

# Recent patterns of global production and GVC participation

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## ABSTRACT

Taking advantage of a new accounting method to decompose GDP production into pure domestic production, traditional trade, simple and complex GVC activities, this chapter examines recent trends in global value chain (GVC) activities across the world. Our main findings show that the pace of GVC activities picked up in 2017 after a period of slow down since 2012; intra-North American and intra-European GVC activities declined relative to inter-regional transactions due to higher penetration via Factory Asia but value

chains still remain largely regional; China is increasingly playing an important role as both a supply and demand hub in traditional trade and simple GVC networks, although the US and Germany are still the most important hubs in complex GVC networks; bilateral trade balances are significantly affected by the supply and demand of third countries; and net imports are no longer a proper measure of the impact of international trade on the domestic economy in the age of GVCs.

- The growth of global value chains has slowed since the 2008-09 Global Financial Crisis but has not stopped. From 2000 to 2007, global value chains (GVCs), especially complex ones, expanded at a faster rate than GDP. During the global financial crisis there was naturally some retrenchment of GVCs, followed by quick recovery (2010-2011), but since then growth has mostly slowed. However, most recent data for 2017 show that complex GVCs grew faster than GDP.
- Value chains remain largely regional but they are not static. Between 2000 and 2017, intra-regional GVC trade increased in "Factory Asia" reflecting, in part, upgrading by China and other Asian economies. In contrast, intra-regional GVC trade in "Factory Europe" and "Factory North America" decreased slightly relative to inter-regional GVC trade reflecting stronger linkages with "Factory Asia".
- China has emerged as an important hub in traditional trade and simple GVC networks, but the United States and Germany remain the most important hubs in complex GVC networks.

**G**lobal value chains, where firms specialize in a particular set of activities in one country to produce parts and components for other countries, have spread the production process across countries; their share of world production and trade has expanded greatly over the past three decades. In the years immediately after the global financial crisis, however, the expansion of GVCs significantly slowed, according to GVC production measures reported in the 2017 GVC development report. At the same time, the world has seen the emergence of populist, protectionist movements in many advanced countries. The looming trade tension between the United States and its major trading partners, especially China, the second largest economy in the world, will have significant consequences for growth opportunities in developing countries, but also, in a world of high levels of interdependence, developed economies.

The first chapter of this report updates trends in GVC production and trade activities in both developed and developing economies by technology (knowledge) intensity and income level, according to the production decomposition method proposed by Wang et al (2017). This approach classifies the embodied factor content in a product into GVC and non-GVC activities

based on whether it crosses national borders or not. Value-added creation is only classified as a GVC activity when the embodied factor content in a product crosses a national border for production purposes (Box 1.1).

The chapter is organized as follows. Section 1 describes the changing pattern of global production activities and GVC participation across countries and industries based on global inter-country input-output (ICIO) tables constructed by Asian Development Bank, which covers 62 economies and 35 industries up to 2017. Section 2 demonstrates the changing distribution of value-added production activities along typical global value chains, as more developing countries have been integrated into the global production network. Section 3 uses network analysis to demonstrate the topology of the global production network structure of traditional trade, simple and complex GVC activities, and their evolution between 2000 and 2017. Section 4 analyzes the multilateral nature of bilateral trade and focuses on three sensitive bilateral trade relations (US-China, US-Germany, US-Japan) to demonstrate the roles third countries have played in determining bilateral trade balances in the age of global value chains. Section 5 concludes.

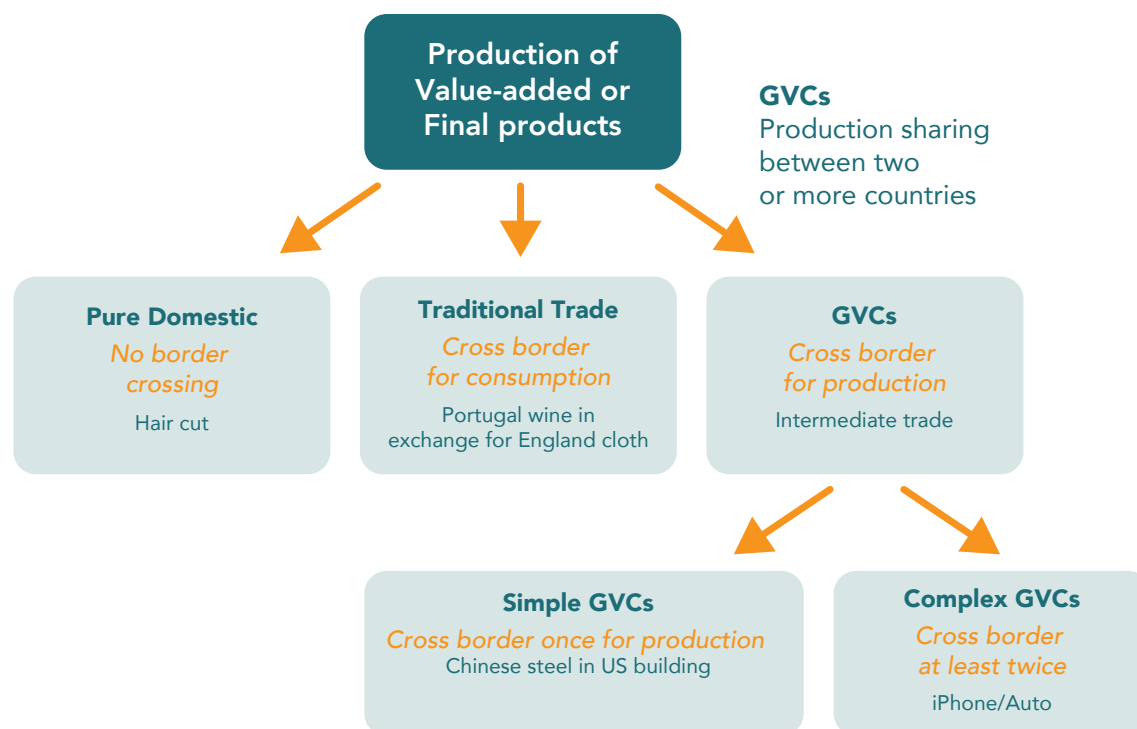
#### BOX 1.1

### A production decomposition to identify and measure GVC activities

In Wang et. al. (2017), production activities are divided into 4 broad types depending on whether they involve production sharing between two or more countries. The first type is value added produced at home and absorbed by domestic final demand without involving international trade. No factor content crosses national borders in the entire production and consumption process. The second type is domestic value added embodied in final product exports, that is, traditional trade: products are made completely by domestic factors and factor content crosses a national border once for consumption only. The third type is domestic value added embodied in a country-sector's intermediate trade that is used by the partner country to produce its domestic products consumed locally, or is foreign value added that is imported directly from partner countries and used for domestically consumed products. Factor content is used in production outside the home country and crosses a national border once for production. Therefore, it is referred to as "simple GVC activities". The last type is value added embodied in intermediate exports/imports that is used by a partner country to produce exports (intermediate or final) for other countries. In this case, factor content crosses a national border at least twice, so is referred to as "complex GVC activities." Production activities in the first two types are entirely conducted within national borders, and

there is no cross-country production sharing; the difference between the two is whether they satisfy either domestic or foreign final demand. The last two types are cross-country production sharing activities; the differences between the two are whether they satisfy partner country or other countries' final demand, and the number of times factor content crosses national borders. Domestic and import input-output coefficient matrixes in ICIO tables are used to distinguish domestic and foreign factor content in various production activities. The classification and relation among the four types of production are depicted in Figure 1.1.

According to this decomposition method, GVC activities as a share of total production activities can be used to measure the intensity of each country-sector's participation in cross-country production sharing activities. Essentially, this approach measures the percentage of production in a particular country-sector that has been engaged in global production networks. The forward GVC participation indicator is based on a decomposition of GDP production; it shows the percentage of production factors employed in a country-sector that have been involved in cross-country production sharing activities. The backward participation indicator is computed based on a decomposition of final goods production; it shows the percentage of final products produced by a country-sector coming from GVC activities.

**FIGURE 1.1** Decomposition of production activities<sup>1</sup>

## 1. The changing pattern of global production activities and GVC participation<sup>2</sup>

GVC activities as a share of global GDP fell from 2011 to 2016, as the share of purely domestic production activities rose (see Figure 1.2, which is an update of Figure 2.3 in the 2017 GVC Development Report based on the newly released ICIO tables by the Asian Development Bank). This continues the downward trend in GVC activities shown in the 2017 GVC report based on data through 2014. However, the growth of global trade surpassed the growth of global GDP for the first time in nearly six years in 2017, and there were signs of a recovery of GVC activities.

The nominal growth rate of all types of production activities (the four activities are defined in Box 1.1) fell sharply during 2012-2016, with a much sharp slowdown in cross-country, production-sharing GVC activities. The decline was the steepest for complex GVC activities, followed by simple GVC activities, traditional trade and domestic production activities; the average annual changes for these four types of activities during 2012-2016 were -1.65%, -1.00%, -0.28% and 1.49% respectively (individual year data are reported in Figure 1.3, which is an update of Figure 2.5 in the 2017 GVC report). Thus, the limited increase in global GDP from 2012-2016 was almost entirely accounted by the growth of pure domestic production; international trade contributed very little during this slow recovery period. In 2017, the growth rate of global trade exceeded that of global GDP, a

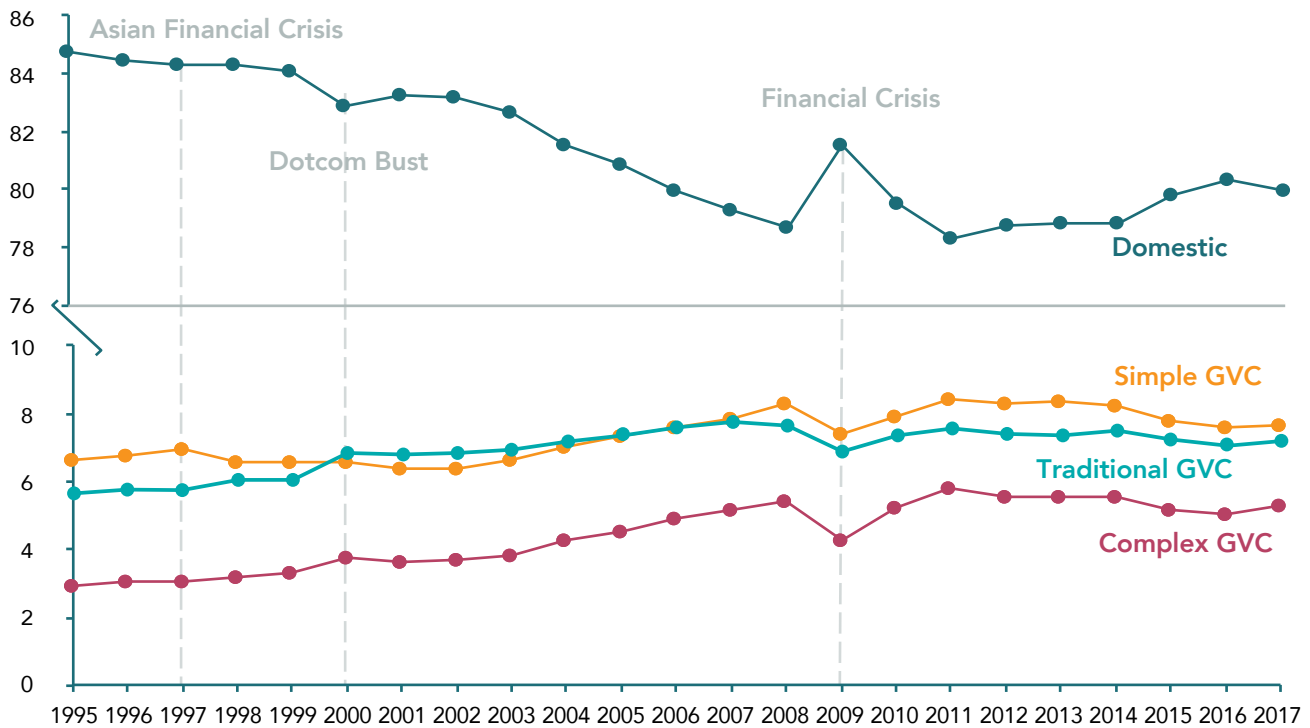
10% increase in complex GVC activities led the growth. However, rising trade tensions between the United States and its major trading partners, especially China, has introduced tremendous uncertainty in the global economy recovery process. Determining whether the recovery of cross-country production sharing activities in 2017 has started a new trend requires more years of data and further analysis.

A first step is to measure the impact of the recent, sharp changes in commodity prices on nominal growth rates of production activities shown above. The global prices of crude oil and other bulk commodities have gone through a “super cycle” since 2000. For example, the per barrel crude oil price (dated Brent) fluctuated dramatically during 2000-2018, rising from less than 30 US dollars in 2000 to over 110 dollars in 2011, falling to less than 50 dollars by 2016, and then rebounding to about 70 dollars since early in 2018. Because crude oil and other bulk commodities are important intermediate inputs in global production, these price fluctuations may affect the relative nominal growth patterns of different types of value-added creation activities measured in current US dollars shown in Figure 1.3.

It appears, however, that the more rapid decline in the nominal value of GVCs than other activities as a share of GDP from 2011-2016 was not due simply to price changes. Figure 1.4 shows the growth rate of the volume of world merchandise trade, world real GDP and their ratio during 1995-2017. For each year when global real trade growth was faster than global real GDP growth, complex GVC activities had the highest nominal rate of growth

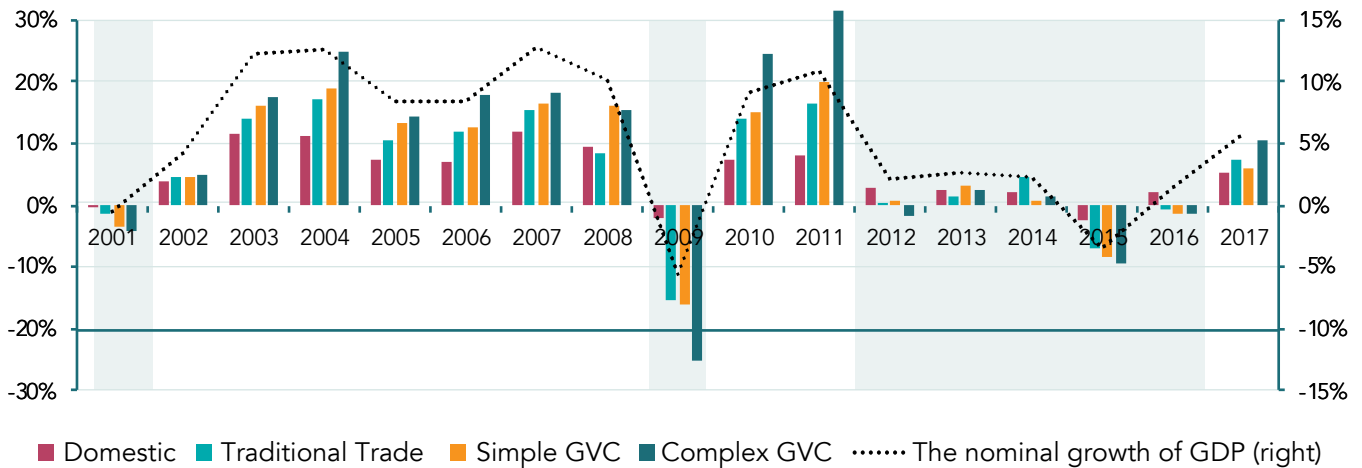
**FIGURE 1.2 Trends in production activities as a share of global GDP, by type of value-added creation activity, 1995-2017**

Percent

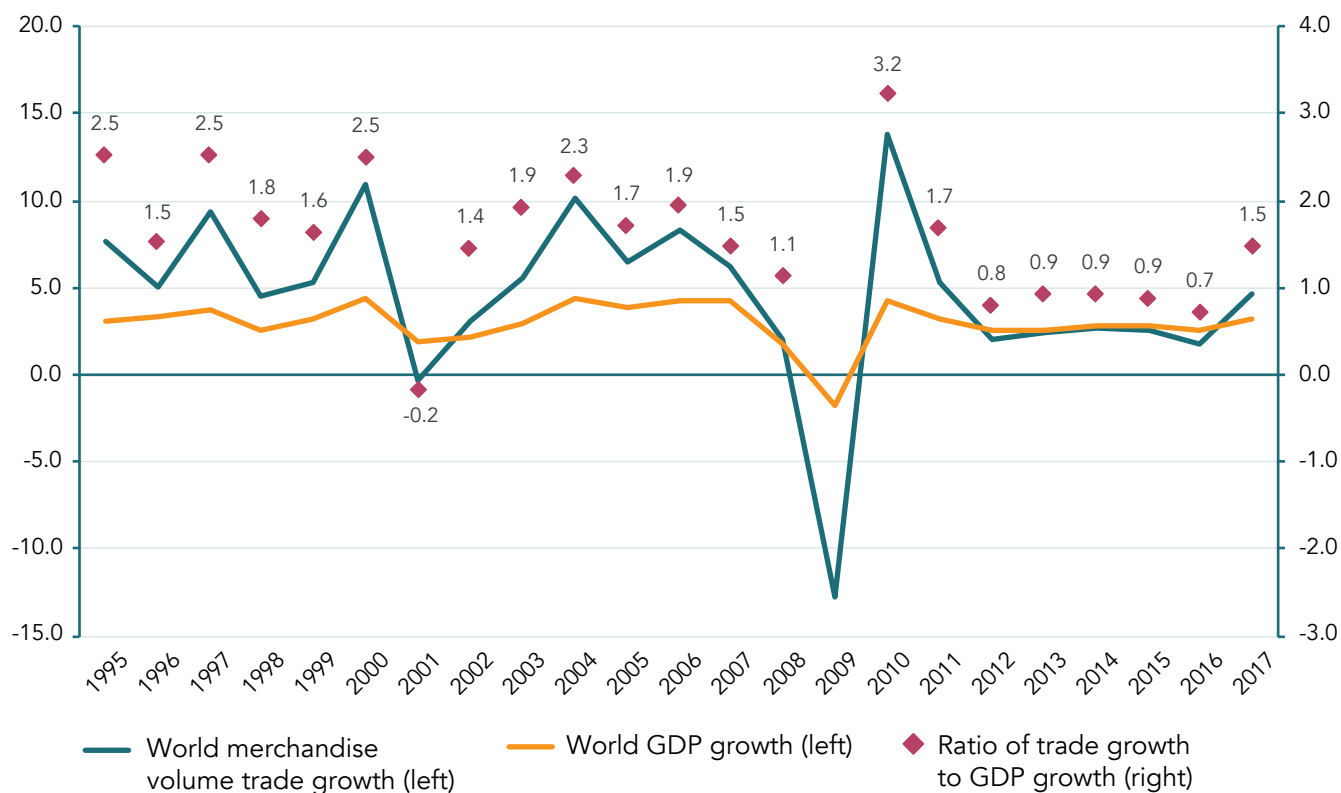


Source: 1995-2009 are based on the University of International Business and Economics (UIBE) GVC indexes derived from the 2016 World Input-Output Table, and 2010-2017 are based on the UIBE GVC indexes derived from the Asian Development Bank (ADB) 2018 ICIO tables.

**FIGURE 1.3 Nominal growth rates of different value added creation activities, global level, 2000-2017**



Source: 2000-2010 are based the UIBE GVC indexes derived from the 2016 World Input-output table, and 2011-2017 are based on the UIBE GVC indexes derived from the ADB 2018 ICIO tables.

**FIGURE 1.4** The growth rate of merchandise trade volume and real global GDP, 1995-2017, %

Source: Global GDP is from World Development Indicators, WB and World Economy Outlook, IMF; Merchandise volume trade is from UNCTAD. The ratio of trade decline to GDP decline in 2009 is 7.4, out of scale shown in the graph.

