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The future of GVCs in a post-pandemic world

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The future of GVCs in a post-pandemic world

Svenja Falk
Accenture Research

Ana Ruiz Hernanz
Accenture Research

Adnan Seric
UNIDO

Frauke Steglich
UNIDO

Ligia Zagato
UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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Abstract

COVID-19 has put the importance of supply chains back onto the global economic agenda. The potential challenges associated with the interconnectedness of economies became much more visible with the pandemic, initiating a discussion on the limitations to participation in global value chains (GVCs). In addition, global trends such as regionalization, digitalization and greening of economies had already emerged prior to the onset of the pandemic. The question of how these trends are shaping global production is now more pressing than ever before. In this paper, we shed light on the impact of these global trends on GVCs from a micro perspective and discuss the future of global production. The contribution of this paper is twofold. First, using unique data on buyer-supplier relationships, we illustrate how global trends are affecting GVCs. Second, we discuss the implications for industrial policy and recommend suitable policy responses in light of these trends and the impact of the pandemic.

Keywords*:* Global value chains, green economies, industrial policy, digitalization, regionalization

JEL codes*:* F10, F23, M10, L2, O14

1. Introduction

It is clear that the paradigm of global value chains (GVCs) has changed dramatically in recent years. Global production no longer takes place solely in vertically-integrated production processes, but increasingly within complex and interconnected value networks. COVID-19 has strengthened the importance of strategically designing GVCs in the minds of policymakers and business leaders alike. And it has shed light on the impact of ongoing megatrends that began shaping global production even before the pandemic.

Multiple global trends have been shaping the world's socioeconomic future. These include the growing middle classes in emerging countries, aging populations in many of the mature economies, urbanization, the industrial revolution (Baldwin 2019), emerging nationalism (Zhan 2021) and the sustainability imperative (UNCTAD 2020; De Backer and Flaig 2017). In this paper, we focus on three key megatrends that are expected to strongly shape GVCs and particularly the future of manufacturing. These trends have been chosen for further examination in the context of *Industrial Development Report 2022* (IDR 2022) discussions, and are interconnected and not exhaustive.

First, we look at the geography of competitiveness in the light of the economic rise of Asia. Beginning roughly with China's accession to the World Trade Organization (WTO) in 2001, the global center of economic gravity has been shifting to Asia. China's emergence has dragged other economies in the region into Chinese supply chains (AMRO 2020). The region is no longer simply producing goods for western consumption. Rising incomes and the emergence of a middle class has shaped demand locally and made the region a destination for many consumer products and services (AMRO 2020). We discuss how these developments might be enforced by other trends, such as digital decoupling or rising competition between countries when it comes to leadership on green technologies.

Second, we look at the trend of digital transformation. New ways of value creation no longer match the traditional structure of GVCs, namely, location-specific and linear economic activities that form a vertically integrated "chain" from upstream to downstream (AMRO 2020). Digital transformation enables new business models, new products and more flexible value chains. It is important for economies, particularly emerging market economies, to find ways to be competitive in this new environment. For many developing and emerging economies, progression along manufacturing value chains remains a viable development strategy. For others, digitalization offers new opportunities to enter global production networks (Ferrantino and Koten 2019).

Finally, we discuss the impact of economic "greening" on GVCs. Climate change has put the need for green economies on the political agenda in many countries. New regulations on sustainable production and environmentally friendly business activities, as well as investment programmes for green technologies, were introduced in several countries. These regulatory changes are expected to create new opportunities for firms—but could also reinforce regionalization trends.

In this paper, we address the following research questions: Which GVC dynamics are induced by mega-trends? And which policy responses are suitable for exploiting opportunities and addressing challenges?

Unique for this type of literature, we rely on firm-level data of buyer-supplier relations to analyse the impact of these three mega-trends on global production patterns. Our findings indicate major changes in GVCs and the nature of production: new ecosystems have arisen as new ways of doing business. It will become increasingly important for businesses to be aware of their competitors and invest in the skills of their workforce. The sustainability paradigm is likely to generate new innovations and investment opportunities as well as create positive spillovers from buyers to suppliers within value chains. The developments outlined in this paper call for policy actions in a new era of industrial policy.

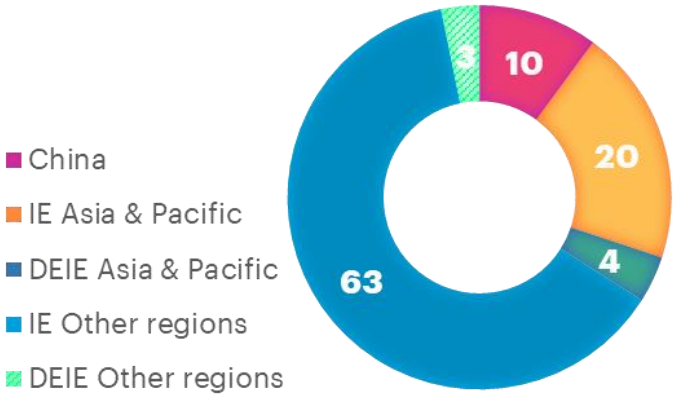
2. Data and methodology

In this paper we use several different data types to address the research questions outlined above. We use the supply-chain relationships database from FactSet (https://www.factset.com) to analyse supplier networks and track environmental, social and corporate governance (ESG) scores through value chains. This data is limited to large public companies (those with more than $1 billion in annual revenue) and based on publicly-available information. If a company does not disclose this information, it is not accounted for in our database. In addition, for insight on small and medium-sized enterprises (SMEs) we use data from the World Bank Enterprise Survey (https://www.enterprisesurveys.org/en/enterprisesurveys). We complement this with information from survey data and a case study. Finally, we rely on country-level data to illustrate the developments of trade, investment and employment patterns.

2.1. Supply-chain relationships

We built a dataset based on the FactSet Supply Chain Relationships database (https://www.factset.com/marketplace/catalog/product/factset-supply-chain-relationships) that includes company-level information for different time periods as well as information on the geographic location of suppliers.[1] The final sample consist of more than 1,300 companies taken from the Greatest 2000 (G2000) companies list—which ranks the world's top 2,000 public companies—for whom we are able to track the suppliers' evolution for 2013-2020. We used a regional classification based on UNIDO's grouping of industrialized economies (IEs) and developing and emerging industrial economies (DEIEs) in Asia and Pacific, as well as other regions. 63% of companies in our sample come from IEs other than Asia, 20% from IEs in Asia and Pacific (excluding China), 10 percent from China, 4 percent from DEIEs in Asia and Pacific and 3 percent from DEIEs in other regions. (Figure 1). One-third of the companies in our sample had total revenues above $20billion in 2020, while only 5% of companies in our sample had total revenues below $50 million in 2020 (Figure 2).

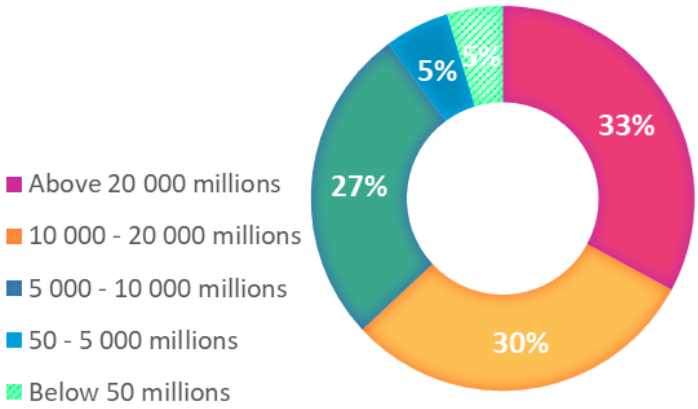
Figure 1: Geographic distribution of G2000 companies



Source: Authors' elaboration based on FactSet financial data and analytics (https://www.factset.com/).
Note: IEs = industrialized economies; DEIEs = developing and emerging industrial economies.

[1] For details, see www.factset.com.

Figure 2: Company size distribution of G2000 companies



Source: Authors' elaboration based on FactSet financial data and analytics (https://www.factset.com/) and Capital IQ (https://www.capitaliq.com/ciqdotnet/).
Note: Company size based on total revenue in 2020 US dollars.

Based on our dataset, we are able to estimate the number of suppliers by company from each region and by year. We can then aggregate this company-level data to estimate the average number of overall suppliers from each region, by industry and for each time period.

To analyse the transmission of "green" practices along the value chain, we match the FactSet Supply Chain Relationships data with data from Arabesque S-Ray (https://www.arabesque.com/s-ray/, provides sustainability data, advisory and insights services, with a quantitative algorithmic approach that combines big data and Environmental, Social, and Governance (ESG) metrics to assess the performance of over 8,000 companies worldwide).[2] which includes information on firms' ESG score. We factor in Environmental Index scores provided as part of the Arabesque's ESG data features. Scores are scaled 0-100 (with 100 the best score) and defined as the average of the following aspects:

- Emissions contributions: Emissions contribution of business activities to the emission of greenhouse gases and other air pollutants
- Environmental management: Environmental management mechanisms and policies to manage overall environmental performance of the business
- Waste generation: Generation of waste and other hazardous output as part of business activities
- Environmental stewardship: Impact of business activities on biodiversity and animal welfare

[2] For more details, see www.arabesque.com.

- Resource use: Efficient use of energy and other natural resources (including land and materials)
- Water efficiency: Efficient and responsible use of water throughout company operations
- Environmental solutions: Environmental impact of products and services and contribution towards sustainable consumerism.

To support the analysis of green practice transmission we focus on three selected industries: the auto original equipment manufacturer (OEM), semiconductors, and apparel and accessories industries. For the auto OEM analysis, our analysis covers suppliers of auto OEM companies from Europe, Asia and the United States[3] as well as the suppliers of the suppliers—in effect, three levels of supplier relationships. This level of analysis enables a holistic understanding of the auto OEM value chain as well its environmental impact. The ability to track each supplier's Environmental Index score helps us identify and examine environmental strategies in the different chains of auto OEM industry GVCs. The sample consists of 34 Auto OEM companies between 2015 and 2020, with more than 830 suppliers on average at each level. Companies with missing ESG information were excluded from the analysis.

Similarly, for the semiconductors industry, we observe 34 companies in Europe and Asia and approximately 520 suppliers, on average, at each of the three levels of the value chain. The sample for the apparel and accessories industry consists of 21 companies from Europe, Asia and the United States, with an average of 760 suppliers at each level of the supply chain.

2.1.1 Additional firm-level data

In addition to buyer-supplier linkage data, we use firm-level data from the 2019/2020 World Bank Enterprise Survey (WBES).[4] The advantage of this database is twofold. First, it covers a broad range of industrialized and non-industrialized countries, and assesses not only large firms but also micro, small, and medium-sized firms. Second, the most recent survey includes a module on the green economy that, among other topics, covers questions on firms' green innovation activities. Our analysis is based on a sample of 32 countries from Eastern Europe, Central Asia and Northern Africa.

[3] For the United States, the interpretation of ESG scores has to be done cautiously given that ESG reporting from US companies has traditionally been low because of institutional differences compared to, for instance, European companies (Harper Ho 2020).
[4] Data available at: https://www.enterprisesurveys.org/en/about-us.

2.1.2 Survey data and case study

We use Accenture's CXO survey to examine whether sustainability efforts are seen as a crucial part of business activities by C-level executives. The survey was conducted between October and December 2020 with 4,051 C-level executives from 13 countries. Further, we showcase the Catena-X automotive network as a case study to illustrate recent developments in operationalizing data-driven value chains through data spaces.

2.1.3 Macro data

Finally, we use country-level data to illustrate macro changes in trade, investment and employment across regions; specifically, UNCTAD data to show developments in investment and gross domestic product (GDP) patterns over time.[5] Further, we use data from the Economic Transformation Database,[6] a recently released database of employment and value-added industry-level information covering the years 1990-2018 and the Asia, Latin America, Middle East and North Africa, and Sub-Saharan Africa regions.[7]

3. Megatrends in GVCs

This section discusses the three megatrends affecting GVCs and their impact on global production and firms. As the focus of this paper is on the firm perspective, the role of megatrends for GVCs is discussed using firm-level data and firm-level case studies.

