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ARTICLE



The fourth industrial revolution, changing global value chains and industrial upgrading in emerging economies

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ABSTRACT

The 4IR can open windows of opportunity for emerging economies but also raises red flags in terms of the main challenges that these changes pose to firms, industrial systems and policy approaches. Benefiting from it will not be automatic, as these economies suffer from several gaps that hamper their possibility to operate in a digital industrial landscape. However, with a capable entrepreneurial state, developing economies could use the ongoing uncertain and fast-changing scenario to fast track their development. As partnerships become more relevant for innovations due to technological convergence, competition policies and standards to avoid monopolistic positions and excessive concentration are needed to maintain the space for bottom-up innovation.

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Policy Highlights

- The 4IR can be windows of opportunity for emerging economies but also raise serious challenges in policies and responses.
- Benefiting from the 4IR will not be automatic, as developing economies suffer from several gaps that hamper their possibility to operate in a digital industrial landscape.
- With a capable and forward-looking entrepreneurial state, developing economies could actually use the ongoing uncertain and fast changing scenario to fast track their development.

1. Introduction

While there is an open debate on the magnitude of the impact of digital technologies and the fourth Industrial Revolution (4IR) on industrial organization and on the definition of the current changes as an industrial revolution, comparable in terms of breadth and depth to the previous ones, there is no doubt that the changes in the patterns of value creation and distribution brought about by the diffusion of digital technologies are marking an epochal change in industrial development, opening up opportunities

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previously not available and not imaginable (OECD 2017). A few days ago the press reported about the first molecule invented by Artificial Intelligence (AI) through a partnership between a first-class university research center, a digital start-up, and a leading multinational (Financial Times 2020).

The papers in this special issue focus on industrial upgrading, which is in line with the view, such as the one put forward by UNCTAD, that robot-based automation *per se* does not invalidate the traditional role of industrialization as a development strategy but that in the current landscape the great difficulty remains in attaining sectoral upgrading and productivity growth by making the best use of new technologies (UNCTAD 2017, 50). The papers in this special issue explore the possibility and the conditions under which emerging and developing economies take industry 4.0 and the 4IR as a window of opportunity for upgrading. To do so, developing economies will need, on the one hand, to pay close attention to the dynamics of Industry 4.0 and the 4IR and, on the other hand, to anticipate their potential impact and to take a proactive stance to shape their effect on their economies.

In fact, most of the developing economies suffer gaps that hamper their possibility of embracing the 4IR and realize the potential of Industry 4.0. Developing economies tend to be specialized in producing and trading commodities, suffer from digital connectivity gaps and especially, have a limited knowledge base, and on average, they invest little and much less than advanced countries in R&D and innovation. In addition, their private sector is more risk-averse and contributes little to national innovation efforts. Given this situation, their participation in global value chains will not activate learning processes *per se*, unless targeted policies are put in place.

While export-oriented manufacturing has been a critical part of the catching-up development story in emerging economies, it has also run into trouble as domestic wages rise with products remaining in the low-end segment. Thus, some economies are showing signs of being stuck in the so-called “middle-income trap” (World Bank 2010; Lee 2013). The 4IR is re-writing the rules of manufacturing. Low-cost labour could become a less relevant competitiveness driver, making traditional FDI attraction strategies outdated; growing automation and technological convergence could shift the competitiveness drivers towards new areas such as proximity to market, quality and depth of the science base and effective and trustable digital standards and regulations. These factors could change the opportunities for manufacturing and industrial upgrading in developing economies.

In addition, these changes are happening in a context in which mixed trends are observed with a growing number of companies trying to re-shore manufacturing back to the rich/developed world and exploring new manufacturing locations in cheaper wage-developing economies beyond China. At the same time, the 4IR may open up new windows of opportunity (Perez and Soete 1988) by bringing in diverse forms of disaggregation and disintegration of the manufacturing process (Schwab 2016, 62), which could open up new entry points for latecomers. In sum, the 4IR could be both a new window of opportunity and a further source of difficulties for emerging and developing economies. The final impact will depend on the capacity of these economies to recognise that Industry 4.0 and the 4IR need to assume a prominent role in the definition of their development strategies. It will also be determined by on the policies and partnerships that

these economies will put in place to make a shift from being users and adopters of innovations to becoming innovators themselves.