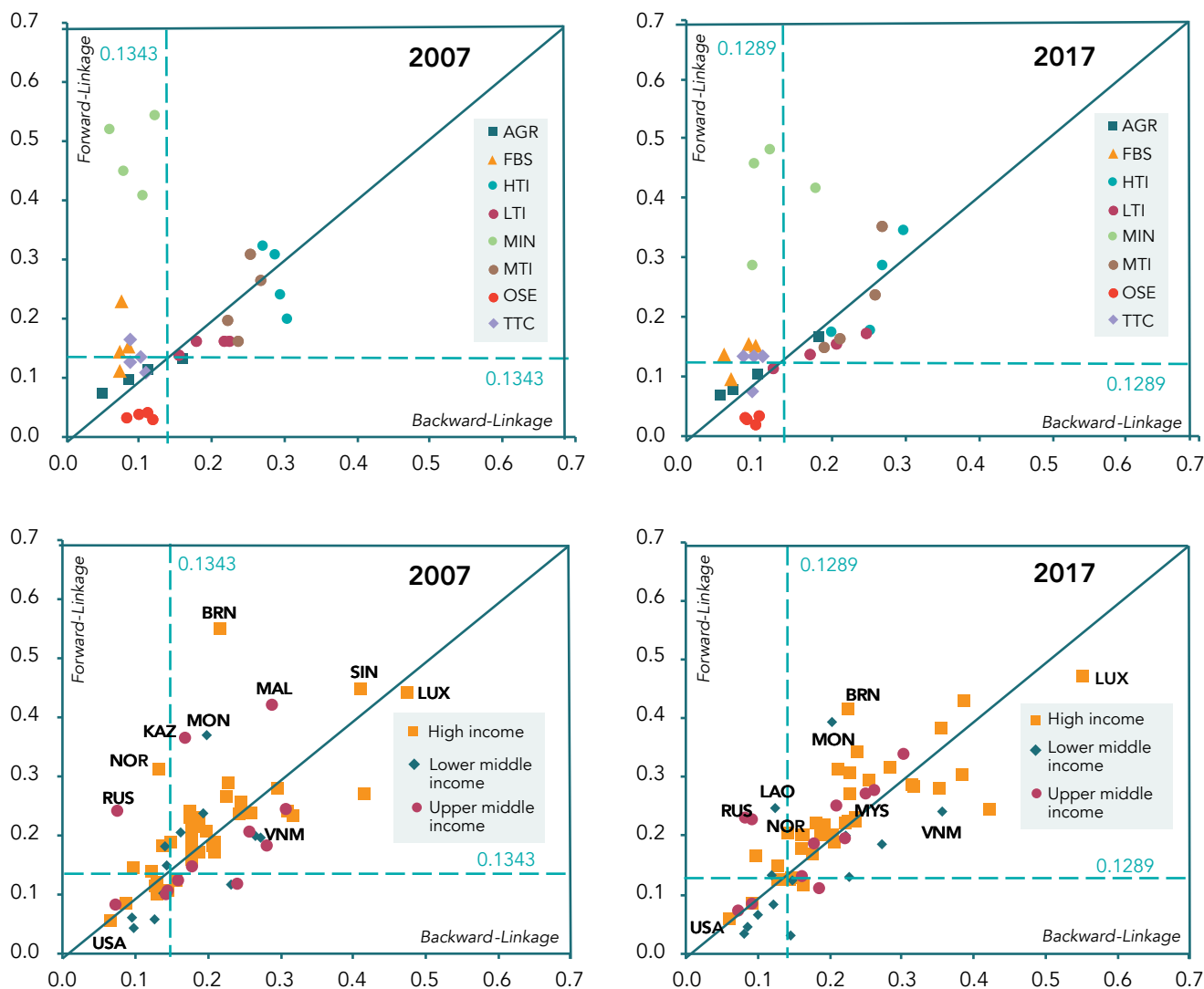
among the four type activities shown in Figure 1.3. And when world trade grew slower than world GDP, complex GVC activities grew more slowly than other activities. This can be understood intuitively, because complex GVC activities are the only one of these four components of value added production where factor content embedded in products cross a national border at least twice. When complex GVC activities grow slower than pure domestic production activities, as happened during 2012-2016, world trade grows slower than GDP.

To evaluate the impact of the shift in production patterns after the global financial crisis to GVC participation across countries and industries, we plot the forward and backward GVC participation indicators jointly in a scatterplot based on ADB ICIO tables (Figure 1.5). The two red dotted lines indicate the world's average forward and backward participation rates and divide the figure into four quadrants. Most countries fall along the 45-degree line, indicating that countries that have a high degree of forward participation also tend to have a high degree of backward participation. Major resource exporters, such as Mongolia, Russia and Norway, fall above the 45-degree line (Figure 1.5, upper left). Since natural resources are the most upstream sectors, these economies tend to have much higher degree of forward GVC participation than backward GVC participation.

Across sectors<sup>3</sup>, mining (represented by the purple dots) is in the upper left corner, indicating a high degree of forward GVC participation but a low degree of backward GVC participation. Most service sectors, especially for sectors in the other services group (utility, education, health care and personal services, represented by the blue dots) tend to be in the lower left corner, meaning that they have low participation in GVC activities by both measures. In comparison, high research and development (R&D) intensity manufacturing sectors (red dots) tend to be in the upper right quarter of the graph, reflecting their active participation in GVCs as both producers and buyers of intermediate products.

Ten years after the global financial crisis, global GVC participation has not returned to pre-crisis levels: the global average GVC participation rate (as a share of GDP) was 0.1289 in 2017, compared to 0.1343 in 2007. GVC activities recovered faster in high-income countries than in middle-income countries. The recovery of specific GVC activities (backward versus forward participation) also differs across income groups. Forward GVC participation increased more rapidly than backward participation in the high-income countries, especially in the high-income Eastern European countries (the forward participation rate of the Czech Republic rose from 0.2355 in 2007 to 0.2812 in 2017, of Estonia

**FIGURE 1.5** GVC participation indicators, country levels and sector levels



Note: AGR is an abbreviation of Agriculture, MIN is Mining; HTI, MTI and LTI are High, middle and low R&D intensive industries respectively; TTC is Trade and Transportation; FBS is Financial and Business services; OSE is other services.  
 Source: the UIBE GVC indexes derived from the ADB 2018 ICIO tables.

from 0.2536 to 0.3151, of Hungary from 0.2298 to 0.2777, and of Latvia from 0.1818 to 0.2712). A higher growth rate of forward participation in manufacturing and service sectors often implies faster upgrade of GVC production activities<sup>4</sup> as well as the deepening of intra-product specialization brought about by the recovery of cross-country production sharing activities. At the same time, some middle-income economies such as Mexico, Romania and Viet Nam moved up faster in backward participation, which mirrors what happened in developed countries. Finally, some Asian developing economies that experienced a decline in both forward and backward GVC participation have not yet seen a

return to pre-crisis levels. For instance, India’s forward and backward participation rate dropped from 0.1006 and 0.1382 in 2007 to 0.0655 and 0.0991 in 2017, respectively. China, Indonesia and Philippines also were subjected to similar declines.

Comparing the development of different GVC activities in different income groups in longer period, significant growth of GVC participation only occurred in high-income countries. In particular, their forward GVC participation rate increased from 9.5 in 2000 to 12.7 in 2017, while simple and complex activities contributed approximately equal shares (Table 1.1). The GVC participation rate actually declined in upper middle income countries.

**TABLE 1.1A Forward GVC participation indexes by country groups**

(Percent of GDP)

Income level	GVC participation			Simple GVC			Complex GVC		
	2000	2007	2017	2000	2007	2017	2000	2007	2017
High	9.5	11.8	12.4	5.6	6.8	7.1	3.8	5.0	5.3
Upper middle	11.4	14.1	10.5	7.2	8.4	6.4	4.2	5.6	4.2
Lower middle	10.8	12.4	9.1	6.9	7.6	5.7	3.9	4.8	3.4

**TABLE 1.1B Backward GVC participation indexes by country groups**

(percent of final goods production)

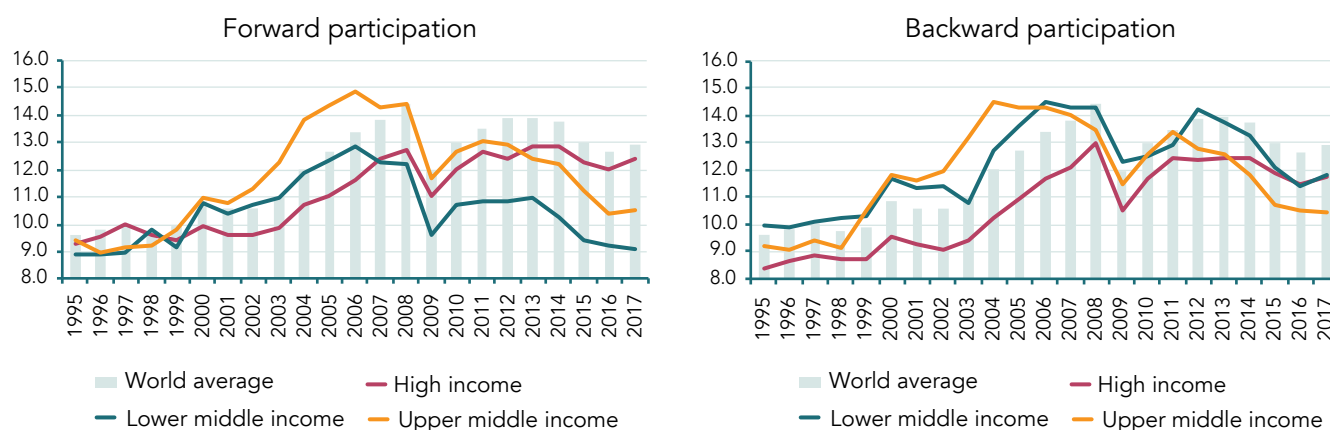
Income level	GVC participation			Simple GVC			Complex GVC		
	2000	2007	2017	2000	2007	2017	2000	2007	2017
High	9.3	11.7	11.8	5.8	6.8	6.5	3.5	4.9	5.3
Upper middle	12.5	14.1	10.5	7.3	7.7	6.3	5.2	6.4	4.2
Lower middle	11.7	14.2	11.8	7.9	9.3	7.6	3.8	4.8	4.2

Source: the UIBE GVC indexes derived from the ADB 2018 ICIO tables.

This is because participation in cross-border production sharing is only one kind of division of labor that can contribute to industrialization. The substitution of imported intermediate inputs by domestically-produced intermediate inputs in advanced developing economies, such as the industrial upgrading in China, may also reduce the intensity of GVC participation due to the deepening of domestic division of labor and the lengthening of

domestic value chains. The proper combination of cross-border and domestic value chains, or domestic and foreign factor content in a particular product, should be determined by market forces (this issue is examined in detail in Chapter 7).

The 2008/2009 global financial crisis had a dramatic, negative impact on GVC participation for all countries in the world (Figure 1.6). The GVC participation rate increased by 4.3% per

**FIGURE 1.6 The changing intensity of GVC participation by income groups, 1995-2017**

Note: 1995-2011 are from WIOD 2014ed, 2012-2017 are from ADB ICIO database. The global average GVC participation ratio may be above all three country groups in some years, due to the incomplete country coverage in both ADB and WIOD database. ADB ICIO table only covers 62 countries and the WIOD ICIO table only covers 43 countries, rest countries in the world are classified as rest of the world in both databases. Therefore, when the GVC participation in those not individually identified countries increase, the global average will be higher than the three country groups reported here, and this is confirmed by the analysis of Figure 1.6-1.8 below.

Source: The UIBE GVC indexes derived from the WIOD and ADB 2018 ICIO tables. In particular, the data from 1995 to 2011 derived from the WIOD, and the data from 2012-2017 derived from ADB.

year during the pre-crisis GVC expansion period (2000-2008). This rate declined by 14.9% during the crisis in 2009, but recovered by 9.0% during 2010-2011. However, the world average GVC participation rate declined by 1.6% per year with the sharp slowdown of global trade from 2012 on, mainly driven by middle-income countries (the complex GVC participation rate of high-income countries was higher in 2017 than in 2007). In particular, the GVC participation rate of the lower middle-income and upper middle-income groups in 2017 was still approximately 2.6 and 3.7 percentage points lower than their participation rate in 2007.

According to the table 1.2a and table 1.2b, the participation rates of most industry groups are still lower than their pre-crisis levels, especially for all the goods producing industries. The tables also indicate that the complex GVC activities rate increased more (or declined more) than did the simple GVC

activities rate in most industry groups, indicating complex GVC activities are more sensitive to external economic shocks.

Analysis over a longer period shows that GVC activities of all sectors increased from 2000 to 2017. The higher the technology (knowledge) intensity of the sector, the larger the increase in complex GVC activities. For instance, the forward GVC participation rate of the high, middle and low technology-intensive manufacturing sectors increased by 4.2, 3.8 and 3.2 percentage points during 2000 to 2017. Complex GVC activities contributed 58.1% of these increases, on average, with a particularly high contribution (76.4%) to the 4.2 percentage point increase of the GVC participation rate in the high-tech sector. The forward/backward GVC participation rates in the business and financial services sector, which also is relatively knowledge intensive, also increased from 10.7/5.8 to 15.2/9.4, respectively (Table 1.2).

**TABLE 1.2A Forward GVC participation indexes by industry groups**

(percent of value added)

Sector level	GVC participation			Simple GVC			Complex GVC		
	2000	2007	2017	2000	2007	2017	2000	2007	2017
High Tech	25.3	30.7	28.8	13.8	16.1	15.6	11.5	14.6	13.2
Middle Tech	22.5	21.6	23.7	14.5	16.4	14.7	8.0	9.7	9.1
Low tech	12.4	15.8	15.3	7.9	9.9	9.5	4.5	5.9	5.8
Business & financial	10.7	14.9	15.2	6.6	9.1	9.0	4.0	5.8	6.2
Trade and transportation	10.2	13.4	13.4	6.2	7.9	8.0	4.0	5.5	5.4
Other services	2.3	3.5	3.3	1.4	2.1	2.0	0.9	1.4	1.3
Agriculture	8.3	11.4	10.6	5.8	7.8	7.2	2.4	3.6	3.5
Mining	39.9	54.3	48.3	25.6	34.5	29.6	14.3	19.8	18.8

Source: the UIBE GVC indexes derived from the ADB 2018 ICIO tables.

**TABLE 1.2B Backward GVC participation indexes by industry groups**

(percent of final goods production)

Sector level	GVC participation			Simple GVC			Complex GVC		
	2000	2007	2017	2000	2007	2017	2000	2007	2017
High Tech	22.3	28.8	26.8	8.4	9.8	9.6	13.9	19.0	17.3
Middle Tech	19.1	26.9	25.9	10.0	14.4	13.2	9.1	12.5	12.7
Low tech	16.6	21.8	20.5	9.9	11.7	10.5	6.7	10.1	10.0
Business & financial	5.8	8.7	9.4	4.2	5.7	5.9	1.7	2.9	3.6
Trade and transportation	7.1	10.3	10.4	4.9	6.8	6.7	2.2	3.4	3.7
Other services	6.9	10.2	10.0	5.3	7.6	7.3	1.6	2.5	2.6
Agriculture	8.4	11.3	9.6	5.7	7.5	6.2	2.7	3.8	3.4
Mining	10.2	12.1	11.4	6.5	6.1	7.6	3.7	5.9	3.8

Source: the UIBE GVC indexes derived from the ADB 2018 ICIO tables.

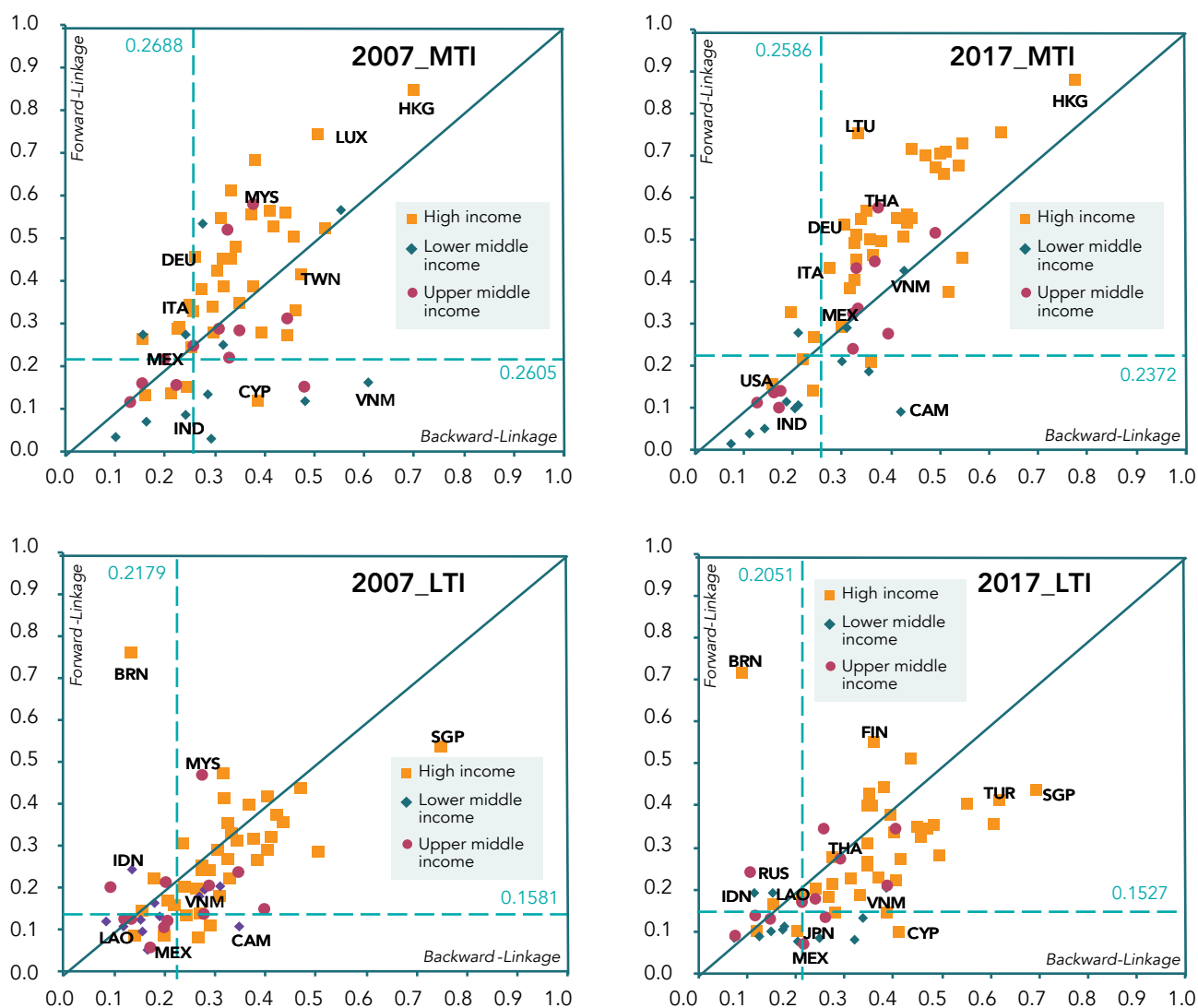


Higher GVC intensity in the high-tech, knowledge intensive sectors in part reflects the role of GVCs in the dissemination of technology from the lead firms to their suppliers (Rodrik, D., 2018).

