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The role of industrial policies in the BRICS economic integration process

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The role of industrial policies in the BRICS economic integration process

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Abstract

This paper discusses industrial policy in BRICS. It contributes to the literature in three ways. First, by approaching BRICS as a single entity, it documents the gradual buy-in to the concept of BRICS by the participating countries and their efforts to strengthen collaboration, including on industrial development matters. Second, it corroborates that differences in individual development paths influence the expected contribution of each member to advancing a joint industrial development agenda, while it is too early to dismiss their ability to consolidate themselves as a major player in global economic dynamics. Third, BRICS's response to the Fourth Industrial Revolution builds on their traditional proactive approach to industrial policy, while their expected collective collaboration with third-party regions, particularly Africa, reflects cumulative interests at the individual country level.

Keywords: BRICS, integration, industrial policy, industrial development; Fourth Industrial Revolution, Africa

1. Introduction

This paper discusses industrial policies in BRICS (Brazil, Russia, India, China and South Africa). The discussion corroborates that the emergence of systems of innovation and the dynamics of industrial development and structural change in BRICS cannot be explained without considering the active role of their national governments, which have supported specific sectors, industries and even firms to rise from national champions to major global manufacturing and technological players (Vértesy, 2011; Scerri and Lastres, 2013; Kahn, Martins de Melo, and Pessoa de Matos, 2014). This active industrial policy approach is likely to continue both at the individual and collective level.

This paper takes previous research on the BRICS--where the notion of BRICS is used as a reference point to analyse individual country experiences and to derive commonalities as well as differences in the policy models followed by the individual members--one step further (Di Maio, 2015; Brigante Deorsola et al., 2017). It explores how the BRICS's approach has been endorsed by the respective countries and the efforts they have undertaken to strengthen integration and collaboration. Industrial development, in general, and industrial policy, in particular, are relatively recent, yet already integral components in the BRICS's integration process.

The analysis also sheds light on the extent to which the recent industrial performance of each BRICS member influences its participation in group dynamics. Differences in the industrial development paths of the BRICS countries suggest widening industrialization gaps, with China increasingly differentiating itself from the rest. This is likely to raise tensions in the integration process. Looking to the future, this paper explores how the BRICS are responding to the opportunities and challenges associated with the Fourth Industrial Revolution (4IR) (Schwab, 2016; Hallward-Driemeier and Nayyar, 2017). This new wave of technological change has the potential to alter industrial leadership, affecting the prospects and conditions for catching up and forging ahead (Liu et al., 2017; Lee et al., 2019).

Lastly, we introduce an international dimension, looking into BRICS's interaction with third-party countries and regions. While each BRICS country is a recognized economic and political powerhouse in their respective geographical region, the African continent seems to represent a place of convergence for all of them.

2. The tradition of industrial policy in the BRICS

One common denominator among the BRICS countries is that recent industrial performance has accompanied processes of sustained capability accumulation and continuous policy reforms to underpin substantive economic and institutional transformations. These experiences lend support to those who advocate active public policy interventions as the basis for industrialization, including conditions for resource mobilization, and more generally, for social and economic agents to thrive.

Cimoli, Dosi, and Stiglitz (2009: 2) argue that as "intrinsic fundamental ingredients of all development processes", industrial policies encompass interventions across multiple policy domains (Di Maio, 2015; Stiglitz, 2017):

- Science, technology and innovation—including intellectual property rights (IPRs);
- Trade policies;
- Policies to foster demand for manufacturing, including public procurement;
- Policies to attract foreign direct investment (FDI) and other financial resources;
- Policies to foster the development of specific industries—including but not limited to the promotion of infant industries; and
- Competition policies and regulation, among others.

Several of these policy domains have been integral components since the end of World War II of each of the BRICS's industrial policy programmes. In addition to direct contributions to the establishment of domestic systems of innovation (Scerri and Lastres, 2013), BRICS governments have promoted the articulation of industrial policies together with innovation, education and other policies to underpin technological and productive capability building. Hence, interlinkages across distinct policy domains have been instrumental for the industrial development trajectories of the BRICS countries (Di Maio, 2015; Liu et al., 2017; Dominguez Lacasa et al., 2019). This interplay is characteristic of co-evolutionary processes whereby investments in science, technology and innovation (STI) capabilities, on the one hand, and industrialization and structural change, on the other, have fed—or failed to feed—on each other over time (Nelson, 1994; Scerri and Lastres, 2013).

The scope of industrial policies has varied over time and across countries in accordance with changes in the prevailing needs and conditions of sectors, industries or firms. External influences on the role of government more generally and on industrial policy in particular, are important in fostering development. Periods of strong government intervention—import substitution, for example—alternate with more liberal approaches—inspired largely by the Washington Consensus—towards the rule of markets in the economy.

BRICS have actively used trade policies in the early stages of industrialization. According to Andreff (2015), unlike Brazil and India, where outward FDI policies mainly serve economic purposes, China and Russia's FDI policies target foreign policy, diplomacy and even state ideology goals. Andreff also points out that the larger share of state-owned companies (SOCs) among Chinese and Russian multinationals means tighter state controls over corporate strategic decisions.

One constant across the board, however, is support for national champion firms, including through direct investment or the creation of SOCs which ultimately take the lead in the development of specific industrial sectors, encouraging them to become major global manufacturing and technological players (Rodriguez-Arango and Gonzalez-Perez, 2016; Santiago, 2015; Liu et al., 2017; Di Maio, 2015). Interventions to assist domestic champions to weather the effects of global economic crises or shocks in relevant markets for their products or services (Simachev et al., 2014; Vértesy, 2011), or the mobilization of national banks and SOCs to leverage private investments in strategic sectors or activities are also common (Di Maio, 2015; Simachev et al., 2014).

BRICS's support for champion firms remains debatable. Cui, Jiao and Jiao (2016) argue that firms in the BRICS tend to show a lower probability of engaging in innovation due to the comparatively high government ownership in the countries; they have strong incentives to capitalize on monopoly positions and protection, while their willingness to tackle emerging market opportunities through entrepreneurship and to engage in innovation is low. Liu et al. (2017) illustrate this using the case of innovation in the growing online payment business, which is often associated with booming e-commerce in China. While none of the four largest state-owned banks was willing to develop such a system, the Alibaba Group took the initiative to develop Alipay, which has developed into a world-renowned model since its launch in 2004.

Turning our attention to individual country experiences, Di Maio (2015) finds that in the case of Brazil, setting aside controversies over the results of the period of import substitution (1950s–1980s), the government undertook great efforts to enhance domestic technological capabilities and economic diversification during those years. The Brazilian government actively guided the direction and pace of industrialization, often as a direct investor and owner/manager of firms (Di Maio, 2015). After the collapse of the import-substitution model during the 1990s, disappointment with the active industrial policies led the Brazilian government—like those of other Latin American countries—to endorse a programme of economic reforms inspired by the Washington Consensus (Di Maio, 2015). This period was characterized by the dismantling of trade barriers, the widespread privatization of publicly owned assets, efforts to restructure the economy and a generalized opening of domestic markets to multinationals. More recently, although the focus on structural change has faded, the government's involvement in industrial development and capability building continues, with an emphasis on STI, support to small and medium-size enterprises (SMEs) and the promotion of clusters and investment in specific sectors, for example, automobiles (Di Maio, 2015).

Russia has had some difficulties managing the transition towards a market-driven economy, inspired mainly by the Washington Consensus, and the corresponding hiatus in the government's ability to implement active industrial policy during the 1990s (Di Maio, 2015). One structural characteristic is the severe lack of transparency in state–business interactions in Russia and the capture of industrial policymaking by lobbyists and interest groups with differing views on how to govern industrial policy implementation (Simachev et al., 2014). In recent years, Di Maio (2015) has noted a "slide to the past", with growing participation of the Russian government in economic activities. State control of a large share of the country's productive assets is characteristic of the current economic model, which is heavily influenced by an industrial policy oriented towards fostering import substitution, employment and a selective and tightly controlled FDI policy. At the same time, Simachev et al. (2014) assert that over the last decade or so, Russia has sought to harmonize its industrial policy with STI policy as the basis for economic diversification, the development of technology-driven sectors and continued growth; this is taking place amidst a slightly adverse international environment and a heavy burden imposed by political affairs at home and abroad. In 2017, the Russian government introduced an ambitious digital economy programme, which aims to foster the institutional structure and infrastructure necessary for digitalization and the use of data at a large scale to increase competitiveness, economic growth and sovereignty (Government of the Russian Federation, 2017).

