associated with these technologies for 2014-16. The figure only shows the shares of the top 50 performers, but the averages are calculated considering all with non-zero values for each indicator. Source: UNIDO IDR 2020 Figure 1.12, page 48

The diffusion of ADP technologies remains confined to a niche of firms and industries

Micro-level evidence collected by UNIDO and partners through surveys of manufacturing firms in five countries—Argentina, Brazil, Ghana, Thailand, and Viet Nam—corroborates these findings. The surveys provide an up-to-date description of the level of adoption of digital technologies by firms in developing and emerging industrial economies (Box 1).

Box 1. The UNIDO surveys

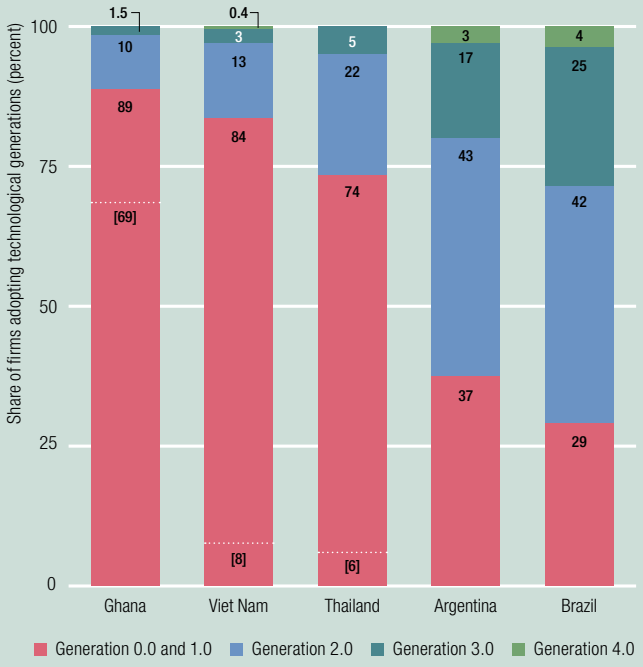
The *UNIDO Surveys on the Adoption of Digital Production Technologies by Industrial Firms* were carried out in 2019 and comprised a representative sample of 658 firms operating in Ghana, Thailand and Viet Nam. They followed an approach pioneered by the Brazilian Confederation of Industry in 2017 , which was also replicated in Argentina during 2018. The surveys represent one of the first systematic attempts at collecting micro-data on the industrial application of ADP technologies in developing and emerging economies.

In the five countries considered, only a small share of firms are already engaging with ADP technologies (associated with digital generations 3.0 and 4.0). This group of firms ranges from about 30 per cent of the sample in Brazil—a country in the follower group—to 1.5 per cent in Ghana, a laggard in the adoption of these technologies (Figure 2).

ADP technologies seem to have only diffused in a niche of firms and industries, even in frontrunner economies, with significant differences remaining in the adoption rates across different types of firms and industrial sectors. In European countries, for instance, the electronics and transport equipment industries are the highest users of cloud computing, 3D printing and industrial robots—at 10-20 percentage points above average—whereas more traditional industries, such as the textile or food manufacturing industries, appear to have below average adoption rates (Figure 3).

Figure 2

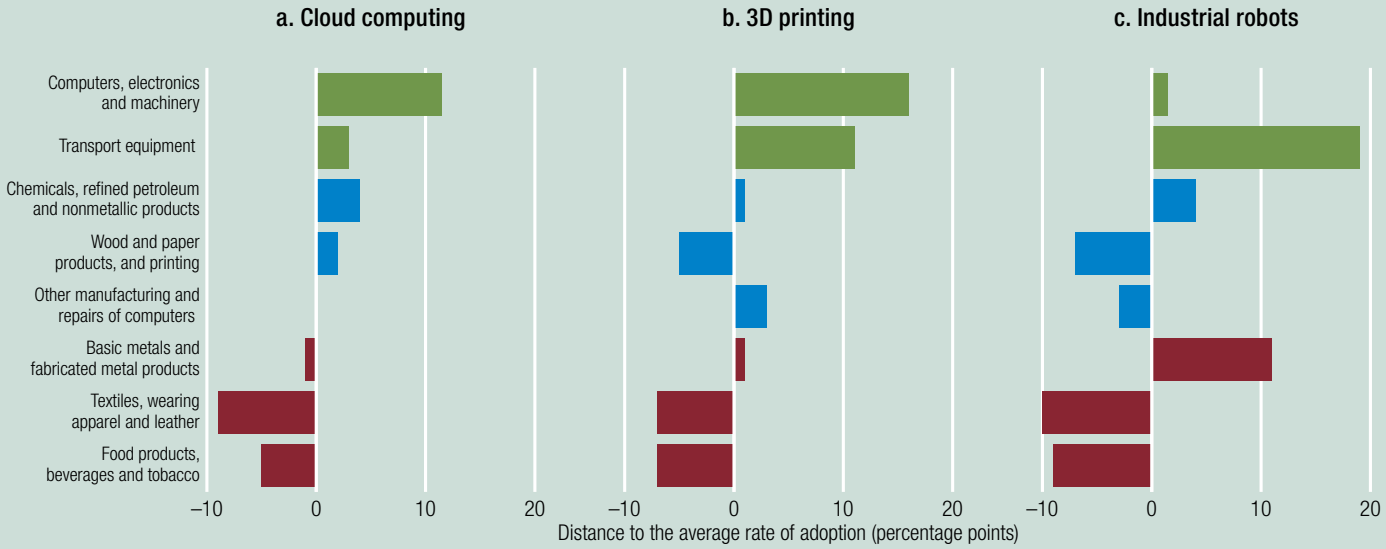
The diffusion of ADP technologies remains limited: firm-level evidence



