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# Digital Technology and Global Integration: Opportunities for Innovative Growth

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## KEY MESSAGES

- The development and adoption of Fourth Industrial Revolution (4IR) technologies can help economies upgrade their participation in global value chains (GVCs) by improving production efficiency, creating new and better products and services, and enabling technological upgrading.

- The APEC region contributes around 80 percent of the global exports of 4IR products and 63 percent of the global imports of the products in 2019. Some APEC economies, such as China; Japan; Korea; and the US, have been particularly active in patenting, with inventions (mostly) in core technologies and applications in home and consumer goods. Economies that are active in patenting also show the highest patent content embedded in their value chains.

- APEC economies are moving in heterogeneous directions in integrating into GVCs. APEC economies such as Mexico and Viet Nam have become increasingly integrated into GVCs, as represented by their high foreign shares in both backward and forward linkages. Meanwhile, economies such as China; Indonesia; and Malaysia show lower participation in global production.

- An economy's GVC integration trajectory may be influenced by its level of technological advancement. The specific trajectory may be attributable to the economy's GVC positioning and upgrading strategies at the economy as well as the sectoral levels, such as labour-intensive production capabilities or policies to attract foreign direct investment (FDI) in prioritised sectors.

- In upgrading, economies could follow a non-linear path, leapfrogging to higher stages through strategic investment in R&D and labour force upskilling. A more gradual, linear upgrading path could be achieved through specialisation, where economies could incrementally build up their technology and production capabilities as they move up the value chains.

- Upgrading to higher value-added stages of GVCs can help economies boost their gains from GVC participation. However, this is a knowledge-intensive process that requires significant investments in human capital and technology. To access the necessary technology for GVC upgrading, economies could consider developing policies to attract high-quality FDI. That means targeting FDI that goes beyond labour-intensive job creation and that holds the promise of extensive technology transfer to the domestic economy (that increases competitiveness at the firm level).

## Introduction

Innovation and digitalisation were high on the agenda of the 2021 APEC Economic Leaders' Week and the Aotearoa Plan of Action, a plan to implement the APEC Putrajaya Vision 2040. The COVID-19 pandemic and the resultant global lockdowns have made more apparent the importance of innovation and digital technology.

Narrowly speaking, digital technology has transformed how business and industry approach face-to-face interactions, and offered solutions to the challenge of physical distancing. Broadly speaking, digital technology has enhanced the resilience of value chains, facilitated innovative global value chain (GVC) participation, and fostered new drivers of growth for post-pandemic economic recovery.[1]

Indeed, GVCs are seen as an important vehicle for firms to join the global production and innovation ecosystem.[2] Although there is a wealth of literature on the gains from GVC participation and the factors influencing an economy's degree of participation in GVCs,[3] our understanding of the impact of innovation and digital technology on GVC organisation and participation remains scant.

While there are several models and alternative measures of GVC participation and upgrading,[4] technology can facilitate access to the supply chain network, both directly and indirectly.

Against this backdrop, this policy brief discusses the intersection between technology and GVC participation and upgrading in APEC economies. The brief utilises data from the Asian Development Bank-ADB Institute (ADB-ADBI) Innovation and Structural Transformation Database.[5]

This brief will start with a discussion of Fourth Industrial Revolution (4IR) technology and the innovation landscape in the APEC region. After that, we will revisit key indicators that help provide insights into the GVC participation of APEC economies, that is, their backward and forward integration.

We will also probe the role of technology in facilitating productive GVC participation and upgrading. To develop and compete in the global market, firms will need to have access to a range of suppliers and markets. Having strong backward and forward integration will also open up access to the latest technology and innovation available for firms to upgrade or to connect to GVCs with lucrative growth potential.

## Fourth Industrial Revolution (4IR): The Technology and Innovation Landscape

GVCs, as a form of intermediate goods trade network between multinational corporations and their globally dispersed suppliers, can be a channel for the transfer of knowledge, know-how and innovation. Also, advanced digital production technologies can bring about GVC integration and upgrading benefits and opportunities:[6]

- Enhance product–service characteristics and functionalities that offer the possibility of industrial revitalisation and growth through the creation of new and better products and services.
- Improve production efficiency through technologies such as big data analytics.
- Enable broader access to and deeper utilisation of capital that enables technological upgrading.

The Fourth Industrial Revolution (4IR) refers to the integration of digital technologies across a range of sectors, such as improving agricultural productivity using greenhouse automation. 4IR inventions are divided into three main sectors by the European Patent Office: core technologies, enabling technologies, and application domains. Table 1 provides an overview of the technology fields under each of the three sectors.

[1] X. Fu, "Digital Transformation of Global Value Chains and Sustainable Post-pandemic Recovery," *Transnational Corporations* 27, no. 2 (2020): 157–66.
[2] World Trade Organization (WTO), *Technological Innovation, Supply Chain Trade, and Workers in a Globalized World* (Geneva: WTO, 2019); Asian Infrastructure Investment Bank (AIIB), "Asian Infrastructure Finance 2021: Sustaining Global Value Chains" (Beijing: AIIB, 2021).
[3] See: M.P. Timmer et al., "Slicing Up Global Value Chains," *Journal of Economic Perspectives* 28, no. 2 (2014): 99–118; R.C. Johnson and G. Noguera, "Accounting for Intermediates: Production Sharing and Trade in Value Added," *Journal of International Economics* 86, no. 2 (2012): 224–36; P. Antras, *Global Production: Firms, Contracts, and Trade Structure* (Princeton, NJ: Princeton University Press, 2016).
[4] AIIB, "Asian Infrastructure Finance 2021"; Y. Xing, D. Dollar, and B. Meng, "Trade in Intangible Assets along Global Value Chains and Intellectual Property Protection," in Asian Development Bank (ADB) et al., *Global Value Chain Development Report 2021: Beyond Production* (ADB, 2021).
[5] N. Foster-McGregor, Ö. Nomaler, and B. Verspagen, "The ADB-ADBI Innovation and Structural Transformation Database: A Guide," UNU-MERIT and ADB Institute, 2022, https://innovatransformation.adbi.org/
[6] United Nations Industrial Development Organization (UNIDO), "Absorbing Advanced Digital Production Technologies to Foster Industrialization: Evidence from Case Studies in Developing Countries" (Vienna: UNIDO, 2020).

The first sector, core technologies, corresponds to the basic building blocks upon which 4IR technologies are built. It consists of inventions that directly contribute to the three established fields of information and communication technologies (ICT) inherited from the previous industrial revolution, that is, information technology (IT) hardware, software, and connectivity.

The second sector encompasses enabling technologies that build upon and complement the core technologies in multiple sectors such as power supply, user interfaces, core artificial intelligence (AI), etc.

The third sector, namely, application domains, includes the final applications of 4IR technologies in various parts of the economy. Examples of technology fields under this sector are agriculture, healthcare, and consumer goods. These frontier technologies can potentially catalyse the structural transformation of value chains in the middle and long run.

**Table 1. Cartography of 4IR inventions**

| Sectors | Field | Definition | Examples |
|---|---|---|---|
| **Core technologies** | IT hardware | Basic hardware | Sensors, advanced memories, processors, adaptive displays |
| | Software | Basic software technologies | Intelligent cloud storage and computing structures, mobile operating systems, blockchain technologies |
| | Connectivity | Basic connectivity systems | Network protocols for massively connected devices, adaptive wireless data systems |
| **Enabling technologies** | Data management | Technological means to create value from data | Diagnostic and analytical systems for massive data; prediction and forecasting techniques; planning and control systems |
| | User interfaces | Enabling the display and input of information | Virtual reality, augmented reality, speech recognition and synthesis |
| | Core artificial intelligence (AI) | Enabling machine understanding | Machine learning, neural networks, statistical and rule-based systems, AI platforms |
| | Geo-positioning | Enabling the determination of the position of objects | Enhanced geo-location and satellite navigation, device-to-device relative and absolute positioning |
| | Power supply | Enabling intelligent power handling | Automated generation, situation-aware charging systems, shared power transmission and storage objectives, smart power-saving management |
| | Data security | Enabling the security of data | Adaptive security systems for devices, services, and data transmission |
| | Safety | Enabling safety of physical objects | Intelligent safety systems for theft and failure prevention |
| | Three-dimensional (3D) support systems | Enabling the realisation of simulated 3D systems | 3D printers and scanners for parts manufacture, automated 3D design and simulation |
| **Application domains** | Consumer goods | Applications pertaining to the individual | Personal health monitoring devices, smart wearables, smart entertainment and sport devices, smart toys and textiles |
| | Home | Applications for the home environment | Smart homes, alarm systems, intelligent lighting and heating, consumer robotics, climate control systems |
| | Vehicles | Applications for moving vehicles | Autonomous driving, vehicle fleet navigation devices |
| | Services | Applications for business enterprise | Intelligent retail, payment and loyalty systems, smart offices |
| | Industrial | Applications for industrial manufacture | Smart factories, intelligent robotics, energy saving |
| | Infrastructure | Applications for infrastructure | Intelligent energy distribution networks, intelligent transport networks, intelligent lighting and heating systems |
| | Healthcare | Applications for healthcare | Intelligent healthcare systems, robotic surgery, smart diagnosis |
| | Agriculture | Applications for agriculture | Climate monitoring systems, greenhouse automation, smart crop and cattle management, smart farming |

Source: Compiled from J. Pose-Rodriguez et al., *Patents and the Fourth Industrial Revolution: The Global Technology Trends Enabling the Data-driven Economy* (Netherlands: European Patent Office (EPO), 2020).