3.1. A new map of competitiveness

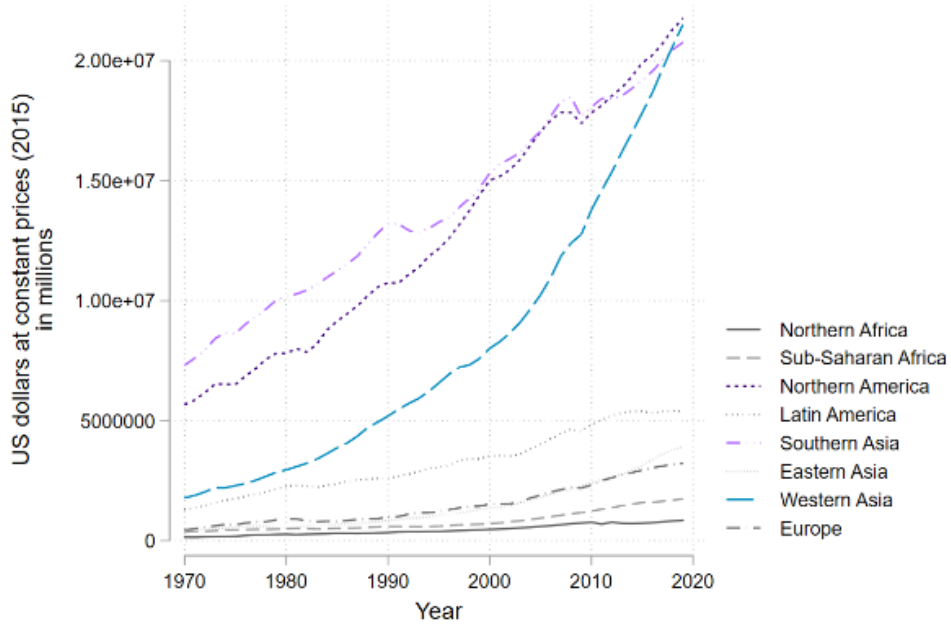
In recent years, new global clusters of economic activity and innovation have emerging in part as a result of Asia's rapid rise as an important economic centre of activity. In this section, we discuss (1) the economic power shift to the East and the regionalization of GVCs within Asia, (2) how this trend might be enforced by digital decoupling, and (3) the impact on firms located outside Asia and what is necessary for other regions to enter global production networks.

[5] Data available at: https://unctadstat.unctad.org/EN/.
[6] Data available at: https://www.wider.unu.edu/database/etd-%E2%80%93-economic-transformation-database.
[7] See De Vries et al. (2021) for details.

3.1.1 Power shift: Emergence of new centres of gravity

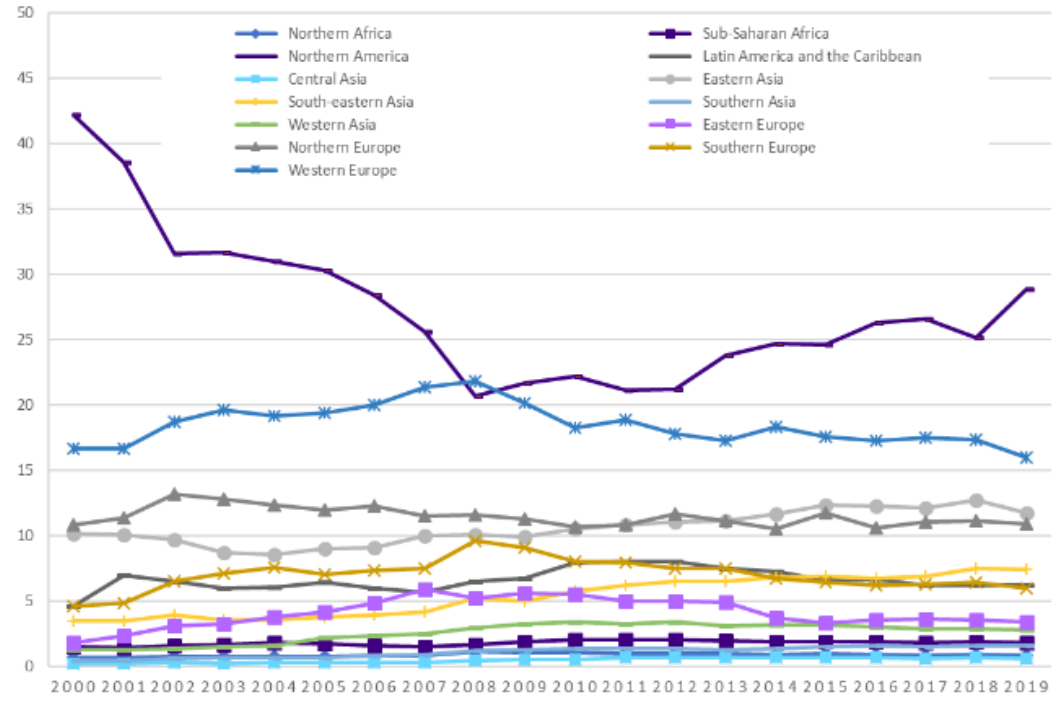
A range of key indicators clearly shows that new centres of economic gravity have emerged in recent decades. Asia's GDP has been growing rapidly for decades (Figure 3), and, despite the pandemic-induced overall decline in foreign direct investment (FDI), India and China were successful in attracting FDI in 2020 (UNCTAD 2020). FDI increased 13% in India (mainly driven by the digital sector) and 4% in China (Figure 4).

Figure 3: GDP growth, by region (million 2015 dollars)



Source: Authors' elaboration based on UNCTAD (2021a).

Figure 4: Foreign direct investment (FDI) inward stock as share of global FDI, by region (percent)



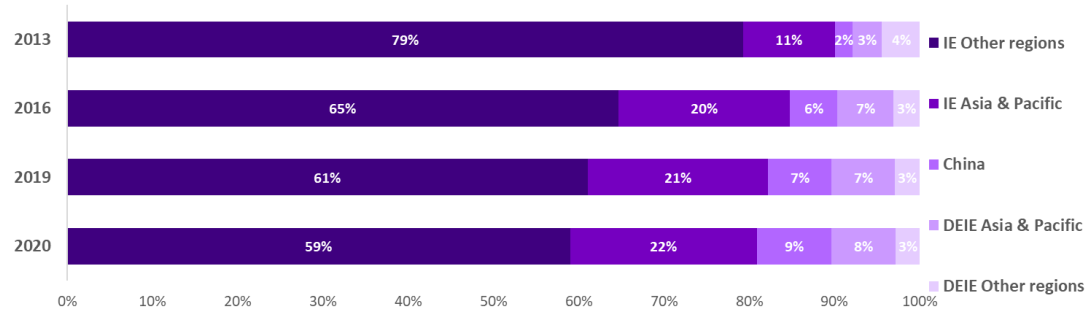
Source: Authors' elaboration based on UNCTAD (2021b).

We also observe, in addition to Asia's growing share of global trade and investment, a shift in supplier distribution to this region. When looking at the regional distribution of suppliers of the G2000 public companies, IEs[8] from Asia and the Pacific—and from China in particular—have increased their participation in recent years. As illustrated in Figure 5, IEs from outside of Asia ("IE, Other regions"), which until 2013 led the world in global share of suppliers, decreased their share significantly over the last decade. Suppliers from IEs in Asia and the Pacific increased from 11% in 2013 to 22% in 2020 (a gain of 11%), while that of suppliers from IEs in other regions fell 20%, from 79% to 59%, over the same time period (Figure 5).

In addition, 65% of companies have increased their share of suppliers from IEs in Asia and the Pacific between 2013 and 2019. The disruption of the COVID crisis does not seem to have impacted this trend. In fact, between 2019 and 2020, the share of suppliers from IEs in Asia and the Pacific as well as China continued to grow while suppliers from other IEs continued to decrease.

[8] We rely on regional groupings by UNIDO, which distinguishes industrialized economies (IEs) and developing and emerging industrial economies (DEIEs) by geographic regions.

Figure 5: Share of suppliers for all G2000 manufacturing companies, by region of origin (2013-2020)

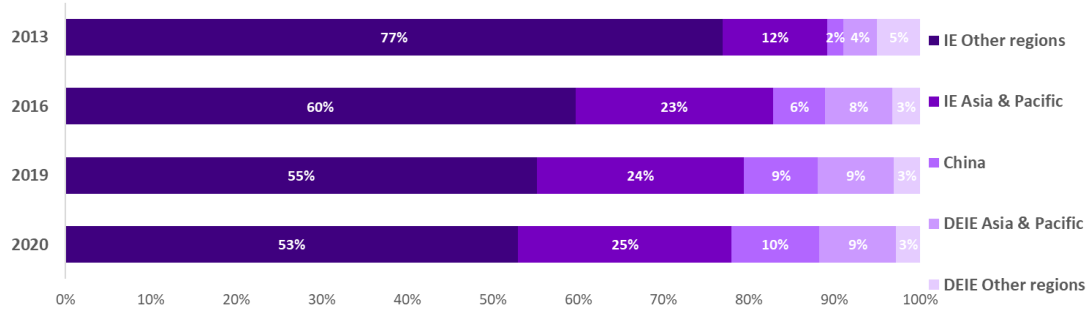


Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: The sample covers over 1,300 companies. Average of companies' suppliers by region and time period. Regional classification is based on UNIDO country grouping: IE = industrialized economies; DEIE = developing and emerging industrial economies.

The development is comparable for the manufacturing sector. The shares of manufacturing suppliers from IEs in Asia and the Pacific as well as from China have been increasing while suppliers from other industrialized economies lost significant share over the last decade (Figure 6).

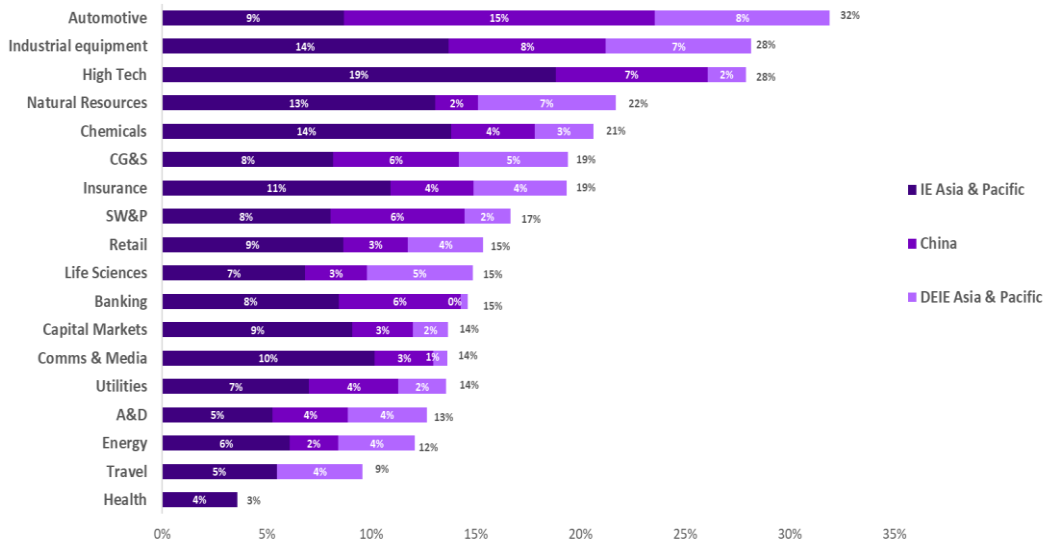
Figure 6: Share of suppliers for all G750 manufacturing companies, by region of origin, (2013-2020)



Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: Average of companies' suppliers by region and time period. Sample of 756 companies. Regional classification is based on UNIDO country grouping: IEs = industrialized economies; DEIEs = developing and emerging industrial economies. Manufacturing industries considered in the analysis: chemicals, energy, food and beverages, machinery and computers, medical equipment, plastics and mineral products, printing, textiles, leather and apparel, transport equipment and wood, paper and furniture.