The articles collected in this special issue aim to answer the following questions: How will the 4IR and Industry 4.0 change GVCs in different parts of the world? What are the “right and dynamic” modes of engaging with GVC in terms of building effective national (or sectoral) innovation systems? How can developing countries and firms respond to the rise of the 4IR and take advantage of it?

Four papers compose this special issue. This Introduction provides an overview of the topic and frames the overall discussion. The four papers provide a comprehensive overview of the ongoing changes in industrial organisation and manufacturing upgrading patterns providing both global and country case evidence. The first paper by Primi and Toselli (2020) takes a global perspective on the meaning of Industry 4.0 for developing countries to provide an updated and comprehensive overview of the issue. The second paper, Lee et al. (2019), conducts case studies of the electronics sector in Penang Malaysia and the auto sector in Thailand with a focus on upgrading into higher ends segment and appropriate responses to the challenges of the 4IR. The third paper by Ferraz et al. (2019) investigates the adoption of digital technologies among Brazilian firms. The final paper by Corrocher, Mavilia, and Giorgio (2018) compares the Industry 4.0 in Germany and Made in China 2025.

2. Globalization 4.0, the 4IR and emerging and developing economies

In January 2019, the World Economic Forum discussed the new global challenges in the era of globalization 4.0 (Schwab 2018). He warned about the three technology-related challenges created by the 4IR to domestic policies and international cooperation, such as (1) urgent ecological constraints, (2) multipolarity of international action, and (3) rising inequality of socio-economic outcomes. He suggested that a proper response to these challenges is “to take back control from global forces and to restore sovereignty in a cooperative world by restoring a new compact between citizens and their leaders in the public and private sectors, so that we may feel more secure enough at home to open up to the world at large” (Schwab 2018).

This issue of globalization has also been present in the innovation system, the GVCs and the development literature. While the innovation system view originally refers to the agents which interact in the production, diffusion and use of new, and economically useful, knowledge at the national, sectoral and firm levels (Lundvall 1992, 2016; Malerba 2002; Lee and Malerba 2017), recently it has stressed the international and global dimensions in innovation systems, by looking at the global extent and interdependence of knowledge, innovation and technology diffusion (Binz and Truffer 2017).

The discussion on innovation systems and their international dimension can be linked to the global value chain (GVCs) literature (Gereffi, Humphrey, and Sturgeon 2005), as supply chains have become global in scope, and more intermediate goods are traded across borders, involving all the newly emerging countries (UNCTAD 2013). A key issue then becomes the possibility of upgrading within GVCs and of activating patterns of learning by operating in complex, global production networks. Based on their studies of firms in Latin America, Giuliani, Pietrobelli, and Rabellotti (2005) conclude that process

or product upgrading has occurred to some extent, but functional upgrading and inter-sectoral upgrading are rare.

Similarly, Pietrobelli and Rabellotti (2011) observe that the GVC approach has paid less attention to how local institutions condition the upgrading opportunities of business activities and pointed out the supplementary role by the Schumpeterian or Innovation System (IS) perspectives. The development literature, mostly in its structuralist and evolutionary streams, has argued that the mastering of knowledge and technology and the relative specialisation with respect to the economic frontier determine the patterns of rent generation and distribution, therefore attributing to the quality, density and dynamism of the production system a prominent role in shaping national development pathways (Prebisch 1950; Nelson and Winter 1982).

The 4IR poses challenges in terms of industrial and labour organisation as well as social norms, rights and responsibilities. From the perspective of emerging or latecomer economies, the challenges from the 4IR would be felt more seriously given their disadvantages in diverse dimensions. Therefore, it is necessary for these economies to devise relevant policy responses. A deeper look at the global trends reveals that few countries, and in practice only some specific areas within them, have been able to benefit from the growing global interconnectedness (Primi and Toselli 2020). Specifically, the challenge for emerging and developing economies is to upgrade into high ends segment of GVCs. This is because merely joining the GVC does not guarantee upgrading (Lee et al. 2018). An economy might be stuck in low-value activities without functional upgrading, causing the so-called middle-income trap (World Bank 2010; Lee 2013). In addition, as the global order changes and as some emerging economies start to accumulate know-how and capabilities, advanced countries have started to feel the pressure of the erosion of their industrial and technological leadership and might change their attitude towards investment, trade and delocalization of production. In fact, one of the major changes that has happened in the global development landscape since the 1990s has been the steady and fast upsurge of China as an emerging global power. The rise of China is redefining the global rules of the game at a time in which digital technologies and the 4IR are expanding, amplifying its potential impact. Moreover, this has a major impact on developing and emerging economies opportunities.

