APO PRODUCTIVITY OUTLOOK 2024

Electrical Equipment and Machinery, Global Value Chain (GVC) and Knowledge Spillover

APO

KDI

The Asian Productivity Organization (APO) is an intergovernmental organization that promotes productivity as a key enabler for socioeconomic development and organizational and enterprise growth. It promotes productivity improvement tools, techniques, and methodologies; supports the National Productivity Organizations of its members; conducts research on productivity trends; and disseminates productivity information, analyses, and data. The APO was established in 1961 and comprises 21 members.

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APO PRODUCTIVITY OUTLOOK 2024

ELECTRICAL EQUIPMENT AND MACHINERY, GLOBAL VALUE CHAIN (GVC) AND KNOWLEDGE SPILLOVER

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APO Productivity Outlook 2024
Electrical Equipment and Machinery, Global Value Chain (GVC) and Knowledge Spillover

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FOREWORD

Productivity is the cornerstone of economic vitality. In an era of rapid technological advances and global interconnectedness, understanding the intricate dynamics of global value chain (GVC) participation and knowledge spillovers is essential. As the primary focus of this report, productivity gains in the electrical equipment and machinery sector not only drive industrial progress but also serve as catalysts for broader economic growth and innovation. By exploring in depth the interactions between GVC dynamics, knowledge spillovers, and productivity in the electrical equipment and machinery industry, it is possible to identify ways to unlock its full potential and lead to sustainable prosperity.

As part of the APO's role as a think tank and regional adviser, the APO Productivity Outlook 2024 critically examines the links among productivity, the electrical equipment and machinery sector, and GVC dynamics and knowledge spillovers. This edition highlights the pivotal role of productivity within the sector, recognizing it not only as a measure of efficiency but also as a driver of industrial transformation and economic progress. By focusing on the electrical equipment and machinery sector, this research elucidates how productivity enhancements in this sector can ripple through the wider economy, fostering innovation, facilitating trade, and promoting inclusive growth. Through careful analysis and strategic insights, it provides a comprehensive understanding of the factors shaping productivity dynamics and offers policymakers and industry stakeholders actionable strategies to leverage the sector's potential for sustainable development and prosperity.

In collaboration with the Korea Development Institute (KDI), the analysis presented in this research will have relevant impacts on productivity policymaking within APO members. It is hoped that the findings and recommendations presented in this report will serve as a guide to help policymakers and stakeholders navigate the complexities of productivity growth and chart a course toward sustainable economic growth and prosperity.

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INTRODUCTION

The APO Productivity Outlook underscores productivity issues in specific sectors of the economy in APO member countries. The inaugural edition of the APO Productivity Outlook on *Manufacturing Labor Productivity: Trends and Linkages* presents key trends and thematic issues such as global value chains (GVCs) and information and communication technology (ICT) in the manufacturing sector of selected APO member countries. Empirical evidence reinforces the importance of developing the manufacturing sector for productivity enhancement, regardless of the level of development of the country. Based on the findings of this report, strengthening the manufacturing sector in middle-income countries shows the potential for a leapfrog in economic development, while for high-income countries this sector remains key as a facilitator of knowledge spillover and technological diffusion to other sectors of the economy. It was identified that GVC participation is positively correlated with productivity growth, especially in the case of backward linkages.

For the second edition of the APO Productivity Outlook 2023 on *Service Sector Productivity*, coverage included extensive assessment of service sector productivity and its sub sectors, considering the growing importance of this sector, spurred by the outbreak of the COVID-19 pandemic and the rapid acceleration of digital technology. The report presents evidence that service sub-sectors such as finance and business services have many strongholds with other sectors of the economy, which implies that services are contributing robustly to economic growth. Trade in services in member countries has shown to have a strong correlation with productivity growth and in terms of GVC participation and revealed comparative advantage (RCA), and compared to other regions it was shown that APO member economies are performing better compared to their peers.

This edition of the APO Productivity Outlook 2024 seeks to extend the preliminary work on manufacturing of the first edition considering its relative importance for APO member countries, while putting special focus on the electrical equipment and machinery industry, a core sector of industrial development and an important driver of productivity gains. This sector will be analyzed in the context of GVCs and how knowledge spillover of related sectors impacts productivity and draws implications for APO member countries.

The report is comprised of four chapters. The first chapter begins by asserting the current status and key features of GVC participation and export diversification of APO member countries, particularly targeting the electrical equipment and machinery sector. The subsequent chapters are organized as follows: The second chapter investigates the effect of GVC participation of the electrical equipment and machinery sector on export diversification in APO member countries. The third chapter discusses the impact of knowledge spillover on productivity growth, with particular attention to high R&D and knowledge-intensive industries such as the electrical equipment and machinery industry. Finally, the fourth chapter, building on the results from the third chapter, provides empirical evidence of the role of financial systems in fostering productivity and innovation by accounting for the participation of GVCs among APO member countries.

TRENDS AND CHARACTERISTICS IN GVCS AND PRODUCTIVITY IN APO MEMBER COUNTRIES

Introduction

Even before the onset of the COVID-19 pandemic, a broad-based slowdown in productivity was evident across all sectors of APO member countries, with a pronounced impact on the manufacturing sector. Given the literature [1, 2] emphasizing the importance of manufacturing as a source of employment, income, investment, and sustainable economic growth, this slowdown raises concerns. Policy efforts aiming to boost productivity became even more critical in these times.

As examined in the first edition, it was shown that significant gaps in overall manufacturing capabilities are present among APO member countries. These can be mainly due to differences in technological advances and absorptive capacities. In the case of low middle-income countries, productivity in the manufacturing sector only reached one-fifth of the level of high-income countries, similar to the case of upper-middle income countries as well. There exists a consensus among scholars that a substantial portion of economic growth and the income gap can be attributed to differences in total factor productivity (TFP).[1]

Therefore, productivity enhancement through the creation, transfer and adoption of new technologies is crucial. While some of these economies have observed productivity gains in the last few decades, it is key to recognize that the source of these gains has often been attributed to a shift in labor towards low-productive sectors or capital accumulation. Despite the observed gains, low- and middle-income countries still lagged behind their advanced counterparts in terms of overall productivity. This productivity gap highlights the ongoing challenge of translating technological advancement into widespread economic efficiency and innovation.

The share of the electrical equipment and machinery industry in APO member countries represents 22.0% of the total domestic value added (DVA) and 27.3% of the total foreign value added (FVA) in total exports in 2022. This sector, in comparison with other manufacturing sectors, is not only a highly technology-driven sector that plays a critical role in enhancing the overall competitiveness of many industries, but also is highly dynamic and geographically intertwined. This sector enables other industries to operate efficiently and effectively by providing essential equipment, parts and components. Moreover, trade in intermediate inputs and capital goods can help upgrade production capabilities and acquire new skills through foreign technology embodied in the imported supplies, which can lead to higher productivity and contribute to overall economic growth.

This chapter serves as an overview into the productivity dynamics in APO member countries. The focus is to understand the role of TFP in the economic growth of the member countries, drawing comparisons with the United States. Subsequently, the chapter delves into a critical examination of recent trends in trade and GVC participation, particularly in the electrical equipment and machinery

1 TFP represents the portion of goods and services produced that cannot be solely explained by capital and labor inputs but instead results from advancement in technology and innovation.

sector. Finally, the chapter outlines the challenges and opportunities faced by APO member countries, providing a roadmap for the ensuing chapters.

Economic Momentum Slowing in APO Member Countries

The global economy has been facing significant uncertainties and challenges amid at negative post-effects of the COVID-19 pandemic, geopolitical tensions such as Russia's invasion of Ukraine, tightening monetary policies in advanced economies, in addition to other world-wide and regional issues, that are leading to further slowdown in economic growth.

Table 1 and 2 depict economic growth forecasts published by the International Monetary Fund (IMF). According to the IMF, global economic growth for the period 2022-28 is projected to fall from an estimated 3.52% over the period 2011-19 period to 3.10%. For advanced economies, growth is expected to decrease to 1.79%, which will be one of the lowest growth rates since the global financial crisis and the COVID-19 pandemic. [3] Among emerging markets and developing economies, the Asian region is more likely to see a dynamic economic growth compared to other regions even in the face of a gloomy world outlook. [3] The gravity of the global economy is shifting towards Asia, and is expected to contribute to almost 50% of world output by 2030. [4]

TABLE 1

CHANGES IN REGIONAL ECONOMIC OUTLOOK

Period	World	Advanced (41)	Emerging Market and Developing Economies (155)						APO (21)
			Total	Asia (30)	Europe (15)	Latin America (33)	Africa (45)		
1991-2000	3.24	2.84	3.82	7.25	-1.52	3.27	2.46		4.84
2001-2010	3.93	1.72	6.23	8.43	4.54	3.28	5.77		4.98
2011-2019	3.52	1.88	4.82	6.72	3.01	1.59	3.75		4.72
2022-2028	3.10	1.79	3.98	4.74	1.99	2.47	4.09		4.07

Source: IMF. [3] Please refer to the list of countries in Annex 1.
Note: Growth Projections are calculated as a ten-year average on real GDP growth (percent), thus for periods 2011-19 and 2022-28, the COVID-19 crisis was considered to reflect pre and post effects.

When comparing pre-COVID-19 growth forecast for the period 2022-24 published in 2019 to the post-pandemic period from 2023, a fall in overall growth is projected (Table 2). The global economic growth outlook for the period 2022-24 falls to 3.09% based on the projection in 2023 from its earlier projection of 3.59 % in 2019. This adjustment was led by a significant downgrade to its prospects in almost all the regions in the world affected by the COVID-19 pandemic, global financial crisis and ongoing geopolitical tensions causing supply chain disruptions, labor shortage and volatile prices. For APO member countries the outlook downgraded 0.46 points from its original projection.

TABLE 2

CHANGES IN GROWTH PROJECTIONS: COMPARISON BETWEEN 2019 AND 2023 FORECAST FOR THE PERIOD 2022-24

Region	Growth Projections		Gap*
	2019 Edition	2023 Edition	
World	3.59	3.09	-0.50
Advanced economies	1.55	1.76	0.20
Developing economies	4.82	4.01	-0.80
Asia	6.01	4.90	-1.11
Europe	2.52	1.50	-1.02
Latin America	2.72	2.59	-0.12
Sub-Saharan Africa	4.07	3.86	-0.21
APO Member Countries (21)	4.43	3.97	-0.46

Source: IMF. [3] Gap is measured as the difference between estimations in 2023 with 2019.
Note: Real GDP growth, %. The gap is calculated as the 2023 (April edition) forecast minus 2019 (October edition) forecast.

By looking into each country individually, based on the projection forecast, the IMF has lowered its economic growth forecast for Sri Lanka, Lao People's Democratic Republic (Lao PDR), Hong Kong, Pakistan, India, Bangladesh, Cambodia, Republic of Korea (ROK), among others (Refer to Table A1 from Annex).

In times of falling long-term growth prospects, APO member countries, like many others, face the challenge of sustaining economic growth and improving living standards. The World Bank [5] emphasized that sustaining high growth in the East Asia and Pacific region will require reforms that maintain the competitiveness of the industrial sector and improve productivity.

In the last few decades, APO member countries have implemented various strategies and initiatives to enhance productivity in their respective economies. These efforts are often driven by the need to boost economic growth, improve competitiveness and address ongoing social challenges. While the specific policy agendas may vary from country to country, there are some common themes pursued by APO member countries such as promoting education and workforce development, innovation and technology, infrastructure development, regulatory reform, industry-specific initiatives, trade and export diversification, among others.

Although there are many channels to enhance productivity, this outlook presents the importance of export diversification, participation in GVCs, and the role of the electrical equipment and machinery sector to enhance national productivity in APO member economies.

For this end, the study will first assess whether the income gap between APO member countries and the frontier has been diminishing. Subsequently, efforts will be made to identify the contributors to this decline. The research adheres to the convention of employing the United States as the reference country for comparative analysis.

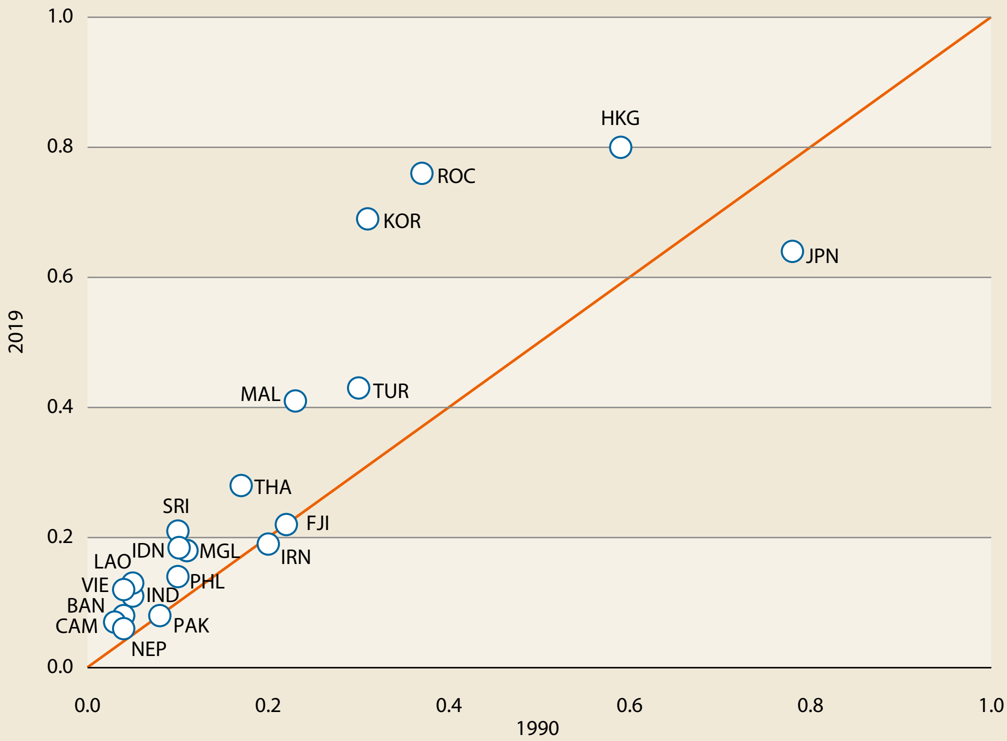
Income Differences and Productivity Gap: APO member countries

Over the last few decades, significant economic growth has been achieved among APO member countries. Figure 1 displays income differences between APO member countries relative to that of the United States for the period 1990-2019. The majority of APO member countries experienced a reduction in income gap with the frontier, except for Japan. Notable cases are the ones such as the Republic of China (ROC), ROK and Hong Kong, where GDP per capita grew faster than in the United States in 2019, meaning that there has been a continuous process of catching up. For the ROC the relative ratio increased from 31% in 1990 to 76% of the income in the United States in 2019, in the case of the ROK from 31% to 69% respectively. The decline in the income gap relative to the United States reflects the faster accumulation of both physical capital and human capital, as well as the TFP gap for the majority of APO member economies. In contrast to the general trend, Japan experienced a slowdown in its economy, resulting in a decline in Japan's relative GDP per capita ratio from 78% to 64% during the respective years.

Despite variations in the speed of convergence among the remaining APO member countries, they continue to lag behind the United States. However, this situation also represents an opportunity to embark on a journey of catching up with their more advanced peers. [4]

FIGURE 1

INCOME DIFFERENCES IN APO MEMBER COUNTRIES RELATIVE TO THAT OF THE UNITED STATES, 1990 AND 2019



Source: Authors' calculation using Penn World Table (PWT), version 10.01.
Note: The gap for Country X is Country X's GDP per capita divided by that of the United States. Singapore and the Islamic Republic of Iran (I.R. Iran) were excluded from the graph as they were considered outliers.

The growth of output is decomposed into factor accumulation and TFP growth. Differences in TFP, reflecting variations in efficiency, provide insight into why some countries achieve higher productivity levels than others.[2]

From Figure 2 to 4, the role of each of the components (capital stock, human capital and TFP) are observed relative to that of the United States. Based on the figures, recently most APO member economies have made significant progress in terms of capital stock and human capital compared to 1990, with a decrease in the relative gap with the United States.

For capital stock, notable cases are seen for the ROK and the ROC, which have achieved significant changes during the period of analysis. Capital stock per capita rose from 27% to 99% and 27% to 76% relative to that of the United States over the period 1990-2019 for each country respectively. Among upper-middle income countries, Turkiye and Malaysia also showed remarkable progress, rising from 19% to 55% and 19% to 49% respectively from the same period.

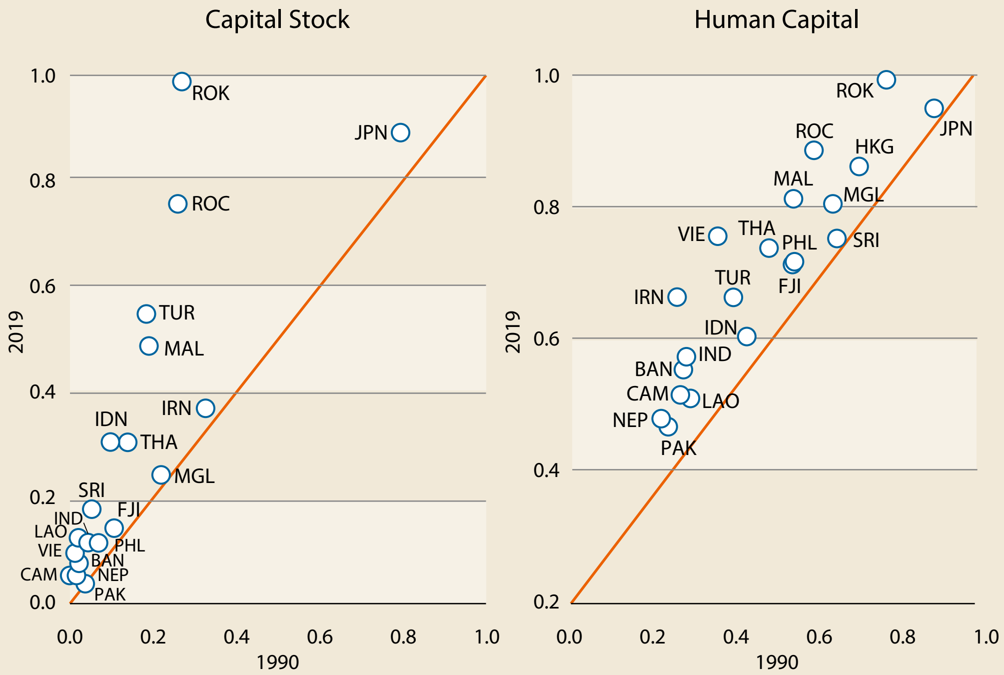
Besides them, Indonesia and Thailand narrowed the gap by more than 20% during the same period. However, empirical evidence suggests that as capital increases, the marginal returns on additional investments diminish, leading to a slowdown in economic growth. To achieve sustained economic growth, other factors must come into play, such as technological progress and improvements in TFP.

For human capital, most APO member countries have made significant improvements in human capital development, investing in education and skills training. Based on Figure 2, countries such as the ROC, Japan, and the ROC have achieved relatively higher levels compared to their peers, by reaching or nearing the level of the United States in 2019. Among APO members, Vietnam and the ROC also registered significant gap reduction by more than 20 percentage points between 1990 and 2019.

[2] Evidence has demonstrated that differences in productivity growth is the most important factor in explaining differences in per capita GDP in all countries. How much would output per worker (labor productivity) increase in response to variation in one of the following factors: physical capital per person, effective labor per person or residual TFP, holding the other two factors fixed. Consider the Cobb-Douglas production function $Y_t = A_t + K_t^{a} L_t^{1-a}$, where K is capital and L is labor. Labor productivity $(G_t) = Y_t/L_t$. Combining these expressions leads to $\Delta g_t = a(\Delta k_t - \Delta l_t) + \Delta a_t$. This equation implies that labor productivity growth depends on the contributions of capital deepening and TFP.

FIGURE 2

CAPITAL STOCK PER CAPITA AND HUMAN CAPITAL OF APO MEMBER ECONOMIES RELATIVE TO THAT OF THE UNITED STATES, 1990 AND 2019

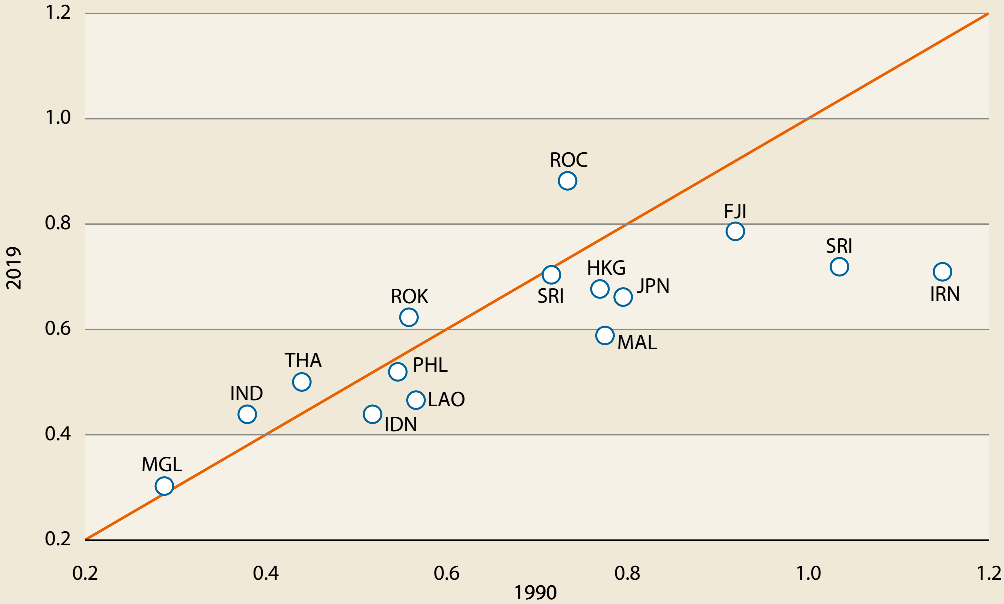


Source: Authors' calculation using PWT, version 10.01.
Note: Capital stock refers to the total amount of physical capital, such as machinery, equipment, and buildings, that is available in an economy, calculated at current PPPs (in million 2017 USD). Human capital index refers to the years of schooling and returns to education.

Based on Figure 3 and 4, in terms of TFP changes, in Figure 3 it is noted that not many member countries have converged but the United States is growing faster. Among them, Thailand, the ROC, Indonesia, the ROK, Mongolia, and Sri Lanka experienced relatively higher TFP.

FIGURE 3

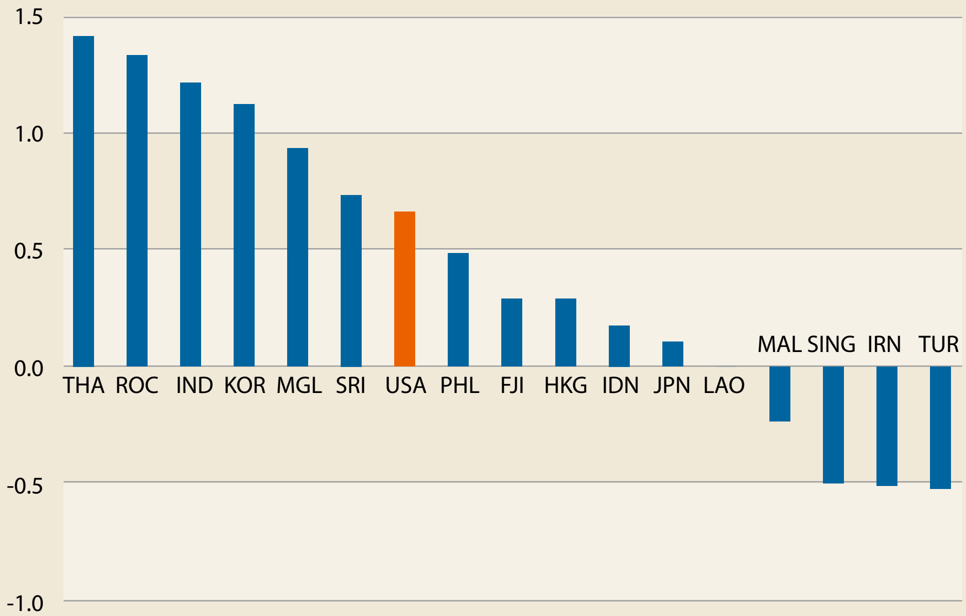
TFP DIFFERENCES RELATIVE TO THE UNITED STATES IN 1990 AND 2019



Source: Authors' calculation using PWT, version 10.01.
Note: TFP for Nepal, Pakistan, Bangladesh, Cambodia and Vietnam are missing due to data availability. Outlier countries such as Singapore are excluded.

FIGURE 4

ANNUAL AVERAGE CHANGE IN TFP BETWEEN 1990 AND 2019



Source: Authors' calculation using PWT, version 10.01.
Note: TFP for Nepal, Pakistan, Bangladesh, Cambodia and Vietnam are missing due to data availability. Outlier countries such as Singapore are excluded.

According to the graphs, income gap between the APO member countries and the United States has narrowed. This was mainly attributed to the rapid accumulation of both physical and human capital. However, a notable contrast is observed in TFP growth, with most APO member countries experiencing a slower TFP growth compared to that of the United States. Given that TFP is a crucial factor influencing long-term economic growth, accelerating TFP growth becomes essential for APO member countries to achieve convergence in living standards.

Cross-Country Income Differences

In this section, the development accounting framework[3] is used to analyze the cross-country income differences and how much of the variance can be attributed to differences in capital stock, human capital differences and TFP. The relative importance of factors in accounting for cross-country income differences is calculated following a Caselli [6] equation 1.1 as below.[4]

$$\frac{y_i}{y_u} = \left(\frac{A_i}{A_u}\right)^{\frac{1}{(1-\alpha)}} \left(\frac{k_i/y_i}{k_u/y_u}\right)^{\frac{1}{(1-\alpha)}} \left(\frac{h_i}{h_u}\right) \qquad (1.1)$$

where lowercase letters denote per capita variables, and subscripts I and u represent APO member countries and the United States, respectively.

Based on such calculation it can be observed in Table 3 that although income differences between APO member countries and the United States narrowed in the last few decades, it was mainly due to the role of capital stock and human capital. In terms of capital, it was mainly due to the non-IT capital stock (Refer to Figure A1 in Appendix). The relative TFP gap has widened, which explains that almost 50% of the differences in income between APO member countries and the United States is mainly attributed to differences in TFP. Refer to Appendix Table A2 and Table A3, to see a detailed calculation in development accounting for each APO member country.

TABLE 3

DEVELOPMENT ACCOUNTING IN APO MEMBER COUNTRIES

Year	GDP per person engaged	Capital/GDP	Human Capital	TFP	Share explained by TFP*
1980	0.23	0.65	0.50	0.71	31.46%
1990	0.20	0.74	0.56	0.47	47.01%
2000	0.21	0.86	0.61	0.40	56.71%
2019	0.30	1.11	0.70	0.38	66.64%

Note: 1) A geometric mean was used to aggregate the data. 2) the TFP share represents explanatory power of the GDP gap, 3) share explained by TFP, means the share of TFP that explains cross-country income differences relative to that of the United States, 4) APO member countries include all 21 members, 5) multiplying the Capital/GDP, Human capital and TFP variables yields exactly GDP per person engaged.

Boosting TFP and overall productivity in APO member countries stands as a pressing priority for policymakers. While the channels to enhance productivity may vary among countries, research underscores the importance of implementing policies that promote greater engagement in GVC to foster productivity enhancement and spur economic growth. [7, 8, 9]

[3] $Y = AK^{\alpha}hL^{1-\alpha}$, where Y is real GDP, A is residual TFP, K is real capital, h is human capital per worker, and L is labor.
[4] We assume that capital share (α) is equal to 0.35 and is the same across countries.

GVC participation plays a vital role in fostering economic and social development for both countries and businesses engaged. Critical elements in this process include promoting in particular activities within the upstream or downstream sectors of the economy, facilitating the exchange of technology through input collaboration and firm interaction, and bolstering resilience to external shocks by increasing interdependence, among other contributing factors. [8, 10]

Overview of Exports and GVC Participation

Trade can be a powerful engine of economic development and technological change, followed by multiple other advantages, especially for developing countries. Extensive literature supports evidence that international trade can lead to significant and positive effects on productivity. [11, 12, 13] When countries engage in trade, they often focus on producing and exporting goods and services in which they have a comparative advantage. This specialization allows them to allocate resources more efficiently, leading to higher productivity levels in those sectors. Moreover, specialization in production of specific goods and services enables countries to harness their comparative advantage. Trade also fosters the exchange of ideas, technologies, and knowledge across borders, which developing countries can benefit from via access to advanced technologies and know-how through the interaction with advanced economies. Empirical evidence shows that there is a robust relationship between trade and TFP growth, since trade channels allow knowledge spillover through the imported goods. [14] It is also argued that it is not only about the amount of exports that leads to economic growth, but the degree of diversification of exports improvements in efficiency of other factors of production, increase in the resilience in terms of trade shocks, and direction towards the production of more sophisticated products that may lead to economic growth. [15, 16]

In this section recent trends in trade, by specifically focusing on export growth by analyzing the concepts of intensive and extensive margin in APO's member economies will be discussed. Additionally, the participation of these economies in GVCs, both backward and forward participation. These concepts provide valuable insights into how trade patterns have evolved in APO member countries, as well as identifying key opportunities for productivity enhancement.

Export Growth of APO Member Countries

An increase in a country's trade can be decomposed into the intensive and extensive margins. In general, the intensive margin refers to increase of already existing trading relationships, while the extensive margin refers to expanding exports through creating new/high growth in total trade in times of trade liberalization and structural change, therefore creating export diversification. The extensive margin of trade plays an important indicator to represent changes in the economic environment such as changes in trade policy (i.e., trade liberalization, tax initiatives, etc.), changes in the composition of structural transformation or changes in business cycles.

Kehoe and Ruhl [17] find evidence that the extensive margin is a significant factor in explaining trade growth. From a policy perspective, the concept of extensive margin is especially important for smaller and poorer countries, where greater diversification of manufacturing means that they are less volatile to external shocks and play a significant role for the growth of its exports. [17] In contrast, countries with the lowest domestic extensive margin, are those countries that depend on few products for export, meaning they are more vulnerable to terms of trade change. [18]

Decomposition of gross exports are reported in Table 4 following the methodology of Kehoe and Ruhl [17] by utilizing data from BACI CEPII database. Columns 4 and 5 represent the growth rate of the extensive and intensive margins and contribution to total exports for selected APO member countries. The ROK's exports to the world grew at a compound annual growth rate (CAGR) of 7.12%[5] over the period 1996-2021. The extensive margin accounted for 1.9% of total trade, while the intensive margin accounted for the remaining 98.1%. A highly intensive margin as seen in this case indicates an increase in the value of trade involving existing trade relationships, in either change of volume or unit prices in existing trade products.

For the period of analysis, substantial changes were experienced in Fiji, Nepal, Lao PDR, Vietnam and Sri Lanka where extensive margin contributes 143.6%, 106.6%, 70.7%, 30.4% and 20.8% of the total export growth respectively in 2021. A higher extensive margin means that for the period 1996-2021 the increase in export growth in each country was mainly due to an increase in the varieties of products.

TABLE 4

DECOMPOSING TOTAL EXPORT GROWTH OF APO MEMBER COUNTRIES

Country	Total Items		Log difference (1996-2021)		
	1996	2021	Total Trade Growth (%)	Intensive margin	Extensive margin
Bangladesh	899	2,670	2.67	2.42 (90.6)	0.25 (9.4)
Cambodia	326	2,300	5.36	4.56 (85.0)	0.80 (15.0)
Fiji	647	2,259	0.63	-0.28 (-43.6)	0.91 (143.6)
Hong Kong	4,848	4,438	0.54	0.66 (122.9)	-0.12 (-22.9)
India	4,711	4,670	2.47	2.22 (89.7)	0.25 (10.3)
Indonesia	4,149	4,357	1.58	1.37 (86.8)	0.21 (13.2)
Japan	4,955	4,622	0.63	0.65 (103.4)	-0.02 (-3.4)
Lao PDR	249	1,770	4.32	1.27 (29.3)	3.05 (70.7)
Malaysia	3,780	4,483	1.84	1.76 (95.7)	0.08 (4.3)
Mongolia	235	1,443	3.69	3.06 (83.0)	0.63 (17.0)
Nepal	682	1,710	1.55	-0.10 (-6.6)	1.65 (106.6)
Pakistan	1,820	3,755	1.65	1.26 (76.4)	0.39 (23.6)
Philippines	2,923	3,671	1.66	1.67 (100.3)	-0.01(-0.3)
ROK	4,720	4,574	1.72	1.68 (98.1)	0.03 (1.9)
Singapore	4,405	4,520	1.76	1.65 (93.7)	0.11 (6.3)
Sri Lanka	1,678	3,609	1.47	1.17 (79.2)	0.30 (20.8)
Thailand	3,881	4,569	2.02	1.76 (87.2)	0.26 (12.8)
Turkiye	4,481	4,627	2.37	2.04 (86.3)	0.33 (13.7)
Vietnam	1,893	4,318	4.26	2.96 (69.6)	1.29 (30.4)

Source: Calculated by authors based on data from BACI CEPII Database.
Note: 1. To measure the extensive margin and the intensive margin, the method developed by Kehoe and Ruhl [17] is used.
2. Numbers in parentheses are the contribution to the total. 3. Data is only available from 1996. 4. I.R. Iran and ROC are missing due to data availability.

[5] $(e^{0.0688} - 1) * 100 = 7.12\%$, where 0.0688 is derived from the log difference divided by number of years $(\frac{172}{25})$.

As in the case of Fiji, Nepal, and Lao PDR, although they have shown an increase in export diversification, exports are mainly composed by light manufacturing, non-metallic and minerals, mining and pulp (Refer to Appendix, Table A4) mainly low-valued added manufacturing. This suggests that while there was an effort to diversify their exports, they still heavily rely on low-skill manufacturing and minerals. On the other hand, Vietnam's major exports shifted significantly over the years, with the electrical equipment and machinery industry playing a prominent role. The growth of this sector, from 1.9% of initial total exports in 1996 to 48.8% in 2021, indicates a substantial transformation in the country's export profile. This shift can be attributed to investments and policies geared towards the promotion of domestic machinery and equipment, which has stimulated production and boosted exports in this industry.

The electrical equipment and machinery sector is a crucial component of the export profile for many other APO member countries, including Japan, Malaysia, Thailand and the ROK. This sector encompasses a wide range of industries involved in the manufacturing and production of machinery, electronics parts, industrial equipment, and technological devices, and represents the core of industrial development (Refer to Box 1 for further definition of electrical equipment and machinery sector). In other words, the products from these sectors often serve as intermediate inputs for the production of final goods in other industries, meaning that this sector is deeply entwined and integrated into the production of numerous industries.

This industry is defined as one of the most dynamic and extensive goods-producing sectors, [19] not only for its capacity to employ a significant workforce and generate substantial revenue, but also its enhancement of productivity in other activities and boosting of innovation across the entire economy. These products often form the backbone of industrial processes and technological advancements, making them critical for economic development and innovation. [20] Countries that have successfully developed and expanded their machinery and electrical equipment sector can benefit significantly from international trade, as these products are in high demand across the globe. Additionally, a strong presence in this sector can contribute to a country's economic competitiveness and technological capabilities.

Additionally, the role of electrical equipment and machinery for GVC formation is undeniable [19] as it accounts for a growing share of intermediate goods in trade. This sector represents a strategic avenue for developing countries, to leverage their resources and capabilities. Beyond being production locations for multinational firms, these countries have the opportunity to actively participate in the sector as suppliers, fostering economic development, technological advancement, and integration into the global economy.

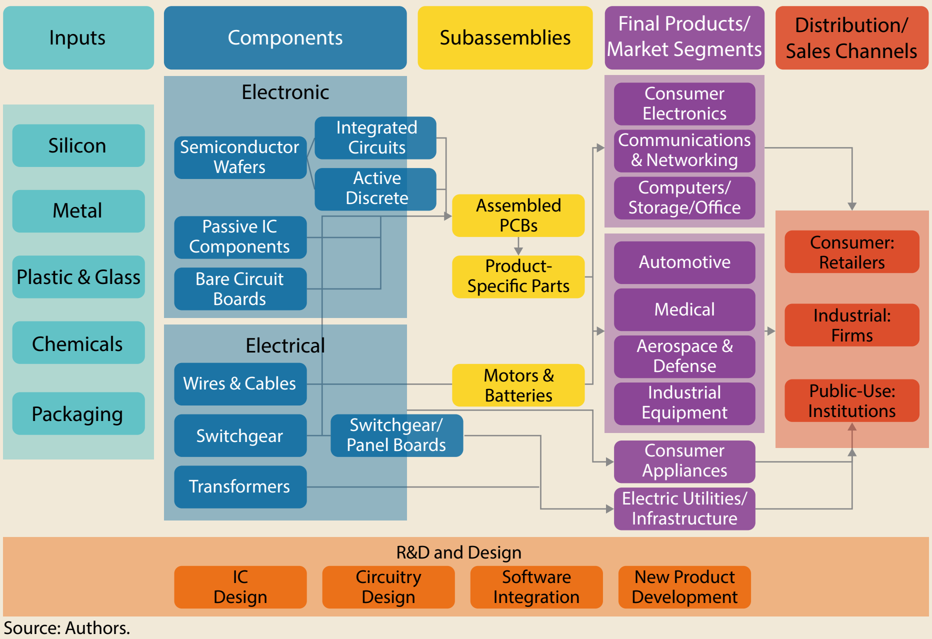
BOX 1: DEFINITION OF THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

The electrical equipment and machinery sector encompasses a broad range of components, and intermediate and final products involved in a number of different markets. This sector is known as one of the core industries for industrial development, since other sectors of the economy highly depend on this sector for capital equipment, technology and final products, and innovation. It is referred to as one of the main drivers of productivity gains and the central sector for job creation. [21]

Another key characteristic of this sector is its rapid technological change, R&D investment and the demand for high quality standards from its customers. [22]

In the case of APO member countries, economies such as the ROC, Japan, the ROK, Malaysia, Singapore, Vietnam, and Turkiye are key players in GVC participation in the electrical equipment and machinery sector. For a better illustration of this sector, the GVC of electrical and electronics originally developed by Frederick and Gereffi [22] is presented. According to the authors the electrical and electronics GVC can be divided into five main production stages: 1) input stage: raw materials, 2) components stage: elements that are used in the production of electrical or electronic components, 3) subassemblies stage: assembly stages that the components go through depending on the final product, 4) final products and market segments: products such as electronics, networking equipment, automobiles, medical equipment, industrial equipment, among others. and 5) distribution and sales channels: sales to consumers, firms or institutions.

Figure I. Electronics and Electrical Global Value Chain



Source: Frederick and Gereffi [22], page 11

For the purpose of this study and to simplify the analysis based on data availability, the scope will be narrowed down to the electrical equipment and machinery sector. This sector is defined as the goods falling within the categories of divisions 29 to 33, which pertains to the manufacture of machinery in the International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 3.1. These categories are specifically named as follows: manufacture of machinery and equipment n.e.c. (29), manufacture of office, accounting and computing machinery (30), manufacture of electrical machinery and apparatus n.e.c. (31), manufacture of radio, television, and communication equipment and apparatus (32) and manufacture of medical, precision and optical instruments, watches and clocks (33).

Additionally, this report utilized the classification from the Asian Development Bank (ADB) Multiregional Input-Output Table (MRIO) category 13 and 14, which are defined as machinery and electrical and optical equipment, respectively.

GVC Participation in APO member countries

GVCs involve the series of stages in the production of a product or service that spans across different countries. Each stage of the production process adds value, and the final product is sold to consumers. Firms are considered participants in a GVC if they are involved in at least one of the production stages within the value chain. This could include activities such as design, manufacturing, assembly or distribution. [23, 24] The essence of the GVC lies in the idea that each stage of the production adds value to the final product, which can occur in various countries, each contributing specialized skills or resources in the overall production process. In other words, a GVC promotes a finer international division of labor allowing countries to specialize in specific stages of production where they have comparative advantage. This specialization leads to greater efficiency and productivity in the economy.

Participating in GVCs emerges as a crucial strategy for stimulating productivity growth and boosting per capita income levels. [25, 26] The impact of GVCs is substantial and extends the benefits for both advanced and emerging economies. In advanced economies, GVC participation offers a gateway for firms to tap into larger markets, access cost-effective and advanced inputs, and capitalize on the benefits of economics of scale. [24] For developing countries, GVCs serve as a pivotal channel for economic diversification steering away from traditional reliance on agricultural products towards manufacturing and services. Beyond this, GVCs play a vital role in driving technology upgrades, boosting employment, and having access to advanced learning. [10] The fragmentation of production represents more than the incorporation of FVA or engaging in trade, it signifies a dynamic process that includes the transfer of technology and information. This transfer occurs through close interactions with high productivity firms involved in the production of goods and services with GVCs. Moreover, GVC participation holds particular appeal for policymakers, due to their multifaceted benefits.

To examine recent trends in GVCs of APO member countries, this study uses the accounting framework for gross exports proposed by Koopman, Wang, and Wei [27] and extended by Borin and Mancini. [28] Following this framework, this study breaks down gross exports into five categories, as shown in Figure 5.[6]

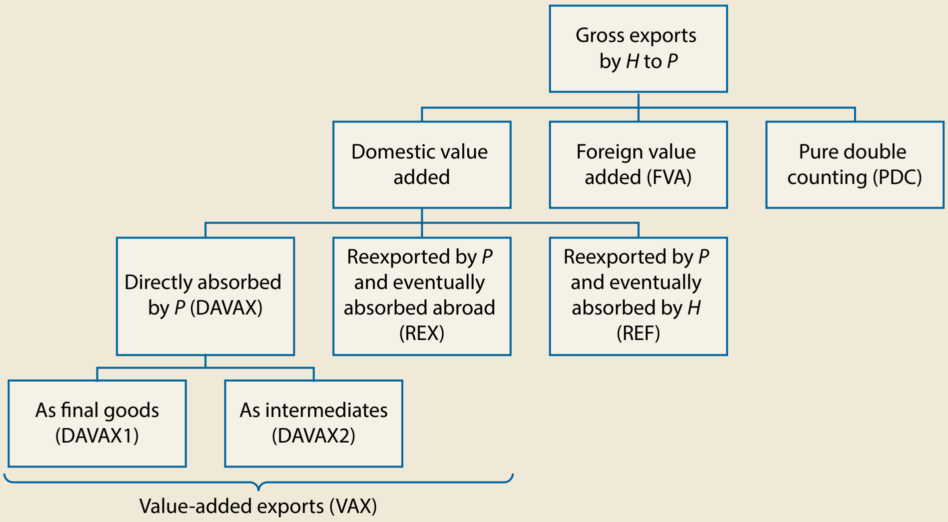
[6] For the mathematical derivations of the value-added trade accounting framework, refer to Koopman, Wang, and Wei [27] and Borin and Mancini [28].

(i) DVA directly absorbed by importer partner (DAVAX1(final goods), DAVAX2(intermediate goods))
(ii) DVA sent to importer partner then re-exported to eventually be absorbed by a third economy or importer partner (REX)
(iii) DVA sent to importer partner then re-exported to be returned to and absorbed by an exporter home (REF)
(iv) FVA in gross exports
(v) Pure Double Counting (PDC) of domestic or foreign origin.

The magnitude of some of the categories reveal the GVC participation of a particular country. According to Borin and Mancini, [28] the GVC participation is measured as the share of indirect trading in gross exports defined as the sum of REX, REF, FVA, and PDC, meaning the portion of exports whose underlying value added crosses two or more borders before final consumption. Additionally, GVC participation takes the form of backward linkage and forward participation. Backward participation means the import content to produce a country's exports are mainly represented by FVA and PDC, which are the share of imported inputs in the overall exports of a country. On the other hand, the import content of other countries for re-export to third countries is eventually absorbed abroad, thus forward linkages are represented by the REX and REF categories.

FIGURE 5

THE VALUE-ADDED TRADE ACCOUNTING FRAMEWORK

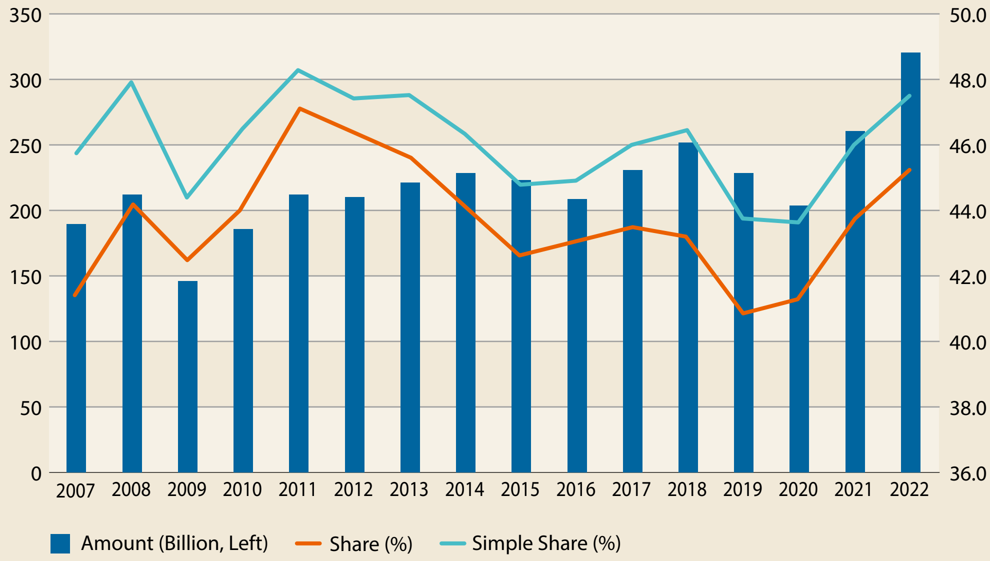


Source: Xing Y., Gentile E., & Dollar, D. [29], page 3
Note: H represents home economy and P represents direct importer or partner economy.

Figure 6 provides an overview of GVC participation in APO member countries in the last decade (2007-22). There is a clear growth since 2021, after a trend of decline following the Global Financial Crisis (GFC). In 2022, the average GVC trade shares to total exports was approximately 45% in APO member countries, and amount USD320 billion.

FIGURE 6

GVC PARTICIPATION RATE IN APO MEMBER COUNTRIES, 2007-22



Source: Authors' calculations based on the ADB Multi Regional Input Output Table Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]
Note: APO represents average weighted by gross exports. The amount on the left is in billion USD in constant PPP, and the left side represents the share of GVC participation as percentage of total exports.

In Figure 7, portrays each APO member country and its main composition of gross exports for the period 2012-22. As previously mentioned, backward linkage is composed by the share of FVA and PDC in total exports (represented in yellow and black respectively), while forward linkage is composed by the share of REX and REF in total exports (represented in orange and red).

As observed in the figure, participation in GVCs exhibits significant variation among member countries driven by diverse economic structure, size of the economies, export compositions and local conditions. [30, 31] GVC represents a complex web of interconnected production processes that transcend national borders and the extent of a country's involvement is shaped by multiple factors.

In the case of APO member countries, the great majority have higher backward participation than forward participation, meaning more foreign inputs/intermediates in the production of goods and services for exports to third countries.

Among them, Vietnam has become the country with the highest proportion of foreign intermediates for its overall exports in 2022 compared to that of 2012, where Singapore was taking the lead. In 2012, the share of imported inputs in the overall exports for Singapore was 55.2%, while for

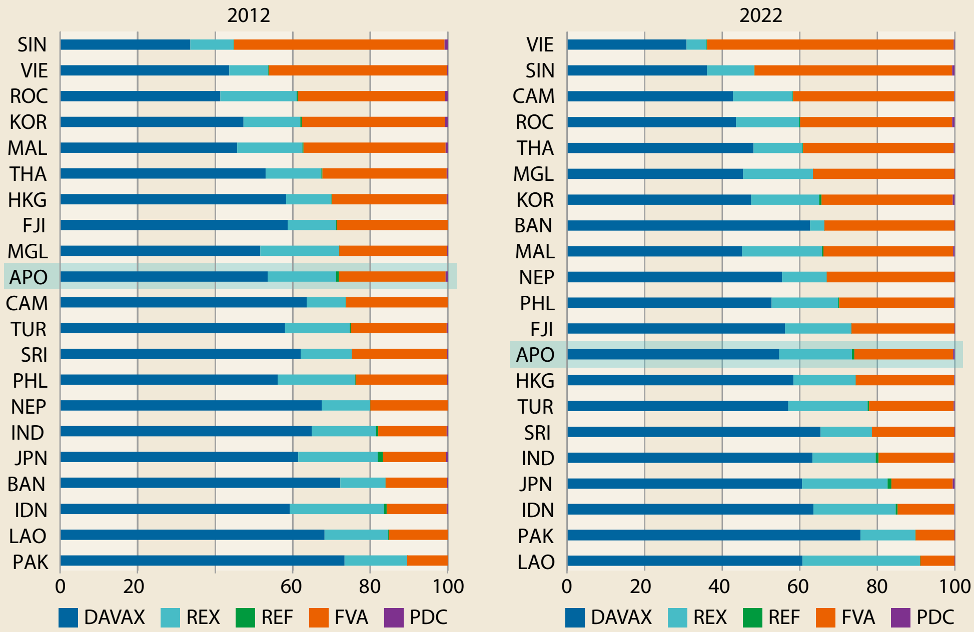
Vietnam it was 46.2%. However, by 2022, Vietnam had increased to almost 64%, while Singapore had decreased to 51.6%. It is also noted that Cambodia recently has become highly integrated into GVCs thorough backward linkages. In 2012, Cambodia's import content of exports was only 26.2%, and by 2022, it had risen to 41.7% from total exports, which indicates the importance of FVA for final goods production. Other countries with relative higher participation in backward linkages are the ROC (39.88%), Thailand (39.10%), and Mongolia (36.49%).

In contrast, for countries such as Lao PDR, Pakistan, Indonesia, and Japan, GVC participation in forward linkages had a higher percentage than backward linkages. In other words, these countries have the lowest share of import contents embodied in their exports, which could be interpreted as having more access and export to a wider range of domestic inputs.

Lao PDR exhibited a significant rise during the period 2012-22. The share of Lao PDR exports that moved further along the chain significantly grew from 16.5% in 2012 to 30.5% by 2022. These numbers are followed by Japan (237%), Indonesia (21.7%), Malaysia (21%), and Turkiye (20.8%), which have the highest share of forward linkage in GVCs among APO member countries.

FIGURE 7

VALUE-ADDED IN TOTAL EXPORTS IN APO MEMBER COUNTRIES: ALL INDUSTRIES (CONSTANT 2010 PRICES)



Source: Authors' calculations based on the ADB Multi Regional Input Output Table Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]
Note: APO represents average weighted by gross exports.

To understand the performance of APO member countries in a more detailed manner, in this section GVC participation and position index will be analyzed, to provide an estimation on the degree of a country's participation in the global production network, and the position of a country's specific sector in the GVC.

The GVC participation index proposed by Koopman et al. [32] is obtained by dividing the sum of backward and forward integration by gross exports.

$$\text{GVC participation} = \frac{GVC\ backward}{Exports} + \frac{GVC\ forward}{Exports} \qquad (1.2)$$

where GVC backward=FVA+PDC and GVC forward=REX+REF. A higher GVC participation index indicates that a country is more integrated in GVCs.

Moreover, GVC position index is also a useful concept to understand a country's participation in GVCs, which refers to the overall position for a country on an aggregate level in the GVCs and gauges whether a country is likely to be in the upstream or downstream of the GVC in a particular sector. [32]

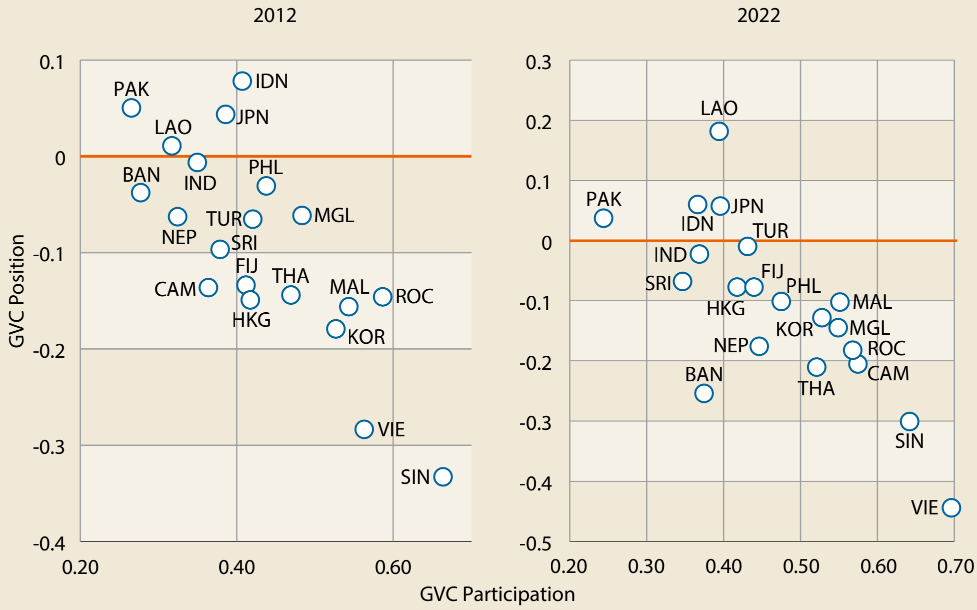
$$\text{GVC position} = \ln\left(1 + \frac{GVC\ Forward}{Exports}\right) - ln\left(1 + \frac{GVC\ backward}{Exports}\right) \qquad (1.3)$$

Economies with a position index value greater than zero lie upstream in the global value chain. It is likely that they have a higher forward participation relative to backward, meaning that they contribute more value added to other countries' exports than other countries contribute to theirs by producing inputs for others, either by providing manufactured intermediates or raw materials (first stages of production).

A negative index suggests that the country imports more value-added content from other countries than it exports to them (a country is downstream in the production network), which means that country uses a large portion of other countries' intermediates to produce final goods for exports. In other words, a higher backward participation has a higher FVA and DVX, then the position index will be negative.

FIGURE 8

CHANGES IN GVC PARTICIPATION AND POSITION OF APO MEMBERS: ALL INDUSTRIES (CONSTANT 2010 PRICES)



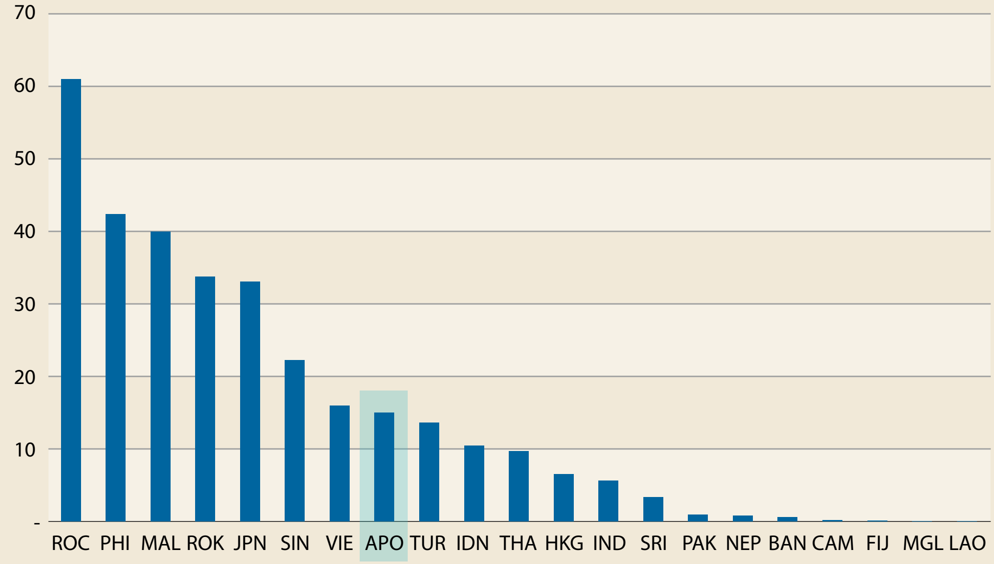
Source: Authors' calculations based on the ADB Multi Regional Input Output Table Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]
Note: The horizontal axis represents GVC participation, and the vertical axis represents GVC position.