### *4IR in APEC economies*

This policy brief uses 'number of patent families' as an indicator to determine the innovation capabilities of APEC economies in the context of GVCs. A patent family is a collection of patent applications covering the same or similar technical content. Specifically, we use the patent-based indicators featured in the ADB-ADBI Innovation and Structural Transformation Database: (1) cumulative number of 4IR patent families; (2) patenting in 4IR sub-fields; and (3) 4IR patent intensity. Here, it is important to acknowledge that not all patented inventions lead to actual innovations and many patents do not materialise into high-value applications. Nevertheless, the number of patent families remains relevant as an indicative measure of innovation capacity and capability across economies.

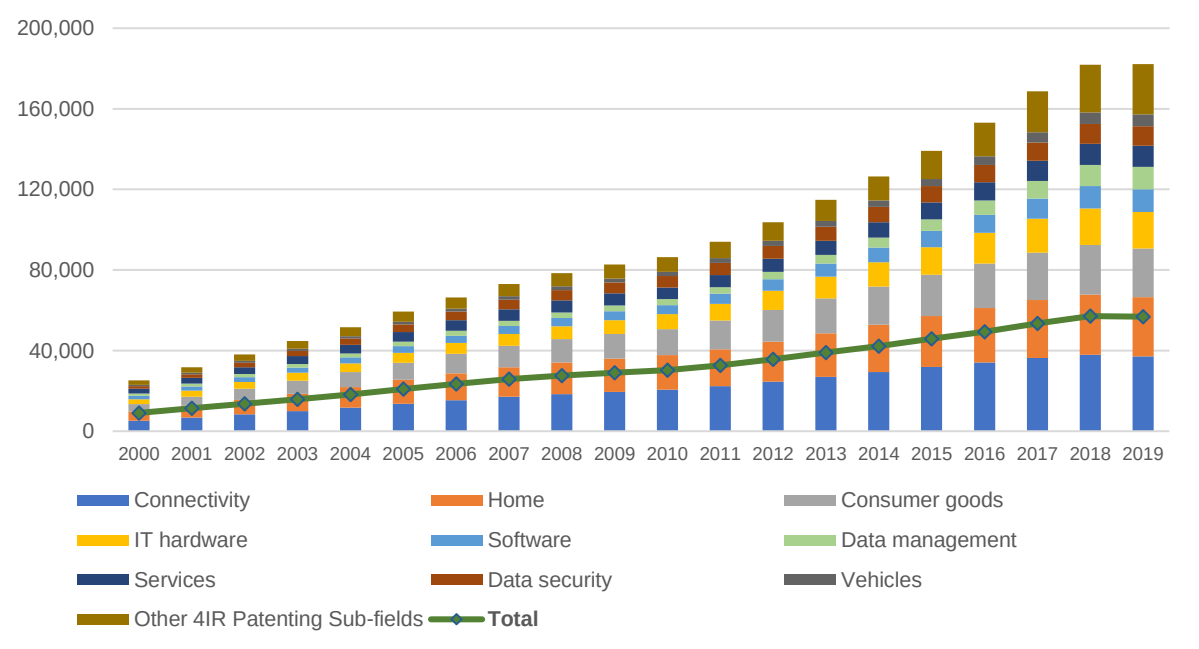
The APEC region is an innovation hub. APEC economies contributed 71 percent of the world's total cumulative patent families in all technologies between 2010 and 2019. APEC's share in 4IR patent families during the same period is even higher, at 82 percent. Nonetheless, the share of 4IR in all patent families in APEC (and globally) remained modest at less than 3 percent, implying significant room for future innovation.

The 10-year moving total for number of 4IR patent families in APEC has increased more than six-fold in the last two decades, from 9,097 in 2000 to nearly 57,000 in 2019. Connectivity, home, consumer goods, IT hardware, and software are the fields that consistently reported the highest numbers of patent families throughout the period covered (Figure 1). Among them, connectivity, IT hardware, and software constitute the core technologies upon which other technologies are built.

Despite recording fewer patent families, core AI registered the fastest growth, rising by more than 48 times between 2000 and 2019. Most of the growth in number of core AI patent families occurred between 2015 and 2019, at an average annual rate of 63 percent.

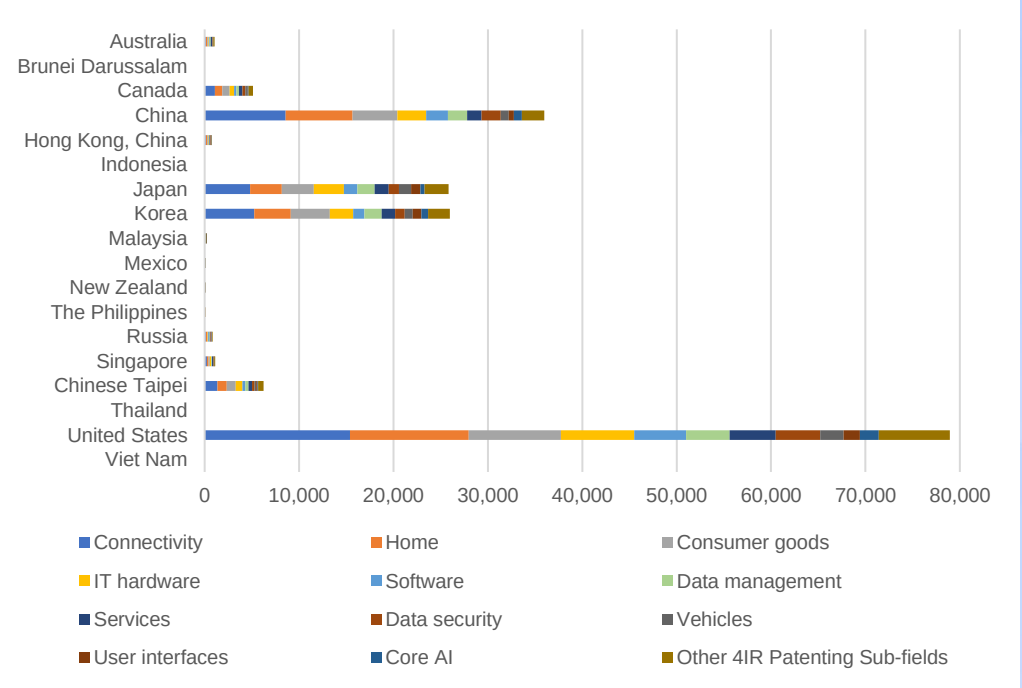
China; Japan; Korea; and the US lead the APEC region in cumulative number of 4IR patent families in 2019 (Figure 2). In these economies, core technologies (connectivity, IT hardware, software) contribute the bulk of patent families; and applications in home and consumer goods also record active patenting. That 4IR patents are concentrated in these few economies is largely due to the high technological threshold of 4IR technologies, which require both general and sector-specific foundational capabilities.