Therefore, the key challenge for emerging and developing economies is to find out the “right and dynamic” mode and ways of participation to GVC, with the long-term goal of building and upgrading own “local chains for value and knowledge creation” thereby leveraging a bigger piece of the pie from the global profit (Lee et al. 2018). Actually, the objective which defines the strategy of entering into a determined value chain has a major impact on subsequent learning and development partners. While participation in the automotive value chain in Mexico was fueled by the need to generate employment, Costa Rica attracted investments in ICT with the objective of entering into production and trade of relatively higher knowledge-intensive activities with respect to its original trade specialization in agricultural commodities (Primi and Toselli 2020). These two different FDI attraction and partnership strategies have engendered different outcomes also because the initial objective was different.

Participating in the GVCs should not be a policy objective but a mean to achieve innovation, upgrading and diversification. In this context, a key indicator for successful integration and upgrading is the degree by which emerging economies increase the

domestic value-added over time from the low domestic value-added when they join the GVC initially. The above discussion leads us to the proposition (Lee et al. 2018) that, while at the initial stage, more integration to the GVC is desirable to learn from foreign sources of knowledge, functional and sectoral upgrading requires an effort or a stage of increasing domestic value-added by seeking a separation and independence from the existing foreign-dominated GVC, and after that stage latecomer firms and economies might have to seek again more opening or integration once they have built their own local value chains. This dynamic sequence of “in-out-in again” would generate a non-linear curve in terms of the degree of participation in the GVC, as measured by FVA (share of foreign value-added in gross exports of an economy).

Actually, in a similar vein, the paper by Primi and Toselli (2020) analyzes how the more interconnected world (with goods and services crossing multiple borders to then be embodied in final outputs to be delivered globally) has redefined not only the geography of trade, investment and production but also the power relationships among different economic systems (Gereffi 2014, 2018; Ahmad and Primi 2017; World Bank 2017). Using the trade in value-added data (OECD/WTO TiVA database), the paper identifies different patterns of participation to GVCs. On the one hand, they identified a group of countries “climbing the ladder” in terms of increasing more proportionally the domestic value-added embodied in foreign exports than the foreign value-added embodied in domestic exports. On the other hand, they identify another group of countries “deepening in assembly” where an increase in foreign value-added embodied in domestic exports increases more proportionally than the domestic value-added embodied in foreign exports.

According to the evidence provided in Figure 2 of Primi and Toselli (2020), China has been able to climb the ladder in three industries (textile, automotive and electronics), by increasing more proportionally the domestic value-added embodied in foreign imports than the foreign value-added embodied in domestic exports. This contrasts with Mexico whose two main sectors – automotive and electronics – belong to the deepening in assembly group. Mexico faces in fact the middle-income trap risk and has not capitalized enough on its participation to GVCs. Thailand is somewhat a mixed case in that its sectors are diverse and show up in both groups.

This observation makes sense, given that per capita GDP levels of China, relative to that of the US, has been increasing very sharply, while Mexico is falling behind. Thailand occupies an intermediate position as its GDP per capita has been slowly increasing; Malaysia, on its turn, is going beyond the middle-income trap and its GDP per capita has already reached 45% of the US level (see Figure 1–1 in Lee 2019). We can conclude, therefore, that, given its income level at 30% compared with that of the US, Thailand still falls within the trap range (20% to 40% of the US) but it has progressed steadily over the last decades without experiencing a decline as several Latin American economies did. For instance, in the early 1980s, Mexico’s income level was as high as 44% compared with that of the US, but it declined to less than 35% in 2015 despite (or owing to) the NAFTA or free trade with the US (the same figure as the above).