Figure 7: Change in Asian share of total suppliers for all G2000 companies, by industry, 2013-2019

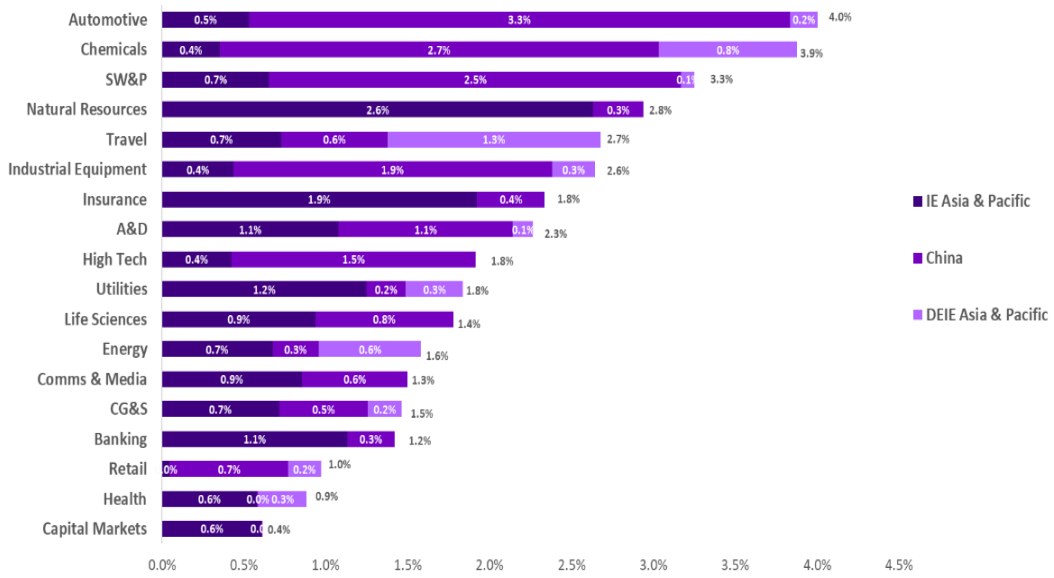


Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: Average of companies' suppliers by region and time period. The sample covers over 1,300 companies. Regional classification is based on UNIDO country grouping: IEs = industrialized economies; DEIEs = developing and emerging industrial economies. A&D = aerospace and defence; CG&S = consumer goods and services; SW&P = software and platforms.

Next, we take a closer look at developments by industry. Figure 7 shows the change in the regional share of suppliers between 2013 and 2019 for different industries. The largest increases in suppliers from IEs in Asia and the Pacific as well as from China have been in automotive, industrial equipment, high-tech and natural resources. Between 2019 and 2020, the net change in the share of suppliers from countries from China and the Asia and Pacific region increased by about 2% (Figure 8)

Figure 8: Change in Asian share of total suppliers for all G2000 companies, by industry, 2019–2020

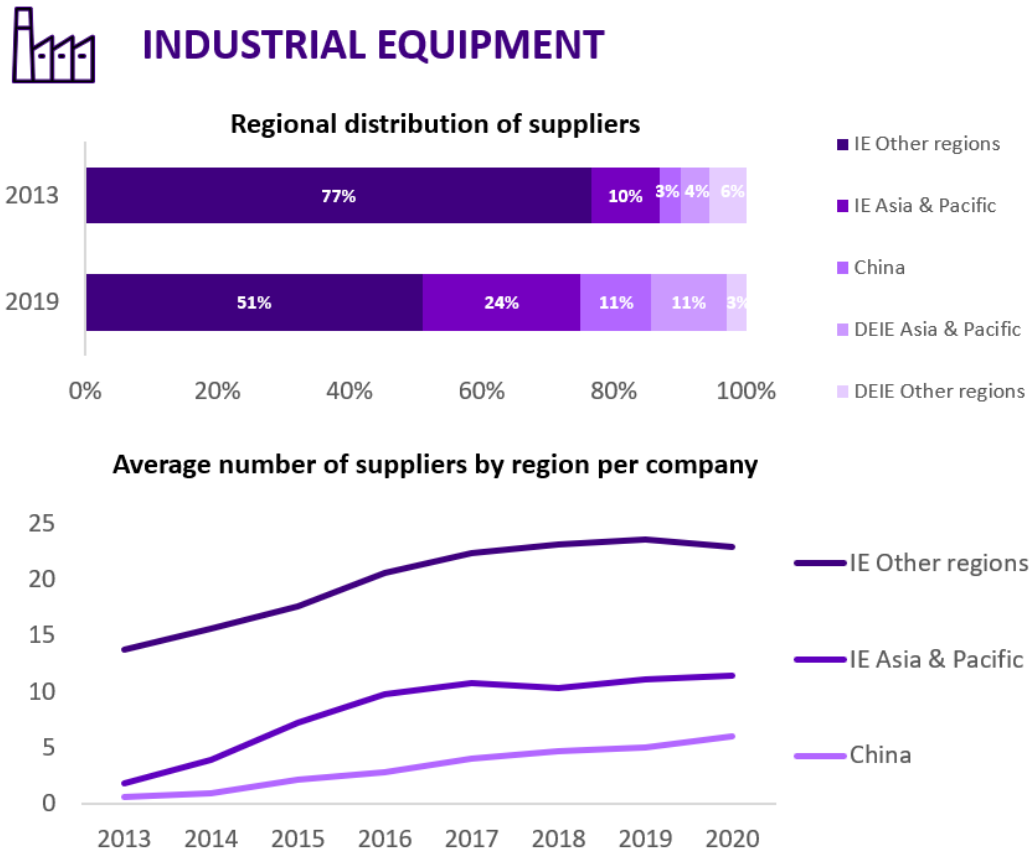


Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: Average of companies' suppliers by region and time period. The sample covers over 1,300 companies. Regional classification is based on UNIDO country grouping: IEs = industrialized economies; DEIEs = developing and emerging industrial economies. A&D = aerospace and defence; CG&S = consumer goods and services; SW&P = software and platforms.

This shift towards Asian suppliers is strongest in industries like industrial equipment and automotive. When examining data for these industries even more closely, we see that the share of suppliers from Asia grew considerably between 2013 and 2019. In 2019, Asian suppliers represented 46% of all suppliers in the industrial equipment and 52% in automotive industries—up from 17% and 21%, respectively, in 2013. Suppliers from China represented 11% of the total in industrial equipment and 17% in the automotive industry (Figures 9 and 10).

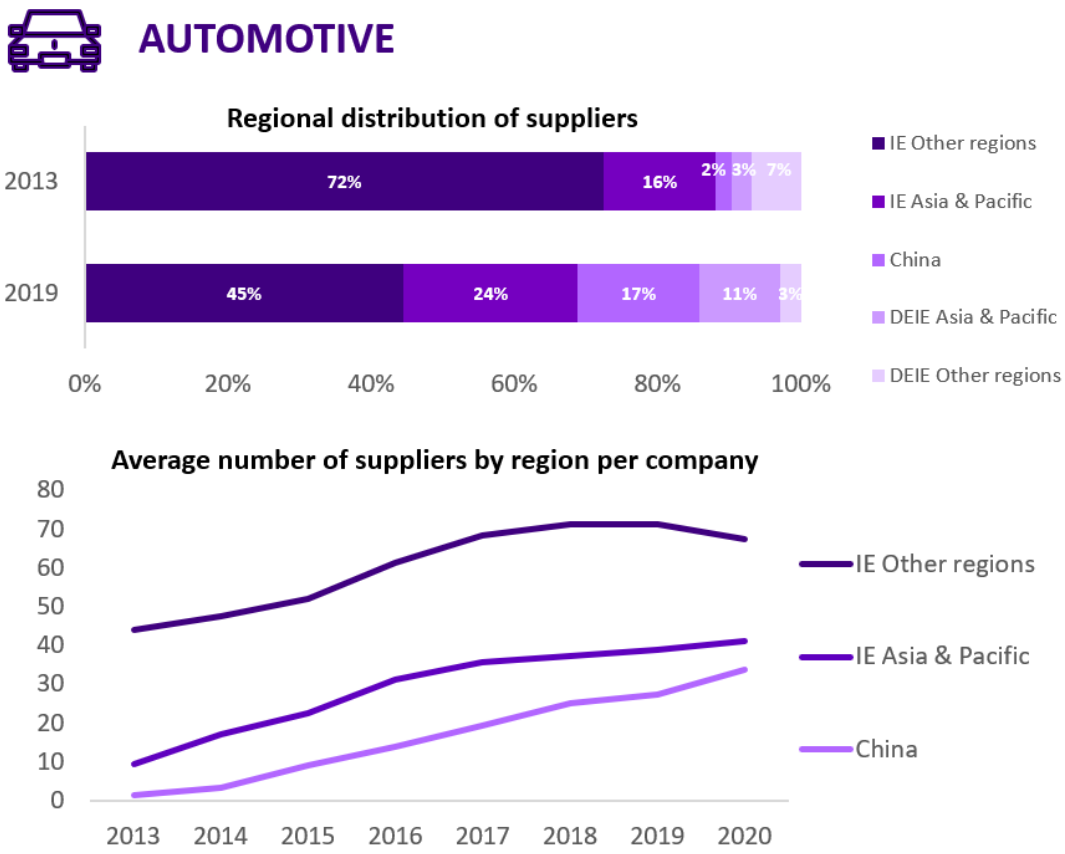
Figure 9: Share of suppliers for G2000 companies in the industrial equipment industry, by region, 2013-2019



Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: Average of companies' suppliers by region and time period. The industrial sample covers 158 companies, mobility sample covers 51 companies. Regional classification is based on UNIDO country grouping: IEs = industrialized economies; DEIEs = developing and emerging industrial economies.

Figure 10: Share of suppliers for G2000 companies in the automotive industry, by region, 2013-2019



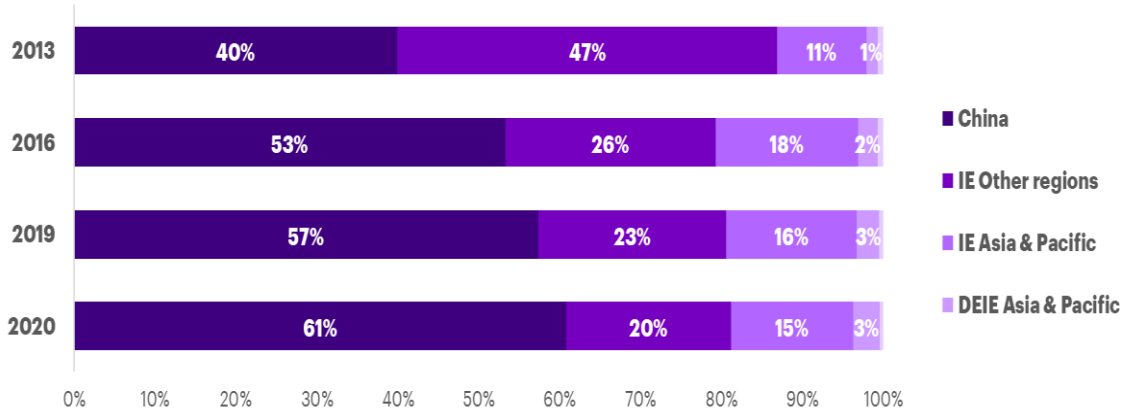
Source: Accenture Research based on FactSet financial data and analytics.

Note: Average of companies' suppliers by region and time period. The industrial sample covers 158 companies, automotive sample covers 51 companies. Regional classification is based on UNIDO country grouping: IEs = industrialized economies; DEIEs = developing and emerging industrial economies.

The shift of economic activity towards Asia is even stronger if we consider only Chinese companies from the G2000. There is strong intra-regional activity, with up to 79% of suppliers of Chinese companies coming from Asia and the Pacific in 2000. Regional distribution of suppliers for the G2000 Chinese public companies shows that Asia, a region that represented more than one-half of the suppliers of Chinese companies in 2013, gained even more over the last decade, increasing its share from 52% in 2013 to 79% in 2020 (plus 27 percentage points) at the expense of suppliers from other regions have (Figure 11). In addition, 77% of Chinese companies increased their share of Asian suppliers between 2013 and 2019.

In absolute terms, the average number of Chinese and Asia and Pacific suppliers per Chinese company has also been growing significantly (Figure 12). The huge increase in the number of Chinese suppliers is behind the rapid growth in participation of Asia and the Pacific (Figure 13).