**Figure 1. Number of 4IR patent families by technology fields in APEC, 10-year cumulative**



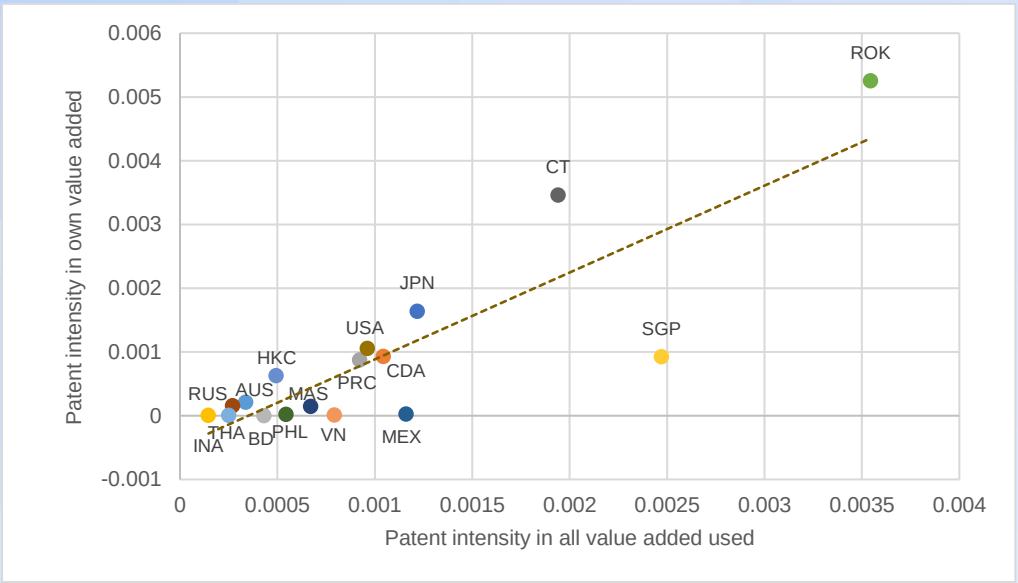

Notes:
1. Data for Chile; Papua New Guinea; and Peru are not available.
2. 4IR inventions can be relevant to, and thus categorised under, one or more technology fields, within one or more technology sectors. The total number of patent families (dark green line with markers) in a given year therefore is not necessarily equal to the sum of individual patent families in all technology fields and sectors (the height of the bar).
Source: APEC Policy Support Unit (PSU) calculations using ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

**Figure 2. Number of 4IR patent families in APEC economies, 10-year cumulative**




Notes:
1. Data for Chile; Papua New Guinea; and Peru are not available.
2. 4IR inventions can be relevant to, and thus categorised under, one or more technology fields, within one or more technology sectors. The sum of individual patent families in all technology fields and sectors (the length of the bar) is not necessarily equal to the total number of patent families.
Source: APEC PSU calculations using ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

**Figure 3. 4IR patent intensity in value-added content of APEC economies, 2019**

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Note: Data for Chile; New Zealand; Papua New Guinea; and Peru are not available.
Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

### *4IR in GVCs*

The adoption and application of 4IR technologies can have transformative impacts on GVC structure and development. Patents for trade products may support knowledge transfer and minimise contractual frictions.[7] Figure 3 plots the patent intensity of APEC economies' own value-added content, defined as the number of patent families per USD 1 million value added by the economy itself to the total output of the value chain, against the patent intensity of all value-added content used for the respective value chain.

The findings suggest that economies with patent-intensive production (shown by higher patent content in own value added) also use more patent-intensive inputs in their value chains (shown by higher patent content in all value-added content used). Economies that are most active in patenting, namely, Canada; China; Japan; Korea; Chinese Taipei; and the US, also show high patent content embedded in their value chains.

### *4IR in trade*

Trade involves both the transfer and delivery of tangible and intangible products. One measure to reveal the transfer and flows of 4IR technologies and innovation is through the trade values of 4IR products. For our analysis, we included six

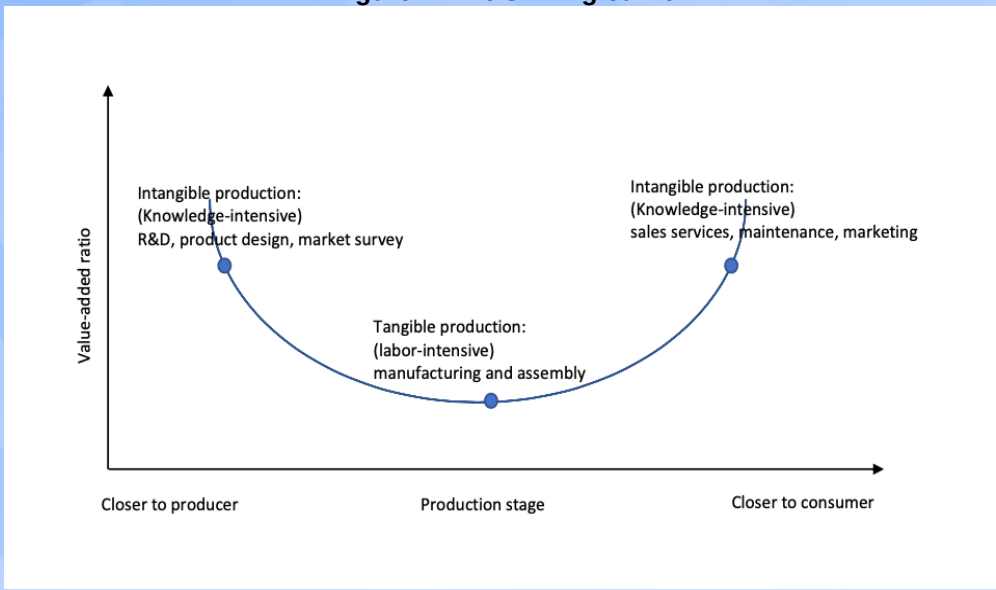
**Table 2. Value of exports and imports for 4IR products in APEC economies, 2019 (in USD 000)**

| Economy | 4IR exports | Share of total APEC 4IR exports | 4IR imports | Share of total APEC 4IR imports |
|---|---|---|---|---|
| Australia | 789,752 | 0.11% | 9,829,052 | 1.84% |
| Brunei Darussalam | 2,868 | 0.00% | 90,152 | 0.02% |
| Canada | 4,887,503 | 0.70% | 9,728,001 | 1.83% |
| Chile | 26,666 | 0.00% | 1,419,094 | 0.27% |
| China | 330,000,000 | 47.24% | 113,000,000 | 21.21% |
| Hong Kong, China | 8,022,879 | 1.15% | 82,900,000 | 15.56% |
| Indonesia | 2,408,226 | 0.34% | 6,467,969 | 1.21% |
| Japan | 46,500,000 | 6.66% | 32,700,000 | 6.14% |
| Korea | 46,300,000 | 6.63% | 22,400,000 | 4.20% |
| Malaysia | 30,000,000 | 4.29% | 14,000,000 | 2.63% |
| Mexico | 42,900,000 | 6.14% | 20,700,000 | 3.88% |
| New Zealand | 185,258 | 0.03% | 1,315,433 | 0.25% |
| Papua New Guinea | 1,213 | 0.00% | 74,360 | 0.01% |
| Peru | 7,543 | 0.00% | 849,045 | 0.16% |
| The Philippines | 17,400,000 | 2.49% | 8,098,484 | 1.52% |
| Russia | 840,152 | 0.12% | 9,390,245 | 1.76% |
| Singapore | 15,900,000 | 2.28% | 21,100,000 | 3.96% |
| Chinese Taipei | 57,200,000 | 8.19% | 15,900,000 | 2.98% |
| Thailand | 32,900,000 | 4.71% | 15,300,000 | 2.87% |
| United States | 38,200,000 | 5.47% | 128,000,000 | 24.02% |
| Viet Nam | 24,100,000 | 3.45% | 19,600,000 | 3.68% |
| APEC | 698,572,060 | 100.00% | 532,861,836 | 100.00% |
| World | 870,339,561 | -- | 844,919,916 | -- |

4IR=Fourth Industrial Revolution.
Source: APEC PSU calculations using ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

[7] N.J. Zolas and T.J. Lybbert, "How Do Patents Shape Global Value Chains? International and Domestic Patenting and Value-Added Trade," in A. Taubman and J. Watal (eds), *Trade in Knowledge: Intellectual Property, Trade and Development in a Transformed Global Economy*, (Cambridge: Cambridge University Press, 2022), 471–97, doi:10.1017/9781108780919.020

**Figure 4. The smiling curve**




Source: Adapted from Asian Development Bank (ADB) et al., *Global Value Chain Development Report 2021: Beyond Production* (ADB, 2021), 17.

subfields of 4IR products: CADCAM, robots, automated welding, 3D printing, regulating instruments, and ICT.[8]

As a region, APEC contributed around 80 percent (USD 699 billion) of global exports of 4IR products and 63 percent (USD 533 billion) in global 4IR imports in 2019 (Table 2).