Thus, the overall picture is that, with the exception of China, few developing economies have been capable to associate this upgrading and increased participation in global production networks to processes of homegrown branding and creation of leading multinationals (Primi and Toselli 2020). In fact, most of the increased participation of

developing economies to global value chains took place through increased absorption of foreign technology, capital and knowledge, therefore resulting in processes of deepening in assembly functions, associated with little, when not absent, home-grown branding creation processes (as in the case of automotive in Mexico and electronics in Vietnam).

This observation does not necessarily mean that emerging economies have no hope – there are stories of promising upgrading. When countries put in place effective strategies for learning and upgrading these processes can be kicked off in developing economies, and can deliver positive results. In fact, the paper in this special issue by Lee et al. (2019) examines the cases of electronics sector in Malaysia and auto sector in Thailand in terms of achieving some upgrading into higher ends segment for higher productivity and sound response to the challenges of the 4IR or Industry 4.0. They show that the 4IR can be a blessing (window of opportunity) for countries like Malaysia and Thailand that are facing labor shortages in that FDI firms may introduce factory automation (smart factory) or other labor-saving technologies that can be used toward the road of upgrading into higher segments with local spillovers.

In both cases, a key factor for this positive scenario is the existence of local institutions that enabled training and upskilling of their local force, with early start and long history going back to the 1960s or 1970s. In Penang (the hub of electronics sector in Malaysia) these institutions include the PSCD, a not-for-profit institution to provide technical knowledge, training program to engineers, and the CREST which hosts multinationals and local firms, universities, and research institutes. In the auto cluster in Thailand, the corresponding institutions include the AHRDP, a collaboration between Thailand and Japanese firms and public agencies to train workers and engineers in auto part manufacturers. Moreover, Thailand has the TAI (Thailand Automotive Institute), a sector-specific promotional and intermediary agency that aims to strengthen cooperation among key actors and enhance the competitiveness of the industry. Nonetheless, realizing the 4IR's opportunity side is not automatic. The Thai automotive sector is facing the challenge of attracting new FDI in related electronic technologies and upgrading local suppliers to produce technologically sophisticated parts in next-generation cars, such as electric cars.

In addition, the overall situation in Southeast Asia is promising, compared to other parts of the world. South East Asia, with its growing industrialization, is the region that reduced extreme poverty the most decreasing its incidence 15 times in the last three decades. The countries in this region have been able, among other factors, to deploy national strategies for industrialization, catching up and innovation; they have set up effective regional integration mechanisms, and they have attracted increasingly high-quality FDI. These countries have shifted their specialization towards manufacturing, nurtured a domestic entrepreneurial class, and now host a multi-polar – Japan, Korea, China – regional industrial landscape where competition and diversification co-exist with specialization in new paradigms, mostly electronics, automotive and digital technologies (see Figure 4 in Primi and Toselli 2020).

Thus, we can say that whether the 4IR can be a new window of opportunity or a source for further risk for the middle-income trap of the emerging economies depends on each country's responses and readiness, including digital literacy, skill and educational level compared with wage rates, population structure, domestic market size, and position in the GVC, as well as on the defined and implemented industrial development strategy.¹ If

emerging economies invest more, and more effectively, in innovation and in strengthening their knowledge base, they could activate learning processes and even leapfrog traditional industrial pathways into emerging 4IR industries. This is what is happening now in China, as shown by Corrocher, Mavilia, and Giorgio (2018) in this issue. The article compares China and Germany and their mutual cooperation, focusing on the two national strategies for innovation, namely the German Industry 4.0 and China's Made in China 2025 plan.

The authors find that the Chinese innovation system is centralized with numerous mission-oriented policy sub-systems; among them, the most important ones are knowledge and innovation, defence-related innovation, regional innovation, social networking and the science and technology agency service system. Currently, China is working to broaden its industrial base, develop knowledge absorption capacity and move to high-tech and higher value-added activities. Compared to Germany's Industry 4.0, Made in China 2025 is broader in scope and includes a more structured implementation phase. Its main goal is to transform China globally from being a manufacturing country to being a manufacturing giant. Made in China includes five main projects related to the construction of manufacturing innovation centres, smart manufacturing projects, manufacturing base strengthening projects, green manufacturing projects and high-end equipment innovation projects.