Similar to the other BRICS, India's rapid industrialization began with an import-substitution model adopted by the newly independent country in the early 1950s. Its industrial development has been guided by five-year plans, giving the Indian government considerable leverage to intervene in economic matters, including the identification of areas suitable for state monopoly and those that private investors could participate in (Di Maio, 2015). The breakdown of the import-substitution model and the ensuing reforms of the early 1990s granted greater freedom to private investors and expanded the scope of partnerships with external economic agents by reducing controls on FDI, allowing foreign majority ownership and facilitating technology transfers. Liberalization and privatization of manufacturing are tangible in the structure of India's manufacturing sector today. The country's specialization in information and communication technologies (ICTs) benefited from accumulated investments in education and research institutions, including several private sector-run initiatives, which also contributes to explaining the rapid expansion of services (Di Maio, 2015). Lee (2019a) argues that this expansion has mostly come at the expense of agriculture, while the share of manufacturing in total GDP remains constant. This process, led by three giants, Infosys, Tata Consultancy Services (TCS) and Wipro, suggests that India bypassed the stage of manufacturing-led growth, leapfrogged into service-led growth and then reversed to promote manufacturing (Lee, 2019a).

China's outstanding industrial and economic performance coincides with an ambitious period of economic reforms that began during the 1970s. The country's leadership has been committed to giving markets greater weight, without, however, renouncing active government influence and guiding of the economic system. This pragmatic approach to industrial policy has prevailed since the 1980s. China has supported structural transformation towards a market-driven economy, combined with heavily selective support, including FDI and compulsory—including coercive—technology transfer to strategic activities and sectors (Di Maio, 2015; Santiago, 2015). Investments have been made in large infrastructure projects; providing physical and digital infrastructure has been a priority, particularly over the last 20–25 years (Liu et al., 2017); and preferential credit and fiscal treatment has in particular been given to manufacturing and non-agricultural raw materials. China is inching closer to or has already reached the end of a rapid catching-up phase (Liu et al., 2017; Tourk and Marsh, 2016). China has moved away from top-down approaches to industrial development, and is increasingly falling under the rules of the markets, private entrepreneurship and distinct institutional conditions for economic agents to operate (Liu et al., 2017; OECD, 2017).

In South Africa, the democratic transition that commenced in 1994 immediately led to efforts to reinsert the country into the international community. The new leadership committed to dismantling industrial policies characteristic of the apartheid regime, including a large privatization programme. In parallel, the government adopted the Black Empowerment Programme to redress profound inequalities in access to skills, employment and economic opportunities for black South Africans. Accession to the WTO and the signing of free trade agreements with the EU and the Southern African Development Community (SADC) signalled the government's intention to promote the internationalization of large domestic firms, particularly in mining (Di Maio, 2015). The evidence suggests that the positive income effects associated with this modernization programme may have started to wear off, as the country's industrial competitiveness seems to be stagnating. Industrial policy measures are also facing difficulties in boosting exports and diversifying manufacturing (Di Maio, 2015). In recent years, the orientation of post-apartheid industrial policies has shifted towards an emphasis on skills and innovation, and from a sectoral focus to a functional approach (Di Maio, 2015).

Taking account of this heterogeneous past engagement of the BRICS countries with industrial policies, how can the recent emergence of the BRICS as a novel political and economic entity within the global landscape be explained?

3. To BRICS or not to BRICS

The literature, particularly from a political science perspective, documents debates on the epistemological, methodological and geopolitical underpinnings of the BRICS, and the implications of the term for the rest of the world, particularly for least developed regions. Considering the immense heterogeneity that characterizes the BRICS, is the term a valid geopolitical configuration? What are the strengths and limitations of the study of the BRICS as an academic undertaking? Are the BRICS a legitimate alternative to contemporary global, Western-dominated economic and political governance, or is it merely an extension thereof? (Gray and Murphy, 2013; Gray and Gills, 2017; Mittelman, 2016).

While addressing these debates goes beyond the scope of this paper, in what follows we offer food for thought from an industrial policy perspective. Notwithstanding the efforts undertaken at the highest possible political level towards a common BRICS development agenda, differences in recent individual industrial performances have given rise to tensions in the BRICS integration process.

3.1 From BRIC to BRICS

Jim O'Neill and his colleagues at Goldman Sachs published several papers from 2001onwards coining the acronym 'BRIC' to acknowledge the growing power and influence of the large and dynamic economies of Brazil, Russia, India and China on global political and economic dynamics (O'Neill, 2001, 2018; O'Neill, Wilson and Purushothaman, 2005). Wilson and Purushothaman (2003) argue that given the pace of their GDP growth, income per capita and currency movements, the BRIC could become a major driver of the world economy by 2050. They could overtake several G6 economies—G7 minus Canada—in US dollar terms by 2025 (Wilson and Purushothaman, 2003). The changed geography of the ten largest economies in the world in GDP terms would result in a more complex and more diversified scenario (Wilson and Purushothaman, 2003).

O'Neill (2001) advocated an "upgraded"[1] G7—the United States, Japan, United Kingdom, Germany, France, Italy and Canada—to include the BRIC, or at least some of them, granting them a stronger say in global policymaking. While China appeared a natural candidate, the potential influence of the other three was undeniable, on par with Canada or Italy. At the same time, O'Neill cautiously speculated whether the BRIC would want to integrate and embrace their potential counterbalancing role in global economic and political affairs (O'Neill, 2001, 2018). After several informal meetings, the first formal meeting of the BRIC's foreign ministers took place at Russia's initiative in Yekaterinburg, Russia on 18 May 2008. The first summit of the BRIC's heads of state followed in Yekaterinburg in June 2009. The induction of South Africa in 2011 expanded the group to form the BRICS as we know it today (BRICS, 2011). Since then, the BRICS countries have sought to tighten collaboration in mutually beneficial ways.

Today, BRICS cooperation mechanisms include annual summits, convening the heads of state of each member country, the most recent taking place in Brasilia in November 2019. Various meetings on specific topics involve representatives from different public, private and academic organizations. Meetings are regularly held as side events of meetings at multilateral organizations such as the United Nations, the G20 or the Bretton Woods Institutions. Several expert working groups contribute to a broader collaboration agenda (BRICS, 2019).

[1] Emphasis in the original by the author.

3.2 BRICS to build an economic block?

Economic collaboration among BRICS evolved gradually. Framed against the global financial and economic crises, negotiations at the early leaders' summits centred on financial, trade and sustainable growth issues (BRIC, 2009, 2010). As interactions intensified and diversified, largely influenced by individual approaches to industrial and other related policies, the agenda began to incorporate broader STI issues—including IPRs—employment creation, connectivity and ICT, and a framework for BRICS e-commerce cooperation.

At the end of the Fortaleza Meeting in 2014, the BRICS leaders agreed to develop a BRICS Economic Cooperation Strategy and a Framework of BRICS Closer Economic Partnership (BRICS, 2014). The former was adopted at the Ufa Summit (BRICS, 2015a) and, together with the BRICS Action Plan on Economic and Trade Cooperation (BRICS, 2015b, 2017a), guides actions intended to strengthen economic collaboration. Progress in the implementation of the Strategy for the BRICS Economic Partnership is reviewed every five years or earlier as necessary (BRICS, 2015b, 2017a).

The BRICS Economic Cooperation Strategy establishes guidelines to increase, expand and promote intra-trade and investment, manufacturing and minerals processing, energy, STI, connectivity and ICT, among others (BRICS, 2015b). The Action Plan calls for joint economic- and trade-related initiatives, including on industrial and technical upgrading, to foster economic complementarity and diversification (BRICS, 2017a). It also targets a reduction in the digital divide and the associated economic and social implications both within and beyond the BRICS. Collaboration on e-commerce should contribute to industrial development and inclusive growth in the BRICS and elsewhere (BRICS, 2017a).

A similarly incremental approach characterizes the BRICS's search for collaboration on industrial development and industrial policy. These topics were absent from the joint statements at the first two BRIC leaders' summits. The term 'industrialization' appeared for the first time in the Sanya Declaration of 2011, in reference to the BRICS's interest in supporting industrialization in Africa (BRICS, 2011). The associated action plan proposed cooperation in pharmaceuticals as part of STI collaboration (BRICS, 2011).

The term 'manufacturing' appeared in the Strategy for the BRICS Economic Partnership at the 7th BRICS leaders' meeting in 2015. The Strategy acknowledges the significant contribution of manufacturing to structural change, the creation of quality jobs and economic growth (BRICS, 2015b). The joint agenda proposes expanding manufacturing and minerals processing (BRICS, 2015a) and fostering industries such as mining and metals, chemicals and petrochemicals. BRICS

is committed to intensifying industrial production capabilities and promoting industrial parks and clusters, technology parks and engineering centres; similarly, they support specialized training for engineering and technical personnel and managers, while encouraging innovation and the development of high-tech industries (BRICS, 2015a, 2015b).