The high intensity of complex GVC activities in high-tech sectors indicates R&D and other technology inputs have promoted intra-product specialization and the extension of global production networks. Slicing the production process into different tasks has greatly extended the depth and scope of international exchange and division of labor, from between products to between stages of the production of individual products, thus

generating new sources of comparative advantage for international exchange. The organization of production based on tasks by multinational enterprises, in which parts and components of special products (such as computers, automobiles and airplanes) cross national borders several times (complex GVC activities) is the fundamental force that drove global trade growth faster than global GDP growth before the global financial crisis. It also provided new opportunities for developing countries to be integrated into global economy by specializing in some simple tasks in which they have a comparative advantage, thus enabling

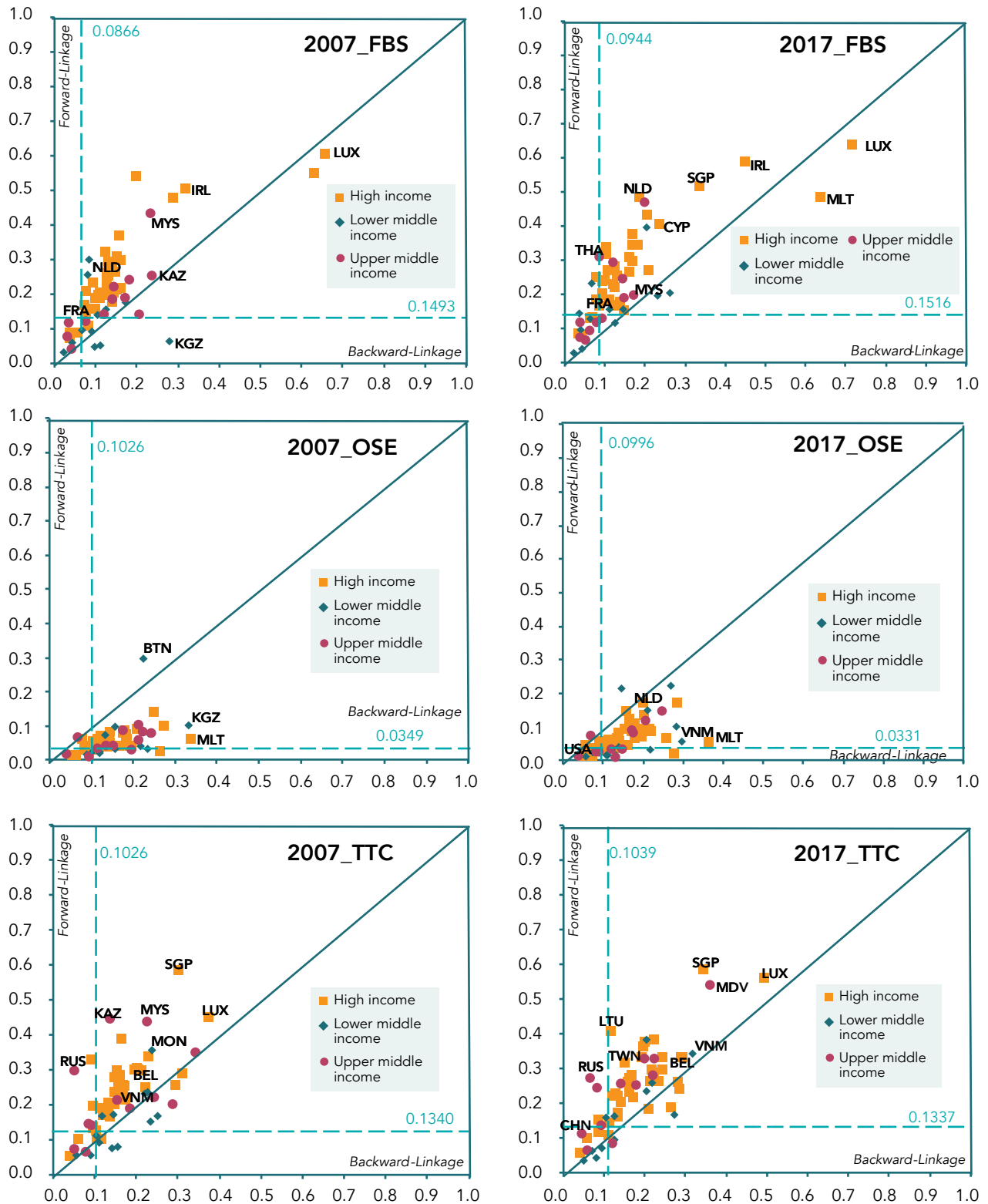
**FIGURE 1.7** GVC participation indicators by countries and sectors, 2007 and 2017, manufactures



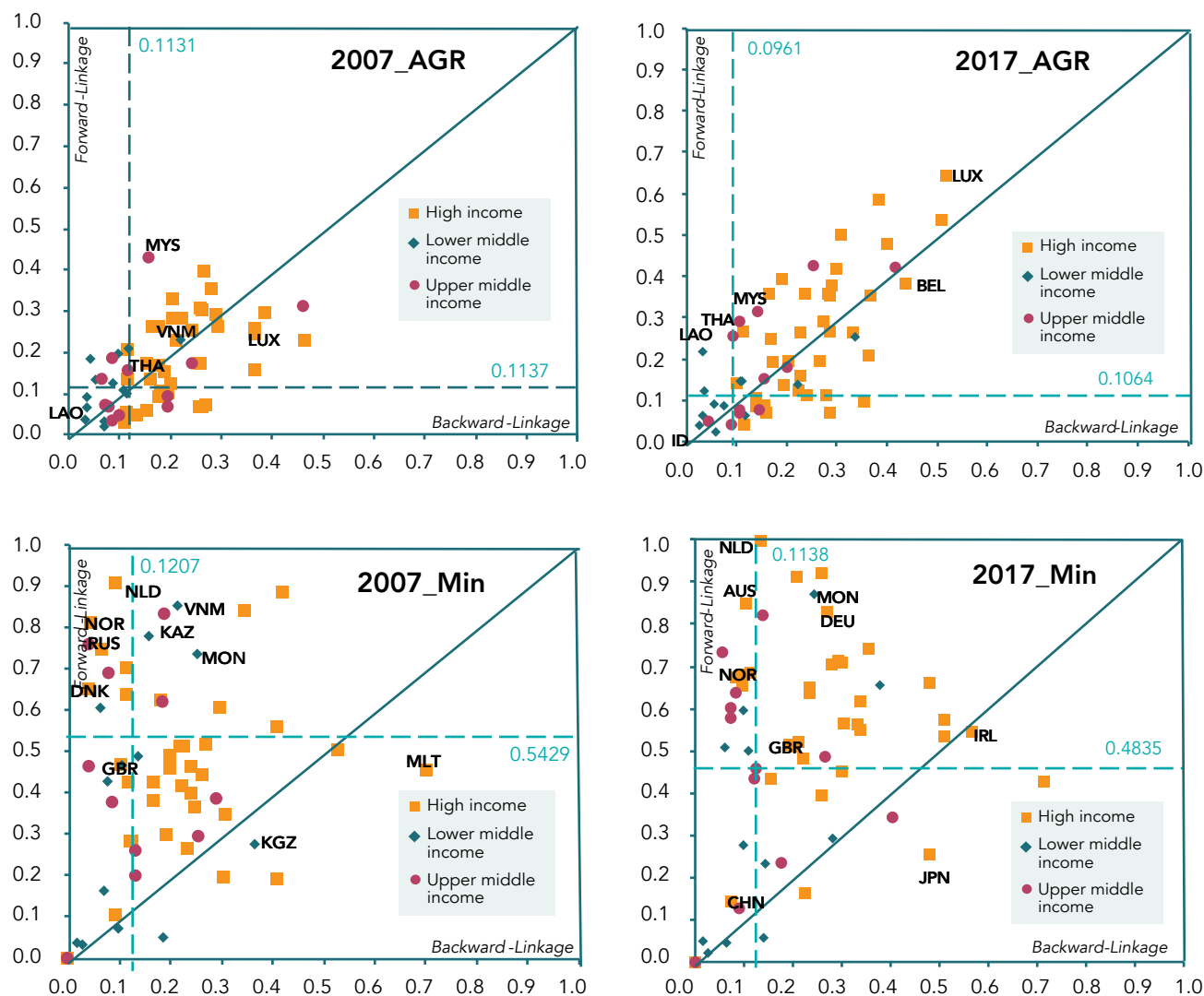
Note: the country abbreviation is according to the ISO 3166-1 alpha-3, and a complete list of the current officially assigned ISO 3166-1 alpha-3 codes is available on the United Nations International Trade Statistics: <https://unstats.un.org/unsd/tradekb/knowledgebase/country-code>.

Source: the UIBE GVC indexes derived from the ADB 2018 ICIO tables.

**FIGURE 1.8** GVC participation indicators by countries and sectors, 2007 and 2017, services



Source: the UIBE GVC indexes derived from the ADB 2018 ICIO table.

**FIGURE 1.9** GVC participation indicators by countries and sectors, 2007 and 2017, agriculture and mining

Source: the UIBE GVC indexes derived from the ADB 2018 ICIO table.

developing countries to achieve rapid industrialization through joining GVCs.

Generally speaking, industry groups in manufactures have higher average GVC participation intensity than industry groups in mining and services (see the scatter plots of backward and forward participation rates across countries—Figures 1.7, 1.8 and 1.9). In the mining sector, which is the main source of raw materials input in the early stages of production, the forward participation ratio is generally higher than backward participation for most countries, while in other services (utilities, education, health care and domestic services), which are closer to the final consumer and placed at the final stage of the production chain, the backward participation is higher than forward participation for most countries. In manufactures, higher R&D and knowledge intensities are associated with a higher GVC participation rate (see above). In services, GVC participation is also

heterogeneous across industries. Communication, financial and business services, as well as trade and transportation services, have much higher GVC participation rates than other domestic services such as education, health care and personal services, because the former are critical inputs in the modern production process.

GVC participation rates also differ significantly by geographic region<sup>5</sup>. Figures 1.10-1.12 report both forward and backward GVC participation intensities and their inter- and intra-regional shares for manufacture industries in the three major supply chain blocks (North America, Europe and Asia). In each figure, the very last pair of columns are the GVC participation rates in levels and the previous columns are the decomposition across regions. For example, in Figure 1.10, which pertains to Asia, the bar for Asia shows the share of intra-regional activities in Asia's total GVC participation, while the other bars show the

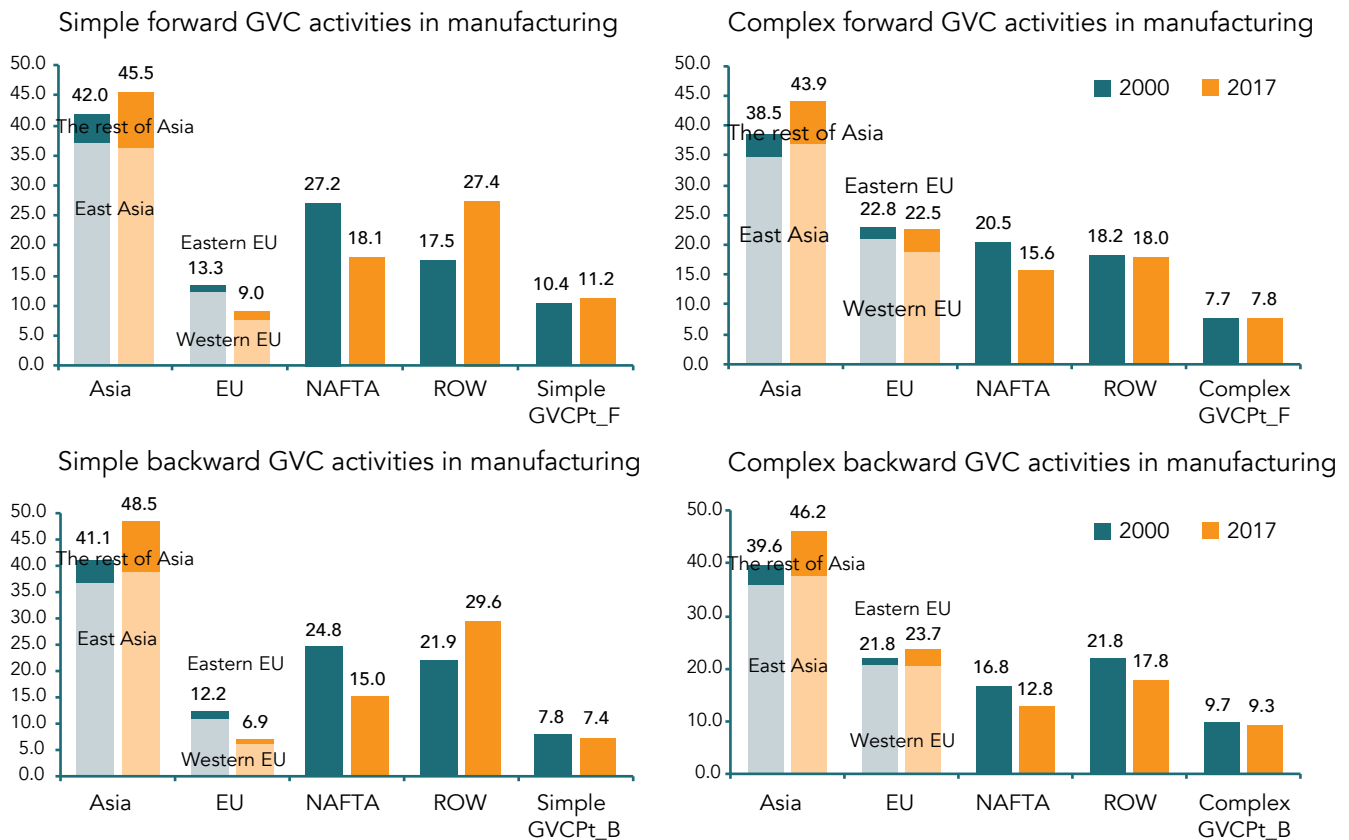
participation of other regions in Asian GVCs, either as suppliers (backward linkages for Asia) or purchasers (forward linkages for Asia). The light- and dark-colored portions of the bar show the shares of different groups inside the region (the light-colored portions represent East Asia and Western Europe, and the dark color portions represent the Rest of Asia and Eastern Europe).

Generally speaking, the higher the degree of economic integration in a regional production network, the higher the intra-regional GVC activities. In 2000, "Factory Europe" had the highest degree of economic integration, so its share of intra-regional GVC activities is the highest among the 3 regional production networks; North America ranks second and Asia third. However, ten years after the financial crisis, along with the rising scale of the regional economy, the share of intra-regional GVC activities in "Factory Asia" exceeded that of "Factory North America", especially in complex GVC participation. In contrast, the share of intra-regional GVC activities has declined in both "Factory Europe" and "Factory North America" and their share of inter-regional production sharing activities has increased, especially their GVC linkage with "Factory Asia".

In "Factory Asia", the increase of cross-country production sharing activities in the last decade was led by intra-regional complex GVC activities. This share increased from 38.5%/39.6% of Asia's total forward/backward complex GVC activities in 2000 to 43.9%/46.2% in 2017. Another notable development was the market-driven enlargement of "Factory Asia", as more Asian lower middle-income countries were integrated into Asian production network during this period. In the "Rest of Asia", the shares of forward and backward GVC activities rose from 10.2% to 11.8% and from 16.6% to 19.4%, respectively. However, the importance of North America and Europe as both destinations of Asia's GVC exports (Figure 1.10, forward GVC activities) and sources of Asia's GVC imports (Figure 1.10, backward GVC activities) has declined.

In Europe, the decline in complex GVC activities representing the breadth of regional production linkages is much more than that of simple GVC activities. In particular, the share of intra-regional complex forward GVC participation decreased by 6.7 percentage points in the last decade, from 47.6% to 40.9%, and intra-regional backward complex cross-border

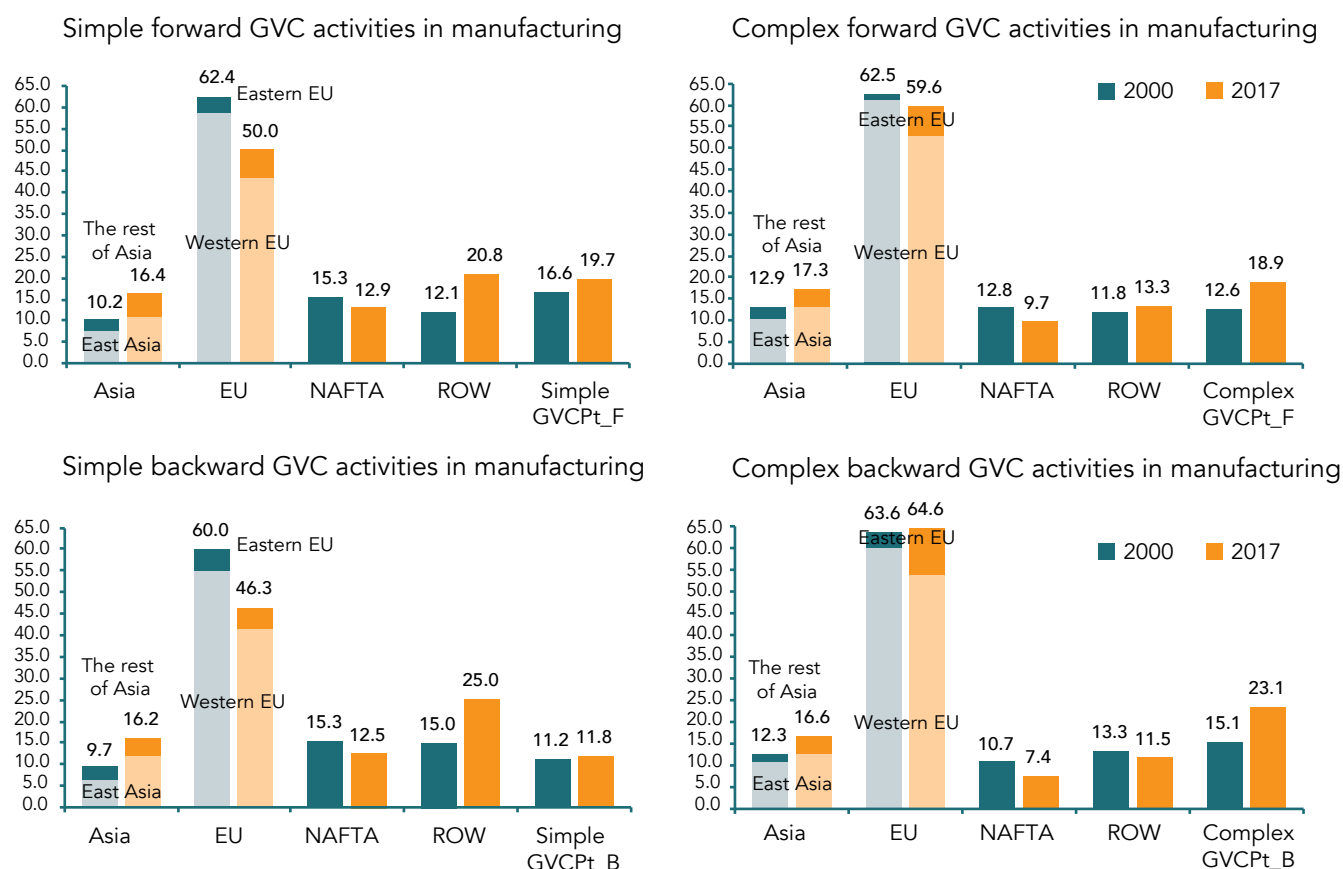
**FIGURE 1.10 Forward and backward (simple/complex) GVC participation, share of intra-and inter-regional GVC activities in manufacturing, (%), 2000 and 2017, Asia**



Note: the last set of bars represent the overall GVC participation ratios for Asia in 2000 and 2017. The country groups refer to footnote 5.

Source: the UIBE GVC indexes derived from ADB 2018 ICIO tables.