According to Figure 8, Pakistan, Lao PDR, Indonesia, and Japan were positioned upstream in GVCs in both 2012 and 2022, indicating that they are actively engaged in forward GVC. In general, there are two cases of forward participation: countries that are abundant in natural resources (mostly developing countries) or increasingly specialized in activities carried out by high-skilled workers (mostly experienced by developed countries) tend to exhibit strong forward participation in GVCs, as their exported materials and inputs are integrated into downstream production processes. For the remaining APO member countries, the GVC position index is negative, meaning that the proportion of imported intermediate goods by these countries is higher than the proportion of exported intermediate goods.

As described in the first section, the goal of this report is to delineate the central importance of the GVC in the electrical equipment and machinery sector for APO member countries. This sector is an important driver of global integration, which is deeply entwined with all sectors of the economy and involves the participation of dozens of countries on a daily basis. The GVC in this industry is more dynamic and geographically extensive compared to other manufacturing sectors since it is composed of a vast part of components used as intermediate inputs for finished goods (Sturgeon, 2010). Figure 9 shows the percentage of electrical equipment and machinery manufacturing from total exports in APO member countries. This sector accounts for 14.92% of the total exports in APO member countries on average and comprises a sizable portion in the ROC (60.6%), Philippines (42.1%), Malaysia (39.7%), the ROK (33.6%), Japan (32.9%), Singapore (22.1%) and Vietnam (15.9%).

FIGURE 9

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE-ADDED EXPORTS IN 2022.



Source: Authors' calculations based on the ADB Multi Regional Input Output Table Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

Figure 10 provides a more detailed overview of the value-added of the exports of the electrical equipment and machinery sector in each country for 2012 and 2022. There is a steady trend over the period, with about 49.6% of APO's total exports of this sector related to GVCs, with an average of 50.4% of its exports with domestic value added in 2022.

In the case of Vietnam, similar to the case of value added of exports of all industries (Refer to Figure 7), the electrical equipment and machinery sector also has large backward linkages. The share of FVA in total exports was 64.7% in 2012, and it increased to 78.4% in 2022. Likewise, import content is also significant in the exports of Cambodia's case, which increased from 48.8% in 2012 to 72.9% by 2022. However, in the case of Cambodia, the value added by the electrical equipment and machinery sector to Cambodia's total exports is very small, representing only 0.17% in 2022 (Figure 8).

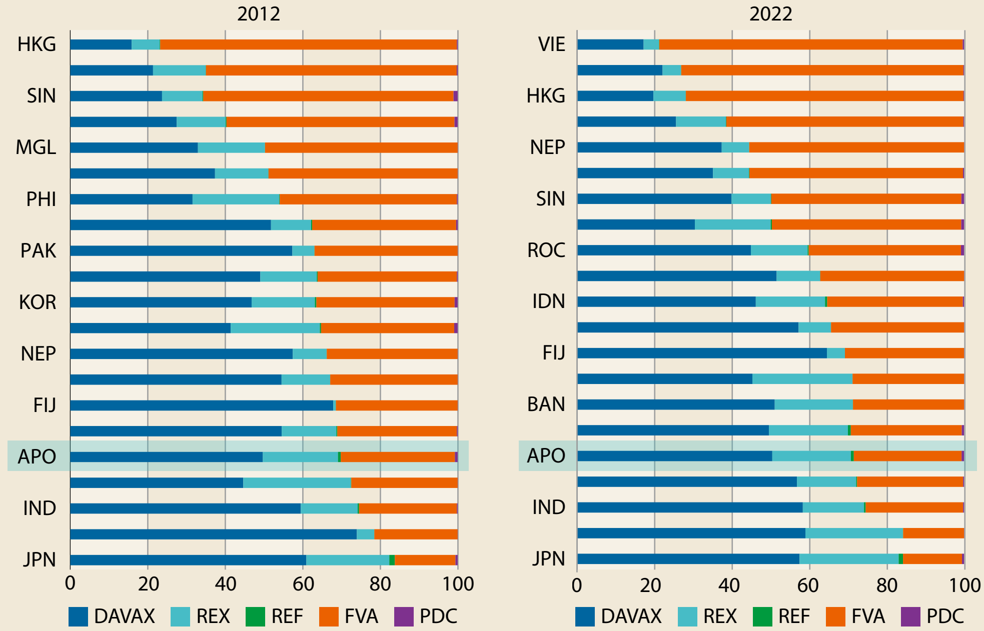
Other countries such as Singapore (51.6%), the ROC (39.9%), Thailand (39.1%), and Mongolia (36.5%) have a relatively higher share of FVA. In other words, these countries depend heavily on imported components and subsystems from other countries either with less expensive labor or advanced technologies.

In contrast, countries such as Japan, Lao PDR, Indonesia and Turkiye have relatively lower FVA, and higher DVA in total exports in the electrical equipment and machinery sector. Lao PDR stands out with a particularly lower FVA of 15.7%, but with a relatively high 58.9% of DVA contained in intermediate inputs exported to economies. The higher DVA is attributed to low-value-added activities such as assembly and testing, which may not require advanced technologies but involve local firms and domestic employment. [33]

Another interesting case is Japan, where its DVA contained in intermediate inputs exported to third economies (REX) from the electrical equipment and machinery industry is the highest among APO member countries with a 57.5%.

FIGURE 10

VALUE-ADDED OF TOTAL EXPORTS FOR APO MEMBERS: ELECTRICAL EQUIPMENT AND MACHINERY (CONSTANT 2010 PRICES)



Source: Authors' calculations based on the ADB Multi Regional Input Output Table Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

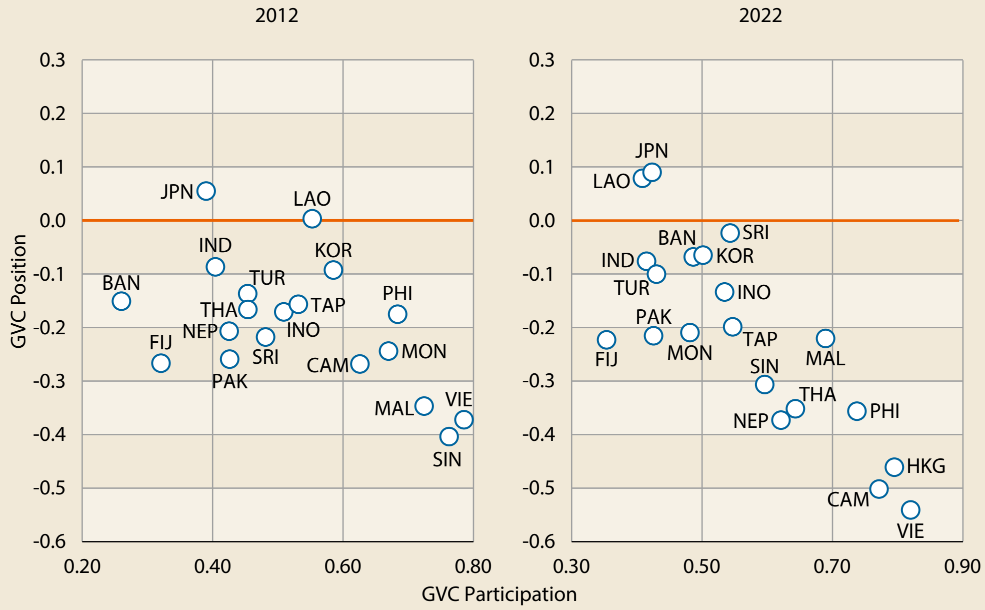
Note: APO represents average weighted by gross exports.

As noted above, some countries participate in export for the electrical equipment and machinery sector, this does not mean that these economies specialize in this sector per se, but in a particular segment in the electronics value chain, [34] which is the case for developing countries.

According to Figure 11, Japan and Lao PDR were positioned upstream in GVC in 2012 and 2022, indicating that they are actively engaged in forward GVC. The other APO members are positioned downstream during the same periods. These results suggest that APO members, except for Fiji, are actively participating in GVCs through forward or backward linkages in the electrical equipment and electronics sector.

FIGURE 11

CHANGES IN GVC PARTICIPATION AND POSITION OF APO MEMBERS: ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: Authors' calculations based on the ADB Multi Regional Input Output Table Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]
Note: The horizontal axis represents GVC participation, and the vertical axis represents GVC position. The data for the Philippines is missing in 2022.

GVC participation (both forward and backward) contributes to enhanced export productivity, sophistication and diversification, even in the presence of varying levels of economic development across member countries. [35] The analysis reveals distinct GVC participation features among APO member countries, indicating unique determinants of participation and suggesting the need for tailored policy. Therefore, countries with higher backward GVC participation are linked to the demand side of the value chain, where market size and industrialization play crucial roles. On the other hand, forward GVC participation is associated with the supply side, characterized by different features depending on a country's specialization (resource-rich, technology-intensive, or service sector-oriented). The government needs to address the obstacles and barriers that can facilitate backward and forward GVC participation by improving the policy environment.

Conclusion

In recent decades, APO member countries have witnessed substantial economic growth, primarily attributed to the accumulation of human and capital resources, mostly in the non-ICT sector. However, a critical examination reveals that the growth trajectory, while impressive, has been predominantly reliant on factors such as labor and capital, with the TFP growth lagging behind that of the frontier. This poses a challenge for achieving sustainable growth in the long term, necessitating thoughtful policy actions.

This chapter delves into the role of trade and participation in GVCs with specific emphasis on the electrical equipment and machinery sector, an industry known for its high value added and knowledge-intensive characteristics. The figures and tables of this section underscore a disparity among APO member countries, with countries like the ROC, Philippines, Malaysia, the ROK, Japan, and Vietnam exhibiting a notable share in the exports of the electrical equipment and machinery sector, while others including Cambodia, Fiji, Mongolia, Bangladesh, and Laos PDR, have a smaller footprint in this domain.

A noteworthy finding is the positive relationship observed between countries with a smaller income gap with the United States and a larger proportion of the GVC in the electrical equipment and machinery industry. This indicates that countries with higher income levels tend to be more actively engaged in the GVC for this particular sector.

The significance of the electrical equipment and machinery sector goes beyond its economic contribution. It serves as a core technological sector capable of augmenting the competitiveness of other industries. For developing countries, the role of this sector is pivotal to enhance competitiveness, as highlighted in the research. The electrical equipment and machinery industry can serve as a core source for improving the competitiveness of a country by embracing new technologies and advanced production equipment. [36] Additionally, for countries that may not have a substantial domestic production of electrical equipment and machinery, an essential avenue for technological advancement lies in imports. The act of importing technology, particularly embedded in machines and components, has been identified as a key channel for technological upgrading and knowledge spillover that can lead to a significant boost in productivity. [37, 38] In essence, the electrical equipment and machinery sector becomes a gateway for technology transfer and knowledge diffusion in developing countries. By importing technology-rich machinery and components, therefore participating in the GVC, can not only enhance their industrial capabilities but also bring about tangible improvements in productivity.

Recognizing this, strategic policy actions are deemed essential for harnessing the full potential of this industry, and by extension, fostering sustainable growth. The challenges lie in determining the specific policies that can effectively propel these countries toward a trajectory of enhanced TFP, innovation, and competitiveness.

In conclusion, this chapter provides an insightful overview of the intricate dynamics at play in APO member countries concerning trade, GVCs, and the electrical equipment and machinery sector. By highlighting the challenges and opportunities, it calls for a nuanced and strategic approach to policy formulation to ensure not only continued economic growth but also its sustainability and inclusivity.

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Appendix

TABLE A1

CHANGES IN GROWTH PROJECTIONS: COMPARISON BETWEEN 2019 AND 2023 FORECASTS FOR THE PERIOD 2022-24

Country	Pre-COVID-19	Post-COVID-19	Gap
	2019 Estimates	2023 Estimates	
Sri Lanka	4.66	-3.41	- 8.07
Lao PDR	6.77	3.41	- 3.36
Hong Kong	2.75	1.03	- 1.72
Pakistan	4.85	3.32	- 1.53
India	7.40	6.35	- 1.05
Bangladesh	7.30	6.37	- 0.93
Cambodia	6.57	5.68	- 0.89
ROK	2.89	2.17	- 0.73
Mongolia	5.54	4.95	- 0.59
APO	**4.43**	**3.97**	**- 0.46**
Thailand	3.65	3.22	- 0.43
Indonesia	5.29	5.11	- 0.18
Philippines	6.50	6.48	- 0.02
Nepal	5.08	5.11	0.03
Singapore	2.36	2.42	0.06
ROC	2.07	2.38	0.31
Vietnam	6.50	6.88	0.38
Turkiye	3.33	3.95	0.61
Japan	0.51	1.13	0.62
Malaysia	4.86	5.90	1.04
I.R. Iran	1.02	2.20	1.19
Fiji	3.20	8.83	5.63

Source: IMF, World Economic Outlook Database (Online) 2023. Gap is measured as the difference between estimations in 2023 with 2019.
Note: Real GDP growth, %. The gap is calculated as the 2023 (April edition) forecast minus 2019 (October edition) forecast.

TABLE A2

DEVELOPING ACCOUNTING FORMULA

Following Caselli (2005) the relative importance of factors in accounting for income differences (equation 1.1) is calculated.

Capital share (α) is assumed to be equal to 0.35 and the same across countries.

$$\frac{y_i}{y_u} = \left(\frac{A_i}{A_u}\right)^{\frac{1}{(1-\alpha)}} \left(\frac{k_i/y_i}{k_u/y_u}\right)^{\frac{1}{(1-\alpha)}} \left(\frac{h_i}{h_u}\right) \qquad (1.1)$$

Where lowercase letters denote per capita variables, subscripts i and u represent APO members and the United States, respectively.

TABLE A3

DEVELOPMENT ACCOUNTING FOR APO MEMBER COUNTRIES

Country	Year	GDP per person engaged	Capital/ GDP	Human Capital	TFP	Share of TFP
Bangladesh	1980	0.06	0.47	0.39	0.34	35.35
	2000	0.05	0.75	0.46	0.14	71.72
	2019	0.09	1.05	0.56	0.15	79.82
Cambodia	1980	0.03	0.73	0.40	0.10	74.93
	2000	0.03	0.64	0.43	0.12	70.32
	2019	0.06	0.91	0.52	0.13	78.96
ROC	1980	0.42	0.58	0.58	1.27	20.81
	2000	0.78	0.78	0.76	1.31	31.31
	2019	0.76	0.99	0.90	0.86	50.66
Fiji	1980	0.25	0.59	0.58	0.73	31.92
	2000	0.17	0.63	0.68	0.39	52.49
	2019	0.30	0.80	0.72	0.52	52.37
Hong Kong	1980	0.53	0.63.	0.67	1.26	25.09
	2000	0.79	1.08	0.76	0.97	45.61
	2019	0.86	1.27	0.87	0.78	58.75
India	1980	0.05	0.77	0.38	0.16	64.42
	2000	0.05	0.85	0.50	0.13	76.60
	2019	0.14	1.08	0.58	0.22	74.17
Indonesia	1980	0.12	0.60	0.45	0.43	38.71
	2000	0.09	0.75	0.61	0.21	69.18
	2019	0.18	1.34	0.61	0.22	78.92
I.R. Iran	1980	0.24	1.15	0.36	0.57	42.16
	2000	0.31	1.16	0.48	0.56	49.79
	2019	0.33	1.38	0.67	0.36	71.94

Country	Year	GDP per person engaged	Capital/ GDP	Human Capital	TFP	Share of TFP
Japan	1980	0.61	1.06	0.90	0.64	59.76
	2000	0.68	1.19	0.94	0.61	64.45
	2019	0.55	1.21	0.96	0.47	71.28
ROK	1980	0.22	0.81	0.72	0.38	60.58
	2000	0.53	0.96	0.89	0.63	57.71
	2019	0.59	1.26	1.00	0.47	73.07
Lao PDR	1980	0.03	0.70	0.40	0.10	74.50
	2000	0.04	0.81	0.47	0.09	80.19
	2019	0.11	1.05	0.52	0.20	72.60
Malaysia	1980	0.30	0.80	0.53	0.71	37.45
	2000	0.35	0.95	0.72	0.50	57.72
	2019	0.45	1.06	0.82	0.52	62.73
Mongolia	1980	0.08	0.96	0.62	0.14	81.09
	2000	0.08	1.30	0.73	0.09	91.63
	2019	0.23	1.11	0.82	0.25	78.18
Nepal	1980	0.03	0.51	0.33	0.17	49.09
	2000	0.03	0.98	0.38	0.09	81.15
	2019	0.04	1.08	0.49	0.08	86.43
Pakistan	1980	0.10	0.53	0.38	0.51	28.29
	2000	0.11	0.61	0.43	0.41	39.12
	2019	0.12	0.68	0.47	0.39	45.08
Philippines	1980	0.14	0.65	0.59	0.37	50.94
	2000	0.12	0.87	0.68	0.21	74.27
	2019	0.16	0.95	0.72	0.23	74.67
Singapore	1980	0.45	0.76	0.49	1.19	24.06
	2000	0.78	0.91	0.76	1.14	37.80
	2019	1.04	1.09	1.16	0.82	60.69
Sri Lanka	1980	0.11	0.71	0.63	0.24	65.47
	2000	0.14	0.62	0.80	0.28	63.95
	2019	0.25	0.95	0.76	0.35	67.57
Thailand	1980	0.12	0.69	0.47	0.37	46.59
	2000	0.15	1.22	0.63	0.20	79.15
	2019	0.25	1.06	0.75	0.31	71.58
Turkiye	1980	0.38	0.91	0.44	0.95	29.53
	2000	0.39	0.85	0.56	0.81	36.83
	2019	0.60	1.16	0.67	0.77	50.08
Vietnam	1980	0.03	0.46	0.52	0.14	62.72
	2000	0.05	0.69	0.55	0.13	75.35
	2019	0.11	0.88	0.77	0.17	80.09

Source: Author's calculation using PWT, version 10.01.

TABLE A4

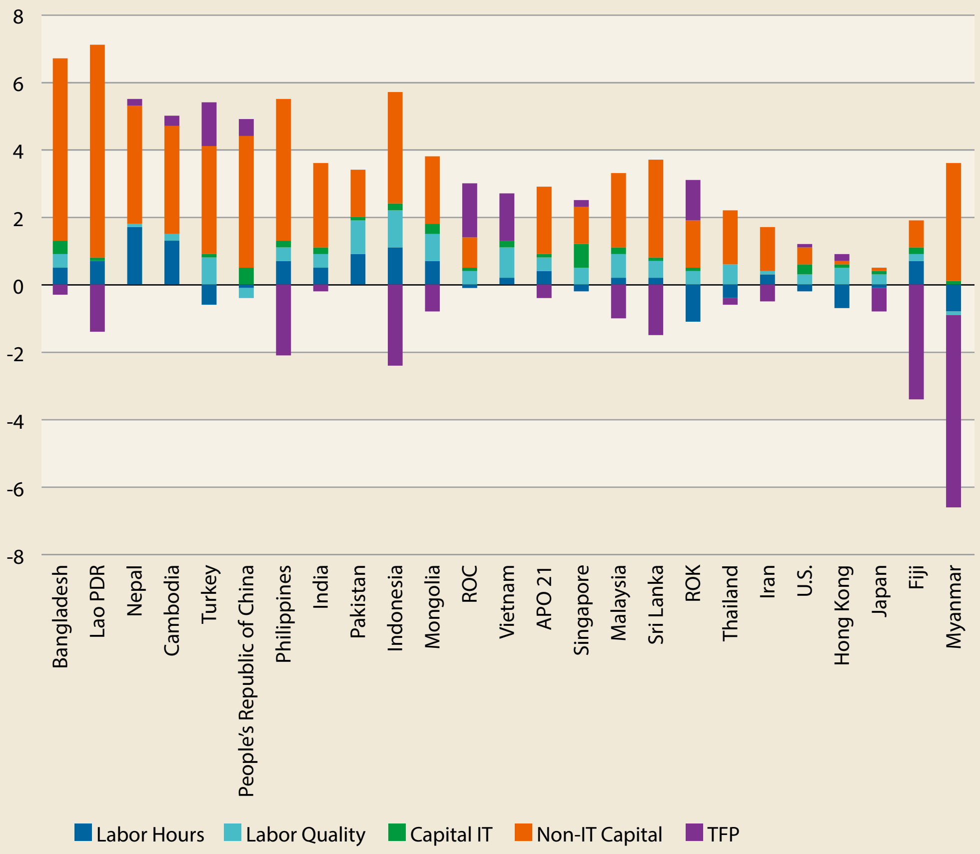
EXPORTS BY INDUSTRY SECTORS IN APO MEMBER ECONOMIES AS % OF TOTAL EXPORTS

Country	Year	Agriculture	Mining	Food, Tobacco	Textiles, Apparel, Footwear	Wood, Furniture	Pulp, Printing	Refined Petroleum, Chemicals	Rubber, Plastics	Non-metallic Mineral, Metals	Machinery, Electrical equip.	Transport	Manufacturing N.E.C.
BAN	1996	1.7	0	8.5	85.7	1	0	1.1	0.1	0.5	0.4	1.1	0
	2021	0.9	0	1.9	93	0.9	0.1	0.9	0.2	0.4	0.5	0.6	0.7
CAM	1996	8.6		4.1	74.7	9.1	0	0.6	0.1	0.8	1.4	0.4	0
	2021	14.6	0.2	2.3	63.3	4.2	0.2	0.5	2.1	2	7.1	2.4	1.1
FJI	1996	6.1	0.0	38.0	33.5	7.4	0.1	0.2	0.1	10.3	1.2	3.1	0.2
	2021	6.6	1.3	51.5	6.3	9.2	1.3	8.0	0.6	8.2	4.4	1.9	0.8
HKG	1996	1.3	0.4	2.6	30.5	8.3	2.2	4.1	2.3	4.1	41.9	1.4	0.9
	2021	3.5	1.2	2.5	4.9	8.0	0.9	5.6	1.5	19.8	41.7	7.4	2.8
IND	1996	7.9	3	13.2	31	14.3	0.8	10.1	1.8	8.2	5.9	3.5	0.3
	2021	4.1	2	8.4	10.6	10.6	0.9	28.9	2.3	13.3	11.5	7	0.4
IDN	1996	7.9	24.4	7.3	17.2	14	2.9	8.4	1.3	4.7	10.5	1.2	0.2
	2021	3.9	20.6	18.7	7.9	5.1	3.5	10.2	1.9	14.1	8.8	4.5	0.9
JPN	1996	0.1	0.1	0.5	1.7	1.5	0.7	9.4	2.3	7.9	52.2	23.4	0.2
	2021	0.2	0.1	1.1	0.9	1.4	0.6	14.6	3.5	11.3	**42.2**	22.7	1.3
LAO	1996	18.3	0	0.2	67.9	12.5	0	0.3	0.1	0.1	0.4	0	0.2
	2021	14	8.6	5.5	5.3	1.9	8.7	4.3	0.1	23.7	6.5	0.1	21.2
MAL	1996	4.1	5.9	5.3	3.9	7.9	0.4	5.8	3	2.2	60.3	0.9	0.3
	2021	1	5.7	8.3	0.9	2.6	0.7	19.5	5.6	7.6	**46.2**	1.4	0.5
MGL	1996	21.9	30.8	2.9	15.5	2.2	0.0	0.4	0.0	21.5	0.4	0.0	4.3
	2021	4.2	72.0	0.7	0.9	0.0	0.0	0.1	0.0	21.6	0.2	0.3	0.0
NEP	1996	6.5	0.0	2.7	80.7	1.0	0.6	5.0	0.1	0.9	0.7	1.3	0.5
	2021	6.9	0.0	60.1	21.8	1.9	0.6	3.1	0.8	2.4	1.1	0.2	1.1
PAK	1996	6.1	0.7	4	81.7	3.6	0	0.4	0.1	1	1.5	0.1	0.8
	2021	5.2	1.8	12.9	61.6	1.6	0.3	4.3	0.6	6.3	2.5	1.2	1.7
PHL	1996	4.5	1.7	8.1	15.1	5.1	0.6	2.3	0.8	3.1	57.4	0.7	0.6
	2021	3.3	3.9	5	2.5	2.2	0.4	4	1.3	6.5	67.4	2.2	1.3
ROK	1996	0.6	0.1	1.9	15.1	2.1	1.3	11.9	2.8	11.8	36.7	15.5	0.2
	2021	0.2	0.3	1.4	1.6	0.5	0.5	23.2	2.6	10.1	**44.5**	14.8	0.4
SIN	1996	0.9	0.1	1.5	1.2	1.2	1.3	15.9	0.7	1.6	73.2	2.0	0.5
	2021	0.2	0.8	3.6	0.7	1.0	0.6	30.6	0.8	7.7	49.4	4.0	0.7
SRI	1996	9.6	1.2	4.6	62.7	9	0.2	1	5.4	1.9	3.2	0.4	1
	2021	11.8	0.5	12.8	43.9	4.6	1	4.6	8.7	2.8	6	2.5	0.7
THA	1996	8.3	0.7	18.3	13.1	10.5	0.5	3.3	2.7	3.5	37.9	1.1	0.3
	2021	5.2	0.4	10.8	2.7	4.2	0.9	13.4	6	7.2	**34.6**	13.6	0.8
TUR	1996	11.1	1.5	9.8	37.2	1.3	0.8	6.5	2.2	15.2	8.9	4.8	0.7
	2021	4.3	2.4	6.7	15.6	5.5	1.4	9.8	4.5	20.3	15.1	13.7	0.5
VIE	1996	11.5	20.2	14.9	43	5.4	0.1	0.7	0.5	1.4	1.9	0.2	0.1
	2021	3.4	0.8	5.2	18.6	7	0.6	3.7	2.5	7.5	**48.8**	1.8	0.3

Source: Author's calculation based on data from CEPII BACI Database [online].
Note: To measure the extensive margin and the intensive margin, the method developed by Kehoe and Ruhl (2013) is used.

FIGURE A1

CONTRIBUTION OF CAPITAL, LABOR AND TFP FROM GROSS OUTPUT, 2015-20



Source: Authors' production based on APO Productivity Database 2022.

GVC PARTICIPATION OF ELECTRICAL EQUIPMENT AND MACHINERY INDUSTRIES: IMPLICATION FOR EXPORT DIVERSIFICATION IN APO MEMBER COUNTRIES

Introduction

GVC participation enhances trade participation, and increased backward or forward GVC participation offers countries increased opportunities for export diversification. This process potentially aids in expanding the export portfolios of countries.

The advantages of export diversification include the stabilization of national economies; stimulation of private sector investments; generation of externalities such as technological spillovers from new techniques of production, new marketing, and management skills; creation of new industries and expansion of existing industries through backward and forward linkage; and reduced vulnerability to disruptions in GVCs.

As shown in Figure 1, countries with higher income have greater export diversification. Many APO member countries exhibit relatively higher levels of export diversification given income level compared to the global average, indicating their significant potential for export growth through their various development stages and technological advancements. Nonetheless, there remains a critical need for these countries to further diversify to reduce the risks associated with export concentration.

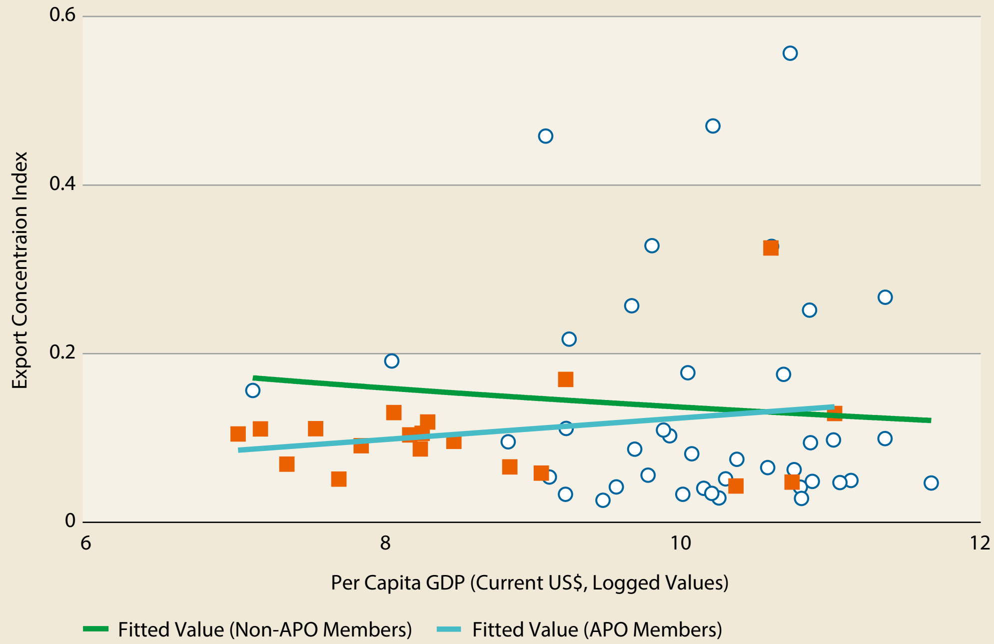
This chapter examines the impact of GVC participation in electrical equipment and machinery (E&M) industries on the export diversification with a focus on APO member countries, using both empirical and computable general equilibrium (CGE) methodologies. The empirical approach adopts conventional random effect regression model using panel data, while the CGE analysis uses the standard Global Trade Analysis Project (GTAP) model.

The findings indicate that GVC participation in electrical equipment or machinery industries has a positive impact on export diversification. This effect is particularly pronounced in the APO member countries especially within the electrical equipment industry and in terms of gross level exports. The CGE analysis corroborates these results with certain limitations.

The remainder of the chapter is structured as follows: The first section presents literature and conceptual review on GVC participation and export diversification; the second section details the empirical analysis based on random effect model with panel data to show the effect of GVC participation; the third section presents the results of CGE analysis; and the last section summarizes and concludes the chapter.

FIGURE 1

EXPORT CONCENTRATION VS. INCOME LEVEL, 2020



Source: Authors' elaboration using APO Productivity Database and UNCTAD database.

Literature and Conceptual Review

GVC participation is widely recognized as an effective way to achieve export diversification, especially in promoting high-value-added exports and dynamic spillover effects. This is particularly evident in knowledge-intensive industries that mainly supply capital goods or components to other industries of the economy. The Asian region, since the 1990s, has seen significant benefits from GVC engagement.

This chapter focuses on the GVC participation in the E&M industries. Ndubuisi and Owusu [1] suggest that GVC participation has a positive impact on the product quality of exports, aligning it closer to the quality frontier. In particular, backward GVC participation holds particular importance for developing countries.

Huong and Park [2] argue that GVC participation contributes to the product and geographical diversification of exports, primarily through backward GVC participation.

APO [3] highlights the crucial role of backward GVC participation for the growth of labor productivity in manufacturing. It argues that the increased access to a variety of foreign intermediate goods can improve overall production efficiency through cost savings, access to superior quality inputs, and technological knowledge spillovers.

Eugster et al. [4] provide empirical evidence on the adverse impact of tariffs on GVCs, both directly and indirectly.

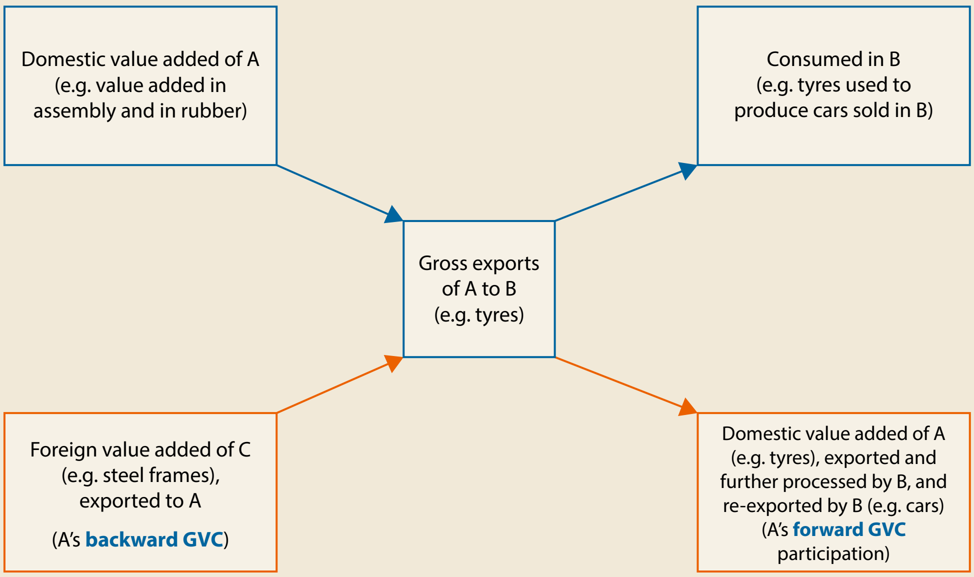
Sung [5] investigates how trade conflicts might impair a country's exports through the deterioration of GVCs, using Recursive Dynamic GTAP Model (G-Dyn) and GTAP DB Version 10.0A for the dynamic CGE analyses.

The primary focus of this chapter is to investigate the relationship between GVC participation in E&M industries and export diversification, specifically within the APO member countries.

As shown in Figure 2, the chapter examines the channels through which GVC participation contributes to export diversification and industrial upgrading. It considers both backward GVC participation—import channels where a country imports foreign intermediates to produce its export production—and forward GVC participation—export channels where it exports domestically-produced inputs to trade partners, which are then incorporated into the exports of those trade partners. The analysis includes a comprehensive examination of these channels and the overall GVC participation rate.

FIGURE 2

DECOMPOSITION OF COUNTRY A'S EXPORTS TO COUNTRY B: ORIGIN AND DESTINATION OF VALUE ADDED

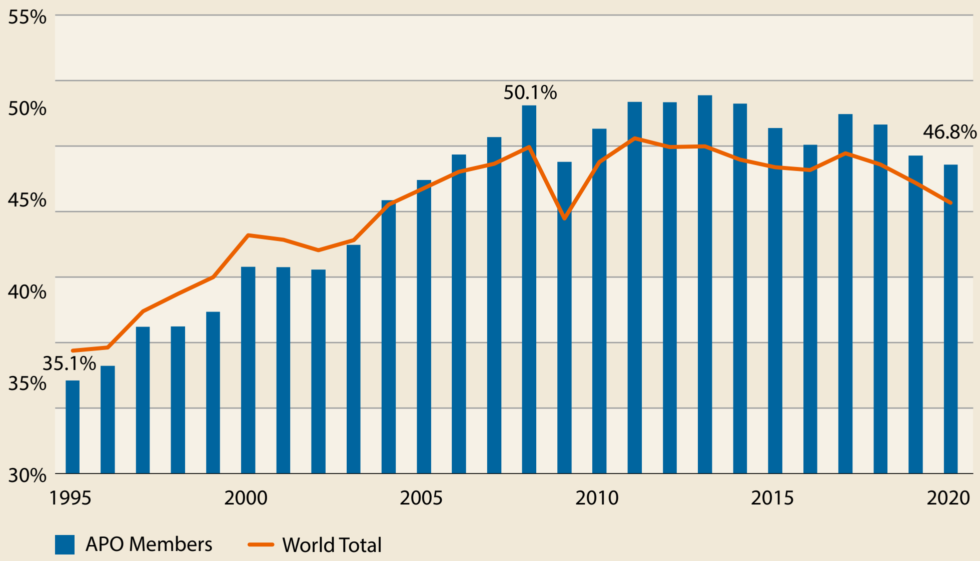


Source: Cigna et al. [6]

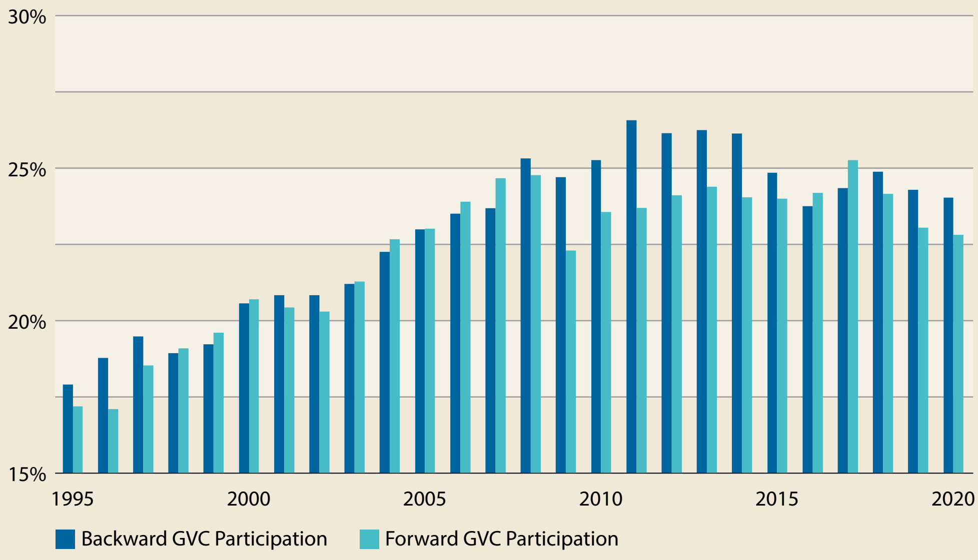
FIGURE 3

SHARE OF GVC TRADE (2020) AND THE EXTENT OF BACKWARD/FORWARD GVC PARTICIPATION IN E&M INDUSTRIES OF APO MEMBER COUNTRIES SHARE OF GVC TRADE, 2020

(a) Share of GVC Trade (2020)



(b) Extent of Backward/Forward GVC Participation

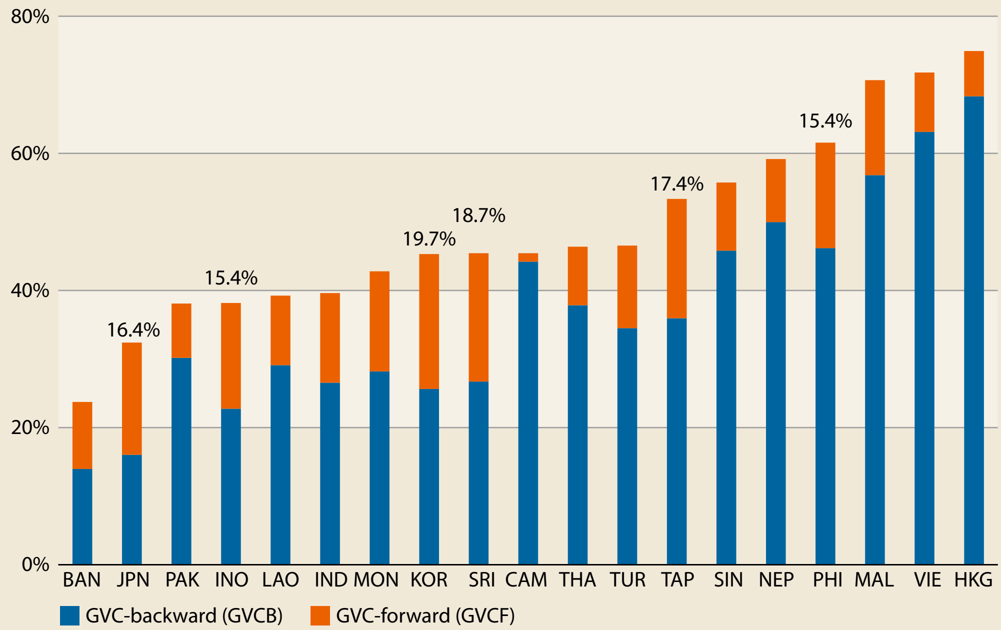


Source: Author construction using the OECD TiVA database.

According to Figure 3, the overall GVC participation rate, which is measured as the share of GVC-related trade in gross exports, shows significant variation among APO member countries. As of 2020, this rate ranges from 74.9% in Hong Kong to 23.7% in Bangladesh. Notably, forward GVC participation rates are particularly high in the ROK (19.7%), Sri Lanka (18.7%), the ROC (17.4%), and Japan (16.4%). Conversely, backward GVC participation is prevalent in Hong Kong (68.3%), Vietnam (63.1%), and Malaysia. With the exception of Japan, all the APO member countries demonstrate a higher rate of backward GVC participation compared to forward participation.

FIGURE 4

GVC PARTICIPATION IN E&M INDUSTRIES BY APO MEMBERS, 2020



Source: Author's construction using the ADB MRIO database.

Impact of GVCs on Export Diversification: Empirical Analyses

Setting Up the Model

This chapter explores the impact of GVC participation on export diversification in APO member countries and others, using a random effect panel analysis. The model is represented by the following equation:

$$ExportDiversification_{it} = \alpha_0 + \beta_0 GVCParticipation_{it} + \gamma_0 X_{it} + u_i + \varepsilon_{it} \qquad (1)$$

where the dependent variable, $ExportDiversification_{it}$, is the Herfindahl-Hirschman Index (HHI) of exports for country i in year t. This index consists of two variables for export diversification based on gross exports and value added of exports for country i in year t. A lower value of the dependent variable indicates a higher level of export diversification. Independent variables include backward GVC share, forward GVC share, and overall GVC participation rate. The independent variable X

may affect export diversification and include GDP and GDP growth rate (GDPGR) in terms of the gravity of trade. The model also includes a dummy variable, APO, and interaction terms between APO and other independent variables. Finally, u_i represents a group-specific error term, while ε_{it} is a random error term. Tables 1 and 2 provide detailed descriptions of these variables.

The analysis considers 61 countries, including 21 APO members from the period 2007-22 (Refer to the list in the Appendix section). Due to the constraints of data availability, the number of countries and period for analyses are limited. Data for the analyses on backward and forward GVC participation are primarily sourced from the ADB's Multiregional Input-Output (MRIO) Database, with machinery and electrical equipment categorized as 13 and 14, respectively, in the same database. Data on GDP and GDPGR are derived from the World Development Indicators and APO Productivity Database. [7]

TABLE 1

EXPLANATION ON VARIABLES

Variable	Explanation
ExpDivG	HHI for gross exports
ExpDivV	HHI for value-added exports
gvbs	backward GVC share (GVC backward/Exports)
gvfs	forward GVC share (GVC forward/Exports)
gvp	GVC participation rate (gvbs+gvfs)
GDP	gross domestic product (unit: USD Billion)
GDPGR	The growth rate of GDP
APO	A dummy variable that is 1 if the country is an APO member and 0 otherwise.

TABLE 2

SUMMARY OF STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
ExpDivG	976	0.126	0.116	0.021	0.685
ExpDivV	976	0.085	0.080	0.019	0.575
gvbs	976	0.361	0.138	0.043	0.782
gvfs	976	0.121	0.055	0.002	0.431
gvp	976	0.483	0.129	0.120	0.871
GDP	976	1.141	2.822	0	25.463
GDPGR	976	2.829	4.106	-17.000	24.370
APO	976	0.328	0.470	0	1
APO*gvbs	976	0.131	0.208	0	0.782
APO*gvfs	976	0.031	0.053	0	0.337
APO*gvp	976	0.162	0.245	0	0.871
APO*gdp	976	0.220	0.742	0	6.272
APO*gdopgr	976	1.412	3.021	-17.000	17.291

Results

The outcomes of the empirical analyses are presented in Tables 3 to 8. Tables 3 and 4 show the results from a random effect panel model to estimate the effect of the export diversification in the GVC participation of the E&M industries. Equation (1) in Table 3 indicates that the coefficients for both backward and forward GVC shares are negative and statistically significant at the 1% level. Patterns in equations (5) to (8) from Table 4 differ from those in equation (1) to (4) in Table 3.

While not all GVC variables are consistently significant, they predominantly show negative signs when significant. More importantly, the interaction terms of APO member countries and backward GVC share are also negative and statistically significant at the 1% level. Similarly, interaction terms between APO and overall GVC participation are negative and significant at the same level. The interaction terms in equations (3), (4), (7), and (8) show a consistent trend. Interaction terms between APO and GDP growth rate are positive and statistically significant at the 1% level, suggesting that APO member countries might experience lower export diversification in gross export as their GDP growth rate increases.

From the results in Tables 3 and 4, it can be concluded that higher shares in both forward and backward GVC are associated with increased export diversification. Equations (2) to (4) in Table 3 demonstrate significant impacts of GVC participation variables on export diversification. It is observed that the implications for gross exports differ from those for value-added exports, although the signs of coefficients for independent variables are mostly consistent across both types of export. Generally, greater GVC participation or share tends to lead to more export diversification. For APO member countries, backward GVC participation notably contributes to higher export diversification, leading to the conclusion that GVC participation of APO member countries facilitates greater export diversification compared to other countries.

TABLE 3

EFFECTS ON THE EXPORT DIVERSIFICATION OF BOTH E&M INDUSTRIES GVC PARTICIPATION: GROSS EXPORT

	Gross Export			
	Eq (1)	Eq (2)	Eq (3)	Eq (4)
gvbs	-0.0533***	0.0435		
gvfs	-0.0968***		0.0435	
gvp		-0.0968***	-0.0533***	-0.0592***
gdp	0.0002	0.0002	0.0002	0.0002
gdpgr	0.0000	0.0000	0.0000	0.0001
APO	0.0946***	0.0946***	0.0946***	0.0985***
APO*gvbs	-0.0929***	-0.0733		
APO*gvfs	-0.0196		0.0733	
APO*gvp		-0.0196	-0.0929***	-0.0816***
APO*gdp	0.0057	0.0057	0.0057	0.0060
APO*gdpgr	0.0012***	0.0012***	0.0012***	0.0012**
Constant	0.1365***	0.1365***	0.1365***	0.1336***
Obs.	976	976	976	976

Note: * p<.1; ** p<.05; *** p<.01

TABLE 4

EFFECTS ON THE EXPORT DIVERSIFICATION OF BOTH E&M INDUSTRIES GVC PARTICIPATION: VALUE-ADDED EXPORT

	Value-added Export			
	Eq (5)	Eq (6)	Eq (7)	Eq (8)
gvbs	-0.0022	0.0631**		
gvfs	-0.0652**		-0.0631**	
gvp		-0.0652**	-0.0022	-0.0108
gdp	0.0006	0.0006	0.0006	0.0006
gdpgr	0.0003	0.0003	0.0003	0.0003
APO	0.0286	0.0286	0.0286	0.0327
APO*gvbs	-0.0509**	-0.0626		
APO*gvfs	0.0117		0.0626	
APO*gvp		0.0117	-0.0509**	-0.0423*
APO*gdp	0.0075	0.0075	0.0075	0.0074
APO*gdpgr	0.0005	0.0005	0.0005	0.0005
Constant	0.0873***	0.0873***	0.0873***	0.0832***
Obs.	976	976	976	976

Note: * p<.1; ** p<.05; *** p<.01

Tables 5 and 6 show the results from the effect of the export diversification of the electrical equipment industry GVC participation on gross and value-added exports respectively. The estimates of coefficient for backward GVC share and GVC participation are negative and statistically significant at the 5% level in gross export. However, unlike Tables 3 and 4, GVC variables in value-added exports are not statistically significant at conventional levels. For APO member countries, in gross exports, the estimates for the interaction terms between APO dummy and backward GVC share or GVC participation are negative and statistically significant at the 5 or 10% level. In contrast, in value-added exports, most interaction terms between APO and GVC variables are negative and significant at the 1% level.

From the results in Tables 5 and 6, it can be concluded that higher shares in backward GVC and GVC participation rates in the electrical equipment industry are associated with increased export diversification in gross exports. In addition, for APO member countries, GVC variables contribute to higher export diversification, suggesting that GVC participation in the electrical equipment industry among the APO member countries leads to greater export diversification compared to other countries.

TABLE 5

EFFECTS ON THE EXPORT DIVERSIFICATION OF BOTH E&M INDUSTRIES GVC PARTICIPATION: GROSS EXPORT

	Gross Export			
	Eq (1)	Eq (2)	Eq (3)	Eq (4)
gvbs	-0.0375**	-0.0126		
gvfs	-0.0249		0.0126	
gvp		-0.0249	-0.0375**	-0.0358**
gdp	0.0002	0.0002	0.0002	0.0002
gdpgr	0.0000	0.0000	0.0000	0.0000
APO	0.0895**	0.0895**	0.0895**	0.0824**
APO*gvbs	-0.0764**	-0.0695*		
APO*gvfs	-0.0069		0.0695*	
APO*gvp		-0.0069	-0.0764**	-0.0439
APO*gdp	0.0045	0.0045	0.0045	0.0050
APO*gdpgr	0.0012**	0.0012**	0.0012**	0.0011**
Constant	0.1216***	0.1216***	0.1216***	0.1225***
Obs.	976	976	976	976

Note: * p<.1; ** p<.05; *** p<.01

TABLE 6

EFFECTS ON THE EXPORT DIVERSIFICATION OF BOTH E&M INDUSTRIES GVC PARTICIPATION: VALUE-ADDED EXPORT

	Value-added Export			
	Eq (5)	Eq (6)	Eq (7)	Eq (8)
gvbs	0.0147	-0.0224		
gvfs	0.0371		0.0224	
gvp		0.0371	0.0147	0.0178
gdp	0.0006	0.0006	0.0006	0.0006
gdpgr	0.0002	0.0002	0.0002	0.0002
APO	0.0593**	0.0593**	0.0593**	0.0559**
APO*gvbs	-0.0869***	-0.0013		
APO*gvfs	-0.0856***		0.0013	
APO*gvp		-0.0856***	-0.0869***	-0.0801***
APO*gdp	0.0069	0.0069	0.0069	0.0070
APO*gdpgr	0.0007*	0.0007*	0.0007*	0.0007
Constant	0.0664***	0.0664***	0.0664***	0.0680***
Obs.	976	976	976	976

Note: * p<.1; ** p<.05; *** p<.01

Tables 7 and 8 show the results from the effect of the export diversification of the machinery industry GVC participation on gross export and value-added exports. The results observed in Tables 7 and 8 are similar to those in Table 5 and 6, with coefficients for backward GVC share and overall GVC participation are negative and statistically significant at the 5% level in gross export. However, for APO member countries, unlike Tables 5 and 6, the estimates for the interaction terms between the APO dummy and GVC variables are mostly not statistically significant. In particular, nearly none of the interaction terms with APO are statistically significant at any conventional level in value-added export. These results indicate that for gross exports in the machinery industry, higher shares in backward GVC and overall GVC participation are likely to result in greater export diversification. However, being an APO member country does not significantly influence export diversification in value-added exports within the machinery industry.

TABLE 7

EFFECTS ON THE EXPORT DIVERSIFICATION OF BOTH E&M INDUSTRIES GVC PARTICIPATION: GROSS EXPORT

	Gross Export			
	Eq (1)	Eq (2)	Eq (3)	Eq (4)
gvbs	-0.0394**	0.0163		
gvfs	-0.0557		-0.0163	
gvp		-0.0557	-0.0394**	-0.0414**
gdp	0.0002	0.0002	0.0002	0.0002
gdpgr	-0.0000	-0.0000	-0.0000	-0.0000
APO	0.0459	0.0459	0.0459	0.0490
APO*gvbs	-0.0032	-0.1048*		
APO*gvfs	0.1015*		0.1048*	
APO*gvp		0.1015*	-0.0032	0.0114
APO*gdp	0.0052	0.0052	0.0052	0.0058
APO*gdpgr	0.0011**	0.0011**	0.0011**	0.0011**
Constant	0.1240***	0.1240***	0.1240***	0.1228***
Obs.	976	976	976	976

Note: * p<.1; ** p<.05; *** p<.01

TABLE 8

EFFECTS ON THE EXPORT DIVERSIFICATION OF BOTH E&M INDUSTRIES GVC PARTICIPATION: VALUE-ADDED EXPORT

	Value-added Export			
	Eq (5)	Eq (6)	Eq (7)	Eq (8)
gvbs	0.0121	0.0009		
gvfs	0.0113		-0.0009	
gvp		0.0113	0.0121	0.0120
gdp	0.0006	0.0006	0.0006	0.0006
gdpgr	0.0003	0.0003	0.0003	0.0003
APO	-0.0024	-0.0024	-0.0024	-0.0011
APO*gvbs	0.0159	-0.0596		
APO*gvfs	0.0755*		0.0596	
APO*gvp		0.0755*	0.0159	0.0243
APO*gdp	0.0058	0.0058	0.0058	0.0062
APO*gdpgr	0.0004	0.0004	0.0004	0.0004
Constant	0.0720***	0.0720***	0.0720***	0.0719***
Obs.	976	976	976	976

Note: * p<.1; ** p<.05; *** p<.01

The results of the regressions reveal several key findings. First, backward GVC share and overall GVC participation in E&M industries have positive impact on the export diversification, while the impact of forward GVC participation share is less evident. Second, in general, APO member countries' backward GVC share or overall GVC participation leads to their higher export diversification in both E&M industries. Third, higher GDP growth rates in APO member countries are associated with reduced export diversification. These results suggest that GVC participation in E&M industries can aid in diversifying exports, particularly for APO member countries in the electrical equipment industry.

The results are relatively robust in most regressions. However, the analysis is limited to 61 countries and offers a constrained interpretation of the relationship between GVC participation in E&M industries and export diversification. As a complementary approach, the following section uses a CGE model that considers a broader range of countries and provides a more comprehensive analysis of the effects of GVC participation.

Impact of GVCs on Export Diversification: CGE Analyses

Model: Standard GTAP Model

This section employs the standard GTAP model, a computable general equilibrium (CGE) model, to analyze the effects of GVC participation on export diversification. The CGE model bases its analysis on actual data and identifies the structure of the economy, including the behavior of economic variables such as households, businesses, and governments, and the interrelationships among these variables.

The model consists of parameters that show influences and equations derived from these variables and parameters. In general, the model is designed to identify new outcomes when variables undergo changes from an initial equilibrium state. These changes in variables, as the model transitions from the initial to a new equilibrium, are observed, reported, and analyzed.

CGE models are primarily used to empirically derive the impacts of shocks and policies in the economy. This model is particularly suited for analyzing scenarios where changes in one event have ripple effects across the entire economy, not just in isolated industry. For example, the GTAP model is employed to calculate the expected effects of trade liberalization initiatives such as the Uruguay Round and free trade agreements, and to assess the implications of regulating carbon emissions through international climate agreements such as the Kyoto Protocol and the Paris Agreement. It is also applicable in estimating the economic integration impacts between the ROK and the Democratic People's Republic of Korea.

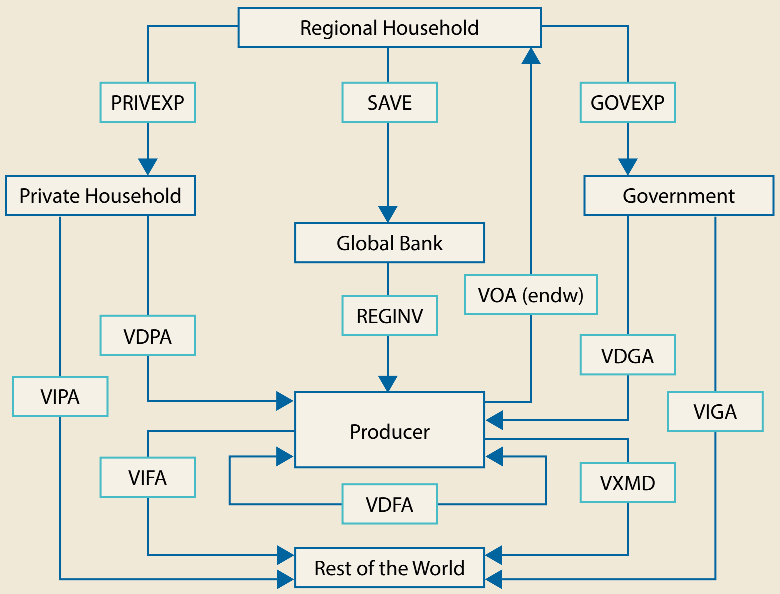
As shown in Figure 5, this study utilizes the Standard GTAP model, which is widely recognized as the most commonly used CGE model for measuring the effects of economic integration or trade liberalization. Figure 5 outlines the interaction within regional households' economic industry, such as private households, governments, and producers, thorough private expenditure, savings, investments, and government spending. As a global model, it also demonstrates interactions with other countries through the trade of goods and services.[7]

The data used in this analysis is from the GTAP DB Version 10.0A. This database, produced by the GTAP Center at the Department of Agricultural Economics of Purdue University, divides the world into 141 countries or regions, 65 industries per country, and 8 production factors.[8] GTAP DB 10.0A collects data including the global social accounting matrix (SAM), imports and exports, national accounts, production by industry, income tax, tariffs, and other relevant economic indicators, which cover available inputs and outputs worldwide. This data is crucial for the analysis, as it provides comprehensive information on global economic interactions. Currently, most CGE model analyses that include multiple countries rely on the GTAP DB; hence, it is the most extensive and reliable dataset available for such studies.