Investment in railways, roads, ports and airports is also envisaged. At the 2018 BRICS leaders' summit in Johannesburg, energy efficiency was recognized as a factor conditioning the achievement of economic targets, such as industrial competitiveness, economic growth, job creation and environmental sustainability (BRICS, 2018). Advancing collaboration in the ocean economy, including through coastal industrial zone development, is also on the agenda (BRICS, 2018).

3.3 Industrial policy coordination

The launch of the BRICS Industry Ministers Meetings institutionalized collaboration on industrial development and industrial policy matters. The first meeting took place in Moscow in 2015 under the Russian presidency (BRICS Industry Ministers, 2015). Intra-BRICS cooperation expects to boost trade and sustainable economic growth, strengthen comprehensive industrial ties, promote technology transfer and innovation, and improve investment climates and job creation (BRICS Industry Ministers, 2015). Joint training and skill development programmes have been proposed, as well as common research and business opportunities in several broadly defined industrial areas (BRICS Industry Ministers, 2015).

The scope of collaboration was subsequently refined with the adoption of a seven-point Action Plan at the end of the second ministerial meeting in Hangzhou, China (BRICS Industry Ministers, 2017). The Action Plan acknowledges the emergence of 4IR and two other major transformations in global manufacturing: the increasing interdependence of manufacturing and manufacturing-related services, with the latter increasingly driving economic development; and the transformational power of concepts such as digitalization, networking and "intellectualization", and their significance for production and business models with the potential to create new industries (BRICS Industry Ministers, 2017). The Action Plan reaffirms the BRICS's commitment to enhance collaboration in industrial capacity building, SME development, industrial policy coordination, standards, development of new industrial infrastructure and technology- and innovation-related projects.

Collaboration in industrial policy matters involves the UN system, for example, the United Nations Industrial Development Organization (UNIDO), to establish the BRICS Consolidated Technology Platform, with a mandate to boost cooperation in the upgrading and/or development of new high-tech engineering industries and innovation, and in the development of capital goods and machinery related to manufacturing and minerals processing (BRICS, 2017c; BRICS Industry Ministers, 2017).

In line with the BRICS's longstanding tradition of supporting large firms, the eThekwini Declaration encourages existing SOCs to explore cooperation and to exchange information and best practices (BRICS, 2013). Simultaneously, each country's ministries and the agency responsible for local SMEs are exploring opportunities to collaborate, particularly in international trade, innovation and joint R&D (BRICS, 2013).

The BRICS approach to collaboration is consistent with individual traditions of creating interdependence and complementarity between industrial policies and other policy areas. This recurs in several of the declarations and action plans across different policy areas. Common interests include technology transfer, support for joint research agendas, intention to leverage on initiatives around training, skilling and upskilling, firm registration and other crosscutting or horizontal policy interventions. Successful integration of different policy areas into a single BRICS industrial development programme should have major implications for manufacturing development in each individual BRICS.

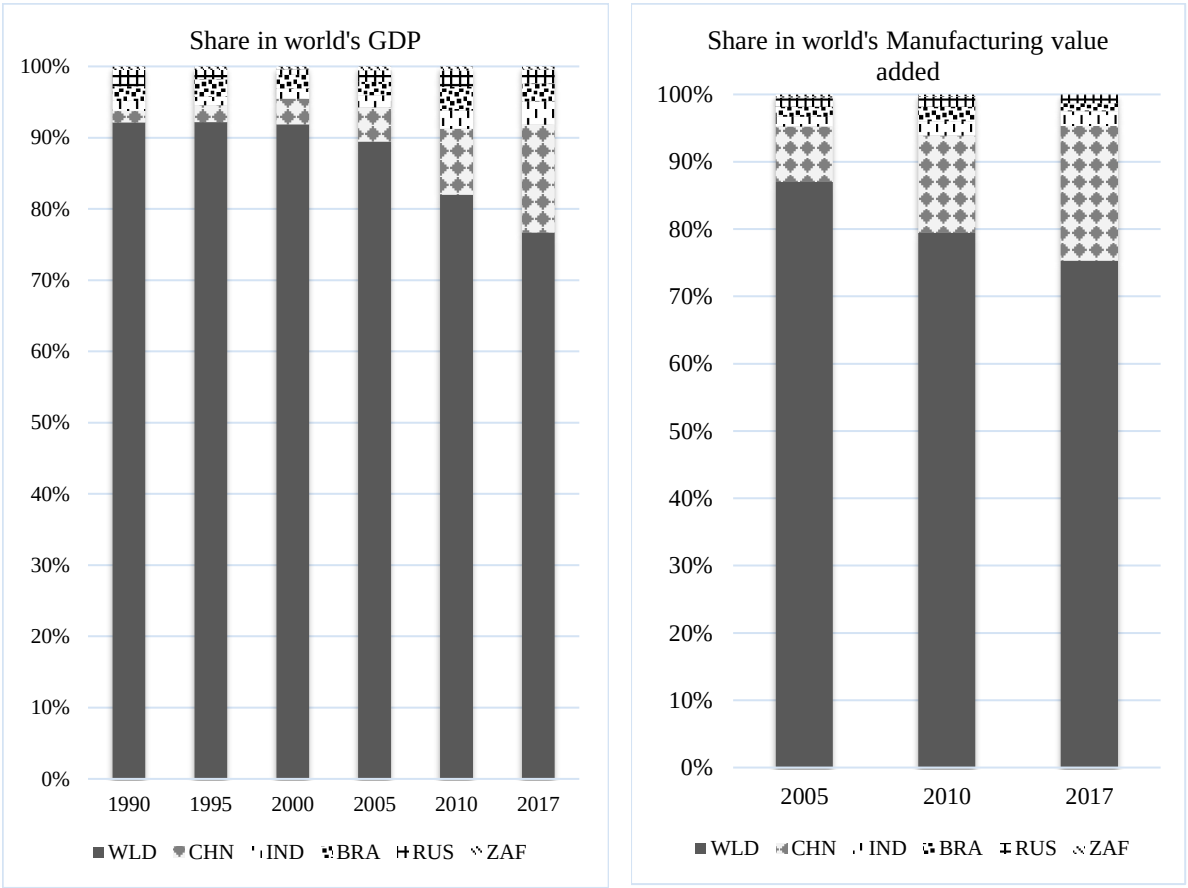
4. The challenge of heterogeneous industrial performances

The ability of the BRICS to overcome their distinct individual economic, political and social conditions and traditions, and to collectively contribute to global economic and political checks and balances is subject to debate. Degaut and Meachan (2015), Di Maio (2015) and Dominguez Lacasa et al. (2019) perceive BRICS as a heterogeneous collection of industrial upgrading models, each of them with distinct perspectives and approaches to the accumulation of technological, productive and other capabilities. However, as discussed below, China's dominance in the group dynamic poses major challenges to BRICS integration. Kejin (2014) argues that with Chinese choices and capabilities continuing to frame the scope of cooperation, attempts to enhance economic cooperation and build consensus are encountering difficulties.

4.1 Contribution to global economic activity

The BRICS's growing global economic significance is evident (Figure 1). In 2017, they represented 23.3 per cent of global GDP, a three-fold increase compared to 1990 (7.9 per cent). Similarly, they contributed about one-third of total global manufacturing value added in 2017. Despite this enhanced collective presence, the individual shares are heterogeneous. China largely drives the dynamics in terms of both total GDP and manufacturing value added, although its rate of expansion has receded slightly in recent years. The most dramatic gains appear in manufacturing value added. Within one decade, China's contribution rose from around 10 per cent (2005) to about 25 per cent of the world total in 2017. The shares of the rest of the BRICS are either growing less rapidly (India), are stagnant (Russia and Brazil) or are shrinking (South Africa). India's share in both GDP and manufacturing value added has overtaken that of Brazil and Russia. Differences in individual contributions to both the group and global economic dynamics will most likely continue to deepen in the short run (Mbele, 2018).

Figure 1: BRICS's growing but heterogeneous contributions to global economic dynamics



Source: Author based on World Bank Development Indicators.

The BRICS's export performance over the period 2005–15 further illustrates the heterogeneity within the group. China has experienced the largest and fastest growing share of manufacturing in total exports. Brazil has recorded a steady increase in the share of exports of agricultural and mining products and, to a lesser extent, services. In Russia and South Africa, manufacturing exports are giving way to mining and services, while services account for 44 per cent of India's exports.

The short-term dynamics should conform to Mbele (2018), who describes the BRICS's growth trajectories as singling out distinct subgroups. China will continue to upgrade its position in global supply chains, consolidating itself as a major global manufacturing centre and boosting the country's share in manufacturing exports within the BRICS and from the BRICS to the world. Brazil, Russia and South Africa, in turn, could consolidate themselves as exporters of natural resource-based products, while India continues to bounce between being a manufacturing- and a predominantly services-based economy (Amirapu and Subramanian, 2015).