**FIGURE 1.11 Forward and backward (simple/complex) GVC participation, share of intra-and inter-regional GVC activities in manufacturing, (%), 2000 and 2017, Europe**



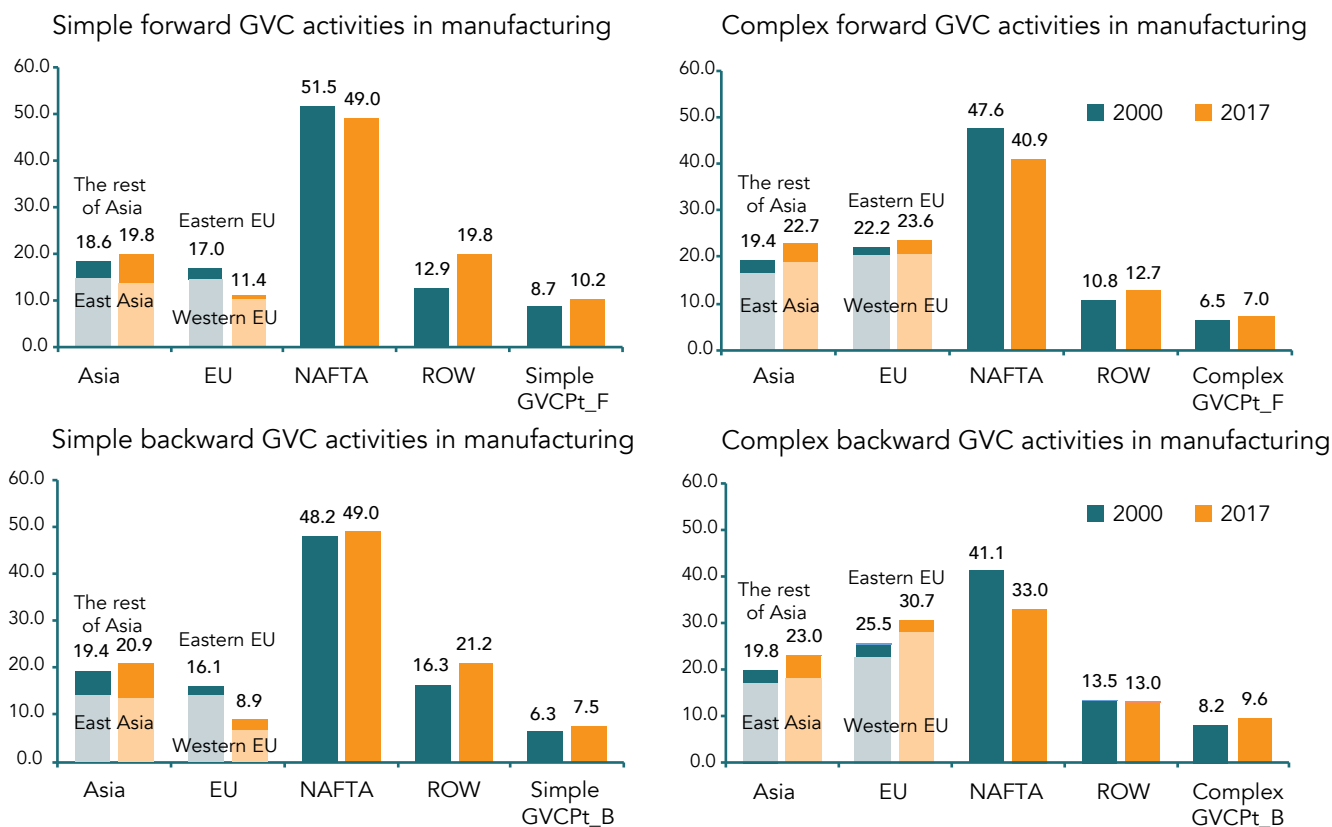
Note: the last set of bars represent the overall GVC participation ratios for Europe.

Source: the UIBE GVC indexes derived from the ADB 2018 ICIO tables.

production sharing activities fell by more than 8 percentage points, from 41.1% to 33.0%. This was mainly due to the relative decline of intra-regional GVC linkages in Western Europe, since this share in Eastern Europe increased during this period. The shares of inter-regional production sharing activities between Europe and Asia and Rest of the World also increased; the manufacturing links between Europe and Asia are more reflected in the complex GVC activities, and the manufacturing links with Rest of World are more reflected in the simple GVC activities. For instance, the share of Asia as the destination of Europe's complex GVC exports and the share of Asia as the source of Europe's complex GVC imports both increased by over 4 percentage points, from 12.9% to 17.3% and 12.3% to 16.6%, respectively. East Asia contributed 79.9% and 81.4% of these changes, respectively. The share of Rest of the World as the destination of Europe's simple GVC exports and as the source of Europe's simple GVC imports increased from 12.1% to 20.8% and 15.0% to 25.0%, respectively during this period.

In North America, the share of intra-regional complex GVC activities in forward/backward linkages fell by 6.7% and 8.1% from 2000 to 2017, respectively, although the share of intra-regional simple GVC activities changed slightly. The concomitant rise in the share of inter-regional complex activities reflects the more globalized supply chains in North America today compared to 17 years ago (recall that complex GVC activities involves products that cross national borders at least twice, which has been the most important driving force behind globalization). Moreover, the development is not only reflected in the manufacturing sectors, but also in services sectors. For instance, in telecommunication, financial and business services, North America's share of both GVC exports to and GVC imports from Asia and Europe exceeded its share of intra-regional GVC activities in 2017, particularly for complex GVC activities.<sup>6</sup> This reflects the intensive outsourcing of services from the United States to Asian countries (such as India and Philippines), and the tightly linked financial and business service supply chain activities between North America and Europe.

**FIGURE 1.12 Forward and backward (simple/complex) GVC participation, share of intra-and inter regional GVC activities in manufacturing, (%) 2000 and 2017, North America**



Note: the last set of bars represent the overall GVC participation ratios for North America.

Source: the UIBE GVC indexes derived from the ADB 2018 ICIO table.

## 2. The changing distribution of value-added along typical GVCs<sup>7</sup>

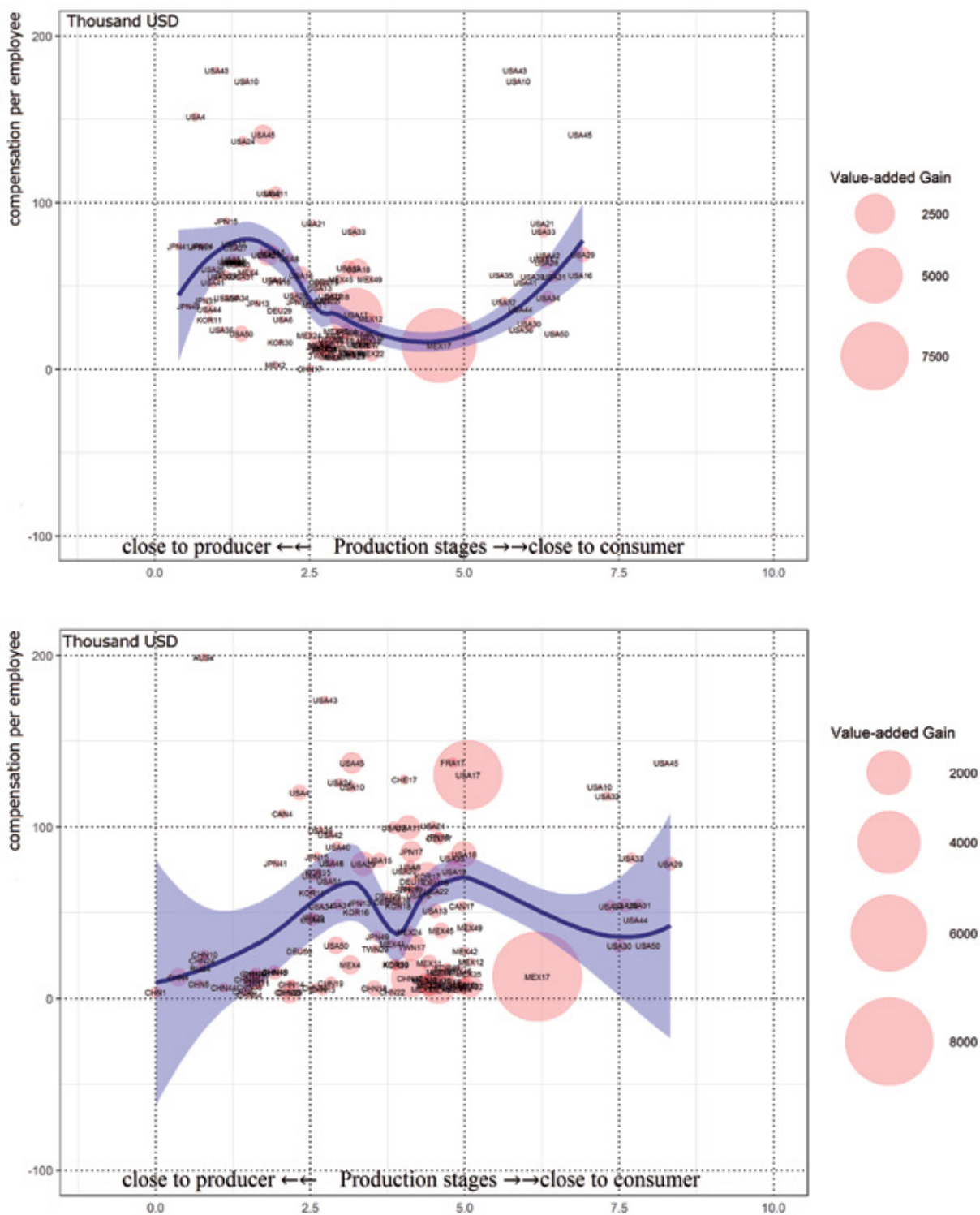
This section uses “smile curve” analysis to discuss how the distribution of value added across countries and industries via GVCs changes when more and more developing countries are participating in global production networks.

The concept of the smile curve was first proposed around 1992 by Stan Shih, the founder of Acer, a technology company headquartered in Chinese Taipei (Shih 1996). In the personal computer industry, Shih observed that both ends of the value chain bring higher value added to the product than the middle part. In business management theory, the smile curve is a graphical depiction of how value added varies across the different stages of bringing a product to the market in a manufacturing industry. The logic of the smile curve has been widely used in case studies of individual firms, but rarely identified, measured, and evaluated at the country level by using real data with explicit consideration of GVCs. As we show in the 2017 GVC Development Report, by borrowing the image of the smile curve and consistently measuring both the value-added gains from GVC participation and the distance between producers and consumers

through a recently-developed input-output based methodology (see Ye, Meng et al., 2015; Meng, Ye et al., 2017), the relationship between value-added distribution and GVC participation can be empirically identified and drawn for various GVCs.<sup>8</sup>

In Figures 1.13 and 1.14, we take the final goods exports of Mexico’s ICT industry and Japan’s auto industry as examples. The y-axis of these figures shows compensation per employee (a proxy for technology level or a first-order approximation of labor productivity)<sup>9</sup> in constant 2000 U.S. dollars, and the x-axis denotes distance showing how far a specific participating country and industry pair in the particular GVC of interest is away from global consumers.<sup>10</sup> The data used is from the WIOD (2016 version), which covers 43 economies and 56 industries over 15 years (2000-2014), with the total number of GVC participants (43 × 56 = 2,408) represented as circles in these figures. The size of the circle represents the absolute value added created by joining the corresponding GVC (the minimum threshold for inclusion in the figure is 0.1% of the total value-added gain measured in million U.S. dollars). The smooth line is fitted by local polynomial regression–smoothing weighted by its value-added volume, and the shadowed area represents the confidence interval around the smooth line. Using the estimated smile curve can enhance our

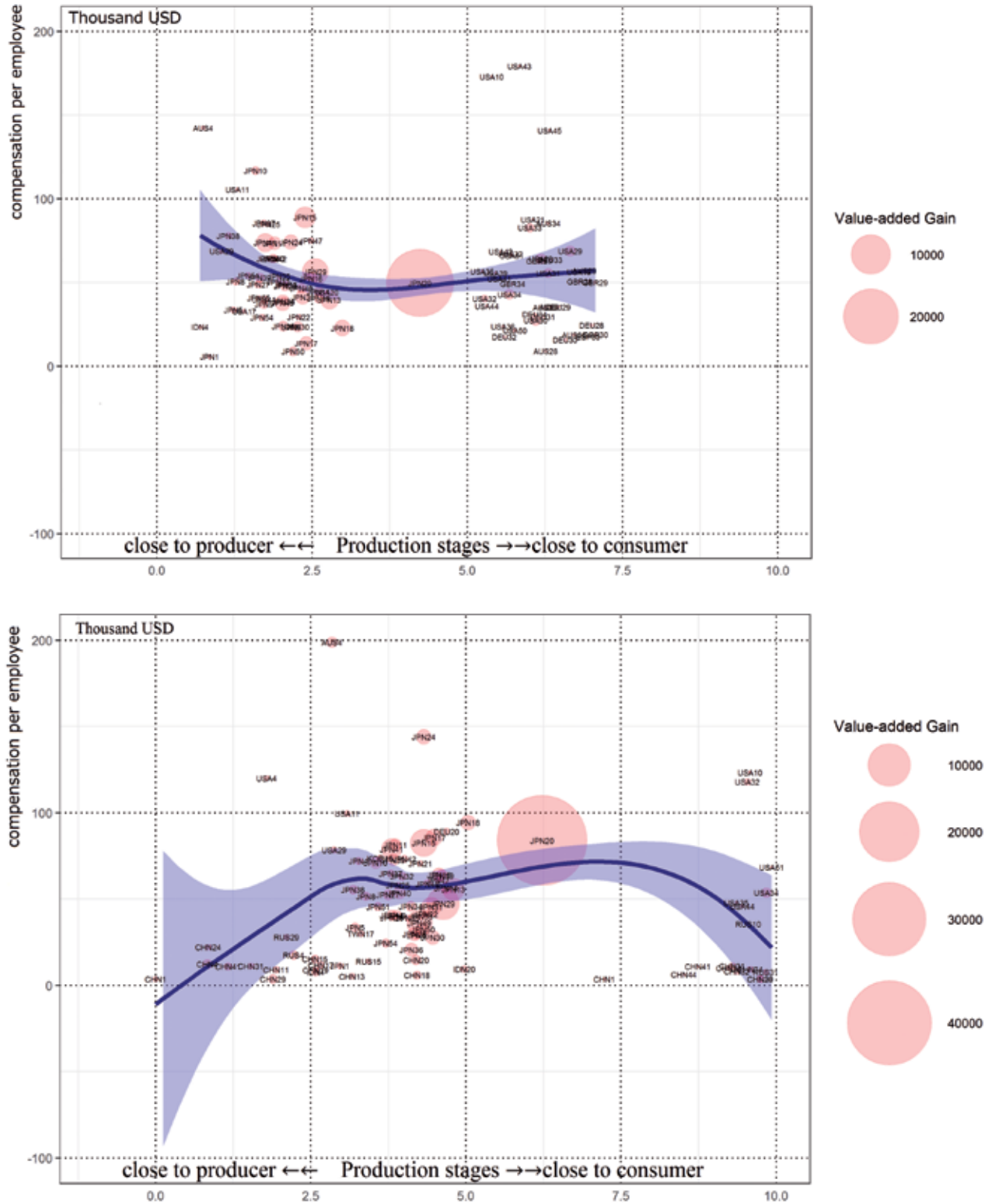
FIGURE 1.13 Mexico's ICT final goods exports related value chain, 2000 and 2014



Note: y-axis represents the compensation per employee in constant thousand U.S. dollars (base year: 2000); the x-axis represents the length of the corresponding production chain in average stages of production.



**FIGURE 1.14** Japan’s auto final goods exports related value chain, 2000 and 2014



Note: -axis represents the compensation per employee in constant thousand U.S. dollars (base year: 2000); the x-axis represents the length of the corresponding production chain in average stages of production.



understanding of the participants (countries and industries) of a specific GVC as well as their positions and economic gains from the chain.

The plotted GVC for Mexico's ICT (MEX17) final goods exports to the world market in 2000 clearly appears as a smile curve (see Figure 1.13). The main participants in the pre-fabrication stages (upstream) of this value chain comprise many US industries, such as ICT (USA17), wholesale trade (USA29), legal accounting, head offices, management consultancy activities (USA45), electrical equipment (USA18), fabricated metal products (USA16), machinery and equipment n.e.c. (USA19), and chemicals (USA11); some Mexican domestic industries, such as chemicals (MEX11), machinery and equipment n.e.c. (MEX19), electrical equipment (MEX18); and several Japanese industries such as ICT (JPN17), basic metals (JPN15), and fabricated metal products (JPN16). The main participants in the post-fabrication stages (downstream) comprise US industries such as wholesale trade (USA29), retail trade (USA30), warehousing (USA34) and so on. Most participating industries upstream and downstream in Mexico's ICT exports-related value chain are from the US and Japan, countries with high levels of labor compensation, while most participating industries in the middle of the value chain are from the Mexico's domestic industries with low levels of labor compensation. Therefore, the whole chain naturally appears as a smile curve.

However, the shape of the curve changed significantly in 2014, from a smile curve to a kind of "W" curve. At least three factors contributed to the remarkable changes in the shape of this smile curve. One was the rapidly increasing presence of Chinese industries in Mexico's value chain upstream. As seen in 2014, many Chinese industries with low compensation per employee, such as ICT (CHN17), wholesale trade (CHN29), mining (CHN4), electrical equipment (CHN18), machinery and equipment n.e.c. (CHN19), and basic metals (CHN15), replaced other countries' positions in the Mexican value chain. Those Chinese industries became some of the main players, with a large value-added gain in the pre-fabrication stage of this value chain. This reflects the fact that producing ICT exports in Mexico used more Chinese intermediate inputs directly and indirectly. The second factor was the rapid technological upgrades that occurred in the US ICT industry (USA17), indicated by the simultaneous increase in compensation per employee and maintenance of a large volume of value-added gain. This implies that Mexico's ICT production was highly dependent on high-tech US intermediates. The third factor was the increasing volume of value-added gain by Mexico's service industries (legal accounting, head offices, management consultancy activities (MEX45); other professional, scientific, technical, and veterinary activities (MEX49)) in the pre-fabrication stage. All these developments may have also contributed to the overall expansion of Mexico's ICT value chain, as the entire length (x-axis) of this chain increased from 6.8 to 8.3 between 2000 and 2014.

Japan's final auto (JPN20) products exports-related value chain also experienced a dramatic change from a smile curve to an inverted smile curve—a frown from 2000 to 2014 (Figure 1.14). To some extent, this may have reflected the successful transition

of Japan's auto industry from traditional mass producer to mass customizer, based on digital technology and artificial intelligence, similar to what happened in German's auto industry (as reported in the 2017 GVC Development Report). The mass customized manufacturing stage accounted for a relatively large portion of the total value gain, while the traditional high-end design and sales functions accounted for only a small portion of total value-added creation, mostly by producers from foreign countries. This is contrary to the typical intuition from the smile curve, in which traditional manufacturing stands only at the low end of the value chain, such as Mexico's ICT final goods exports in 2000. But it could also reflect the ongoing structural change in GVCs, such as the emergence of the customer to manufacturing (C2M) business model in several industries. The most important changes between 2000 and 2014 were the increasing number and variation of foreign participants and the increasing length of the curve. In 2000, the United States and Germany dominated foreign participants upstream and downstream, while in 2014, more industries from foreign countries were involved, especially industries from China. This clearly reflects the increasing diversity and complexity of international fragmentation in Japan's auto production. In addition, given the increase in labor compensation and absolute volume of value-added gain in Japan's auto industry, along with the relatively low level of labor compensation of upstream and downstream participants from China, the slope of the entire curve became much steeper. This implies that Japan's auto sector has enhanced its comparative advantage by outsourcing more upstream and downstream tasks that were formerly done by Japanese employees to China through GVCs.

### 3. The topology and structure change of GVC production and international trade<sup>11</sup>

Network analyses have been used widely to visually simplify the image of GVC activities given their increasing complexity (see Ferrarini, 2013; Ferrantino and Taglioni, 2014; Zhou, 2016; Xiao *et al.*, 2017). Unlike the literature in international trade-related network analyses, we separate bilateral trade flows across countries into three types of networks (traditional trade networks, simple GVC networks and complex GVC networks) based on the production activity decomposition method proposed by Wang *et al.* (2017) (see Box 1.2).<sup>12</sup> The network analysis in this section provides a new view about how trade and production sharing activities are concentrated among bilateral trade partners, as well as the changing interdependency among trading partners in different networks.