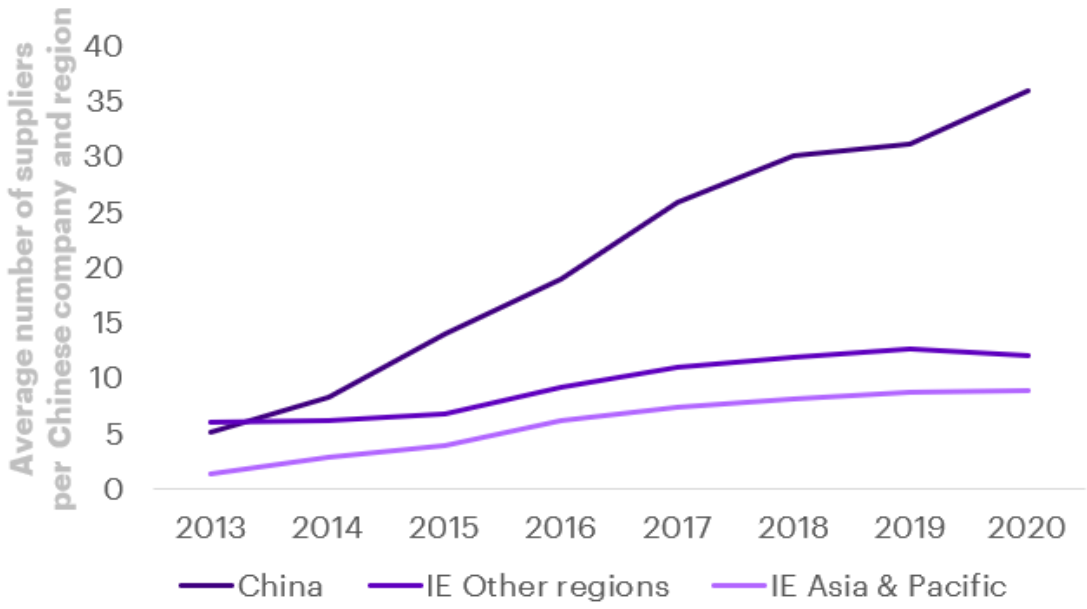
Figure 11: Share of suppliers for Chinese companies, by region, 2013-2020



Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: Average of Chinese companies' suppliers by region and time period. The sample covers 63 Chinese companies. IEs = industrialized economies; DEIEs = developing and industrial economies.

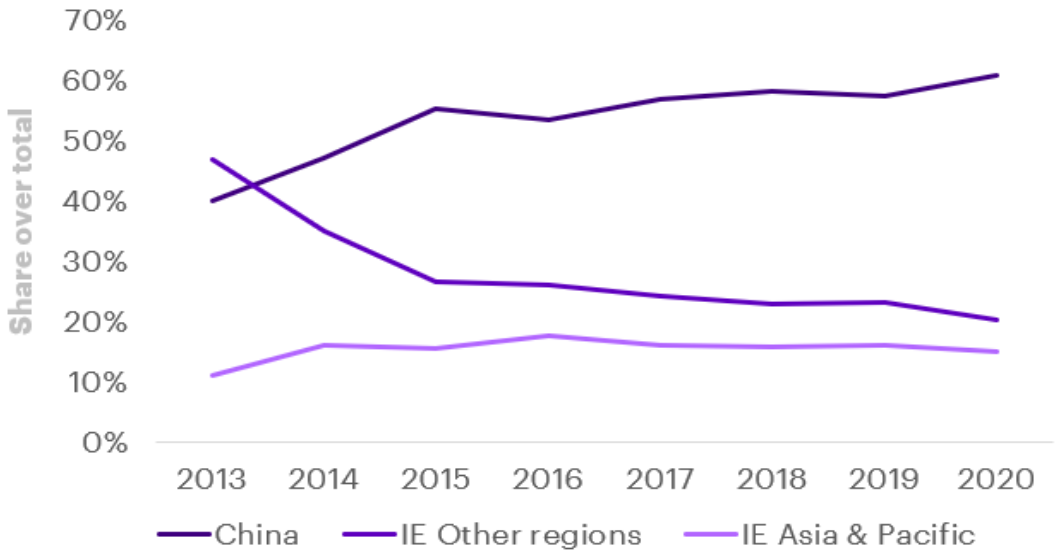
Figure 12: Number of suppliers for Chinese companies, by region, 2013-2020



Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: Average of Chinese companies' suppliers by region and time period. The sample covers 63 Chinese companies. IEs = industrialized economies.

Figure 13: Share of suppliers for Chinese companies, by region, 2013-2020

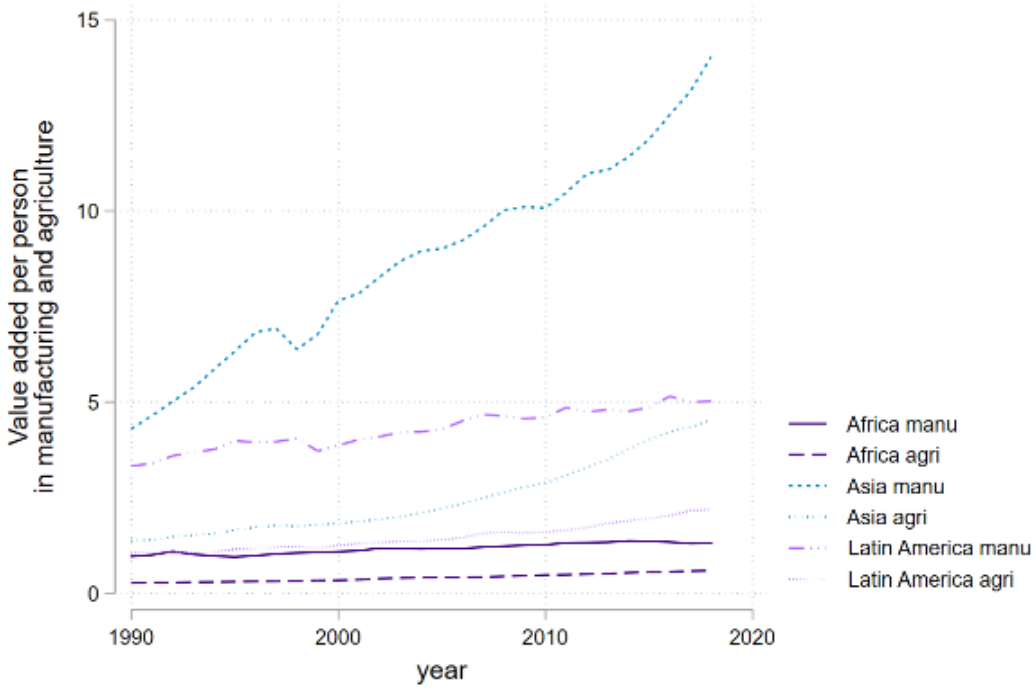


Source: Accenture Research based on FactSet financial data and analytics (https://www.factset.com/).

Note: Average of Chinese companies' suppliers by region and time period. The sample covers 63 Chinese companies. IEs = industrialized economies.

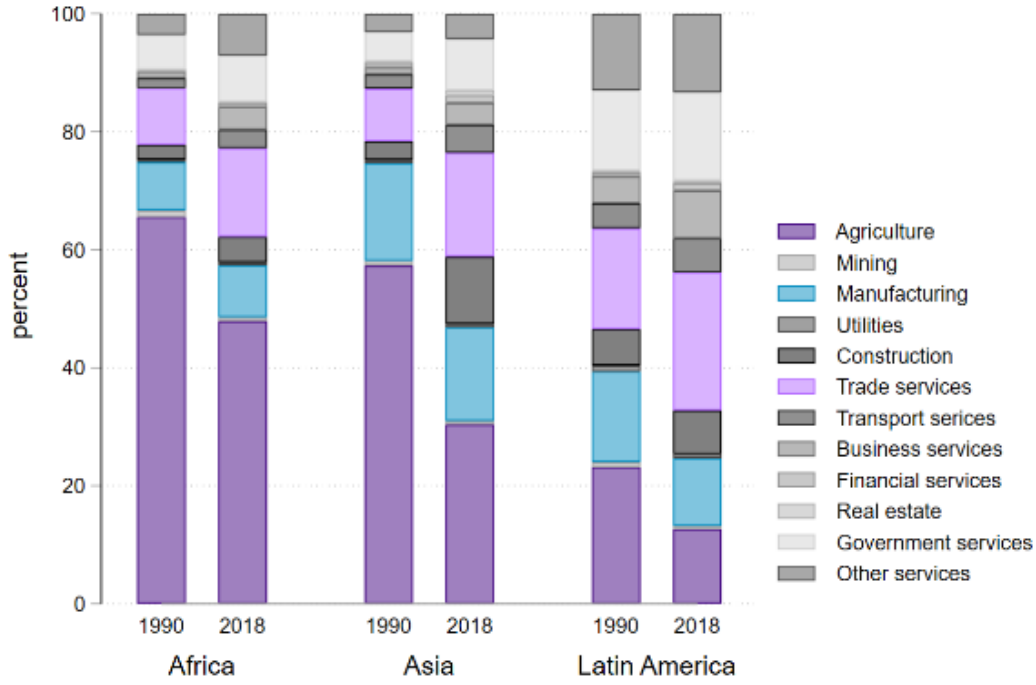
The emergence of new economic centres is accompanied by changes in the international division of labour. Figure 14 shows the development of value added per person employed in the manufacturing and agriculture industries between 1990 and 2018 in Africa, Asia and Latin America. Value added per person captures productivity and thus serves as proxy for an industry's skill level. In the manufacturing industry it has remained more or less constant in Latin America and Africa from 1990-2018, whereas it increased significantly in Asia. Figure 15 illustrates the evolution of employment by industry. Employment in agriculture decreased in all three regions from 1990-2018—from 65.6% to 47.9% in Africa, 57.3% to 30.4% in Asia, and 23.2% to 12.7% in Latin America.

Figure 14: Development of skills in manufacturing and agriculture, by region, 1990-2018



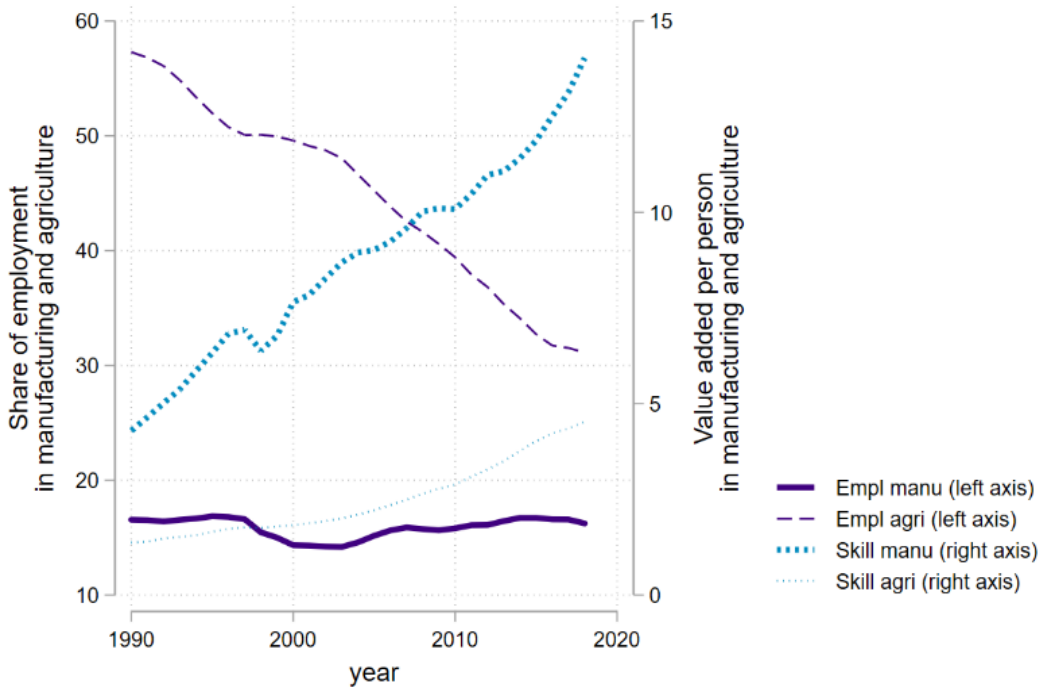
Source: Authors' elaboration based on UNU-WIDER (2021).

Figure 15: Change in employment share, by industry and region, 1990 vs. 2018



Source: Authors' elaboration based on UNU-WIDER (2021).

Figure 16: Development of skills and change in employment in manufacturing and agriculture in Asia, 1990-2020



Source: Authors' elaboration based on UNU-WIDER (2021).

Demand for high-skilled labour is expected to increase even further. The skill levels of workers employed in manufacturing has been increasing globally while employment in manufacturing remains more or less constant. In Asia, for instance, the sharp increase in manufacturing skills has been accompanied by a relatively stable share of employment in manufacturing (Figure *16*). In the aftermath of the COVID-19 pandemic, several countries increased efforts to promote the manufacturing sector, which is likely to further raise the demand for skilled labour (see, for instance, The White House 2021 for the US strategy).

These developments could also have a huge impact on other regions. Some have argued that rising labour costs in China will result in industrial offshoring to Africa and spur growth on the continent (Carmody 2020). However, this view is challenged by fact that Asian value chains are becoming more regionally focused, strengthening the argument of "trouble in the making" (Hallward-Driemeier and Nayyar 2017).