China was the leading global exporter of 4IR products, exporting around USD 330 billion in trade value (almost 50 percent of APEC 4IR exports) followed by Chinese Taipei; Japan; Korea; and Mexico.

On the import side, the US and China were the two main contributors, contributing 24 percent and 21 percent, respectively, of total APEC 4IR imports, followed by Hong Kong, China; Japan; and Korea.

## GVC Participation and Upgrading in APEC

With globalisation, the production of one single product can be divided into several stages and be assembled in several different economies. This unbundling of production has increased the importance of intermediate trade and the concept of GVCs.[9]

Of note, the revenue generated from each stage is not equally distributed. According to the 'smiling curve' hypothesis, the two ends of the smile have a higher gain in terms of value-added compared to the middle point (Figure 4).

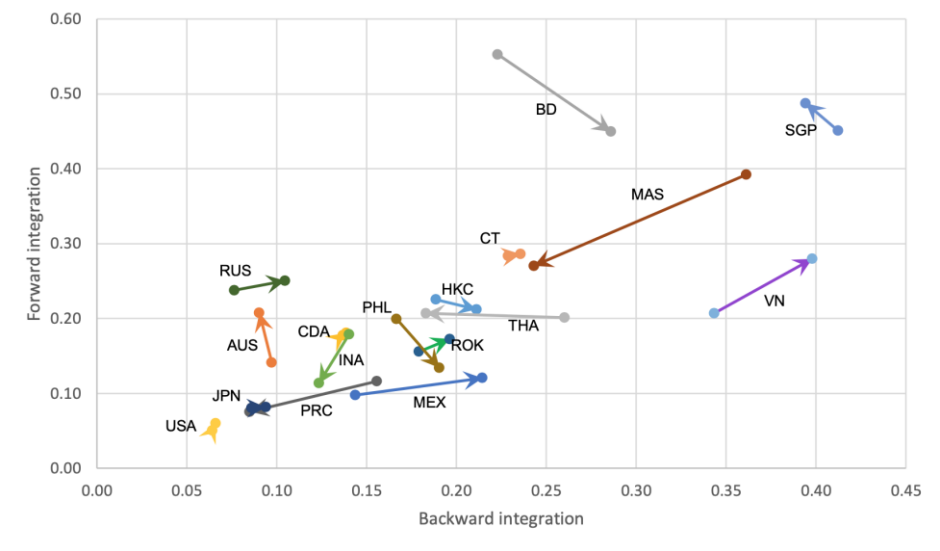
The two ends of the smile represent value-added from intangible production, which relies more on human capital. For example, R&D and product design are heavily dependent on people's ideas and innovation; marketing is also a knowledge-intensive procedure that requires novel ideas on how best to present the products to consumers. The middle part of the smile is the labour-intensive manufacturing stage, which generally contributes lower value-added ratio.[10]

Thus, to obtain higher marginal revenue, economies could move their position upstream toward R&D or downstream toward activities such as branding and marketing. Foreign direct investment (FDI) can also help to upgrade GVCs, by providing access to new technologies to increase a sector's competitiveness in the global market.[11]

An iconic example is the Apple iPhone. Most of the value add for this product is captured by the company's headquarters in the US, which engages

[8] Foster-McGregor, Nomaler, and Verspagen, "The ADB-ADBI Innovation and Structural Transformation Database: A Guide."
[9] R. Baldwin, *The Great Convergence: Information Technology and the New Globalization* (Cambridge, MA: Belknap Press, 2016).
[10] ADB et al., *Global Value Chain Development Report 2021.*
[11] United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP), "Asia-Pacific Trade and Investment Report 2015: Supporting Participation in Value Chains" (UN, 2015).

**Figure 5. Forward and backward integration in APEC, 2007 and 2019**

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Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

in (1) basic and applied R&D, product design, and supply chain management; and (2) marketing, brand management, and after-sales services. The value added generated by factories doing the assembly is only a small fraction of the product's value.[12]

The next section will focus on the development of GVC participation and integration in APEC economies between 2007 and 2019. The section reviews the data at aggregate economy level to understand economies' performance, and further examines three sectors – textiles and textile products; transportation equipment; and electrical and optical equipment.

***GVC participation in APEC economies***

Figure 5 shows the changes in backward and forward integration between 2007 and 2019 at the aggregate economy level. Using ADB's definition, backward integration is measured as foreign share of total demand served. Forward integration is measured as foreign share of total value added produced.[13]

As Figure 5 shows, APEC economies are moving in heterogeneous directions in the nature of their GVC integration. Their respective trajectories are likely influenced by a combination of their global positioning in the value chain(s) and their domestic economic conditions.

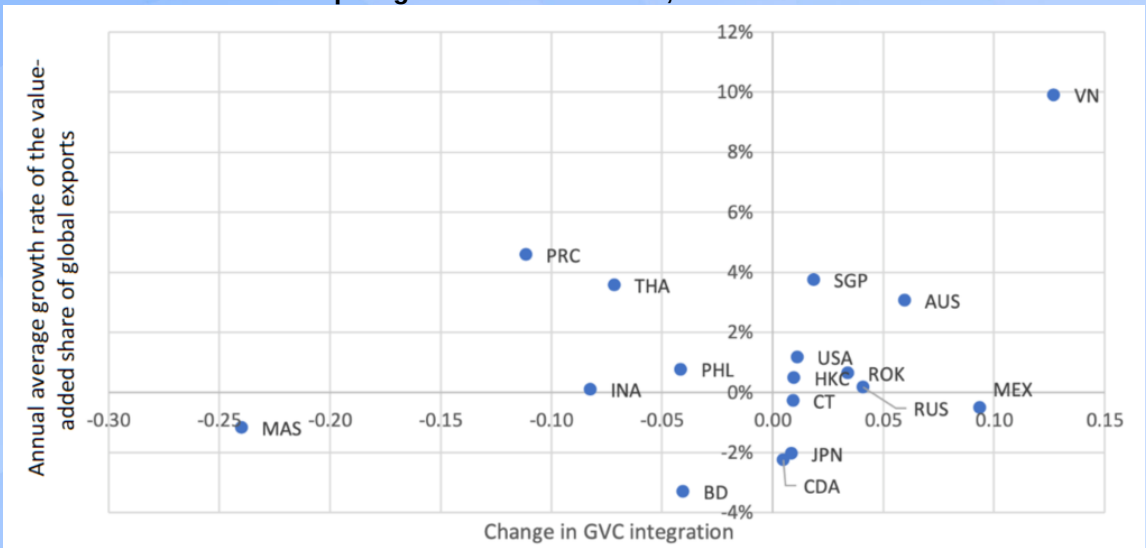
APEC economies can be classified into three groups depending on their GVC trajectories: (1) where both backward and forward integration have increased; (2) where backward and forward integration are moving in different directions; and (3) where both backward and forward integration have decreased.

Economies such as Viet Nam and Mexico had higher forward integration in 2019 (compared to 2007), showing that these economies have become more connected to global trade and GVCs. Take Viet Nam for example. The economy has developed a competitive advantage by attracting labour-intensive manufacturing industries, and this has largely increased Viet Nam's forward participation rate (i.e., increased their value added in exported products). Meanwhile, in recent years, foreign investment has brought capital into the domestic economy and strengthened workers' capabilities, which has led to the upgrading of Viet Nam's GVC participation structure.

[12] G. Gereffi, "Economic Upgrading in Global Value Chains," in S. Ponte, G. Gereffi and G. Raj-Reichert (eds), *Handbook on Global Value Chains* (Cheltenham: Edward Elgar, 2019), 240–54.

[13] ADBI, "ADB-ADBI Innovation and Structural Transformation Database: Global Value Chain Integration – GVC Positioning," accessed 22 September 2022, https://innovatransformation.adbi.org/global-value-chain-integration-main/

**Figure 6. Change in GVC participation and value-added export growth rates in APEC, 2007–2019**

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Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

In the second group, Australia has been able to improve its forward integration while slightly retracting on its backward integration, indicating a more global upstream position. The Philippines, on the other hand, has managed to improve its backward integration (it has imported more intermediate products) while experiencing a significant decline in forward integration.