4.2 Structural change and capabilities accumulation

Industrial development implies structural change, or the transformation from traditional agriculture or natural resource-based economies to economies led by increasingly complex manufacturing activities (Haraguchi, Cheng and Smeets, 2017). There are multiple dimensions to structural change: technological, industrial and organizational. It involves deliberate and decisive efforts to learn and accumulate different capabilities (UNIDO, 2005, 2002). Liu et al. (2017) argue that building innovation capabilities is a precondition to overcoming the middle income trap; they assert that a lack of capabilities—more so than political institutions—may be the most significant binding constraint for middle-income countries.

Countries achieve productive and technological upgrading by balancing different framework conditions to support capabilities to absorb and use different kinds of knowledge, to mobilize investments and to accumulate the necessary capital to undertake structural change (Abramovitz, 1986), to catch up and eventually leapfrog. At least two kinds of capability accumulation processes exist (Lee, 2019b). First is the accumulation of production capabilities, which refers to the accumulation of advanced physical capital and the associated human capital required to run productive facilities at given levels of efficiency. Second, innovation capabilities assist economic agents in mastering and changing the technology they already use, eventually allowing them to develop new technology. They also help latecomers close the gap to the technological frontier and, under certain conditions, seek to overtake incumbents and assume leadership to advance the technological frontier (Lee and Malerba, 2017). By tapping into emerging market opportunities,

for example, through exports, latecomers can reduce their dependence on global value chains, gradually capturing market shares and increasing domestic value addition (Lee, 2019b).

However, because capability building is path dependent, it may constrain the ability to identify and capture emerging windows of opportunity to advance upgrading (Lee and Malerba, 2017) and limit the flexibility to accommodate changes in technological and productive trajectories (Abramovitz, 1986). Globalization and international conventions around IPRs also restrict the scope of technology transfer and limit the possibilities of imitating and reproducing technologies through R&D (Dominguez Lacasa et al., 2019; Lee, 2019a). Latecomers should focus on developing small but incremental innovations while avoiding confrontation with incumbents and their IPRs (Hobday, Rush and Bessant, 2004).

Productive capabilities

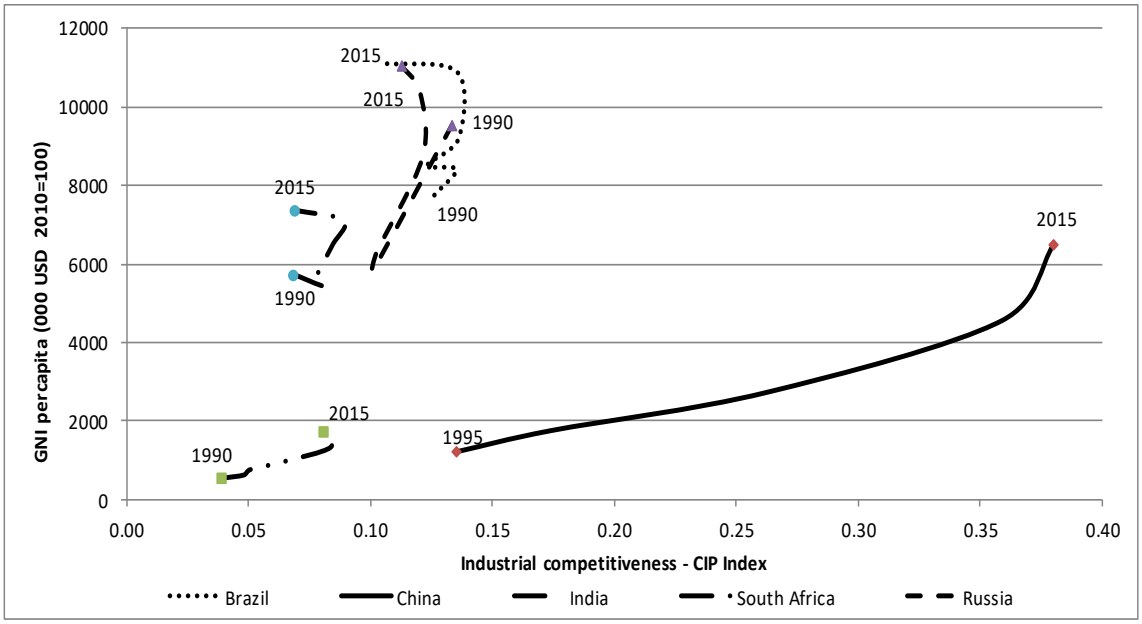
Compared to other developing countries and on account of a process broadly described as economic modernization, BRICS's productive competencies tend to feature greater technological content and complexity relative to peer countries. Moreover, each of the BRICS hosts several of the largest and most important multinational firms in the developing world (Rodriguez-Arango and Gonzalez-Perez, 2016; Andreff, 2015). Several of those firms are coming closer to, or have already attained, global leadership in areas traditionally reserved for firms from highly industrialized countries, including aerospace, transport, pharmaceuticals and advanced ICT applications (Daudt and Willcox, 2016; Santiago, 2015).

Modernization does not suffice, however, to achieve long-term sustainability and growth (Cimoli, Dosi and Stiglitz, 2009). Notwithstanding progress in specific sectors or individual firms, the BRICS's economic structures have yet to achieve sustainable catching up. They face overexposure to external shocks and risk dependence on external technology suppliers; moreover, differences in their endowments, technological progress and integration in global flows of trade and investment remain significant (Di Maio, 2015).

Figure 2 illustrates these points. It plots the industrial and economic performance of each of the BRICS over the last 20–25 years along two dimensions. First, the x-axis plots long-term industrial performance as measured by each individual country's score on UNIDO's Competitive Industrial Performance Index (CIPIndex), which benchmarks a country's ability to competitively produce and export manufactured goods (UNIDO, 2019, Annex 1). The index helps identify the occurrence of structural change towards high value added technology-intensive industrial sectors, and to assess the impact of a country's industrial production on the world market. Second, the y-

axis plots the value of gross national income (GNI) per capita measured in constant US dollars of 2010.

Figure 2: BRICS structural change and catching up, 1990-2015



Notes:[1]Constant thousand USD (2010=100), [2]CIP Index. The earliest date available for CIPIndex for China is 1995.
Source: Authors based on the UNIDO CIP database and World Bank Development Indicators.

The performance of the BRICS is heterogeneous. China stands out as it has managed to combine and sustain structural change with a rapid expansion in GNI per capita. According to CIPIndex scores, China's increased industrial competitiveness was primarily fuelled by a rapid expansion in its ability to generate manufacturing value added and a strong export-led growth model that seems to have reached a tipping point (Tourk and Marsh, 2016). Over a period of two decades, China's positive industrial performance has been accompanied by a five-fold increase in GNI per capita.

By contrast, the CIPIndex scores of Russia, Brazil and South Africa suggest processes of gradual industrial recession; in the best case scenario, these countries are stuck in a period of industrial stagnation. Russia, in particular, is slowly recovering from the negative effects of the end of the Soviet era on industrial competitiveness. While GNI per capita continues to grow, albeit at a slower pace relative to China, the country's CIPIndex score remained constant for most of the 1990–2015 period. Similar conclusions apply to Brazil, although the drop in the country's CIPIndex ranking seems to have accelerated throughout the 2010s. By contrast, South Africa's gains in income per capita have rarely been accompanied by improvements in its industrial competitiveness. This results from the country's weak production skills and digital infrastructure, poor access to finance and high energy costs, while firms that have addressed these challenges

have continuously upgraded their capabilities by investing in innovative technologies (UNIDO, 2020). Finally, India registered much steadier growth in terms of both industrial competitiveness and GNI per capita, but from a much lower base relative to South Africa, Brazil or Russia. Overall, the data show that China is rapidly closing the gap in terms of GNI per capita compared to the other BRICS while it has forged ahead in terms of industrial competitiveness.

Innovation capabilities

Dominguez Lacasa et al. (2019) argue that innovation, broadly defined as a process that includes but is not limited to R&D, lies at the core of technological upgrading. While improvements in infrastructure and the institutional environment have generally enhanced innovation in the BRICS, particularly in China, their innovation performance remains modest relative to that of developed countries (Franco and Oliveira, 2017). Innovation performance corroborates the very distinct development paths followed by the individual BRICS countries.