3.1.2 Digital decoupling revisited

The increase in regionalization is likely to be reinforced by "digital decoupling", the breaking away of technologies (systems, data architectures, teams, methodologies, standards, internet protocols, hardware design and manufacturing)—as well as the development and deployment of these technologies—that previously were integrated into global industrial manufacturing (Garcia-Macia and Goyal 2021). Decoupling could create multiple spheres of operation, and in fact is currently led by two major economic blocs: the United States (or more broadly, the 'West') on one side of the divide and China on the other (Lopez and Smith 2021). Digital decoupling is driven by political ambitions rather than market forces as the interconnections of the digital era blur traditional distinctions between economic, competitiveness and security issues. Growing competition between the United States and China has already led to trade bans on technologies, such as 5G technologies and semiconductors (Garcia-Macia and Goyal 2021).

Since the 2008 financial crisis, countries have been raised incentives and requirements to operate and sell within their borders, including requirements on the capture and storage of data (Garcia-Macia and Goyal 2021). Tensions will continue to grow as technology increasingly becomes a key determinant of national power. The politicization of technology is expected to obscure positive technological developments taking shape, like artificial intelligence (AI), quantum computing and even sixth-generation wireless networks. Correspondingly, market access and dominance as well as technical standards-setting will emerge as greater points of competition (Noor 2020).

Should digital decoupling continue, it will yield operational challenges, high costs and management risks for firms operating in several markets. Multiple spheres of operation might force firms to maintain distinct operations depending on the market. This could, in turn, reinforce the regionalization trend. This may become particularly problematic for firms from emerging and developing economies and act as barrier to entry in global production.

3.2. Digital transformation

As indicated in the previous chapter, digitalization is the second major trend significantly impacting global production. Despite recent regionalization discussed in the previous section, the world is indeed more interconnected. Digitalization is fundamentally changing production and value creation across manufacturing and services and has led to an explosion in data flow and information exchange (AMRO 2020). Digital transformation has been widely discussed across all disciplines. The key focus now is on the emergence and adaptation of new technologies and the extent to which they have transformed economic, social and political realities. At the heart of

these changes are technologies such as automation technologies, AI, cloud computing, robotics, 5G and others. And technology advancement is set to continue with 6G, quantum computing, 4D printing, nanotechnology and smart materials on the horizon (Riasanow et al. 2019).

Initial digital technology applications in consumer industries (B2C) have led to widely discussed industry disruptions and concentration (Martens 2021). While we do not observe the same trends in manufacturing industries (B2B) (BMWi 2019), digital transformation has instigated far-reaching trends such as servitization, mass customization and others, with significant implications for production processes and the international division of labour (Hallward-Driemeier and Nayyar 2017; Rodrik, 2018). These challenges are expected to become more pronounced because of COVID 19 (Fu 2020).

In this section, we discuss the impact of the digital transformation on GVCs and how new ways of value creation and doing business are shaping opportunities for firms from developing countries to participate in GVCs.

3.2.1 Future of value creation in production: Rise of the intelligent product

Value pools in any given product have shifted from its mechanical features to software and digital technologies. According to estimates, current sources of value in a typical product are 40% software, 30% electronics, 20% mechanical parts and 10% digital components (Schaeffer & Sovie 2019). Digital components include artificial intelligence (AI)—for example, machine learning—as well as analytical capabilities to capture and process data (Schaeffer & Sovie 2019). Through sensors, products are connected to the internet. Its embedded software allows for analysing data while operating the product. As a result, product engineering could radically transform with hardware becoming a 'shell with functionalities' (Schaeffer and Sovie 2019). One of the most widely discussed use cases is the automobile, with the engine being replaced by an operating system that updates features "over the air" (Bauwens 2020).

The connected "smart product" and its operating data—which will provide the basis for further development of engineering and manufacturing—is at the core of differentiation. Already today, installed products and plants, equipped with "intelligence" will provide the real-time data needed for differentiating customer experience (Falk and Riemensperger 2020). Rather than selling the mechanical product as a standalone, new business models such as "as-a-service" are becoming more widespread (Stojkovski et al. 2021). The digital twin as a digital representation of the physical product introduces a new era of engineering and product lifecycle management (Wang et al. 2020). Relatedly, the nature of the firm is expected to change significantly (Porter and

Heppelmann 2015). A multi-tier interaction model—for example, OEM, dealers, customers—is expected to move to a direct customer interaction model.

Platforms and ecosystems are the products' "new habitat" (Schaeffer and Sovie 2019), GVCs are expected to become more intelligent and flexible (Agarwal et al. 2018; Ferrentino and Koten 2019), and a new topography (Dachs and Seric 2019) is the result of the varying adoption of Industry 4.0 and digital technologies (World Economic Forum 2017).

3.2.2 Industry 4.0: From the intelligent factory to collaborative value creation

Initially, Industry 4.0 referred to the optimization of factory operations and was largely associated with the automation of production. Although the Siemens factory in Amberg is one of the more widely-referenced use cases, there are others across the globe (World Economic Forum 2021).

The rise of the intelligent product is at the heart of cross-company—and increasingly, cross-industry—ecosystems and makes companies shift their focus from "in-company optimization" to "inter-company optimization" approaches. Managing cooperation with competitors is one of the key challenges in the digital economy, and cooperation is becoming an important driver for growth and innovation. Partnering with competitors starts with a mindset shift. Dataconnect, for example, enables interoperability via cloud-to-cloud connection for agriculture equipment. Farmers can digitally manage their entire machine park independent of provider. Claas (Germany), John Deere (USA), New Holland and others are also participating.[9]

Ecosystems are already widely discussed as the emerging architecture in which to create value (Khademi 2020). To that end, we should see a rise of ecosystem partnerships in traditional industries; this increase is in fact already visible in some traditional industries such as mining (Käpylä 2020) and pharmaceuticals (Olk and West 2020). In effect, they are co-creating new solutions in partnerships. The emergence of industrial data space (such as in automotive, mobility and manufacturing industries) is a clear indicator. For example, the European Commission aims to create EU-wide data spaces that will allow industry to harness the value of large pools of previously unconnected and inaccessible industrial data, in compliance with EU privacy laws and under European sovereignty.

Platform Industrie 4.0's working group on digital business models has analysed ecosystems in German manufacturing and has identified two main clusters (BMWi 2021). First, community-based ecosystems focus on formulation of standards or R&D on Industrie 4.0 applications. Cooperation between actors often takes place in a pre-competitive framework where commercial

[9] See https://www.365farmnet.com/en/products/dataconnect/ for details.

transactions are not a primary goal. Second, platform-based ecosystems develop cross-company technical solutions and / or digital services as a commercial offer. They coordinate through a joint technical platform, which is typically chargeable. Embedded in these models is the notion that the future of value creation will look very different (Kurznack et al. 2021).

As GVCs become more flexible and new forms of cooperation across industries, companies and countries develop, this offers new opportunities for companies from developing countries to participate in global production. However, there are concerns that the emergence of ecosystems might increase entry barriers for companies from developing countries as they are, so far, regionally clustered—centred, for example, in the United States, Europe or China. Key for the inclusion of companies from other regions is to improve digital infrastructure and knowledge.

To reiterate, digitalization is not a standalone trend acting in isolation, but rather one that interconnects with other megatrends. Section 3.1 discussed how competition for technological leadership between large economic blocs in the 'West' and the 'East' might reinforce regionalization and the emergence of new economically strong regional blocs. In a similar vein, digital transformation is expected to facilitate the implementation and monitoring of new regulatory requirements in the context of increasing urgency of sustainability, which is the focus of the next section.

3.3. Greening of global value chains

The third trend with important implications for global production is the greening of economies. Economic greening is driven by two broad developments. First, climate change is increasingly seen as threat to economies' growth and resilience. Multilateral organizations and governments around the world are prioritizing sustainable models to ensure long-term growth. This includes both regulation as well as the provision of investment incentives for green technologies. Second, negative externalities of global production are increasingly seen as problematic. More and more, companies are seen as just one part of the solution in reaching the goal of greening economies and generating sustainable growth in the long run. Increasing regulation for multinational companies, the pressure of civil society and improvements in monitoring of social and environmental impacts—like ESG reporting—have changed companies' way of operating abroad (UNCTAD 2020). Even though the social dimension, like labour rights and gender equality, is important and shapes companies' governance, it is the environmental dimension that is expected to change international production (UNCTAD 2020). The shift towards economic greening will have a significant impact on GVCs as products and processes along GVCs continue to move towards sustainability. That is why this paper focuses on environmental sustainability. This

section briefly describes trends in new green regulations and discusses the potential impact of this type of legislation on global production. Next, we discuss the growing role of corporate sustainability practices, like ESG policies, in addressing new regulations and stakeholder preferences.

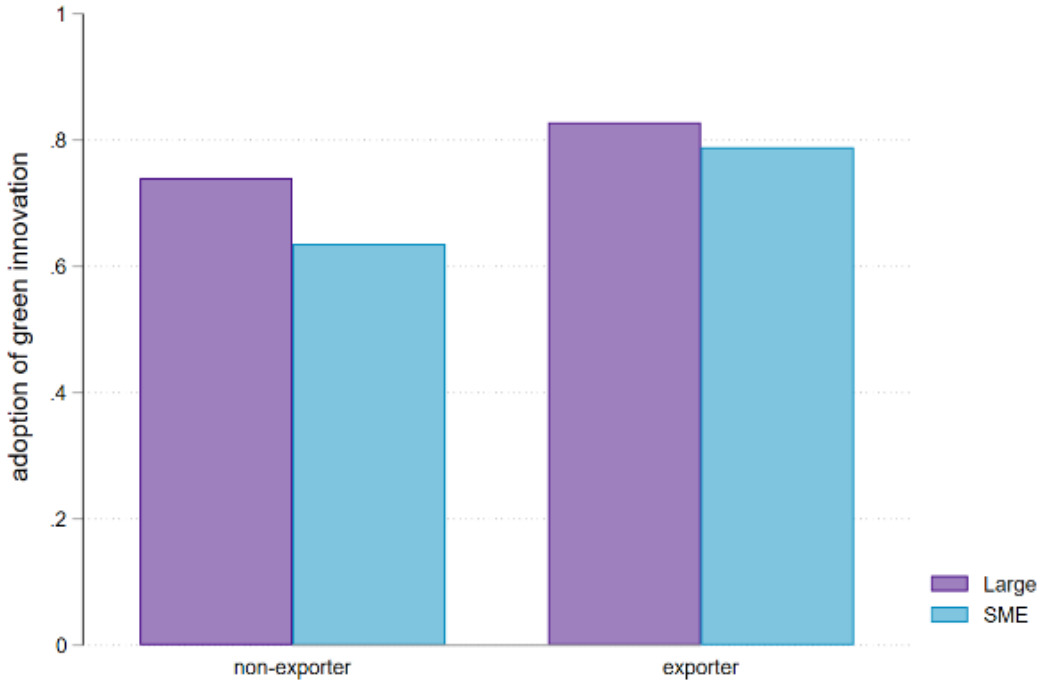
3.3.1 Trends in green regulations

The threat of climate change to growth and resilient production has prompted a series of initiatives around the world and three major economic blocs put the greening of their economies at the top of their political agenda. In 2019, the European Commission introduced the European Green Deal, which aims at reaching climate neutrality by 2050 within the EU. To achieve this goal, the initiative foresees investments in environmentally friendly technologies, measures to decarbonize the energy sector, investment in cleaner forms of private and public transport, and improving global environmental standards in cooperation with international partners (European Commission 2019). In February 2021, the United States rejoined the Paris Agreement on climate change, committing the United States to reduce its emissions by about 25% by 2025 compared with 2005 levels. China's current Five-Year Plan focuses on decarbonization and investment in green solutions and emphasizes China's goal for leadership in green technologies (Holzmann and Grünberg 2021). Increasing competition for leadership in green technologies, particularly between the United States and China, does not come without potential drawbacks. For example, it could increase the risk of enforcing regionalization (AMRO 2021).

Recent incentives by these major economic regions offer new investment opportunities for firms in both developing and developed countries. In fact, since 2015, developing countries have been investing more in green energy than developed countries (Frankfurt School-UNEP Centre/BNEF 2020). Further, FDI is expected to increasingly focus on "sustainable" investments, such as in renewable energies and green technologies (Zhan 2021).

An important driver of innovation and investment in green technologies is internationalization of firms. Recent firm-level surveys by the World Bank reveal that almost 70% of firms in the sample have adopted at least one green innovation within the last three years. As for the adoption rates of green technologies, on average larger firms are more likely to adopt green innovation compared to SMEs. Interestingly, the gap between large firms and SMEs closes for exporters (Figure 17), which is in line with recent findings demonstrating that export activity facilitates firm's investment in green technologies (Hanley and Semrau 2019). Integration into global markets will remain a crucial factor for countries to 'green' their economies and to cope with the challenges induced by climate change.