Corrocher, Mavilia, and Giorgio (2018) confirm some signs for success in that there is an increased number of Chinese firms and inventors applying for patents to the European Patent Office, in particular an increased number of applications in fourth industrial revolution related International Patent Classes (IPC). They also show increasing collaboration between German and Chinese scholars and the consequent increase in the number of co-authored scientific articles in the fields related to Industry 4.0. It could be argued that while third Industrial Revolution was a window of opportunity for Korea and Taiwan to leapfrog into digital consumer goods, the 4IR could be opening up such window for China.

While China is exploiting the opportunities offered by the 4IR, success stories from other parts of the world, such as Latin America, do exist, but they do not go yet beyond the level of anecdotes and remain scantily visible at the aggregate level. The article by Ferraz et al. (2019) in this issue provide a snapshot of the situation in Brazil. The authors show that Brazilian firms in 2017 only display a basic digitalization level and that when looking at 2027, around 60% of the surveyed firms expects to move forward, to face a future where advanced digital solutions are perceived to prevail especially along GVCs. Nevertheless, a substantive group of firms do not share similar visions and are not taking any actions to build their future; they either lack knowledge about how contributions in advanced digital devices can potentially bring about advantages for their products and markets or believe in their survival with less advanced technical solutions (Ferraz et al. 2019).

So, what determines the firms' response to the challenges associated with the 4IR? Ferraz et al. (2019) in this issue confirm with regression analysis that it is not the structural characteristics of the firms, such as size and sectors, but their level of capabilities that determines whether firms are more ready to adopt digitalization. The higher the level of firm capabilities, the more likely or eager firms adopt digitalization. In their study, firm capabilities are measured by the level of human capital. This finding opens a

promising avenue in the sense that small, competent, firms (and not necessarily big firms) can grow bigger if they take advantage of the new trend of digitalization as a window of opportunity.

This finding is consistent with similar results in Malaysia and Thailand studied in Lee et al. (2019) in this special issue. This confirms the relevance of the innovation and sectoral system approach and its emphases on learning and capability accumulation. Regardless of their capital ownership from advanced, emerging or developing economies, the more capable firms are the ones that are readier and better equipped to adopt digitalization and are the ones that respond better to the changing technological environment. These however also means that we could be facing increasing divergence rather than convergence within and between firms and emerging and developing economies in the future. This possibility of divergence rather than convergence is also a call for policy intervention toward the lagging firms and lagging sectors.²

3. Policy issues and challenges

While the key innovative agents and the protagonists of innovation and upgrading remain the industrial firms, in a context of major and fast new technological changes and of economic and technology uncertainty, the quality, density and dynamism of the innovation system is a major determinant and the quality of public policies is paramount in determining firms' responses and performances. Firms are not monads and especially in digitally connected production systems, their performance is shaped by several exogenous factors, including national and international standards and targeted innovation, trade and industrial policies. However, "moving targets" constitute a major policy challenge (Freeman 1987). To overcome them, it is essential that policies rely on incentives and schemes capable of signaling the risks and success probabilities.

This special issue provides evidence that the capabilities and the behavioral features of firms should remain a central feature of policy design and implementation. A fertile ground for learning happens when the domestic economy has a clear strategy and targeted effort to build local capabilities, in terms of skills, regulations and institutions (Reinert 2008; Lee 2019; Ang 2016). An economy like this builds effective institutions over time and allows processes for public and private sector learning in its development path.

Furthermore, innovations in the 4IR require new forms of public policy and public-private and business to business and business to consumer partnerships. The comprehensiveness and across-the-board nature of the 4IR require policy response from multi-ministries with the coordination of the prime minister's office. Only with proper responses emerging and developing economies can realize their potentials. Moreover, the responses should be timely because the negative impacts of the 4IR can happen earlier than expected, such as in assembly jobs and Business Process Outsourcing (BPO) jobs and could have higher impacts than simple job losses, locking out countries from future learning trajectories. The 4IR is already disrupting and reshape GVCs, and the new forms of insertion into the new GVC may not necessarily be at firm but at individual level. In this light, education and training are crucial. Integration of the labor market at the multilateral level is also desirable, along with the promotion of startups by young

entrepreneurs through information dissemination about successful role models and cases.