Building on patent data to study technological upgrading in the BRICS over the period 1980–2015, Dominguez Lacasa et al. (2019) propose a statistical framework that distinguishes between three interrelated dimensions: 1) the intensity of technology upgrading, 2) structural change and 3) global interaction. The authors find multiple unique paths of technology upgrading in the BRICS, with differences across the three dimensions. Generally, the BRICS's innovation capabilities have increased, while they reduced their dependence on foreign actors and external knowledge transfer in order to catch up. They have progressively developed the ability to carry out technological frontier-pushing activities – with the sole exception of Russia. As a result, the structure of technological knowledge—measured by the share of high-tech and knowledge-intensive patent applications—has increased across countries (Dominguez Lacasa et al., 2019). China and Russia are the only two countries to have expanded, or at least kept the intensity of behind-the-frontier technological activities constant. China is unique in this regard, as it has rapidly enhanced its innovation capabilities, diversified technology knowledge bases and entered dynamic frontier-pushing areas. The country promotes structural change and global interactions towards technological frontier-expanding activities—a process that according to Dominguez Lacasa et al. (2019), emulates the Republic of Korea or Taiwan Republic of China during earlier periods of technological upgrading and catching up. By contrast, foreign knowledge still tends to crowd out domestic behind-the-frontier technological efforts in Brazil, India and South Africa.

Massive R&D investments are evidence of China's strong commitment to the building of productive and particularly technological capabilities relative to other BRICS. In 2011, China became the world's second largest investor in R&D in terms of volume, second only to the United States (UIS, 2019). While China still ranks behind most developed countries in GDP terms, it tends to outperform the other BRICS (Table 1). R&D funding and the execution structure show that business enterprises account for about 75 per cent, a structure similar to that of advanced countries and in stark contrast with the general situation of government-driven R&D in most other BRICS and in developing countries.

Table 1: Benchmarking R&D investment in the BRICS, 2015

		By business enterprises	
	GERD/GDP (%)	% total GERD	% GDP
Brazil	1.34	--	
China	2.06	76.8	1.58
India	0.62	43.6	0.27
Russian Federation	1.10	59.2	0.65
South Africa	0.80	42.7	0.34

Source: (UIS, 2019)

4.3 Integration through trade and investment

Integration through value addition incorporated in manufacturing exports within the BRICS has grown steadily over the past decade, but bilateral relationships are rather mixed (Table 2). With the exception of China, and to a lesser extent Russia, the BRICS have enhanced their backward integration with others in the group. For instance, the share of value addition of Brazilian manufacturing exports originating from the BRICS grew from 1.2 per cent in 2005 to 2.7 per cent in 2015. The figures for India and South Africa are more noteworthy, from 3.2 per cent to 5.2 per cent and from 2.1 per cent to 6.9 per cent, respectively. These two countries show the strongest level of backward linkages with other BRICS. At less than 1.5 per cent, Chinese exports registered the lowest level of backward integration

Table 2: Composition of gross manufacturing exports by country of origin of value added, 2005-2015

	2005	2010	2015	2005	2010	2015	2005	2010	2015	2005	2010	2015	2005	2010	2015
	Brazil			China			India			Russia			South Africa		
Brazil	----	----	----	0.3	0.6	0.4	0.2	0.4	0.4	0.2	0.2	0.1	0.3	0.4	0.7
China	0.6	1.1	2.0	----	----	----	1.5	2.7	3.7	0.7	1.8	2.0	1.2	2.2	4.7
India	0.2	0.3	0.3	0.4	0.4	0.3	----	----	----	0.1	0.2	0.2	0.4	0.7	1.1
Russia	0.3	0.3	0.3	0.8	0.6	0.5	0.8	0.9	0.6	----	----	----	0.2	0.3	0.4
South Africa	0.1	0.1	0.1	0.2	0.3	0.2	0.7	0.8	0.5	0.1	0.2	0.1	----	----	----
Domestic value added	86.3	86.9	83.8	71.6	77.4	81.3	74.8	66.5	72.7	85.9	86.3	85.9	77.8	76.1	70.1
BRICS[1]	1.2	1.8	2.7	1.7	1.9	1.4	3.2	4.8	5.2	1.1	2.4	2.4	2.1	3.6	6.9
Rest of the world	12.5	11.4	13.4	26.7	20.9	17.4	21.9	28.7	22.0	13.1	11.4	11.7	20.0	20.3	23.0

Notes: BRICS minus the specific member country reporting exports

Source: Author based on OECD's Trade in Value Added (TiVA) database. http://oe.cd/tiva.

The situation is less straightforward if we consider the industry of the value-added origin in each of the BRICS's manufacturing exports (Table 3). Generally, Chinese manufacturing value added contributes 50 per cent or more of other BRICS's manufacturing exports. By contrast, with the exception of India, which contributes about 39.5 per cent to Chinese manufacturing exports, the rest of the BRICS have seen declining shares of local manufacturing value addition in Chinese manufacturing exports. In 2015, the figures were 19.9 per cent for Brazil, 22.5 per cent for Russia and 15.3 per cent for South Africa. Long-term trends show a decline in the intra-BRICS value-added content of Chinese manufacturing exports, with mining and quarrying products representing the main input to Chinese manufacturing exports. While South African exports tend to incorporate a more significant share of manufacturing inputs from other BRICS, mining and quarrying products are the main source of South African value added incorporated in other BRICS manufacturing exports. This intra-BRICS pattern of trade is likely to continue influencing the bargaining power of individual members, particularly vis-à-vis China.

Table 3: BRICS integration through trade, by main sector of origin of value added incorporated in final exports

	Exporter														
	Brazil			**China**			**India**			**Russian Federation**			**South Africa**		
Source of value addition	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
World	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry and fishing	7.6	7.9	7.0	4.7	3.8	4.1	10.7	9.2	8.7	1.7	1.7	2.6	1.6	2.6	2.1
Mining and quarrying	8.3	7.6	6.0	8.8	10.8	7.4	15.4	20.9	13.6	10.6	11.1	14.1	21.0	23.7	20.9
Manufacturing	51.8	48.2	46.5	58.5	57.9	55.8	47.2	43.8	49.5	60.5	54.2	51.1	49.1	42.6	43.7
Electricity, gas, water supply, sewerage, waste and remediation services	3.8	3.6	3.4	3.9	3.0	3.0	3.4	2.8	3.0	4.1	5.4	4.2	2.0	3.1	4.2
Total services*	28.5	32.6	37.1	24.2	24.4	29.7	23.3	23.4	25.2	23.2	27.6	28.1	26.3	28.0	29.1
Brazil	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry and fishing	8.3	8.7	7.8	8.7	5.8	13.1	3.2	2.3	3.6	12.1	11.7	13.0	4.7	5.0	3.8
Mining and quarrying	5.6	5.0	3.7	26.6	45.6	25.9	23.9	42.5	23.4	12.4	19.2	8.1	8.3	15.1	9.2
Manufacturing	54.6	50.6	49.2	27.5	15.1	19.9	33.1	18.4	27.6	35.7	26.6	30.0	46.4	35.2	38.1
Electricity, gas, water supply, sewerage, waste and remediation services	3.9	3.8	3.6	4.4	2.7	2.8	4.3	2.9	4.2	4.2	3.4	3.3	4.2	3.5	5.3
Total services*	27.5	32.0	35.7	32.7	30.8	38.2	35.6	33.9	41.2	35.7	39.1	45.6	36.4	41.2	43.6
China (People's Republic of)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry and fishing	5.0	4.6	4.2	5.9	4.4	4.6	4.4	3.4	4.1	5.9	4.0	4.9	4.5	4.0	3.9
Mining and quarrying	10.1	10.4	6.5	7.0	7.0	5.0	15.1	12.4	7.6	14.5	10.7	6.2	9.1	8.5	6.3
Manufacturing	56.4	56.4	53.2	64.2	64.1	58.9	51.9	55.7	52.1	51.3	56.2	52.2	57.4	57.4	53.0
Electricity, gas, water supply, sewerage, waste and remediation services	5.0	3.9	3.7	4.5	3.2	3.2	5.6	4.1	4.1	6.0	3.9	3.8	5.1	3.5	3.7
Total services*	23.4	24.8	32.4	18.4	21.2	28.3	22.9	24.4	32.1	22.3	25.2	32.9	23.8	26.4	33.1