One conclusion of the network analysis, which covers 62 countries and 35 sectors from 2000 to 2017, is that the topology structure of networks (at the aggregate and individual sector levels) changes only gradually. Even the financial crisis of 2008 did not result in a significant change in the network topology in 2009. This implies that the structure of global production networks expressed by the topology of country to country relationships is resilient, even when economic shocks of a large magnitude hit

**BOX 1.2****How network graphs are drawn in our GVC analysis**

We draw two types of networks from ADB ICIO data to identify the hubs of various networks from importer and exporter perspectives. One takes a specific country as a supply hub if the majority of the imports by most countries in the network is from that country. Another takes a specific country as a demand hub if the majority of the exports from most countries in the network goes to that country. In our network figures, the size of the bubble represents the share of a country's value-added exports or imports in total value-added exports or imports. The share of value-added flow between each trading partner in total value-added flow is represented by the thickness of the linkage. The

arrow of the linkage shows the direction of the value-added flow. Two tests are used to determine whether a linkage line appears between trading patterns (taking the case of supply hub related networks as an example): 1) if country A takes the largest share in country B's value-added imports, a linkage will be shown from A to B; or 2) if country A's share in country B's value-added imports is larger than 25%, a linkage will be shown from A to B. The first standard is the so-called "Top1" threshold widely used in network analyses to identify the most important linkages. The second standard is used to adjust the density of the network, in order to avoid losing other important linkages.<sup>14</sup>

the global economy. Therefore, this analysis considers only the long-term change from 2000 to 2017.<sup>13</sup> We consider both the networks for the aggregate economy (all goods and all services), as well as selected typical GVC sectors (textile, ICT, and services) as examples.

**3.1 Supply hubs of value-added trade***Supply hubs of value-added trade at the aggregate level*

As shown in the upper-left part of Figure 1.15, the three large regional supply hubs in the traditional trade networks in 2000 were the US, Germany and Japan. Obviously, these three hubs have very important linkages with their neighbor countries. The US has strong linkages to its two North American partners, Canada and Mexico, the two large Asian countries, Japan and the Republic of Korea, and Brazil, India and Australia. Japan can also be considered as a regional supply hub in the Asia-Pacific region, since the US, China, the Republic of Korea, Chinese Taipei and many Asian countries have Japan as their most important value-added supplier through final product trade. Germany is the largest supply hub in the European area, because the majority of value-added imports in final products by almost all European countries is from Germany. When zooming in the figure, we can also find some small regional hubs in the European area, such as the UK, France, Italy, Spain, Belgium, and Russia, and in the Asia-Pacific region, such as China, the Republic of Korea, India, Thailand, and Singapore, who have more than two linkages with other countries.

Comparing the situation of 2000 to that for 2017 (the upper-right part of Figure 1.15), it seems there was no significant change in the network topology in Europe and North America, but dramatic changes occurred for Asia: China took over Japan's position and became a global supply hub of value-added export through final products trade. China not only had important linkages with other hubs (the US and Germany), but also with its Asian neighbors (Japan, the Republic of Korea, Chinese Taipei, and almost all Asian countries) and other emerging countries

(Russia, Brazil, India). When comparing the magnitude of the value-added flows across countries over time, it is easy to see that the linkages between China and other main regional hubs as well as its surrounding countries became much thicker.

The middle-left part of Figure 1.15 shows the simple GVC trade networks for all goods and services in 2000. Compared to the traditional trade networks, the US was a global supply hub with important outflow linkages to the other two regional hubs, Germany and Japan. Some remarkable differences can be observed within each region. For example, compared to the traditional trade networks, more extra-regional countries had the US as their main supplier of value added through simple GVC trade. This also reflects the fact that US intermediate products were greatly used as inputs for many countries to produce domestically-used final products. The UK, which was a sub-hub in Europe in the traditional trade networks, becomes a sub-hub with important linkage with the US in the simple GVC trade networks.

A remarkable structural change in the simple GVC trade networks occurred between 2000 and 2017 (the middle-right part of Figure 1.15). In 2017 there was no longer any important linkage between any two hubs, as simple GVC activities became more concentrated within Europe, North America and Asia. The US and Germany connected to each other indirectly through the Netherlands. The number of countries with strong linkages to the US decreased dramatically, as most of the surrounding linkages moved to China. Germany maintained its position as a regional supply hub in Europe with strong linkages to more countries. China replaced Japan and part of the US position and became the second largest supply hub in terms of both the magnitude of its value-added exports and the number of strong linkages to other countries.

Looking at the evolution of the complex GVC trade networks from 2000 to 2017 (see the bottom panel of Figure 1.15), trade became more concentrated among regional trading partners, and there was no important direct linkage among regional hubs.

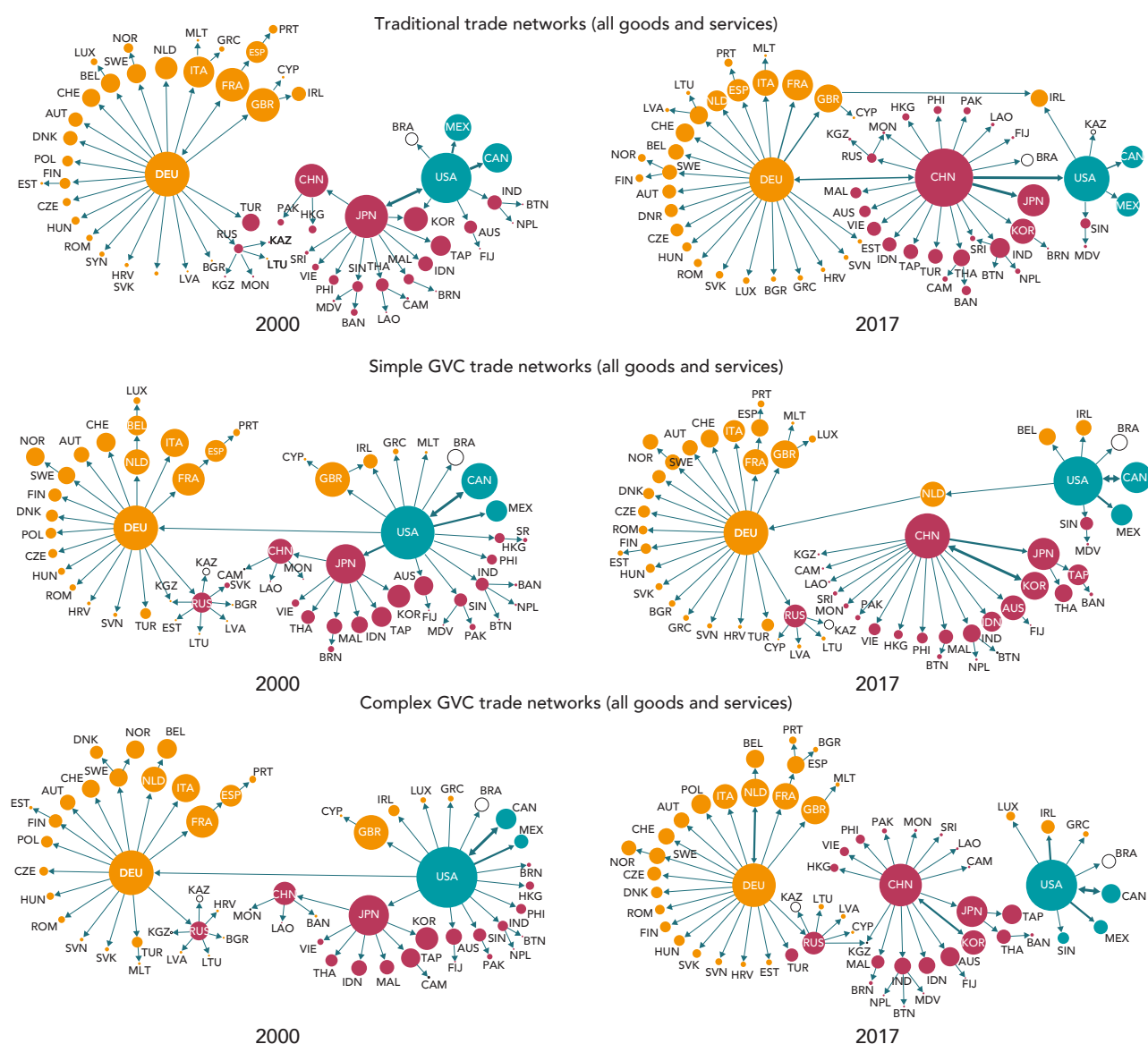
The US connected with Germany indirectly through two countries, Luxembourg and the UK. In addition, the volume of China-made intermediates used as inputs for its downstream countries to further produce exporting products increased rapidly over the period as seen from the bubble size change for China.

### Supply hubs of value-added trade in various networks for selected sectors

The topologies and changes in structure over time in individual sectors may differ considerably from the aggregate patterns shown above. Figure 1.16 shows the textile sector related networks.

Obviously, there were many regional supply hubs in the traditional trade networks in 2000. There were three main regional supply hubs in Europe, Germany, Italy and the UK, who exported textile sector value-added to their trading partners through final goods trade. Germany and the UK connected indirectly through Turkey. India was also a sub-supply hub with inflow linkage from the UK and outflow linkages to Nepal and Bangladesh. The presence of Italy, as the most traditional country with strong fashion sectors, can be clearly identified in these networks. This is very different from the networks at the aggregated level shown in Figure 1.15, in which Italy's presence in the textile sector is largely masked.

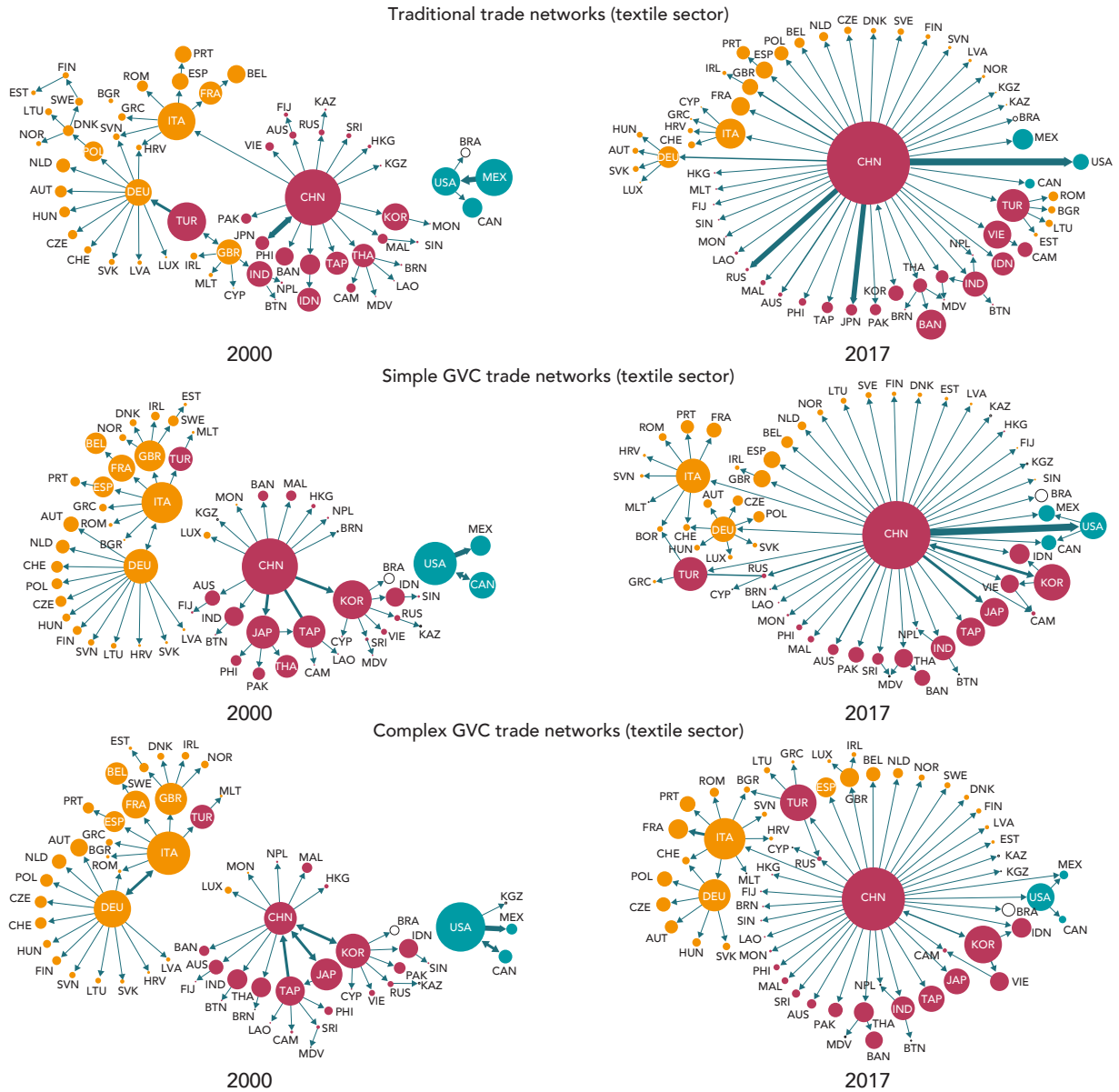
**FIGURE 1.15** Supply hubs of trade in value-added in various networks at the aggregate level



Note: the size of the circles represents the magnitude of value-added exports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

**FIGURE 1.16 Supply hubs of trade in value-added in various networks for the textile sector**

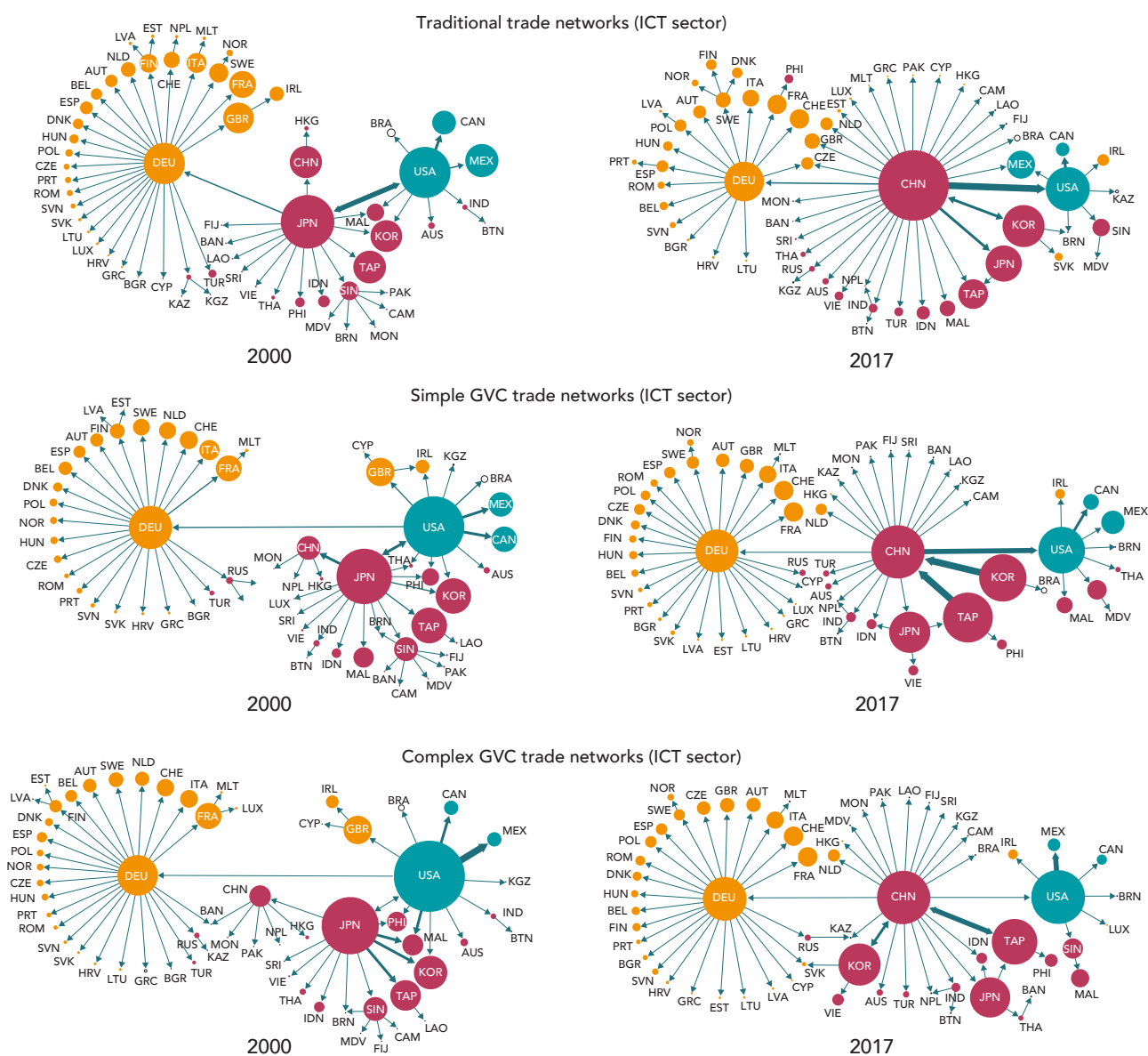


Note: the size of the circles represents the magnitude of value-added exports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

The structure of textile networks changed dramatically from 2000 to 2017. China became the largest and the unique global supply hub; in the figure China has pushed away all the other regional hubs and surrounding countries to the periphery of the traditional trade networks. This phenomenon is consistent with the fact that textile final goods made in China can be found everywhere in the world. Mixed reasons may explain this phenomenon. China already had substantial textile production capacity in its early stage of development. Thus it easily joined GVCs by exporting more final textile products when tariff and non-tariff barriers decreased in other countries after its WTO accession. Moreover,

China had a significant comparative advantage in exporting apparel, given its large labor force with lower wages, while FDI inflows from developed countries helped make China the largest exporter of textile and apparel products in the world. By 2017, China's textile sector played a dominant role in traditional trade networks as well as the simple and complex GVC trade networks. This implies that China is gradually upgrading its textile sector, and thus can export more intermediates to other countries through GVC trade. Although China has grown to become a new rival in GVC trade through upgrading of intermediate exports of textile, Italy can still maintain its position as a regional hub especially in the complex

**FIGURE 1.17 Supply hubs of trade in value-added in various networks for the ICT sector**

Note: the size of the circles represents the magnitude of value-added exports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

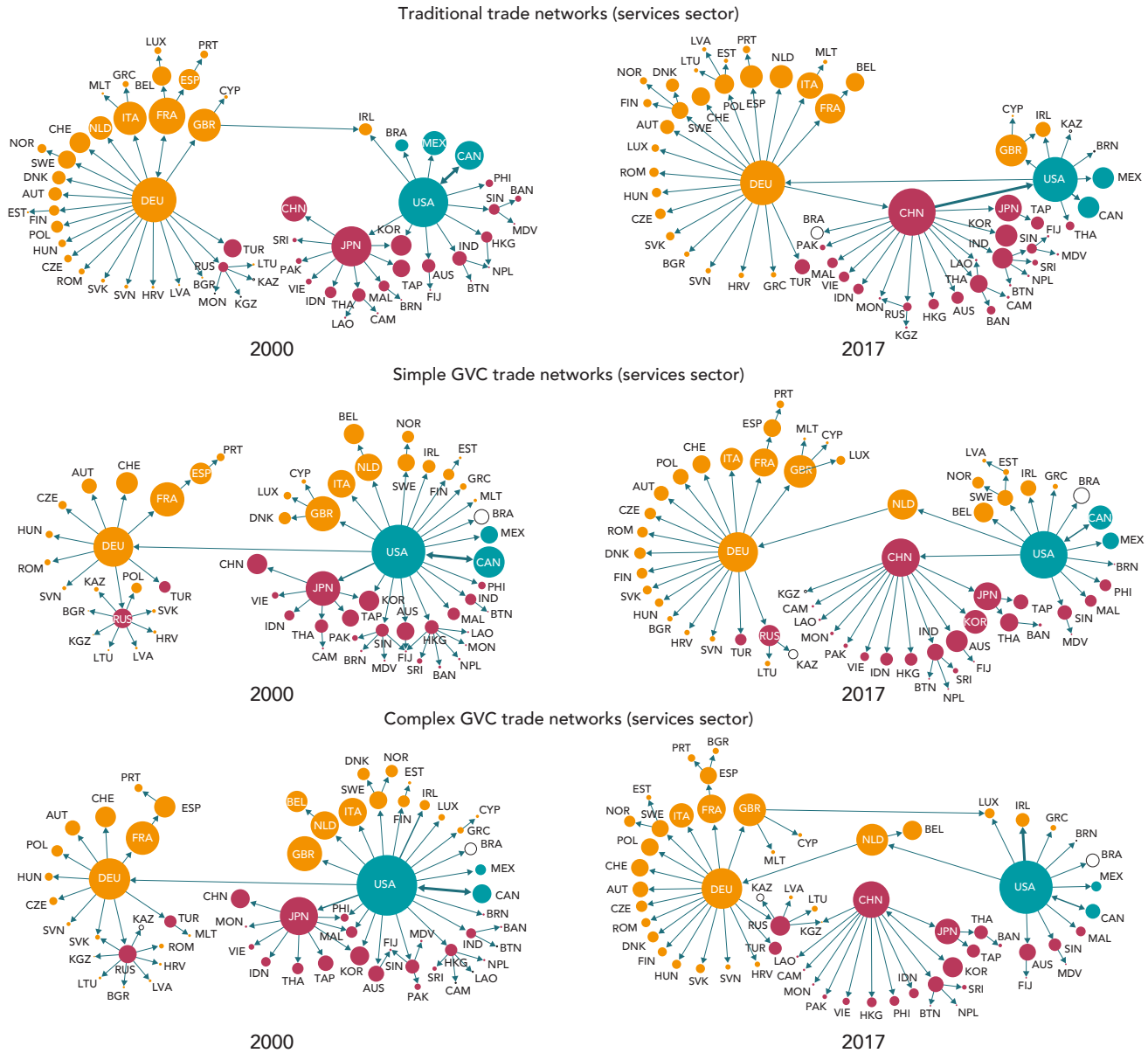
GVC trade networks. This indirectly reflects the strength of Italy's technology in producing complex textile products compared to other European countries whose presences have declined in complex GVC trade networks over time.