Policies also need to factor in the changing nature of globalization. While Schwab (2018) stresses that domestic policies should not be subject to the forces of global market forces, ensuring an effective policy space is getting more difficult, which is a new challenge for emerging countries. There is some argument for the need to take not a national but a global innovation system perspective, in which global interdependencies and international links are taken into account (Binz and Truffer 2017).

For instance, we face a tough question of whether we should keep encouraging scaling-up of the domestic startup or allow them to be acquired by multinationals (MNCs), like Google or Amazon. This is indeed a major dilemma because whereas Mergers and Acquisition (M&A) is an effective exit option for startups, these companies may not remain as independent companies in local economies after the acquisition. They may be even closed after the M&A in view of potential competition against the existing businesses by MNCs. In other words, if startups keep growing locally, one may expect more local value-chains, spillovers and local jobs, but often their growth is limited. On the contrary, if an M&A takes place, a more monopolistic situation in market structures may take place.

A related issue is the potential risk of growing concentration and increasing monopoly power of some of the global platform providers, like Google, Face and Amazon. While they represent digitalization of the GVCs and provide a less-costly outlet for many commodities produced by SMEs and startups, there is an increasing concern over their market power (Schwab 2018), especially as core value shifts from tangible outputs to data and related services. For mobile game companies, these mobile app platform owners tend to charge as much as 30% of the revenues as a fee. So, the concern is that such a high fee is actually rents rather than normal profits (Mazzucato 2018).

Thus, while digitalization of GVCs reduced the former monopoly power of brand owners against the Original Equipment Manufacturers (OEM), firms from emerging economies doing business online now face a new kind of market power by platform owners. This means the continuation, but in different forms, of global competition for a bigger pie among the participants of GVCs located at the different tiers of the chain. Overall, this implies the difficulty in understanding and separating the impact of globalization versus the innovations associated with the 4IR.

In addition, in an Industry 4.0 landscape firms will increasingly bundle their traditional outputs (e.g. products and services) into value-options based on data (which will be a new source of revenues) and experiences (e.g. Amazon, world leader in book-sales online, owns physical bookstores with differentiated prices in store and online). This trend will determine that the core value, i.e. those activities that firms need to control to maintain leadership and control of the value chain, could increasingly shift from R&D and design to ownership of platform and integrated systems. Power and positioning in networks could become more important in terms of value generation than investments in innovation. This is not necessarily a positive trend, as it could determine a reduction in breakthrough innovations, as profitability from managing platforms could offset the innovation payoff (Primi and Toselli 2020).

4. Conclusions

The four papers of this Special Issue and this Introduction clarify that the 4IR and Industry 4.0 can be windows of opportunity for developing and emerging economies but also raise red flags in terms of the main challenges that these changes pose to developing and emerging economies firms, industrial systems and policy approaches. Benefiting from them will not be automatic, as developing economies suffer from several gaps that hamper their possibility to operate in a digital industrial landscape. However, with a capable and forward-looking entrepreneurial state, developing economies could actually use the ongoing uncertain and fast-changing scenario to fast track their development.

A major novelty with respect to the past, which the four papers show in different ways, is that as partnerships become more relevant for innovations due to technological convergence, competition policies and standards to avoid monopolistic positions and excessive concentration are needed to maintain the space for bottom-up innovation.

To do so, developing and emerging economies will need to manage complex policy agenda, ranging from skill development and infrastructure, through standards, intellectual property and taxation. Investing in strengthening domestic firms' capabilities and implementing policies to foster learning and capabilities accumulation in national innovation systems remain crucial building blocks of industrialization strategies and in successful participation and upgrading in GVCs, even in an Industry 4.0 landscape.

Notes

1. Importance of education and training has also been pointed out as an important factor that determines the impact of the adoption of AI (artificial intelligence) on job replacement. Clifton, Gray, and Glasmeier (2020) observed that even in the same sector the less-educated workers are more vulnerable to the effects of automation.
2. Ferraz et al. (2019) also find across-sector difference in the readiness toward digitalization.

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