[7] A detailed introduction to the model is presented in Hertel and Tsigas. [8]
[8] For a detailed explanation of the list of countries and regions, industries, and production factors please refer to the GTAP DB Version 10.0A that is available on the website of the GTAP. [9]

FIGURE 5

STANDARD GTAP MODEL STRUCTURE



Source: Hertel and Tsigas [8], page 44

Setting Up the Model

This section focuses on establishing a model that categorizes countries, industries, and production factors. In general, only the countries under analysis are separately categorized. Therefore, for examining the export diversification effects through GVC participation of APO member countries, it is appropriate to consider the 21 APO member countries as a single region. In addition, the United States (U.S.) and the European Union (EU) are categorized separately. All other countries are grouped into a single category named ROW (Rest of the World).

TABLE 9

COUNTRY CLASSIFICATION

	Countries	Description
1	APO	21 APO member countries
2	U.S.	Major economy but not located in Asia
3	EU	Major economy but not located in Asia
4	ROW	Rest of the world

Source: Authors' elaboration

For industry classification, a total of 65 industries have been reclassified according to the focus areas of the analysis. Therefore, the product industry is classified into five categories: agricultural industry electrical equipment industry, machinery industry, other manufacturing industry, and service industry. Given this study's particular interest in the electrical equipment and machinery industries, these are classified separately.

Similar to existing related research, there are eight production factors identified. In this study, they are classified into three types: capital, labor, and natural resources.

TABLE 10

INDUSTRY CLASSIFICATION

	Industry Classification
1	Agricultural industry
2	Electrical equipment industry
3	Machinery industry
4	Other manufacturing industry
5	Service industry

Source: Authors' classification

This section relies on findings from existing literature for analysis. The GTAP model and similar CGE models lack direct variables for representing GVC participation. While it is possible to calculate GVC participation within these models, significant modifications are required to incorporate the variable to be shocked for estimating export diversification. Consequently, this study uses the results from Eugster et al. [4] as proxy variables for GVC participation.

According to Table 11 in Eugster et. al, [4] a 1% decrease in import tariffs results in a 0.1447 to 0.1941% increase in value added, which can be interpreted as a change in GVC participation. This implies that a 1% increase in value added corresponds to a 5.152 to 6.191% decrease in import tariffs. This relationship is employed in the GTAP model to simulate the impact of tariff reduction. Thus, changes (reduction) in import tariff replaces the GVC participation in CGE analyses.

A total of 12 scenarios where tariffs are reduced are proposed for CGE analysis for all countries including APO member countries. As shown Table 11, two scenarios are presented: a low-tariff-reduction-rate scenario with a 5.152% reduction and a high-tariff-reduction-rate scenario with a 6.191% reduction.

Scenarios 2-1 and 2-2 focus on tariff reductions in the machinery industry of APO member countries, categorized as high tariff reduction rate and low tariff reduction rate, respectively. Scenarios 3-1 and 3-2 consider tariff reductions in both electrical equipment and machinery industries of APO member countries, with distinctions between low and high tariff reduction rates. Tariff reduction at a low level means 5.152% and a high level means 6.191%, based on the calculation in the previous paragraph.

Table 12 outlines scenarios similar to those in Table 11 but considers tariff reductions in the electrical equipment or machinery industries across all countries.

TABLE 11

SCENARIOS FOR THE CGE ANALYSES: TARIFF REDUCTION IN APO MEMBER COUNTRIES

Scenario	Conditions
Scenario 1-1-1	A low tariff reduction rate of 5.152% in the electrical equipment industry of APO countries
Scenario 1-1-2	A high tariff reduction rate of 6.191% in the electrical equipment industry of APO countries
Scenario 1-2-1	A low tariff reduction rate of 5.152% in the machinery industry of APO countries
Scenario 1-2-2	A high tariff reduction rate of 6.191% in the machinery industry of APO countries
Scenario 1-3-1	A low tariff reduction rate of 5.152% in both electrical equipment and machinery industries of APO countries
Scenario 1-3-2	A high tariff reduction rate of 6.191% in both electrical equipment and machinery industries of APO countries

Source: Authors' elaboration

TABLE 12

SCENARIOS FOR THE CGE ANALYSES: TARIFF REDUCTION ACROSS ALL COUNTRIES

Scenario	Conditions
Scenario 2-1-1	A low tariff reduction rate of 5.152% in the electrical equipment industry of all countries
Scenario 2-1-2	A high tariff reduction rate of 6.191% in the electrical equipment industry of all countries
Scenario 2-2-1	A low tariff reduction rate of 5.152% in the machinery industry of all countries
Scenario 2-2-2	A high tariff reduction rate of 6.191% in the machinery industry of all countries
Scenario 2-3-1	A low tariff reduction rate of 5.152% in both electrical equipment and machinery industries of all countries
Scenario 2-3-2	A high tariff reduction rate of 6.191% in both electrical equipment and machinery industries of all countries

Source: Authors' elaboration

Results from the CGE Analyses

Table 13 shows the impact in export diversification of changes in tariff reduction rates that result from varying degrees of GVC participation in E&M industries. The table offers a comparison between scenarios of GVC participation change in APO member countries (as shown in Table 11) and scenarios involving all countries (as shown in Table 12). A comparison should be made between corresponding rows.[9] It shows that the GVC participation of all countries, measured by reduction of tariff imposed, has less effects in both export diversification and concentration than that of APO member countries. This implies that impacts of the APO member countries' GVC participation are larger than those of non-APO member countries.

Further analysis of the second and third columns in Table 13 that represent the GVC participation of non-APO member countries and all countries, respectively, indicates that export diversification

[9] For instance, in Table 2-13, the scenario in the second row should be compared with the scenario in the eighth row.

tends to be greater in non-APO member countries, as shown by negative changes in HHI values. However, when all countries, including APO member countries, are considered for HHI calculations, the expected export diversification decreases, as indicated by positive changes in HHI values. This implies that while GVC participation in electrical equipment and machinery industries of APO member countries may reduce their own export diversification, it contributes to more export diversifications in non-APO member countries.

The results from CGE analyses are consistent with those in regressions, indicating that GVC participation by APO member countries generally contributes to export diversification in most countries. However, this may necessarily apply to export diversification within APO member countries. It is important to note that the CGE results should be interpreted with caution, as the analysis uses tariff reduction as a proxy variable for GVC participation in the GTAP analyses, and the significance of these results is not directly demonstrated.

TABLE 13

CHANGES IN EXPORT DIVERSIFICATION (HHI) IN APO MEMBER COUNTRIES

Scenario	Non-APO member countries	All countries
Scenario 1-1-1	-0.053 %	0.021 %
Scenario 1-1-2	-0.071 %	0.028 %
Scenario 1-2-1	-0.016 %	0.006 %
Scenario 1-2-2	-0.022 %	0.009%
Scenario 1-3-1	-0.069 %	0.027 %
Scenario 1-3-2	-0.093 %	0.037 %
Scenario 2-1-1	-0.012 %	0.011 %
Scenario 2-1-2	-0.016 %	0.015 %
Scenario 2-2-1	0.006 %	0.002 %
Scenario 2-2-2	0.008 %	0.003 %
Scenario 2-3-1	-0.006 %	0.013 %
Scenario 2-3-2	-0.008 %	0.017 %

Source: Authors' elaboration
Note: Since this paper uses HHI as an indicator of export diversification, negative numbers in changes mean larger export diversifications and vice versa.

Conclusion

The chapter examined the relationship between GVC participation rates and export diversification, with a focus on APO member countries. Analysis of random effect regressions using panel data reveals that increased GVC participation, particularly in the E&M industries, positively influences the export diversification. Moreover, in APO member countries, higher backward GVC share or overall GVC participation, especially in the electrical equipment industry, is associated with higher export diversification. The chapter also concludes that GVC participation in E&M industries contributes to some extent to export diversification. This is partially corroborated through the CGE analyses that included all countries. It is observed that GVC participation by APO member countries can foster export diversification for other countries as shown with the predictions made in the empirical studies, which are based on a random effect model utilizing panel data.

The findings suggest several policy implications. First, GVC participation appears to be an effective strategy for reducing economic dependence for both APO member countries and others, potentially lowering economic risks. Second, the impact of GVC participation is more pronounced in the electrical equipment industry than in the machinery industry. This suggests that APO member countries should prioritize research and development in the electrical equipment industry, considering its potential complementary relationship with GVC participation (Hur and Lee [10]). Third, GVC participation by APO countries contributes to export diversification in non-APO member countries. This implies that APO member countries should aim to convert the diversified exports of other countries, resulting from their GVC participation, into opportunities for APO member countries by establishing reciprocal and sound supply chains to secure economic stability.

Although this chapter presents the relationship between GVC participation rates and export diversification, certain limitations are acknowledged. First, the panel regression analysis is based on data from only 61 countries, including APO member countries, due to data availability constraints. Second, the CGE analyses substitute tariff reduction for GVC participation, following the approach proposed by Eugster et al., [4] which may yield different effects. Future research should address these limitations and expand on the findings presented in this chapter.

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Appendix

List of 61 Countries for the Empirical Analyses.

- Countries: Australia, Austria**, Bangladesh**, Belgium, Bhutan, Brazil, Brunei Darussalam, Bulgaria, **Cambodia,** Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, **Fiji**, Finland, France, Germany, Greece, **Hong Kong**, Hungary, **India, Indonesia**, Ireland, Italy, **Japan,** Kazakhstan, Kyrgyz Republic, **Lao People's Democratic Republic**, Latvia, Lithuania, Luxembourg, **Malaysia**, Malta, Mexico, **Mongolia**, **Nepal**, Netherlands, Norway, **Pakistan**, People's Republic of China, **Philippines**, Poland, Portugal, **Republic of Korea**, Romania, Russia, **Singapore**, Slovak Republic, Slovenia, Spain, **Sri Lanka**, Sweden, Switzerland, **Republic of China**, **Thailand, Turkiye,** United Kingdom, United States, **Vietnam**

THE EFFECT OF KNOWLEDGE SPILLOVER ON PRODUCTIVITY ENHANCEMENT

Introduction

Knowledge spillover is crucial in elevating participation in GVCs and serves as a wellspring of substantial added value. Piermartini and Rubínová [1] underscored that knowledge exchange, often called knowledge spillovers, amplifies the intensity of interconnections within supply chains linking different countries. Furthermore, it has been recognized that knowledge spillovers traveling through these supply chains are more resilient than the conventional understanding, which relied on factors such as geographical proximity or the volume of trade flows. Singh [2] notably reveals significant productivity improvements attributable to various sources. These include an industry's own research and development (R&D) efforts and the diffusion of knowledge from domestic and foreign sources. In essence, this research underscores the positive impact of knowledge spillovers on industry productivity, highlighting the importance of knowledge transfer in driving innovation and enhancing the competitiveness of industries within GVCs.

The stagnation in productivity growth is attributed to the slow accumulation of knowledge-based capital and the decrease of newly created enterprises. Labor productivity continued to rise from 1990 until the financial crisis but decreased. Both emerging and developing countries and OECD countries display similar labor productivity growth rates. Most countries are expected to experience a slowdown in potential global growth by 2060 due to a weakening labor force resulting from aging populations. [3] Consequently, future economic growth will increasingly depend on advancements in TFP. [4] TFP is critical in investing in knowledge-based capital, implementing competition-friendly reform policies, and disseminating new technologies in advanced global companies. In the future, TFP's growth will significantly impact GDP growth more than labor or capital contributions. In particular, from the perspective of digital transformation, the productivity improvement of medium-high R&D, and knowledge-intensive industries such as electrical equipment and machinery will be more important for growth. In general, these industries play an important role not only in reducing costs, but as a channel of interlinkage with other industries. Han [5] estimated the returns of R&D investment and the magnitude of the spillover effect of all manufacturing companies. This study found that the social and private returns of domestic R&D investment are relatively large in such industries as equipment, electronic parts, and computers, calculated by applying the Bloom, N., Mark Schankerman, and John Van Reenen (BSV) method. In addition, the spillover effect of R&D in the electrical equipment and machinery industry was also relatively high among the entire manufacturing industry, excluding medical materials and pharmaceuticals.

Our study aims to estimate the effect of knowledge spillovers on productivity enhancement with special attention to knowledge-intensive industries (i.e., electrical equipment and machinery) thereafter referred to as the ICT industry. To achieve this, the procedures are set as follows. First, a range of studies that explore the role, characteristics, and effects of knowledge spillovers on productivity growth are identified. Knowledge-based capital comprises intellectual property rights, management know-how, design, software, databases, etc. It is important in promoting technology dissemination and knowledge of advanced global companies. Second, a dynamic panel regression is used to analyze the empirical impact of knowledge spillovers on productivity. Third, barriers to the international knowledge spillover effect are introduced by reviewing the research and analysis conducted by the ROK's Knowledge Sharing Program (KSP) projects, with the aim to derive key common barriers particularly for developing countries. Finally, based on our empirical research findings, the study suggests policy implications focusing on APO member countries. These implications may include promoting collaboration among firms and universities, investing in R&D, improving human capital through education and training, and enhancing institutional quality to facilitate knowledge diffusion and innovation, all of which can contribute to productivity growth. This methodology is adjudicated as appropriate, given its exposition of the causal nexus between knowledge transfer and productivity through the application of dynamic panel regression analysis. Complementary elucidations are furnished via the KSP report, augmenting the foundational analysis.

Literature Review

The amalgamation of empirical research findings offers valuable insights into the intricate dynamics of knowledge transfer and spillovers in international trade and economic development. Knowledge spillovers occur not only domestically but also internationally. Generally, multinational enterprises from high-income countries would carry out much of the world's total R&D activities, possess the bulk of the world's stock of advanced commercial technologies and have most of the advanced technology. These advanced technologies are introduced to developing countries through multiple channels. And it has an impact on improving their productivity. However, no theoretical consensus has yet been reached on the international spillover path of knowledge. [6]

For empirical analysis, there is extensive literature on the impact of the R&D of other firms on the productivity of a particular firm in a closed economy. Despite differences in data, methodology, and measurement methods used in R&D, most studies find that R&D productivity ripple effects exist, although their significance varies significantly from study to study. [7]

Research on the international R&D spillover effect recently originates from Coe and Helpman. [8] This research found that a country's TFP depended on accumulative domestic R&D capital and accumulative foreign R&D capital. Lichtenberg [9] has re-examined the results of Coe and Helpman's estimates, and the empirical results confirm that the more open to trade a country is, the more likely it is to benefit from foreign R&D. Coe and Helpman's method is continuously re-examined through improved econometric methods or different data sets, and each result has been made. Although unstable results are sometimes yielded, the main conclusions remain unchanged most of the time. Kao and Chiang [10] methodologically re-examined the CH method with the panel cointegration method, and empirical results on TFP and domestic R&D capital stock have a positive relationship, yet trade-related international R&D spillover effects do not.

R&D capital stock is insufficient to explain the innovative production process fully. This is the reason why other factors have been added to the Coe and Helpman (CH) model. Human capital variables are considered as direct factors of production [11, 12, 13] as expected, and prove to be statistically significant, while coefficient estimates of domestic R&D capital and international R&D spillover effects are found to be relatively small. Also, several institutional factor variables could be included to address the coefficient robustness issue. The productivity effects of international R&D spillovers largely depend on host country policy environments [14] and local enterprises' technical capabilities. [15]

Supply chain linkages play a crucial role in shaping knowledge spillovers and productivity. Piermartini and Rubínová [16] emphasize the significance of international supply chain connections in amplifying knowledge spillovers, showing their greater robustness compared to traditional determinants like geographical proximity. Active participation in supply chains is vital for economic development.

Di Ubaldo [17] uses Irish firm-level data to explore intraindustry and intraregion spillovers through supply chain linkages, heterogeneity of investors, and domestic firms' absorptive capacity condition spillover effects from multinationals. Results reveal a negative link between foreign-owned firms' and domestic firms' productivity. Selling to foreign-owned firms has a positive effect, while buying from them negatively impacts domestic firms' average productivity.

Kaur and Singh [18] study the relationship between economic growth and knowledge economy variables in 19 developing countries. Positive impacts on TFP are observed with domestic knowledge stock, openness, and interaction terms of foreign R&D spillovers with openness, human capital, and FDI. Higher human capital and international trade lead to increased productivity growth through knowledge spillovers.

Eduardo [19] assesses the role of trade openness as a technology transfer channel across 58 countries over 45 years. While trade openness variation temporarily boosts TFP, its level does not directly affect productivity growth. High- and middle-income countries experience positive effects, while low-income and emerging countries face negative impacts, especially when openness interacts with domestic knowledge stock.

Studies on R&D cooperation and innovation networks highlight various impacts on productivity. Gömleksiz [20] finds that knowledge spillovers via high-tech imports significantly contribute to long-term economic growth, with domestic knowledge stock enhancing growth. However, R&D cooperation's impact is weak, emphasizing the importance of considering the complementary relationship between incoming knowledge and absorptive capacity.

Bernal [21] distinguishes collaboration spillover scenarios in Spanish firms, revealing that incoming knowledge spillovers may amplify or limit collaboration. Cooperation and incoming spillovers may reinforce each other or serve as substitutes, with managerial implications for innovation performance.

Eugster et al. [22] focus on foreign knowledge's impact on domestic innovation, noting a reduction in barriers to the diffusion of foreign knowledge, particularly in emerging economies. Foreign knowledge has a significant influence on domestic innovation, especially amid heightened international competition.

Chen and Dauchy [23] explore the efficacy of foreign R&D for firms, finding substantial benefits for those with a substantial presence in technology frontier nations. The directional vector of technology sourcing is critical in modulating the potency of knowledge spillovers.

Min et al. [24] evaluate regional efficiencies of technology development and commercialization in the ROK, emphasizing the importance of innovation network size and public R&D. Commercialization efficiency is higher in regions with larger innovation networks, and technology development efficiency is higher in regions with more public-focused R&D,

suggesting the need for government policies combining public investment with network building for regional innovation.

Kim et al. [25] investigated knowledge spillovers and their impact on knowledge production and productivity growth in ROK firms. The study, based on firm-level data, revealed that high-technology firms experienced significantly higher growth rates in output, patents, and productivity. Importantly, spillover effects were particularly pronounced for smaller firms and surged after the strengthening of intellectual property rights in the ROK.

Crespi et al. [26] estimated the direct and spillover effects of two matching grants schemes for firm-level R&D investment in Chile. Results indicated that only FONDEF-funded projects generated positive spillovers on firms' productivity. The analysis showed an inverted-U relationship between spillover effects and the intensity of public support, occurring primarily when firms were both geographically and technologically close.

Singh [27] focused on productivity growth in ROK manufacturing industries, using an endogenous growth framework and new international trade theory principles. The study uncovered substantial productivity gains attributed to indigenous R&D efforts and domestic and foreign knowledge spillovers. Notably, international knowledge spillovers through trade played a paramount role during the 1970s and 1980s but diminished in significance in the 1990s. These findings have significant implications for the ROK technology policy and the prevailing intellectual property rights regime.

These studies emphasize the role of intangible assets, particularly human capital and absorption capacity, in enhancing productivity. Aghion and Jaravel [28] highlight the importance of absorptive capacity for growth dynamics and international policy coordination. Demmou et al. [29] explore the intricate relationship between productivity growth, financial development, and institutional factors. Nonnis et al. [30] stress the significance of considering complementarities in intangible assets for detecting knowledge spillover effects, with domestic spillovers proving more effective than foreign ones. David et al. [31] provide clear evidence that R&D and knowledge spillovers complement each other in boosting firm productivity, with R&D policies stimulating investments for other firms and open innovation models increasing demand for R&D within individual firms.

Ali et al. [32] examine the impact of knowledge spillovers on total factor productivity, employing the cross-sectionally augmented autoregressive distributive lag (CS-ARDL) econometric technique. Results indicate that knowledge spillovers contribute to domestic productivity, but the relationship depends on institutional characteristics. Countries with high-quality institutions benefit more from knowledge spillovers, highlighting the prerequisite of policy complementarity for domestic productivity. Weak policy complementarities necessitate a strategy to improve structural and institutional quality.

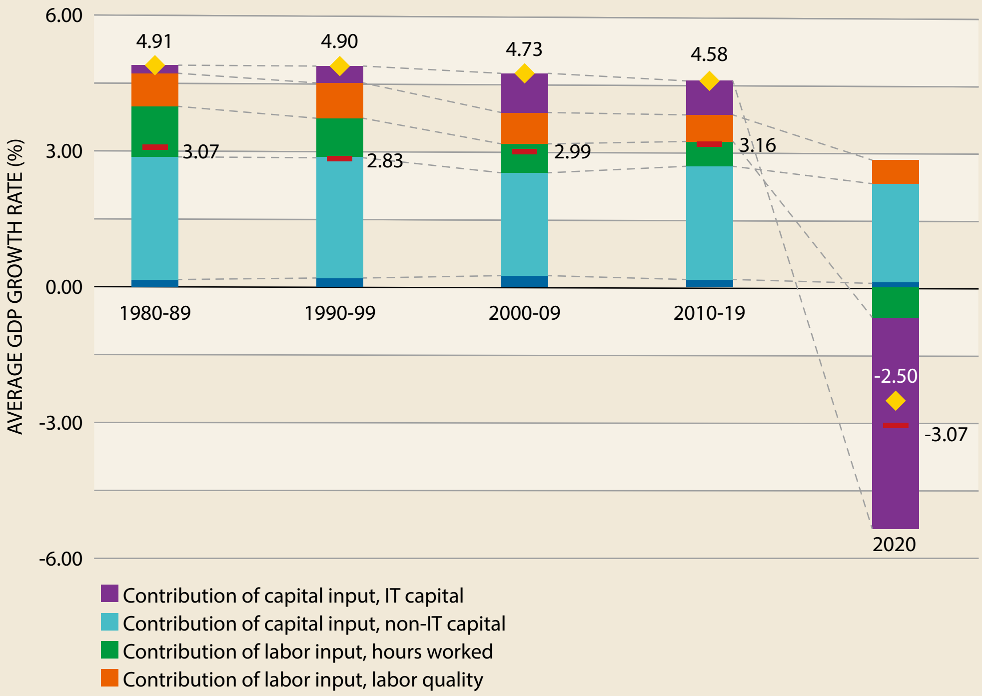
In a related context, Jordaan et al. [33] conduct a comprehensive survey of recent empirical studies on productivity spillovers from affiliates of multinational corporations in developing and emerging economies. The literature survey reveals that various characteristics of multinational corporations, domestic firms, host economy conditions, and mediating factors influence the utilization of local suppliers, the nature of technology dissemination, and the realization of productivity spillovers among domestic firms, with backward linkages from foreign-owned firms to local suppliers serving as the primary channel.

Knowledge Spillover and Productivity Trends

Economic growth is one of the significant national goals worldwide and is always measured by the rate of indicator economic growth. Economic growth can be fostered by increasing the labor and capital inputs used in production. Figure 1 shows APO member countries' average GDP growth rate and growth rate decomposition. The economic growth rate of APO member countries has been above the global average since 1980. On average, it remained about 2% higher and decreased slightly before the COVID-19 crisis. The decline in growth due to the crisis was also affected less than the global average. The TFP in APO member countries was increasing its share of economic growth. Figure 1 shows that the growth contribution (green box) by labor input is decreasing, while the productivity improvement (purple box) is increasing. It showed a sharp turnaround in the face of the COVID-19 crisis.

FIGURE 1

GDP DECOMPOSITION IN APO COUNTRIES, 1980-2020



Source: APO Productivity Database 2022 Version 1, Updated 31 October 2022.
Note: APO member countries only, the value calculated as a simple average of the APO member countries and period due to the availability of the data. However, for 2020, single-year data are presented for comparison.
World averages are shown in red lines, and the 1980s average was 3.07%. APO averages are shown in green dots, and the 1980s average was 4.91%.

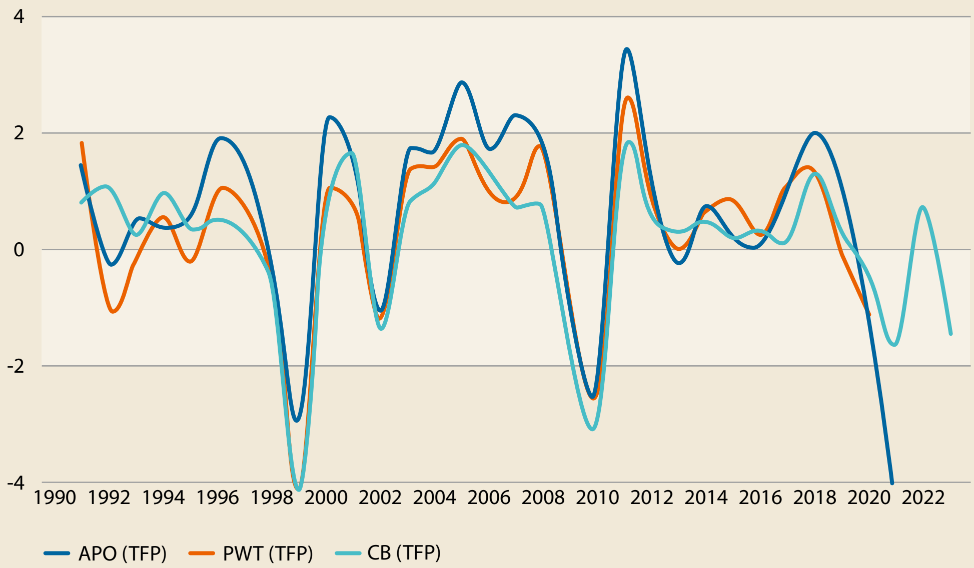
However, the economic growth rate and decomposition alone do not express the economy's productivity well. Productivity is widely accepted as a key economic performance indicator. Productivity is a concept related to increasing output through the same input, which is related to sustainable prosperity, economic efficiency, lower cost, and sustained competitiveness. The most widely used productivity indicator is labor productivity, such as output per worker, value-added units, or TFP.

Since the 1990s, the productivity growth rate of advanced countries has decreased, which is now at historically low levels. [34] However, compared with developed countries, the productivity of APO member countries appears to be relatively higher, and before the COVID-19 crisis, it was around 2%. However, since the COVID-19 crisis, TFP has shown a rapid decline, and policy efforts to recover it are drawing attention.

Figure 2 shows the average TFP growth rate of APO member countries. For comparison, data from the APO productivity database, Penn World Table (PWT), and Conference Board were used, respectively. These three different data sets show the same trend but at different levels. It can be seen that the TFP growth rate of APO member states were growing steadily before 2012, except during the 1998 and 2008 crises. After the global financial crisis, APO member countries faced the problem of declining global productivity. In 2018, when it was recovering, TFP showed a sharp decline in the face of COVID-19 again.

FIGURE 2

COMPARISON OF TREND IN TFP GROWTH RATE OF APO COUNTRIES, 1990-2022

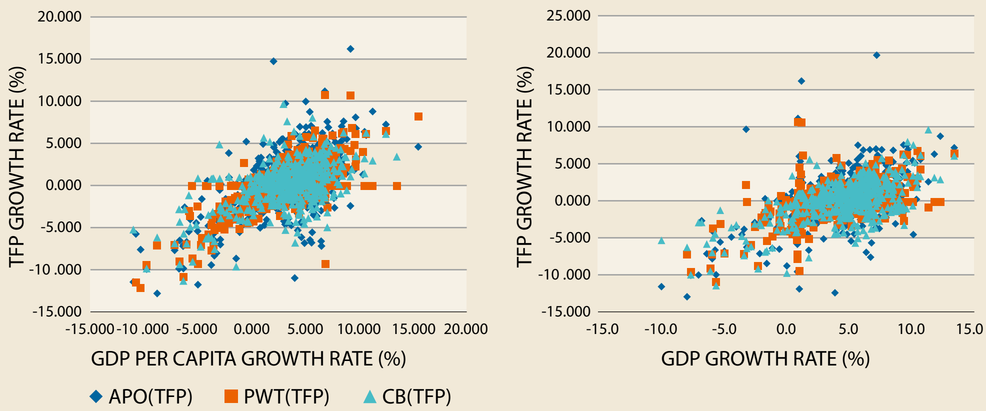


Source: APO Productivity Database 2022 Version 1, Updated 31 October 2022.
PWT version 10.01, 23 January 2023.
The Conference Board Data, Growth Accounting and Total Factor, 2023. 05.03.
Note: APO member countries only, the value is calculated as a simple average of the APO member countries and period.

It is known that economic growth and TFP have a close relationship and have a significant effect on the increase in income. TFP shows productivity changes according to measurable changes in factors, and representative factors include real capital stock, R&D investment (capital input side), quantitative input and human capital of labor (labor input side), learning effect, and technology transfer (market structure and openness side). The same pattern between economic growth and TFP can be seen in APO member countries, and the relationship between the economic growth rate and the TFP growth rate confirmed by available data has a strong positive relationship. Therefore, it proves that TFP can have a major impact on driving economic growth.

FIGURE 3

RELATIONSHIP BETWEEN GDP AND TFP GROWTH RATE

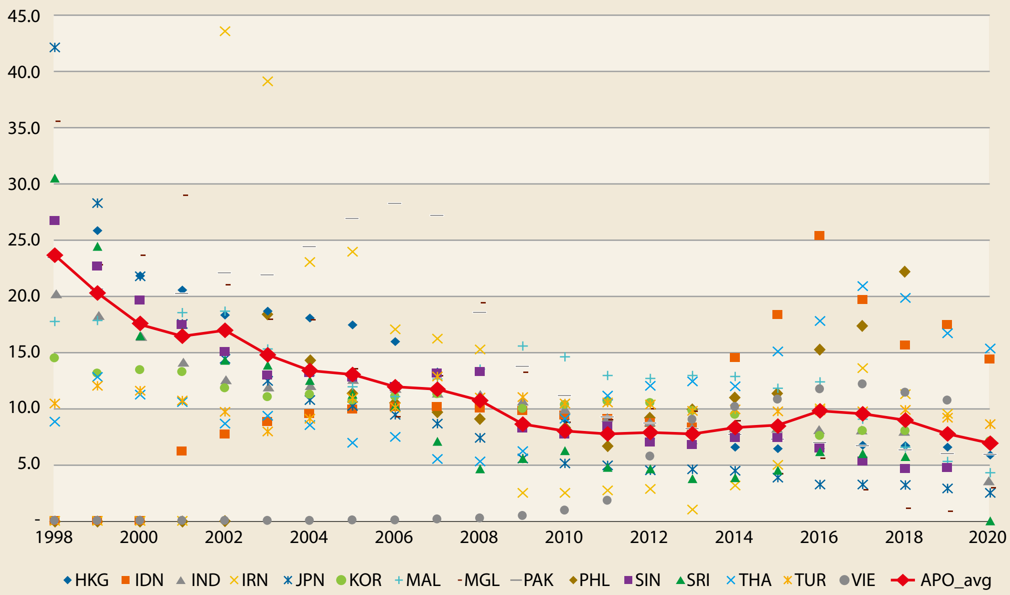


Source: APO Productivity Database 2022 Version 1, Updated 31 October 2022.
Note: All APO member countries included, but outliers and missing data has been deleted, e.g. Bahrain's TFP (APO) does not exist.

After the economic downturn, economic activity is reallocated from high-productivity sectors such as information and communication technology (ICT) to low-productivity sectors such as social services and real estate. This suggests that more productive sectors contract more during recessions. [35] Therefore, this research estimates the impact of a high-productivity industry such as ICT on APO member country's productivity. In this research, due to the data availability, the ICT industry is defined as combining electrical machinery and apparatus, machinery and equipment n.e.c., office, accounting and computing machinery, radio, television, and communication equipment. In particular, it aims to estimate the effect of increasing productivity through knowledge spillover and review the barrier factors that hinder productivity improvement. Through this, productivity improvement in the ICT industry can create high value added during a period of economic recovery.

FIGURE 4

R&D STOCK CAPITAL GROWTH RATE, 1998-2020



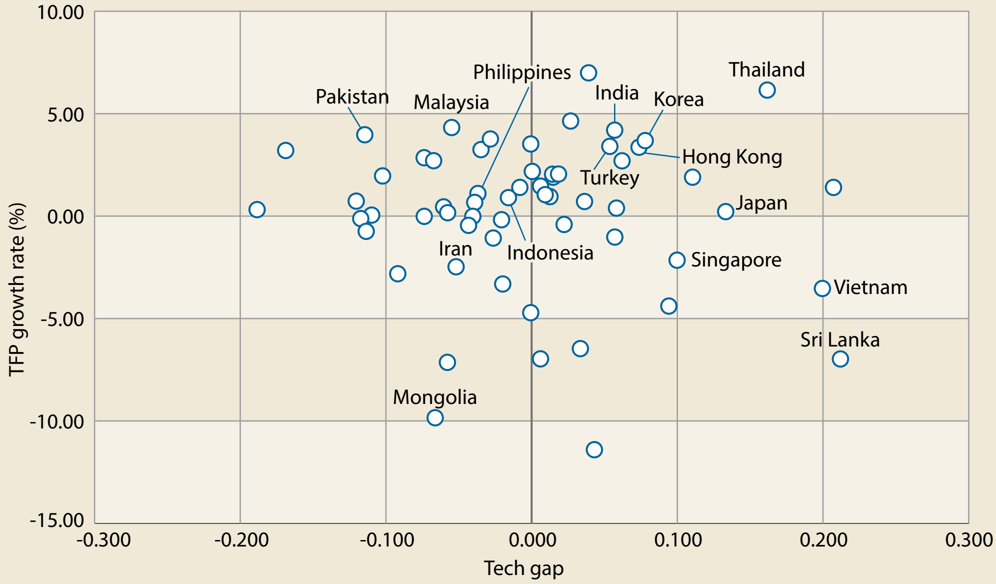
Source: Authors' calculations based on the UNECE GERD, WB WDI, and WITS database (online).
Note: Most APO member countries are included, but some countries are excluded from the graph since they are outliers or their data does not exist.

This study estimated the effect of knowledge spillover using the LP (Lichtenberg and van Pottersberghe de la Potterie) method. Figure 4 provides a year-on-year R&D capital stock growth rate of APO member countries, and the red line in the figure represents the average of the APO member countries. APO member countries' R&D capital stock growth rate has been slowing down since 1998. In recent years, notable countries are Indonesia, Thailand, and the Philippines. These countries converted to a higher level of R&D capital growth than the APO average before and after the 2008 global financial crisis, and until recently, they have shown a high level. This background is due to the government-level investment attraction strategy to overcome low growth, and as a result, foreign direct investment in these countries has been successful as of 2023 (AIF 2023/08/18, AIF 2024/01/04). On the other hand, countries such as Pakistan and I.R. Iran show the opposite trend, which appears to be due to factors such as increased political instability, external debt, and supply chain disruptions.

Another variable considered in the productivity estimation is the technology gap. In this study, for the convenience of analysis, the level of technology gap was calculated based on the TFP average of all APO member countries. This indicates whether it is superior or inferior to the average technical level of APO member countries. The comparison between the technology gap and the growth rate of the TFP is shown in the following figure. Based on zero, a group of countries with an edge in the technology gap and a positive TFP growth rate and a group of countries that are inferior in technology gap but have a negative TFP growth rate are visible.

FIGURE 5

TECHNOLOGY LEVEL GAP AND TFP GROWTH RATE IN APO MEMBER COUNTRIES



Source: Authors' calculations based on the UNECE GERD, WB WDI, and WITS database (online) and APO Productivity Database 2022.

Note: Most APO member countries are included, but some countries are excluded from the graph since they are outliers or their data is not available.

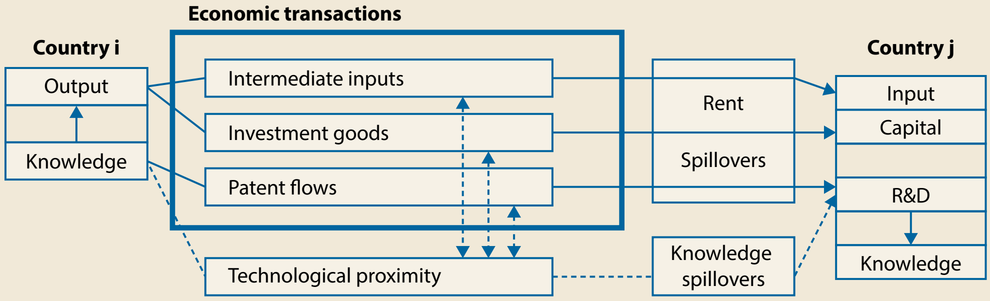
Analysis of Knowledge Spillover Effect

Method

In recent economic growth theories, trade is recognized as a crucial mechanism for disseminating knowledge across borders. Through international trade, domestic productivity experiences an upswing as products infused with foreign knowledge are imported. The quality of imported goods plays a pivotal role in this dynamic, intricately linked to foreign investments in R&D. Consequently, the augmentation of domestic productivity through trade is intimately connected to the influence of overseas R&D efforts.

FIGURE 6

ROUTE OF RESEARCH AND DEVELOPMENT BETWEEN COUNTRIES



Source: van Pottelsberghe [36]

A dynamic panel regression is employed to analyze the dynamic empirical impact of knowledge spillovers on productivity across various countries. To estimate dynamic effects in panel data, the model has current levels of productivity as a function of a proxy variable for knowledge transfer and other control variables. Our panel regression model includes a fixed-effect model specified as follows:

$$TFP_{\mathrm{i,t}} = \alpha + \gamma K_{i,t} + \delta X_{i,t} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

where the subscripts i and t represent country and periods, respectively. TFP is a total factor of productivity. K represents a knowledge variable. Thus, γ is the coefficient of primary interest, reflecting the productivity effect of knowledge transfer, and it is expected to be positive. X is a set of control variables that significantly impact productivity, such as domestic R&D stock, human capital, and other variables (trade openness, labor force, GDP growth, population, and inflation). These variables are in detail below. θ_i and μ_t are countries and time-fixed effects, respectively, and $\varepsilon_{i,t}$ is the error term. The panel fixed effect controls the common characteristics between countries or the effect of common changes by year, it is generally evaluated as a useful method for analyzing the characteristics of individual countries.

Coe and Helpman [8] pioneered domestic TFP based on endogenous growth theory. The study constructed a model influenced by overseas R&D capital stock. Additionally, the research considered the technological gap between countries. The basic model is outlined as follows, with the specified type:

$$TFP_{\mathrm{i,t}} = \alpha + \gamma K_{i,t} + \delta X_{i,t} + \beta TG_{i,t} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

where TG represents the technology gap. The technological gap of country i can be defined as the disparity between the total factor productivity of country i and other countries' average TFP. Hence, a positive technology gap for country i implies that it possesses a higher technology level than the average TFP of the reference APO target country.

Following Nelson and Phelps [37] and Benhabib and Spiegel, [38] this was included to determine the impact of human capital as a determinant of long-term TFP. The study investigated how the impact of R&D on TFP changes by introducing human capital.

$$TFP_{i,t} = \alpha + \gamma K_{i,t} + \delta X_{i,t} + \beta TG_{i,t} + \mu HC_{i,t} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (3)$$

To assess the impact of Griffith et al. [39] and Cameron et al. [40] on technological innovation concerning the technological gap and absorptive capacity, a cross term involving human capital and the technological gap was introduced. The study aimed to investigate the role of human capital in augmenting TFP through technological innovation and to evaluate the effectiveness of improving absorptive capacity in enhancing domestic TFP by facilitating the introduction of technology.

$$TFP_{i,t} = \alpha + \gamma K_{i,t} + \delta X_{i,t} + \beta TG_{i,t} + \mu HC_{i,t} + \Omega TG_{i,t} * HC_{i,t} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (4)$$

Apart from the contribution of human capital to boosting TFP through technological innovation, there is an opportunity to evaluate the impact of improving absorptive capacity. This involves enhancing the ability to absorb and implement technologies from leading countries, testing its effectiveness in elevating domestic TFP. In this context, let $TG*HC$ denote the absorptive capacity of human capital, and Ω signifies the specific effect or outcome resulting from this enhanced absorptive capacity. The goal is to assess how strengthening the capacity to adopt technologies from technologically advanced nations contributes to overall productivity growth.

Data

The dependent variables of this study are productivity-related variables such as GDP, value added, and TFP by industry. The “APO Productivity Databook” and “APO Productivity Database” contain data related to the macroeconomics and productivity of APO member countries, and this data is provided by the APO. This database covers data related to economic development from 1970 to 2020 from Asian countries, with economic growth projections and labor productivity improvement through 2030.

Alternatively, data from international organizations can be used. For example, it is possible to analyze using productivity data from the World Bank. In addition, it is possible to secure consistency through comparative analysis. Using macro data from APO member countries is also considered to calculate labor productivity for the sophisticated analysis through a specific classification of industries. To calculate productivity by sector, UNIDO’s production, added value, and employment data by industry are used. In particular, to classify the ICT industry, Industry 29-32 based on ISIC were classified as ICT industries.

The explanatory variables of this study are the R&D expenditure variable provided by the OECD and UNIDO. However, if the missing value exists between the two periods, it is an imputation with the period average. Conversely, missing values existing at the beginning and end of the time-series were left in a missing state without imputation. Although it is not an elaborate interpolation method, it has been adjusted to increase data availability and suit the model. Then, the data expressed as the proportion of GDP was converted by multiplying the constant GDP as of 2015.

The R&D capital stock was obtained using the permanent inventory method, as in previous studies. The depreciation rate was assumed to be 5% and 15% as in CH, and the average growth rate (g) of R&D expenditure was calculated by averaging the logarithmic value of expenditures in 1996/2021 based on the data availability used in this study. However, the difference between 5% and 15% depreciation rates is not significant, so a 5% depreciation rate was applied in this study. According to Griliches, [41] the R&D capital stock for the initial year used in this study and the R&D capital stock by year using the permanent inventory method are as follows. S is R&D capital stock in the initial year, S^d_t is R&D capital stock by year by permanent inventory method, and RD is R&D investment amount. Subscripts i and j represent APO member countries, and t is the period, respectively.

$$S^d_{96} = \frac{RD_{96}}{0.05 + g}, \; S^d_t = (1\text{-}0.05)\, S^d_{t\text{-}1} + RD_t\text{-}1 \tag{5}$$

The foreign R&D capital stock flowing into the domestic economy obtains the total amount of technology embodied in imports by weighted average based on its income, and three overseas R&D capital stocks can be calculated according to the weight calculation method. Since trade measures the degree of interrelationships between different national economies, all foreign knowledge stocks should be weighted on average by imports from that country.

The weighted average is used in two ways, depending on CH and LP. First, according to the Coe and Helpman [8] method, embodied knowledge from foreign countries uses import value between countries as weights, reflecting the direction of trade and deriving a long-term relationship between variables. The foreign knowledge stock flow is derived by a weighted average of imports from that country. In the following equation, S^d_{jt} is the R&D capital stock of country j, M used the trade amount data of the WITS, M_{it} is the import amount from country j, and M_{it} is the total import amount of country i.

$$S^{CH}_{it} = \sum_{j \neq i} (M_{ijt}/M_{it})\, S^d_{jt} \tag{6}$$

Lichtenberg and van Pottersberghe de la Potterie [36] criticized the CH method, pointing out the possibility of aggregation bias and that it does not reflect the strength of trade. Accordingly, it was proposed to use the domestic import to the GDP of the other country as a weight for the overseas R&D capital stock instead of the total import. Finally, it can be obtained by simply averaging the R&D capital stock of each country.

This study measured knowledge transfer from abroad using a modified LP method to measure knowledge transfer between APO countries. This method was chosen due to the incomplete trade and R&D data between countries. In the following estimation, in the same way as the above equation M used the trade amount data of the WITS, and Y is the constant GDP as of 2015.

$$S^{LP}_{it} = \sum_{j \neq i} (M_{ijt}/Y_{it})\, S^d_{jt} \tag{7}$$

Finally, the obstacles to accepting knowledge transfer in each country were considered. In addition, explanatory variables generally used to analyze productivity were included. [42, 43, 44, 45, 46] Therefore, the analysis included human capital, income level (GDP per capita), institution, regulation, foreign direct investment (FDI), and overseas development assistance (ODA).

Country-level data are used for 15 APO member countries observed between 1996 and 2020, collected primarily from OECD’s Research and Development Statistics database, UNESCO’s science, technology and innovation database, and the World Development Indicators’ online database. Among the 21 APO member countries, Bangladesh, Cambodia, the ROC, Nepal, Fiji, and Lao PDR were excluded due to data availability, as time-series gaps exist or some variables were missing in the target period. Detailed source, coverage, and descriptive statistics of the variables used in this study are as follows.

TABLE 1

VARIABLE CONTENTS

Category	Contents	Coverage
Productivity	APO, Productivity Database TFP, Labor productivity (LP) PWT Database TFP The Conference Board Data TFP UNIDO, INDSTAT 2 2023, ISIC Revision 3 Sectoral output, value added, employment	1996-2020 15 Selected APO member Countries
Knowledge	OECD & UN, Science and Technology Indicators GERD as a percentage of GDP World Bank, WDI Research and development expenditure	1996-2021 15 Selected APO member Countries
Import Share	WITS, Trade statistics by Country Trade statistics by country and product (product code using ISIC Rev. 3)	1996-2021 15 Selected APO member Countries
Other	PWT Database Human capital index (based on years of schooling and returns to education) World Bank, WDI GDP per capita Export and Import goods and services Foreign direct investment, net inflows Net official development assistance received Rule of Law & Regulatory Quality	1996-2021 15 Selected APO member Countries

Source: APO Productivity Data, PWT 10.01, The Conference Board Data Central, WB- Global Productivity, WITS, UNIDO- INDSTAT,
https://www.apo-tokyo.org/publications_category/data-book/
https://www.worldbank.org/en/research/publication/global-productivity
http://wits.worldbank.org/
https://www.rug.nl/ggdc/productivity/pwt/?lang=en
https://www.oecd.org/sti/msti.htm
https://stat.unido.org/database/INDSTAT%202%202023,%20ISIC%20Revision%203

TABLE 2

DESCRIPTIVE STATISTICS OF VARIABLES

Variable		Mean	St. Dev	Min	Max	N
Productivity	APO	0.9748	0.1014	0.6764	1.2281	375
	PWT	0.9337	0.1039	0.6150	1.1620	312
Tech gap		-0.0006	0.0841	-0.2710	0.3240	375
Knowledge	Domestic	7,056.11	7,492.24	4.10	32,017.30	339
	Foreign	3,006.51	3,769.40	1.30	22,245.30	339
Import Share	Total	0.1440	0.1453	0.0100	0.6300	353
	ICT	0.0615	0.0852	0.0000	0.4500	353
Other	Human capital	2.5890	0.5570	1.4690	4.3520	360
	Export	218,410.13	211,918.36	2,320.00	871,000.00	376
	Import	220,434.63	205,442.39	3,010.00	856,000.00	376
	Openness	1.0310	0.9928	0.1969	4.1224	376
	FDI inflow	14,390.22	24,891.72	-4,950.00	181,000.00	390
	ODA received	864.56	1,036.22	-939.00	4,220.00	291
	Role of law	0.1812	0.8198	-1.0537	1.8702	345
	Regulation	0.2107	0.9294	-1.7092	2.2553	345

Source: APO Productivity Data, PWT 10.01, The Conference Board Data Central, WB- Global Productivity, WITS etc.

TABLE 3

MAJOR EXPORTERS AND IMPORTERS OF CHARGES FOR THE USE OF INTELLECTUAL PROPERTY

Unit: Million USD, %

	Export Value in 2020	Export Value in 2021	Export Share in 10 economies 2020	Import Value in 2020	Import Value in 2021	Import Share in 10 economies 2020
European Union	144,002	163,303	37.5	206,018	242,204	50.5
Extra-EU exports	93,251	115,259	24.3	152,291	188,583	37.3
United States of America	115,558	124,613	30.1	47,708	43,342	11.7
Japan	43,065	47,860	11.2	37,629	46,889	9.2
United Kingdom	23,873	23,503	6.2	28,223	29,222	6.9
Switzerland	23,242	29,916	6.0	26,418	27,457	6.5
People's Republic of China	8,879	11,948	2.3	16,031	17,759	3.9
Singapore	8,673	11,648	2.3	15,345	17,813	3.8
Canada	7,210	8,535	1.9	13,684	16,311	3.4
Republic of Korea	6,855	8,023	1.8	9,890	11,130	2.4
United Arab Emirates	3,050	3,268	0.8	7,241	8,632	1.8

Source: WTO, World Trade Statistical Review 2022

Results

Empirical Results on TFP

In Model (1), the study investigated how domestic and foreign research and development (R&D) capital stocks impact productivity. The results revealed a positive influence of only domestic R&D capital stocks on productivity. Importantly, the impact of foreign R&D capital stock is not significant. This indicates that when analyzing TFP from a capital input perspective, knowledge spillover from abroad does not have a substantial impact on domestic productivity.

Model (2) analyzed the impact of the technological gap and other factors on TFP. The results revealed a positive influence of both domestic and foreign R&D capital stocks on productivity. And it was found that the lower the technological gap in each country, the worse the TFP. This suggests that TFP will improve if one country can reduce its technological gap compared to other countries, and this can be achieved through knowledge spillover or domestic R&D capital input.

Following Nelson and Phelps [37] and Benhabib and Spiegel [38] this was included to determine the impact of human capital as a determinant of long-term TFP. In Model (3), an analysis included the human capital index to assess the role of human capital as a determinant of long-term TFP. The findings indicated that even when considering the human capital factor, overseas research, and development capital stock continues to exert an impact on productivity, and human capital also contributes positively to total factor productivity, although not significantly.

In Model (4), the study investigated the impact of the technology gap and absorptive capacity as defined by Griffith et al. [39] and Cameron et al. [40] on technological innovation. A cross term between human capital and the technological gap was introduced to assess its effect. The analysis aimed to test the role of human capital in enhancing TFP through technological innovation and to evaluate the effectiveness of improving absorptive capacity to boost domestic TFP by facilitating the introduction of technology from technologically advanced countries. The findings indicated that human capital contributes to increased TFP through technological innovation. In addition, it indicates that the reduction of technology gaps has a greater impact on TFP. Consequently, this implies that overall productivity can also rise by improving the country's technological gap by effectively utilizing human capital.

TABLE 4

THE IMPACT OF KNOWLEDGE TRANSFER TO TFP

	M1	M2	M3	M4
Domestic R&D stock	**0.0655**** (2.45)	**0.0649***** (6.49)	**0.0595***** (5.84)	**0.0579***** (5.26)
Foreign R&D stock	0.0224 (1.01)	**0.0184**** (2.56)	**0.0167**** (2.69)	**0.0169***** (3.11)
Technology gap		**-0.8206***** (-14.09)	**-0.8176***** (-16.39)	**-1.1842***** (-6.08)
Human capital			0.0305 (1.71)	**0.0355*** (1.81)
Human capital *Technology gap				**0.1544*** (1.92)
Constant	-0.8159*** (-4.90)	-0.7771*** (-15.84)	-0.7938*** (-22.04)	-0.7936*** (-18.73)
Observations	307	307	307	307
R^2	0.559	0.856	0.859	0.861
Adjusted R^2	0.556	0.855	0.857	0.859

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The findings of this study indicate that TFP is experiencing a positive impact due to the influence of research and domestic development capital stock in both developed and developing countries (Table 5). Meanwhile, foreign R&D capital stock appears to have a significant positive effect on total factor productivity in developing countries. This indicates that knowledge transfer from abroad in developing countries is a major factor in improving productivity. However, it was observed that the influence of the technological gap on TFP is more pronounced in developing countries than in developed ones. Additionally, while human capital growth in developing countries appears to have a positive effect on TFP, it was not a significant coefficient.

TABLE 5

COMPARISON OF HIGH- AND MIDDLE-LOW-INCOME GROUPS

	High-income group		Middle-low-income group	
	M2	M3	M2	M3
Domestic R&D stock	**0.088*** (2.53)	0.080 (1.93)	**0.055***** (6.09)	**0.052***** (5.04)
Foreign R&D stock	0.007 (0.28)	0.008 (0.33)	**0.022***** (3.19)	**0.019**** (2.84)
Technology gap	**-0.765***** (-10.10)	**-0.725***** (-8.41)	**-0.826***** (-14.34)	**-0.835***** (-14.99)
Human capital		0.022 (0.72)		0.034 (0.76)
Constant	**-1.095***** (-6.17)	**-1.087***** (-6.31)	**-0.884***** (-12.51)	**-0.880***** (-10.47)
Observations	93	93	214	214
R^2	0.886	0.888	0.848	0.850
Adjusted R^2	0.882	0.883	0.846	0.847

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: High-income countries were classified according to the World Bank's national classification as of 2021. For other countries, middle-income and low-income were classified into one classification.

Empirical Results on ICT Productivity

Our study estimates the effect of productivity through knowledge spillover in the ICT industry. To do that, a variable for foreign ICT R&D stock is made. ICT productivity is calculated using UNIDO's Industrial Statistical Data, using ISIC industry classification that regards electrical machinery and apparatus, machinery and equipment n.e.c., office, accounting and computing machinery, radio, television, and communication equipment as ICT industries. Labor productivity in the ICT industry is a concept that measures the number of workers as a denominator and the added value in molecules. Value added includes not only labor but also the value created by various factors of production. Meanwhile, the knowledge spillover effect of the ICT industry is measured by ICT import. The LP method described above was used in the same manner.

In models (1) and (2), domestic R&D stock was found to have a positive effect on productivity, and no statistically significant coefficients were derived in the remaining models. However, all models showed that foreign ICT R&D stock positively affected productivity. It was found that although a technological gap worsens productivity and an improvement of human capital strengthens productivity, it does not show consistent results. This suggests that even if ICT knowledge spillover is absorbed domestically, there is a limit to increasing productivity through technological innovation.

TABLE 6

THE IMPACT OF KNOWLEDGE TRANSFER TO PRODUCTIVITY IN THE ICT INDUSTRY

	M1	M2	M3	M4
Domestic R&D stock	**0.1980**** (2.47)	**0.1948**** (2.53)	0.1371 (1.67)	0.1271 (1.59)
Foreign ICT R&D stock	**0.1755***** (4.37)	**0.1756***** (3.96)	**0.1607***** (3.00)	**0.1617***** (3.32)
Technology gap		0.5485 (0.80)	0.5899 (0.84)	-0.7299 (-0.22)
Human capital			0.2772 (1.72)	**0.3007*** (1.86)
Human capital * Technology gap				0.5715 (0.41)
Constant	1.4781** (2.35)	1.5084** (2.52)	1.4323** (2.55)	1.4603** (2.68)
Observations	297	297	290	290
R^2	0.567	0.574	0.583	0.585
Adjusted R^2	0.564	0.570	0.577	0.577

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In advanced economies, productivity seems to be driven by human capital development. However, in developing countries, the impact on productivity is more pronounced with both foreign and domestic ITC R&D investments. Furthermore, the widening technology gap significantly hampers productivity in developing countries, and there is a notable lack of influence from human capital on productivity. Hence, it is crucial to thoroughly examine the factors hindering the transfer of human capital and knowledge to enhance productivity in the ICT industry and incorporate these insights into policymaking.

TABLE 7

COMPARISON OF HIGH- AND MIDDLE-LOW-INCOME GROUPS

	High-income group		Middle-low-income group	
	M2	M3	M2	M3
Domestic R&D stock	0.2295 (2.06)	0.0418 (0.42)	**0.2112**** (2.30)	**0.2278**** (2.56)
Foreign ICT R&D stock	0.0852 (0.64)	0.1288 (1.06)	**0.1764***** (3.45)	**0.1875**** (2.44)
Technology gap	-1.0618 (-0.92)	-0.0575 (-0.06)	0.8410 (1.22)	0.7805 (1.14)
Human capital		**0.4730**** (4.88)		-0.1422 (-0.29)
Constant	2.3521 (2.30)	2.6009** (3.34)	1.1305 (1.67)	1.2403 (1.38)
Observations	96	93	201	197
R2	0.596	0.664	0.587	0.585
Adjusted R2	0.583	0.649	0.581	0.576

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Note: High-income countries were classified according to the World Bank's national classification as of 2021. For other countries, middle-income and low-income were classified into one classification.