	Exporter														
	Brazil			**China**			**India**			**Russian Federation**			**South Africa**		
Source of value addition	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
India	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry and fishing	8.3	11.0	5.9	5.8	7.0	7.1	13.8	13.1	11.3	10.8	9.2	9.0	8.6	7.8	5.5
Mining and quarrying	14.0	11.7	7.3	25.2	25.8	6.1	6.9	8.6	5.3	8.4	9.2	4.7	7.9	9.9	6.8
Manufacturing	41.1	40.5	44.2	25.0	25.0	39.5	54.3	54.0	57.4	36.6	36.2	38.6	45.1	43.6	49.6
Electricity, gas, water supply, sewerage, waste and remediation services	3.6	2.6	2.9	4.4	3.1	2.9	3.7	2.9	3.1	3.4	2.6	2.6	3.6	2.7	3.0
Total services*	33.0	34.2	39.7	39.6	39.1	44.4	21.3	21.3	22.9	40.8	42.7	45.1	34.8	36.0	35.1
Russian Federation	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry and fishing	1.6	1.2	1.4	9.7	4.9	3.0	1.2	1.0	1.3	1.5	1.5	2.4	1.6	1.1	2.8
Mining and quarrying	23.5	20.5	22.5	18.1	22.3	34.5	13.7	19.6	21.8	9.8	11.0	14.0	26.6	26.3	20.1
Manufacturing	38.4	37.3	36.0	34.8	30.2	22.5	48.9	38.1	36.7	64.2	56.6	53.4	33.9	29.8	36.9
Electricity, gas, water supply, sewerage, waste and remediation services	4.0	5.2	4.7	3.5	4.7	3.8	4.6	5.8	5.2	4.2	5.7	4.4	3.7	4.8	4.9
Total services*	32.6	35.8	35.4	33.9	37.9	36.1	31.5	35.5	35.1	20.2	25.2	25.7	34.1	38.1	35.2
South Africa	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry and fishing	0.7	1.1	1.1	0.5	0.7	0.9	0.4	0.6	0.5	2.6	1.7	5.5	1.6	2.7	2.0
Mining and quarrying	37.5	42.6	39.1	48.7	58.3	48.5	37.7	48.9	54.4	32.1	59.5	40.8	20.0	22.5	18.8
Manufacturing	30.9	23.0	21.4	22.4	12.3	15.3	32.7	20.0	12.0	32.1	10.5	16.6	52.9	45.7	47.1
Electricity, gas, water supply, sewerage, waste and remediation services	2.0	3.6	5.0	2.0	3.1	5.4	2.1	3.7	5.0	2.0	2.9	4.9	1.9	3.3	4.9
Total services*	28.9	29.7	33.3	26.4	25.8	29.9	27.2	26.8	28.0	31.2	25.4	32.2	23.6	25.9	27.1

Source: Author based on OECD's Trade in Value Added (TiVA) database. http://oe.cd/tiva.

The BRICS have emerged as both major destinations and sources of FDI. In 2018, they represented 20 per cent of FDI inflows and around 10 per cent of the inward FDI stock in the world (UNCTAD, 2019). Despite this growing importance at the global level, and notwithstanding the positive growth trends in intra-BRICS FDI in the early 2000s (UNCTAD, 2013), the level of integration within the group remains low (Table 4). The strongest linkages appear in inward FDI stock from China to South Africa (5.0 per cent), followed by Russia (1.6 per cent), while the share of South Africa and Russia in Chinese inward FDI stock is considerably lower. South African investments in India (1.2 per cent) stand out compared to the rest of the BRICS, which generally show very limited integration; individual shares hardly exceed 0.3 per cent of total inward FDI stocks in each individual BRICS. Overall, South Africa is the country with the largest share of inward FDI stocks from the BRICS (5.7 per cent), followed by India (2.3 per cent) and Russia (2.0 per cent). The data also corroborate that circular FDI flows (round-tripping) are of greatest importance for China and Russia. Andreff (2015) attributes this to the tradition of BRICS's multinationals targeting tax havens or, in the case of China, benefiting from the favourable tax conditions offered to foreign investors in mainland China.

Table 4: UNCTAD FDI estimates by ultimate investor, share in inward FDI stock, 2017

	Recipient				
Investor	Brazil	China	India	Russia	South Africa
Brazil	0.0	0.1	0.0	0.0	0.0
China	0.7	7.8	0.8	1.6	5.0
India	0.1	0.2	1.6	0.3	0.4
Russia	0.2	0.3	0.3	6.5	0.2
South Africa	0.1	0.5	1.2	0.1	0.1
BRICS	1.1	1.1	2.3	2.0	5.7

Notes*:* UNCTAD estimates for 108 recipient countries, corresponding to 93% of the value of global inward FDI stock. Details in *Transnational Corporations,* vol. 26(1), pages 109-146.

Source: UNCTAD (2019).

The low level of integration through FDI can largely be explained by the BRICS's multinationals predominantly market-seeking strategy, which reflects a preference for investing in regional value chains—including through trans-border mergers and acquisitions—and in tax havens or markets in (tax-friendly) developed countries (UNCTAD, 2013; Andreff, 2015). China, and to a lesser extent Russia, show a stronger inclination to diversify geographically, including to developing regions – notably Africa and in the case of China, also to Latin America (Andreff, 2015).

According to Andreff (2015), BRICS's investment in developed countries mainly takes the shape of mergers and acquisitions rather than greenfield investments. Regarding sectoral composition, the evidence suggests resource-seeking behaviour with relevant shares in primary sector activities, followed by services in overall outward FDI.

5. BRICS and the 4IR

An analysis of patent and trade data conducted by UNIDO (2020) involving the advanced digital technologies usually associated with the 4IR—industrial Internet of Things, big data analytics, advanced robotics, artificial intelligence, cloud computing and additive manufacturing—characterizes the global landscape of production and the use of those new technologies. About 167 economies were divided into four distinct groups according to their level of engagement with the new technologies.

Looking at the BRICS, only China made it to the frontrunners' group, which includes the top ten countries—mostly developed—in terms of innovation in advanced digital production technologies. These economies account for more than 90 per cent of all patent applications and about 70 per cent of the exports of goods associated with these technologies (UNIDO, 2020). The other four BRICS appear in the follower group, economies that actively engage with new technologies, producing and selling in international markets, but to a much lesser extent than the frontrunners. Some differences persist within this group. While Brazil, Russia and India appear as producers and exporters of 4IR technologies, South Africa mainly remains a user—importer—of such technologies (UNIDO, 2020).[2]

Lee et al. (2019) explore to what extent the 4IR represents a window of opportunity for upgrading or whether, on the contrary, this process will likely reinforce a country's risk of becoming stuck in the middle income trap. Similar questions influence strategic thinking and policymaking within the BRICS, and efforts are already underway towards establishing a joint BRICS 4IR development agenda. The emerging evidence suggests that each country is positioning itself differently depending on its individual industrial development trajectory and approach to industrial policy.

Generally, the BRICS are among the few developing countries where a dedicated strategy, or at the very least, some explicit policy efforts, are geared towards addressing the 4IR (UNIDO, 2020; Santiago, 2018). The BRICS aspire to build innovation-driven economies, moving away from

[2] The classification further includes a group of latecomers, economies with marginal patent or trade activity in this field, but which have already engaged with 4IR technologies. Finally, a larger group of laggards includes economies with no or very low engagement with these technologies (UNIDO, 2020).

commodities and traditional industrial products and shifting increasingly towards higher value-added sectors. China, in particular, is steadily moving towards industrial development strategies that seek to capitalize on the country's increasing ability to reproduce and produce new technologies; the search for value addition and enhanced technological content is superseding traditional cost advantage strategies (Li, 2017).

Similar to the case of advanced countries, the BRICS's national 4IR strategies are a blend of policy realms and approaches, including industrial policies (China and South Africa), STI plans (Brazil and South Africa), digitalization strategies (Russia), national digital agendas (China) or standalone documents using such terms as 'Industry 4.0' and 'advanced manufacturing', or referring to specific technologies (UNIDO, 2020). South Africa exemplifies the latter approach, as it has recently introduced a strategy that builds on additive manufacturing (CSIR and DST, 2016). India, in turn, is leveraging on existing industrial development plans, such as 'Make in India', strengthening linkages to the digitalization of industry.

One interesting feature of 4IR is its ability to underscore the need for novel approaches to strategy setting. In his study of industrial policies in the BRICS countries, Di Maio (2015) finds that the adoption of principles of the so-called new industrial policy is a recent trend in industrial policy design, stressing multi-stakeholder participatory processes and the contribution of public–private dialogue to policy design and implementation. UNIDO (2020) supports this finding, as several BRICS countries have followed participatory processes in the preparation of national I4R strategies. Country responses are often built around a 'multiple helix' involving the government, academia, private entities and civil society; the challenging nature of this consultative approach should not be underestimated. Future research on the BRICS should consider how to organize, govern and sustain such participatory processes and, more importantly, how the BRICS are moving forward in the implementation of those strategies at the individual and, as we discuss next, the collective level.