Meanwhile, China; Indonesia; and Malaysia have seen a decrease in both forward and backward integration, suggesting that they may be less connected to global production networks. One study suggests that Malaysia may have experienced a 'premature deindustrialisation', leading to a significant downward shift of backward integration in GVCs.[14] Nevertheless, Malaysia's backward and forward integration are still relatively high compared to other APEC economies.

Figure 5 also suggests that more developed economies, such as Japan; Korea; and the US, tend to witness smaller changes in their GVC positions, whereas developing economies like Malaysia; Mexico; and Viet Nam documented more significant changes over time.

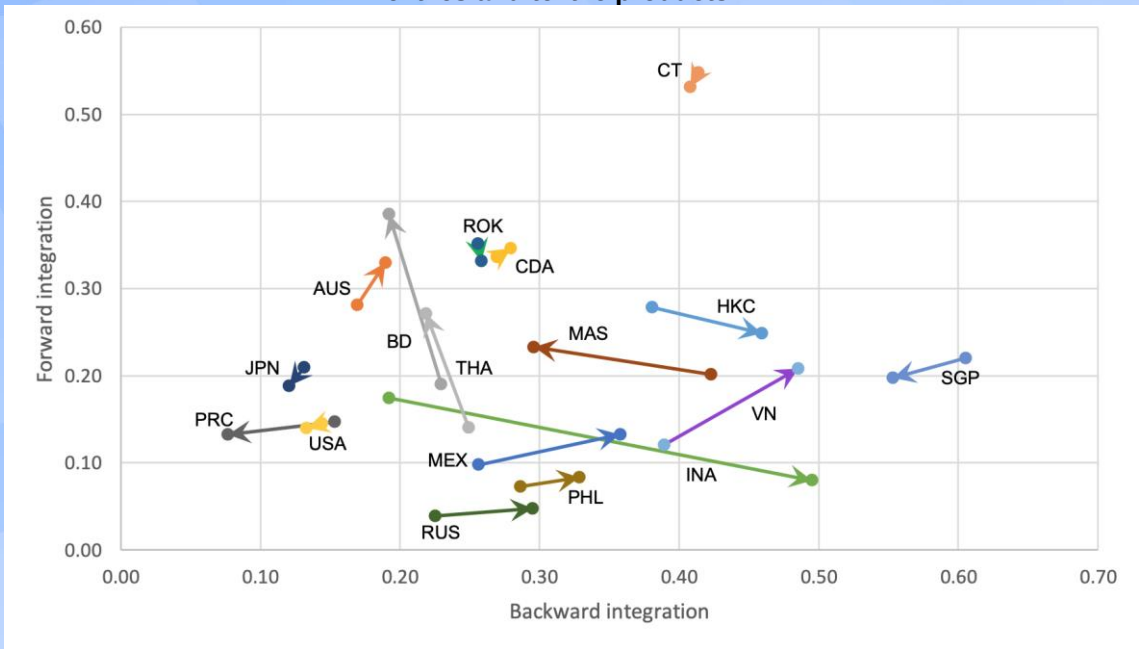
It is also important to understand how participating in GVCs can impact export performance. Figure 6 examines the relationship between the change in each economy's GVC participation rate[15] and the average growth rate of the value-added share of global exports from 2007 to 2019. Growth in value-added share of global exports is found to be positive in more than half of the reporting APEC economies, regardless of their progress in GVC participation.

Viet Nam had the highest growth in value-added share in its exports, averaging 9.9 percent, which may indicate the success of the government at attracting FDI.[16] At the other end of the spectrum, Malaysia, even while not having a significantly negative export growth, has seen a decrease in GVC participation.

Overall, APEC members have improved the share of value-added content in their exports. They were able to do this through higher GVC participation, or by exploiting their domestic scale of production. China provides an interesting example. It had previously attained higher GVC participation. However, its integration level has declined since the global financial crisis, likely due, according to an ADB study, to (1) slower growth in the domestic

[14] C. Lee, "GVCs and Premature Deindustrialization in Malaysia," Economics Working Paper, ISEAS-Yusof Ishak Institute, Singapore, 2020.
[15] Total GVC participation is defined as the sum of backward and forward integration into global trade.
[16] H.H. Nguyen and Q.H. Truong, "The Nexus between Inward Foreign Direct Investment and Global Value Chains in Developing Countries: A Case Study of Viet Nam," Discussion Paper, Economic Research Institute for ASEAN and East Asia (ERIA), 2022.

**Figure 7. Forward and backward integration in APEC, 2007 and 2019: Textiles and textile products**

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economy; (2) lower trade balance; and (3) increase in global trade tensions from 2018 to 2019.[17] Nevertheless, China is still able to improve its value-added share of global exports compared to 2007, but it now uses more local components, which translates into a decline in GVC participation.[18]

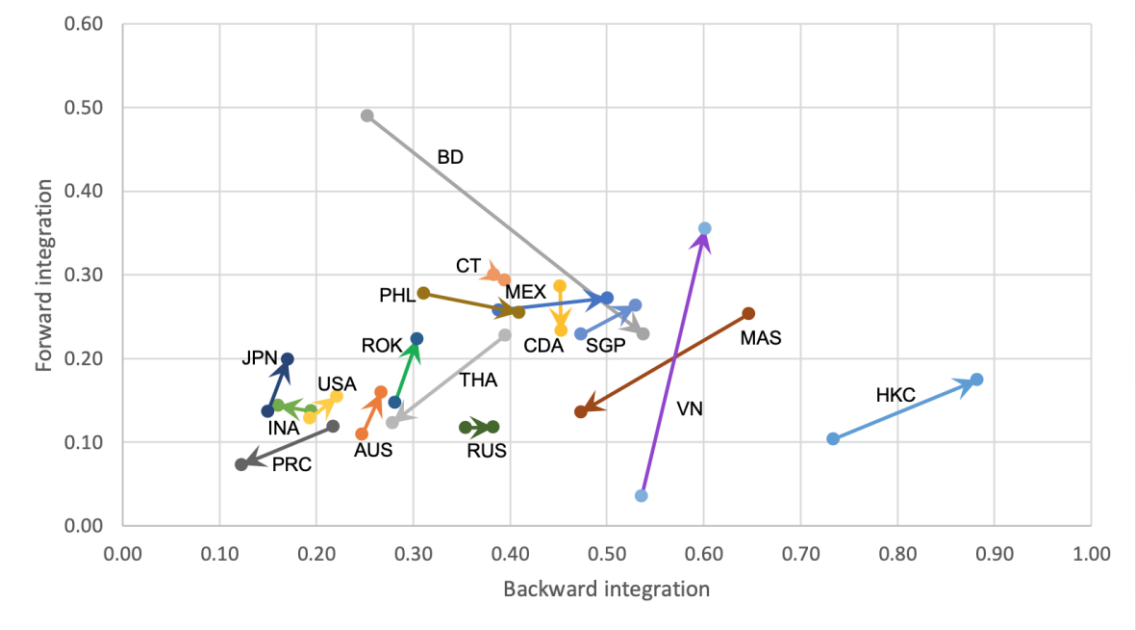
***Sectoral analysis***

As 4IR technologies could be applied in various industrial sectors, this section selects textiles and textile products, transportation equipment, and electrical and optical equipment for further analysis. These three sectors are the most traded sectors in manufacturing GVCs[19] and are classified as low and medium-to-high technological manufacturing.[20] The development of GVC integration in these three sectors is also related to technological development both domestically and globally.