Barriers to International Knowledge Spillover Effect

In the previous analysis, it was observed that the productivity of APO member countries is affected not only by domestic R&D capital, human capital, and technological gap but also by foreign R&D capital, which proxies knowledge spillover between nations, and that the effects of such knowledge spillover varied depending on the income levels of countries. Particularly, it was the developing countries that were more affected by international knowledge spillover and technology gap in ICT industry. Thus, in this section, the factors that hinder and weaken the effects of international knowledge spillover are to be explored, with a particular focus on developing countries.

The channels through which knowledge is transmitted and spilled between countries include 1) direct learning through communication, including face-to-face interaction, and 2) indirect diffusion of technological knowledge embodied in intermediate goods via trade and foreign direct investment. [47]

For these channels to work and give rise to international knowledge spillover effects, minimizing the impediments to the inflow, transfer, learning, and internalization of knowledge is crucial. Among various factors that affect the channels, the domestic status of institutions, absorptive capacity, and finances are emphasized here as they were in previous literature and are amenable to improvement through policy cooperation and government efforts.

Institutions are related to appropriability conditions, which refer to environmental factors that enable an innovator to capture private returns from innovation by creating barriers to imitation. [48] The most common proxy used for institutions is the protection of intellectual property rights. Foreign investors are unlikely to invest in a place where their investment benefits are not guaranteed but instead exploited. Therefore, it would be challenging for knowledge to flow from the outset in countries without a patent protection system.

Absorptive capacity refers to the ability to identify, assimilate, and exploit knowledge from the environment. [49, 50] If there is a scarcity of skilled workforce and the levels of R&D investment and science, technology and innovation (STI) system are low in the country, it would mean that the country's absorptive capacity is very limited.

The financial status of a country should also be considered. Limited financial capability would hamper domestic firms' further investment in capitalizing on the transferred knowledge and further innovation. The firms would face challenges in financing innovation because intangible assets from knowledge investments might be difficult to use as collateral in securing loans, [51] in which case government intervention would be necessary.

Coe & Helpman [52] include variables related to institutions and absorptive capacity—the strength of intellectual property rights (IPR), ease of doing business, and the quality of tertiary education—in their empirical research on the impact of foreign R&D capital stocks on TFP and find that they are important determinants of TFP. Silva and Vonortas [53] also list limited absorptive capacity, institutional, and financial barriers as moderating variables that hamper innovation's effect.

TABLE 8

KEY BARRIERS TO KNOWLEDGE SPILLOVERS

Barriers	Contents	Measures
Institutional Barriers	- Explicit structure: differences in legal systems, IPR regime, licensing agreements, industrial standards, taxation legislation - Tacit elements: bad business practices, inefficient bureaucratic patterns	- IPR index - FDI Regulatory restrictiveness index - Industrial standards alignment - Doing Business / Business Ready Index
Limited Absorptive Capacity	- Scarcity of human capital - Low R&D investment - Lack of STI system - Lack of information on markets and technologies	- The average number of years of schooling or school enrollment [54, 55] - Standardized science and engineering test scores [56] - R&D investment variables
Financial Barriers	- Uneven access to funding across countries - Underinvestment in R&D of knowledge identified as a quasi-public good - Difficulty in securing loans with intangible knowledge assets	- Sensitivity of R&D investments to changes in cash-flows [57] - Combining financial data with innovation survey data [58]

Source: Silva and Vonortas [53]

This section aims to identify the kinds of institutional barriers, absorptive capacity limitations, and financial barriers to international knowledge spillovers. As a way of confirming the barriers suggested in the traditional literature and delving into more specific causes on a country-by-country basis, the study reviewed final consultation reports of the Knowledge Sharing Program (KSP)[10] conducted with APO member countries on IPR protection, R&D and innovation, education (technical and vocational education and training (TVET) and higher education), and financial sector initiatives from the period 2011-23. The reason for adopting such a method is that these KSP reports conduct in-depth interviews and surveys with local government officials and key stakeholders and analyze the current situation and major issues of the target country through field investigations. Therefore, reviewing the KSP reports allows for identifying evidence-based specific barriers and also providing insights into creating an environment conducive to knowledge spillover through policies and institutional arrangements.

Institutional Barriers (Lack of Intellectual Property Protection)

Institutional barriers can include tacit elements such as inappropriate business practices, lack of social trust, inefficient bureaucratic patterns, and tangible structure of regulatory framework. Among the latter, the most essential factor is related to the regime of intellectual property rights.

The extent to which intellectual property rights are well-protected institutionally is crucial in assessing an environment conducive to effective international knowledge spillovers. In countries with strong intellectual property rights protection, there is a greater likelihood of a more proactive inflow of foreign technologies. Ultimately, this facilitates the dissemination of technology and knowledge, leading to higher rates of domestic patent applications, thereby fostering the advancement of domestic technology and TFP. In the case of the ROK, it has been observed that a 1% increase in the patent application rate results in a 0.11% increase in GDP within three to five years. [59]

Recognizing the importance of intellectual property (IP) protection, many APO member countries, including countries from the Association of Southeast Asian Nations (ASEAN), the regional intergovernmental organization comprising ten-member states in Southeast Asia, applied for KSP consultation on IP management, valuation, and infrastructure.

According to the 2018 and 2021 KSP with ASEAN, although ASEAN has continuously strived to create a harmonious IP system in line with its goals of an integrated economic community, there were evident disparities among member countries in the field of IP protection. Among them, Malaysia (IP marketplace, invention rating, invention value assessment support, IP financing through IP value assessment), Thailand (IP prototype production, IP marketplace, patent transaction experts, IP transaction consulting), and Singapore (patent management, IP marketplace, patent transaction experts, IP financing through IP value assessment) have implemented the most diverse range of IP utilization policies and programs. Other countries have much room for improvement in these institutional and policy aspects. Lao PDR and Cambodia, among others, have very minimal patent applications themselves, and their related laws and regulations are either absent or at a very

[10] ROK's Knowledge Sharing Program (KSP) is a development cooperation platform designed to share the development experience of the ROK and knowledge and collaboratively devise practical solutions for the development challenges faced by partner countries. Annually topics are selected based on the needs of partner countries, and through field studies and surveys, the current situation and key issues in the respective countries are analyzed. Due to limited number of projects each year, the standardized approach of addressing the same topic across all APO countries each year is not followed, making a direct country-by-country comparison difficult. Also, the topics are not specific to electric and machinery industries. Nevertheless, by examining the status and issues of countries that have previously undertaken similar projects in the past, it is possible to extract specific constraint factors and derive insights for all relevant countries. Note that projects dating 2010 and earlier have been excluded for temporal relevance. For more information on the KSP, refer to its website (https://www.ksp.go.kr/english/index).

early stage of development. The countries with relatively solid institutional measures for IP protection show a much higher number of patent applications. As a result, it appears challenging to expect the inflow of foreign knowledge and regional spillover effects as a cohesive ASEAN community.

Despite these disparities in terms of institutions and the capacity of examiners between countries, a few common barriers related to IPR could be extracted from the analyses of the reports. They can be summarized as 1) no linkage between IPR policies and small medium enterprises (SMEs) and industrial policies, which would lead to a lack of strategic planning and ineffective incentives for innovation companies, 2) low awareness of the importance of IPR protection among the public, including government officials, 3) scarcity of qualified IP service human resources including examiners.

TABLE 9

BARRIERS IDENTIFIED IN KSP REPORTS RELATED TO IPR

Country	KSP year and topic	Identified Barriers
Philippines	IP Human Resources (2021) [60]	- No comprehensive law governing IP service human resource development - Weak and blurry accreditation system for each IP legal agent, valuation analyst, technology transfer agent, information analyst, personnel at R&D institutes
ASEAN	IP Valuation (2021) [61]	- Valuation model not considering the country's main industrial technologies - Only a few countries have laws, guidelines, and education programs relevant to IP valuation (Singapore, Thailand, Malaysia, the Philippines) - Lack of IP Valuation framework and system (Brunei, Cambodia, Lao PDR)
	IP Infrastructure (2018) [59]	- Need for support policies for IP creation and utilization among local SMEs - Low public awareness on the importance of IPR - Lack of a standardized common application format and procedure → Constraints on regionally integrated system - Disparity in patent substantive examination (e.g. Brunei delegates to Europe, Australia, Cambodia to Japan, Singapore, Europe) - Scarcity of Examiners (Lao PDR, Cambodia)
Islamic Republic of Iran	IP Enhancement (2016-18) [62]	- Prolonged economic sanctions, continuous decline of foreign patents → Lack of knowledge sharing - No linkage between IPR policies and SME policies - Outdated and ambiguous copyright system
Bangladesh	IP Management (2014) [63]	- Need for coherent IP policy & strategy - Low public awareness - Limited IP education in universities

Source: KSP Policy Consultation Reports of each mentioned country and year.

Limited Absorptive Capacity (Scarce Qualified Human Capital)

Human resources are a core factor in economic development, and production can be maximized when an adequate supply of human resources is available. Furthermore, having skilled and competent human resources is essential for absorbing and internalizing knowledge from abroad, contributing to enhanced domestic productivity. Achieving the development of human resources and the improvement of vocational skills among the population requires substantial efforts and investment at the national level to establish a comprehensive system.

To adapt to the increasing economic activities and the development of the manufacturing sector, it is essential to forecast the changes in labor demand and to develop vocational education programs that meet these evolving demands.

Common barriers identified in the analysis of past KSP projects include 1) lack of linkage with corporates that results in vocational education curricula leaning towards theory rather than practical application, 2) inadequate competence of instructors, 3) lack of independent trainee evaluation, 4) the absence of an integrated plan for human capital and vocational education leading to inefficient management systems among institutions, 5) scarcity of data and shortage of experts for labor demand forecast for technical workforce within industries.

TABLE 10

BARRIERS IDENTIFIED IN KSP REPORTS RELATED TO EDUCATION & TVET

Country	KSP year and topic	Identified Barriers
Vietnam	Linkage between TVET and Enterprises (2017) [64]	- TVET programs focusing on theoretical aspects, lacking practical application - Low corporate support - Lack of trainers with practical skills - Lack of independent trainee evaluation - Ineffective organization management - Lack of statistics on system performance - Need for a better forecasting of industrial demands for labor: more granular data and regular establishment census needed
	HRD for Enterprises & Labor Demand Forecast (2012-13) [65]	- Need for annual workforce survey for labor demand forecast - Need for a nationwide online network interconnected as a system to facilitate rapid execution of job placement - Limited investment in the budget, facilities, equipment and organization of the central employment information management office

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Country	KSP year and topic	Identified Barriers
Sri Lanka	Education ICT (2016, 2014) [66,67]	- Poor facilities and programs lead to low educational quality - Significant regional disparities. Completion rates for secondary education also vary widely across regions. → ICT leveraging initiatives required to overcome such regional gap - Establishment of ICT Hubs that connect national, provincial, and zonal levels is recommended. However, the school internet penetration rate is around 30%, with a very slow speed, making it impossible to use e-learning services - No dedicated institution for educational informatization
	TVET (2012) [68]	- No vocational high school, only training institutions - Sub-par programs at the vocational training institutions, failing to meet the demands of new industrial sectors - Lack of social awareness—wage levels in the government sector are the highest, followed by agriculture, manufacturing, and services - Training for educators needed - Poor infrastructure and lack of resources
Vietnam, Sri Lanka, Indonesia, India	TVET (2012) [69]	- Much room for improvement in the quality of education, curriculum development, teacher training, facilities and equipment. Urgent need for a budget increase overall - Ineffective industry-academia collaboration due to insufficient ability of industries to participate - (India & Sri Lanka) With over 70% of the workforce engaged in agriculture and majority of industries consisting of SMEs, there is a shortage of active participation in industry-academia collaboration. In a system centered around SMEs, entrepreneurship education and business incubation initiatives should be expanded - (Vietnam) Some universities are in the early stages of initiatives such as internships and curriculum development linked to industries. However, they are still small-scale, and there is a need to expand and systemize these efforts

Source: KSP Policy Consultation Reports of each mentioned country and year.

Limited Absorptive Capacity (Need for National Technology Innovation System (NIS) and R&D System)

The technological development strategy in developing countries can be broadly categorized into two main approaches: the multinational corporation (MNC)-led strategy and the national-led strategy.

The latter involves domestic companies and government collaboration to drive technological advancement. In this approach, the emphasis is not solely on domestic sourcing but also on introducing, assimilation, and improving foreign technologies through technology licensing and strategic partnerships. This becomes a significant source of technological innovation, with domestic companies and government research and development investments playing crucial roles. The ROK has adopted the national-led strategy, separating capital and technology imports and supporting technology transfer through government-funded research institutions. The focus is on absorbing and improving introduced technologies through dedicated research and technology consulting. [65]

Other countries, such as Cambodia, have opted for the former approach, where capital, technology, and managerial expertise integrated by MNCs are transferred. However, a drawback is that these resources may only be utilized within the MNC and may not easily transfer to other companies or industries.

To overcome this limitation, active government intervention is necessary to encourage domestic companies to enter and compete. The government needs to proactively provide incentives, such as tax benefits, to multinational corporations, urging them to enhance education and training for local employees. This ensures that domestic engineers understand the know-how and knowledge, enabling them to improve and effectively utilize the technology.

Other key barriers to weakening absorptive capacity in the national R&D and science and technology innovation system include the following, 1) low technological demand, especially in the early stages of industrial development, and the country relying on external funding such as ODA without making significant domestic investment, 2) weak industry-academia collaboration, 3) discrepancies between science and technology strategy and national development strategy, resulting in a system that moves in a dispersed manner, 4) lack of infrastructure in related areas such as ICT.

TABLE 11

CONSTRAINTS IDENTIFIED IN KSP REPORTS RELATED TO NIS AND R&D SYSTEM

Country	KSP Year and Topic	Identified Barriers
Lao PDR	Start-up and Exporters promotion (2021) [70]	- Very complex business registration procedure, high taxes, strict regulations for startups - Low ICT infrastructure
Pakistan	Knowledge-based Economy: NIS (2014) [71]	- Limited and blurred role of R&D organization - Low level of technology demand - Insufficient educated and skilled workforce. The education system is built upon the colonial legacy of producing people for government jobs and not for entrepreneurship - Political instability
Sri Lanka	Techno-entrepreneurship (2013, 2014) [67] Technology Business Incubators	- Very low R&D investment - Reluctance to try technology startups remains large - S&T lectures focus on teaching, rather than conducting market-driven research - S&T graduates leaving the field due to poor salary and research culture - Difficulty of entrepreneurship to access seed funding
Cambodia	STI Promotion (2013) [72]	- Insufficient government investment in S&T—70% of R&D funding coming from ODA and NGOs - Low level of technology demand - Need for strengthened education and training systems - Insufficient capacity of public research institutions, weak collaboration among industry, academia and research institutions

Source: KSP Policy Consultation Reports of each mentioned country and year.

Financial Barriers (Underdeveloped Financial Sector)

To realize the utilization of incoming knowledge for technological innovation and increased productivity, it is imperative for enterprises to invest resources. However, if domestic funding is inherently insufficient or the financial system is not well developed, posing challenges in mobilizing external funds, the realization of the knowledge spillover benefits may become difficult. In intangible assets, obtaining loans from banks is more challenging than for physical assets. Therefore, these hindering factors will likely have a more significant impact on those trying to assimilate transferred technology and seek innovation.

To overcome these, KSP has conducted research on capital market development, technology guarantee and rating system issues.

TABLE 12

CONSTRAINTS IDENTIFIED IN KSP REPORTS RELATED TO THE FINANCIAL SECTOR

Country	KSP Year and Topic	Identified Barriers
Mongolia	Cross-border Securities Issuance and Investment Infrastructure (2019) [73]	High transaction costs Top tier companies' preference for overseas direct listing Insufficient information disclosure by state-owned enterprises (SOEs) Lack of legal systems and supervision
Thailand	Technology Guarantee and Rating System (2015-16) [74]	Relatively well established with National Science and Technology Development Agency (NSTDA) support programs, venture capital fund and SME banks. NSTDA's subsidy programs to be improved
Vietnam	Technology Evaluation System (2015) [75]	Loans from financial institutions mostly offered to SOEs, making it more difficult for SMEs to secure funds No system to evaluate innovative SMEs and provide information to foreign investors
Indonesia	Credit Rating System for MSMEs (2014-15) [76]	Reluctance from banks to lend to cooperatives and SMEs, especially for new start-ups and innovative SMEs Insistence on collateral-based lending Non-existent or limited credit guarantee schemes Credit ratings and credit information systems not available Non-bank financing not widely explored (e.g. venture capital, angel investment, factoring and leasing)
Lao PDR	IT Infrastructure and System for Bond Market (2014) [77]	Concentration in short-term government bonds Lack of investor diversity Insufficient legal framework Lack of understanding about capital markets Lack of specialized workforce

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Country	KSP Year and Topic	Identified Barriers
Cambodia	Bond Market (2014) [78]	Limited financial accessibility for SMEs, with no funding support mechanisms through policy intermediaries
	Industrial Development through Financial System (2013) [79]	Scarce non-bank markets: underdeveloped securities, bond, insurance markets which are key windows for long-term fund supply to industry
		Underdeveloped money market: highly dollarized transactions and lack of electronic financial networks
	SME Banking (2011)	Low public participation in financial markets: only 12% of the population has financial transactions with banks.

Source: KSP Policy Consultation Reports of each mentioned country and year.
Note: Micro small and medium-sized enterprises (MSMEs)

In conclusion, all of these barriers—institutional and financial barriers and limited absorptive capacity—are expected to impact knowledge transfer channels through FDI and trade significantly. From the perspective of foreign companies and investors, factors such as the protection of intellectual property rights and the skill level of the local workforce are crucial determinants in the decision-making process for entering and investing in a particular country. However, these hindering factors will likely have a lesser impact in channels involving direct learning, such as technology cooperation ODA and knowledge-sharing initiatives. Therefore, from the perspective of developing countries, there is a need to pursue knowledge sharing through such channels actively. Strengthening institutional capacity and absorptive capabilities through this direct learning can create a foundation for smoother knowledge diffusion and a more significant spillover effect through trade and FDI.

Policy Implication and Limitation

The enhancement of TFP can be achieved through the transfer of knowledge from one country to another. This phenomenon not only elevates the productivity levels within the recipient country but also positively impacts global productivity as the disseminated knowledge becomes integrated into various facets of production, such as capital and R&D, among others. This research investigates the potential of knowledge transfer in augmenting productivity across member countries of the APO. Additionally, a more detailed examination is conducted within the context of the ICT industries including the electronics and electrical industries.

The study highlights a positive correlation between domestic and foreign R&D capital stocks and productivity. Notably, the impact of domestic R&D capital stock was more substantial than that of its foreign counterpart, underscoring the significant influence of knowledge spillover from foreign sources on domestic productivity. Moreover, the research identified that a wider technological gap in each country correlates with lower TFP. This suggests that enhancing TFP is attainable by narrowing the technological gap relative to other countries, a feat achievable through knowledge spillover or the cultivation of human capital. The results also demonstrated that human capital contributes to increased TFP through technological innovation, emphasizing the potential for overall productivity improvement by effectively leveraging human capital to bridge the country's technological gap.

The study reveals a favorable effect stemming from the influence of R&D capital stock in developed and developing countries. Notably, the impact of the technological gap on TFP is more accentuated in developing countries than in developed ones in APO member countries. Furthermore, an increase in human capital in developing nations appears to have a positive correlation with TFP, suggesting that improving human capital could enhance overall productivity by narrowing the technology gap.

Our study focuses on estimating the impact of knowledge spillover on productivity within the ICT industry. The analysis indicates a positive correlation between domestic R&D stock and productivity. Moreover, the findings reveal statistically consistent and significant positive effects of foreign ICT R&D stock on productivity. Despite the aggravation of productivity due to a widening technological gap, introducing human capital does not seem to generate absorptive capacity. This implies that while the domestic absorption of ICT knowledge occurs, there are constraints on leveraging technological innovation to enhance productivity further.

The analysis results of classifying the country's income level showed that it is important to reduce the technology gap and increase openness (Appendix table A1). These results are consistent with previous studies. In developed countries, factors such as the development of human resources, the establishment of research networks, the strengthening of corporate-level technology absorption capacity, international R&D cooperation, and domestic intellectual property protection appear to be more important than the capital accumulation or capital input. In addition, since the major policy tasks facing each country are different, and it appears that research by country is being conducted to solve them. And beyond the knowledge spillover, research on the reverse knowledge spillover is also being conducted.

Therefore, from the perspective of policymakers, policies to increase the inflow of R&D capital stock and national-level R&D investment policies are expected to be effective in developing countries, and policies to improve the quality of domestic human capital and establish an international R&D cooperation system are expected to be effective in developed countries. And basically, from a long-term perspective, it is believed that human resource development policies should be accompanied.

Knowledge spillover in APO member countries can be impeded by various factors, with notable obstacles including institutional barriers, limited absorptive capacity, and financial constraints. Institutional barriers, exemplified by inadequate protection of intellectual property rights in certain nations, hinder foreign technology inflow due to unmet appropriability conditions. The absence of skilled human resources poses a challenge in absorbing and internalizing knowledge transmitted from abroad. Developing a competent workforce and enhancing vocational skills demand substantial national-level efforts and investment, including forecasting labor demand and formulating suitable education programs. In case of financial barriers, if domestic funding is inherently insufficient or the financial system is not well developed, posing challenges in mobilizing external funds, the realization of knowledge spillover benefits may be difficult. It is particularly so for intangible assets that face more difficulty securing loans. Policies to develop capital markets technology guarantee and rating systems are required in many countries. Additionally, even with FDI inflow, the transferred knowledge may be confined within MNCs and not easily disseminated to other firms and industries. Overcoming this limitation necessitates government intervention, encompassing incentives for MNCs, technological licensing, strategic partnerships, and substantial investments in national science, technology, and research and development (S&T and R&D) to maximize the international knowledge spillover effect.

The process of knowledge spillover from abroad to impact domestic productivity may involve a significant time lag. Acquiring new or essential knowledge is one step, but its utilization within the relevant industry takes additional time. To address this delay, policies are crucial to expedite the application of overseas patents and promote swift utilization of foreign knowledge by domestic companies. Government interventions, such as the removal of obstacles hindering the application of foreign patents, along with the provision of active tax benefits, can facilitate the rapid assimilation and application of overseas knowledge within the domestic industry.

Moreover, when MNCs establish a presence in a specific country, they often refrain from subcontracting to local firms and typically utilize inexpensive local labor solely for assembling imported components into finished products. While this may yield short-term advantages, it does not facilitate knowledge spillover. Local entities do not reap the benefits of acquiring advanced skills, sophisticated management practices, improved technologies, and training opportunities. In the cases of the ROK and the ROC, various regulatory measures were implemented to attract multinational companies and encourage technology transfer, resulting in the emergence of world-class multinational corporations. To enable APO member countries to effectively absorb knowledge transfer from multinational companies within their borders, the role of government regulations that enhance human capital and absorptive capacity becomes paramount.

In conclusion, the research underscores the critical role of knowledge spillover, particularly in the medium to high R&D and knowledge-intensive industries (i.e., electrical equipment and machinery sector), for enhancing TFP across APO member countries. The positive correlation between domestic and foreign R&D capital stocks and productivity highlights the substantial impact of knowledge spillovers from foreign sources. However, challenges such as institutional barriers, limited absorptive capacity, and financial constraints can impede effective knowledge spillover. Policymakers should focus on reducing the technological gap, increasing openness, and implementing policies tailored to the specific needs of both advanced and emerging APO member countries. Additionally, fostering human capital development and establishing international R&D cooperation systems are crucial for long-term productivity improvements. Overcoming obstacles to knowledge spillover requires strategic government interventions, including incentives for MNCs, technological licensing, and investments in science, technology, research, and development.

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Appendix

Model Robustness Check

The following table shows the analysis results, including other control variables, to verify the robustness of the data used in the analysis and the model. In addition to the basic model, FDI inflow, income level, and rule of law variables were added to examine the main variables' coefficient changes. As a result of the analysis, it was found that the coefficient of the extra control variables was not significant, and reduced data availability caused distorted estimation results.

TABLE A1

THE IMPACT OF KNOWLEDGE SPILLOVER TO TFP (APO)

	M1	M2	M3	M4	M5	M6	M7	M8
Domestic R&D stock	**0.065****	**0.065*****	**0.059*****	**0.058*****	**0.059*****	**0.063*****	**0.057*****	**0.075*****
	(2.45)	**(6.49)**	**(5.84)**	**(5.26)**	**(6.11)**	**(6.91)**	**(6.80)**	**(6.89)**
Foreign R&D stock	0.022	**0.018****	**0.017****	**0.017*****	**0.011****	**0.011***	0.003	-0.002
	(1.01)	**(2.56)**	**(2.69)**	**(3.11)**	**(2.46)**	**(2.14)**	(0.45)	(-0.22)
Technology gap		**-0.821*****	**-0.818*****	**-1.184*****	**-1.360*****	**-1.381*****	**-1.454*****	**-1.618*****
		(-14.09)	**(-16.39)**	**(-6.08)**	**(-8.03)**	**(-7.42)**	**(-7.78)**	**(-6.08)**
Human capital			0.030	**0.035***	0.023	0.019	0.017	0.013
			(1.71)	**(1.81)**	(1.47)	(1.22)	(1.06)	(1.23)
TG * HC				**0.154***	**0.244*****	**0.254*****	**0.294*****	**0.389*****
				(1.92)	**(3.51)**	**(3.50)**	**(4.27)**	**(3.33)**
Openness					**0.056*****	**0.057*****	**0.058*****	**0.076*****
					(4.39)	**(4.61)**	**(5.52)**	**(6.43)**
FDI inflow						-0.001	-0.002	0.000
						(-0.46)	(-0.99)	(0.07)
GDP per capita							0.056	
							(1.71)	
Rule of law								-0.001
								(-0.21)
Constant	-0.816***	-0.777***	-0.794***	-0.794***	-0.803***	-0.799***	-1.142***	-0.947***
	(-4.90)	(-15.84)	(-22.04)	(-18.73)	(-20.03)	(-12.10)	(-4.78)	(-8.43)
Observations	307	307	307	307	297	290	290	137
R2	0.559	0.856	0.859	0.861	0.849	0.854	0.857	0.881
Adjusted R2	0.556	0.855	0.857	0.859	0.846	0.851	0.853	0.874
sigma_u	0.177	0.171	0.163	0.160	0.169	0.174	0.209	0.163
sigma_e	0.057	0.033	0.032	0.032	0.031	0.031	0.031	0.028
rho	0.906	0.965	0.962	0.961	0.967	0.969	0.979	0.971

The analysis results divided by the country's average income level were additionally presented. In high-income countries, it was confirmed that the technology gap and openness had a significant influence. On the other hand, in middle-low-income countries, both foreign and domestic R&D capital stock were confirmed to be significant variables, and openness also affects productivity improvement.

TABLE A2

THE IMPACT OF KNOWLEDGE SPILLOVER TO TFP (APO): HIGH INCOME

	M2	M3	M4	M5	M6
Domestic R&D stock	**0.088* (2.53)**	0.080 (1.93)	0.080 (1.93)	0.046 (1.41)	**0.074** (3.22)**
Foreign R&D stock	0.007 (0.28)	0.008 (0.33)	0.000 (0.02)	0.005 (0.31)	-0.006 (-0.41)
Technology gap	**-0.765*** (-10.10)**	**-0.725*** (-8.41)**	-3.304 (-2.09)	**-1.127* (-2.44)**	**-1.165* (-2.36)**
Human capital		0.022 (0.72)	0.015 (0.70)	0.042 (2.02)	0.026 (1.82)
TG * HC			0.834 (1.70)	0.229 (1.78)	0.229 (1.61)
Openness				**0.097** (3.57)**	**0.075** (4.68)**
FDI inflow					-0.000 (-0.05)
Constant	-1.095*** (-6.17)	-1.087*** (-6.31)	-0.987** (-4.48)	-0.915*** (-6.44)	-1.037** (-5.05)
Observations	93	93	93	93	90
R2	0.886	0.888	0.895	0.919	0.929
Adjusted R2	0.882	0.883	0.889	0.913	0.923
sigma_u	0.173	0.161	0.161	0.076	0.037
sigma_e	0.030	0.029	0.029	0.025	0.024
rho	0.972	0.968	0.969	0.900	0.698

TABLE A3

THE IMPACT OF KNOWLEDGE SPILLOVER TO TFP (APO): MIDDLE-LOW INCOME

	M2	M3	M4	M5	M6
Domestic R&D stock	**0.055*** (6.09)**	**0.052*** (5.04)**	**0.052*** (4.85)**	**0.058*** (3.99)**	**0.074** (3.22)**
Foreign R&D stock	**0.022*** (3.19)**	**0.019** (2.84)**	**0.019*** (3.22)**	0.015 (1.79)	-0.006 (-0.41)
Technology gap	**-0.826*** (-14.34)**	**-0.835*** (-14.99)**	**-1.082*** (-5.29)**	**-1.079*** (-4.85)**	**-1.165* (-2.36)**
Human capital		0.034 (0.76)	0.036 (0.73)	0.025 (0.54)	0.026 (1.82)
TG * HC			0.110 (1.23)	0.104 (0.89)	0.229 (1.61)
Openness				0.035 (1.01)	**0.075** (4.68)**
FDI inflow					-0.000 (-0.05)
Constant	-0.652*** (-15.55)	-0.685*** (-17.01)	-0.686*** (-13.64)	-0.728*** (-16.07)	-1.037** (-5.05)
Observations	214	214	214	204	90
R2	0.848	0.850	0.850	0.813	0.929
Adjusted R2	0.846	0.847	0.847	0.807	0.923
sigma_u	0.126	0.111	0.110	0.118	0.037
sigma_e	0.033	0.033	0.033	0.033	0.024
rho	0.934	0.918	0.916	0.927	0.698

The same robustness check was performed for ICT labor productivity and ICT R&D capital stock. In the case of the ICT industry, the effect of foreign R&D stocks was more pronounced, and the impact of human capital was consistently positive. As in the above results, the extra control variables' coefficient was insignificant, and reduced data availability caused distorted estimation results.

TABLE A4

THE IMPACT OF ICT KNOWLEDGE SPILLOVER ON ICT PRODUCTIVITY

	M1	M2	M3	M4	M5	M6	M7	M8
Domestic R&D stock	**0.198**** **(2.47)**	**0.195**** **(2.53)**	0.137 (1.67)	0.127 (1.59)	0.118 (1.46)	0.128 (1.61)	0.069 (0.98)	0.109 (0.99)
Foreign ICT R&D stock	**0.176***** **(4.37)**	**0.176***** **(3.96)**	**0.161***** **(3.00)**	**0.162***** **(3.32)**	**0.177***** **(3.18)**	**0.143**** **(2.36)**	0.099 (1.64)	0.171* (1.83)
Technology gap		0.549 (0.80)	0.590 (0.84)	-0.730 (-0.22)	-0.709 (-0.19)	-1.526 (-0.40)	-1.853 (-0.55)	0.512 (0.43)
Human capital			0.277 (1.72)	**0.301*** **(1.86)**	**0.331**** **(2.25)**	**0.328**** **(2.30)**	**0.305*** **(2.06)**	**0.336***** **(5.08)**
TG * HC				0.572 (0.41)	0.550 (0.34)	0.869 (0.52)	1.060 (0.72)	-0.491 (-0.98)
Openness					-0.139 (-0.73)	-0.117 (-0.60)	-0.108 (-0.61)	-0.118 (-0.58)
FDI inflow						0.029 (0.90)	0.022 (0.68)	-0.014 (-0.59)
GDP per capita							0.389 (1.13)	
Rule of law								-0.015 (-0.25)
Constant	1.478** (2.35)	1.508** (2.52)	1.432** (2.55)	1.460** (2.68)	1.512** (2.77)	0.997 (1.27)	-1.360 (-0.60)	2.165*** (3.70)
Observations	297	297	290	290	289	282	282	132
R2	0.567	0.574	0.583	0.585	0.594	0.593	0.600	0.633
Adjusted R2	0.564	0.570	0.577	0.577	0.586	0.583	0.589	0.609
sigma_u	0.476	0.478	0.437	0.437	0.503	0.483	0.299	0.652
sigma_e	0.237	0.235	0.231	0.231	0.225	0.222	0.220	0.190
rho	0.802	0.805	0.781	0.782	0.833	0.825	0.648	0.922

The ICT industry was also analyzed by dividing the national income level. In high-income countries, most variables except human capital were not found to be significant. In other words, ICT productivity in high-income countries could be confirmed through more sophisticated corporate-level analysis. On the other hand, in middle-low-income countries, both foreign and domestic R&D capital stock were confirmed to be significant variables as in the above results. In particular, in Model 5, the intersection term shows a significant positive effect, which means that if there is no technology gap, the productivity improvement effect through human capital is great.

TABLE A5

THE IMPACT OF ICT KNOWLEDGE SPILLOVER TO ICT PRODUCTIVITY: HIGH-INCOME

	M2	M3	M4	M5	M6
Domestic R&D stock	0.229 (2.06)	0.042 (0.42)	0.049 (0.50)	0.124 (0.60)	0.234 (1.36)
Foreign ICT R&D stock	0.085 (0.64)	0.129 (1.06)	0.151 (1.21)	0.140 (0.99)	0.112 (0.76)
Technology gap	-1.062 (-0.92)	-0.058 (-0.06)	9.394 (0.76)	4.611 (0.32)	5.432 (0.46)
Human capital		**0.473**** **(4.88)**	**0.500**** **(3.39)**	0.441 (2.32)	0.368 (2.31)
TG * HC			-3.049 (-0.82)	-1.723 (-0.42)	-2.091 (-0.63)
Openness				-0.215 (-0.54)	-0.317 (-0.88)
FDI inflow					-0.008 (-0.30)
Constant	2.352 (2.30)	2.601** (3.34)	2.217 (2.22)	2.055 (2.03)	1.666 (2.02)
Observations	96	93	93	93	90
R2	0.596	0.664	0.672	0.680	0.700
Adjusted R2	0.583	0.649	0.653	0.658	0.674
sigma_u	0.519	0.425	0.416	0.673	1.019
sigma_e	0.204	0.186	0.185	0.184	0.182
rho	0.866	0.839	0.834	0.931	0.969

TABLE A6

THE IMPACT OF ICT KNOWLEDGE SPILLOVER TO ICT PRODUCTIVITY: MIDDLE-LOW INCOME

	M2	M3	M4	M5	M6
Domestic R&D stock	**0.211**** **(2.30)**	**0.228**** **(2.56)**	**0.187**** **(2.23)**	**0.226**** **(3.02)**	0.234 (1.36)
Foreign ICT R&D stock	**0.176***** **(3.45)**	**0.188**** **(2.44)**	**0.191***** **(3.46)**	**0.137*** **(2.07)**	0.112 (0.76)
Technology gap	0.841 (1.22)	0.780 (1.14)	-5.490 (-1.33)	**-8.610*** **(-1.89)**	5.432 (0.46)
Human capital		-0.142 (-0.29)	-0.081 (-0.23)	-0.162 (-0.53)	0.368 (2.31)
TG * HC			2.927 (1.49)	**4.502*** **(2.03)**	-2.091 (-0.63)
Openness				0.341 (1.42)	-0.317 (-0.88)
FDI inflow					-0.008 (-0.30)
Constant	1.131 (1.67)	1.240 (1.38)	1.437* (1.98)	1.401* (2.15)	1.666 (2.02)
Observations	201	197	197	196	90
R2	0.587	0.585	0.611	0.643	0.700
Adjusted R2	0.581	0.576	0.600	0.632	0.674
sigma_u	0.372	0.416	0.372	0.405	1.019
sigma_e	0.244	0.243	0.236	0.222	0.182
rho	0.698	0.746	0.712	0.769	0.969

SPILLOVER OF ELECTRICAL EQUIPMENT AND MACHINERY INDUSTRIES THROUGH FINANCIAL DEVELOPMENT ON PRODUCTIVITY

Introduction

The Asia-Pacific region has emerged as an undeniable powerhouse in the globalized world. Its economies have woven themselves into a complex tapestry of interdependence fueled by the relentless rhythm of GVCs. These intricate networks, where production fragments and disperses across borders, have led to Asia-Pacific's economic success. But beyond the staggering trade figures and rising GDPs lies a more nuanced story, one where GVCs and productivity engage in a delicate interaction, shaping the region's economic trajectory.

To understand this intricate interplay, it is imperative to first grasp the multifaceted nature of GVCs. Imagine an ordinary smartphone. Its journey from conception to consumer's fingertips is a testament to the interconnectedness of our world. Raw materials like cobalt and lithium, mined in multiple countries, converge in factories across continents, and continents, and by skilled workers into circuit boards and intermediate products, before being finalized into consumable products. These components then embark on a logistical challenge, crossing borders, exchanging hands, and undergoing complex processes before finally being bought by consumers worldwide. This is the essence of a GVC—a collaboration at the international level and specialization through which value is added at every step.

For Asia-Pacific economies, GVC integration has been a double-edged sword. On the one and possibly more dominant hand, it has unleashed a wave of productivity gains. Specialization allows countries to focus on their comparative advantages, mass-producing high-quality goods and services at a competitive pace. Knowledge transfers foster technological advancements and innovation in the Asia-Pacific region facilitated by foreign direct investment and international collaborations. The outbreaks of innovation in the electrical equipment and machinery industries have been especially noteworthy. The E&M industries act as the heart of the Asia-Pacific region's economy. More than just nuts and bolts, they are the invisible hands shaping its industrial landscape, driving productivity, and fueling its ascent in the GVC race. The involvement in GVC translates to tangible results—a surge in labor productivity, a decline in production costs, and a strengthened position in global markets.

However, on the other hand, the GVC line has its complexities. Participants often come at the cost of vulnerability. Dependence on imported inputs and export markets exposes economies to external shocks such as volatile commodity prices or trade tensions. The whole world observed and experienced the seriousness of interconnection when COVID-19 disrupted the supply chains. The relentless pursuit of efficiency can lead to overspecialization, locking countries into low-value-added segments of the chain and even trapping some countries due to insufficient international flows of intermediate goods. Moreover, the benefits of GVC participation are often unevenly distributed across countries. Countries with specialization in specific industries will benefit differently or even be hurt by GVC participation.

Therefore, endeavors to benefit from GVC must be strategic and multidimensional. Merely inserting oneself into the chain is not enough. Maximizing the potential benefits requires a conscious effort to climb the value ladder. Investments in education and training are crucial to equip workforces with the skills needed for higher-order tasks. Fostering innovation and technological prowess allows countries to move beyond mere production and embrace design, research, and brand development. Strengthening regional infrastructure and regulatory frameworks facilitates seamless trade and collaboration, creating an environment conducive to shared prosperity. Lastly, providing a market in which financing is achieved with reasonable standards and haste is crucial for businesses to get involved. Government aid to enhance the absorptive capacity of domestic companies should be provided. Knowledge and technology spills across borders throughout the process of GVC and countries, especially developing countries, need to be prepared to exploit the exposure and find ways to substantially increase their added value.

This chapter looks at the role of E&M industries in APO member countries in inducing national productivity through GVC and considers each country's financial development as a channel through which the spillover effects occur across countries. This chapter constructs a variable that uses productivity measures of machinery and electrical industries separately for each APO member country. Value-added information from the Inter-Country Input-Output table is used to account for the channel that connects the E&M industries of one country to the TFP of another. The weight is used to represent how much of the productivity spillovers across borders.

This research shows interesting results. Machinery industry productivity spillover effects are positive for low-income countries when the local government gets involved. Electrical industry productivity spillover effects are affected by the bank channel. Both spillover effects are negative but have the potential to become positive with enough financial development. Both E&M spillover effects are significant only for low-income countries. The rest of the chapter is as follows. The second section overviews the literature on GVC, financial development, and productivity. The third section describes the data and empirical specification. The fourth section presents the empirical results. And the final section concludes and provides policy implications.

Theoretical Review

Financial Development and Productivity

Financial development acts as a conductor in the intricate collaboration between GVCs, productivity, and knowledge spillovers. Its influence can amplify or dampen the reverberations of knowledge and innovation, ultimately shaping a country's economic trajectory within the GVC framework. A well-developed financial system acts as a platform for countries aspiring to boost productivity. By providing access to diverse financial instruments—loans, equity, trade finance—it empowers businesses to invest in technology and innovation, embrace specialization, and navigate through multinational complexities.

Upgrading machinery to keep up with other countries, adopting cutting-edge practices, and venturing into R&D all require substantial capital. Financial markets facilitate this by channeling funds from savers to innovative ventures, bridging the gap between ideas and implementation. By equipping a sound financial system, FDI and foreign portfolio investment (FPI) are attracted, bringing capital along with valuable expertise, technology, and managerial know-how. This influx of knowledge spillovers accelerates a country's learning curve, enabling it to catch up with and even surpass its GVC peers.

Additionally, participating in higher-value segments of GVCs often demands upfront investments in specialized skills and infrastructure. A skilled workforce is essential for absorbing and utilizing knowledge effectively. Financial development enables businesses to acquire the necessary expertise and technology, transforming them from unskilled into skilled workers that are high in productivity and knowledge intensive.

Lastly, international transactions involve managing currency fluctuations, mitigating risk, and ensuring timely payments. Robust financial markets offer a range of hedging tools and trade finance solutions. Financial markets facilitate the dissemination of information—market trends, technological breakthroughs, best practices—through media and reports and analyst commentary. This transparency helps businesses make informed decisions, adapt to changing dynamics, and capitalize on emerging knowledge opportunities within the GVC landscape.

However, financial development can also have a paradoxical effect. While it can be a potent force for good, it can exacerbate existing inequalities and hinder knowledge diffusion if not managed effectively, i.e., "Too much finance." Too much access to finance can deviate an economy away from its efficient outcome by misallocating resources and promoting investments in areas that are suboptimal. [1]

Electrical Equipment and Machinery Industries

From sophisticated semiconductor fabrication equipment in the ROK to high-precision machine tools in Japan, E&M industries are at the forefront of technological innovation. From Vietnam's garment workshops to Japan's tech assembly lines, E&M industries provide the region's economic engine that can ultimately promote economic growth and productivity boost. They attract top talent, drive R&D, and cultivate a skilled workforce that can not only operate but also design and improve upon machines of higher quality. By supplying the tools to build the next generation of electronics, automobiles, and aircraft, they enable the region to compete with, and even surpass, established players in the global arena.

Interaction between domestic and foreign companies, research collaborations between universities and industry leaders, and open-source platforms all create fertile ground for knowledge exchange. This ensemble of ideas and expertise accelerates innovation, leading to the development of new technologies, materials, and production processes that benefit not just individual companies but the entire economy.

The rise of digitalization and Industry 4.0 is transforming the E&M landscape. Smart factories, connected machines, and real-time data analysis create vast repositories of knowledge and insights. The ability to share and analyze this data across companies and countries through cloud platforms and digital networks amplifies the impact of knowledge spillovers. Best practices can be disseminated instantly, problem-solving solutions can be crowdsourced globally, and collaborative innovation can happen at lightning speed, all thanks to the digital revolution.

While both electrical equipment and machinery industries play a crucial role in the knowledge spillovers and productivity of APO member countries, they exhibit some key differences when it comes to their relationship with financial development. The key differences are categorized as follows:

Access to Capital:

Electrical equipment industry: Requires large upfront investments for R&D, infrastructure development (cleanrooms, fabrication plants), and expensive equipment like semiconductor etching tools. This necessitates robust financial markets with access to long-term loans, venture capital, and specialized trade finance solutions.

Machinery industry: While requiring capital for research and machinery acquisition, the upfront costs are generally lower compared to the electrical industry. This allows for greater reliance on traditional bank loans and export credit guarantees.

Risk Profile and Volatility:

Electrical equipment industry: Highly cyclical and susceptible to global economic downturns. Technological advancements can rapidly render existing equipment obsolete, requiring continuous investment. This demands a financial system that can tolerate risk and provide flexible financing options.

Machinery industry: Generally, less volatile than the electrical industry. Demand is often driven by domestic and regional infrastructure projects, offering some stability. However, fluctuations in raw material prices and competition can still pose financial challenges.

Knowledge Absorption and Innovation:

Electrical equipment industry: Heavily reliant on foreign technology transfer and talent acquisition. This necessitates financial systems that facilitate FDI, cross-border mergers and acquisitions, and skilled labor migration.

Machinery industry: While benefiting from knowledge spillovers, the focus is often on adapting and improving existing technologies for regional markets. This requires a financial system that supports domestic R&D, vocational training, and technology incubation programs.

Financial Inclusion and Spillover Impact:

Electrical equipment industry: Due to high capital requirements, benefits of participation tend to be concentrated in large, established companies. This can exacerbate existing inequalities if financial inclusion initiatives are not prioritized.

Machinery industry: SMEs can play a significant role. Financial inclusion becomes crucial to ensure SMEs have access to capital and can participate in the knowledge spillover effect.

Long-term Sustainability and Growth:

Electrical equipment industry: Financial development needs to be coupled with policies promoting environmental sustainability and responsible resource utilization. This requires long-term investment horizons and innovative financial instruments like green bonds.

Machinery industry: Financial development should support the transition towards cleaner production technologies and circular economy models. This involves promoting green technology financing and ensuring access to capital for smaller players in the green machinery space.

While both electrical equipment and machinery industries benefit from a robust financial system, their specific needs and vulnerabilities differ. Tailoring financial development strategies to address these differences is crucial to maximize their potential for knowledge spillovers, inclusive growth, and long-term economic sustainability in the Asia-Pacific region.

Interconnectedness and Spillover

The degree to which spillovers occur depends on the level of interconnectedness. One way to quantify this channel within GVC is by using the Inter-Country Input-Output table. The Multi Regional Input Output Table (MRIOT), constructed by the ADB, serves as a tool for analyzing not just trade flows but also the currents of value added through GVCs in Asia. This chapter uses the comprehensive term ICIO, but, more specifically, it consistently uses ADB's MRIOT. By allowing for the quantification and mapping of knowledge spillover effects, this table sheds light on the region's economies' capacity to learn and innovate through interconnectivity.

The ICIO table tracks imports and exports of not just final goods but also intermediate inputs, providing the value added from a specific industry of one country to another industry of another country. ICIO distinguishes domestic input-output links from international input-output. This represents the decomposition of the value created within a country that reflects its own expertise and innovation from the knowledge embedded in the components and materials imported from other countries. Inter-Country Input-Output tables are utilized to gain insights into a country's dependence on external value added and track the internal movements of its own. Unveiling knowledge flow paths unlocks the ability to quantify the specific channels through which knowledge and technology spillover occurs in sectors. APO provides the data on TFP of all its member countries. Labor productivity of each country's E&M industry can be measured by APO productivity database. The interconnectedness between one country's E&M industry (origin) and TFP of another country (destination) is measured using the value-added share.

Empirical Review on GVCs

The methodology for measuring GVC participation using Inter-Country Input-Output hinges on a computational device, conceptualized by Borin and Mancini. [2, 3] Using these measures, many studies showed the impact that GVC activities have on economic growth and productivity. Embedding themselves in GVC production provided fertile ground for growth in thriving emerging economies. [4] This was the case until the recent global shock. Optimism about GVCs has recently given way to concerns about their vulnerability to various disruptions. Extreme weather events, natural disasters, and other unforeseen events can ripple through global supply chains, jeopardizing firms and countries by cutting off access to vital resources. This highlights the increasing risks associated with complex, interconnected production networks. [5, 6] While the roots of this backlash are intricate and differ slightly across countries, a key factor identified by research is the long-standing decline of manufacturing jobs in advanced economies [7, 8, 9, 10] The reallocation and reconsideration of GVC benefits is in question. [11] It is important to understand the role that electrical equipment and machinery sectors have in the GVC among APO member countries.

Data and Empirical Specification

There are three main sources of data for this research: Productivity data from APO, Financial Development indicators from the World Bank, and Multi Regional Input Output table (ICIO) from ADB. APO database provides GDP of specific industries such as electrical equipment and machinery industries for most APO member countries. However, employment data for each sub-industry within manufacturing industries are not given. Thus, labor productivity of the manufacturing industry is used as a proxy for the electrical equipment and machinery industries. APO also provides national total factor productivity for all the APO member countries. When all three datasets are merged, the sample has 18 countries from 2007 to 2019. The World Bank's historical income classification is used to categorize countries to be high, upper-middle, lower-middle, and low-income countries. The APO-member countries that are included in the analysis are Bangladesh, Cambodia, Fiji, Hong Kong, India, Indonesia, Japan, the ROK, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka, Thailand, and Turkiye. Vietnam is excluded because the World Bank database does not have information on government expenditure and trade.

The World Bank provides various types of indicators that reflect the degree of financial development, but this research uses the three variables that are also used in Yang. [12] This chapter uses broad money to GDP (M3), domestic credit to GDP, and government expenditure to GDP. The first two represent the bank aspect of the financial market. The values indicate how active the lending market is for a country. Government spending is to account for the fiscal channel. Yang [12] additionally uses stock market indicators to test the importance of equity channel but no significant results were found with these variables.

Spillover measures of electrical equipment and machinery industries are constructed separately. First, it is necessary to find the total amount of value added transferred from country i to country j in year t. Then, the total amount of value added transferred from machinery industry of country i to country j in year t is calculated as. The sector code for machinery and mechanical products is 13 and 14 for electrical equipment, both of which are classified as high- and medium-technology industries. The classifications are from the industrial departments in ADB-MRIO database. The methodology resembles the construction of weight that Coe and Helpman [13] employed.

The weight of machinery industry is shown as the following:

$$w_{i13,j,t} = VA_{i13,j,t} / VA_{i,j,t} \tag{1}$$

The machinery productivity spillover from country i to country j in year t is:

$$MSP_{i,j,t} = w_{i13,j,t} * Productivity_{iM,t} \tag{2}$$

Where $Productivity_{iM,t}$ is the labor productivity of manufacturing industry of country i on year t.

The total amount of machinery productivity spillover that country j receives then is:

$$MSP_{j,t} = \sum_{j \neq i} MSP_{i,j,t} \tag{3}$$

Similarly, electrical equipment industry spillovers are measured by the following equation:

$$ESP_{i,j,t} = w_{i14,j,t} * Productivity_{iM,t} \tag{4}$$

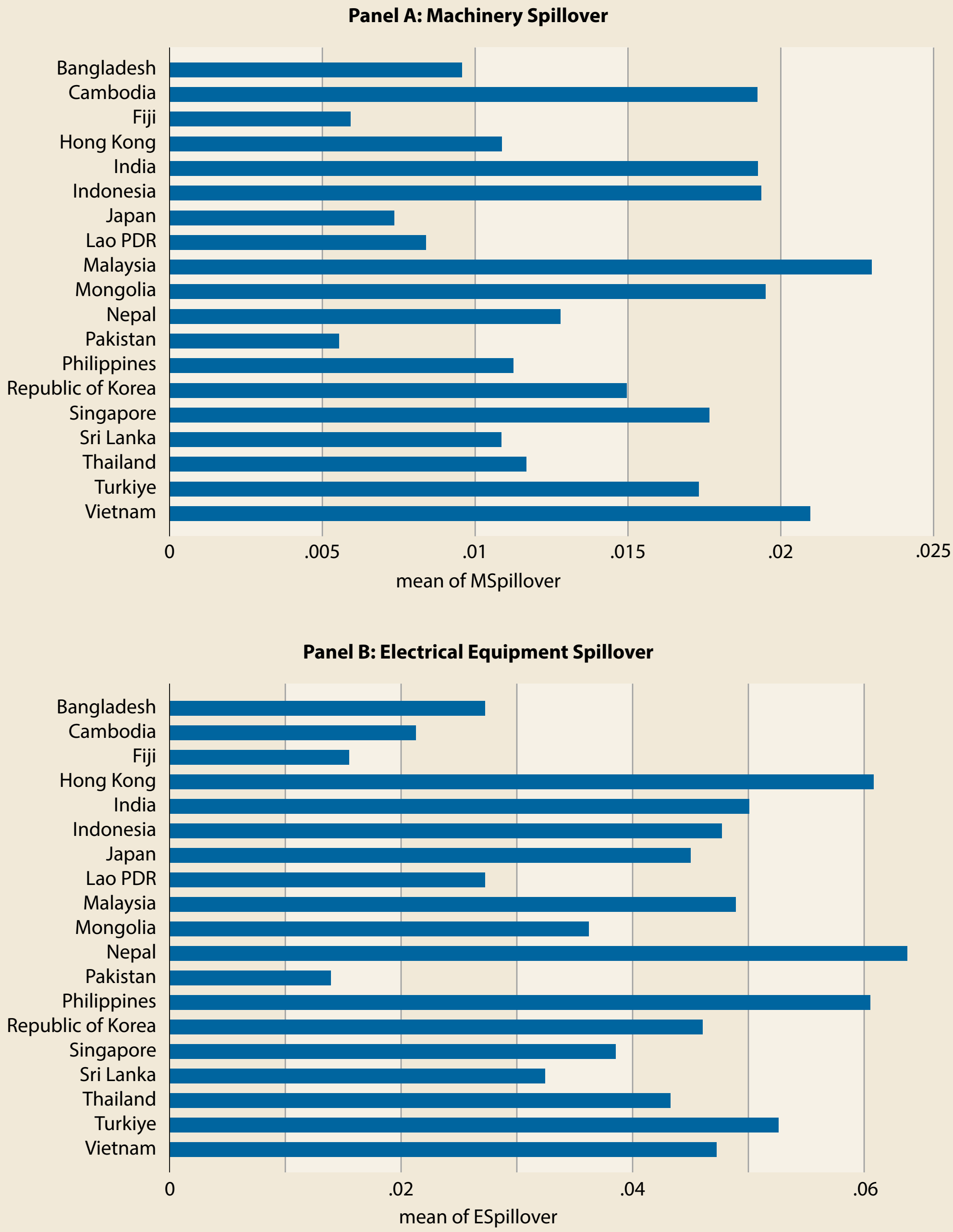
where $w_{i14,j,t}$ is the weight of the electrical equipment industry. Then the total productivity spillover from electrical equipment industries that country j receives is:

$$ESP_{j,t} = \sum_{j \neq i} ESP_{i,j,t} \tag{5}$$

The mean of machinery productivity spillover (MSpillover) and electrical equipment spillover (ESpillover) exposed to APO member countries are shown in Figure 1.