Figure 17: Green innovation, by firm size and export status



Source: Authors' elaboration based on World Bank Enterprise Surveys, 2019/20 (https://www.enterprisesurveys.org/en/enterprisesurveys).

Note: The sample covers 32 countries from East Europe, Central Asia and North Africa.

3.3.2 Growing role of sustainability standards

Corporate sustainability standards and corporate ratings like ESG rankings have evolved rapidly to improve visibility and increase resilience of GVCs. ESG disclosure plays an increasing role in meeting both stakeholder demand and new regulations, and the quality of ESG reporting is expected to further improve. The social component of ESG will gain more attention as worker safety and diversity come into the centre of discussion. However, the need for disclosing the environmental component is sure to rise, given the agenda of the current US administration and the EU Green Deal.

Sustainability issues have gained prominence in corporations in recent years. A recent survey of C-level executives conducted by Accenture shows that two in five (43%) of organizations have a Chief Sustainability Officer who leads the sustainability agenda in their company. Most executives (67%) also report that their enterprise has sustainability action plans across the organization and around one-third (30%) report that this applies in at least some business units.[10]

[10] Accenture proprietary survey, for details see https://www.accenture.com/us-en/insights/strategy/european-double-up.

In general, sustainability standards are perceived as beneficial for firms and their workers. Research does show that environmental and social policies of firms have a positive impact on their financial performance (Schiller 2018). Firms with a positive social and environmental image should benefit in light of growing consumer awareness for ethical production. However, the impact of emerging sustainability standards and reporting requirements on SMEs is less clear. Some fear that particularly small firms in developing countries that cannot bear the cost of compliance may be expelled from GVCs as a result (Lay et al. 2021). Advancing digitalization is expected to facilitate reporting and monitoring and can thus enable more transparent GVCs.

4. New paradigms GVC design

The three megatrends discussed above are poised to transform GVCs over the long term and new paradigms of GVC design are emerging as a response. These megatrends have brought to the forefront the concept of "industrial ecosystems" as a future core principle and policy objective to address the complex and changing operating environment for manufacturing enterprises.

4.1. Ecosystem participation

4.1.1 Building the data economy

How do you make the data economy work without compromising on data ownership? The question of harvesting and monetizing data while avoiding lock-in effects is at the heart of many corporate strategies. From a political standpoint, concerns about losing digital sovereignty (arguably, a type of "lock-out" effect) have become more important and are increasingly reflected in technology and industry policies. For example, in February 2020, the European Commission announced the European Strategy for Data, which aims to create a single market for data in Europe. The objective is to make Europe a world leader in the global data economy and to promulgate European values on data protection. More specifically, Europe will focus on building data spaces that accelerate European tech and European industrial advances through data.[11] China has issued multiple data strategies (Liu 2021) including targeted approaches to advance smart manufacturing (BWWI 2020). Data and technology strategies are associated with significant investments, highlighting the increasing technological competition especially between the United States and China.

[11] https://ec.europa.eu/commission/presscorner/detail/en/fs_20_283

European states have begun responding to these changing dynamics at the national level. Initiated by the German Federal Ministry of the Economy and Energy (BMWI), Gaia-X was launched, with the ambition to create a blueprint for a secure, open ecosystem, where data and services can be made available, collated and shared in an environment of trust.[12] Gaia-X was recently expanded across Europe and is now institutionalized as an international non-profit association under Belgian law.

4.1.2 Role of data spaces

The centrepiece of this soft infrastructure is the data space, which is a "federated data ecosystem within a certain application domain and based on shared policies and rules" (OPEN DEI 2021). Data spaces consist of a set of critical building blocks: (1) data platforms for sharing data effectively as well as for engineering and deploying data exchange and processing capabilities, (2) data marketplaces where data and data processing applications can be exchanged, and (3) building blocks guaranteeing data sovereignty (OPEN DEI 2021). The three technological requirements are connectivity, digital twins to access and combine data from different sources, and a software layer to create, manage and share the digital twins' data (OPEN DEI 2021).

4.1.3 Snapshot: Catena-X

In March 2021 Catena-X expanded existing auto industry alliances to become the first "data-driven value chain" for the automotive industry. The vision of the alliance is the "provisioning of a user-friendly environment for building, operating and collaborating on end-to-end data chains along the entire (automotive) value chain." The Catena-X partner network includes BMW AG, Volkswagen AG, Deutsche Telekom AG, Robert Bosch GmbH, SAP SE, Siemens AG, ZF Friedrichshafen AG, Mercedes-Benz AG and Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., among others. The partnership has agreed to 10 initial use cases in the areas of sustainability, quality, demand management and supply chains.

4.2. Understanding the nodes of the competitive map

To remain competitive, companies have to reconsider their business models and their role in international markets. Unsurprisingly, studies show that countries with high internet penetration and high share of firms with digital entrepreneurial skills have an advantage in adapting to changing value chains (Ferrentino and Koten 2019).

[12] For more information on Gaia-X, see https://www.data-infrastructure.eu/GAIAX/Navigation/EN/Home/home.html.

Digital transformation goes hand-in-hand with skill-intensive tasks and high capability requirements, which are usually less available in developing countries, which undermines their comparative advantage of participation in GVCs (Rodrik 2018). In contrast, digital transformation might also offer new possibilities for countries to trade and may not necessarily lead to concentration of production. For instance, Freund et al. (2018) show that world trade increased when 3D printing was developed in the hearing aid industry. They find that although early innovator countries in that industry remained top exporters, middle-income countries like China, Viet Nam and Mexico were also able to increase their market shares. A key challenge for developing countries that hope to keep pace is to invest in their economies' fundamentals, like human capital, and to strengthen domestic firms' integration with global companies (Rodrik 2018).

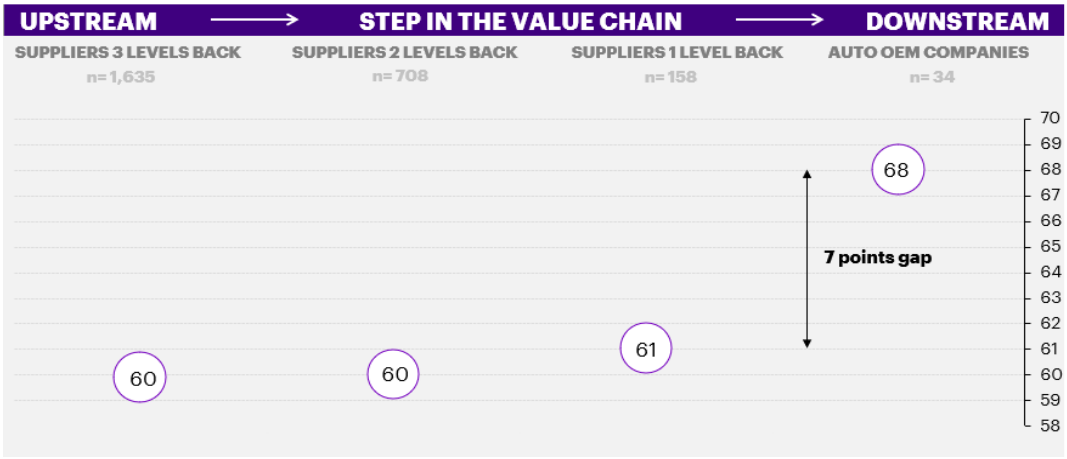
4.3. Sustainability spillovers

The trend of greening economies—and, consequently, new regulation with respect to environmental aspects of production—will no doubt continue. As most of this development is driven by governments and consumers in industrialized countries and affects mainly large companies, an important question is how this trend will affect other, smaller firms along the value chain and those located in other regions of the world.

In an attempt to answer this question, we merge buyer-supplier data of FactSet with ESG scores from Arabesque, looking specifically at three GVCs—automotive, semiconductor and apparel GVCs—and identifying the differences between them.

In analysing the automotive GVC, we find that automotive original equipment manager (OEM) companies have higher Environmental Index scores than their suppliers along the value chain. Moving forward along the chain shows slightly better Environmental Index performance; yet scores of suppliers are still seven points below those of auto OEM companies (Figure 18). This finding that environmental and social expenditures are higher for more downstream firms is in line with recent literature. For instance, Herkenhoff et al. (2021) show that corporate social responsibility expenses of suppliers in India increase along the value chain from upstream to downstream positions.

Figure 18: Environmental Index scores of auto OEM firms vs. their suppliers along the GVC, 2000

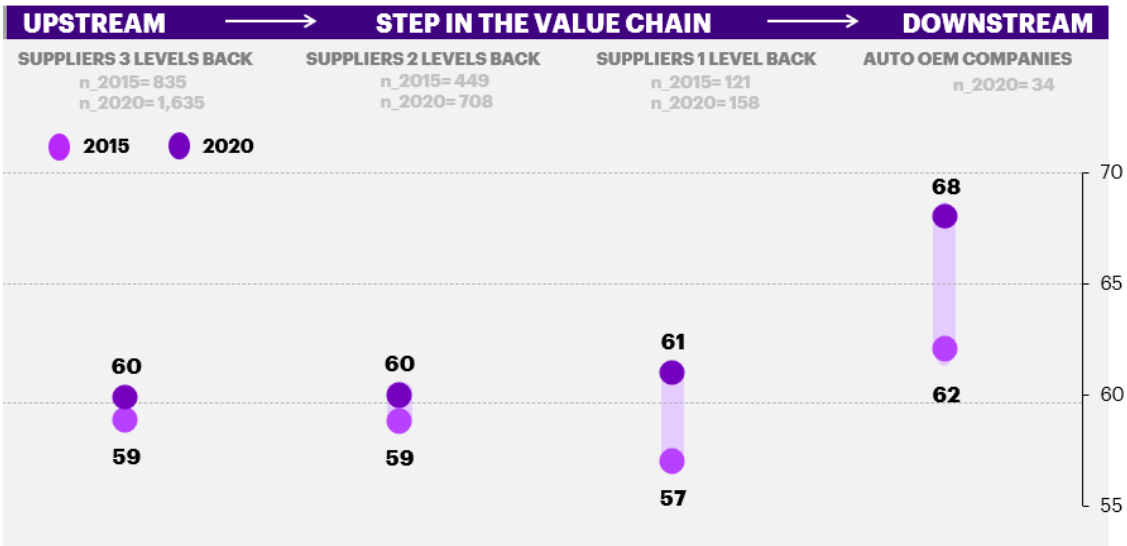


Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 34 auto OEM companies from Europe and Asia.

In general, environmental scores have been improving over the last five years, especially among auto OEM companies. And auto OEM companies, as well as their suppliers along GVCs, improved their environmental practices between 2015 and 2020. However, improvement is higher the nearer the company is to the final customer. While level-three suppliers increased the environmental score by one point, auto OEM companies their scores increased by six points (Figure 19).

Figure 19: Environmental practices of auto OEM companies and their suppliers along the GVC, 2015-2020

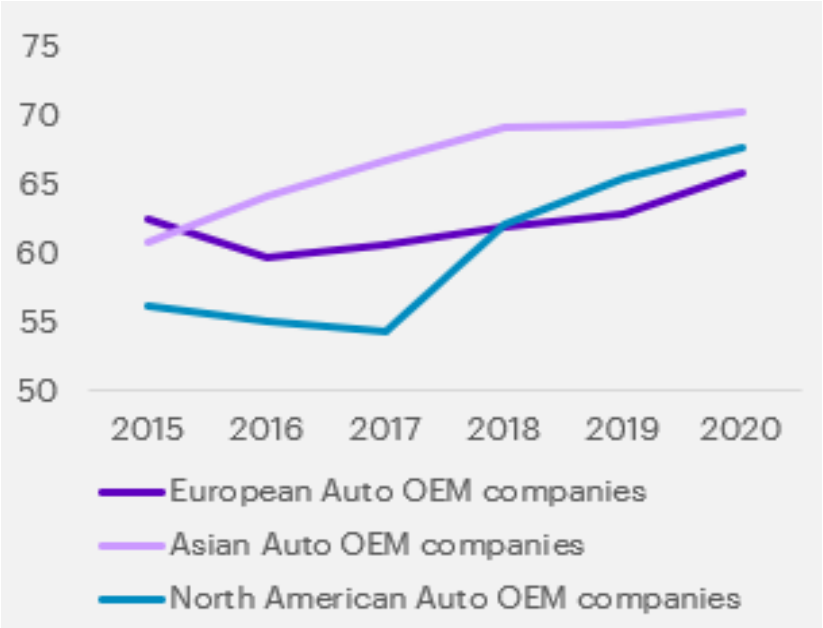


Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 34 auto OEM companies from Europe and Asia.