5.1 Collective responses

At the end of their most recent meeting, the BRICS Ministers of Industry acknowledged that intensifying collaboration on industrial development matters should help them address what they have termed the "Digital Industrial Revolution" (BRICS Industry Ministers, 2018). They are committed to boosting industrialization through new high-tech-driven innovative policy and regulatory frameworks (BRICS, 2017b) and the adoption of joint initiatives around the 4IR (Business Report, 2018). While it is difficult at this early stage to document BRICS's initiatives in this regard, a few proposals have been tabled. Based on a relatively common approach to

industrial policy design, the proposals focus on three key areas: 1) building basic framework conditions, 2) fostering demand for and the adoption of 4IR technologies, and 3) strengthening skills and research capabilities at different levels (López-Gómez et al., 2017; UNIDO, 2020).

Building basic framework conditions

Framework conditions refer to regulations and digital infrastructure. They also include the institutional framework for strategy setting, policy formulation and governance, which is increasingly perceived as multi-stakeholder collaboration involving close private–public partnerships. The BRICS countries have initiated a dialogue on these issues. At the 2018 summit in Johannesburg, the BRICS leaders endorsed the creation of a BRICS Partnership on New Industrial Revolution (PartNIR) (BRICS, 2018), as previously agreed by the respective Ministers of Industry at their 3rd Ministerial Meeting (BRICS Industry Ministers, 2018). An Advisory Group to include representatives from the BRICS Ministries of Industry and experts from all BRICS members will be responsible for operationalizing the PartNIR. The terms of reference and work plan focusses on digitalization, industrialization, innovation, inclusiveness and investments (BRICS Industry Ministers, 2018). Close collaboration with the private sector will be achieved through working groups in a wide variety of industrial and manufacturing sectors.

The intended outcomes of the PartNIR include boosting economic growth, strengthening sustainable industrial production capacity and creating networks of science parks and technology business incubators; the inclusion of SMEs in technology-intensive areas is of particular importance (BRICS, 2018, Item 56). Concrete initiatives include the establishment of the BRICS Networks of Science Parks, Technology Business Incubators and Small and Medium-sized Enterprises (BRICS, 2018).

Regarding infrastructure, UNIDO (2020) documents that digitalization remains a binding constraint for the development of advanced manufacturing. South Africa, a laggard among the BRICS, needs to address high costs and limited bandwidth, skill shortages in ICT and data analysis, not to mention innovation system weaknesses such as poor interaction between firms, universities and research centres (UNIDO, 2020). The upgrading of ICT infrastructure and connectivity are generally among the BRICS's priorities; they are committed to promoting internationally accepted and applicable standards for ICT infrastructure security, data protection and the internet (BRICS, 2017b). All these initiatives are consequential on the BRICS's intention to foster the digital economy through the BRICS ICT Development Agenda and Action Plan (BRICS, 2017b).

Global debates around the developmental implications of big data cannot be overlooked as capabilities to generate, process and extract value from rapidly expanding pools of datasets are prone to a high concentration both geographically and in terms of monopolistic power (Cable, 2018; Marr, 2018). The BRICS could potentially play a major role in advancing a global agenda around the development of big data and its associated implications for security, privacy and the capabilities required for handling growing and increasingly complex volumes of varied forms of data (Mahrenbach, Mayer and Pfeffer, 2018).

China is among the most advanced developing countries in the use of data as an economic driver; development strategies stipulate data analytics and big data platforms to support new industries and the upgrading of traditional ones (Mahrenbach, Mayer and Pfeffer, 2018). The Chinese government encourages innovation and funds big data research, while scientists are compelled to link and share their research findings with industry, and companies are expected to increase productivity and growth by incorporating big data and the associated technologies in high-tech manufacturing and in new business models (Mahrenbach, Mayer and Pfeffer, 2018). All private-sector activities have to take place within specified regulatory and incentive frameworks.

While this performance potentially locates China among the forerunners in the development of big data at the global level, any counterbalancing or supplementary role for the other BRICS countries in the consolidation of generally agreed guidelines to regulate the development of markets for big data has yet to emerge. Sing (2017) proposes three possible emerging models. At one end is the model led by the United States, centred on a global laissez-faire approach and largely dominated by domestic digital firms and free and unregulated data flows. At the opposite end is the Chinese approach to state-led capitalism, with the government enjoying strong surveillance rights and control of digital transactions. Between these two models, Sing (2017) places the mixed-economy approach to digitalization, which is found in India or the European Union, with the government playing a major role in fostering infrastructure and regulation to support competitive and efficient open data market operations, without renouncing the control of monopolies and concentration, or oversight of areas that are of social and economic importance.

Similarly, as part of the BRICS's Action Agenda on Economic and Trade Cooperation, the group adopted an Intellectual Property Rights Cooperation Mechanism (BRICS IPRCM) which aims to enhance cooperation and coordination in this area, particularly through the BRICS's IPR Cooperation Guidelines and an Action Plan on BRICS IPR Cooperation (BRICS, 2017a). Concrete activities include fostering information exchange among the BRICS's IPR offices and capacity-building on IPR issues.

Fostering demand and the adoption of 4IR technologies

According to UNIDO (2020), even if suitable framework conditions are established, countries need to encourage the adoption and adaptation of advanced digital production technologies. Given the novelty of many of the products and services that can be derived from 4IR technologies, economic agents have difficulty appraising their value propositions relative to competing existing technologies, while challenges to assess the expected return on investments contrast with the perceived high upfront investment requirements (Steinmueller, 2001). Addressing this situation requires concentrated policy efforts to raise firms' awareness about the potential benefits of new technologies. It also requires funding for their adoption to be facilitated. Countries may adopt and jointly implement dedicated programmes and incentives to raise awareness and rally the interest of domestic agents or to foster emerging behaviours and initiatives related to the 4IR.

The BRICS expect to enhance collaboration on STI through joint proposals to mobilize their accumulated technological and R&D capabilities (BRICS, 2018). The BRICS's exploration of collaboration is already motivating joint research activities and innovation agendas on big data, ICTs and other advanced manufacturing technologies and their applications, as well as on ICT infrastructure and connectivity (BRICS, 2017b). Concrete proposals include establishing the BRICS Institute of Future Networks, which will support joint BRICS research and innovation in ICT—including the Internet of Things, cloud computing, big data, data analytics, nanotechnology, artificial intelligence and 5G—and their applications (BRICS, 2017b). The suggested approach is to encourage partnerships between multiple stakeholders to devise and implement proofs-of-concept and pilot projects in these areas.

Strengthening skills and research capabilities

UNIDO (2020) documents that governments can play a major role in the creation of capabilities necessary to adopt 4IR technologies, for example, by dedicating learning centres and new approaches to technical and vocational education and training. Expanding the scope and number of research institutions to specifically deal with these technologies is key for their absorption and adaptation under local circumstances.

López-Gómez et al. (2017) advocate the building of human capabilities, particularly to enable adjustments in labour markets and systems of education, training and retraining. Concrete activities along these lines have yet to emerge but, as agreed in the most recent Ministers of Industry meeting, the BRICS intend to enhance policy coordination around advanced technical skills and training, exchange of information and best practices with respect to digitization. Securing inclusive and equitable growth while developing synergies in the use of financial and human resources is likewise important (Business Report, 2018).

Interesting initiatives recently implemented at the individual country level may serve as examples for larger, BRICS-level interventions. For instance, in Russia, the Agency for Strategic Initiatives (ASI) and Skolkovo (Moscow School of Management) have developed the Atlas of New Professions, an online platform intended to help understand what the 25 most promising sectors will be for the next 15–20 years, together with relevant occupations and their respective skill requirements and associated organizational practices; likewise, taking stock of more than 50 occupations that are bound to become outdated—including both routine and high-skilled ones (ASI and Skolkovo, 2019)—is important. In parallel, ASI initiatives such as 'Skill Development for Industrial Growth' are working to improve matching between industry's skill demands and the supply from educational establishments (Roland Berger GMBH, 2016).

According to Tourk and Marsh (2016), China promotes programmes to attract foreign talent to supplement its limited domestic innovation capabilities. For example, in 2013, the Fozhou Bureau of Foreign Experts Affairs was established in Fozhou, the capital city of Fujian Province, providing free work spaces and funding for start-up firms and arrange matching them with potential investors (Tourk and Marsh, 2016). By the end of 2014, ten start-ups had been established in the city, and it recorded a significant flow of returning students; moreover, the model attracted the attention of other provincial governments in China (Tourk and Marsh, 2016).

6. The international dimension

The BRICS's cooperation agenda is broad, with an ever-growing number of items. From an initial focus on global governance and diplomacy—including UN reform and the enlargement of the UN Security Council to include some BRICS as permanent members—or the reform of the current international financial architecture, the agenda has evolved to include STI topics and economic development. The BRICS expect to influence global peace and security, energy and climate change, and social and economic issues in a non-confrontational spirit, together with other global governance arrangements (BRICS, 2019).