For the textiles and textile products industry, Indonesia demonstrated the largest change in GVC participation among the economies studied (Figure 7). The economy had become more active in GVC participation as a labour provider, with the foreign share in its backward integration more than doubling from 0.2 to 0.5. This is because the textiles and textile products industry is more buyer-driven, where the higher value-added stages, such as design and branding, are often done by the more developed economies. Emerging economies like Indonesia; Mexico; and Viet Nam have developed specialisation expertise in the more labour-intensive production stages.[21] To move up the value chain, economies may need to pay attention to three areas: improving the quality of the

[17] ADB, "Forging Economic Resilience in the People's Republic of China through Value Chain Upgrading and Economic Rebalancing," ADB Briefs 178 (2021).
[18] X. Li, B. Meng, and Z. Wang, "Recent Patterns of Global Production and GVC Participation," in WTO, *Technological Innovation, Supply Chain Trade, and Workers in a Globalized World*, 9–43, https://doi.org/10.30875/6aa1a271-en
[19] G. Lai, Q. Nguyen, and A. Bayhaqi, "The FDI Network, Global Value Chain Participation and Economic Upgrading" (Singapore: APEC, May 2022), https://www.apec.org/docs/default-source/publications/2022/5/the-fdi-network-global-value-chain-participation-and-economic-upgrading/222_psu_fdi-and-gvc-transformation.pdf?sfvrsn=cda431fb_2
[20] ADB, "Economic Insights from Input–Output Tables for Asia and the Pacific" (Manila: ADB, 2022), https://doi.org/10.22617/tcs220300-2
[21] ASEAN Promotion Centre on Trade, Investment and Tourism, "Global Value Chains in ASEAN: Textiles and Clothing," ASEAN-Japan Centre, Tokyo, 2020.

**Figure 8. Forward and backward integration in APEC, 2007 and 2019: Transport equipment**




AUS= Australia; BD=Brunei Darussalam; CDA=Canada; PRC=China; HKC=Hong Kong, China; INA=Indonesia; JPN=Japan; ROK=Korea; MAS=Malaysia; MEX=Mexico; PHL=the Philippines; RUS=Russia; SGP=Singapore; CT=Chinese Taipei; THA=Thailand; USA=United States; VN=Viet Nam
Note: Data for Chile; New Zealand; Papua New Guinea; and Peru are not available.
Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

workforce, enhancing service diversification, and promoting technology adoption.[22]

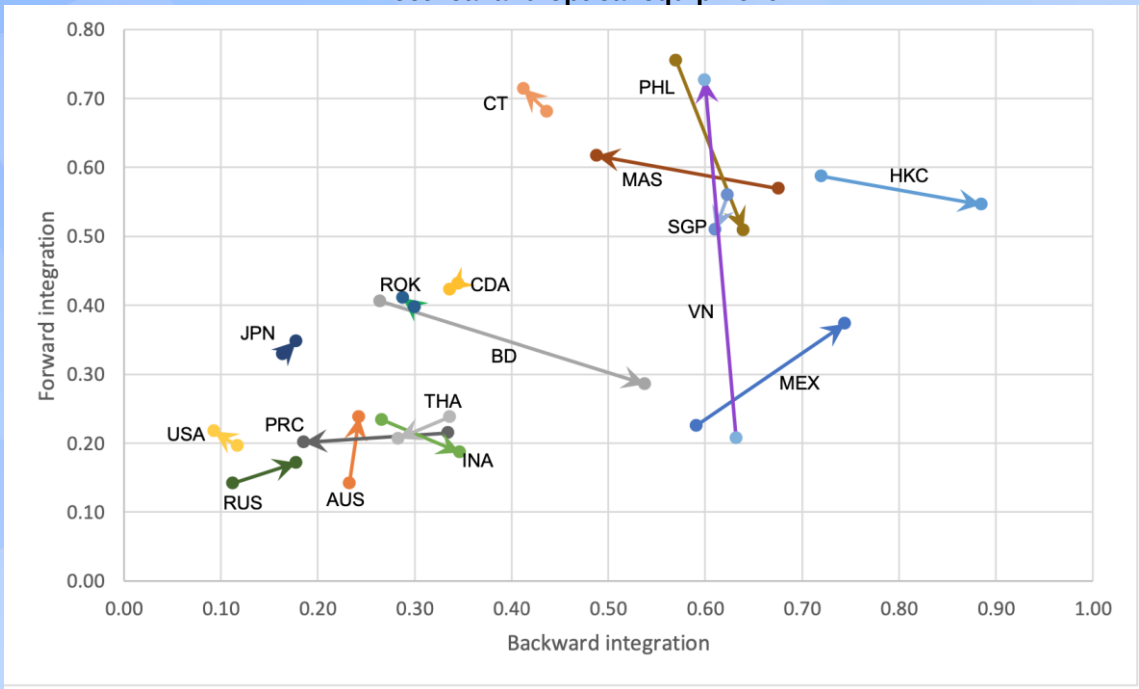
In the transport equipment sector (Figure 8), most APEC economies have not experienced sharp changes in GVC participation during the observed period. The exceptions are Brunei Darussalam; Malaysia; and Viet Nam. Brunei Darussalam had established a manufacturing and assembly plant for energy-powered vehicles, which could explain the increase in its backward integration.[23] Malaysia has experienced a decline in its forward integration; it is also trying to position its automobile industry as a hub for energy-efficient vehicles, but has had to contend with the challenge of fully integrating its automobile industry into the global production network.[24] Viet Nam's increase in backward and forward integration reflects its small yet growing automobile industry; its automobile assembly segment relies heavily on imported parts and serves a primarily domestic market while also focusing on exports of certain auto parts and components.[25]

Figure 9 shows the electrical and optical equipment sector. It is worth noting that Viet Nam's backward integration has decreased slightly while its forward integration has vastly improved. To upgrade Viet Nam's position in GVCs, strengthening domestic production capacity will allow local firms to establish stronger linkages with the FDI sector.[26]

In terms of understanding of 4IR, companies vary in their level of understanding. Based on surveys of employers in Cambodia; Indonesia; the Philippines; and Viet Nam, those in the following sectors have considerably good understanding of 4IR technologies and their relevance for their companies: automotive (78%), information technology and business process outsourcing

[22] J. Choi et al., "The Role of Vietnam's FDI Inflows in Global Value Chains Participation and Economic Growth," Working Paper WP/21-02, AMRO, Singapore, 2021.
[23] ASEAN Promotion Centre on Trade, Investment and Tourism, "Global Value Chains in ASEAN: Automobile," ASEAN-Japan Centre, Tokyo, 2020.
[24] ASEAN Promotion Centre on Trade, Investment and Tourism, "Global Value Chains in ASEAN: Automobiles," ASEAN-Japan Centre, Tokyo, 2020.
[25] C.H. Hollweg, T. Smith, and D. Taglioni, "Vietnam at a Crossroads: Engaging in the Next Generation of Global Value Chains" (Washington, DC: World Bank, 2017).
[26] M.H. Hinojales, "Vietnam's Route to Moving Up Global Value Chains," AMRO, 16 June 2021.

**Figure 9. Forward and backward integration in APEC, 2007 and 2019: Electrical and optical equipment**

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Note: Data for Chile; New Zealand; Papua New Guinea; and Peru are not available.
Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

(73%), food and beverages (59%), logistics (57%), electronics (56%) and agro-processing (56%).[27]

## 4IR Technologies and GVC Structure

Although GVC participation became stagnant following the 2008–2009 global financial crisis, there is evidence that the sectors with higher technology intensity registered a larger increase in complex GVC participation rate between 2000 and 2017 than sectors with less technology intensity.[28] This seems to suggest that technology and knowledge can help make GVCs more resilient.

To see the possible connection between 4IR technologies and GVC participation, this section looks at patent intensity in foreign and domestic value chains.[29] Figures 10, 11, 12, and 13 plot the 4IR patent content in domestic contributions against foreign contributions at the aggregate economy level as well as in the same three value chains examined in the previous section, namely transport equipment; textiles and textile products; and electrical and optical equipment.

At the aggregate economy level (Figure 10), five economies, namely, China; Japan; Korea; Chinese Taipei; and the US, are leading in terms of patent intensity in contributions by domestic value chains. For patent intensity by foreign value chains, the five leading economies are Canada; China; Mexico; the Philippines; and Singapore.

There are observable variations in the degree of patent intensity among APEC economies and between different sectors. In the electrical and optical equipment sector, all economies report relatively high patent content in foreign contributions (Figure 11). Electrical and optical equipment value chains also record the lowest patent intensity in domestic contributions in APEC economies, ranging from 0 to 0.0017 patent families per USD 1 million value added, much lower than in transport equipment and textiles value chains. The high patent intensity in foreign contributions in the electrical and optical equipment

[27] The percentages refer to respondents who agree or strongly agree. ADB, "Reaping the Benefits of Industry through Skills Development in High-Growth Industries in Southeast Asia: Insights From Cambodia, Indonesia, the Philippines, and Viet Nam" (Manila: ADB, 2020).