FIGURE 1

MSPILLOVER AND ESPILLOVER EXPOSED TO EACH APO MEMBER COUNTRY

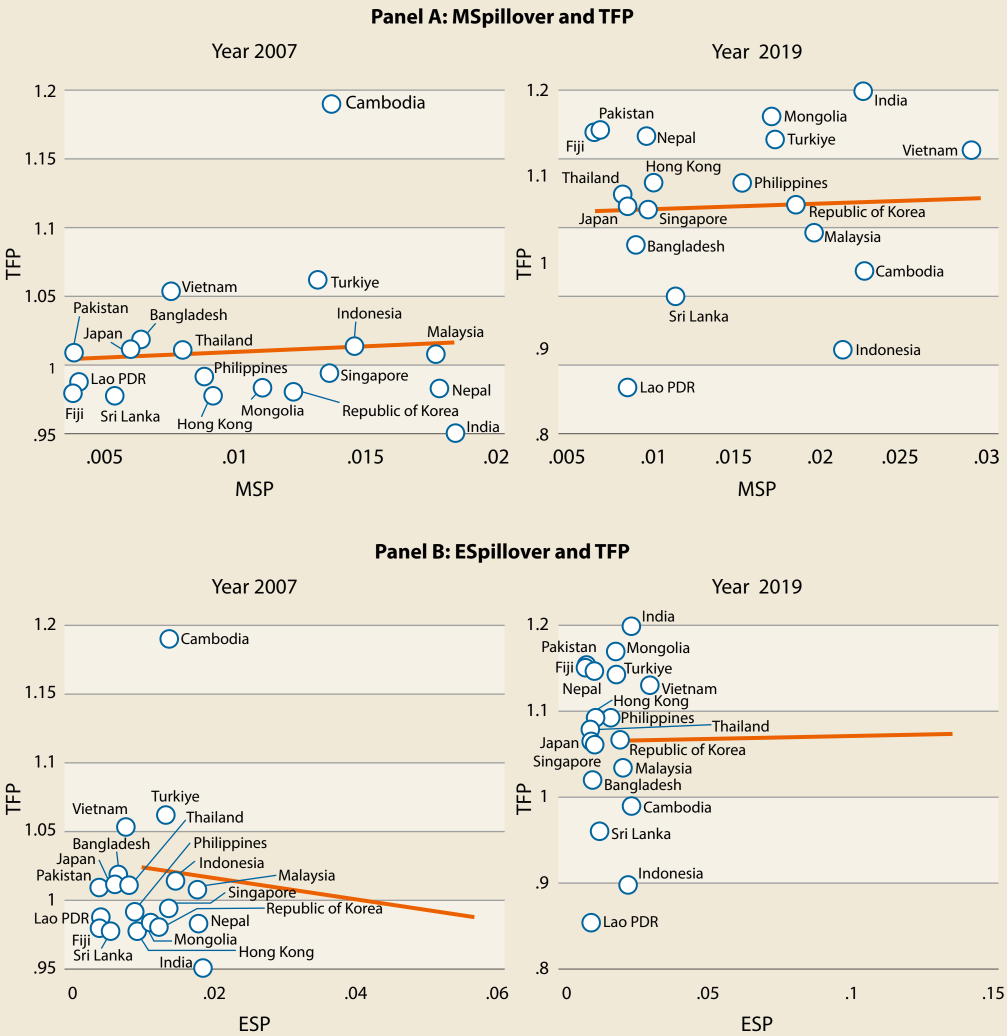


Source: The authors' calculation using ADB's MRIOT database and APO Productivity database (2022).

The relationship between spillover measures constructed and TFP are portrayed in Figure 2. Figure 1 and 2 only use information from APO productivity database and ADB's MRIOT, both of which have full information on Vietnam. Thus, Vietnam is included for Figure 1 and 2 but excluded for the empirical regressions because its financial development indicators contain missing values.

FIGURE 2

HOW THE TRENDS OF M/ESPILLOVER AND TFP VARIED



Source: The authors' calculation using ADB's MRIOT database and APO Productivity database (2022).

With financial development indicators and E&M productivity spillovers provided, empirical specification like that of Coe et al. [14] utilized in this chapter is shown in Equation (6) and (7):

$$TFP_{i,t} = \alpha + \beta_1 FinDev_{i,t} + \beta_2 MSpillover_{i,t} + \beta_3 MSpillover_{i,t} * FinDev_{i,t} + \theta Controls + \gamma_i + \delta_t + \varepsilon_{i,} \quad (6)$$

$$TFP_{i,t} = \alpha + \beta_1 FinDev_{i,t} + \beta_2 ESpillover_{i,t} + \beta_3 ESpillover_{i,t} * FinDev_{i,t} + \theta Controls + \gamma_i + \delta_t + \varepsilon_{i,} \quad (7)$$

where $FinDev_{i,\,t}$ is domestic credit, M3, or government expenditure to GDP, MSpillover and ESpillover are measures of productivity spillover that country i receives from machinery industries and electrical industries, respectively. $TFP_{i,t}$ is the total factor productivity of country i on year t. Control variables are trade volume, inflation, and exchange rate. Yang [12] uses more but they contained many missing values for APO member countries.

Results

This section provides the empirical results that show how E&M productivity spillovers to other country's TFP and the role of financial development in the process. Table 1 provides the summary statistics.

TABLE 1

SUMMARY STATISTICS

Variable	Obs	Mean	Std. dev.	Min	Max
TFP (APO)	247	1.024582	0.068548	0.849511	1.19889
MSpillover	247	0.013975	0.00617	0.003764	0.029321
ESpillover	247	0.040845	0.020467	0.009662	0.135786
Gov Spending (WB)	231	11.76596	3.964323	4.806798	20.11512
M3 (WB)	238	100.6774	75.95873	24.10189	403.3394
Domestic Credit (WB)	235	80.71383	51.46483	6.54326	236.755
Trade (WB)	231	108.8526	101.9516	24.39017	442.62
Inflation (WB)	247	5.129288	4.464346	-1.35284	27.95567
Ex Rate	237	2261.357	5217.15	1.249676	23050.24

Table 2 shows the result when machinery productivity spillover is used in the regression. The coefficient of MSpillover is negative suggesting that there is a rivalry effect. However, the interaction between Gov Spending and MSpillover is positive. This suggests that the rivalry effect can be overturned and become a positive spillover effect if the government intervenes. Specifically, the government spending needs to exceed approximately 11% of GDP to make the net effect positive. Table 1 shows that Gov Spending ranges from 4.8% to 20.1%. Thus, it is possible to positively exploit machinery spillover.

TABLE 2

MACHINERY SPILLOVER AND TFP

VARIABLES	(1) TFP_{t+1}
Gov Spending	-0.001 (-0.13)
MSpillover	-7.249** (-2.02)
Gov_MSP	0.626** (2.02)
Trade	-0.000 (-0.47)
Inflation	-0.000 (-0.14)
Ex Rate	-0.000*** (-4.93)
Constant	1.055*** (19.14)
Observations	207
Number of Country	18
R-squared	0.4962

Note: This table presents the results of fixed-effect panel regression as specified in equation (6). The spillover effect measured in this regression is that of the machinery sector. Statistical significance at 10%, 5%, and 1% level are indicated by *, **, and ***, respectively.

The results suggest that in order for a country to receive a positive net effect from another country's machinery sector productivity is to have sufficient involvement from the government. The nature of the machinery industry may differ substantially from the electrical equipment industry. While machinery industries require capital for research and initial acquisition to begin its competitiveness, the upfront costs may be generally lower compared to the electrical industry. This means that instead of giant conglomerates setting barriers to entry, smaller and medium-sized enterprises can be active and play a significant role. Additionally, machinery industries are less volatile in supply and demand.

Table 3 shows the results by low- and high-income countries separately. The World Bank's historical income classification system is employed to stratify the participating countries into two distinct cohorts. Low-income economies are defined as those designated as either "Low" or "Lower-Middle" according to the World Bank's classification. Conversely, economies categorized as "Upper-Middle" or "High" are grouped as high-income. The results are statistically significant only for low-income countries. Low-income countries are found to benefit from machinery spillover when the government prepares the market for the knowledge and productivity being transferred.

TABLE 3

MACHINERY SPILLOVER AND TFP: BY INCOME

VARIABLES	High TFP_{t+1}	Low TFP_{t+1}
Gov Spending	0.013** (2.25)	-0.014* (-1.95)
MSpillover	1.114 (0.32)	-20.936*** (-3.21)
Fiscal_MSP	-0.203 (-0.73)	1.831*** (3.14)
Trade	-0.000 (-0.34)	-0.002* (-1.84)
Inflation	0.002 (1.04)	-0.000 (-0.12)
Ex Rate	-0.000 (-0.08)	-0.000*** (-4.53)
Constant	0.835*** (10.56)	1.358*** (13.13)
Observations	93	114
R-squared	0.8235	0.4348
Number of Country	10	12

Note: This table presents the results of fixed-effect panel regression as specified in equation (6). The spillover effect measured in this regression is that of the machinery sector. The World Bank's historical income classification standard is used to categorize the countries into subsamples. Statistical significance at 10%, 5%, and 1% level are indicated by *, **, and ***, respectively.

The result suggests that within the Asia-Pacific region, the high-income countries do not benefit within the region. Rather, it is the low-income countries that have the potential to exploit the incoming overflow of technology and productivity from other APO member countries. As in Table 2, government involvement is crucial to have the net positive effect.

Table 4 shows the electrical equipment spillover effects on TFP with financial development. While government spending shows no significance for ESpillover, the bank channel seems to play a role. The influence of financial development is more pronounced for low-income countries shown in Table 5. This result is consistent with the estimates from Table 2, when machinery spillovers were used.

TABLE 4

ELECTRICAL EQUIPMENT SPILLOVER AND TFP

VARIABLES	(1) TFP_{t+1}	(2) TFP_{t+1}	(3) TFP_{t+1}
Gov Spending	0.005 (1.40)		
Fiscal_ESP	0.018 (0.22)		
M3		-0.002*** (-4.01)	
M3_ESP		0.005** (2.04)	
Credit			-0.002*** (-4.90)
Dom_ESP			0.005 (1.51)
ESpillover	-0.008 (-0.01)	-0.205 (-0.34)	0.142 (0.24)
Trade	-0.000 (-0.67)	0.000 (0.54)	0.000 (0.23)
Inflation	0.000 (0.13)	0.001 (0.52)	0.001 (1.16)
Ex Rate	-0.000*** (-4.82)	-0.000*** (-5.55)	-0.000*** (-4.14)
Constant	0.983*** (20.03)	1.147*** (28.17)	1.101*** (32.65)
Observations	207	207	204
R-squared	0.4846	0.5164	0.5491
Number of Country	18	18	18

Note: This table presents the results of fixed-effect panel regression as specified in equation (6). The spillover effect measured in this regression is that of the electrical equipment sector. Statistical significance at 10%, 5%, and 1% level are indicated by *, **, and ***, respectively.

As opposed to the machinery industry, electrical equipment industries may require a large upfront investment for R&D, infrastructure, and expensive equipment. This industry is heavily reliant on foreign technology transfers and talent acquisition. The demand and supply of electrical industry move hastily to trend, and thus are susceptible to global economic downturns and business cycles. This is a market that government intervention has no significant impact on. Rather, countries need to have a financial system to connect the supply and demand of capital and to ensure efficient allocation of resources.

TABLE 5

ELECTRICAL EQUIPMENT SPILLOVER AND TFP: BY INCOME

VARIABLES	High TFP_{t+1}	High TFP_{t+1}	High TFP_{t+1}	Low TFP_{t+1}	Low TFP_{t+1}	Low TFP_{t+1}
Gov Consumption	0.014*** (2.86)			-0.004 (-0.65)		
Fiscal_ESP	-0.094 (-1.32)			0.273 (1.41)		
M3		0.000 (0.32)			-0.005*** (-6.12)	
M3_ESP		-0.001 (-0.41)			0.057*** (3.25)	
Domestic Credit			0.000 (0.54)			-0.004*** (-6.45)
Dom_ESP			-0.004 (-0.73)			0.053*** (2.97)
ESpillover	0.940 (1.16)	0.152 (0.20)	0.605 (0.56)	-2.469 (-1.00)	-3.738** (-2.57)	-1.930* (-1.75)
Trade	-0.000 (-0.05)	0.000 (0.09)	0.000 (0.13)	-0.002* (-1.85)	0.000 (0.43)	-0.000 (-0.42)
Inflation	0.001 (0.68)	0.000 (0.01)	-0.000 (-0.10)	0.000 (0.26)	-0.001 (-0.88)	0.001 (0.40)
Ex Rate	-0.000 (-0.09)	-0.000 (-0.05)	-0.000 (-0.06)	-0.000*** (-4.19)	-0.000*** (-4.65)	-0.000*** (-4.32)
Constant	0.806*** (11.73)	0.967*** (17.19)	0.954*** (17.66)	1.222*** (11.52)	1.319*** (18.97)	1.219*** (19.24)
Observations	93	93	92	114	114	112
R-squared	0.8243	0.8030	0.8017	0.3858	0.5634	0.6019
Number of Country	10	10	10	12	12	12

Note: This table presents the results of fixed-effect panel regression as specified in equation (6). The spillover effect measured in this regression is that of the electrical equipment sector. The World Bank's historical income classification standard is used to categorize the countries into subsamples. Statistical significance at 10%, 5%, and 1% level are indicated by *, **, and ***, respectively.

Policy Implications and Conclusion

This chapter investigates the dynamics of productivity spillovers within the GVCs of the E&M industries, focusing on the specific experiences of low-income countries among APO member countries. It argues that, while these nations stand to benefit from knowledge diffusion facilitated by GVC participation, they also face the potential challenge of "market stealing" effects—where technological advancements in one country can negatively impact the competitiveness of others within the same sector.

The chapter explores the multifaceted nature of productivity spillovers from E&M GVCs. On the one hand, advancements from research and development can yield positive externalities for all economies by increasing product variety and consumer welfare. On the other hand, breakthrough innovations can also disrupt existing market dynamics, potentially jeopardizing the viability of coexisting producers in less technologically advanced countries.

Recognizing this duality, the chapter delves into the specific spillover effects relevant to low-income countries within the E&M GVC. While opportunities include potential gains in skilled workforce development, innovation diffusion, and job creation, the threat of industry decline due to "market stealing" remains a concern. To optimize their GVC participation, low-income countries must understand how to leverage positive spillovers and mitigate negative ones.

The chapter suggests financial development as a potential catalyst for maximizing the benefits of GVC participation. By bolstering access to capital, fostering technological advancements, and facilitating knowledge transfer, robust financial systems can equip low-income countries to transform "market stealing" into positive knowledge spillovers, enabling them to climb the GVC ladder and achieve sustainable economic growth. However, the approach to effectively benefit from spillovers differs for the two industries.

While both electrical equipment and machinery industries significantly contribute to the industrial landscape, their capital requirements and market dynamics diverge substantively. The electrical industry demands substantial upfront investments for R&D and specialized infrastructure, creating higher entry barriers. In contrast, the machinery industry generally exhibits lower entry thresholds, enabling the active participation of SMEs. This fosters a more diverse and competitive ecosystem. Furthermore, the machinery industry typically experiences less volatility in supply and demand compared to its electrical counterpart. Such inherent characteristics influence the nature of government intervention. Notably, policies like firm subsidies or domestic protectionism can significantly impact whether spillover effects from GVC participation become beneficial or detrimental, particularly for low-income countries.

Compared to the machinery industry, the electrical equipment sector often necessitates significant upfront capital outlays for research and development, infrastructure development (such as cleanrooms and fabrication plants), and high-value equipment (e.g., semiconductor etching tools). This dependence on cutting-edge technologies often translates into reliance on foreign technology transfer and skilled talent acquisition. Furthermore, the demand and supply dynamics in the electrical industry are highly sensitive to market trends and susceptible to global economic downturns and business cycles. Due to this inherent volatility, direct government intervention may not be the most effective policy approach. Instead, fostering a well-developed financial system capable of efficiently connecting capital supply and demand becomes crucial to ensure optimal resource allocation and navigate the cyclical nature of the sector. With improved access to credit and financial instruments, low-income countries participating in the electrical equipment GVC can strategically leverage spillover benefits. By harnessing a well-developed financial system, these countries can transform the "overflow" of electrical equipment productivity into a catalyst for sustained economic growth and diversification.

By implementing these policy measures, APO member countries can leverage the power of GVCs in the E&M industries to drive economic growth, create high-quality jobs, promote technological advancements, and ensure inclusive and sustainable development for the entire region.

An examination of high-income countries within the Asian Pacific region reveals a lack of statistical significance concerning the impact of productivity spillovers in the machinery and electrical equipment industries among APO member countries. Despite this, it is noteworthy that countries in the Asian Pacific region engage in global interactions with diverse economic backgrounds across different continents. While acknowledging the positive impact of knowledge spillovers from countries outside the Asian Pacific region is of great importance, such considerations fall beyond the purview of this chapter, which is specifically focused on exploring the interactions among APO member countries.

Recognizing the inherent diversity within the region, countries will likely gravitate towards specific sub-sectors based on their unique aspirations and capabilities. Some nations may choose to high-tech realm of electrical equipment by channeling their resources into a well-developed financial system that plays a crucial role in facilitating access to capital. Others might find greater success in the machinery industry where aggressive government intervention in areas like R&D and infrastructure development are necessary.

Harnessing the power of financial development for GVC success necessitates a balanced approach. Building inclusive financial systems, promoting competition and transparency, and investing in human capital development are crucial to ensure that finance plays its role in amplifying knowledge spillovers and propelling countries towards productivity boosts. Financial development can transform the spillover effects from machinery and electrical industries within APO member countries. The results show that electrical equipment and machinery spillovers affect the APO member countries differently. Also, whether a country is affected by the spillovers depends on the income level. The implication for machinery spillovers is to have the governments support the domestic markets to enhance absorptive capacity while for electrical spillovers, the private sector needs to be able to obtain credit. This is due to the differences in the nature of electrical equipment and machinery industries.

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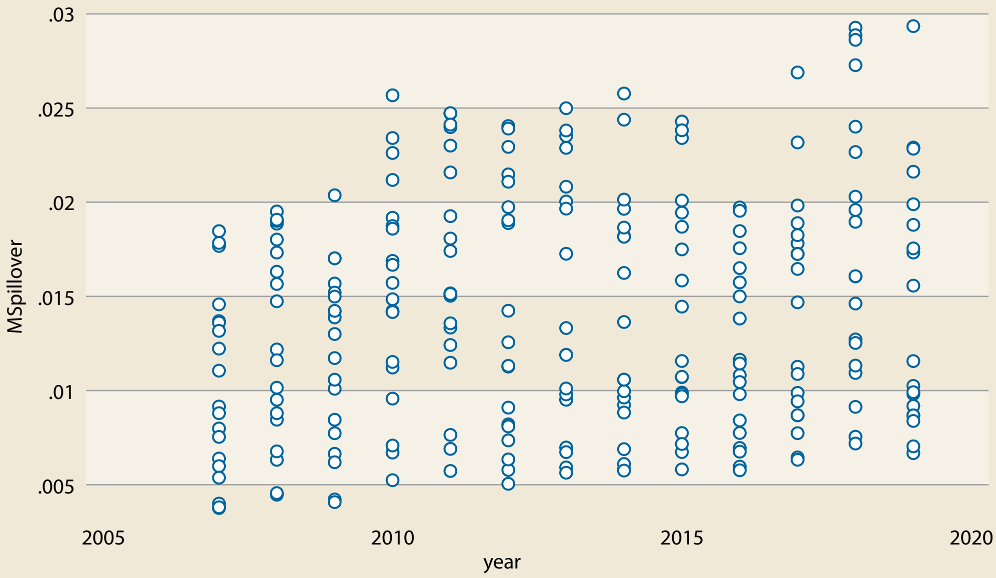
Appendix

FIGURE 1

TREND OF MACHINERY SPILLOVER (MSPILLOVER) THROUGHOUT THE SAMPLE PERIOD

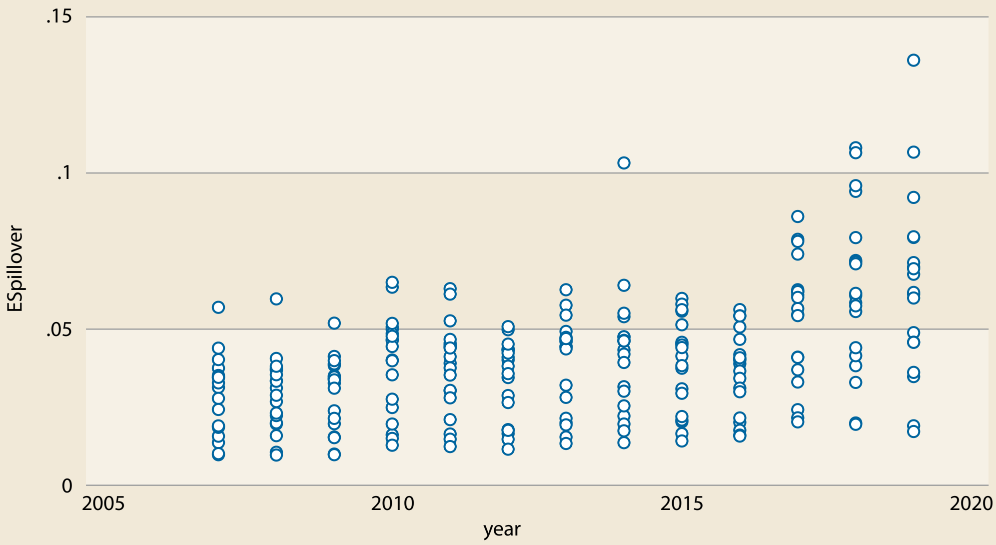


Source: The authors' calculation using ADB's MRIOT database and APO database.

The overall trend of MSpillover is increasing throughout time. The dispersion shows no significant change.

FIGURE 2

TREND OF ELECTRICAL EQUIPMENT (ESPILLOVER) THROUGHOUT THE SAMPLE PERIOD



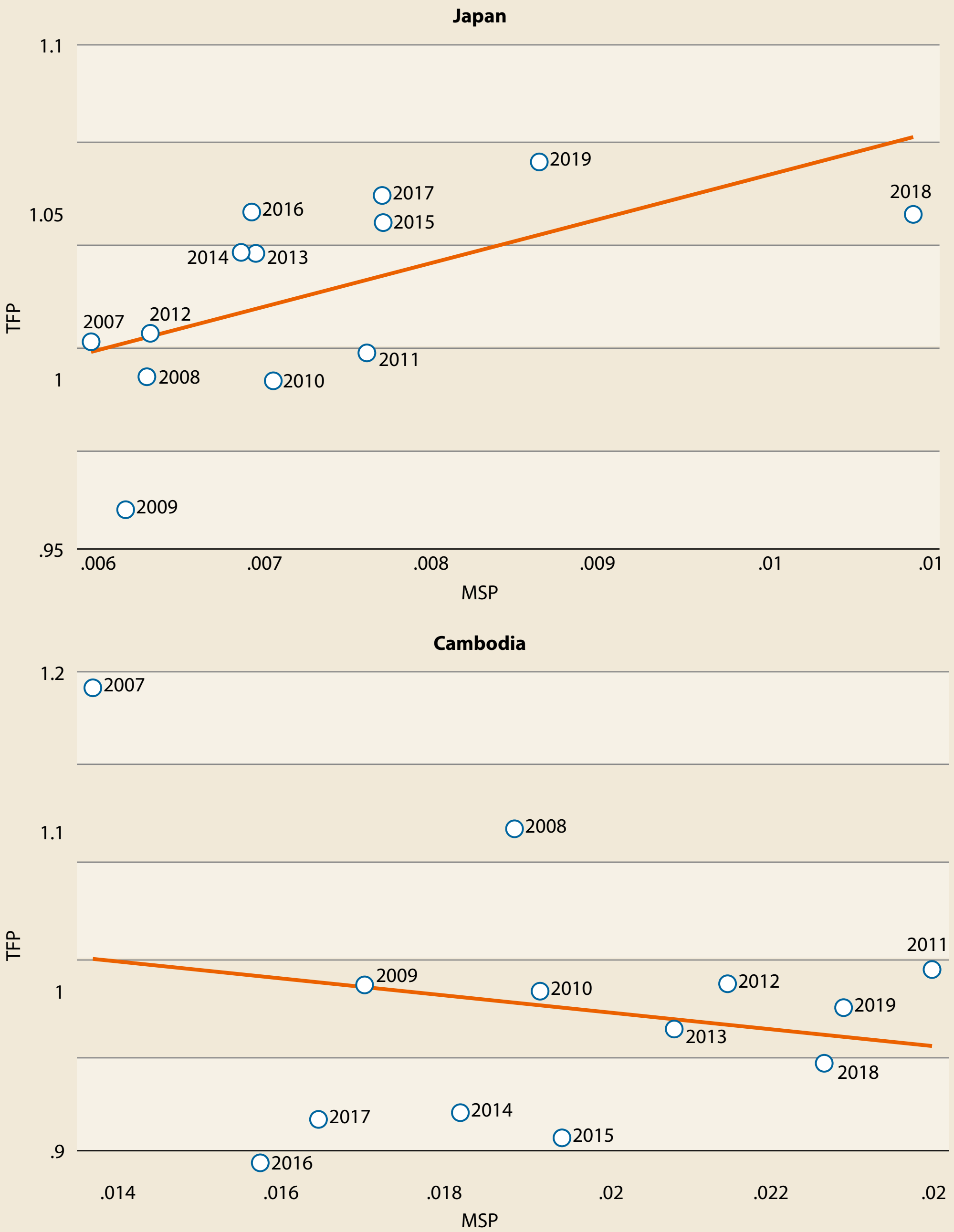
Source: The authors' calculation using ADB's MRIOT database and APO database.

There is a steep increase in ESpillover after 2017. The dispersion sharply increases around the same time.

Figures 3 and 4 show how MSpillover and ESpillover exposed to Japan and Cambodia (one case for each group was selected) changes throughout the same period. Japan shows an upward trend while Cambodia shows a decreasing trend. The two countries are selected to show how the productivity spillover exposure differs by country.

FIGURE 3

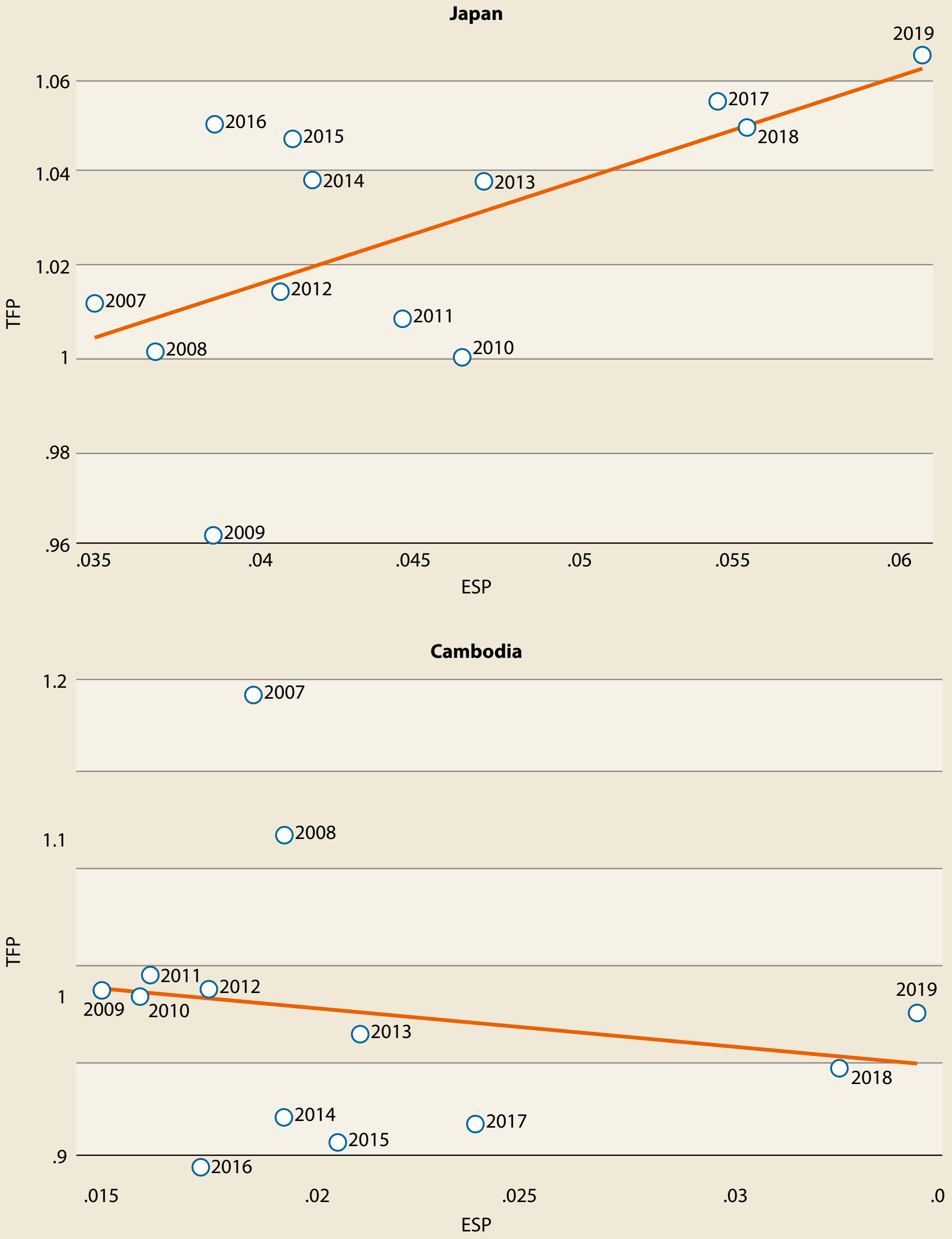
MSPILLOVER FOR JAPAN AND CAMBODIA THROUGHOUT THE SAME PERIOD



Source: The authors' calculation using ADB's MRIOT database and APO database. MSP refers to machinery spillover.

FIGURE 4

MSPILLOVER FOR JAPAN AND CAMBODIA THROUGHOUT THE SAME PERIOD



Source: The authors' calculation using ADB's MRIOT database and APO database. ESP refers to electrical machinery spillover.

CONCLUSION

Between 1990 and 2019, a trend of narrowing income gaps relative to the United States was observed in the majority of APO member countries. This shift was primarily attributed to capital accumulation and human capital, with slight changes in TFP. Hence, there is an urgent need for policies aimed at enhancing productivity, with TFP being identified as the dominant force influencing economic performance and explaining income disparities among countries.

In the opening chapter, a breakdown of export growth exposed distinctive patterns among APO member countries. Notably, countries like Vietnam and Lao PDR have successfully pursued export diversification, while others such as the ROK and Japan tended towards more specialization. Typically, countries exhibit a tendency to specialize in specific product ranges, progressing from light manufacturing to industries like electrical equipment and machinery as they attain higher income levels.

In terms of GVC participation, APO member countries experienced a decline following the global financial crisis but showed signs of recovery in 2021, as highlighted in the analysis. Some notable characteristics in the electrical equipment and machinery industry, countries like Japan and Lao PDR engage in forward GVC participation, while the rest of the APO members, especially the case of the ROK, the ROC, and Vietnam engage in backward GVC participation. Given the distinct characteristics, it is imperative to formulate policies to address the specific needs and dynamics of each country.

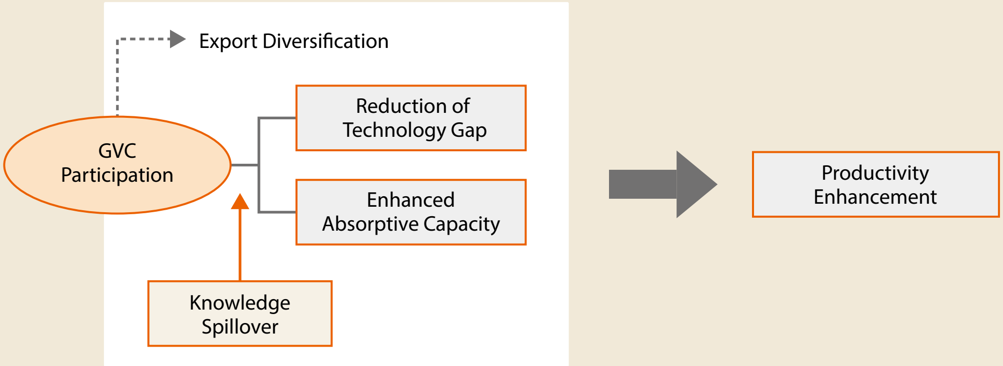
Chapter 2 explores the connection between GVC participation and export diversification among APO member countries. The study reveals that engaging in backward GVC participation within the electrical equipment sector is associated with increased levels of export diversification.

In the following chapter, Chapter 3, the emphasis lies on the pivotal role of knowledge spillover, particularly within medium-high R&D, knowledge intensive sectors such as the electrical equipment and machinery industry, in enhancing productivity across APO member countries. The study reveals a positive correlation between domestic and foreign F&D capital stocks and productivity, underscoring the significant impact of knowledge spillovers from foreign sources. However, obstacles such as institutional constraints, limited absorptive capacity, and financial constraints can hinder effective knowledge spillover. Consequently, policymakers are urged to concentrate on reducing technological gaps, enhancing openness and implementing tailored policies for each APO member country. Furthermore, fostering human capital development and encouraging international R&D cooperation are deemed crucial for sustained long-term productivity improvements.

Finally, in Chapter 4, the analysis delves into the benefits of GVC participation, with particular focus on the pivotal role played by the electrical equipment and machinery sector. The chapter underscores the critical influence of financial development in facilitating knowledge spillover and fostering sustainable productivity across APO member countries. The findings indicate positive spillover in manufacturing productivity, especially notable for low-income APO member countries with active government involvement. This emphasizes the importance of implementing targeted strategies to promote inclusive growth in APO member countries.

FIGURE 1

SUMMARY OF THE MAIN RESULTS



Source: Authors' elaboration

Figure 1 presents a comprehensive overview of the key findings from this report. The empirical evidence underscores a positive association between GVC participation in the electrical equipment and machinery sector and export diversification. In addition to the impact of domestic R&D capital, human capital and technology on productivity, the role of knowledge spillover is significant in boosting productivity across APO member countries. The analysis indicates that the electrical equipment and machinery sector exhibits spillover effects particularly for emerging APO member countries. This emphasizes the importance of endorsing financial development to enhance the productivity spillover effects. GVC participation, rather than leading to automatic development, necessitates an enhancement in the quality of various contributing factors.

COUNTRY PROFILES

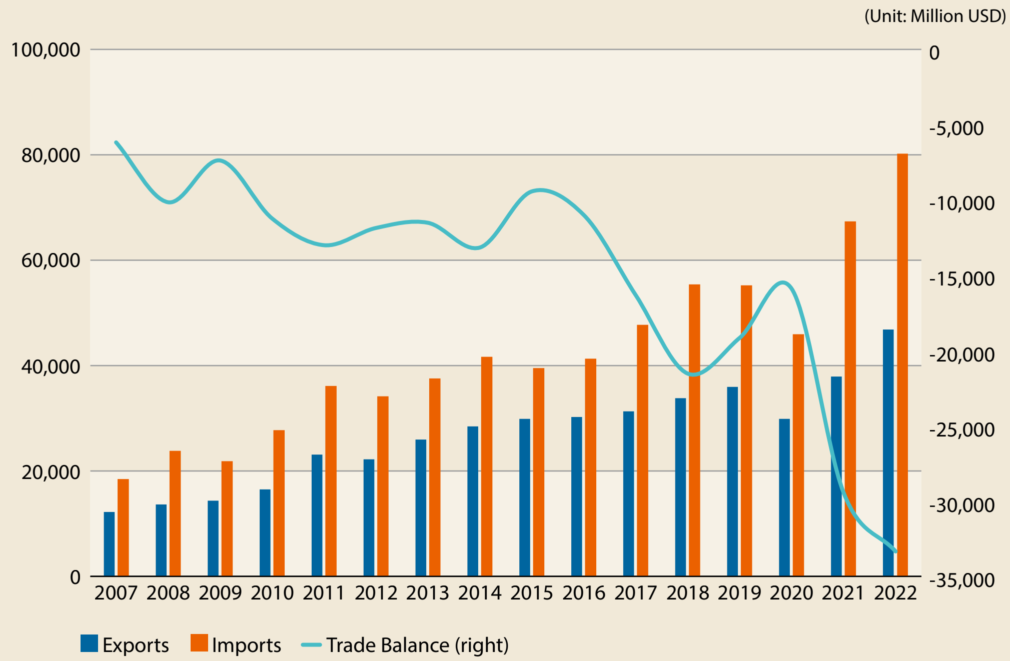
COUNTRY PROFILE: BANGLADESH

- Bangladesh has consistently experienced trade deficits since before 2007, primarily due to the substantial value of imports. In 2022, the country's exports amounted to USD46,851 million, while imports nearly doubled that figure at USD80,161 million. According to the BACI-CEPII database, textiles, apparel, and footwear constituted the majority of exports (93%), followed by food and tobacco-related industries (1.9%) in 2021. Its top five export partners are China, India, the United States, Germany, and Singapore (UN Comtrade).

- Regarding GVC (global value chain) participation, Bangladesh exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

TRENDS OF TRADE

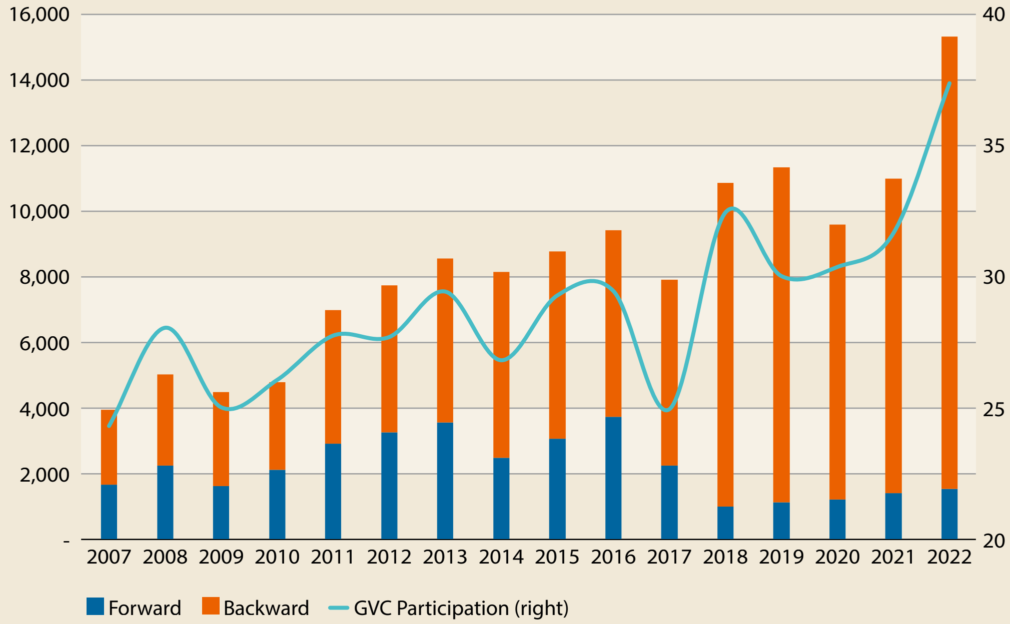


Source: IMF, Direction of Trade Statistics (DOTS).

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

(Unit: Million USD (left), percentage (right))



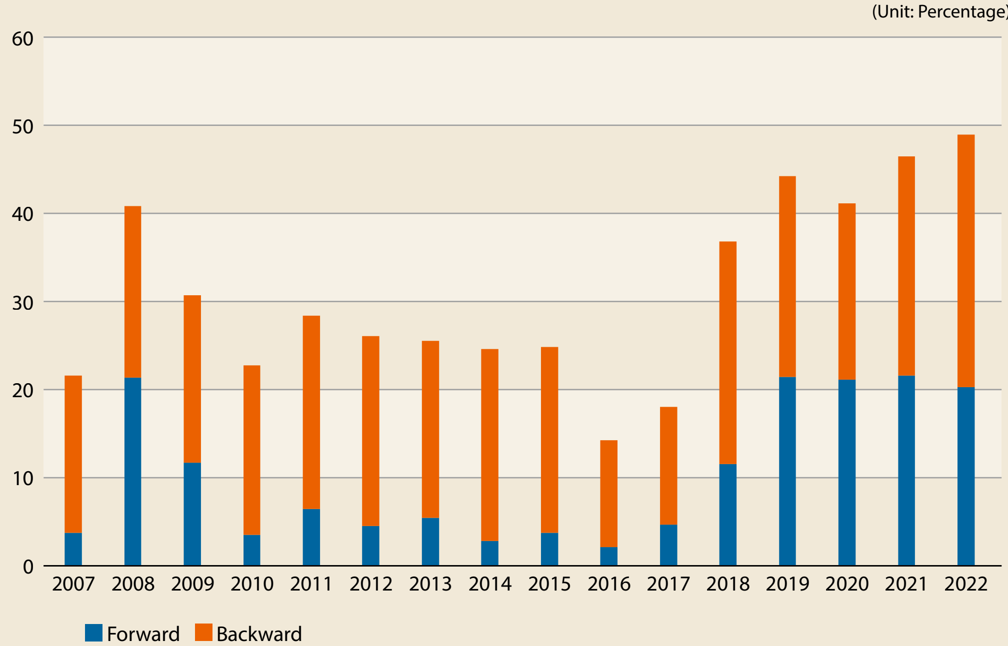
Source: ADB, Multi-Regional Input-Output (MRIO) Tables Database

- In 2022, the electrical equipment and machinery industry contributed 0.6% to Bangladesh's total value-added exports, of which nearly 50% involved in GVCs, which it has grown since 2018. Backward GVC participation of this sector has been more steady than forward GVC participation.

FIGURE 3

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

(Unit: Percentage)

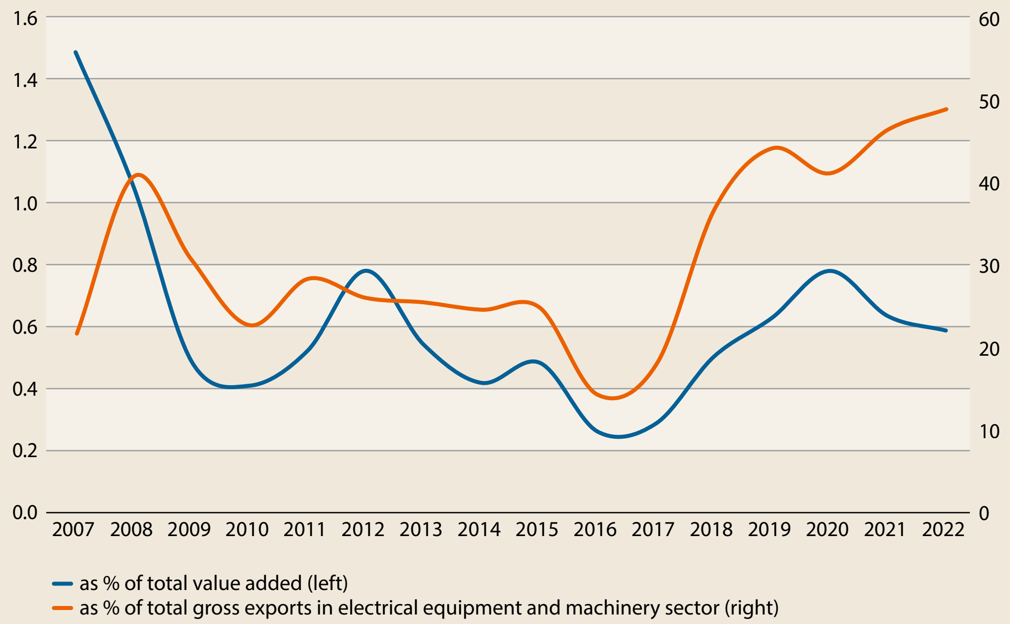


Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED

(Unit: percentage)



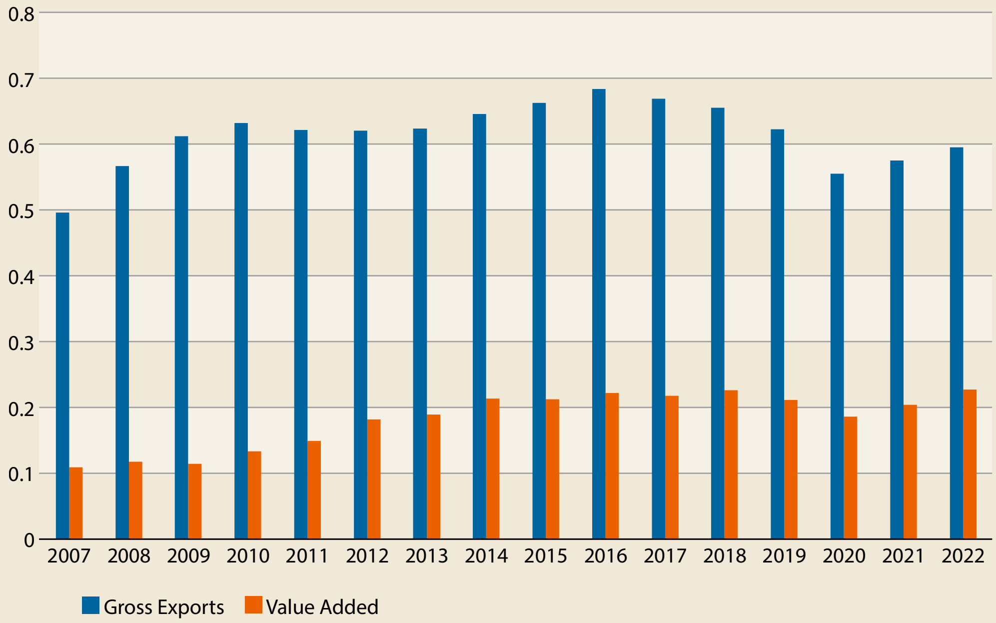
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Bangladesh recorded an export concentration in gross exports of approximately 0.6, showing a decline from 2018. The export concentration in value-added exports was around 0.22 in 2022, and it has remained consistent since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

Note: Data related to knowledge spillover are not included due to data availability.

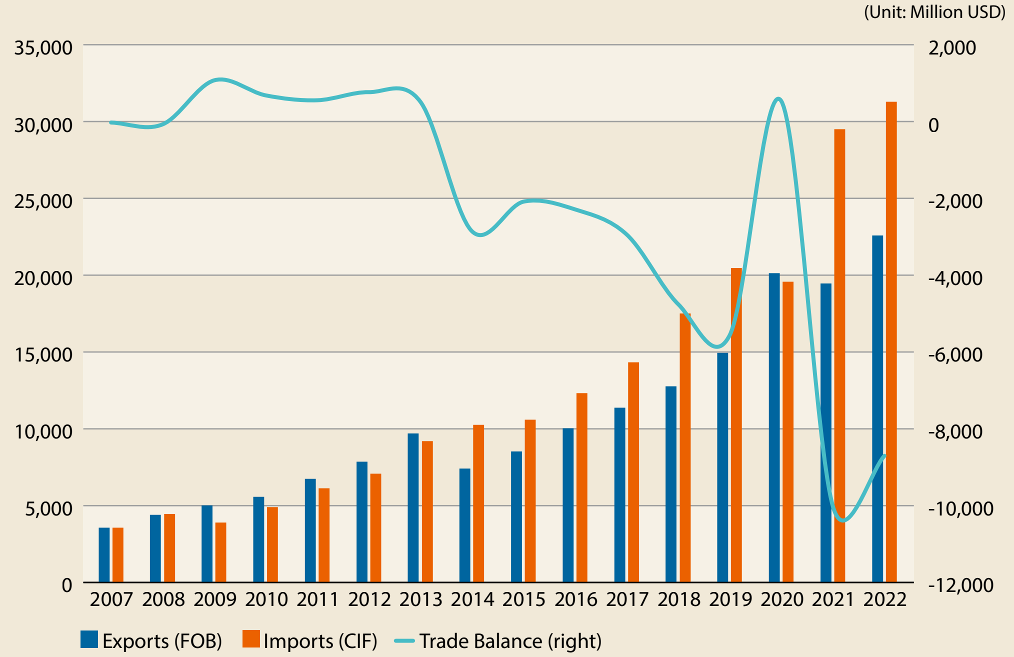
COUNTRY PROFILE: CAMBODIA

- In 2021, Cambodia's total exports reached USD22,606 million, while imports totaled USD31,313 million. According to the BACI-CEPII database, the primary exports comprised textiles, apparel, and footwear constituting over half of total exports (63.3%), followed by agricultural products (14.6%) and machinery and electrical equipment (7.1%). As of 2022, its main export partners included China, the United States, Thailand, Vietnam, and the Republic of China (UN Comtrade).

- Regarding GVC participation, Cambodia exhibits a relatively higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

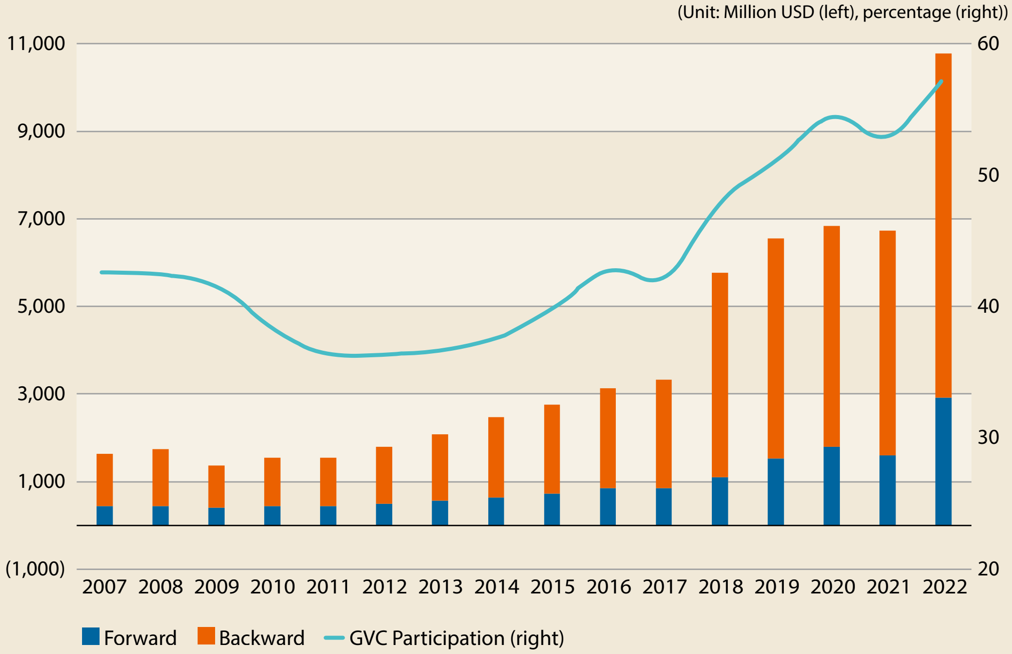
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

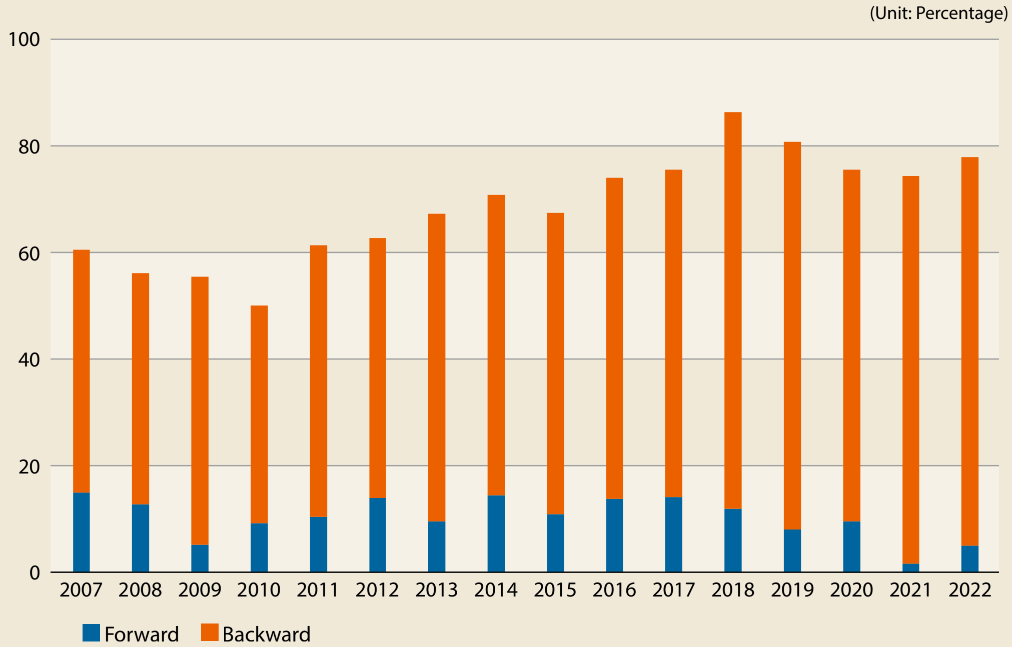


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 0.16% to Cambodia's total value-added exports, of which nearly 78% involved in GVCs, with a higher backward GVC participation.

FIGURE 3

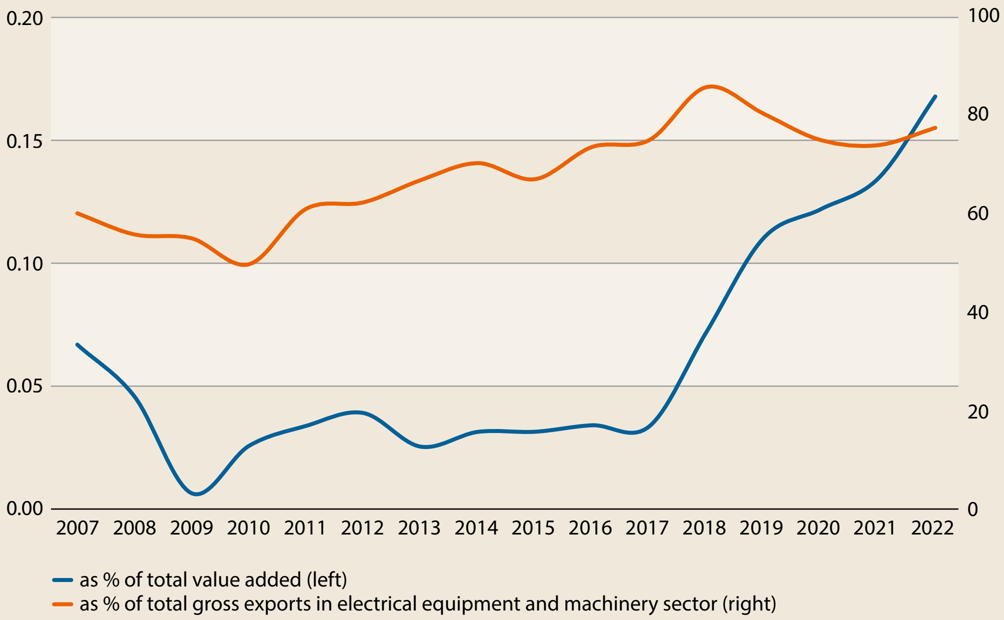
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED

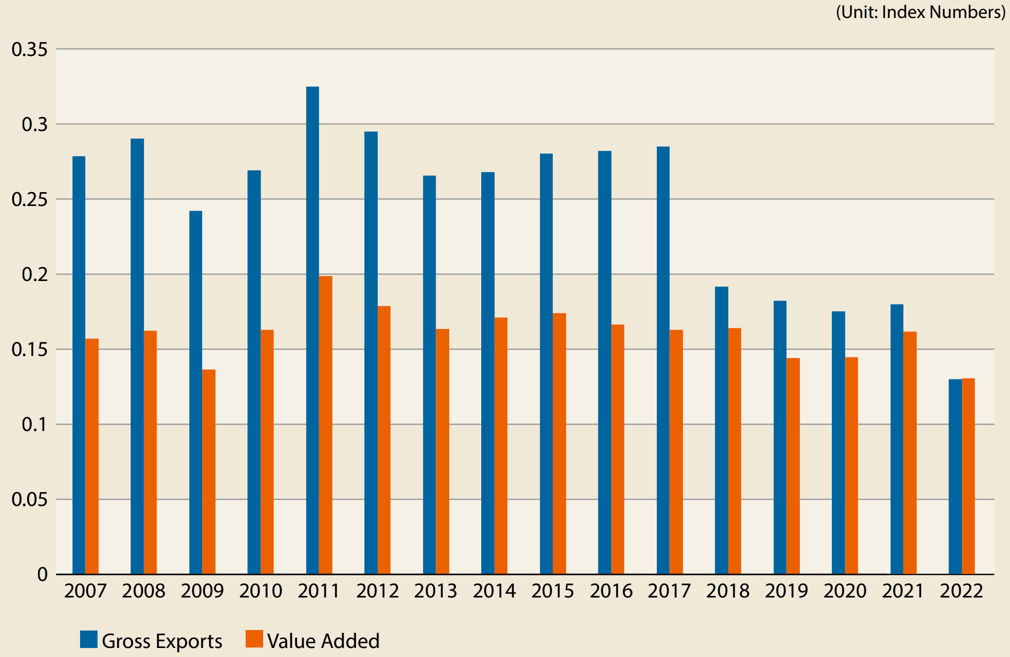


Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Cambodia registered an export concentration in gross exports of approximately 0.13, indicating a decline from 2018. The export concentration in value-added exports was also close to 0.13 in 2022, remaining unchanged since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

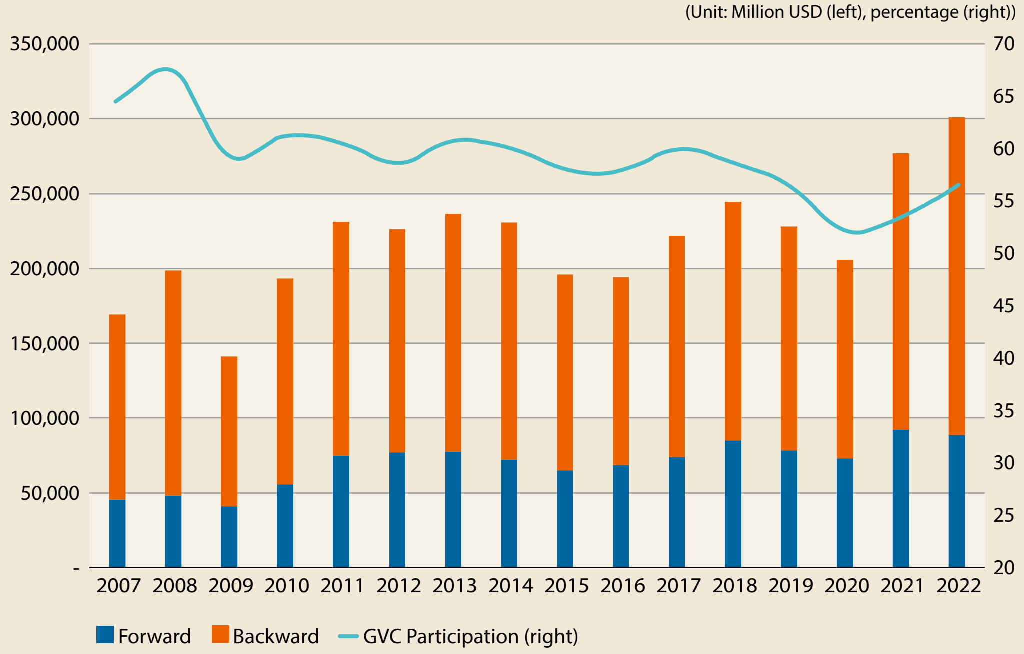
Note: Data related to knowledge spillover are not included due to data availability.