The network topology for ICT experienced dramatic changes from 2000 to 2017 (Figure 1.17 shows the ICT sector's value-added exports related networks). In 2017, China took over Japan's position, becoming a global supply hub in both traditional trade and simple GVC networks. Inside Asia in 2017, Japan, the Republic of Korea and Chinese Taipei played very important roles as sub-hubs. The US became a largely regional supply hub,

keeping just important linkages with a limited number of countries. Japan's presence decreased dramatically, as it moved from a global supply hub in the traditional trade networks and regional supply hub in the simple GVC networks in 2000 to the periphery of the Asia-Pacific region in 2017. These changes reflect the so-called industrial hollowing<sup>15</sup> out in the US and Japan's ICT sectors (especially for final goods production), accompanied by large scale FDI from these countries to China. The latter made an important contribution to China's ICT development, since even in recent years more than half of China's ICT exports were produced by foreign-owned enterprises.



**FIGURE 1.18 Supply hubs of trade in value-added in various networks for the services sector**



Note: the size of the circles represents the magnitude of value-added exports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

Nevertheless, the US and Japan remained important hubs in complex GVC networks in 2017, in terms of both the volume of value added traded and the number of countries with strong linkages. The US and Japan were still the main suppliers of complex intermediate goods used by downstream countries through complex GVC activities. At the same time, China’s ICT sector exported more value added through both simple and complex GVC trades. This provides some evidence of the ongoing industrial upgrading in China’s ICT industries, since more intermediate products have been made in China.

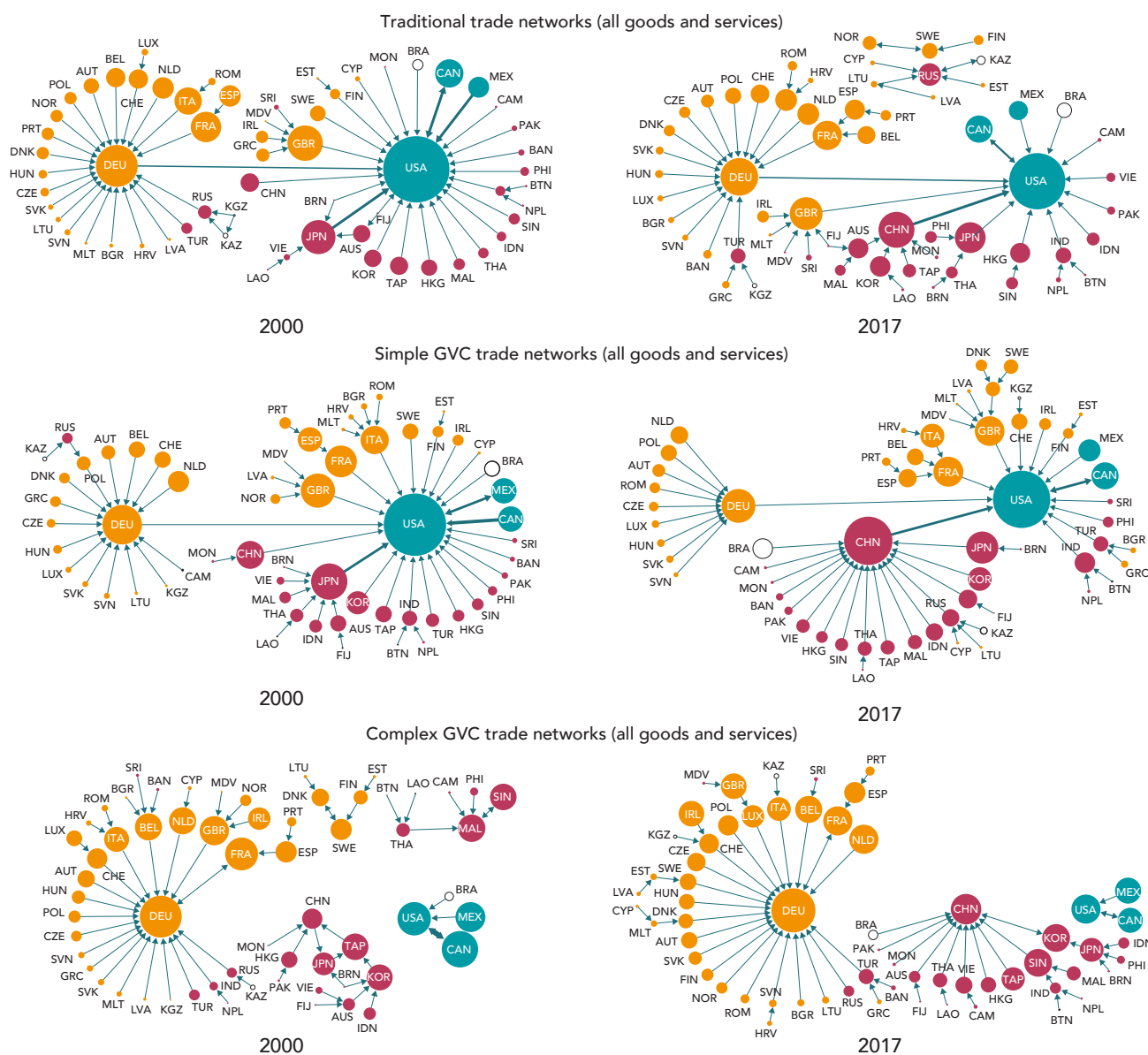
The US was the largest supply hub for services in 2000 in the traditional trade networks (Figure 1.18 shows the services sector’s value-added exports related networks). The US had significant outflow linkages to Canada and Japan, and indirectly connected with the other supply hub, Germany, through third countries (Ireland and the UK) in 2000. In 2017, however, the US had few direct outflow linkages going to Asia. In 2017, Germany maintained its presence as a regional supply hub with important linkages to other sub-regional hubs (France and Italy), lost its linkage with the sub-regional hub Russia, and added a linkage

with the new sub-regional hub, Poland, in Europe. China took over Japan's position in Asia and became a large supply hub with an important presence in exporting service sector value added to the US and other Asian economies in the traditional trade networks. While China did not export a large amount of services to the global market directly, China was the largest manufacturing final goods exporter and the value added of China's domestic services were embodied in these exports.

In the simple GVC trade networks, the US maintained its role as the largest supply hub in 2017, but lost some important trading

partners, such as the UK (which joined the European networks as a sub-supply hub), as well as Japan, the Republic of Korea and Hong Kong, China (which have joined the Asia networks as sub-hubs surrounding China). There was no longer any direct linkage between the US and Germany in 2017, but they indirectly linked to each other through the Netherlands. China took over Japan's role, becoming a regional supply hub with an important inflow linkage from the US and outflow linkages to other Asian economies. This implies that China's services sector directly and indirectly exported value added to other Asian economies

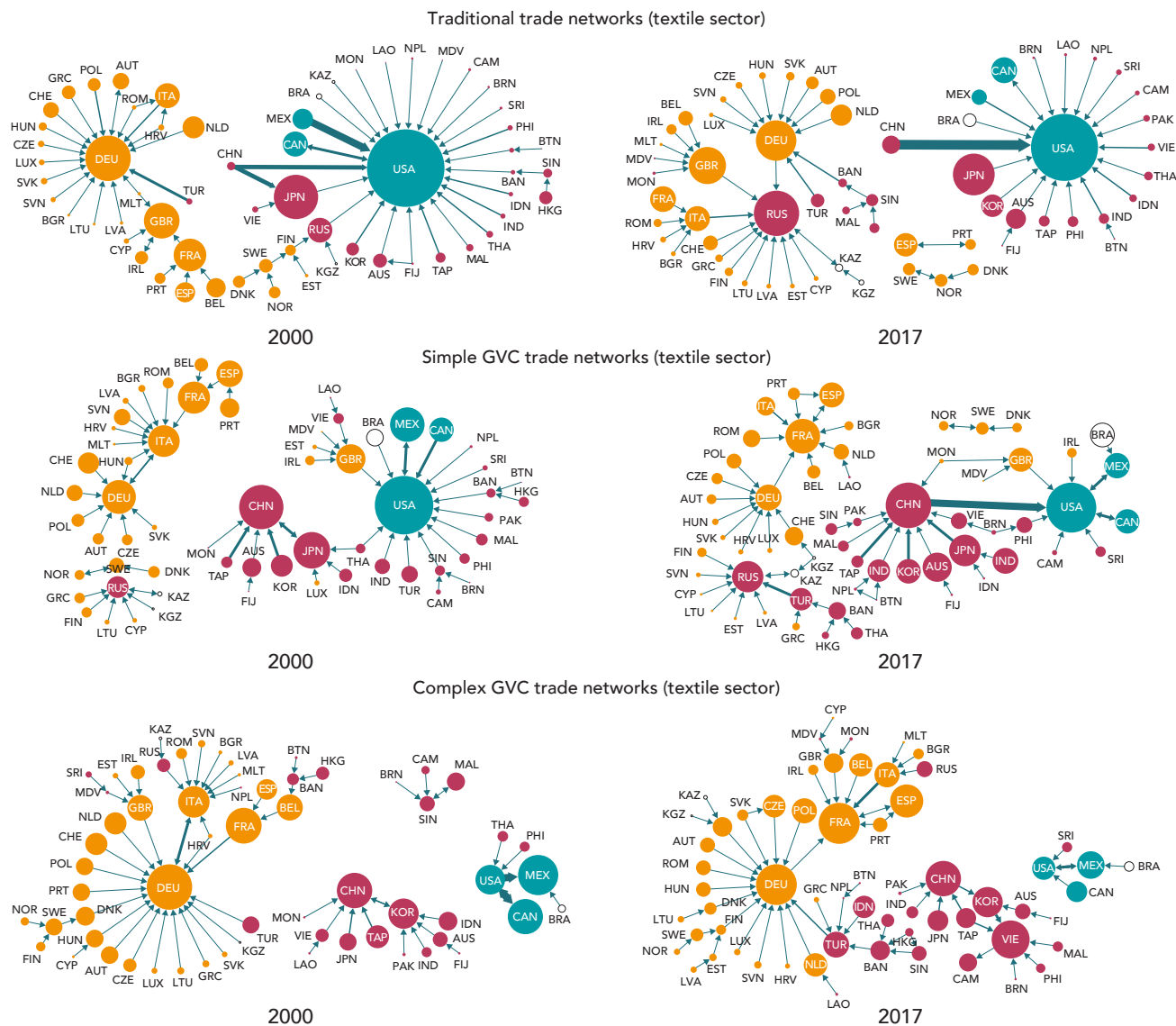
**FIGURE 1.19** Demand hubs of trade in value-added in various networks at the aggregate level



Note: the size of the circles represents the magnitude of value-added imports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

**FIGURE 1.20 Demand hubs of trade in value-added in various networks for the textile sector**



Note: the size of the circles represents the magnitude of value-added imports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

used to produce final goods. However, China still largely relied on US-made intermediate services when producing domestically-used final goods.

A very similar pattern can also be found in the complex GVC trade networks. One difference is that Germany’s services sector had a much larger presence in exporting value added through multiple cross-border transactions of intermediate goods in GVCs. This is probably due to the following fact: Germany has a high comparative advantage in exporting high-tech and complex intermediate goods, which embody value added from the domestic services sector, since producing these high-tech intermediate exports requires inputs from the domestic services sectors, such as business supporting services and financial intermediaries.

### 3.2 Demand hubs of value-added trade in various networks

#### *Demand hubs of value-added trade in various networks at the aggregate level*

The US was the unique global import demand hub in 2000, with connections to several Asia Pacific economies and some European counties, and stronger linkages with the regional demand hubs of Germany, the UK and Japan (upper part of Figure 1.19). The structure didn’t change greatly in 2017, except for the dramatic rise of China as a new regional demand hub in Asia with the strongest outflow linkage to the US. A similar pattern can be seen in the change in the simple GVC trade networks (the middle part of Figure 1.19) from 2000 to 2017, except that China became a regional demand hub with more inflow linkages from Asian



economies, as well as from some emerging countries outside Asia (Russia and Brazil). However, there was no global demand hub in the complex GVC trade networks (the bottom part of Figure 1.19) in either 2000 or 2017, as GVC imports of Germany, the US and China were concentrated with their regional trading partners. Germany's presence increased by 2017 to larger than that of the US, and China expanded rapidly. The US only maintained important linkages with its two regional partners, Canada and Mexico.

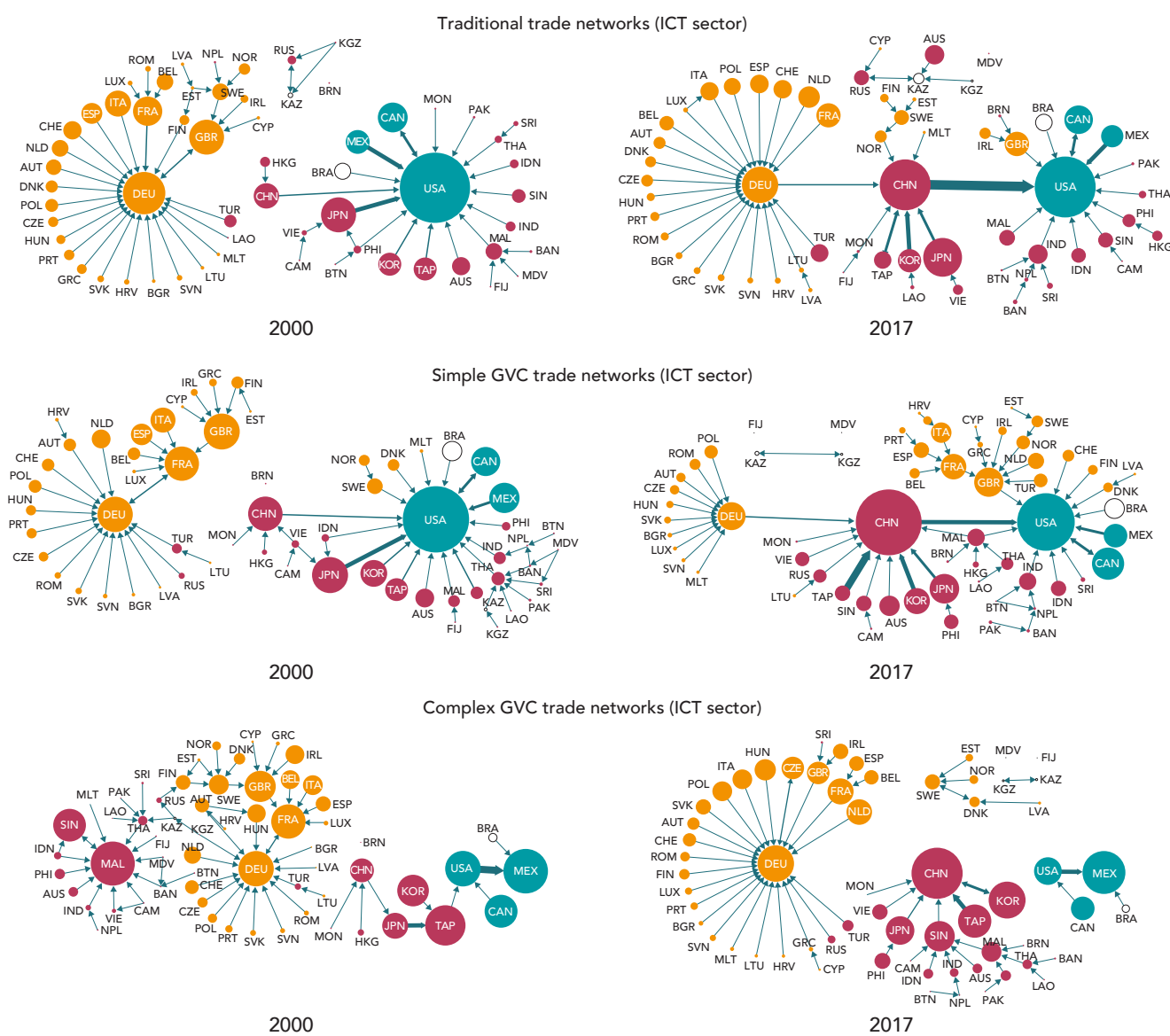
All the above observations imply that the more complex the network, the more concentrated the cross-border transactions of intermediate goods in GVCs. In other words, geographic distance

still matters in globally fragmented production, especially in complex GVCs. This is because regional trade agreements recently have made greater progress than WTO negotiations in reducing the transaction costs, including tariffs and non-tariff barriers, involved in each border crossing. At the same time, regional trade agreements also follow rules-of-origin which likely promote complex GVC activities.