[28] Li, Meng, and Wang, "Recent Patterns of Global Production and GVC Participation."

[29] Higher patent intensity indicates a higher number of patent families per USD 1 million value added for the total output of the respective value chain.

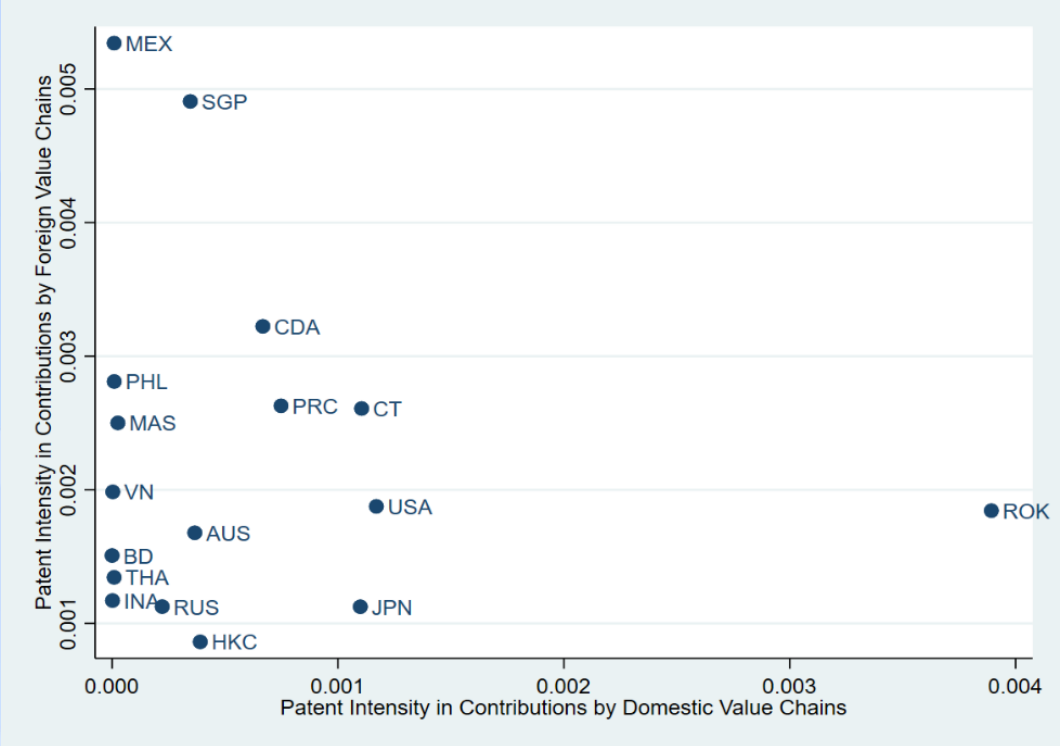
sector correlates with an earlier finding that the sector's GVC integration is high (Figure 9). This suggests that the foreign contributions in the electrical and optical equipment sector provided patented technology that is important to value-adding activities.

Meanwhile, in the transport equipment and textiles value chains (Figures 12 and 13, respectively), economies that are most active in patenting show higher patent content in domestic contributions compared to foreign value chains. This is seen for Japan; Korea; and the US in transport equipment value chains, and for Japan and Korea in textiles and textile products value chains. It reflects these economies' advanced domestic industrial capability for innovation in transport equipment and textiles value chains.

Korea consistently leads the region with the highest patent intensity in domestic contributions in all three value chains, whereas Mexico shows the highest patent content in contributions by foreign value chains. They exemplify two different trends in moving along the value chains: while Korea is among those with relatively stable foreign GVC shares between 2007 and 2019 (Figures 7, 8, and 9), Mexico has witnessed increasing foreign shares in both backward and forward linkages, indicating a deeper integration into GVCs.

Korea's relatively stable position in GVCs can be explained by its innovative capability shown by the high patent content in its domestic value chains. On the other hand, as Mexico becomes more integrated into GVCs, the increasing foreign shares in its GVC linkages seem to bring along patented technology embedded in those foreign value chains. With low domestic R&D spending in Mexico, the foreign R&D pool provided the much-needed resources for GVCs.[30]

**Figure 10. 4IR patent intensity in APEC, 2019: Aggregate economy**




4IR=Fourth Industrial Revolution; AUS=Australia; BD=Brunei Darussalam; CDA=Canada; PRC=China; HKC=Hong Kong, China; INA=Indonesia; JPN=Japan; ROK=Korea; MAS=Malaysia; MEX=Mexico; PHL=the Philippines; RUS=Russia; SGP=Singapore; CT=Chinese Taipei; THA=Thailand; USA=United States; VN=Viet Nam
Note: Data for Chile; New Zealand; Papua New Guinea; Peru are not available. Patent intensity is calculated as number of 4IR patent families per USD 1 million value added.
Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

[30] E. Gentile et al., "Productivity Growth, Innovation, and Upgrading along Global Value Chains" (Manila: ADB, 2021).