COUNTRY PROFILE: REPUBLIC OF CHINA

- GVC participation in the Republic of China exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

TRENDS IN GVC PARTICIPATION



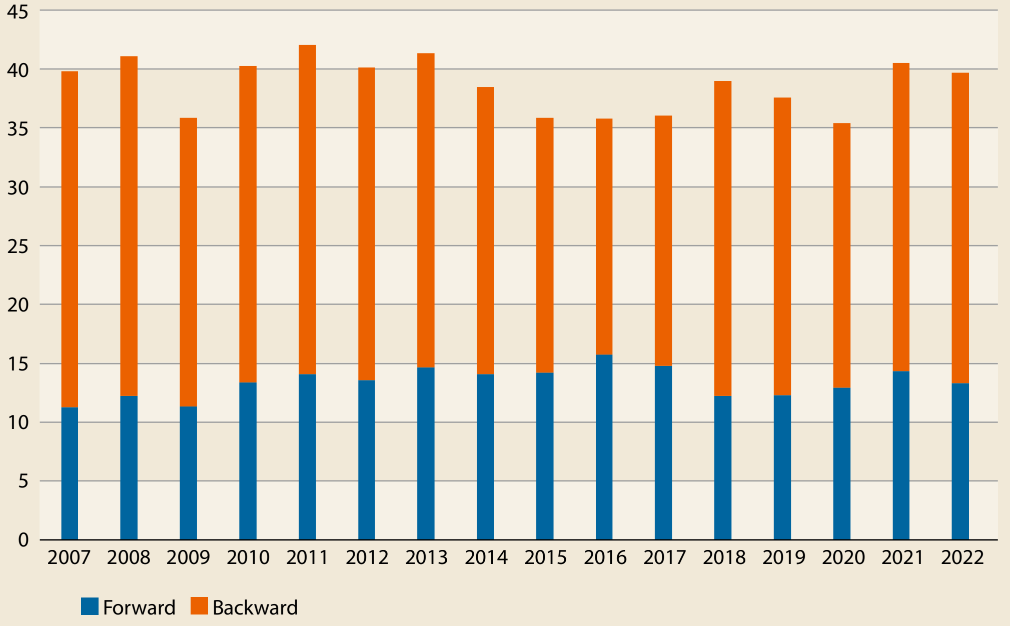
Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 65% to the Republic of China's total value-added exports, of which nearly 55% involved in GVCs.

FIGURE 2

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

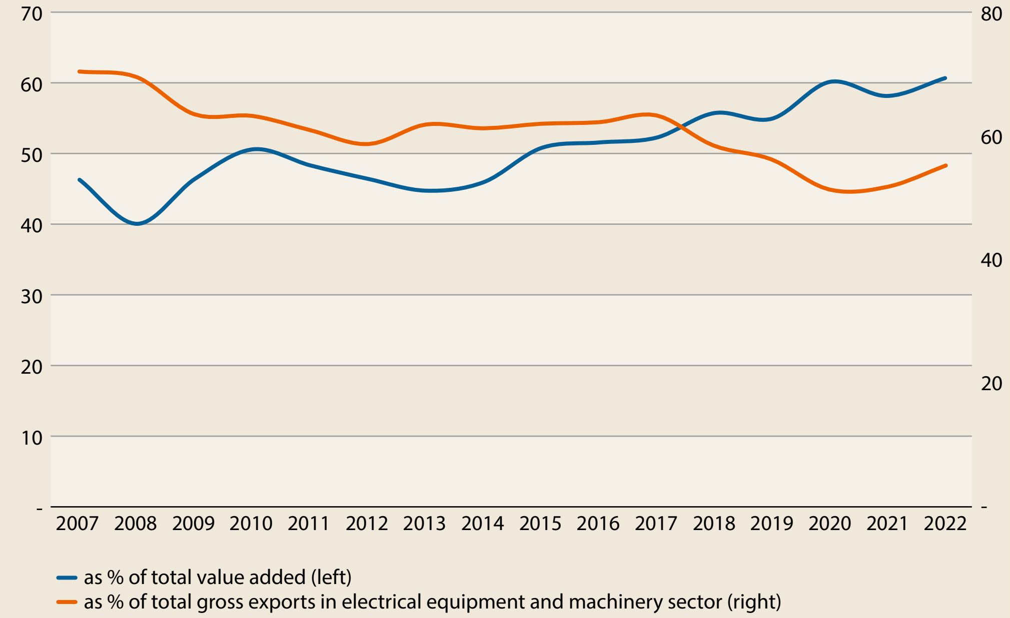
(Unit: Percentage)



Source: ADB, MRIO Tables Database

FIGURE 3

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS

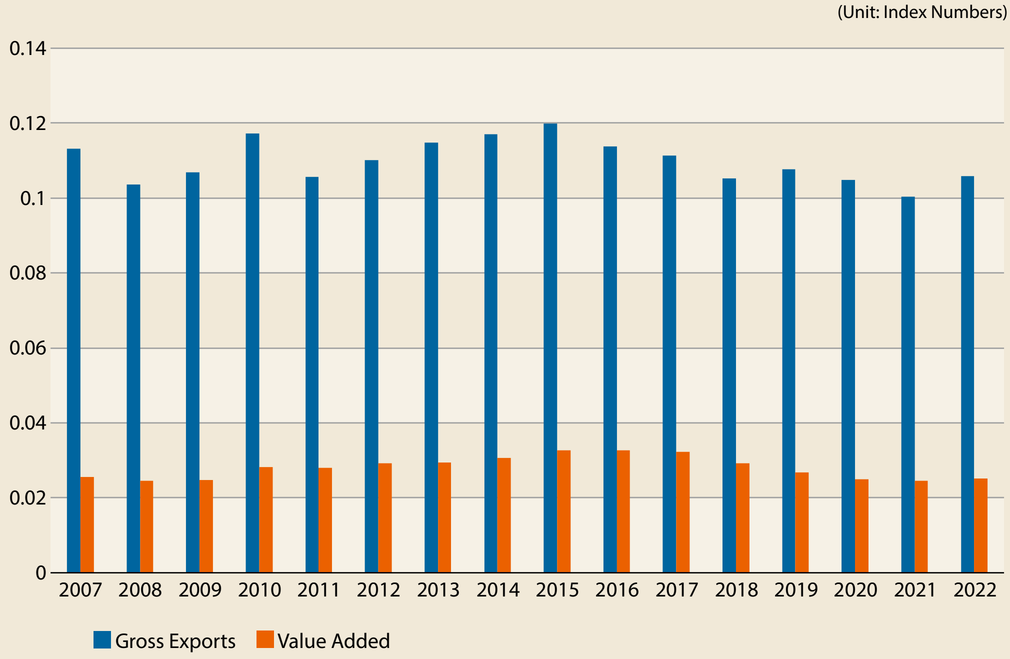


Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, the Republic of China documented an export concentration in gross exports of approximately 0.11, maintaining stability since 2018. However, the export concentration in value-added exports was close to 0.025 in 2022, indicating a decline from 2018.

FIGURE 4

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

Note: Data on trends of trade and knowledge spillover are not included due to data availability.

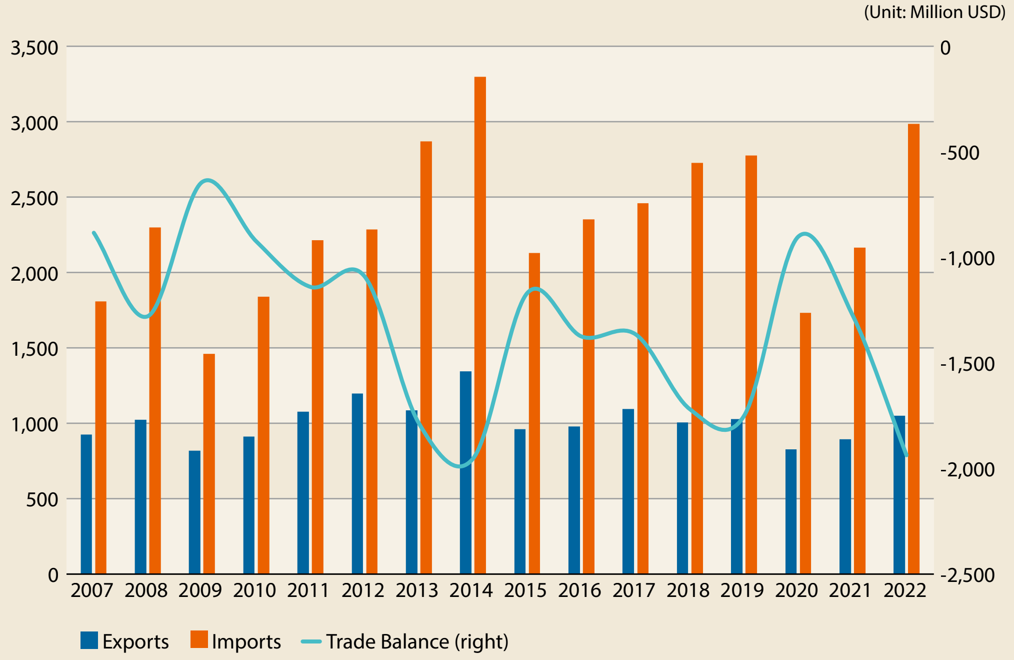
COUNTRY PROFILE: FIJI

- Fiji's total exports amounted to USD1,049 million, while imports accounted at USD2,987 million in 2021. According to the BACI-CEPII database, in 2021 the main exports were food, tobacco (51.5%), wood furniture (9.2%), and refined petroleum and chemicals (8%). As in 2022, its main export partners included Singapore, Australia, China, New Zealand, and the United States (UN Comtrade).

- Regarding GVC participation, Fiji exhibits a relatively higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

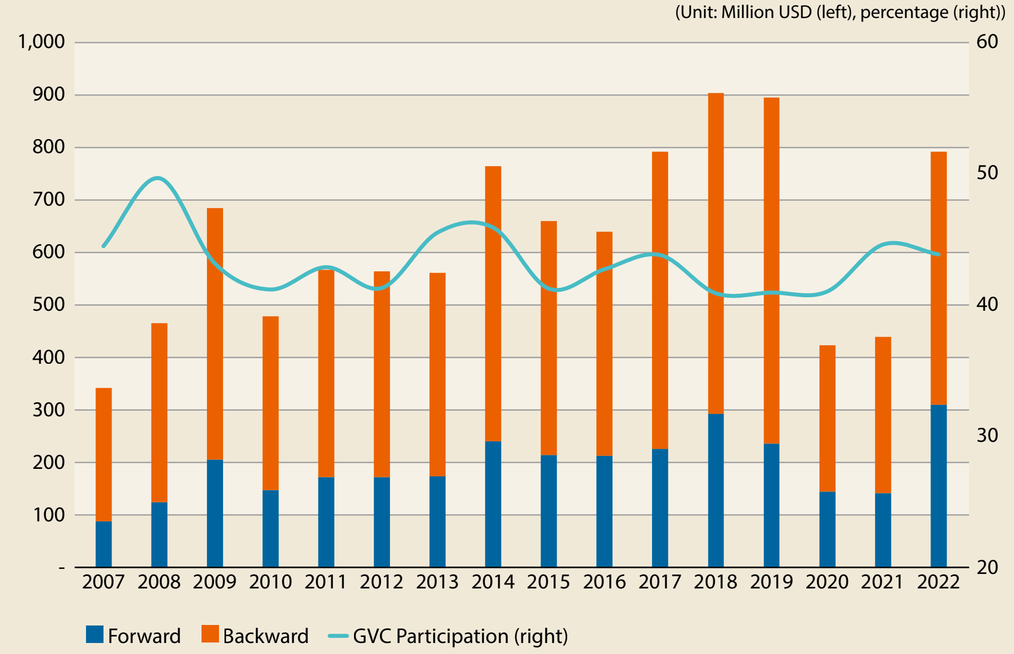
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

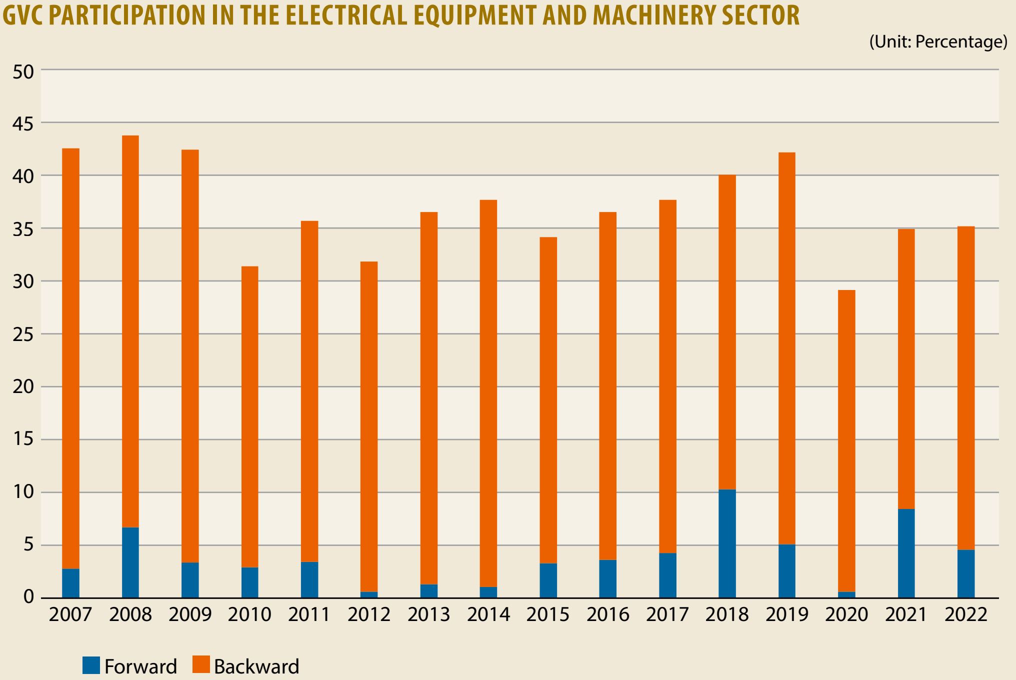


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 0.1% to Fiji's total value-added exports, of which nearly 35% involved in GVCs and higher backward GVC participation.

FIGURE 3

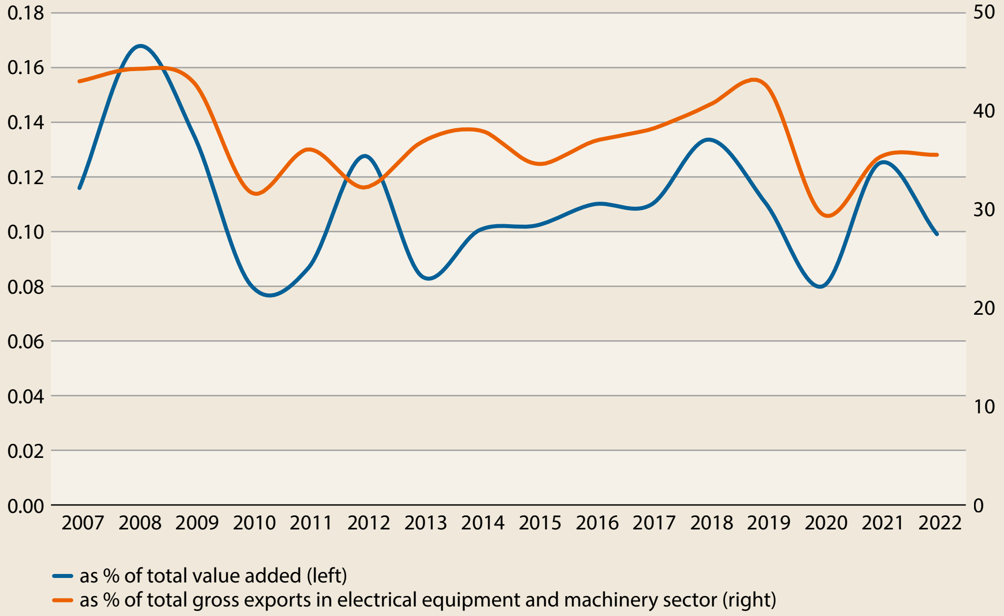
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



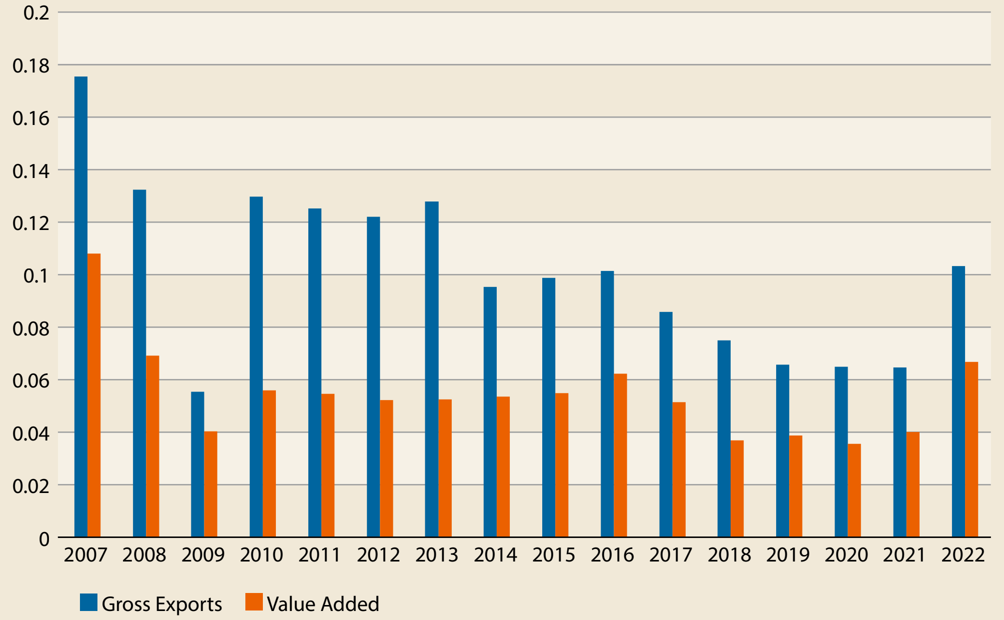
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Fiji documented an export concentration in gross exports of approximately 0.1, reflecting a decrease from 2018. Conversely, the export concentration in value-added exports was close to 0.065 in 2022, indicating an increase from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB Input-Output Tables for Asia and the Pacific Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

Note: Data related to knowledge spillover are not included due to data availability.

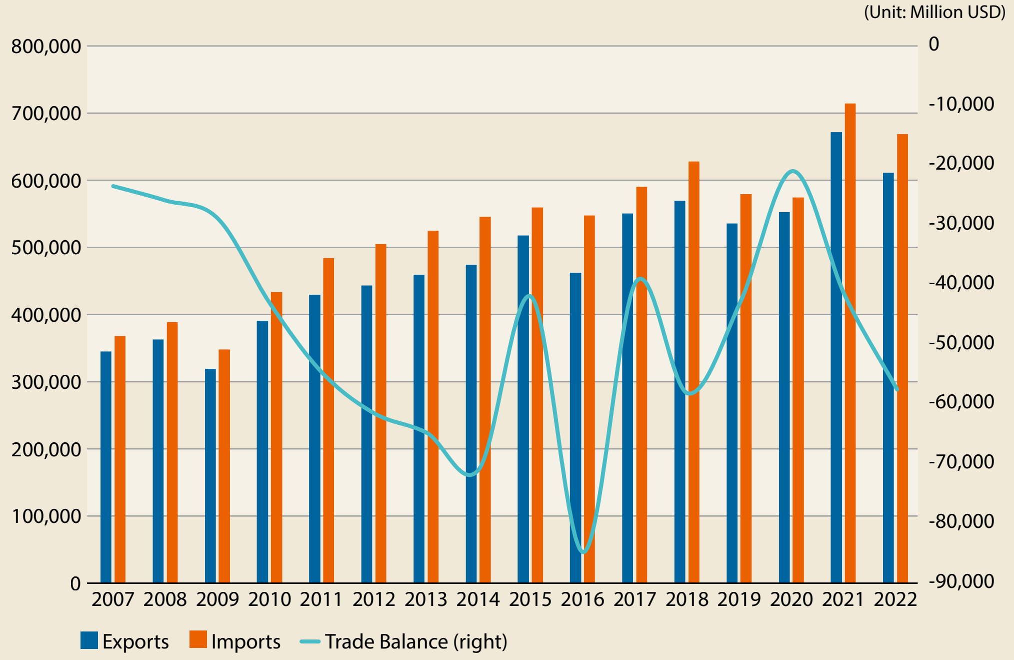
COUNTRY PROFILE: HONG KONG

- Hong Kong's total exports amounted to USD61,136 million, while imports accounted at USD66,984 million in 2021. According to the BACI-CEPII database, in 2021 the main exports were machinery, electrical equipment (41.7%), non-metallic minerals, metals (19.8%), and wood furniture (8%). In 2022, its main export partners included China, the United States, Singapore, Japan, and the Republic of Korea (UN Comtrade).

- Regarding GVC participation, Hong Kong exhibits a relatively higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

TRENDS OF TRADE

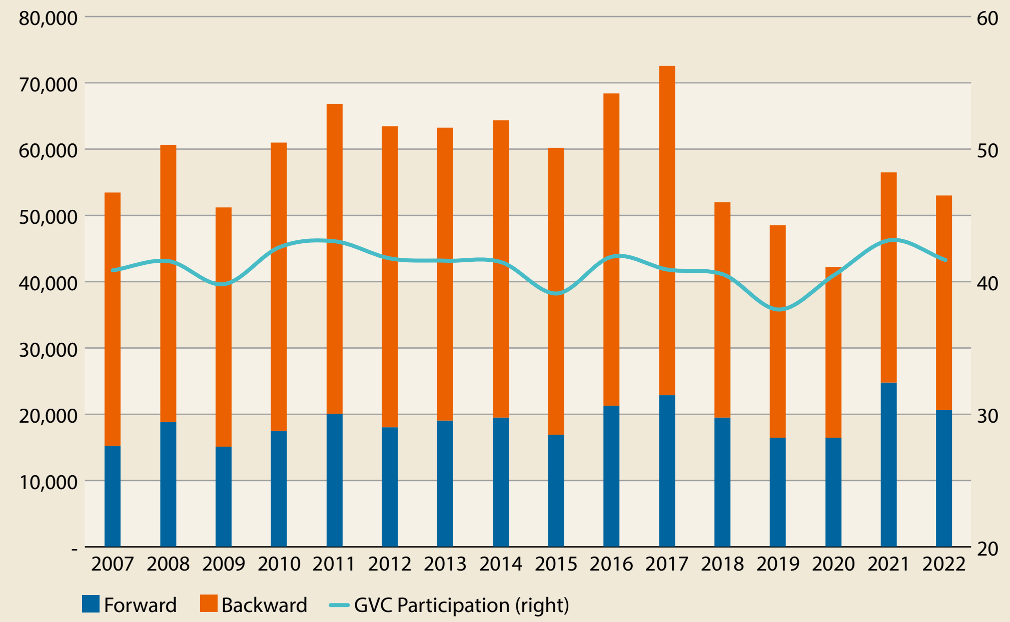


Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

(Unit: Million USD (left), percentage (right))



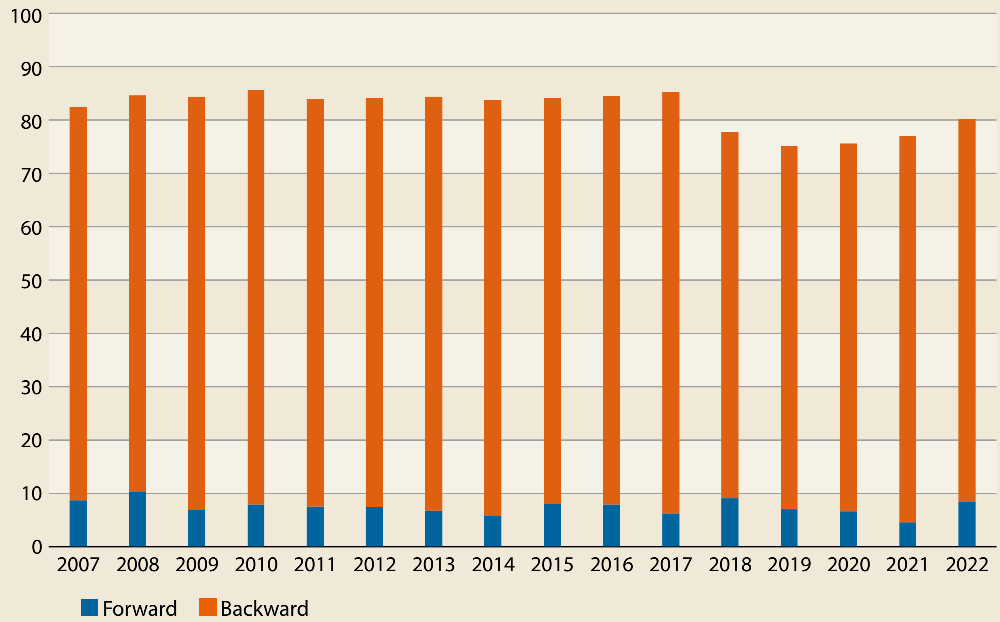
Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 6.5% to Hong Kong's total value-added exports, of which nearly 80% involved GVCs, particularly demonstrating a higher backward GVC participation.

FIGURE 3

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

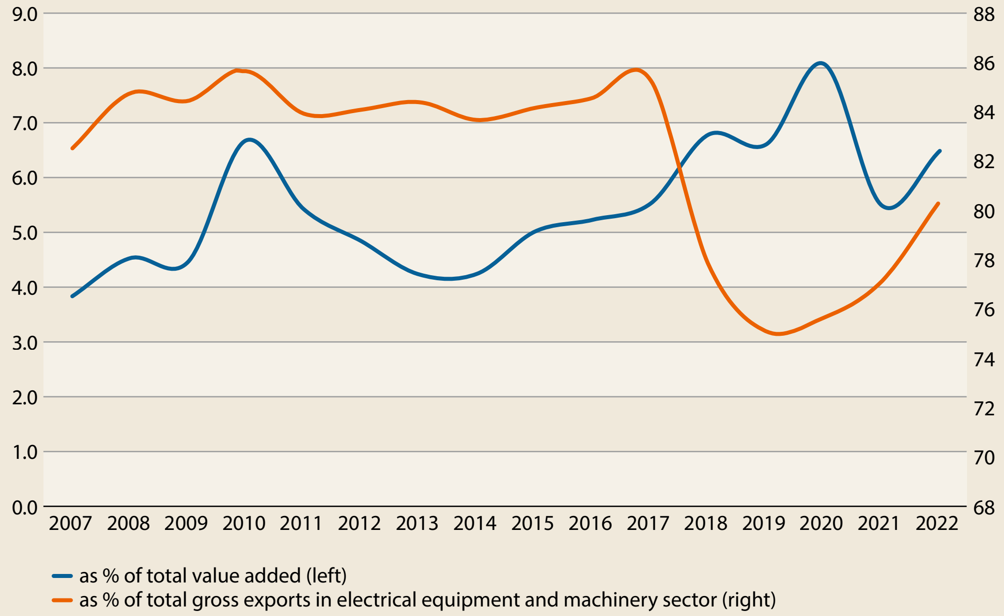
(Unit: Percentage)



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



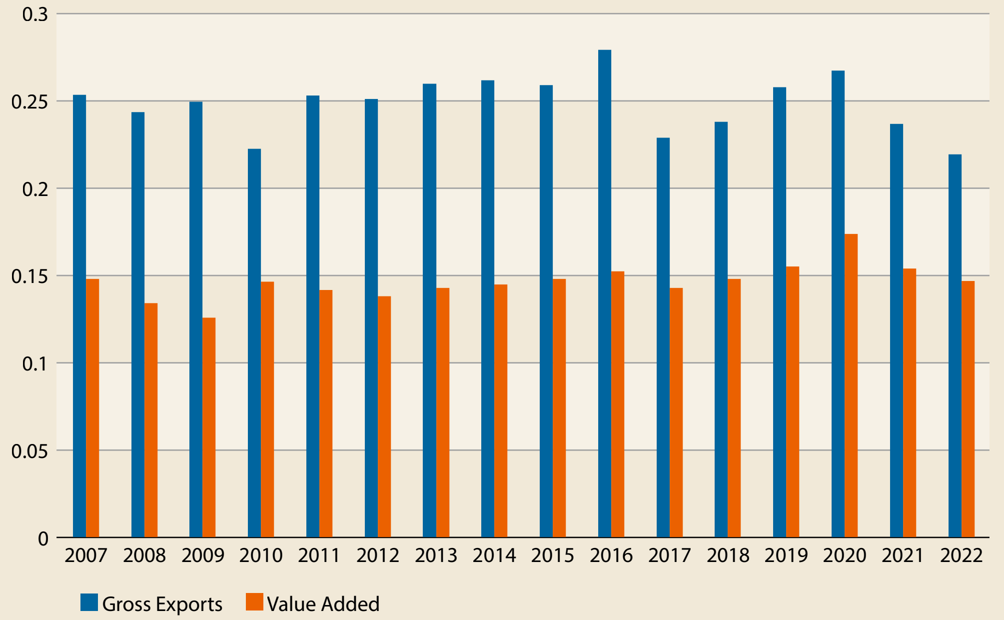
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Hong Kong documented an export concentration in gross exports of approximately 0.23, displaying fluctuations since 2018. Meanwhile, the export concentration in value-added exports was close to 0.15 in 2022, indicating an upward trend from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- The accumulation of knowledge capital in Hong Kong appears to be growing steadily, and the productivity of the ICT industry, measured by value added compared to the number of workers, also appears to increase as of 2020. Accordingly, it is expected that there will be a significant increase in the productivity of other industries in the future.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

Year over year (YoY), %

	Hong Kong
Domestic R&D stock growth (2020)	5.876
Foreign R&D stock growth (2020)	5.722
ICT industry labor productivity growth (2020)	3.392
Human capital growth (2019)	0.461

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

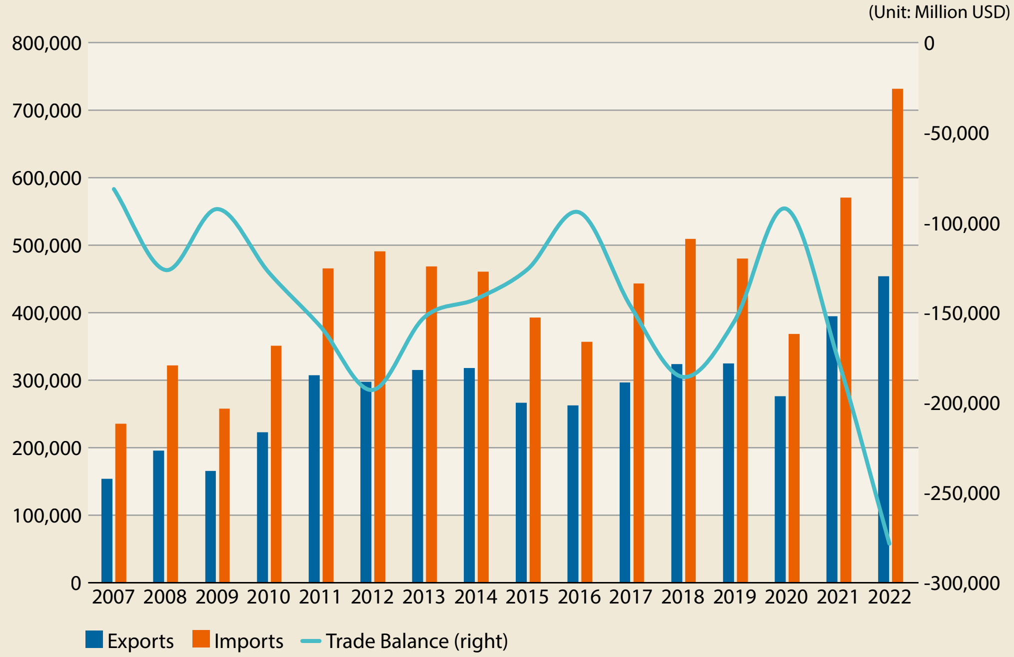
COUNTRY PROFILE: INDIA

- India's total exports amounted to USD453,196 million, while imports accounted at USD73,1907 million in 2021. According to the BACI-CEPII database, in 2021 the main exports were refined petroleum and chemicals (28.9%), non-metallic minerals and metals (13.3), and machinery and electrical equipment (11.5%). In 2022, its main export partners included the United States, China, the United Arab Emirates, Saudi Arabia, and Russia (UN Comtrade).

- Regarding GVC participation, India exhibits a relatively higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added (inputs) across all industries.

FIGURE 1

TRENDS OF TRADE

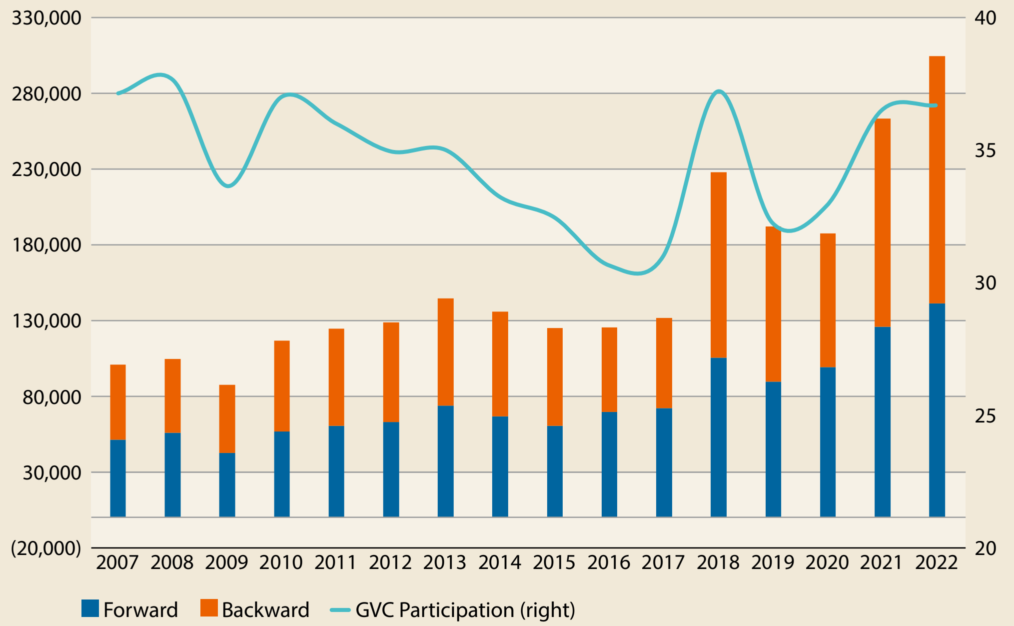


Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

(Unit: Million USD (left), percentage (right))



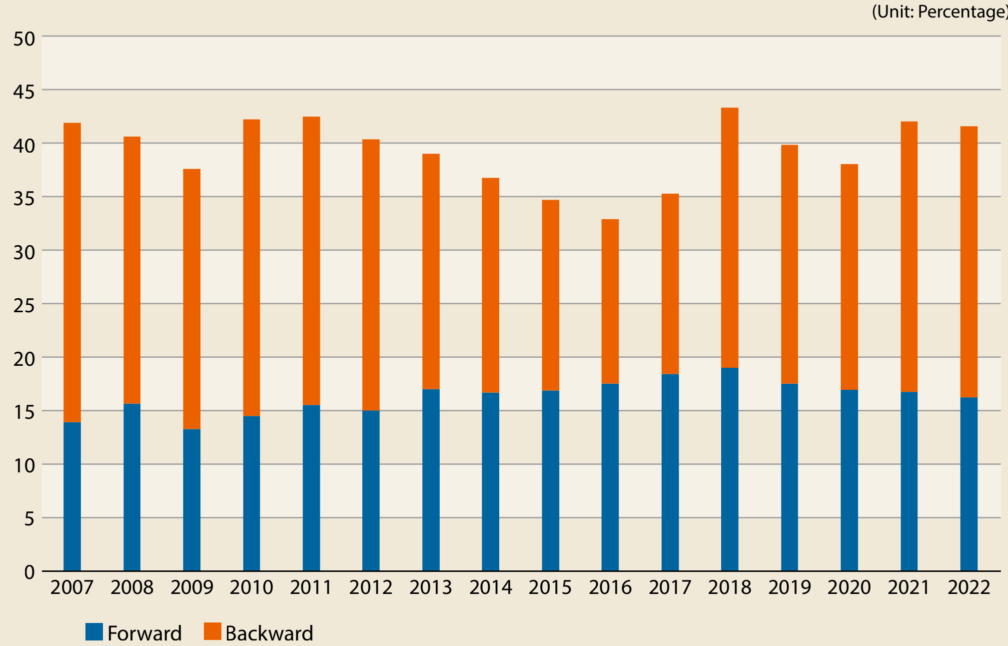
Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 5.6% to India's total value-added exports, of which nearly 42% involved in GVCs and relatively higher backward GVC participation.

FIGURE 3

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

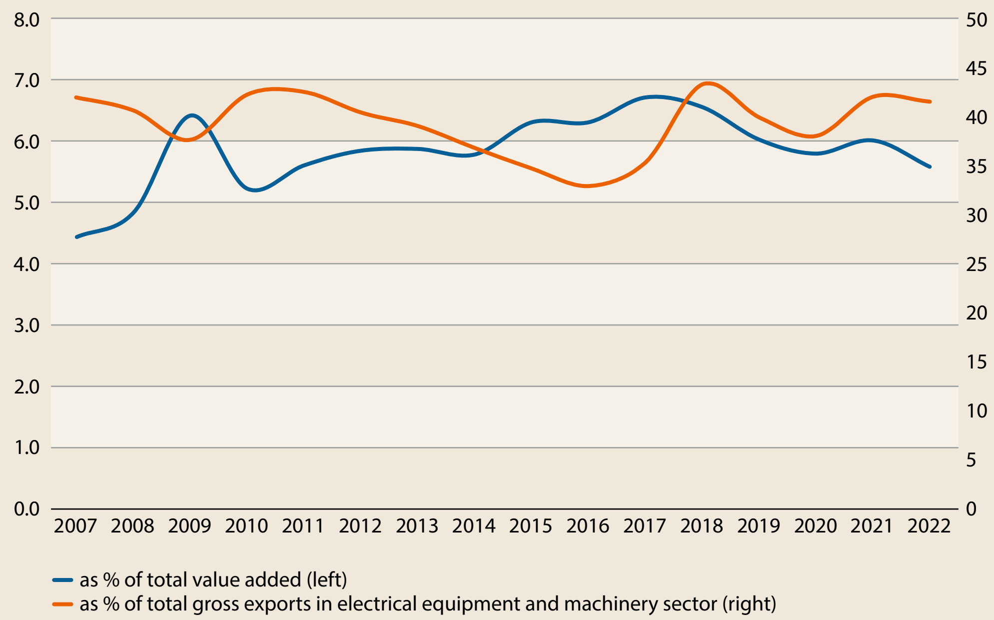
(Unit: Percentage)



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



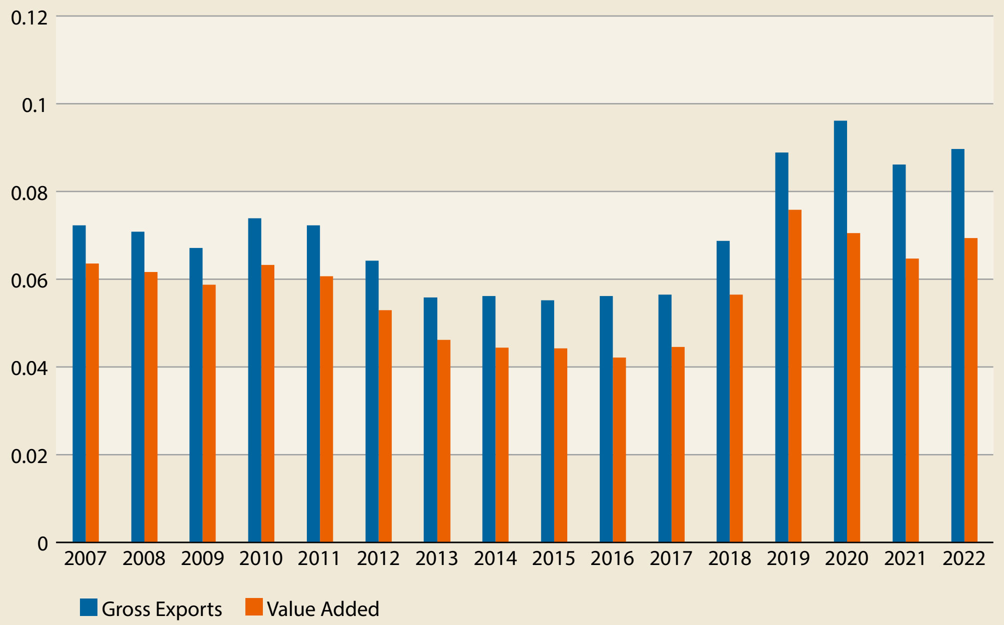
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, India reported an export concentration in gross exports of around 0.09, demonstrating an increase from 2018. Conversely, the export concentration in value-added exports was approximately 0.07 in 2022, indicating a decline since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- India's R&D investment is confirmed up to 2018 data due to data availability. India's R&D investment decreased from 0.84% of gross domestic product (GDP) in 2008 to 0.69% in 2018, and knowledge transfer from overseas also decreased. However, productivity in the ICT field appears to have increased, so it is necessary to observe future trends.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	India
Domestic R&D stock growth (2018)	6.297
Foreign R&D stock growth (2020)	-18.830
ICT industry labor productivity growth (2020)	1.339
Human capital growth (2019)	1.118

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

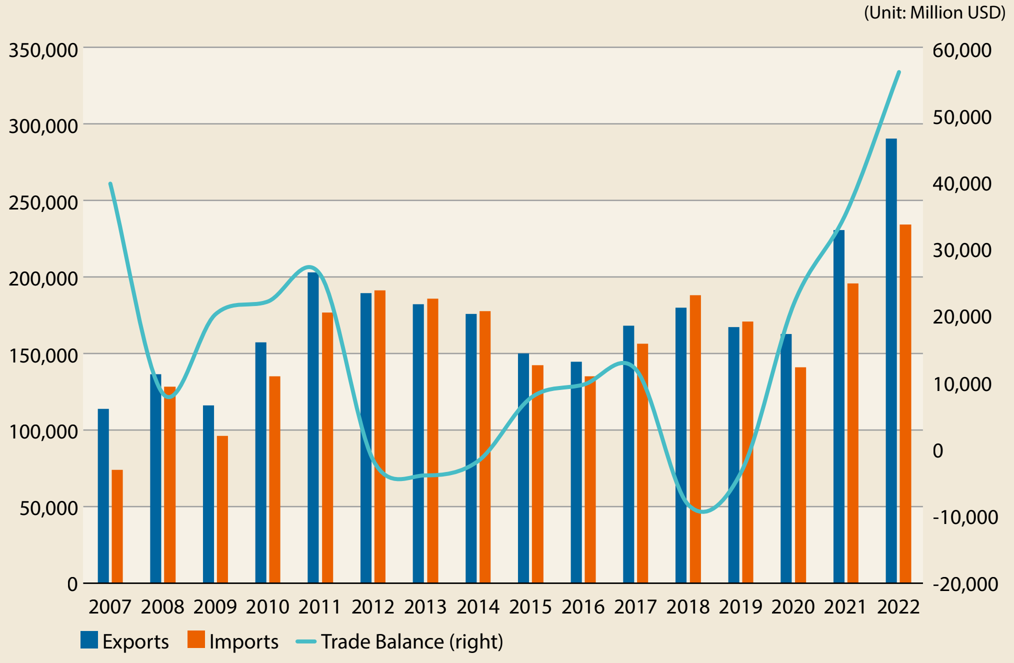
COUNTRY PROFILE: INDONESIA

- Indonesia's total exports amounted to USD291,490 million, while imports accounted at USD235,094 million in 2021, with a trade surplus of USD56,395 million, one of the biggest trade surpluses according to the Ministry of Trade from Indonesia. According to the BACI-CEPII database, in 2021 the main exports were mining such as coal, iron and steel (20.6%), food and tobacco (18.7%), and non-metallic minerals and metals (14.1%). Machinery and electrical equipment accounted for 8.8% of total exports. In 2022, its main export partners included China, Japan, the United States, Singapore, and India (UN Comtrade).

- Regarding GVC participation, Indonesia exhibits a relatively higher degree of forward participation than backward participation, indicating the involvement of upstream activities, in other words Indonesia's domestic value added are used as inputs of other countries to produce final goods.

FIGURE 1

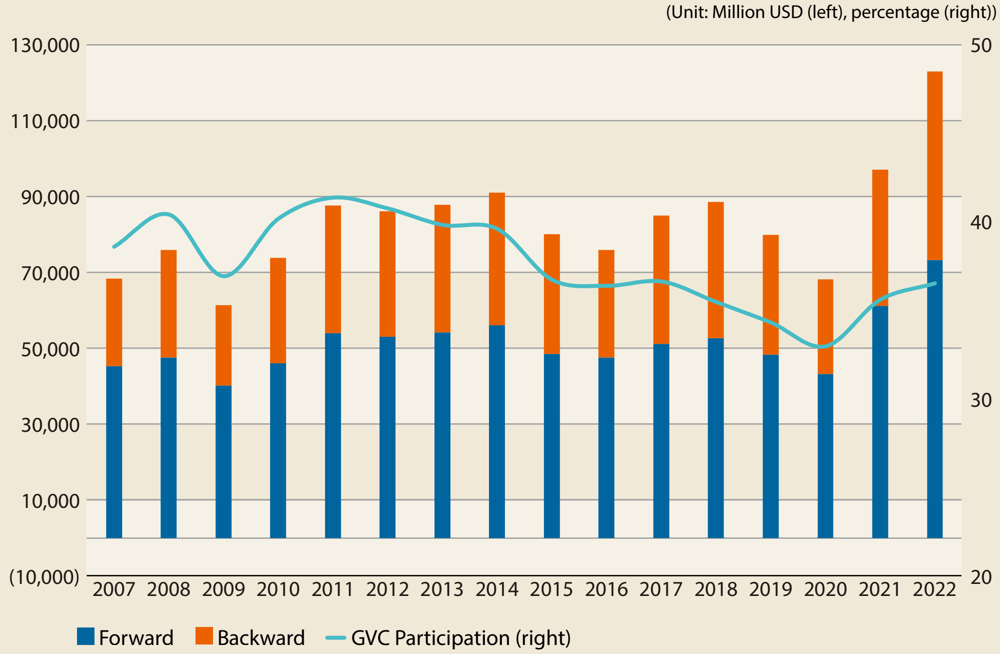
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

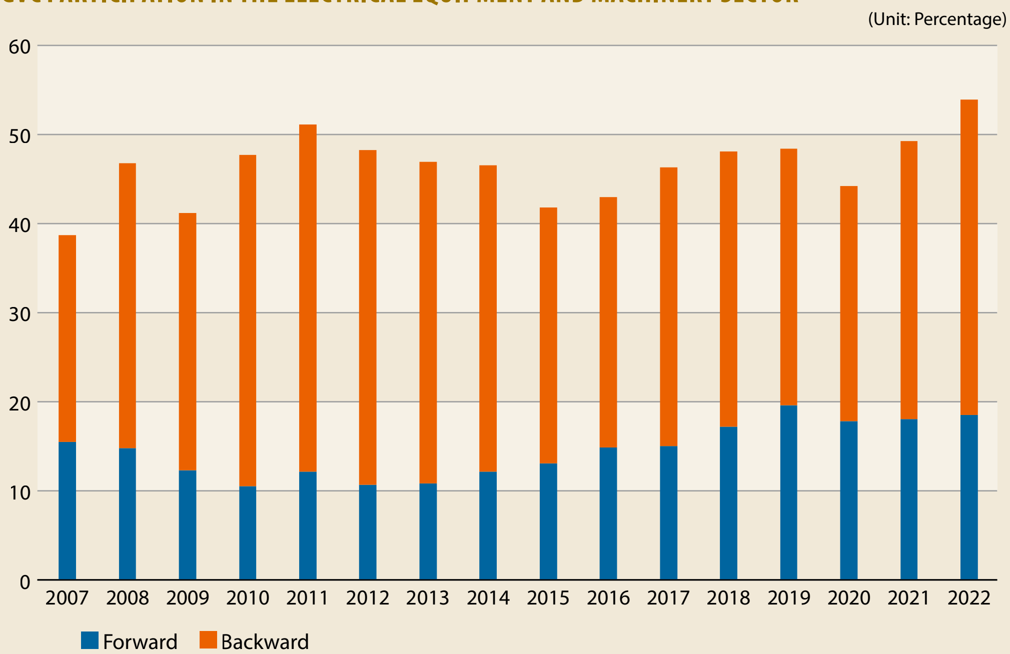


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 10.4% to Indonesia's total value-added exports, of which nearly 54% involved in GVCs, with relatively higher backward participation.

FIGURE 3

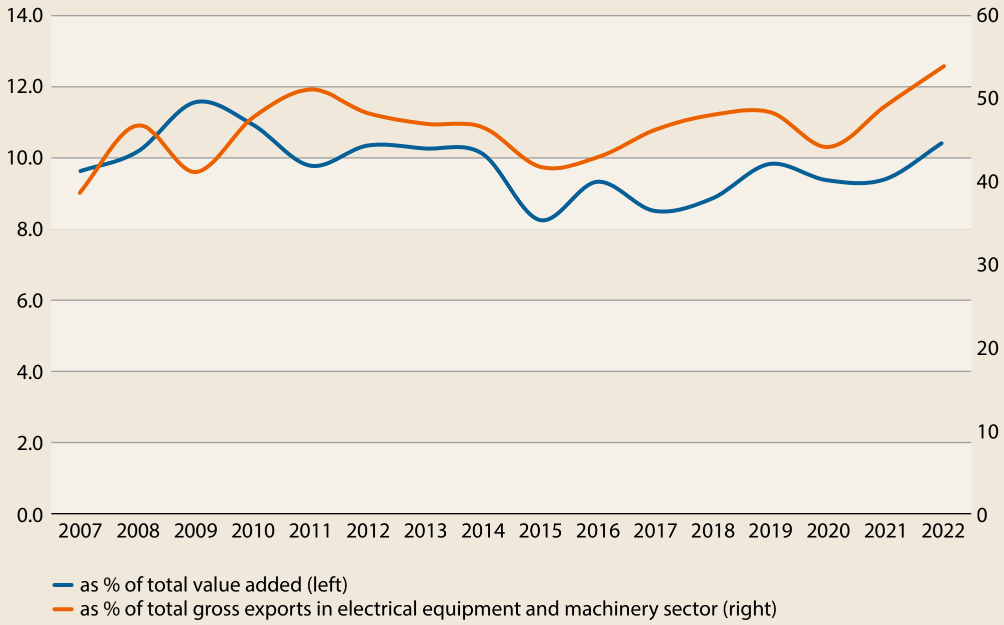
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



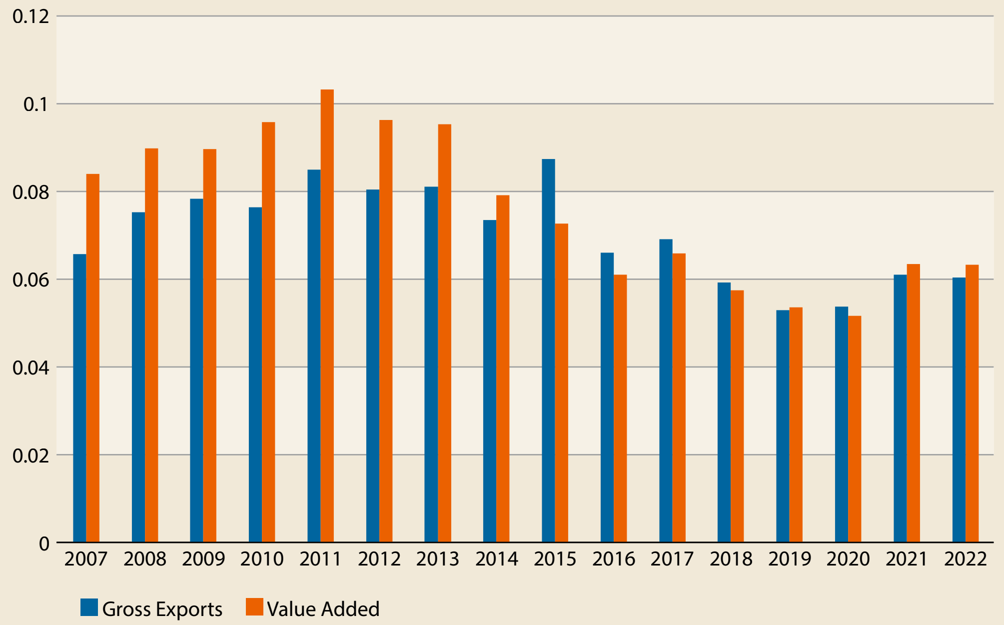
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Indonesia documented an export concentration in gross exports of approximately 0.06, maintaining stability since 2018. Similarly, the export concentration in value-added exports was close to 0.06 in 2022, showing no significant change since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Indonesia shows a continuous increase in domestic R&D investment as part of Making Indonesia 4.0. However, knowledge transfer from overseas appears to have decreased. In addition, the level of human capital appears to be decreasing, so it is necessary to wait and see the trend's development due to impact of the economy overcoming COVID-19.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Indonesia
Domestic R&D stock growth (2020)	14.437
Foreign R&D stock growth (2020)	-22.660
ICT industry labor productivity growth (2020)	5.381
Human capital growth (2019)	-0.608

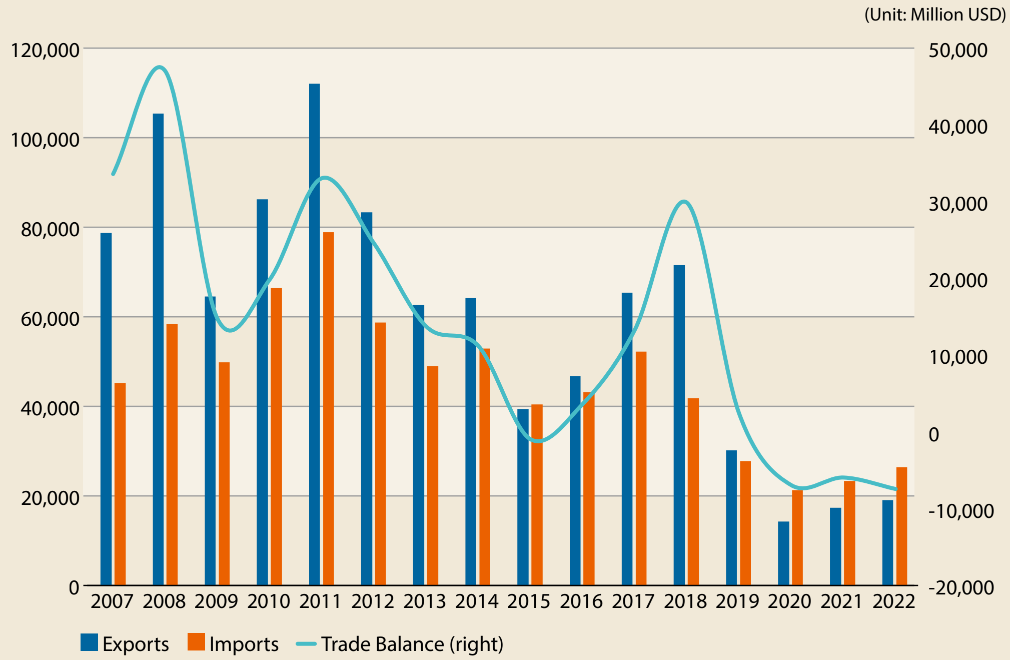
Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

COUNTRY PROFILE: ISLAMIC REPUBLIC OF IRAN

- The Islamic Republic of Iran's (I.R. Iran) total exports amounted to USD18,992 million, while imports accounted at USD26,489 million in 2021. According to the BACI-CEPII database, in 2022 the main exports were petroleum oils and products, iron and steel, natural gas, etc. Machinery and electrical equipment accounted for 8.8% of total exports. In 2022, its main export partners include China, the United Arab Emirates, Turkiye, Iraq, and India (UN Comtrade).