However, these improvements have been unevenly distributed across regions. The evolution of Environmental Index scores for auto OEM companies and their suppliers between 2015 and 2020 illustrates that Asian auto OEM companies are the best-performing companies, in terms of environmental practices, with US companies showing the most significant improvements over the last five years. European companies, originally the best performing in terms of sustainability, have demonstrated less advancement over the same period (Figure 20). In terms of suppliers, it is worth noting the initial very low scores of North American auto companies that have been catching up in their environmental practices.[13]

Figure 20: Change in Environmental Index scores of auto OEM companies, by region, 2015-2020



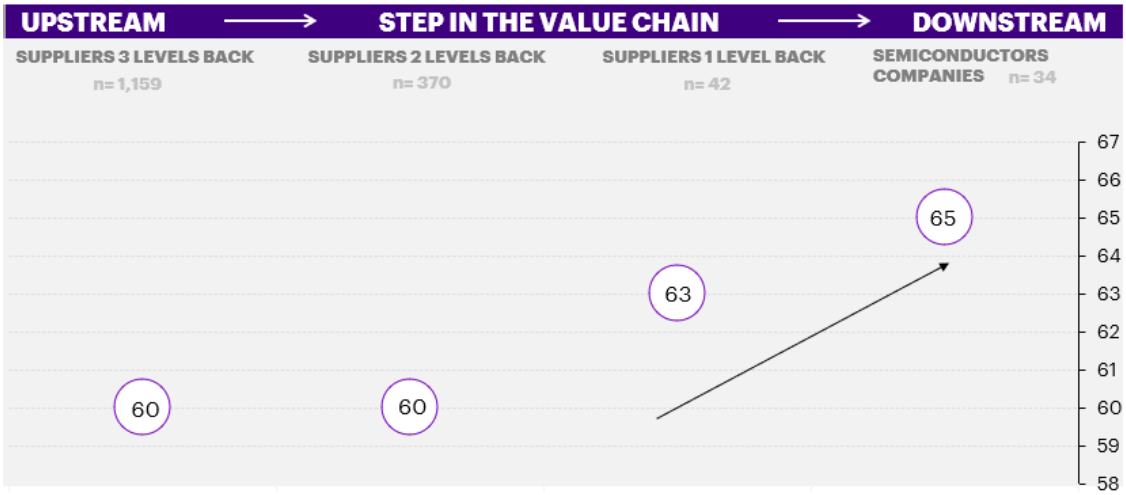
Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 34 auto OEM companies.

Our analysis shows that semiconductor companies, too, have a stronger environmental performance than their suppliers along the value chain. Moving forward along the value chain reveals better Environmental Index scores, with upstream suppliers five points below that of semiconductors companies (Figure 21).

[13] For the United States, interpretation of ESG scores has to be done cautiously given that ESG reporting from US companies has traditionally been low because of institutional differences compared to, for instance, European companies (Harper Ho 2020).

Figure 21: Environmental Index scores of semiconductor firms vs. their suppliers along the GVC, 2020

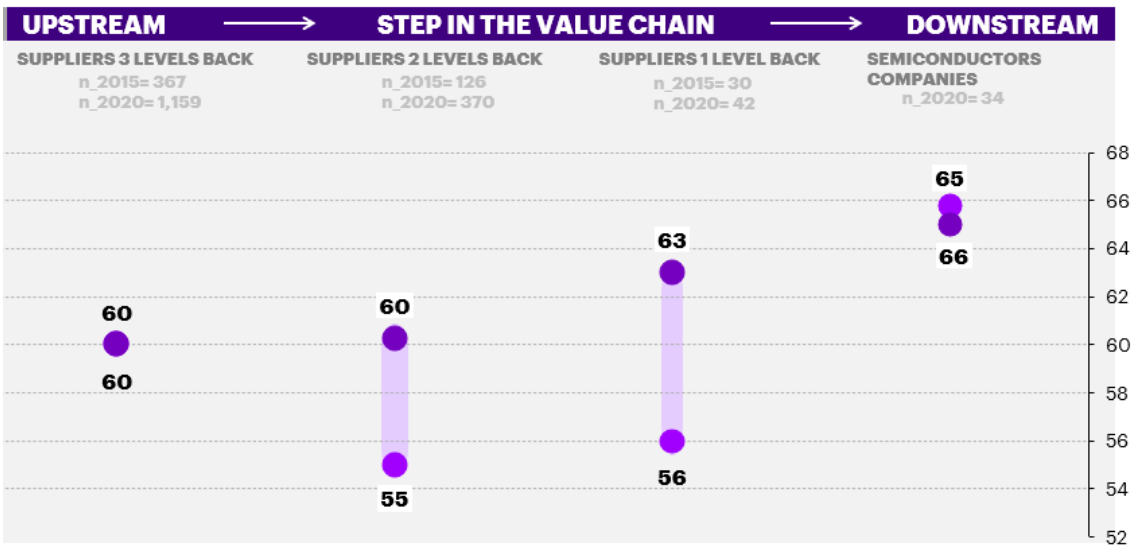


Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 34 semiconductor companies from Europe and Asia.

Semiconductor companies and their suppliers along the GVC have managed to sustain or improve their environmental practices between 2015 and 2020. Although level 2 and level 1 suppliers had the biggest improvements in Environmental Index scores, semiconductors companies maintain the highest average scores when analysing the entire value chain (Figure 22).

Figure 22: Environmental practices of semiconductor companies and their suppliers along the GVC, 2015-2020

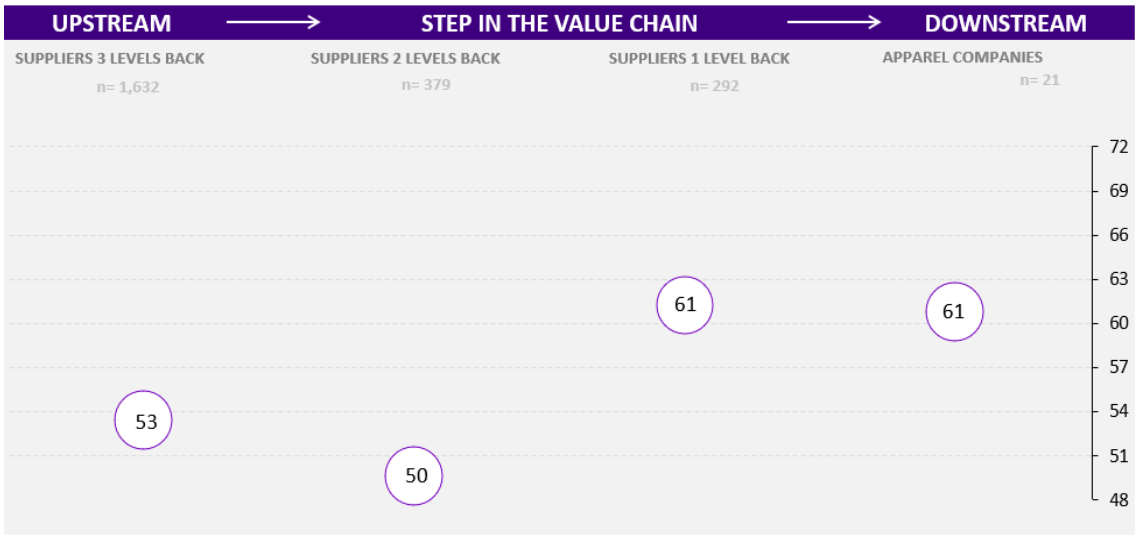


Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 34 semiconductor companies from Europe and Asia.

Finally, in examining the apparel and accessories GVC—a comparatively more labour-intensive industry—we find that apparel companies and their immediate suppliers have similar Environmental Index scores. Yet, again, there is a large gap in scores between the first and second level of suppliers, indicating little visibility and control over environmental practices once there is no direct interaction (Figure 23).

Figure 23: Environmental Index scores of apparel firms vs. their suppliers along the GVC, 2000

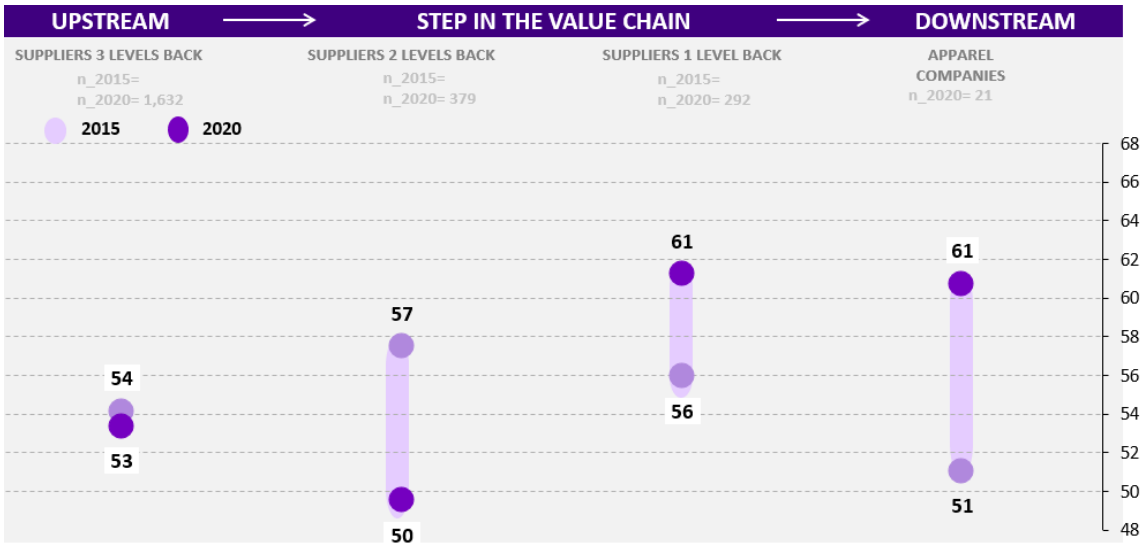


Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 21 apparel companies from Europe, North America and Asia.

Apparel companies and their direct suppliers along the GVC have managed to improve their environmental practices between 2015 and 2020. Level 2 suppliers started with higher average scores than level 1 suppliers, but registered a strong decline (Figure 24). There is an upward trend in Environmental Index scores across the different regions, particularly for Asian apparel companies. In 2020, we observe a small decline for both European and North American companies (Figure 25).

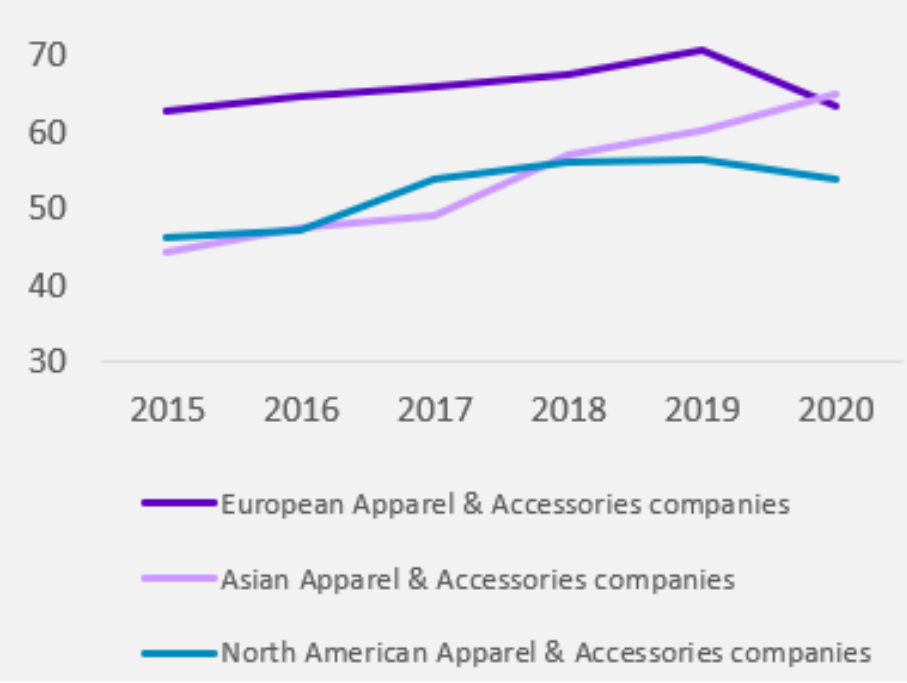
Figure 24: Environmental practices of apparel companies and their suppliers along the GVC, 2015-2020



Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 21 apparel companies from Europe, North America and Asia.