**Figure 11. 4IR patent intensity in APEC, 2019: Electrical and optical equipment value chains**

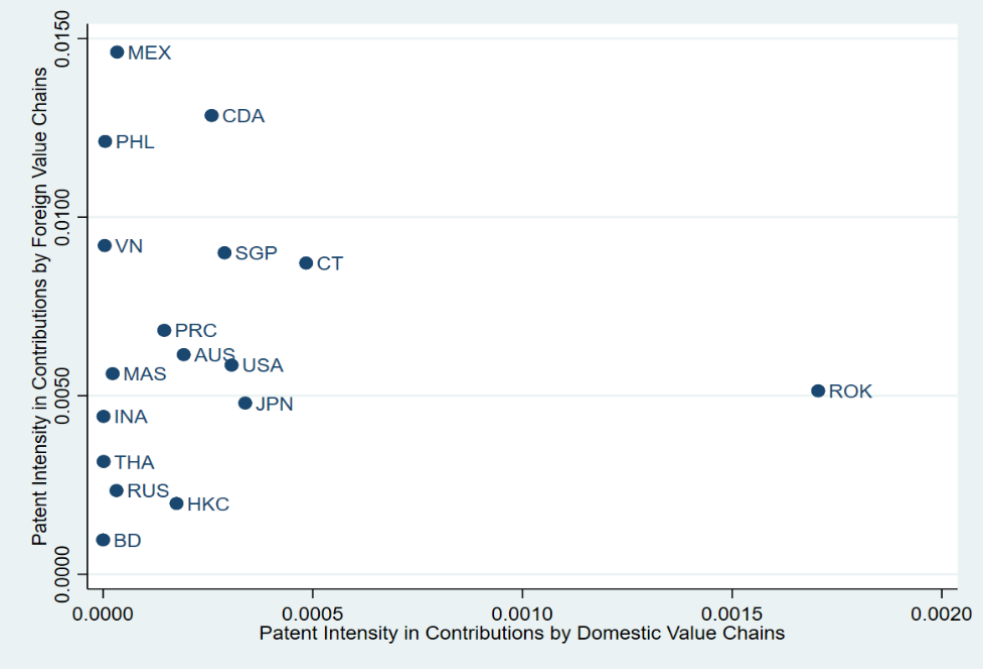
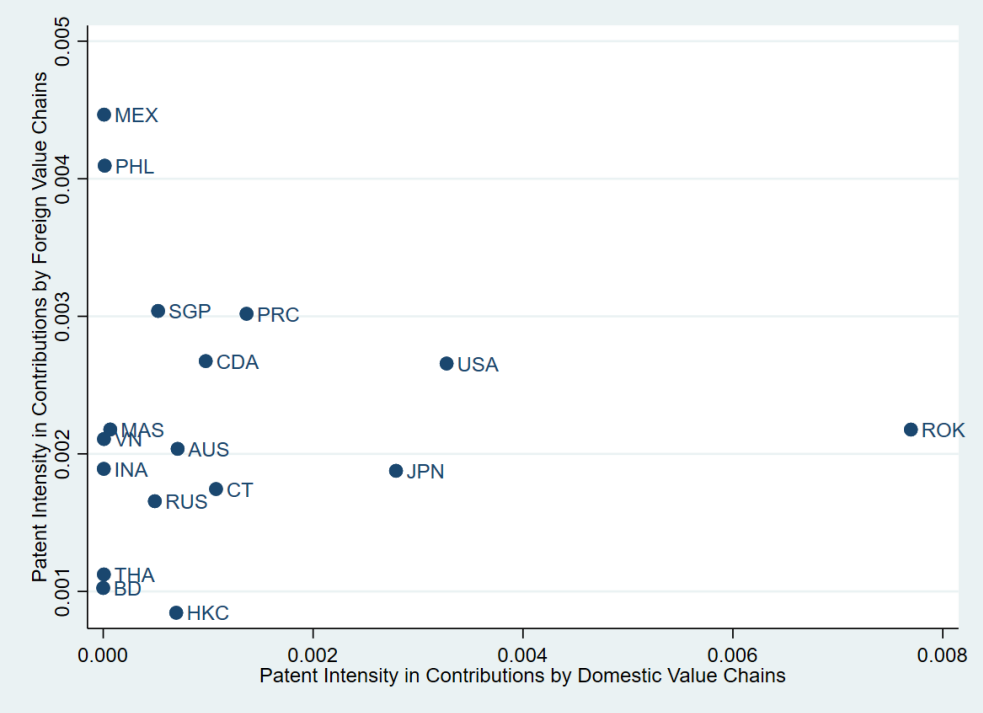
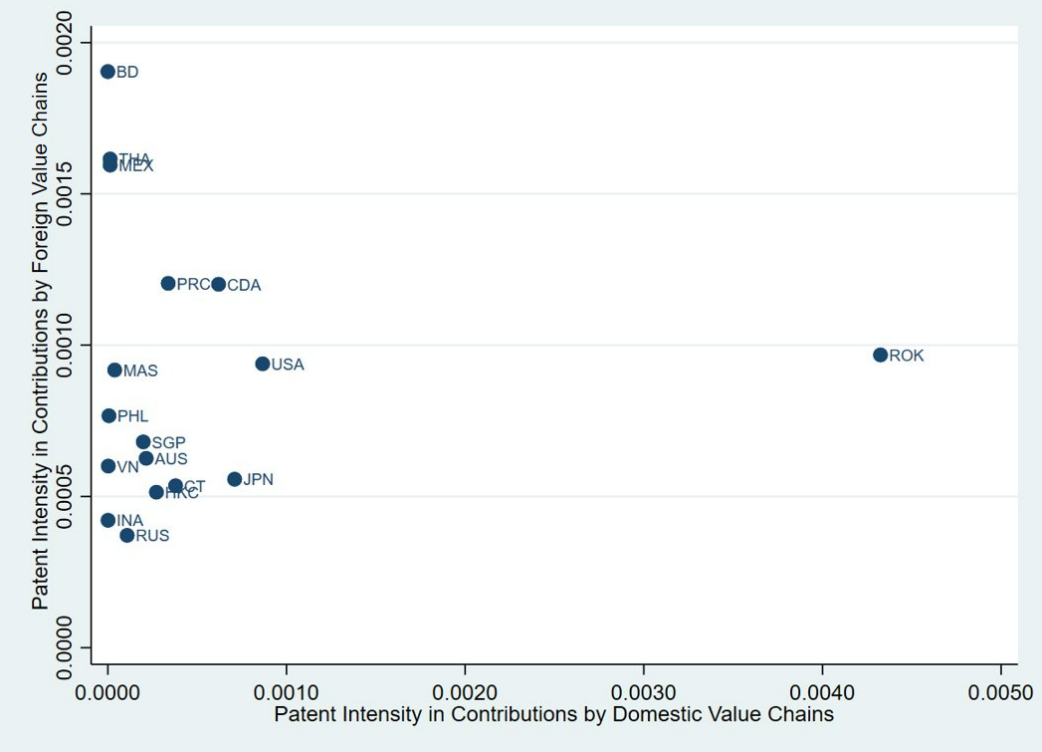



**Figure 12. 4IR patent intensity in APEC, 2019: Transport equipment value chains**




*For Figures 11 and 12:*
4IR=Fourth Industrial Revolution; AUS=Australia; BD=Brunei Darussalam; CDA=Canada; PRC=China; HKC=Hong Kong, China; INA=Indonesia; JPN=Japan; ROK=Korea; MAS=Malaysia; MEX=Mexico; PHL=the Philippines; RUS=Russia; SGP=Singapore; CT=Chinese Taipei; THA=Thailand; USA=United States; VN=Viet Nam
Note: Data for Chile; New Zealand; Papua New Guinea and Peru are not available. Patent intensity is calculated as number of 4IR patent families per USD 1 million value added.
Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

**Figure 13. 4IR patent intensity in APEC, 2019: Textiles and textile products value chains**




4IR=Fourth Industrial Revolution; AUS=Australia; BD=Brunei Darussalam; CDA=Canada; PRC=China; HKC=Hong Kong, China; INA=Indonesia; JPN=Japan; ROK=Korea; MAS=Malaysia; MEX=Mexico; PHL=the Philippines; RUS=Russia; SGP=Singapore; CT= Chinese Taipei; THA=Thailand; USA= United States; VN=Viet Nam
Note: Data for Chile; New Zealand; Papua New Guinea; and Peru are not available. Patent intensity is calculated as number of 4IR patent families per USD 1 million value added.
Source: ADB-ADBI Innovation and Structural Transformation Database, accessed 20 July 2022.

## Conclusion

Participating in GVCs is a common avenue for economies to join the global production and innovation ecosystem. Different GVC positioning, however, can be accompanied by different levels of value added in production as suggested by the smiling curve. Although upgrading GVCs by moving into higher value-added stages in the smiling curve can help economies to boost their gains from GVC participation, this is a knowledge-intensive process that requires significant investments in human capital and technology.

Economies can follow a non-linear path in upgrading, and leapfrog to higher stages, through strategic investment in R&D and labour force upskilling. A more linear path would involve specialisation, which allows economies to gradually build up their technology and production capabilities as they move up the value chains.

APEC economies are moving in heterogeneous directions in integrating into GVCs. APEC economies such as Mexico and Viet Nam have become increasingly more integrated into GVCs, represented by their high foreign shares in both backward and forward linkages. Other APEC economies, such as China; Indonesia; and Malaysia, have shown a certain retraction from global production.

Our sectoral analysis echoes the observation of different economies pursuing different GVC upgrading tracks. The differences may reflect the technological advancement levels of specific economies, and may be attributable to their GVC positioning and upgrading strategies at the economy and sectoral levels, such as a focus on labour-intensive production capabilities, or policies to attract FDI in prioritised sectors.

Despite the varying upgrading trajectories, most APEC economies have reported positive average annual growth rates in their value-added share of global exports between 2007 and 2019, regardless of GVC participation rate. This is because in some economies, growth has been driven by not just

GVC participation, but also domestic scale of production.

The development and adoption of 4IR technologies can help economies upgrade their GVCs by improving production efficiency, creating new and better products and services, and enabling technological upgrading.

Some APEC economies, such as China; Japan; Korea; and the US, have been particularly active in patenting, with inventions mostly in core technologies (e.g., connectivity, IT hardware, software) and applications in home and consumer goods.

Although the degree of patent intensity in domestic and foreign contributions in GVCs vary between economies and sectors, those that are active in patenting also tend to be capable of embedding patent content in their domestic production. These economies also show relatively stable foreign shares in both GVC backward and forward linkages during the period 2007–2019. Economies with fewer patent families have recorded higher patent intensity in their foreign shares in production.

Investing in technologies, and 4IR specifically, could be a forward-looking strategy to help economies move upward into the higher value-added stages along GVCs. Nonetheless, this might be easier said than done, considering the prerequisite capital, both physical and human, required to enhance technological advancement.

While 4IR may represent a window of opportunity for a leapfrogging strategy, it may also involve significant risks of failure; success will depend on several factors, such as level of digital literacy, training and upskilling of the local workforce, domestic market size, and the dynamic involvement of multinational corporations and FDI.[31]

A path that economies could consider to gain access to the necessary technology for GVC upgrading is to develop policies to attract high-quality FDI. That means targeting FDI that goes beyond labour-intensive job creation and that holds the promise of extensive technology transfer to the domestic economy (that increases competitiveness at the firm level). Such a path to innovative economic growth may be considered to ensure a more sustainable economic recovery and development.

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[31] K. Lee, "Economics of Technological Leapfrogging," in J. Lee et al. (eds), *The Challenges of Technology and Economic Catch-up in Emerging Economies* (New York: Oxford University Press, 2021), 123–59.