FIGURE 1

TRENDS OF TRADE



Source: IMF, DOTS.

- I.R. Iran's domestic R&D investment and ICT productivity appear to have risen as of 2020. Accordingly, it can be seen that economic growth continues due to domestic R&D. However, it is judged that there are some limitations to accurate analysis due to continuous political instability and lack of data availability.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	I.R. Iran
Domestic R&D stock growth (2019)	9.557
Foreign R&D stock growth (2020)	-10.591
ICT industry labor productivity growth (2020)	30.304
Human capital growth (2019)	1.943

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

Note: Trends in GVC participation was not included due to data availability.

COUNTRY PROFILE: JAPAN

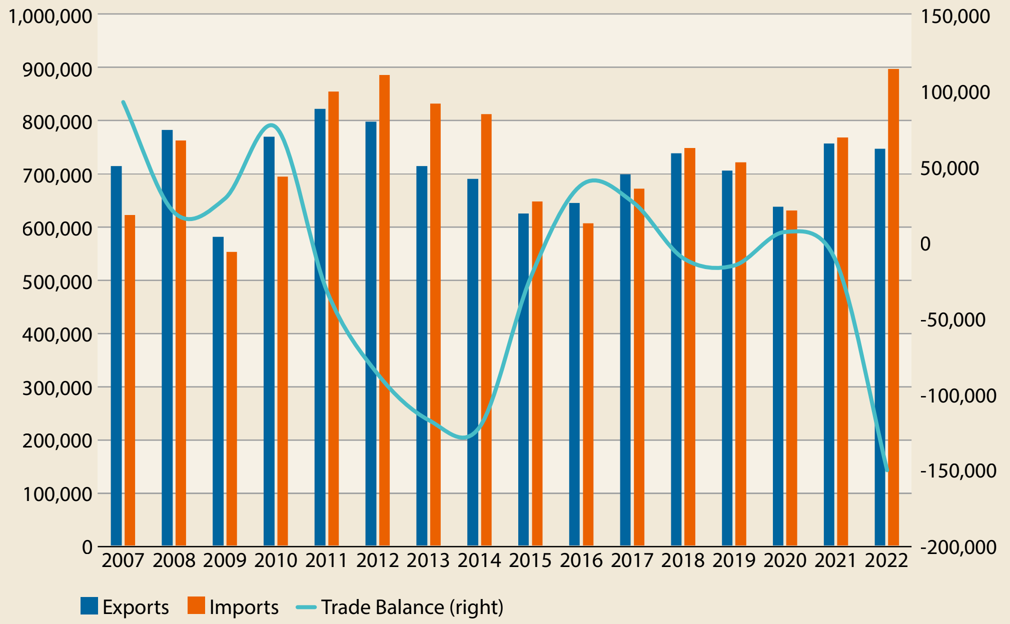
- Japan's total exports amounted to USD746,720 million, while imports accounted at USD897,017 million in 2021. According to the BACI-CEPII database, in 2021 the main exports were composed of machinery and electrical equipment (42.2%), transport-related commodities (22.7%), and refined petroleum and chemicals (14.6%). In 2022, its main export partners included China, the United States, the Republic of Korea, Australia, and Thailand (UN Comtrade).

- Regarding GVC participation, Japan exhibits a relatively higher degree of forward participation than backward participation, indicating the involvement of upstream activities, in other words Japan's domestic value added are used as inputs of other countries to produce final goods.

FIGURE 1

TRENDS OF TRADE

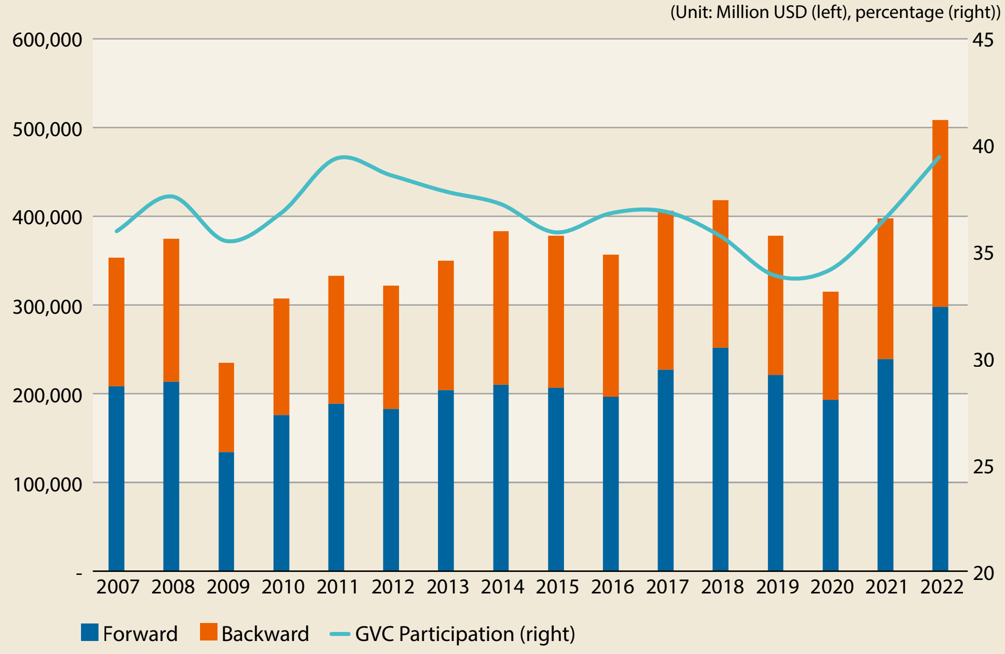
(Unit: Million USD)



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

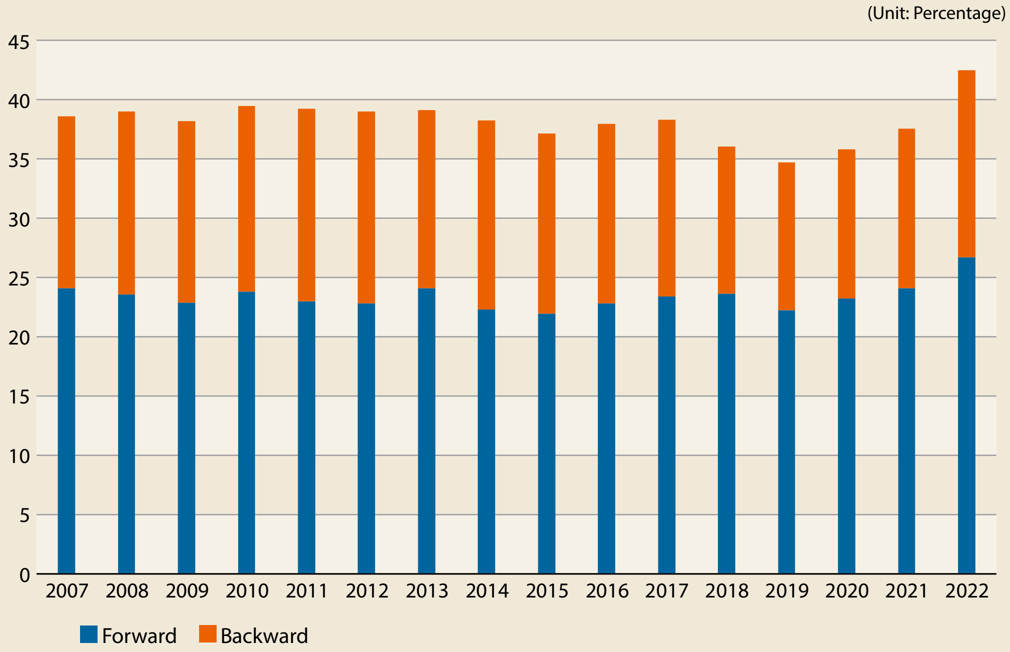


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 32.9% to Japan's total value-added exports, of which nearly 43% involved in GVCs with a relatively higher forward GVC participation.

FIGURE 3

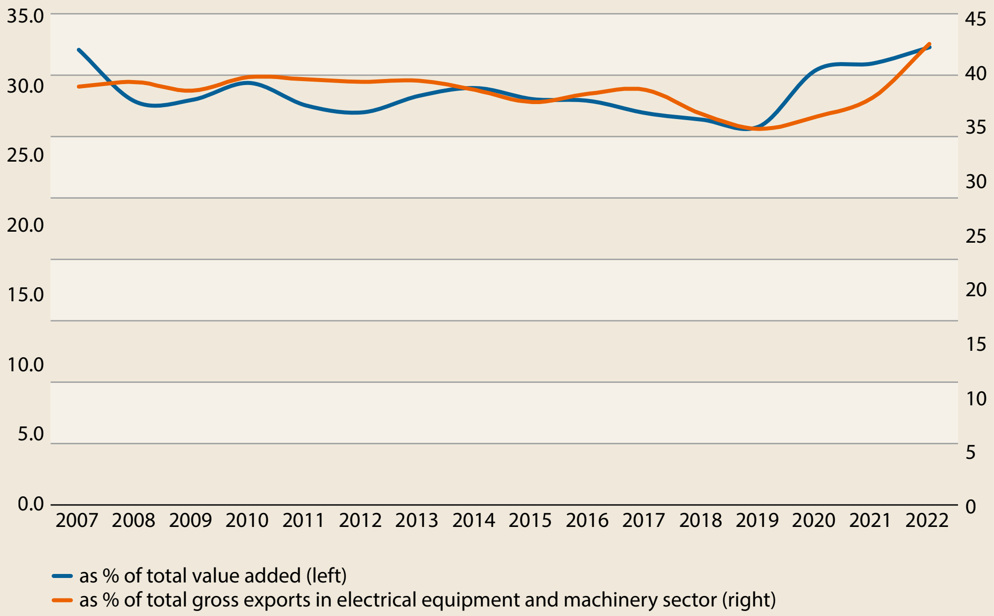
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED

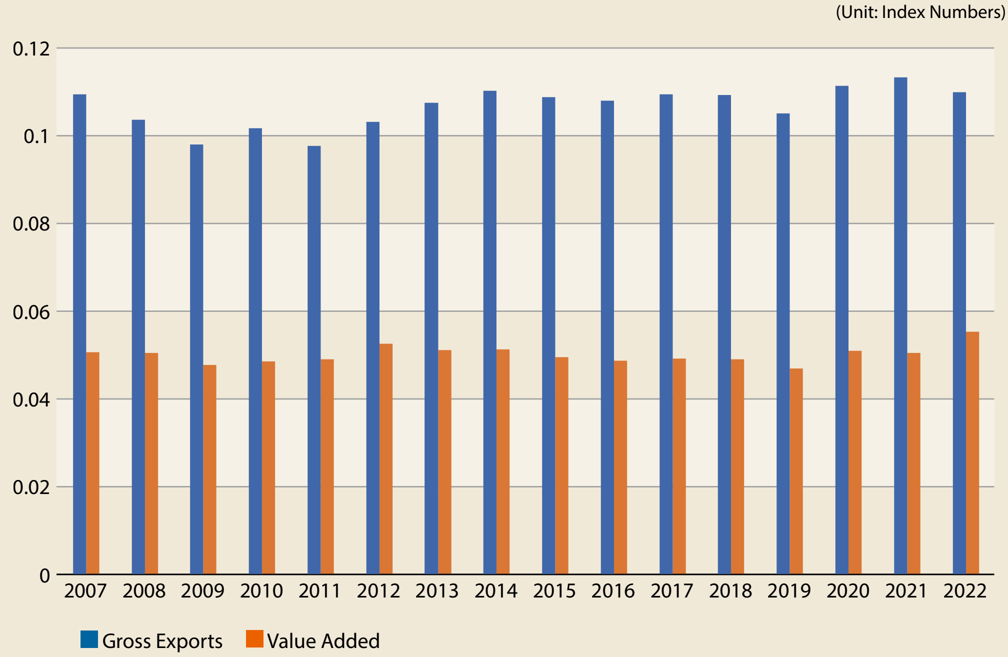


Source: Authors' calculations based on the ADB Input-Output Tables for Asia and the Pacific Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Japan reported an export concentration in gross exports of approximately 0.11, remaining unchanged since 2018. Conversely, the export concentration in value-added exports was close to 0.05 in 2022, indicating growth since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

- Japan's domestic R&D investment is at a high level and appears to have recorded steady growth. Likewise, human capital and ICT productivity seem to have risen as of 2020. However, it seems that there was a negative impact on the external sector due to negative interest rates and falling exports to China and ASEAN.

YoY, %

	Japan
Domestic R&D stock growth (2020)	5.263
Foreign R&D stock growth (2020)	-19.923
ICT industry labor productivity growth (2020)	2.069
Human capital growth (2019)	0.307

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

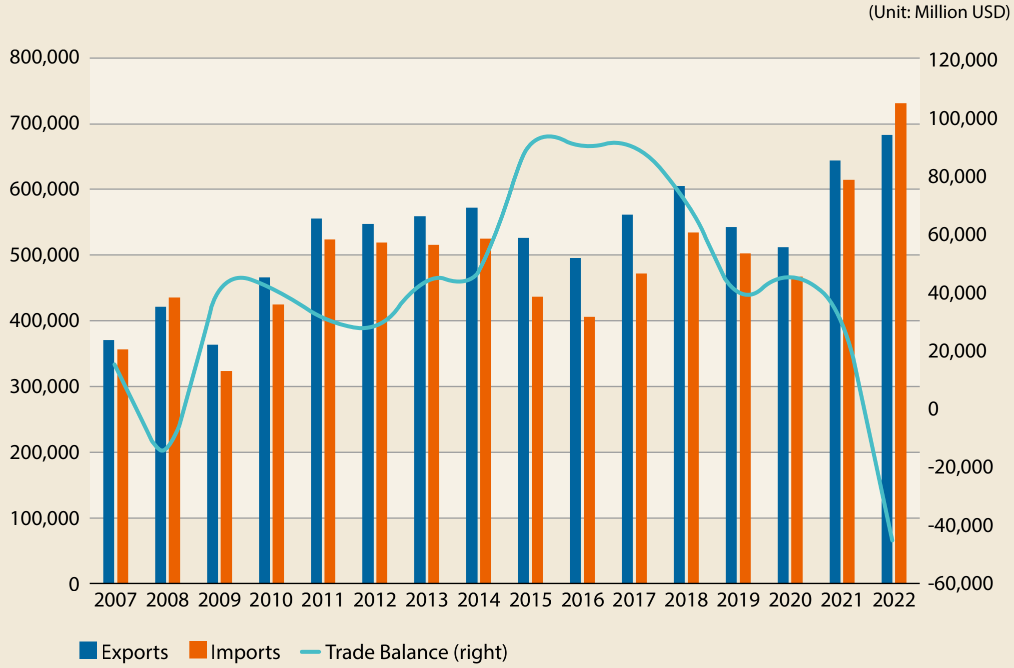
COUNTRY PROFILE: REPUBLIC OF KOREA

- The Republic of Korea's (ROK) total exports amounted to USD683,583 million, while imports accounted at USD731,369 million in 2021. According to the BACI-CEPII database, in 2021 its main exports were machinery and electrical equipment (44.5%), refined petroleum and chemicals (23.2%), transport-related goods (14.8%), and mining-related commodities (3.9%). In 2022, its main export partners were China, the United States, Vietnam, Japan, and Australia. (UN Comtrade).

- Regarding GVC participation, the ROK exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

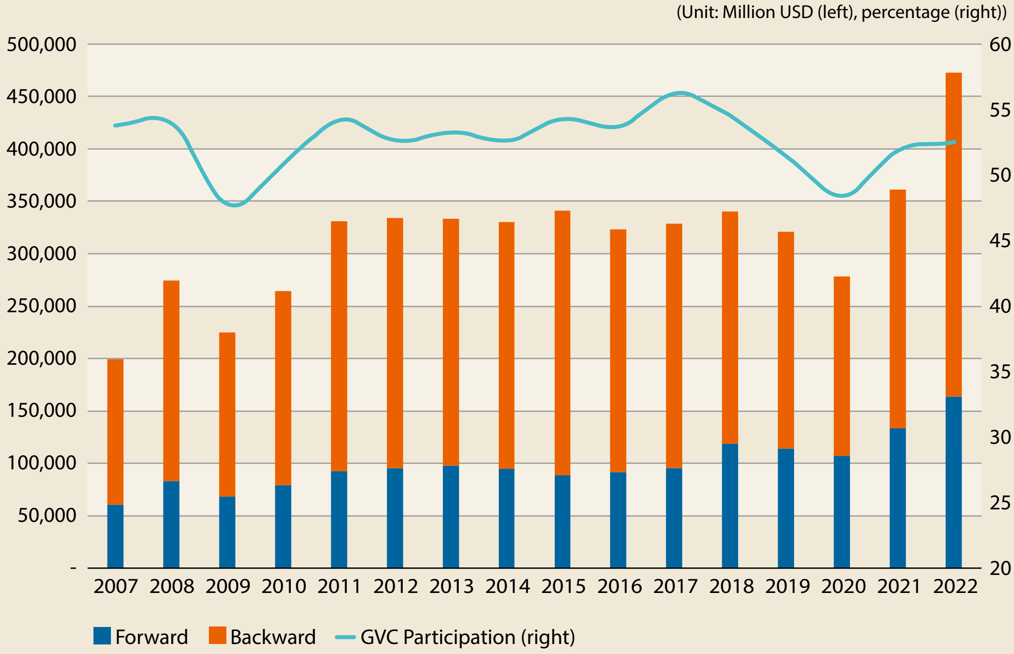
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

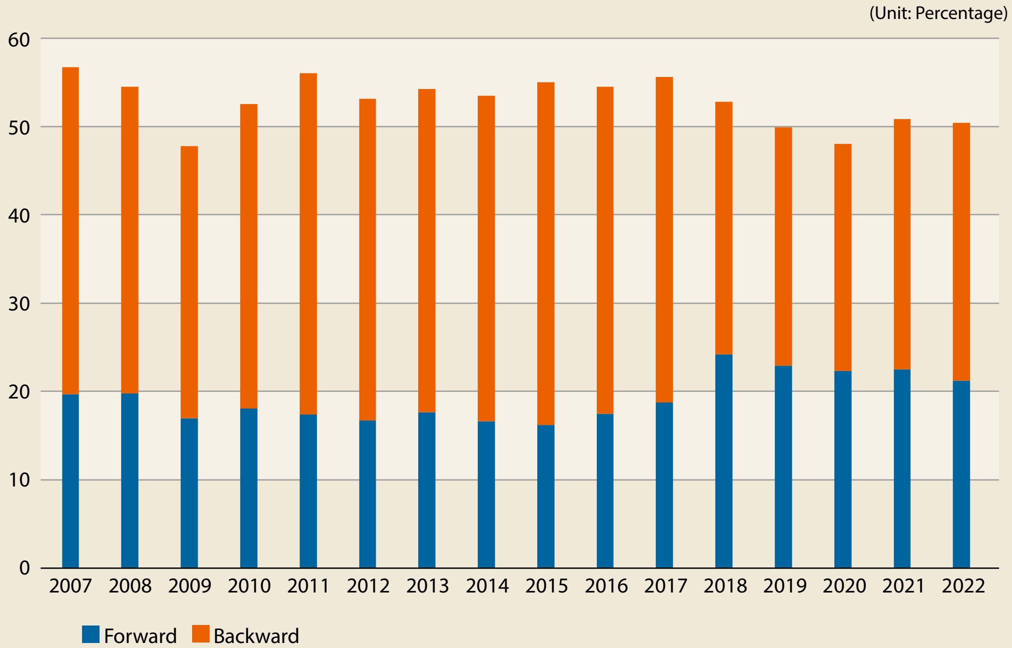


Source: ADB Input-Output Tables for Asia and the Pacific Database

- In 2022, the electrical equipment and machinery industry contributed 33.6% of the ROK's total value-added exports, of which nearly 50% involved in GVCs, with a higher backward GVC participation.

FIGURE 3

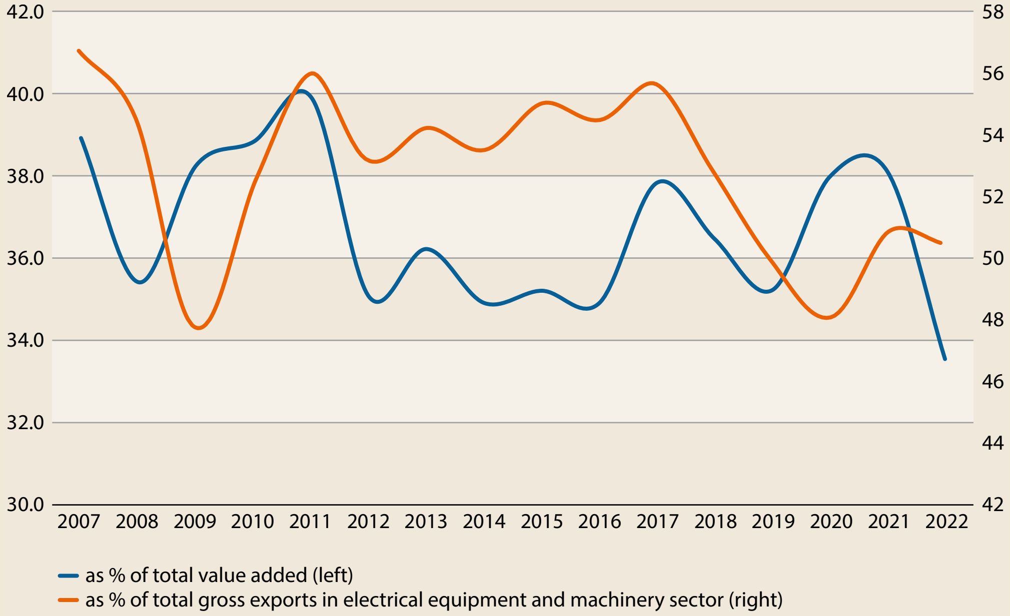
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS



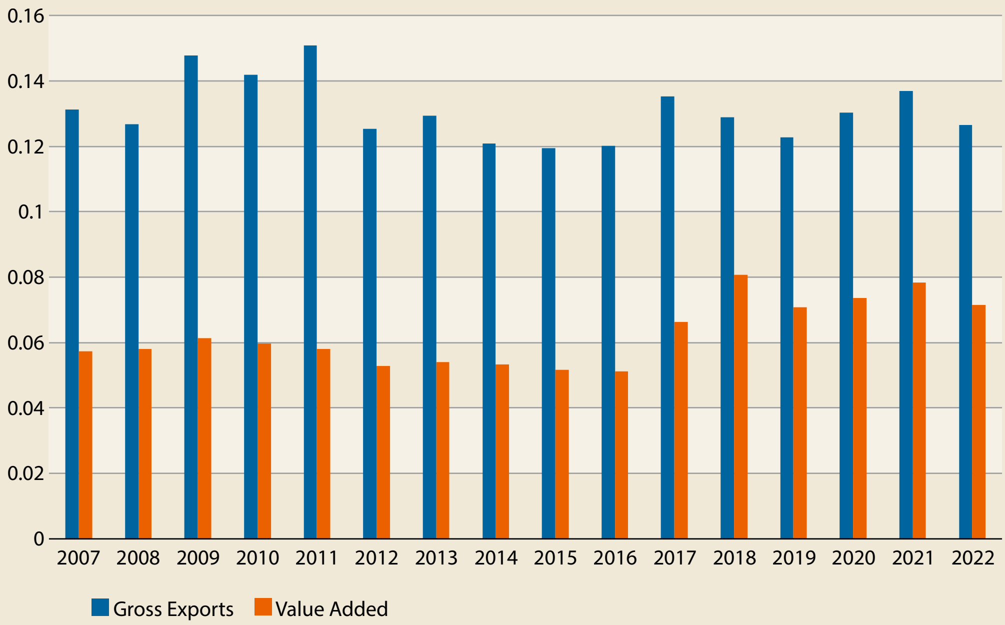
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, the ROK documented an export concentration in gross exports of approximately 0.11, maintaining stability since 2018. Similarly, the export concentration in value-added exports was close to 0.07 in 2022, showing no significant change from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- The ROK's domestic R&D investment seems to have recorded growth, but overseas knowledge transfer and ICT productivity seem to have declined. This seems to be due to the stagnation of exports of other parts, while the proportion of exports of some items such as computers and semiconductors is increasing during the COVID-19 crisis. As a result, the proportion of ROK's ICT exports in the global market appears to have decreased.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	ROK
Domestic R&D stock growth (2020)	7.101
Foreign R&D stock growth (2020)	-2.429
ICT industry labor productivity growth (2020)	-8.649
Human capital growth (2019)	0.965

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

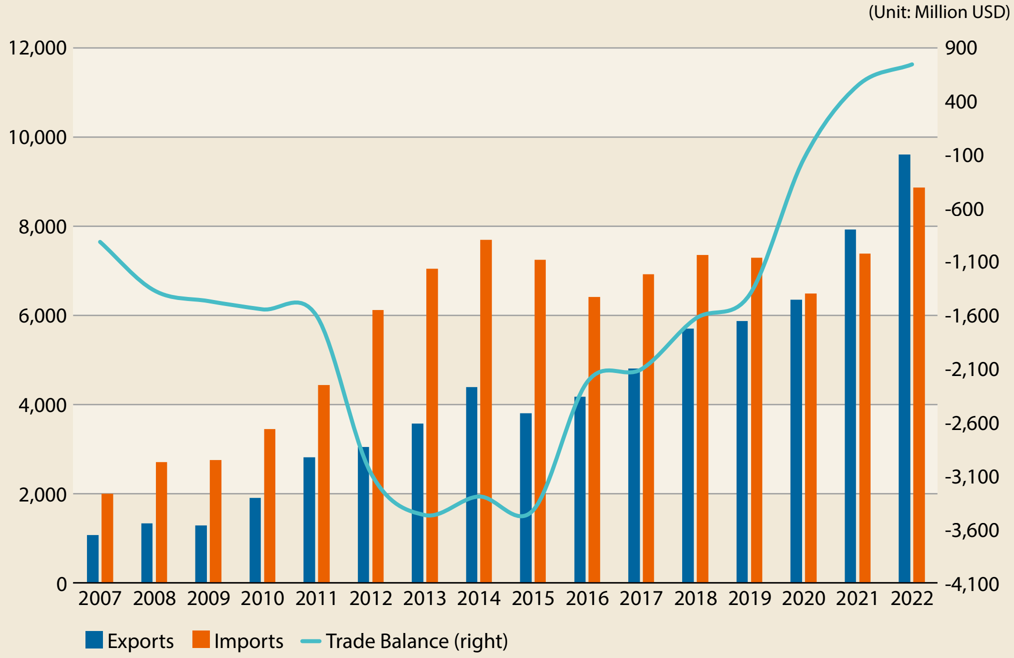
COUNTRY PROFILE: LAO PDR

- Lao People's Democratic Republic's (Lao PDR) total exports amounted to USD9,583 million, while imports accounted at USD8,846 million in 2021. According to the BACI-CEPII database, in 2021 the main exports were nonmetallic minerals and metals (23.7%), other manufacturing commodities (21.2%), and pulp and printing (8.7%). Machinery and electrical equipment accounted for 6.5% of total exports. In 2022, its main export partners included Thailand, China, Vietnam, Australia, and Switzerland. (UN Comtrade).

- Regarding GVC participation, Indonesia exhibits a relatively higher degree of forward participation than backward participation, indicating the involvement of upstream activities, in other words Lao PDR's domestic value added are used as intermediate inputs of other countries to produce final goods.

FIGURE 1

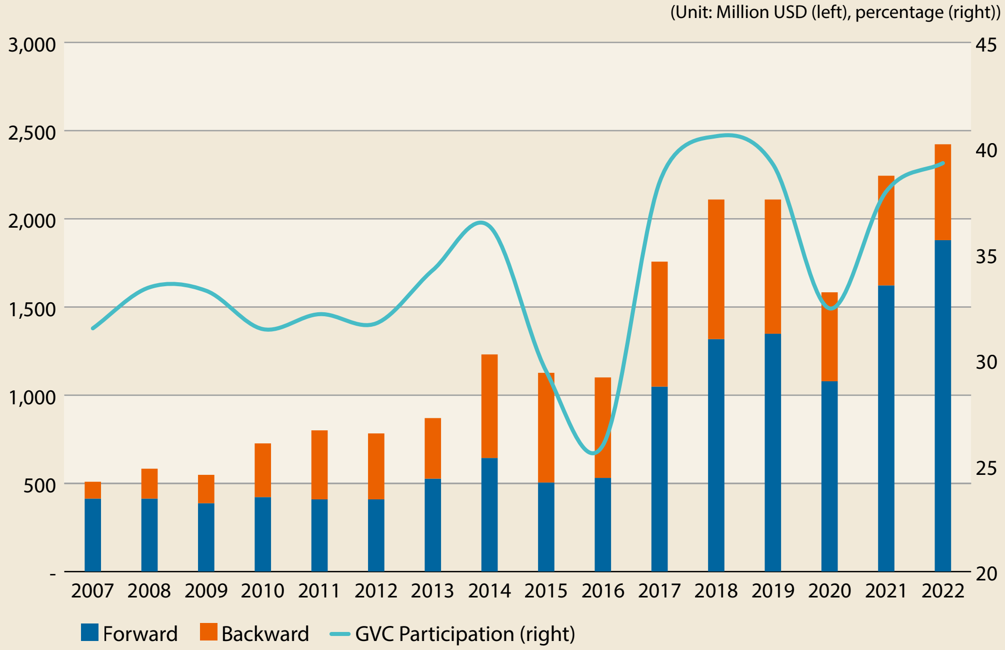
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

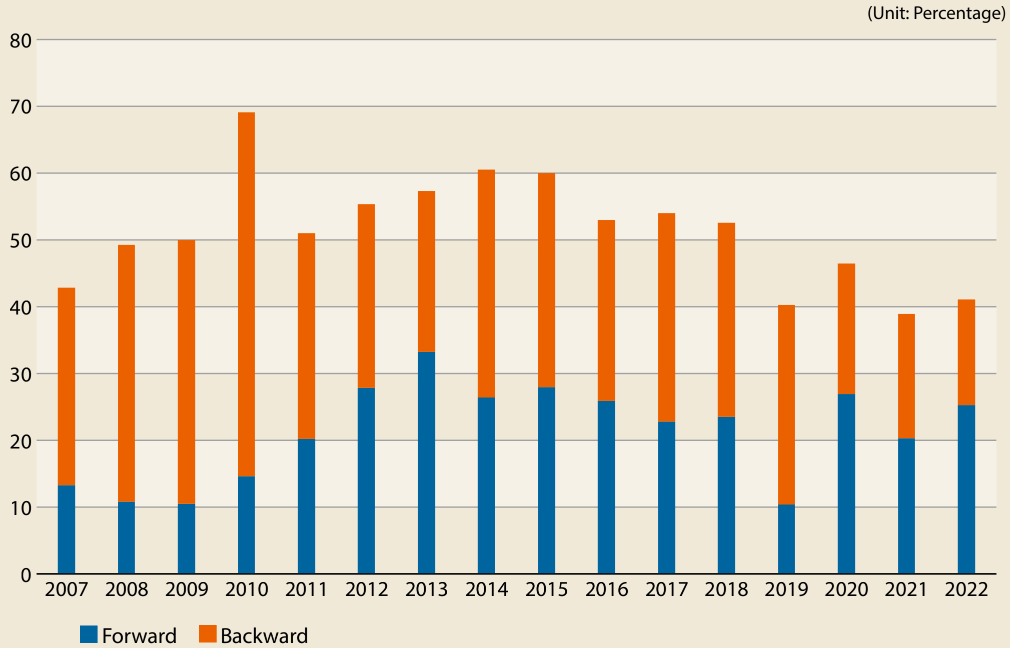


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 0.02% to Lao PDR's total value-added exports, of which nearly 41% involved in GVCs, and with a relatively higher forward GVC participation.

FIGURE 3

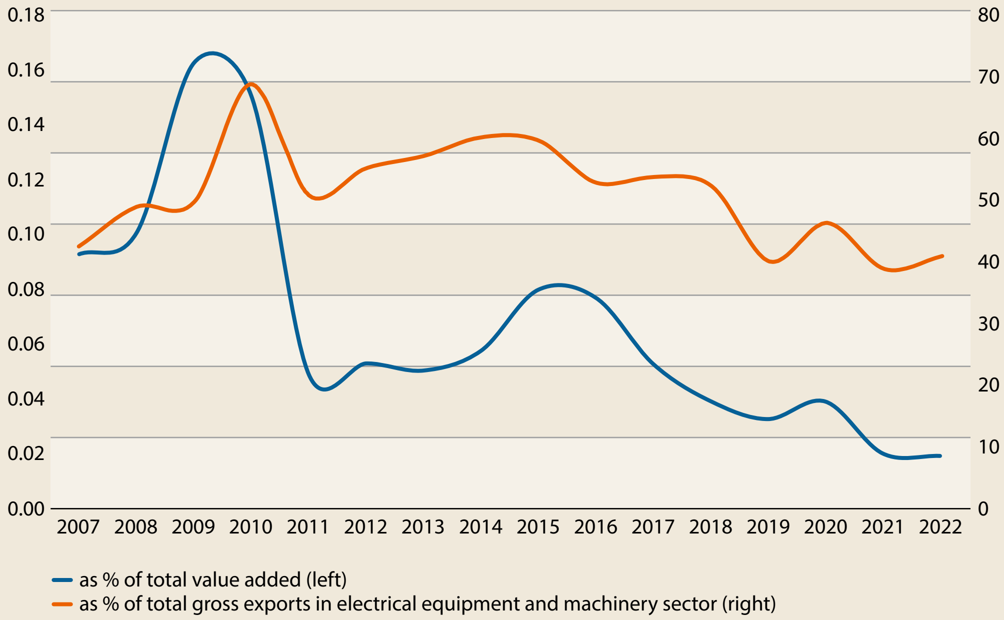
GVC PARTICIPATION OF THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



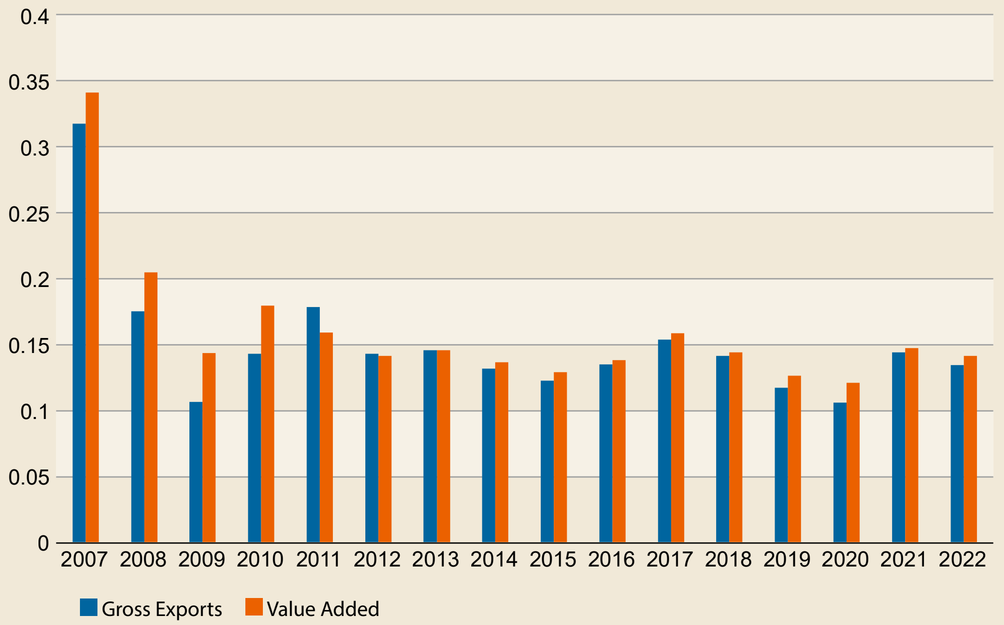
Source: Authors' calculations based on the ADB Input-Output Tables for Asia and the Pacific Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Laos PDR documented an export concentration in gross exports of approximately 0.14, maintaining stability since 2018. Similarly, the export concentration in value-added exports was close to 0.14 in 2022, showing no significant change since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

Note: Data related to knowledge spillover are not included due to data availability.

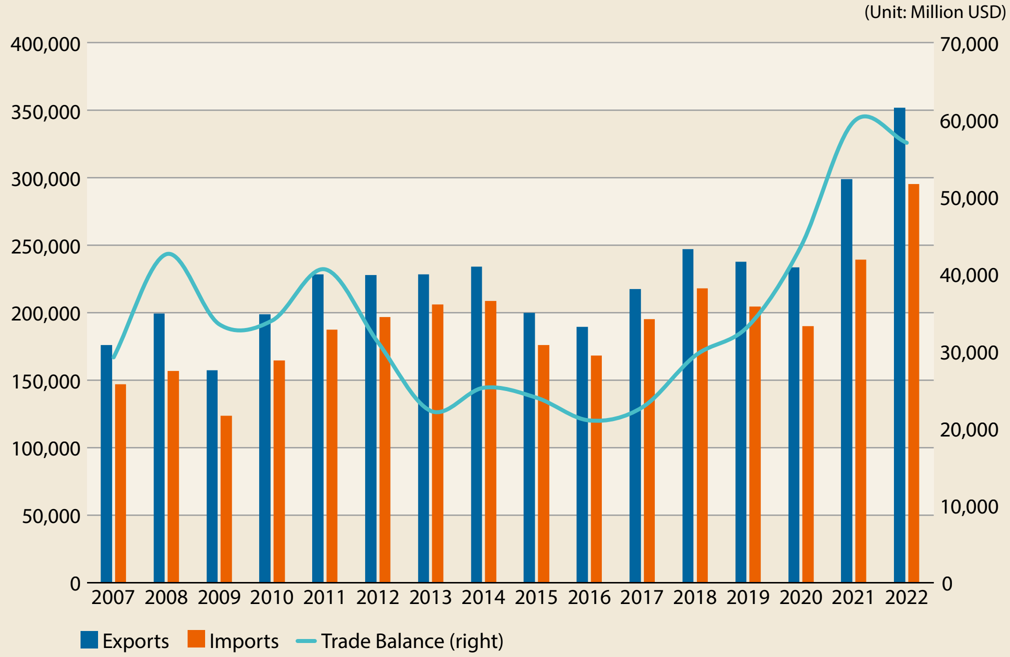
COUNTRY PROFILE: MALAYSIA

- Malaysia's total exports amounted to USD352,337 million, while imports accounted at USD295,275 million in 2021, with a trade surplus of USD57,061 million. According to the BACI-CEPII database, in 2021 the main exports were machinery and electrical equipment (46.2%), refined petroleum and chemicals (19.5%), and food and tobacco (8.3%) In 2022, its main export partners were China, Singapore, the United States, Japan, and Indonesia. (UN Comtrade).

- Regarding GVC participation, Malaysia exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

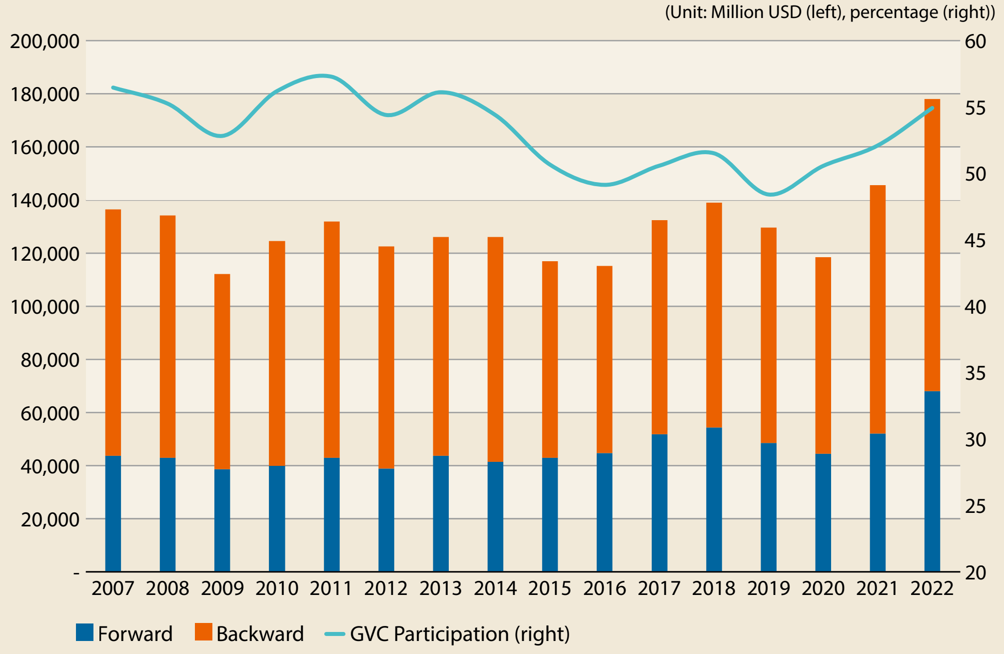
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

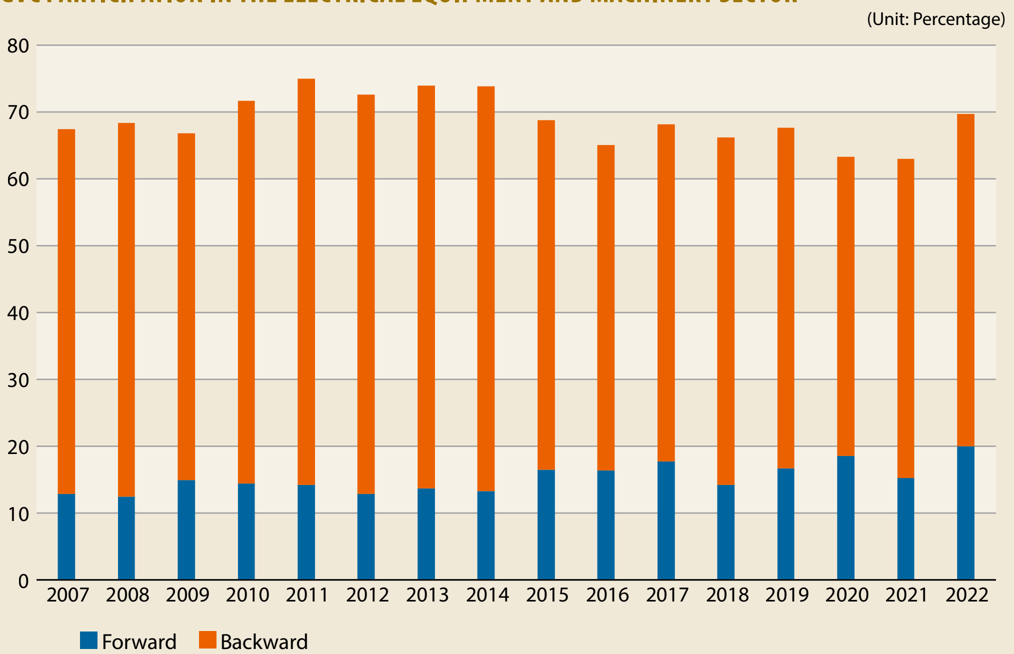


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 39.7% to Malaysia's total value-added exports, of which nearly 70% involved in GVCs and relatively higher backward GVC participation.

FIGURE 3

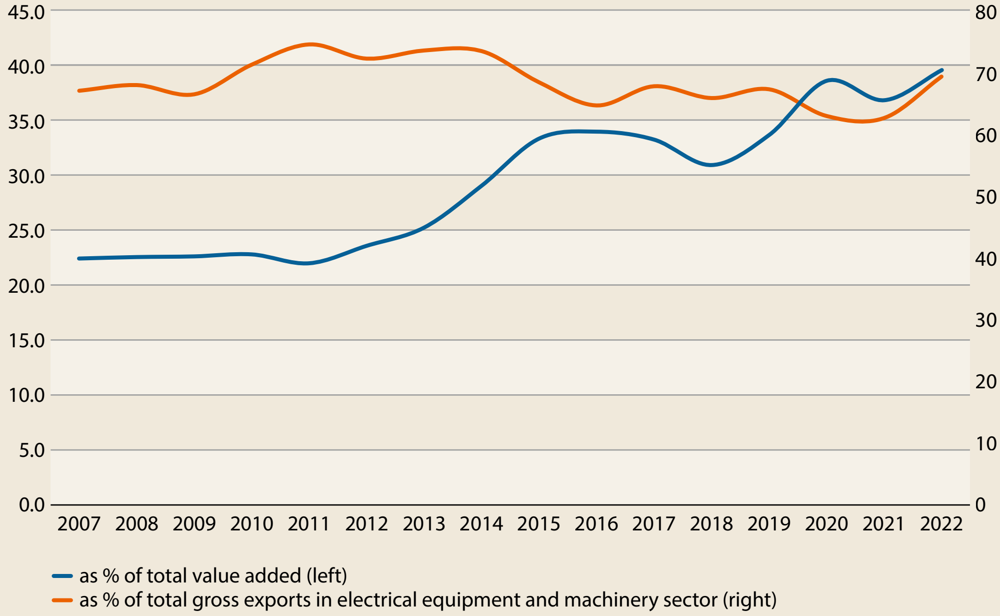
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



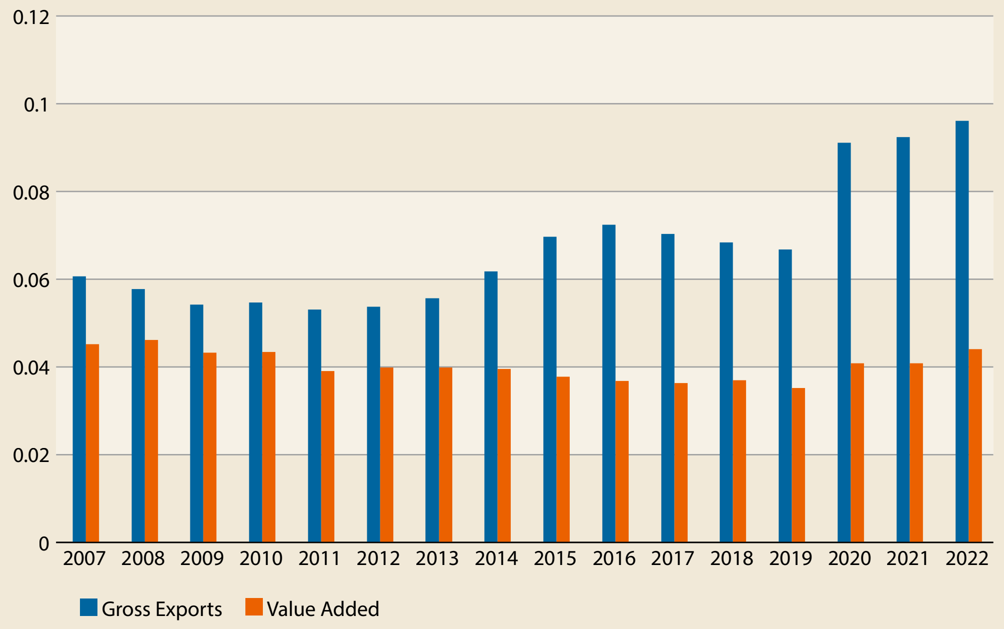
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Malaysia registered an export concentration in gross exports of approximately 0.095, reflecting growth since 2018. Similarly, the export concentration in value-added exports was close to 0.045 in 2022, indicating an increase from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Malaysia's domestic R&D investment, knowledge spillover, and ICT productivity all appear to have increased. This seems to have overcome supply chain disruptions faster than in 2019 while the economy was recovering. In addition, having competitiveness in the ICT sector through ICT promotion policies such as Multimedia Super Corridor seems to have driven the continued increase in added value.

TABLE 1

KEY INDICATORS RELATED WITH KNOWLEDGE SPILLOVER

YoY, %

	Malaysia
Domestic R&D stock growth (2020)	4.292
Foreign R&D stock growth (2020)	4.145
ICT industry labor productivity growth (2020)	2.997
Human capital growth (2019)	0.753

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

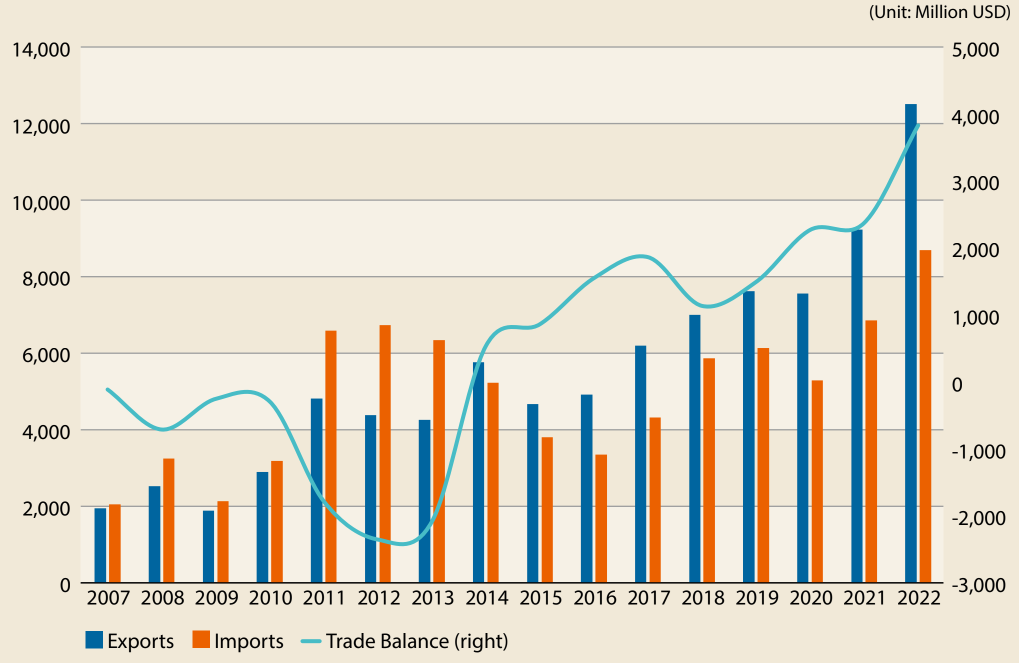
COUNTRY PROFILE: MONGOLIA

- Mongolia's total exports amounted to USD12,525 million, while imports accounted at USD8,692 million in 2021, with a trade surplus of USD3,833 million. Natural resources accounted for more than 90% of total exports. According to the BACI-CEPII database, in 2021 the main exports were mining commodities such as coal (72%), non-metallic minerals and metals (21.6%) and agricultural products (4.2%), while machinery and electrical equipment only accounted for 0.2% of total exports. In 2022, its main export partners were China, Russia, Switzerland, Japan, and the Republic of Korea. (UN Comtrade).

- Regarding GVC participation, Mongolia exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

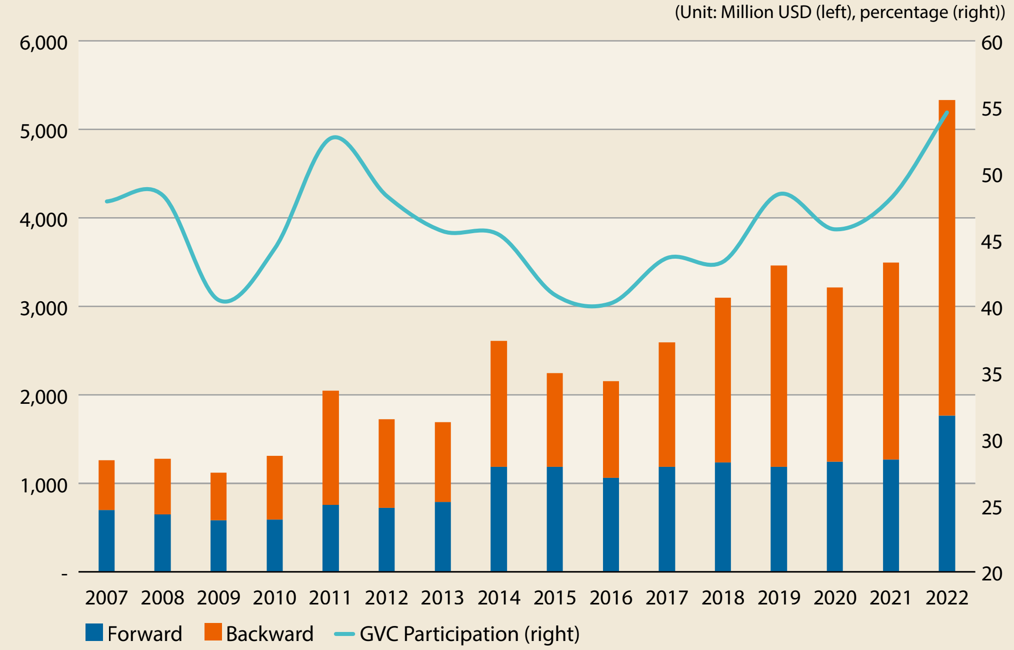
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

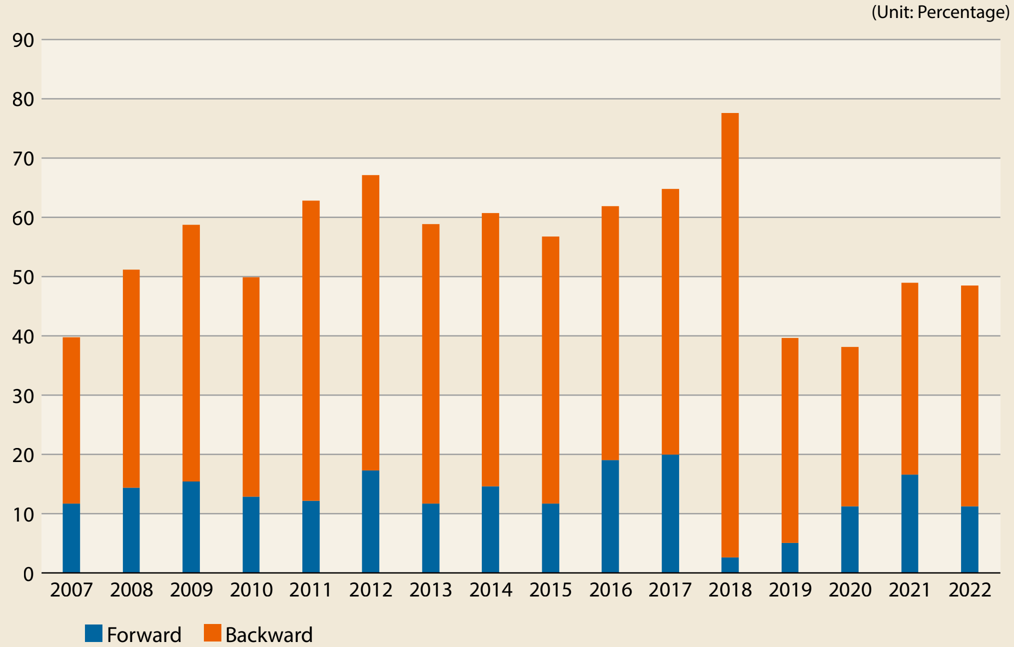


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 0.06% to Mongolia's total value-added exports, of which nearly 48% involved in GVCs, with a relatively larger backward GVC participation.