#### *Demand hubs of value-added trade in various networks for selected sectors*

Greater variation in the structural change in networks can be found at the sector level. In the textile sector, the volume of

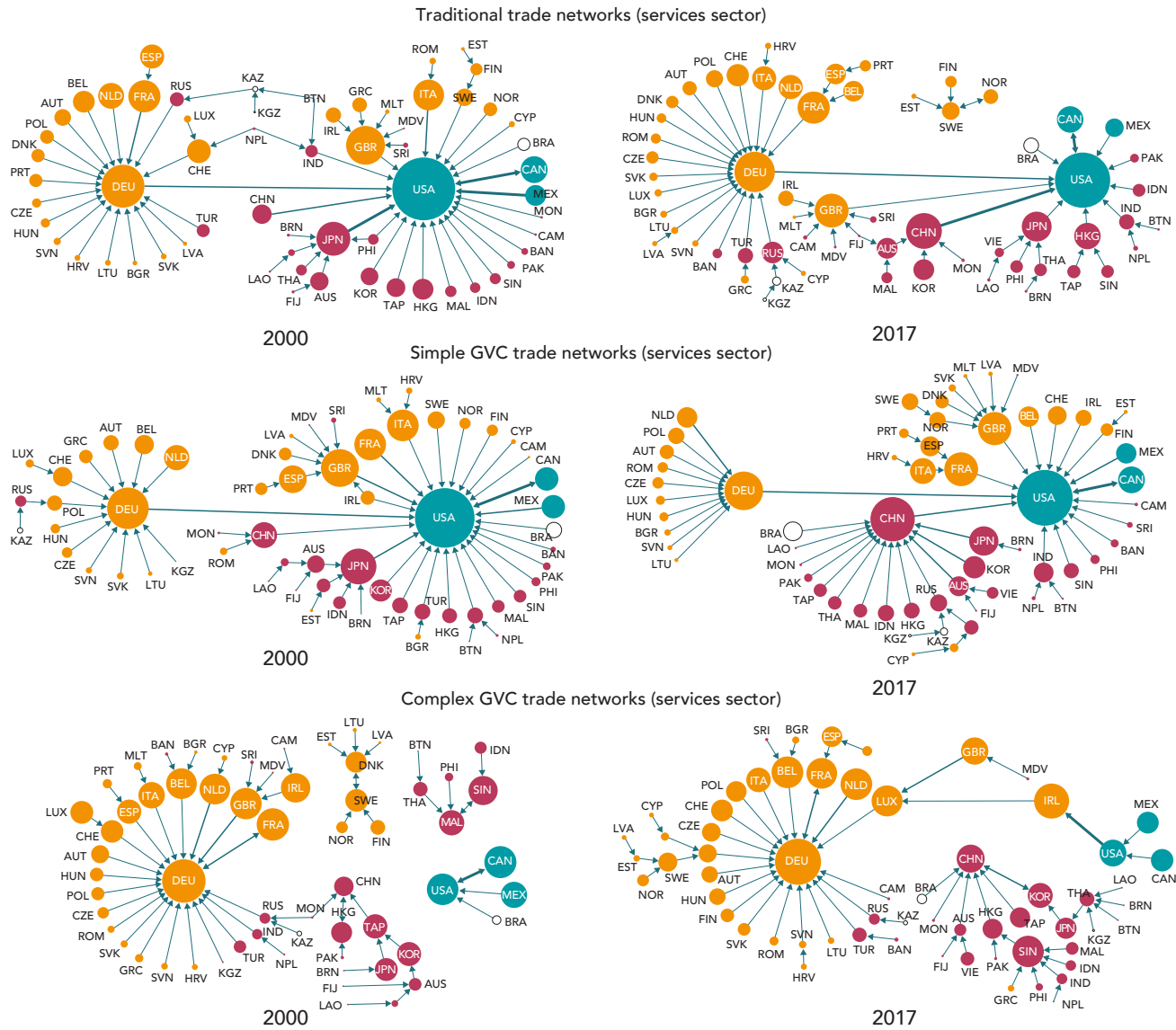
**FIGURE 1.21 Demand hubs of trade in value-added in various networks for the ICT sector**



Note: the size of the circles represents the magnitude of value-added imports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

**FIGURE 1.22 Demand hubs of trade in value-added in various networks for the services sector**



Note: the size of the circles represents the magnitude of value-added imports. The volume of value-added flow between each pair of trading partners is represented by the thickness of the line linking the two.

Source: Meng et al. (2018) based on the UIBE GVC indexes derived from the ADB 2018 ICIO table.

China’s trade increased sharply from 2000 to 2017, but its only important outflow linkage was to the US (Figure 1.20). Germany’s presence as a regional demand hub fell from 2000 to 2017, while Russia became an important regional demand hub in Europe with inflow linkages from some Eastern European and Central Asian countries. In the simple GVC networks, China’s importance as a regional demand hub increased, with an important outflow linkage to the US and inflow linkages from most Asian economies. On the other hand, Italy changed from the largest regional demand hub in Europe to an isolated country, as Italy’s participation pattern in simple GVCs changed from an intermediate goods-oriented importer to an intermediate goods-oriented exporter. In

the complex GVC networks, the connection in Europe, Asia and North America became more concentrated with their regional partners. The importance of France, Turkey and Viet Nam as sub-regional demand hubs increased substantially by 2017. Compared to the position in simple GVC trade networks, Russia’s presence was very low in the complex GVC trade networks.

In the ICT sector, China became the largest demand hub for the traditional trade networks. In 2017, China had the largest magnitude of imports (indicated by the size of the circle) and important inflow linkages from Germany, Japan, the Republic of Korea, Chinese Taipei, and outflow linkages to the US (Figure 1.21). A very similar pattern for China can also be found in the simple GVC trade

networks. By 2017 the US had lost many inflow linkages from Asia, but still maintained many inflow linkages from other economies in the simple GVC trade networks. In the complex GVC trade networks, Europe, Asia and North America had become more separated, as there was no longer any direct or indirect linkage among the regional hubs Germany, China and the US. Europe changed from multi-hubs to a single hub type network, while Asia changed from a single hub to a multi-hub type network.

The most important structural change in the services sector was the rise of China, which in 2017 became a regional demand hub in all three networks (Figure 1.22). The US was still the only global demand hub in services for both traditional and simple GVC trade networks. The complex GVC trade networks are largely separated, since there was no direct linkage among regional hubs in both 2000 and 2017. Germany's presence in the complex GVC trade networks had increased by 2017, reflecting the significant dependence of most European countries' services sectors on German demand for intermediate imports.

From the perspective of global production networks, we can see that the rise of China has dramatically changed the whole topology of GVCs from both the demand and supply sides at both the aggregated and individual sector levels. This clearly reflects the fact that China is no longer just a "factory" exporting huge amounts of final goods to the world; China has emerged as a new "superpower" through rapid industrial upgrading, which is reflected in the large scale of its exports and imports of intermediate goods and services via both simple and complex GVC trade networks. In other words, more countries, especially in Asia, have become highly dependent on China's supply of value-added and its demand for value-added directly and indirectly via GVCs. Another interesting finding that is not so remarkable, but can be clearly observed in our results, is that most of China's final demand in the past was previously satisfied by its own domestic suppliers, whereas nowadays imports play

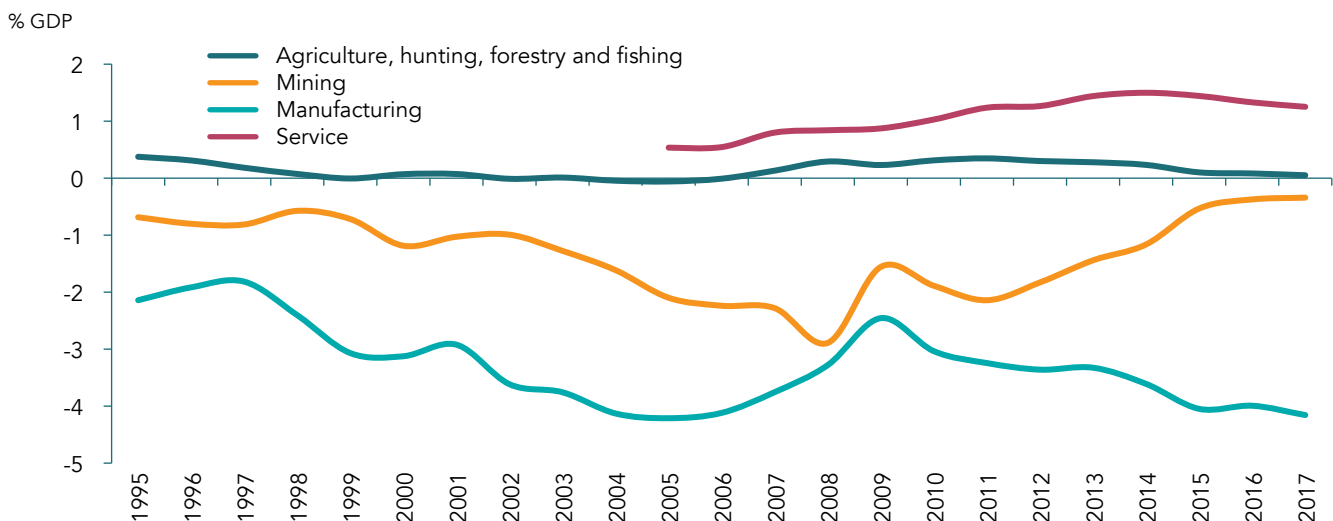
a greater role in meeting this demand. Because of this and due to China's rapid increase in purchasing power, China has become one of the most important demanders of value-added through final goods trade for several other countries. While China's per capita GDP is still lower than most developed countries (US\$8,827 for China versus US\$59,532 for the US in 2017 according to data from the World Bank Group), given China's potential for positive economic growth, the ongoing process of further opening-up, and its large population size, it is not difficult to imagine that China will become an important demand hub even in traditional trade networks as a large buyer of final goods in the near future. No doubt, this will also significantly change the world map of economic interdependence, as well as the distribution pattern of countries' influential power in many senses.

#### 4. The multilateral nature of bilateral trade balances in the age of GVCs<sup>16</sup>

Discussions of the US trade deficit in the press often focus on the aggregate deficit. The US has run huge trade deficits in manufacturing products, but has enjoyed a trade surplus in agricultural products and services (Figure 1.23). The US trade deficit in manufacturing products increased sharply in the late 1990s, accelerated after China joined the WTO in 2001, and further widened a few years after the global financial crisis.

The dramatic increase in the U.S. manufacturing trade deficit with China since China's WTO accession is largely a result of the movement of production facilities from other industrialized countries (mainly Japan and the Asian NICs) to China (Table 1.3 reports the share of U.S. major trading partners' contribution to the U.S. trade deficit in manufactured products between 1990 and 2017). For example, in 1990, Japan and the four Asian Tigers

**FIGURE 1.23 United States worldwide trade balance in broad economic sectors**



Source: Bureau of Economic Analysis, US Department of Commerce, available online at <https://www.bea.gov/>

**TABLE 1.3** Share of U.S. trade deficit in manufacturing products with partners

(percent)

	CAN	JPN	Four Asian NICs	DEU	MEX	ASEAN9	CHN	Rest of OECD	ROW	G7
1990	7.5	49.4	25.7	10.2	-1.9	6.1	10.3	-6.7	-0.5	70.4
1995	6.7	45.3	10.8	10.0	5.7	13.1	24.2	-6.0	-9.8	66.9
2000	6.2	24.9	9.1	8.3	3.6	11.5	25.5	7.3	3.7	45.1
2005	4.1	15.1	3.7	8.5	4.2	9.4	37.0	12.9	5.1	34.3
2008	-2.2	16.5	1.6	8.6	5.8	11.1	57.6	9.2	-8.2	31.0
2009	-7.0	14.6	1.7	8.0	6.8	13.0	70.5	7.9	-15.5	21.7
2010	-5.9	15.1	-0.2	7.9	8.1	11.0	67.1	9.7	-12.8	22.9
2011	-7.5	15.0	-0.2	10.4	6.1	11.1	67.6	9.0	-11.5	23.4
2012	-8.6	16.9	0.1	12.2	5.6	11.7	70.6	7.3	-16.0	27.0
2013	-9.5	16.4	-1.4	13.8	5.2	12.8	72.6	8.5	-18.4	28.4
2014	-8.4	13.5	0.4	13.2	5.2	13.6	67.7	11.0	-16.2	25.5
2015	-5.1	11.2	1.7	11.1	7.3	13.6	59.5	11.3	-10.5	23.5
2016	-4.5	11.0	1.9	9.2	8.2	14.3	55.4	11.9	-7.4	21.4
2017	-4.7	10.5	1.2	8.5	8.1	14.7	56.1	12.8	-7.2	20.1

Data Source: OECD Bilateral Trade in Goods by Industry and End-use (BTDI\*E), ISIC, Rev.4, available online: [https://stats.oecd.org/Index.aspx?DataSetCode=BT-DIXE\\_I4](https://stats.oecd.org/Index.aspx?DataSetCode=BT-DIXE_I4). ASEAN 9 include MYS, PHL, THA, IDN, VNM, BRN, KHM, MMR and LAO. SGP is included in Four Asian NICs.

**BOX 1.3****Identifying and measuring the third country effect in bilateral trade**

An integrated mathematical framework to trace value added and identify double counted items in gross trade flows is provided in Koopman, Wang and Wei (KWW, 2014). A country's gross exports can be decomposed into the sum of four conceptually different components: (a) domestic value added that is ultimately absorbed abroad, or value-added exports (VAX) as named by Johnson and Noguera (2012); (b) domestic value added that is exported (as intermediate exports) and then returned home (RDV); (c) foreign value added used in the production of exports (FVA); and (d) multiple counted value added due to back and forth cross-border intermediate trade (PDC). KWW further shows that these components of gross exports all have specific types of relationships with GDP statistics: VAX is the home country's GDP used to satisfy foreign demand, in which the factor content embodied in gross exports crosses national borders at least once; RDV is not part of home country's value added exports, but is part of home country's GDP that is eventually absorbed at home as the country's final demand, through which domestic factor content crosses national borders at least twice; FVA is a part of other countries' GDP, or the factor content

in exports that also crosses national borders at least twice; PDC counts in no country's GDP, as it is the factor content that has already been counted by at least one of the three components above and crosses national borders at least three times but is recorded in gross trade statistics by each country's custom authority.

By identifying which parts of the gross trade transactions are double counted relative to GDP statistics, the KWW method provides a way to correctly interpret gross trade data in value added terms (relative to GDP) and links gross trade and GDP statistics (the two most important and popular used economic statistics today) based on the System of National Accounts standard (SNA). Wang, Wei, and Zhu (2014) extend the KWW accounting framework to trade at the bilateral, sector, and bilateral sector levels and provide a consistent accounting framework that resembles in spirit that of KWW (2014) across different levels of aggregation. By splitting these four broad components into more detailed items, the roles of third countries in bilateral trade can be clearly identified and measured, as indicated by Table 1.4.

**BOX 1.3** (continued)**Identifying and measuring the third country effect in bilateral trade****TABLE 1.4** Decomposition of bilateral gross trade to identify and measure the roles of third countries in bilateral trade (percent)

Core KWW decomposition	Detailed Decomposition	Economic interpretation	Relation to GDP statistics	Number of border crossings
VAX_G Value added exports	DVA_DIR	Domestic VA in production of exports that is finally absorbed by trading partner	Home GDP satisfies final demand in partner country	<b>At least once</b>
	DVA_IND	Domestic VA in production of exports that is finally absorbed by third countries	Home GDP satisfies final demand in third countries	
RDV_G Returned DVA	RDV_G	Domestic VA first exported but finally returned home and consumed there	Home GDP satisfies own domestic final demand through international trade	<b>At least twice</b>
FVA Foreign value added	MVA	Trading partner's VA used in production of exports that return to and is absorbed by partner	Partner's GDP satisfies final demand in partner country	
	OVA	Third countries' VA used in production of exports that is finally absorbed by partner	Third countries' GDP satisfies final demand in partner country	
PDC Pure double counting	ODC	Pure double counting in gross exports sourced from third countries	No country's GDP	<b>At least three times</b>
	DDC	Pure double counting in gross exports sourced from home	No country's GDP	
	MDC	Pure double counting in gross exports sourced from partner	No country's GDP	

The decomposition of bilateral trade at a detailed level shows that the role of third countries in bilateral trade can be measured by 3 of the 8 detailed components (in blue font): DVA\_IND, OVA and ODC. The ratio of DVA\_IND to gross trade is used to measure the importance of a partner country as a transfer platform for the home country's DVA absorbed in third countries. This ratio is determined by the production sharing arrangement between the home and partner country, as well as by final demand in third countries. Similarly, the ratio of OVA to gross trade is used to measure the importance of third countries' factor content for the home country's export production.

This ratio is driven by final demand in the partner country and the production sharing arrangement between the home and third countries. Finally, the ratio of ODC to gross trade is used to measure the complexity of the third-country effect. This ratio is determined by the production arrangement among home, partner and third countries. ODC refers only to intermediate inputs that cross a national border at least three times (a firm uses intermediate inputs from a country to produce intermediate inputs in another country for production of exports to a third country, involving production sharing activities of at least among 3 countries).

were the source of about 75% of the U.S. worldwide trade deficit in manufactured products, but by 2017 their share had declined to less than 12%. Over the same period, China's share of the U.S. trade deficit in manufacturing products increased dramatically from 10% to about 73% in 2013, and has declined since then. In other words, while China was becoming an increasingly important source of manufactured goods, the relative importance of the rest of the industrialized world as a whole was declining (see the last column of Table 1.3), because many firms in these economies were shifting their manufacturing and assembly facilities to China via their FDI to China. Trade statistics by ownership from China Customs confirm that China's trade surplus in manufacturing products with the US was mainly generated by wholly foreign-owned enterprises (FIE) and joint venture companies (JOV), although Chinese-owned private firms (PRI) have played an increasing role in recent years<sup>17</sup>.

Along with China, other emerging economies, such as Mexico and the ASEAN countries, have been increasingly integrated into

global production networks over the last two decades and have increased their share of the US global trade deficit in manufactured goods (Table 1.3). This suggests that the development of various global production chains is one of the fundamental driving forces of the growing U.S. bilateral trade deficit with China in manufactured products during the past two decades.

To examine the role GVCs have played in the geographical shifting of the US trade deficit in manufacturing products, this section analyzes the value-added structure of the three trade routes where the US has the largest deficit, namely US trade with China, Japan and Germany, using the gross trade accounting method proposed by Koopman et. al (2014, see Box 1.3 for details).

We first look at the value-added structure for US net imports of computer, electronic and optical equipment (OECD-ICIO C30, 32 and 33) from China as an example. The decomposition results are reported in Table 1.5. Column (1) reports gross exports in millions of dollars (current prices). Column (2) reports value

**TABLE 1.5 US-China trade of computer, electronic and optical equipment**

(million USD)

Year		TEXP	VAX_G	DVA_DIR	DVA_IND	RDV_G	DDC	MC	OVA	ODC
		(1)=2+3+4 +5+6+7	(2)=2a+2b	(2a)	(2b)	(3)	(4)	(5)	(6)	(7)
<b>China exports to the United States</b>										
2000	Value	17,553	4,356	3,652	704	21	64	1,785	9,385	1,942
	Share	100	24.8	20.8	4	0.1	0.4	10.2	53.5	11.1
2007	Value	94,153	33,869	29,826	4,043	195	1,003	6,229	47,502	5,356
	Share	100	36	31.7	4.3	0.2	1.1	6.6	50.5	5.7
2014	Value	166,296	76,573	67,422	9,151	675	2,537	9,301	69,035	8,176
	Share	100	46	40.5	5.5	0.4	1.5	5.6	41.5	4.9
<b>US exports to China</b>										
2000	Value	5,362	3,441	2,504	936	572	139	46	725	440
	Share	100	64.2	46.7	17.5	10.7	2.6	0.9	13.5	8.2
2007	Value	13,930	9,182	4,891	4,291	2,016	237	427	886	1,182
	Share	100	65.9	35.1	30.8	14.5	1.7	3.1	6.4	8.5
2014	Value	25,054	18,544	11,099	7,445	3,346	317	754	1,033	1,061
	Share	100	74	44.3	29.7	13.4	1.3	3.0	4.1	4.2
<b>US net imports from China</b>										
2000	Value	12,191	915	1,148	-232	-551	-75	1,739	8,661	1,502
	Share	100	7.5	9.4	-1.9	-4.5	-0.6	14.3	71.0	12.3
2007	Value	80,223	24,687	24,935	-248	-1,821	765	5,802	46,616	4174
	Share	100	30.8	31.1	-0.3	-2.3	1.0	7.2	58.1	5.2
2014	Value	141,242	58,029	56,323	1,706	-2,671	2,220	8,547	68,002	7,114
	Share	100	41.1	39.9	1.2	-1.9	1.6	6.1	48.1	5.0

Source: The UIBE GVC indexes derived from the 2017 OECD ICIO table.



added exports (VAX\_G) associated with these gross trade flows. In the next five columns, major components of gross exports are reported: domestic value added that is ultimately absorbed by partner country ((2a) DVA\_DIR); domestic value added that is ultimately absorbed by third countries ((2b) DVA\_IND), which depends upon final demand in the third country; domestic value added in exports that is ultimately returned and consumed at home (column (3) RDV\_G), which is part of home country's GDP and final demand; loop effects between bilateral trading partners (Column (4) and (5) DDC and MC), third countries' value added in gross exports (column (6), OVA) and pure double counting sourced from third countries (column (7), ODC).