Note: Numbers in brackets are Generation 0.0 firms. For Argentina and Brazil, no information on Generation 0.0 firms is available due to the structure of the survey questionnaires. Generation 0.0 represents a stage of production that makes no use of digital technologies. Once firms start adopting digital production technologies, four generations are distinguished, characterized by an increasing level of technological prowess. ADP technologies are associated with Generations 3.0 and 4.0. Source: UNIDO IDR 2020 Figure 3.1, page 100.

Figure 3

Even in frontrunner economies, the adoption of ADP technologies remains concentrated in a few industries



Note: The figure shows how the diffusion of key ADP technologies relative to the average rate of adoption across the entire manufacturing sector differs across individual industries. Source: UNIDO IDR 2020 Figure 2.1, page 66.

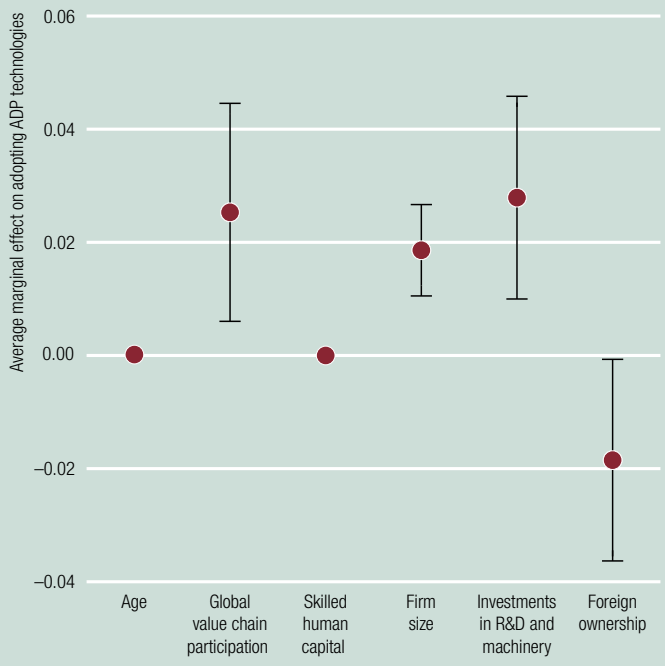
International trade can foster technology diffusion

Building production capabilities and gradually investing in a stronger science base remain a must for developing and emerging industrial economies to bridge the digital capability gap with frontrunners. Industrialization offers a path towards achieving both goals. Another interrelated avenue to stimulate capacity-building and to foster the diffusion of new technologies is to increase one's participation in international trade and production networks. Importing capital goods embodying ADP technologies is one important example in this regard (as shown in Figure 1).

Integration within manufacturing GVCs represents another important opportunity for follower and lagging economies to upgrade their capabilities and enter the technological race on stronger footing. Indeed, the IDR 2020 finds that participation in GVCs is positively and significantly associated with the uptake of ADP technologies at the firm level (Figure 4). This positive association holds when controlling for other drivers of the adoption of new technologies, such as firm size, human capital endowments and investments in R&D and new equipment.

Figure 4

Exposure to global value chains incentivizes the adoption of ADP technologies



Note: The figure reports the average marginal effects and 95 per cent confidence intervals from a probit regression testing the effects of the variables listed on the horizontal axis on the probability that a firm is currently engaging with ADP technologies (using Generations 3.0 or 4.0). Source: UNIDO IDR 2020 Figure 3.4, page 102.

Conclusions

- The diffusion of ADP technologies remains confined to a handful of frontrunner economies and within them, to the firms and industries with the highest levels of technological and production capabilities.
- Manufacturing firms in developing and industrial economies that adopt ADP technologies are in the minority. New evidence collected by UNIDO suggests that there is significant heterogeneity between countries.
- Exposure to international trade and production networks helps firms and countries build stronger production capabilities and upgrade their technology.

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