The creation of the New Development Bank (NDB) is a major initiative representing the BRICS's collective presence and global influence. The NDB mobilizes resources for infrastructure and sustainable development projects in the BRICS and other emerging and developing economies (New Development Bank, 2019a).[3] In addition to strengthening intra-BRICS cooperation, the NDB expects to supplement the funding of multilateral and regional financial institutions (BRICS, 2014). It became operational with the signing of the Headquarters Agreement with the Government of China and the Memorandum of Understanding with the Shanghai Municipal People's Government on 27 February 2016 (BRICS, 2019). The first loans, approved in 2016–17, support projects in green and renewable energy, transportation, water sanitation and irrigation (BRICS, 2019). By the end of 2019, the total loan portfolio was to amount to USD 16 billion (New Development Bank, 2019c), double the USD 8.1 billion at the end of 2018 (New Development Bank, 2019b).

The creation of the NDB has, however, caused some tension. Its operational structure envisages an initial authorized capital of USD 100 billion, with a first subscription of USD 50 billion equally shared among the founding members. Governance and leadership are divided among the BRICS, with the headquarters in Shanghai and an Africa Regional Centre in South Africa (BRICS, 2014). Kejin (2014) and Degaut and Meachan (2015) assert that although the BRICS contributed equally to the first tranche of funding for the capitalization of the NDB, China seems to be the only member that is ready and able to expand and fulfil its future commitments. China could take the lion's share of the decision-making power, particularly as the conditions for non-BRICS membership of the NDB remain uncertain (Kejin, 2014).

6.1 Focus on Africa

It is no surprise that Africa occupies a prominent place on the BRICS agenda. Even before the BRICS was created, each member already had established close social, political and economic ties with the continent. The steady increase in BRIC FDI to Africa suggests attempts at breaking with customary regional specialization regarding destination countries. At the same time, the growing presence of the BRIC among Africa's major trade and investment partners is perceived as a counterbalance to traditional partners, namely the United States, Europe or Japan (Kimenyi and Lewis, 2011). The BRIC countries were already important donors in the region through concessionary and soft loans, credit lines and grants; China, in particular, has actively supported infrastructure projects (Kimenyi and Lewis, 2011).

[3] The BRICS have also enacted a Contingency Reserve Arrangement to support one another in situations of balance-of-payments instability (BRICS, 2014).

Coinciding with South Africa's accession to the BRICS, the Sanya Declaration made the BRICS's intention to collaborate with Africa clear, with the New Partnership for Africa's Development (NEPAD) identified as the relevant interlocutor (BRICS, 2011). Engagement with South African Union countries followed at the 5th BRICS Leaders' Summit in Durban under the overarching theme of 'BRICS and Africa: Partnership for Development, Integration and Industrialization' (BRICS, 2013). BRICS's support for Africa's industrialization seeks to intensify the continent's development efforts through FDI, knowledge exchange, capacity-building and trade diversification. One priority is to assist the continent in redressing its infrastructure deficits, which is necessary to boost regional integration and industrialization (BRICS, 2013). This is consistent with the longstanding presence of the BRIC in Africa's infrastructure market (Kimenyi and Lewis, 2011) and the potential gains offered by a continent where investments in infrastructure to provide basic services to the population compete heavily against resources to improve or expand transport and other economic infrastructure (Oxford Economics and Global Infrastructure Hub, 2017). The establishment of a Multilateral Agreement on Infrastructure Co-Financing for Africa with support from the BRICS's export–import and development banks has been proposed to strengthen collaboration (BRICS, 2013).

The BRICS presence in Africa has attracted some criticism. Kimenyi and Lewis (2011) decry the perceived appetite for Africa's natural resources, notably oil—with the presence of principally China and Brazil expanding in Angola, Nigeria and Sudan—mining in Liberia and Mozambique, and gas in Nigeria. Similarly, India's presence has expanded in textiles, social services—health and education—ICT and automobiles. Mbele (2018) highlights the asymmetrical patterns of trade and investment between the BRICS and Africa. South Africa's accession to the BRIC provoked strong criticism; in addition to the huge economic asymmetries, South Africa is perceived as supporting the BRIC, particularly Chinese interest in the continent. Kimenyi and Lewis (2011) point out ties between Chinese investments and Chinese-sponsored infrastructure development projects over the last two decades, while South African firms provide a platform for a cooperation model based on African exports of raw materials and manufacturing imports (Carmody, 2017).

Africa is likely to continue to play a major role in the context of China's Belt and Road Initiative, (BRI) launched in 2013, which endeavours to transform six trade and investment corridors across Asia, Europe and Africa, with an emphasis on infrastructure and connectivity. Underscoring the benefits of the BRICS's closer collaboration will be the possibilities of channelling funding through the NDB and other funding mechanisms—for example, the Asian Infrastructure Investment Bank—that the BRICS participate in. However, geopolitical tensions associated with

the BRI should not be ignored, particularly as India and Russia maintain close ties and interests in regions directly located along several BRI main economic corridors.

7. Conclusions

The formation of the BRICS block is a work in progress, and is at a very early stage of development. The process faces a significant number of constraints rooted in the history, structure and recent economic and industrial performance of the member countries. Several substantial shortcomings could intensify in the near future. This paper corroborates the widening gap in the performance between China and the other BRICS countries. This gap could potentially represent a major obstacle, as it exacerbates the differences in interests and capabilities within the group (Degaut and Meachan, 2015). While BRICS integration would benefit from closing productive and technological capability gaps, acknowledging this challenge has largely remained absent from policy documents governing the integration process.

The BRICS seem to understand the value of establishing a strong block. Those who dismiss the possibility of these countries achieving closer collaboration should remember that the BRICS is mostly an informal collaboration mechanism; each participant plays according to its own rules and interests (Kejin, 2014). BRICS integration is and will continue to be gradual but systematic, through dedicated strategies or action plans to govern collaboration in several areas. Other more mature international governance mechanisms—the G7 or even the G20—also evolved progressively; there is no reason to expect the BRICS to move any faster or for their integration to be any deeper.

As the areas for collaboration expand at every leaders', ministerial or expert meeting, a systematic and empirically-driven evaluation of the BRICS's commitments and tangible outcomes is necessary to draw conclusions. Industrial development offers considerable potential for making strides in the future. Despite its novelty within the BRICS collaboration agenda, industrial development is an area that could integrate and expand individual BRICS approaches to STI, IPRs, e-commerce, infrastructure and other related areas.

The BRICS's, and particularly China's strategic policy responses to the 4IR, have attracted significant attention. Unlike many other developing countries, the member countries have experienced extensive structural change with a strong reliance on manufacturing. They are and will remain role models for other developing countries where industrial development has yet to take root. As the ongoing technological and productive transformations continue to unfold in uncertain directions, the BRICS continue to foster structural change and the development of innovation-driven economies, moving away from commodities and traditional industrial products

and increasingly into higher value-added sectors and products. At the same time, the BRICS's progress up the ranks of global industrial leadership increases the risks of widening gaps relative to least developed economies (Liu et al., 2017; Mayer, 2018).

Among the BRICS, China seems ready to tap into the current juncture to explore new development paths, steadily shifting from a mindset of catching-up centred on labour-cost advantages to one of capitalizing on its growing role as a leading global technology and manufacturing hub (Li, 2017; *The Economist*, 2015). The implications for the future of industrial dynamics in both developed and developing countries may be significant.

Finally, but importantly, from a historical perspective, the experience of the BRICS reminds us that catching up entails active industrial policies to underpin the creation of absorptive technological and productive capabilities. This characteristic should continue to assist the BRICS in their individual and collective development efforts.

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Annex 1. UNIDO's Competitive and Industrial Performance Index

The United Nations Industrial Development Organization's Competitive and Industrial Performance Index (CIPIndex) captures countries' ability to produce and export manufactured goods competitively and to achieve structural change; it includes eight indicators, defined along three dimensions:

1) Capacity to produce and export manufactured goods, captured by two indicators:
   a) Manufacturing value added per capita;
   b) Manufactured exports per capita.
2) Level of technological deepening and upgrading captured by two composite indicators:
   a) Industrialization intensity – the share of manufacturing value added (MVA) in total gross domestic product and the share of medium high- and high-tech MVA in total MVA;
   b) Export quality – share of medium high- and high-tech manufactured exports in total manufactured exports, and the share of manufactured exports in total exports.
3) Impact on world manufacturing as measured by the country's share in world manufacturing value added and world manufacturing trade.

The calculation of the CIPIndex is the equal weighted geometric mean of the different components of these three dimensions.

Source: UNIDO CIPIndex

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