The decomposition results not only reveal the misleading nature of the balance of trade computed from gross trade statistics, but also the sources of such statistical illusion. Value added in exports (VAX\_G) accounted for only 25% of China's exports of computer, electronic and optical equipment to the US before China's WTO accession. This share increased afterwards, but remained lower than 50% in 2014. The value added in exports from third countries consistently accounted for more than 50% of China's exports of these goods throughout the sample period. The composition of US exports to China was the opposite, as the share of VAX\_G dominated throughout the sample period (between 65-75%). The value added content from third countries (OVA+ODC) accounted for less than 20% of US gross exports of these goods, and declined to only about 8% in 2014. MC+OVA+ODC accounts for the largest portion of China's exports, as China used upstream inputs from the US and third countries to produce its exports; DVA\_IND+RDV+DDC is the largest portion of US exports, which are US products imported by China used as inputs to produce China's exports for US and third country markets. Therefore, the main source of the trade imbalance in China-US bilateral trade in computer, electronic and optical equipment was the third countries' value added in gross trade flows. Third countries accounted for 80.3% of the total trade imbalance in 2000, falling to 53.1% in 2014.

Bilateral trade balances (net imports) are often used by trade and labor economists as a measure of import penetration and the impact of external trade on domestic economic activity. When traditional (final goods) trade dominated international trade flows, the net imports captured the imported factor content from the surplus economy to the deficit economy. However, when global trade is dominated by global value chains, gross trade balance is no longer a reliable measure of import penetration. As shown in the bottom panel of Table 1.5, US net imports of computer, electronic and optical equipment only contain a very small portion of Chinese factor content. In 2000, Chinese value added (factor content) only constituted 7.5% of US total net imports from China. This share increased rapidly after China joined the WTO, reaching 30.8% in 2007 and 41.1% in 2014.

Differences in the value-added structure of exports between China and the US reflects the different role that the two countries' firms played in this sector. With high design and system integration capacities, US multinationals were the lead firms of global value chains and occupied a top and central position in

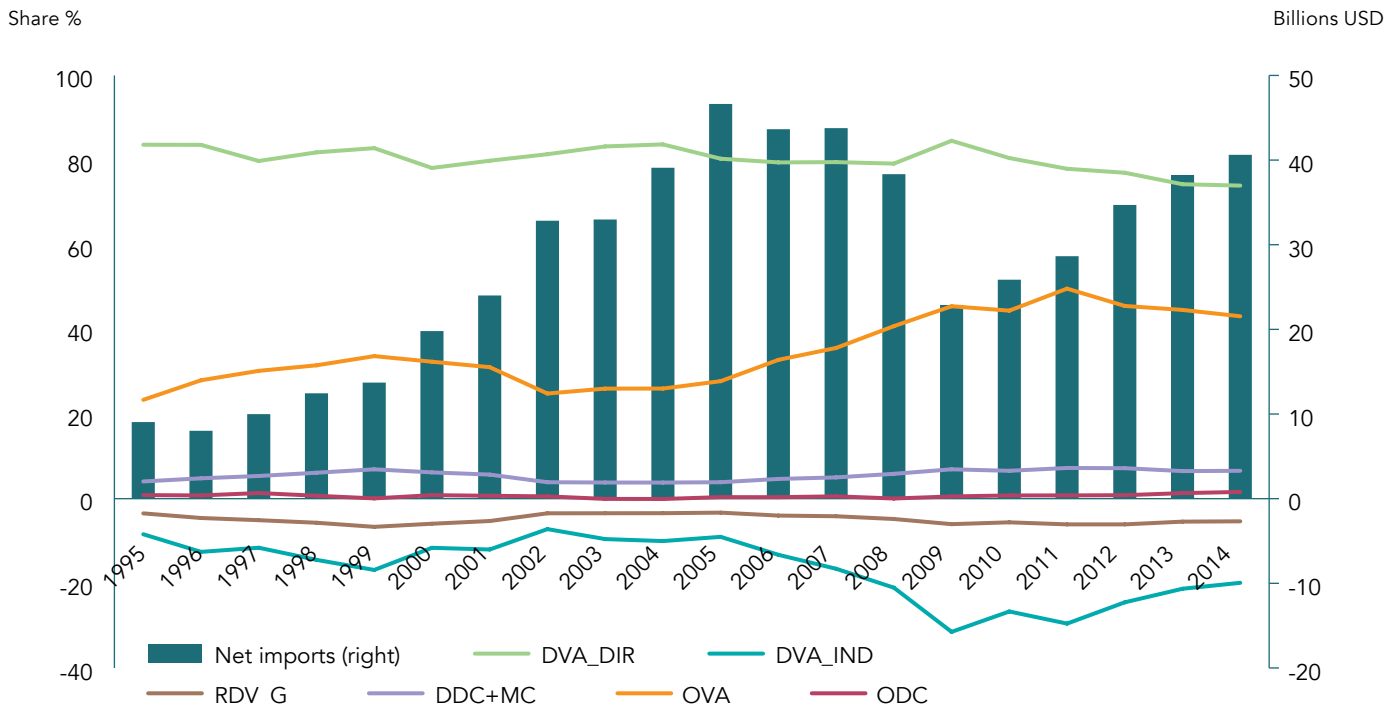
the global production network. By contrast, Chinese firms began to join the global value chains since deregulation of foreign investment in 1992, undertaking processing and assembly tasks, so that the ratio of domestic value added to gross exports was very low; a great deal of value came from foreign upstream suppliers of raw materials, parts and components. In 2000, 98.7% of China's exports of computer, electronic and optical equipment to the US were processing exports. After China entered the WTO, Chinese firms started to move up the global value chains. More Chinese firms upgraded to general trade, and the proportion of processing trade fell (from 87.3% in 2007 to 77.4% in 2014).

Such a value-added structure of US net imports from China is not uncommon. The important role played by third countries also can be observed in US net imports from Germany, Japan and many other trading partners. Figure 1.24 shows the value-added structure of US total net imports from Germany. A much larger portion of US intermediate goods exports to Germany were re-exported to third countries compared to the share of US imports from Germany (DVA\_IND, which depends on final demand in third countries) that was re-exported. Thus, in this re-exported portion, the US actually ran a large surplus with Germany in terms of value added, especially in services sectors. Compared to US net imports from China, US net imports from Germany contain a much higher share of Germany's factor content (around 80%), but third countries' suppliers also accounted for around 40% (third countries' final demand accounted for a negative 20%, implying that Germany's imports from the US depended more on third countries' final demand for Germany's products that use US intermediate inputs). All of this demonstrates the complex composition and offsetting factors involved in gross net trade flows.

To further demonstrate the differing roles of third countries across bilateral trade routes, Figure 1.25 compares the changing value-added structure of: US net imports of computer, electronic and optical equipment from China and US net imports of transport and storage services from Germany; and US net imports of motor vehicles from Germany and Japan.

US net imports of ICT products from China increased rapidly after China joined the WTO, jumping from less than 10% of US sector value-added (11 billion USD) in 2001 (right scale of Figure 1.25, top left) to over 60% (141 billion USD) in 2014. Factor content from third countries played the most important role in this dramatic growth (well above 50%). This reflected other countries using China as an assembling hub to re-export their domestic value added to satisfy US final demand. Similarly, demand for German goods by third countries, mostly nearby European economies, were the driving force behind the rise in US net exports of transport and storage services to Germany (Figure 1.25, bottom left).

Third countries' production significantly affected US deficits in motor vehicles with Germany and Japan from 1995 to 2014. A substantial portion of US net imports from Germany (more than one fourth of US net imports in 2014) reflected factor content from third countries, mostly Eastern EU countries and China, while final demand in third countries accounted for only about 5% of US net imports over this period (Figure 1.25, bottom right).

**FIGURE 1.24 Value-added structure of US net imports from Germany**

Note: Refer to Box 1.3 for symbol definitions.

Source: The UIBE GVC indexes derived from the 2017 OECD ICIO tables.

The importance of third countries' factor content supply and final demand in US net imports of motor vehicles from Japan increased towards the end of this period, but remained at a lower level than in Germany.

This analysis illustrates that in the age of global value chains, when embodied factor content and sources of final demand of gross trade flows vary significantly across trade routes by countries and products, net bilateral imports are no longer a reliable measure of the impact of trade with a partner country on domestic prices and wages. This also implies that any change in bilateral trade policy can have a significant impact on third countries that should not be overlooked in dealing with bilateral trade issues.

## 5. Conclusions

The rise of GVCs has significantly changed the nature and structure of the world economy. The increasing complexity of GVCs also brings great challenges to policy making in both developed and developing countries. This chapter has presented trends in GVC production and trade up to 2017 from various perspectives, based on a recently developed production decomposition method that classifies factor contents embodied in a product into GVC and non-GVC activities depending on whether they cross national borders.

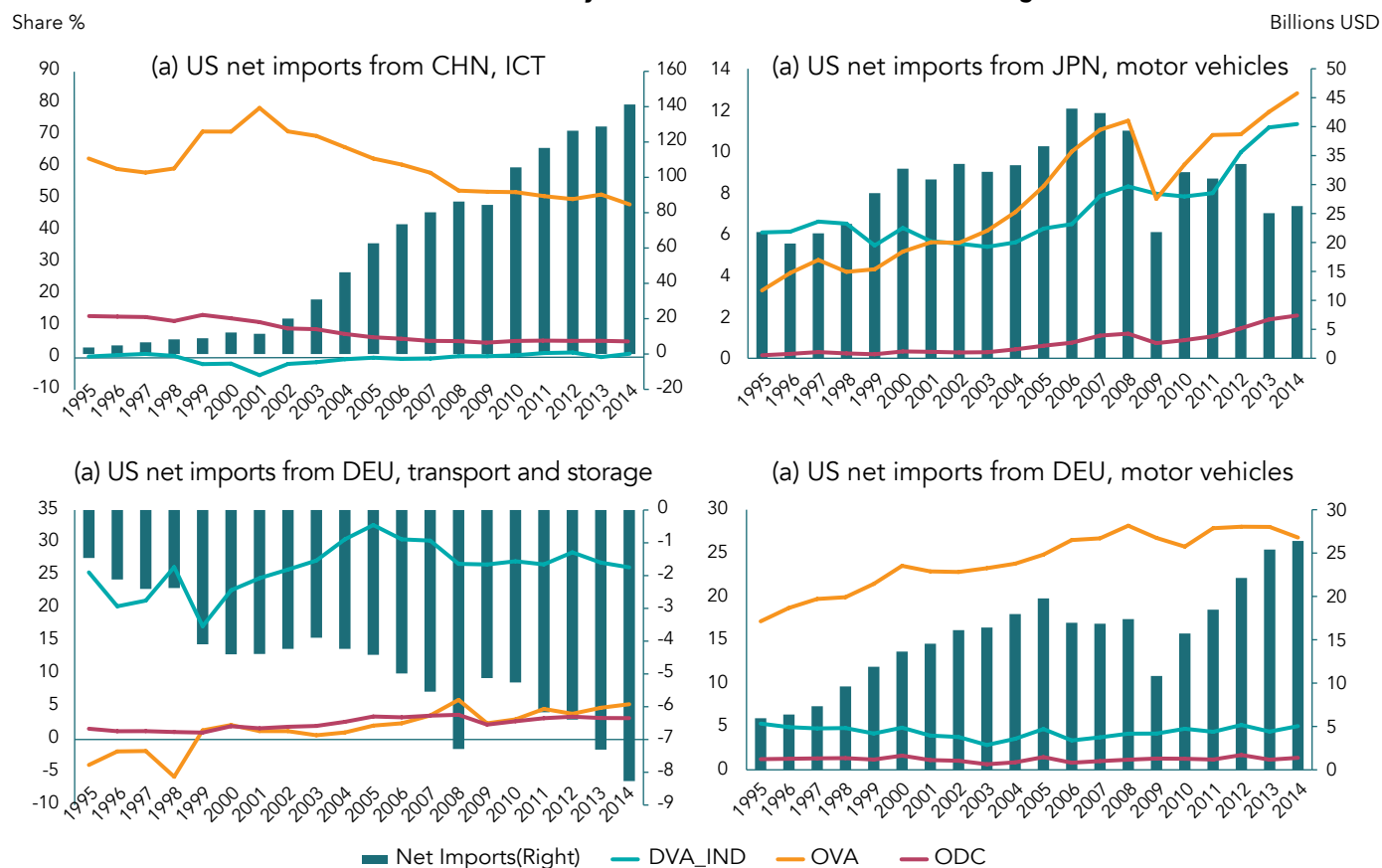
Several findings emerge from this chapter:

First, the globalization of production slowed after 2011, indicated by the increase of purely domestic production and the decline of GVC activities as a share of total production activities. As the growth of global trade surpassed the growth of global GDP for the first time in nearly six years, there were some signs of recovery of GVC activities in 2017, especially for complex GVCs activities. However, 10 years after the global financial crisis, global GVC participation has not returned to the pre-crisis level. Considering a longer period, the higher technology (knowledge) intensity of a sector, the more significant the increase of complex GVC activities.

Second, while the share of intra-regional GVC activities in total GVC activities increased in Asia from 2000 to 2017, the share of intra-regional GVC activities declined in both Europe and North America and their share of inter-regional production sharing activities increased, especially their GVC linkages with "Factory Asia". GVC trade became more global in 2017 compare to 2000.

Third, from the view of global production network topology, China played an increasingly important role as both a supply and demand hub in traditional trade and simple GVC activities, while the US and Germany remained the most important hubs in complex GVC networks. China has emerged as a new hub through rapid industrial upgrading, represented by its more high-tech



**FIGURE 1.25** The roles of third countries can be very different in different bilateral trading routes

Note: The blue bars represent net gross imports, measured in percent of US sector value-added according to the scale in vertical axes on the right, a positive number indicates US trade deficit, a negative number indicates US surplus; The lines represent third countries' roles, measured in percentage point according to scale in vertical axes on the left. The y-axis indicates calendar years. Refer to Box 1.3 for symbol definitions.

Source: The UIBE GVC indexes derived from the 2017 OECD ICIO tables.

intermediate exports and imports. Bilateral trade, especially complex GVC trade, became more concentrated among major regional trading partners, indicating distance matters even for value-added trade and GVCs.

Fourth, in the age of GVCs, bilateral trade balances are no longer a reliable measure of the impact of partner countries on domestic economic activities. For example, production and final demand from third countries have had a significant impact on US net imports from China, Germany and Japan. And factor content from third countries accounted for more than half of the burgeoning deficit in US net imports of ICT products from China, which increased 12.8 times in the 15 years up to 2014 to reach 141 billion USD.

One important policy implication is that changes in trade policy can have broad and unanticipated effects. Unilateral imposition of trade protection on exports from a partner country can have a significant impact on third countries when trade is carried out through GVCs, particularly complex GVCs. Indeed, as many products today are already "made in the world", increasing import protection can even harm exports from the home country.

More policy analyses on the impact of technology changes and GVC trade on labor markets in developed and developing countries will be discussed in detail in other chapters of this report.

Current residence-based national account rules treat all firms within national borders as domestic firms, so the value-added creation of foreign affiliates is treated as part of purely domestic production activities if they do not engage in cross border trade. However, some of their production may also be a type of GVC activity, especially in services because the supply of services through commercial presence abroad is an important way of conducting international transactions in services (mode 3 – commercial presence). The distinction between foreign and domestic owned firms is particularly relevant. However, no ICIO table currently available is able to separate production activities between domestic firms and foreign affiliates to allow us to develop GVC measurement for such activities. Initiatives in this direction are being taken in the international statistical community. Chapter 8 of this report will discuss this and related GVC measurement issues in more details.

## Notes

1. "Pure domestic" means domestic value-added in domestically produced final products that satisfy domestic final demand without involving cross border trade and production sharing activities, it can also be phrased as "not traded internationally"; "Traditional trade" is final goods and services produced for exports with only domestic factor content, it can also be phrased as "Trade in final products" or "Ricardian Trade"; "GVCs" are basically "trade in intermediate products". The distinction between simple and complex GVC activities in our estimates are determined by the number of national border crossing, not the differences in technology or the complexity of actual production process (although there is a correlation between them), so they can be phrased as "value-added activities cross one or more than one national borders". Some care is needed in interpretation, for example a large economy is likely to see lower levels of estimated complex GVCs than would be the case if the same economy was split into a series of smaller economies.
2. This section was written by Xin Li and Zhi Wang.
3. We aggregate the 65 WIOD industries into 8 industry groups: (1) AGR: Agriculture, Hunting, Forestry and Fishing (ISIC rev.3 "01T05"); (2)Min: Mining and Quarrying (ISIC rev.3 "10T14"); (3) HTI: High R&D intensive industries (ISIC rev.3 "24, 29T34, 352,353, 359");(4) MTI: Medium R&D intensive industries (ISIC rev.3 "25T28, 351, 37"); (5) LTI: low R&D intensive industries (ISIC rev.3 "15T23, 36"), (6) TTS: Trade and Transportation (ISIC rev.3 "50T52", 55, "60T63");(B)FBS Post and Telecommunications, Financial and Business services (ISIC rev.3 "64, 65T67, 71T74"); (8) OSE: Real Estate Activities, Utility, Construction, and: other services (ISIC rev.3 "70, 75, 80, 85, 90T93, 95, 40,41, 45").
4. The relative value of the forward and backward participation indices indicates a country-sector's position in the global production network. A higher degree of forward participation than backward participation implies that the country is more actively engaged in upstream production activities in GVCs. Some care is needed in interpretation however, see Ahmad, N., et al. (2017), "Indicators on global value chains: A guide for empirical work", OECD Statistics Working Papers, No. 2017/08, OECD Publishing, Paris, <https://doi.org/10.1787/8502992f-en>.
5. As a result, industry became an inappropriate analytical unit for the study of international trade. See the discussion on firm heterogeneity for the empirical challenges to tackle this problem in Chapter 8.
6. Its GVC exports share to Europe and Asia was 40.4% and 20.4% respectively, higher than its share of intra-regional complex GVC activities at 18.1%; Its complex GVC imports share from Europe and Asia was 31.2% and 27.8% respectively, also higher than its share of intra-regional complex GVC activities at only 20.7%.
7. This section was written by Bo Meng and Ming Ye.
8. Some care is needed in interpreting smile curves produced using input-output tables in basic prices, see also Chapter 8.
9. The data for compensation per employee is from the WIOD Socio Economic Accounts 2016 version (compensation of employees / number of employees).
10. The distance is measured by a value-added weighted average of production stages. For detailed methodology, one can refer to Ye, Meng et.al. (2015).
11. This section was written by Bo Meng, Hao Xiao and Jiabai Ye.
12. Data are from the ADB ICIO database (the 2018 version).
13. It should be noted, these types of plots are better for capturing long-run changes on the extensive margin rather than short-run changes that occur on the intensive margin.
14. It should be noted that country size may result in some bias in our analysis. For example, countries exporting to the US are more likely to see their exports classified as 'simple' than 'complex' GVC activities, compared to exports within a 'fragmented' region of smaller countries (e.g. EU).
15. A large number of studies have argued that due to rising manufacturing costs in developed nations, many companies are looking to less-developed nations to set up manufacturing facilities in hopes of reducing costs. These developed countries are being "hollowed out", which poses a threat to many factory workers because they could lose their job to someone in another country. The level of industrial hollowing out can be measured by net FDI outflows, unemployment rates, the share of manufacturing industries in GDP, and other means.
16. This section was written by Fei Wang, Zhi Wang and Kunfu Zhu.
17. Based on trade statistics collected by the General Administration of Customs of the People's Republic of China (GACC), China had a 304.8 billion USD trade surplus in manufacturing products with the United States in 2017. The share of FIE and JOV was 55%, the share of PRI was 41%, while SOE and other firms represented only about 4%.

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