Figure 25: Change in Environmental Index scores of apparel and accessories companies, by region, 2015-2020

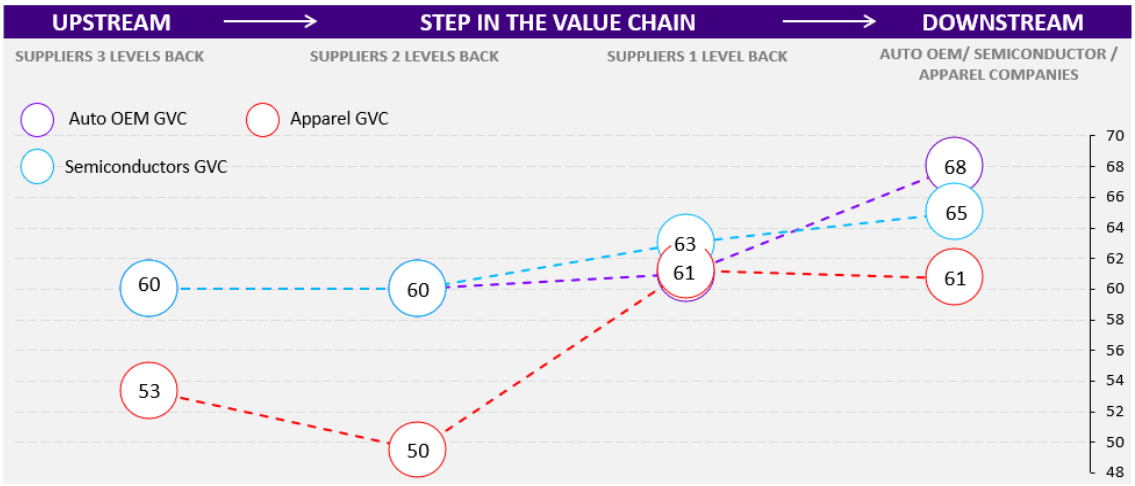


Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 21 apparel companies from Europe, North America and Asia.

The semiconductor and automotive industries show similar scores along different steps of their value chains: the closer companies are towards the end of the value chain, the greater the improvement over time. Both GVCs show gaps between the first and second level of suppliers more upstream (Figure 26).

Figure 26: Environmental Index scores along the auto OEM, semiconductor and apparel GVCs, 2020



Source: Accenture Research based on FactSet financial data (https://www.factset.com/solutions/business-needs/data-solutions) and analytics and Arabesque S-Ray®, 2021 (https://www.arabesque.com/s-ray/).

Note: The sample covers 34 Auto OEM, 34 semiconductor and 21 apparel companies from Europe, North America and Asia.

Our results illustrate that firms closer to final consumer demand on the GVC are better-performing in terms of environmental sustainability compared to relatively upstream firms. However, it is important to point out the limitations of our sample. In our data we analyse only large and public companies, which excludes many firms globally. Further, we only track value chains until the third level of supplier, thus observing only a selective and relatively downstream part of the value chain. Despite these limitations, our findings are in line with the broader literature on environmental and social responsibility of firms active in GVCs, which hypothesizes three main explanations for the observation that downstream firms perform better on environmental and social aspects. First, downstream firms are closer to the final consumer and thus more visible and easier to monitor by civil society and stakeholders. Downstream firms are relatively easy targets for campaigns or even consumer boycotts when they are involved in environmental or social scandals related to their production. Second, the beginning of a value chain is often characterized by relatively "dirty" industries, measured by emissions. Capital-intensive industries are usually located upstream, whereas downstream industries are mainly labour-intensive (Shapiro 2021; Copeland et al. 2021). It is therefore, by design, easier for downstream firms to have, for instance, better performance on environmental criteria compared to very upstream firms. Semrau (2021) shows that, in India, the more upstream firms operate, the higher their energy consumption and

CO_2 emissions and the lower their energy efficiency. Third, GVCs are characterized by incomplete contracts (Antràs 2003). This implies that it is difficult for downstream firms to enforce standards among their suppliers along the value chain. Incomplete contracts are shown to play a role when it comes to firms' investment in corporate social responsibility (CSR) along value chains (Herkenhoff et al. 2021).

Each of these explanations may apply to a different extent depending on the type of value chain. The relatively strong Environmental Index performance of downstream auto OEM companies compared to their suppliers in our data might reflect specific characteristics of the auto industry. Auto OEM companies are very close to the final consumer and thus more visible. In contrast, the semiconductor GVC is not as close to the final consumer; semiconductors are used as inputs in other industries.

Environmental requirements imposed by developed countries could be seen problematic as they impose additional costs on firms and their suppliers. However, this could be also an opportunity for firms to innovate and enter value chains. Recent literature shows that increasing engagement in ESG policies by downstream firms is likely to benefit suppliers along value chains. Schiller (2018) shows that corporate environmental and social policies propagate along GVCs, and that this is driven by sourcing firms' incentives to reduce potential risks. Large downstream firms are known to train their suppliers and assist them in complying with sustainability standards (Görg and Greenaway 2004; Schiller 2018). In general, our data show that Environmental Index scores have improved along all stages of the examined value chains in recent years. This greening trend is expected to generate sustainability spillovers and benefit upstream suppliers in the future, particularly when the standards in suppliers' countries are lower than in buyers' countries.

5. Future of GVCs: Long-term changes in the horizon?

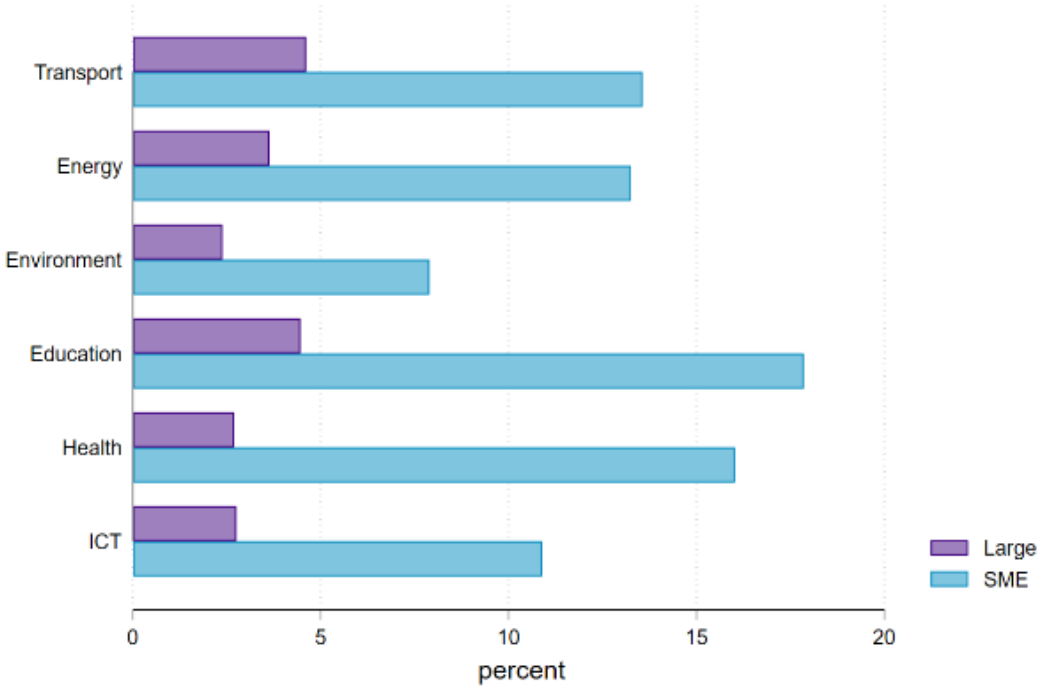
In this paper we have discussed the impact of three key megatrends on the reconfiguration of GVCs. The shift of the economic centre to Asia and increasing regionalization, including the regionalization of Asian value chains, pose challenges for countries and their ability to benefit from integration in international production. In addition, advancing digitalization is changing the way business is done and how value is created, opening new windows of opportunity but also making investments in digital infrastructure and skills even more relevant. Finally, the threat of climate change and the rising role of sustainable production has initiated new regulations and new investment incentives for companies.

Together, these developments have resulted in geographic redistribution of the division of labour and redefinition of value chains. The new paradigm of GVCs and the likely changes arising from the impact of these megatrends has given risen to rethinking industrial policy and multilateral cooperation. Industrial policy is already back on the political agenda in many countries. For instance, the United States, EU and China have developed industrial policy plans to foster innovation and remain competitive. It is crucial for developing countries to design policies that support these developments in GVC design and reap the benefits of GVC integration.

Overall, international integration remains key for countries to keep pace with the challenges induced by the megatrends and to grow sustainably. However, developing countries should rethink their comparative advantage, as their labour-cost advantage is likely to be insufficient to participate in GVCs (McKinsey Global Institute 2019). Given that Asian value chains are becoming more regional, other developing economies might instead focus on investment facilitation, support for domestic industries in agro-processing and investment in local infrastructure (Carmody 2020).

A main prerequisite needed for countries to remain competitive is digital infrastructure. Multinational companies are looking for production sites with high-quality infrastructure to establish the core of their supply chains (World Economic Forum 2020). Besides digital infrastructure, intellectual property rights protection and a well-educated workforce are also key for innovation and keeping up with digitalization. Skill upgrading should thus remain a key priority for governments. According to recent World Bank Enterprise Surveys, firms reported that the areas of highest priority for public spending should be education, health, transport and energy. Overall, SMEs deem public spending more important compared to large firms. And SMEs believe the major priority area for public spending is education (Figure 27). An inadequately educated workforce is seen as major obstacle to business operations, independently of firm size (Figure 28). Overall, countries need to be aware of upcoming changes, shifts and transformations impacted by the three megatrends discussed in this paper and prepare accordingly. Governments should rethink their innovation and investment policy measures enabling the conditions for long-term sustainable growth.

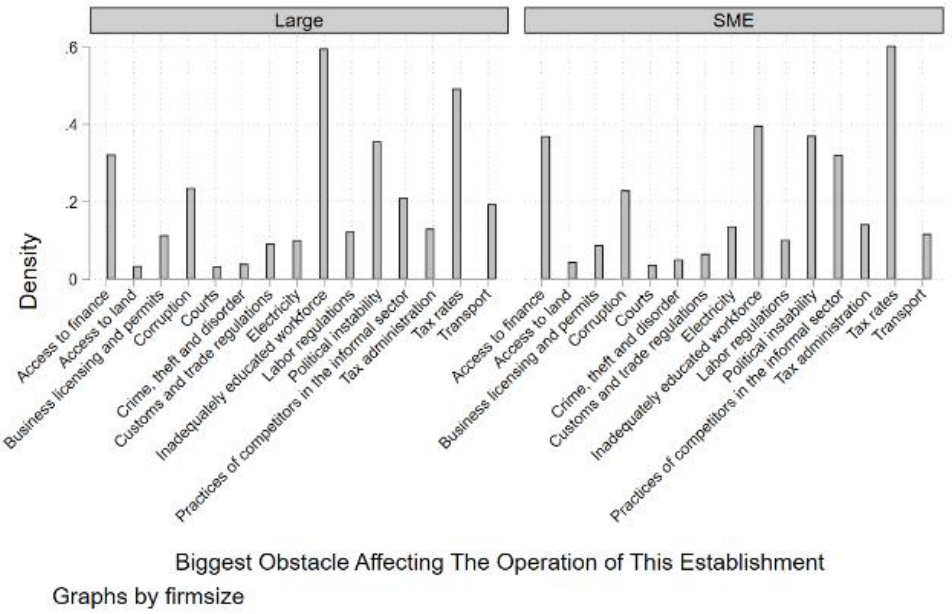
Figure 27: Firms' assessment of areas of highest priority for public spending, by firm size



Source: Authors elaboration based on World Bank Enterprise Surveys, 2019/20 (https://www.enterprisesurveys.org/en/enterprisesurveys).

Note: The sample covers firms in 32 countries from East Europe, Central Asia and North Africa.

Figure 28: Firms' assessment of biggest obstacle affecting firm operation, by firm size



Source: Authors elaboration based on World Bank Enterprise Surveys, 2019/20 (https://www.enterprisesurveys.org/en/enterprisesurveys).

Note: The sample covers firms in 32 countries from East Europe, Central Asia and North Africa.

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Vienna International Centre · P.O. Box 300 9 · 1400 Vienna · Austria
Tel.: (+43-1) 26026-0 · E-mail: info@unido.org
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