FIGURE 3

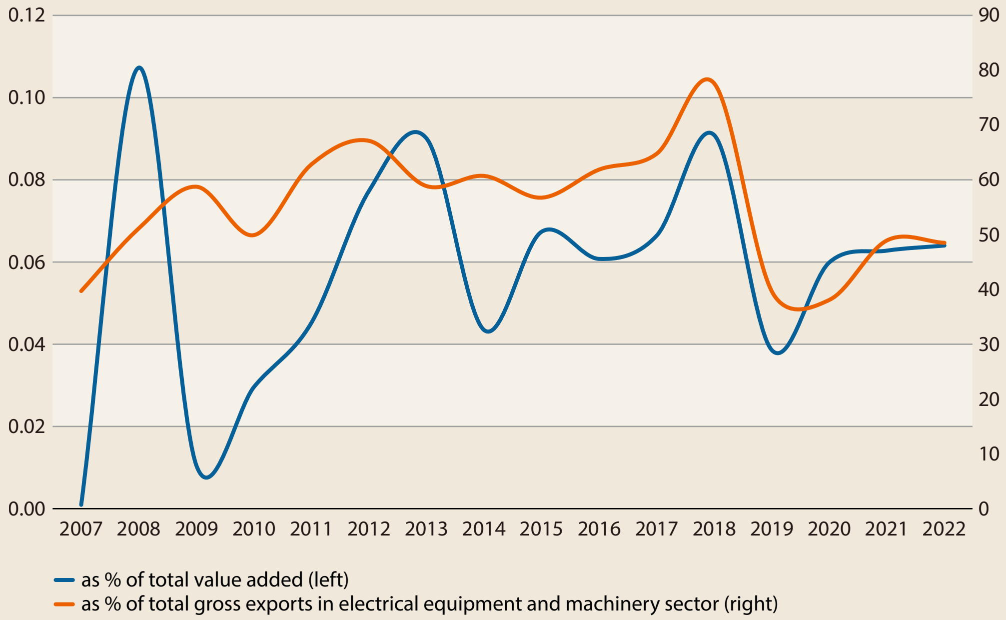
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database.

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED

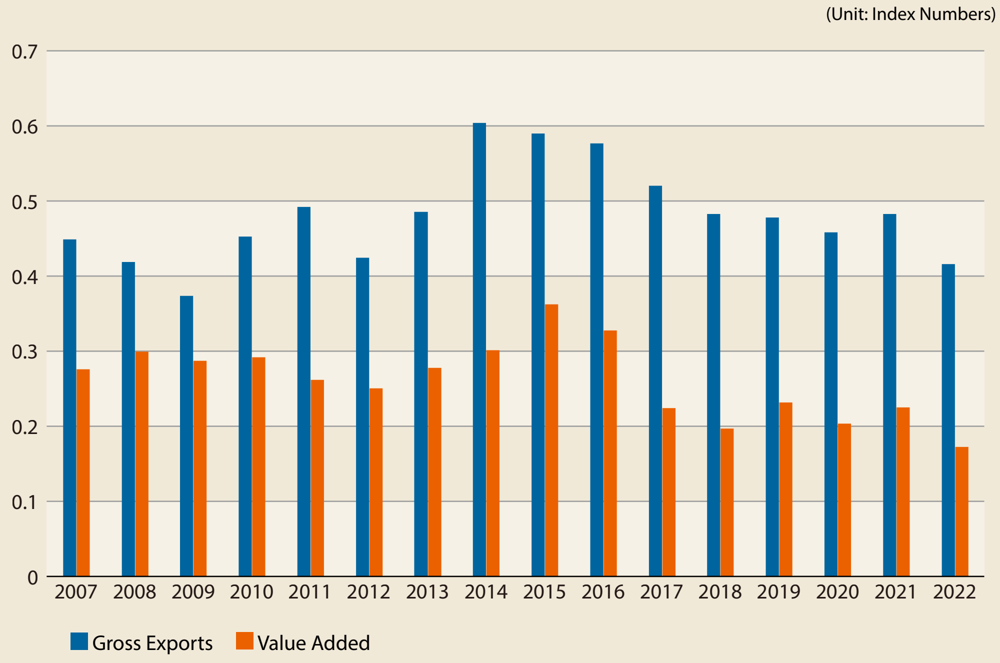


Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Mongolia documented an export concentration in gross exports of approximately 0.42, showing a decline from 2018. Meanwhile, the export concentration in value-added exports was close to 0.16 in 2022, remaining unchanged since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Mongolia's domestic R&D investment and ICT productivity appear to have risen as of 2020. In particular, Mongolia's ICT productivity shows a high growth rate despite the low global competitiveness index. However, policies such as improving accessibility, bridging the digital gap, and strengthening public access to broadband were actively promoted. As a result, it appears that a high level of productivity improvement in the ICT sector was recorded.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Mongolia
Domestic R&D stock growth (2020)	2.632
Foreign R&D stock growth (2020)	-19.832
ICT industry labor productivity growth (2020)	24.324
Human capital growth (2019)	1.059

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

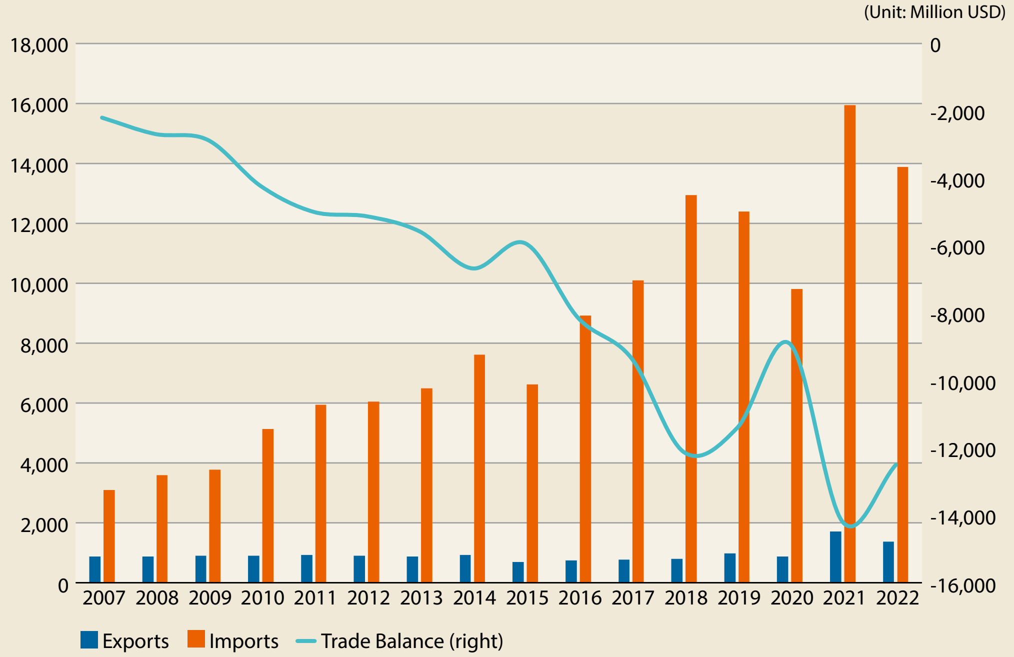
COUNTRY PROFILE: NEPAL

- Nepal's total exports amounted to USD1,371 million, while imports accounted at USD13,861 million in 2021, and recorded a significant trade deficit of USD12,490 million. According the BACI-CEPII database, in 2021 the main exports were food and tobacco (60.1%) and apparel and footwear (21.8%). Machinery and electrical equipment only accounted for 1.1% of total exports. In 2022, main export partners were India (corresponding almost 60% of export destination), China, the United States, Indonesia, and the United Arab Emirates. (UN Comtrade).

- Regarding GVC participation, Nepal exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

TRENDS OF TRADE

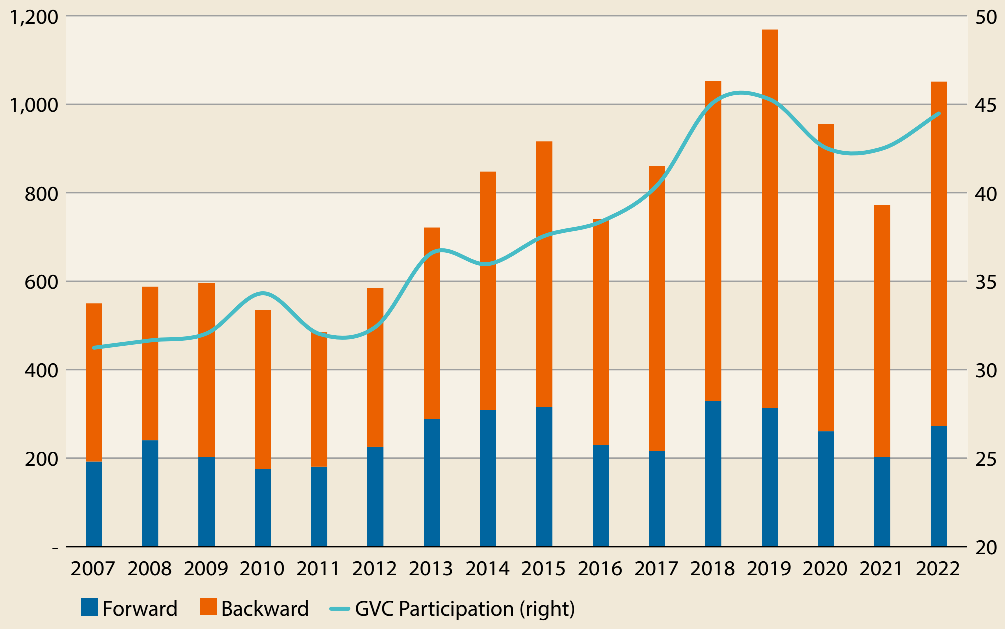


Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

(Unit: Million USD (left), percentage (right))



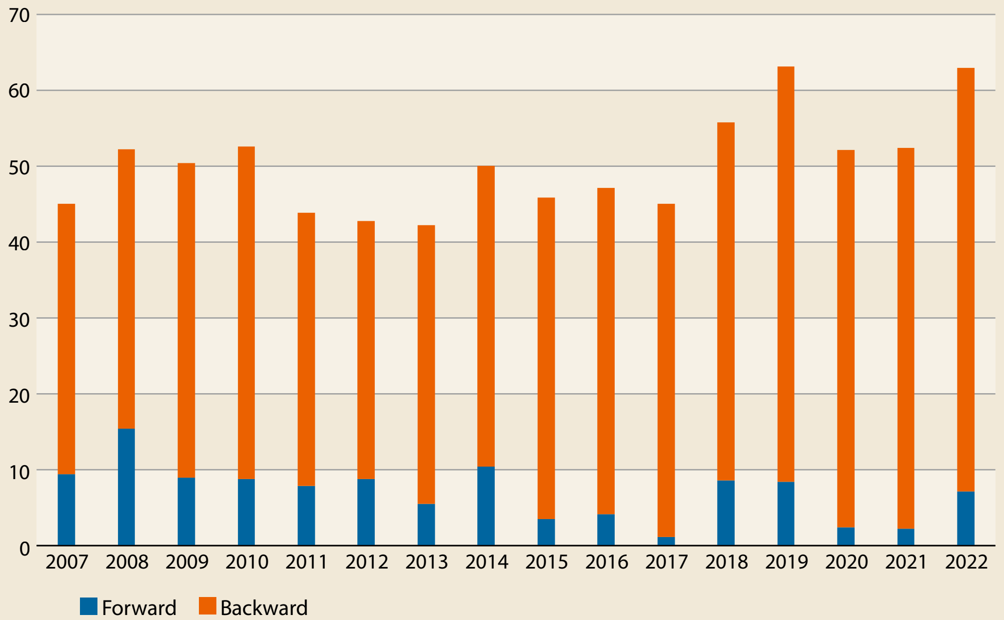
Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 0.8% to Nepal's total value-added exports, of which nearly 63% involved in GVCs, with relatively higher backward GVC participation.

FIGURE 3

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

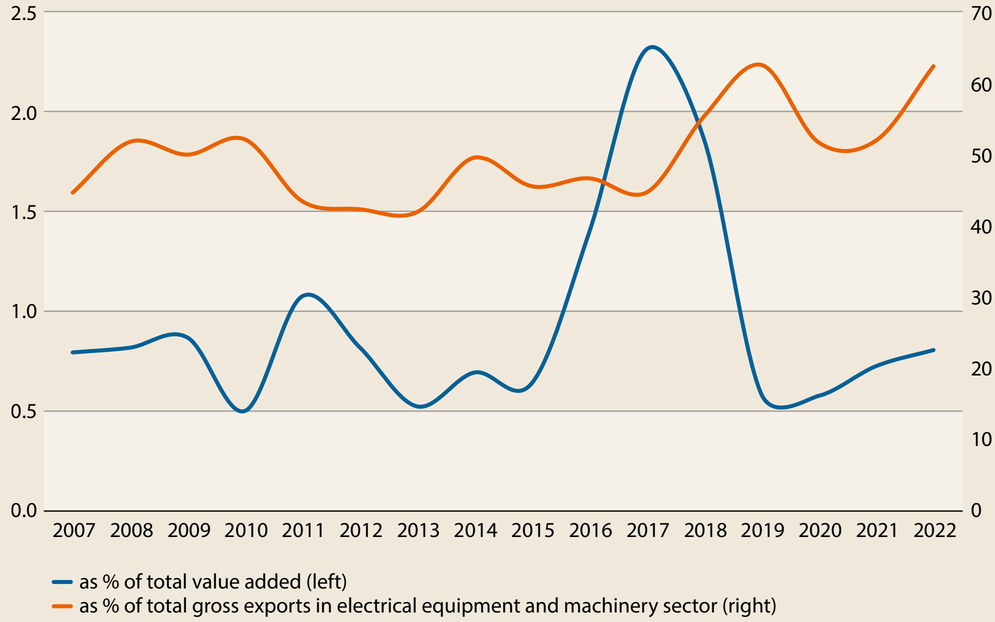
(Unit: Percentage)



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



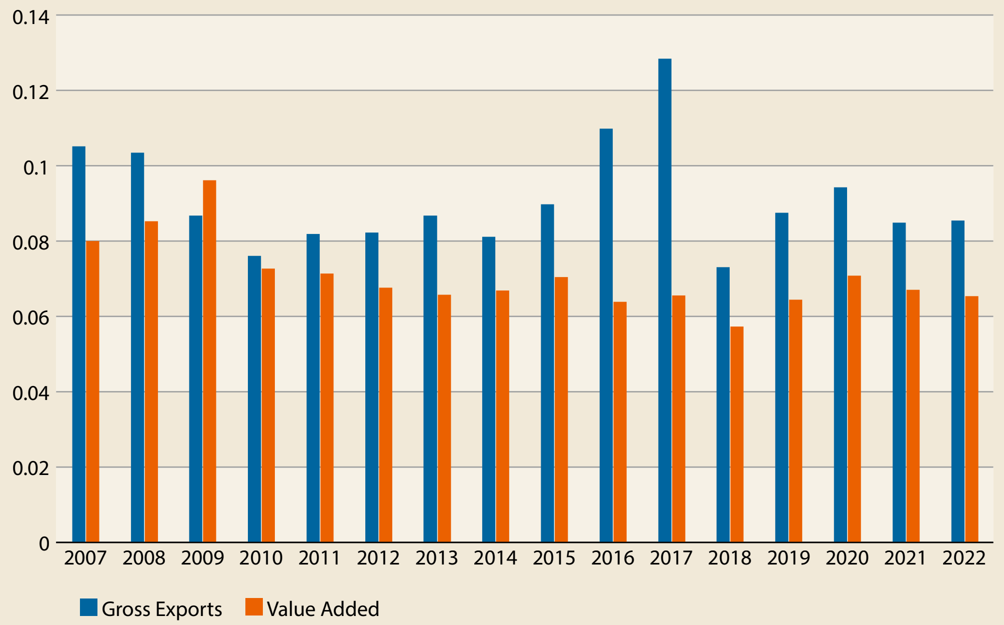
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Nepal reported an export concentration in gross exports of approximately 0.09, indicating growth from 2018. Similarly, the export concentration in value-added exports was close to 0.07 in 2022, demonstrating an increase since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

Note: Data related to knowledge spillover are not included due to data availability.

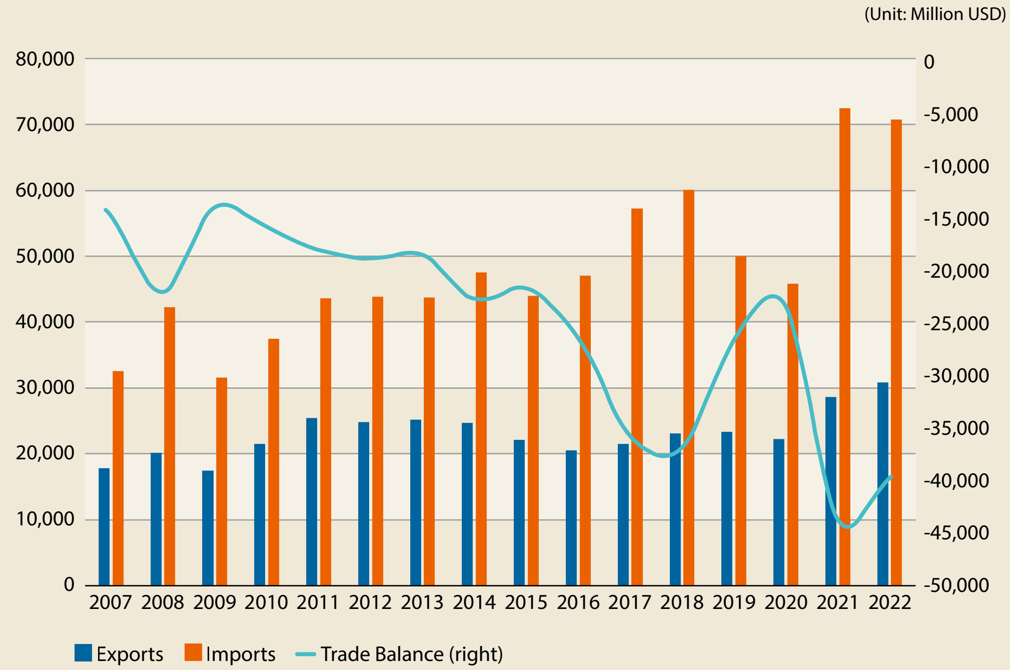
COUNTRY PROFILE: PAKISTAN

- Pakistan's total exports amounted to USD30,872 million, while imports accounted at USD70,687 million in 2021, with a trade deficit of USD39,814 million. According to the BACI-CEPII database, in 2021 the main exports were food and tobacco (60.1%), textiles, apparel and footwear (21.8%), and agricultural commodities (4.2%). Machinery and electrical equipment represented 2.5% of total exports. In 2022, its main export partners were China, Arab Emirates, the United States, Saudi Arabia, and Indonesia. (UN Comtrade).

- Regarding GVC participation, Pakistan exhibits a higher degree of forward participation than backward participation, indicating a larger proportion of domestic value added are used as intermediate inputs of other countries to produce final goods.

FIGURE 1

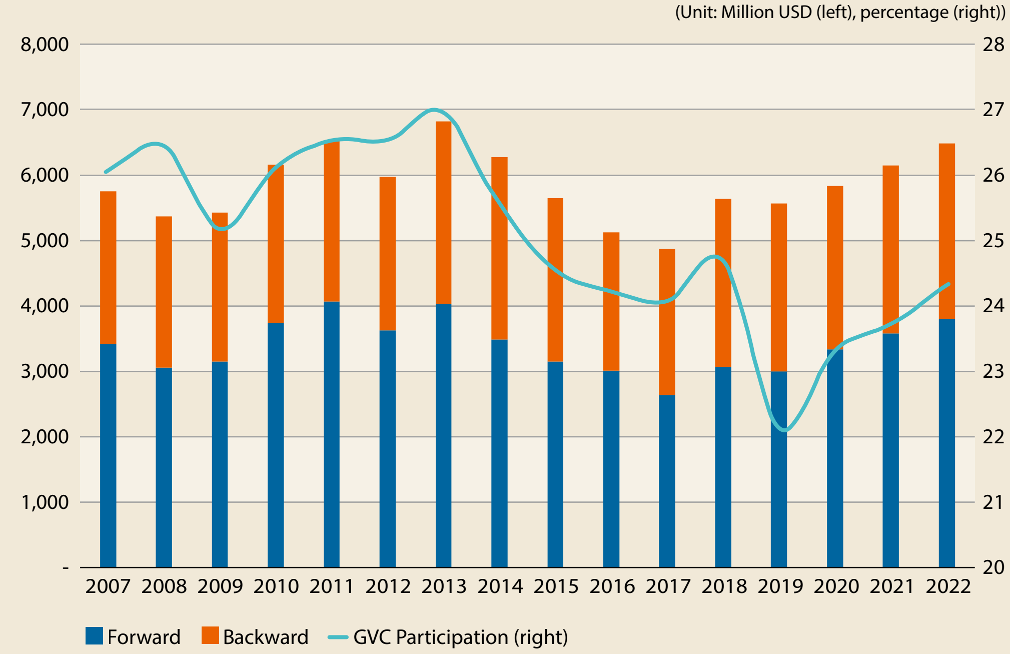
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

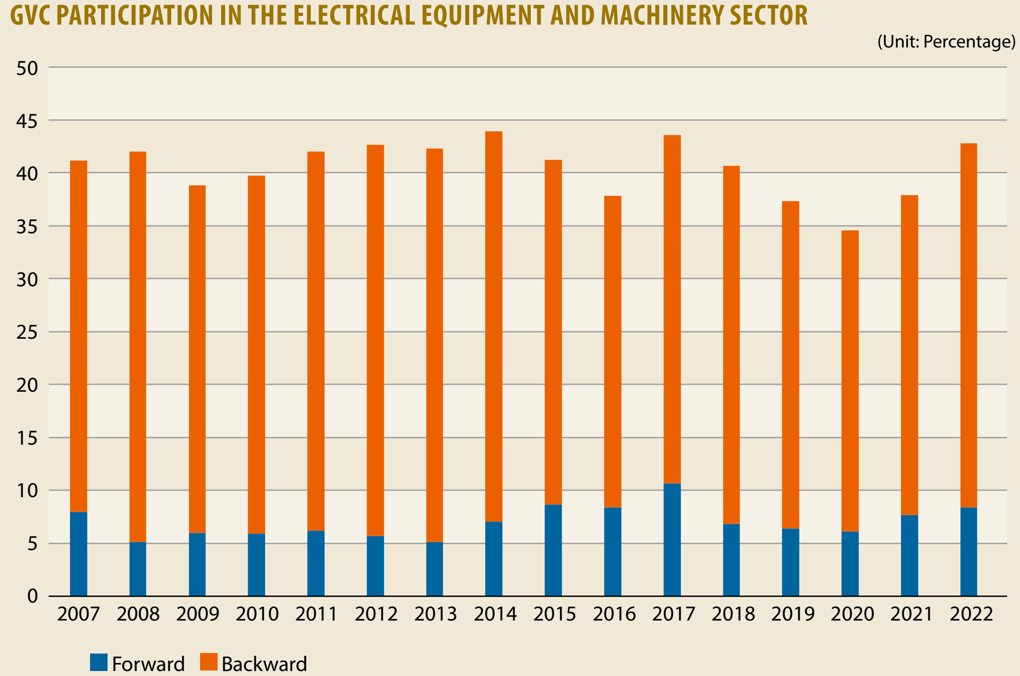


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 0.89% to Pakistan's total value-added exports, of which nearly 43% involved in GVCs, with a relatively higher participation in backward GVC participation.

FIGURE 3

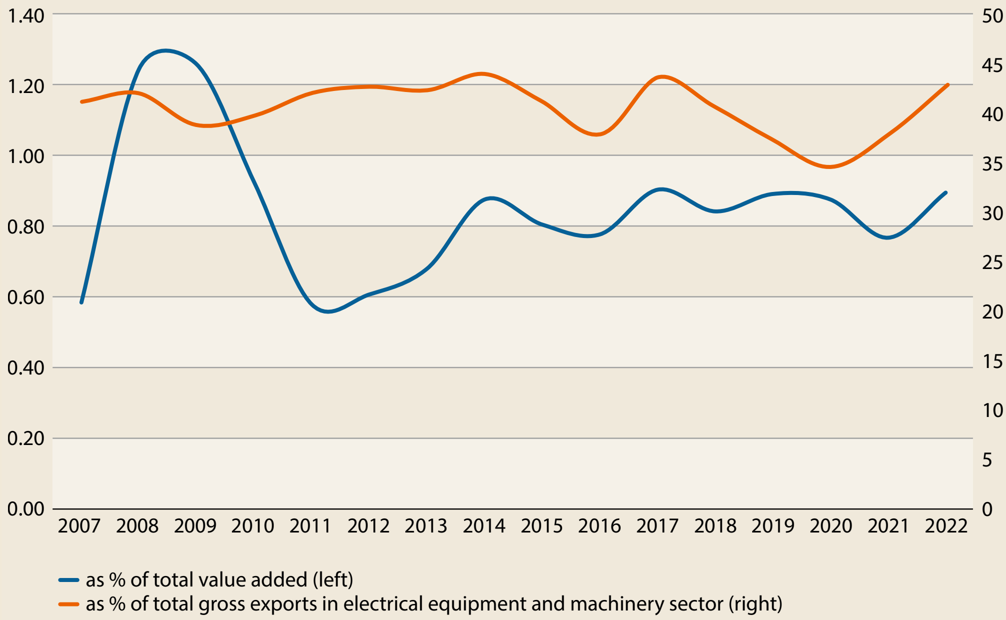
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED



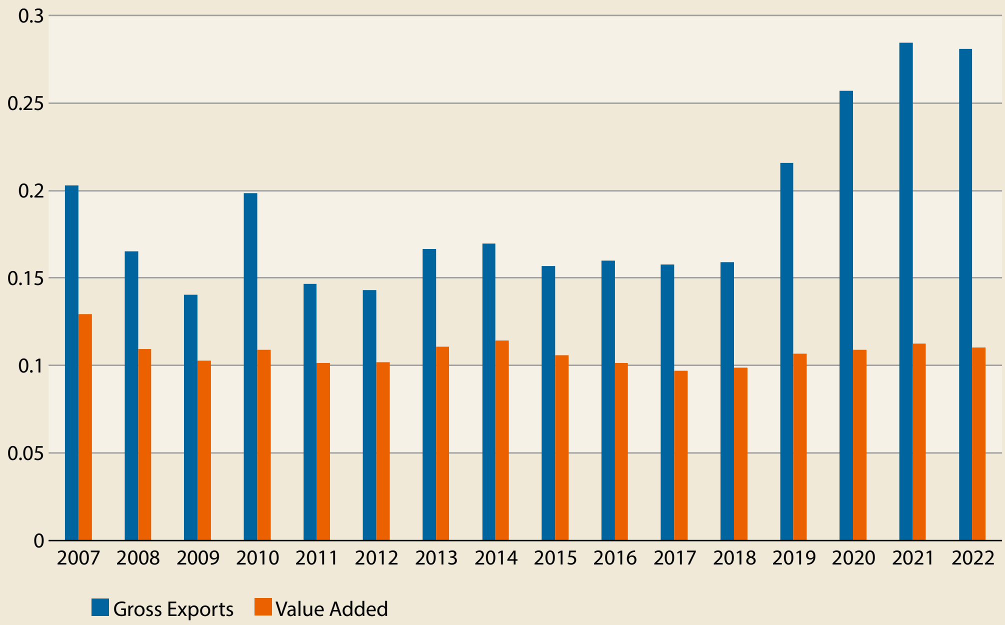
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Pakistan documented an export concentration in gross exports of approximately 0.27, showcasing growth from 2018. Meanwhile, the export concentration in value-added exports was close to 0.11 in 2022, remaining consistent since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- The accumulation of Domestic R&D capital stock and foreign knowledge spillover in Pakistan appears to be growing steadily. However, the productivity of the ICT industry, measured by value added compared to the number of workers, appears to have decreased. Moreover, as the level of human capital appears to have decreased, it is worth paying attention to this along with the decrease in productivity in the ICT industry.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Pakistan
Domestic R&D stock growth (2020)	1.092
Foreign R&D stock growth (2020)	4.379
ICT industry labor productivity growth (2018)	-9.038
Human capital growth (2019)	-0.113

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

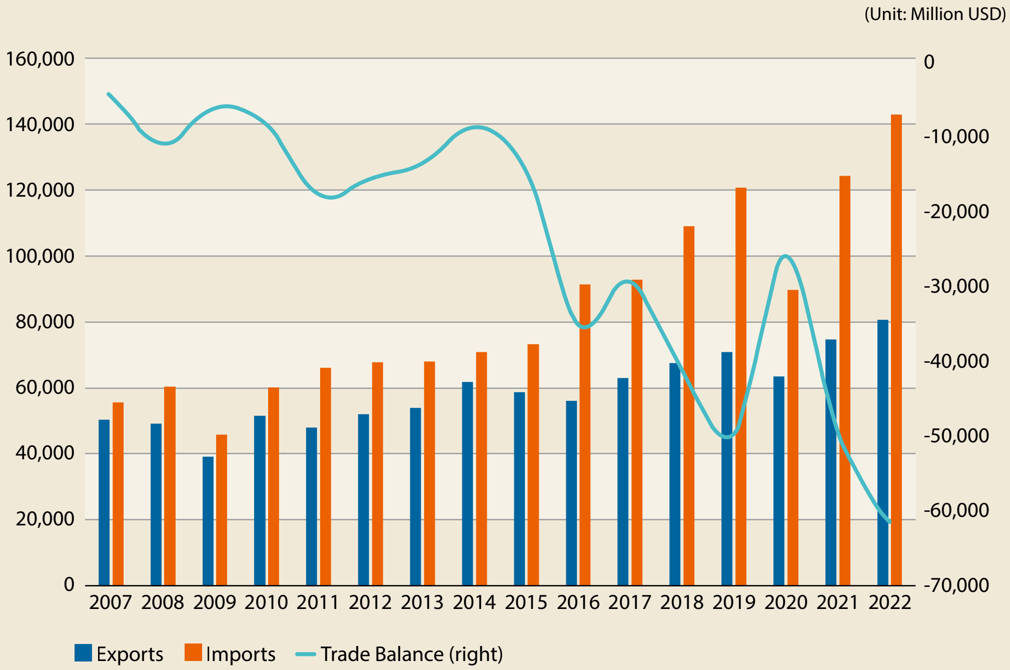
COUNTRY PROFILE: PHILIPPINES

- Philippines total exports amounted to 80,744 million, while imports accounted at USD142,903 million in 2021, with a trade deficit of USD62,159 million. According to the BACI-CEPII database, in 2021 the main exports were machinery and electrical equipment (67.4%), nonmetallic minerals and metals (6.5%), and mining-related commodities (3.9%). In 2022, main export partners were China, Japan, the United States, the Republic of Korea, and Indonesia. (UN Comtrade).

- Regarding GVC participation, Philippines exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

TRENDS OF TRADE

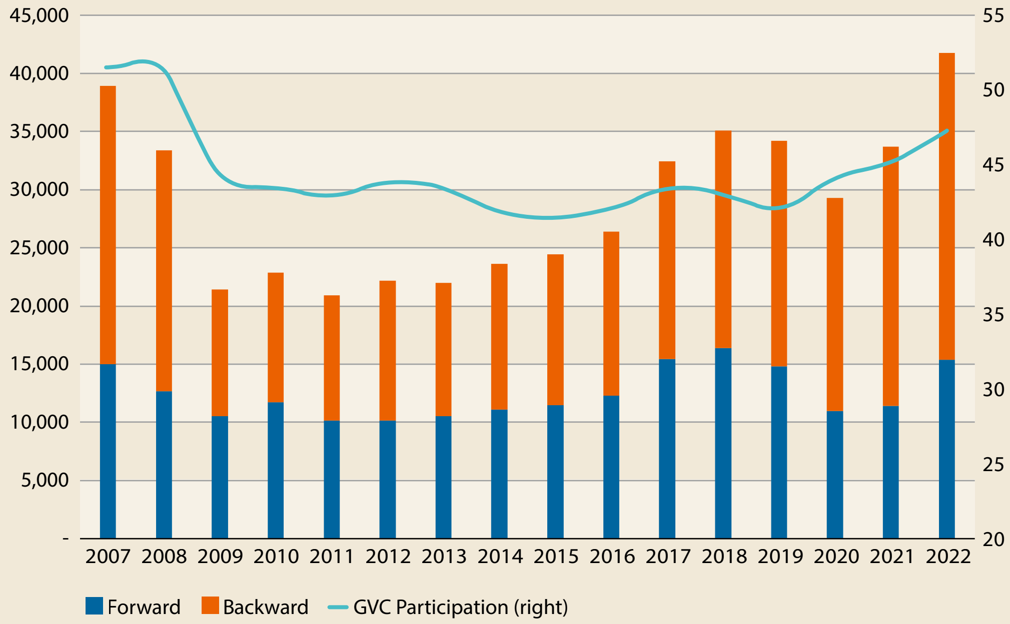


Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

(Unit: Million USD (left), percentage (right))



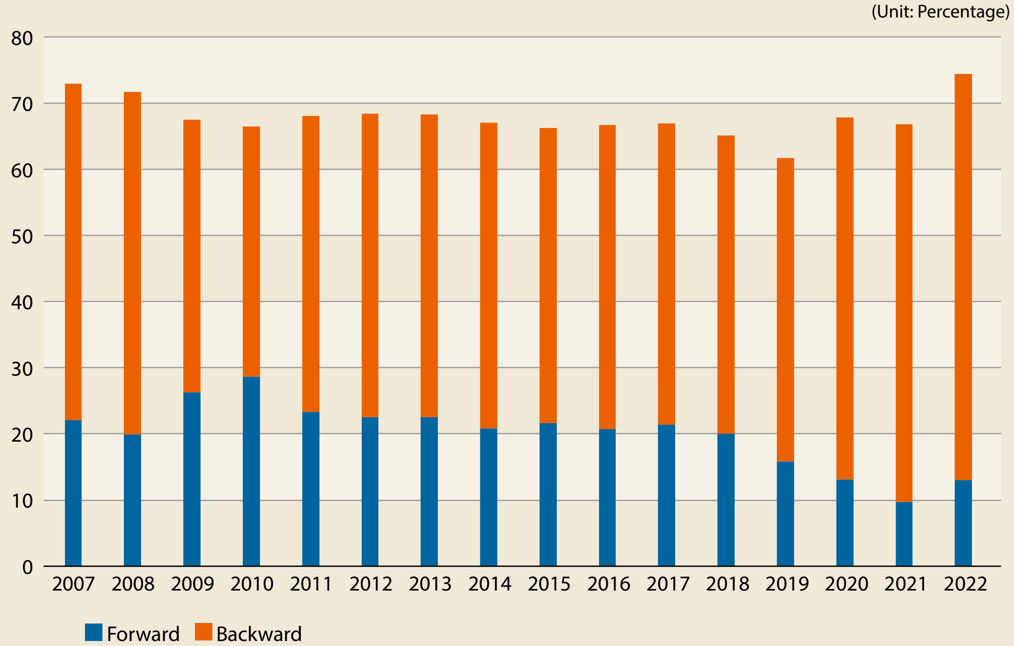
Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 42% to Philippines total value-added exports, of which nearly 74% involved in GVCs, with relatively higher backward GVC participation.

FIGURE 3

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

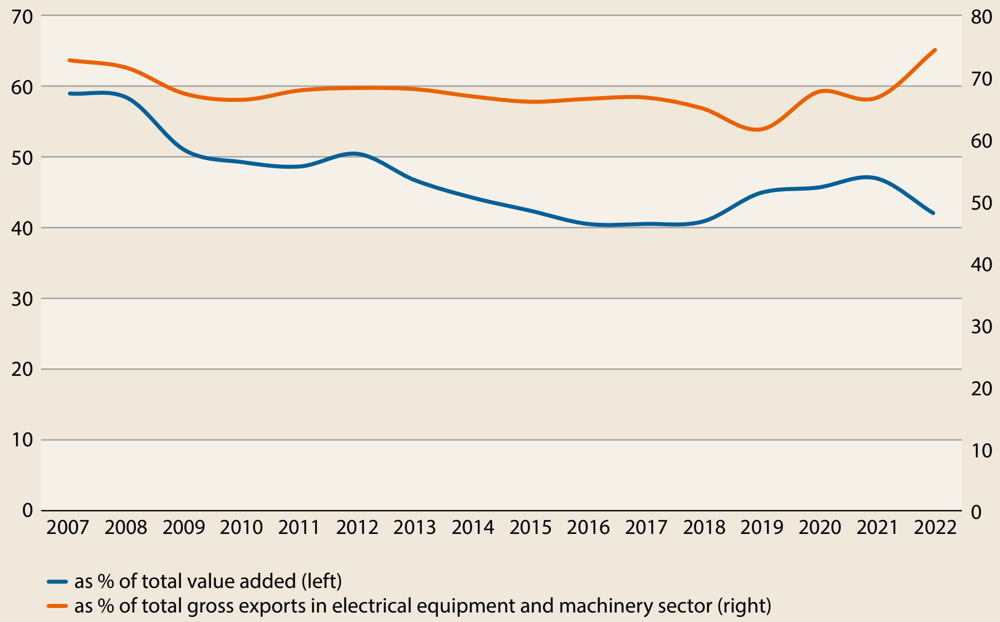
(Unit: Percentage)



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS

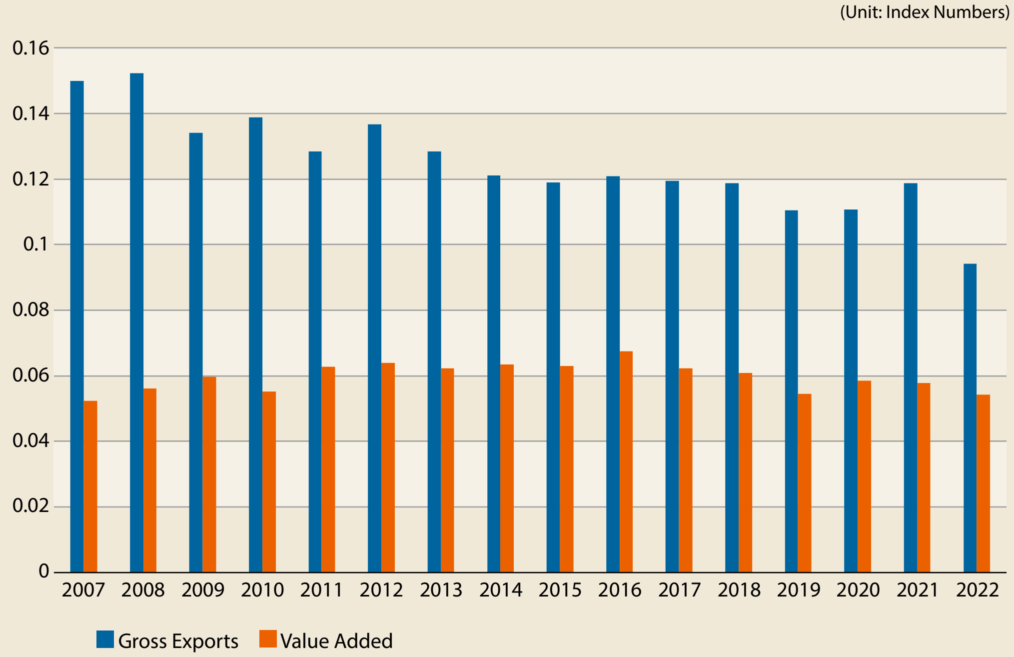


Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, the Philippines reported an export concentration in gross exports of approximately 0.09, indicating a decline from 2018. Conversely, the export concentration in value-added exports was close to 0.05 in 2022, remaining unchanged since 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- The Philippines' domestic R&D stock appears to have increased significantly as of 2018. However, similar to other countries, overall industrial R&D has declined due to the influence of COVID-19. It also has a solid domestic market with continuous growth, but shows a decreasing trend in ICT value-added production, with the global innovation index low.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Philippines
Domestic R&D stock growth (2018)	22.344
Foreign R&D stock growth (2020)	-12.737
ICT industry labor productivity growth (2020)	-12.254
Human capital growth (2019)	0.518

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

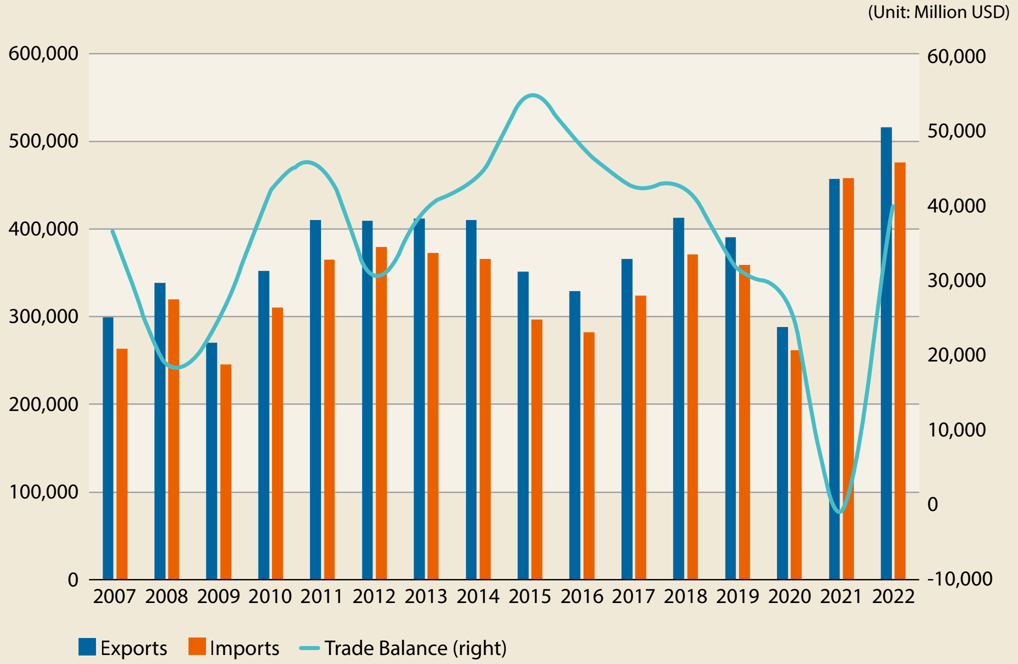
COUNTRY PROFILE: SINGAPORE

- Singapore's total exports amounted to USD516,016 million, while imports accounted at USD47,5832 million in 2021, recording a trade surplus of USD40,183 million. According to the BACI-CEPII database, in 2021 the main exports were machinery and electrical equipment (49.4%), refined petroleum and chemicals (30.6%), transport-related goods (4%), and food and tobacco (3.6%). In 2022, main export partners were China, Malaysia, the United States, Hong Kong, and Indonesia. (UN Comtrade).

- Regarding GVC participation, Singapore exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

TRENDS OF TRADE

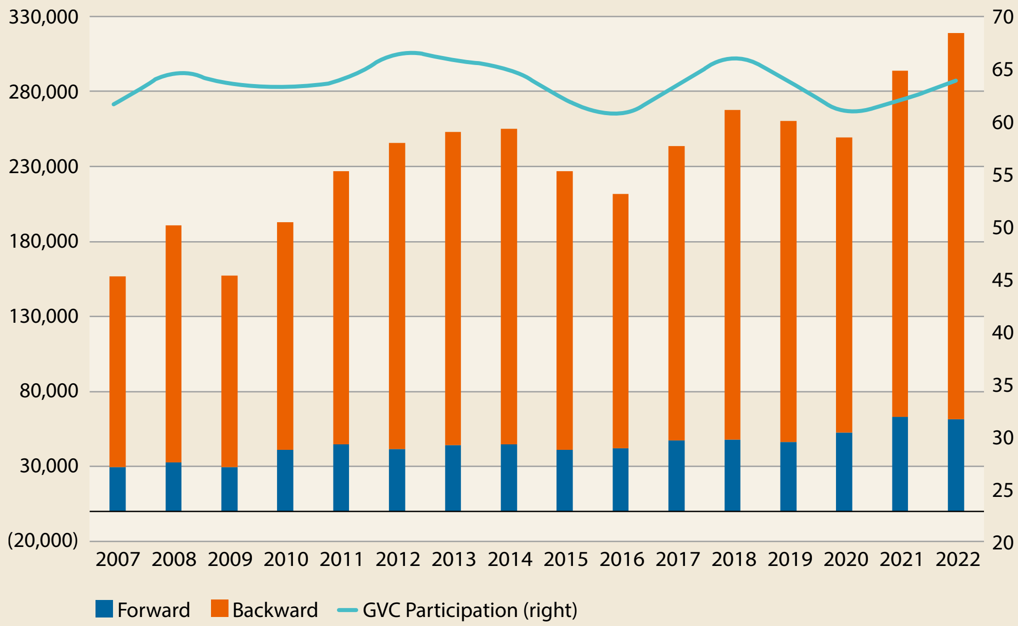


Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

(Unit: Million USD (left), percentage (right))



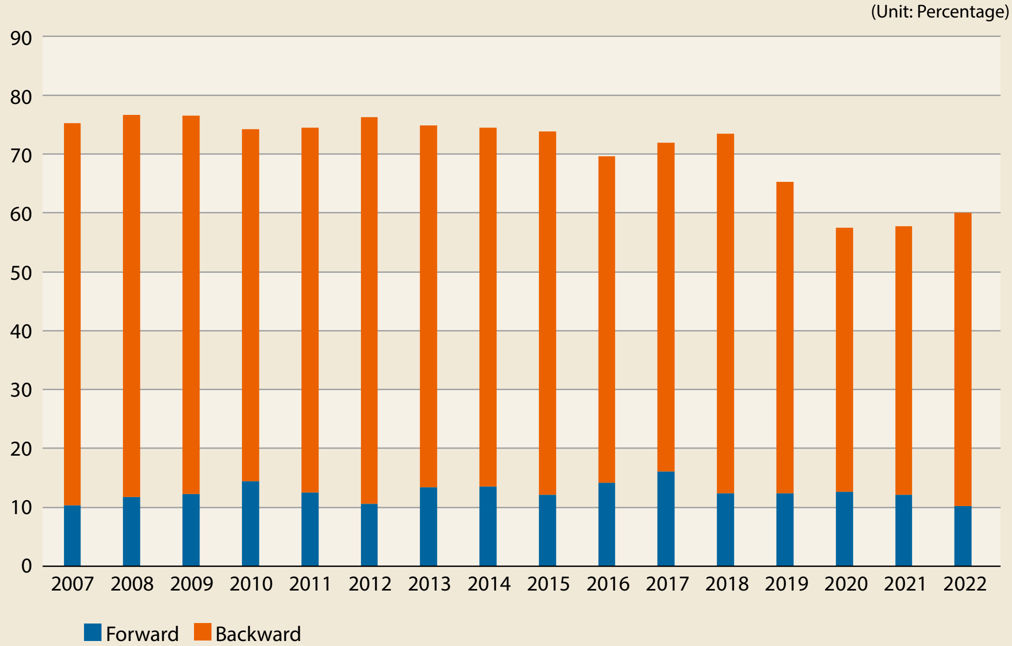
Source: ADB Input-Output Tables for Asia and the Pacific Database

- In 2022, the electrical equipment and machinery industry contributed 22% of Singapore's total value-added exports, of which nearly 60% involved in GVCs, with relatively higher backward GVC participation.

FIGURE 3

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

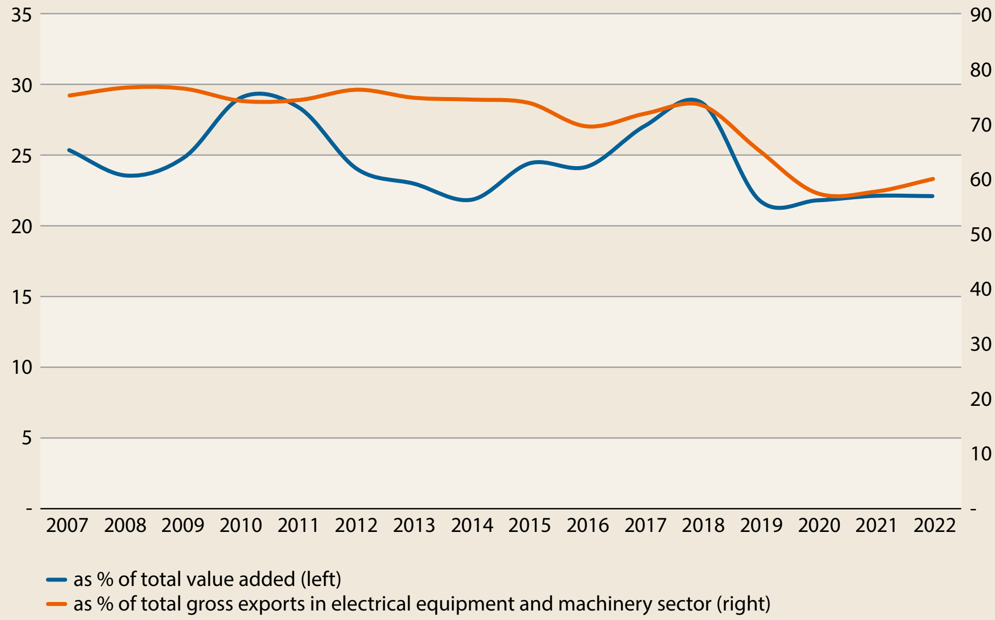
(Unit: Percentage)



Source: ADB, MRIO Tables Database.

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS



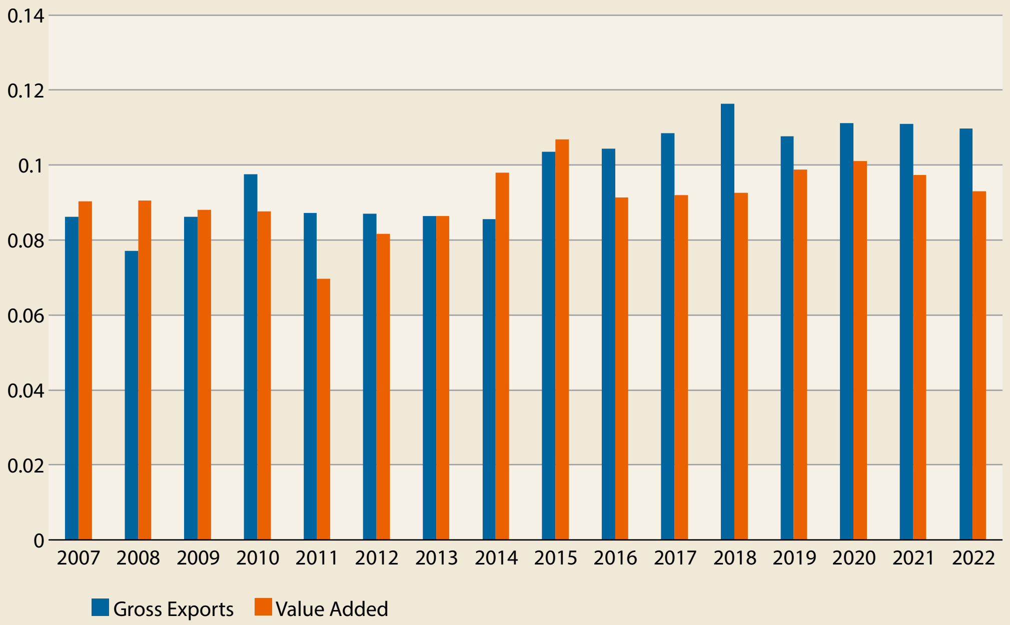
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Singapore reported an export concentration in gross exports of approximately 0.11, remaining consistent since 2018. Similarly, the export concentration in value-added exports was close to 0.09 in 2022, showing stability from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Singapore's domestic R&D stock, ICT industry labor productivity, and human capital all appear to have increased. Singapore, a leading developed country in the region, shows a high level of most indicators and shows steady growth. It also ranks 7th in the world in the Global Innovation Index, and it is steadily using the industrial sector's open-door policy due to business-friendly policies such as zero tariffs and low corporate taxes.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Singapore
Domestic R&D stock growth (2019)	4.717
Foreign R&D stock growth (2020)	-0.253
ICT industry labor productivity growth (2020)	3.876
Human capital growth (2019)	4.766

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

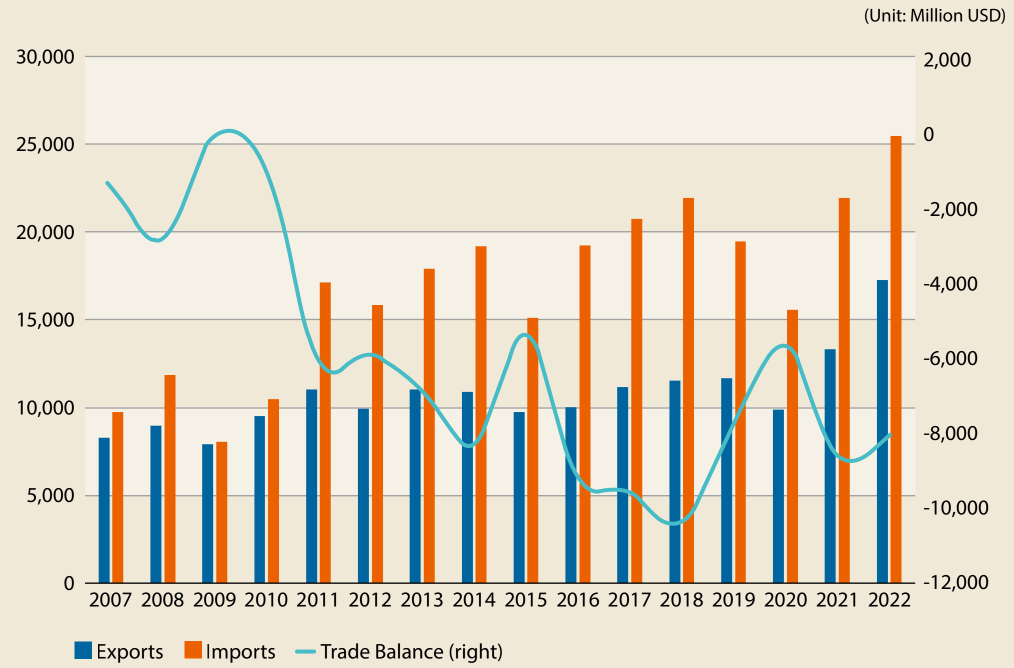
COUNTRY PROFILE: SRI LANKA

- Sri Lanka total exports amounted to USD17,279 million, while imports accounted at USD25,455 million in 2021, recording a trade deficit of USD8,175 million. According to the BACI-CEPII database, in 2021 the main exports were textiles, apparel and footwear (43.9%), food and tobacco (12.8%), and agricultural commodities (11.8%). Machinery and electrical equipment accounted for 6% of total exports. In 2022, main export partners were India, the United States, China, the United Arab Emirates, and the United Kingdom. (UN Comtrade).

- Regarding GVC participation, Sri Lanka exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

TRENDS OF TRADE

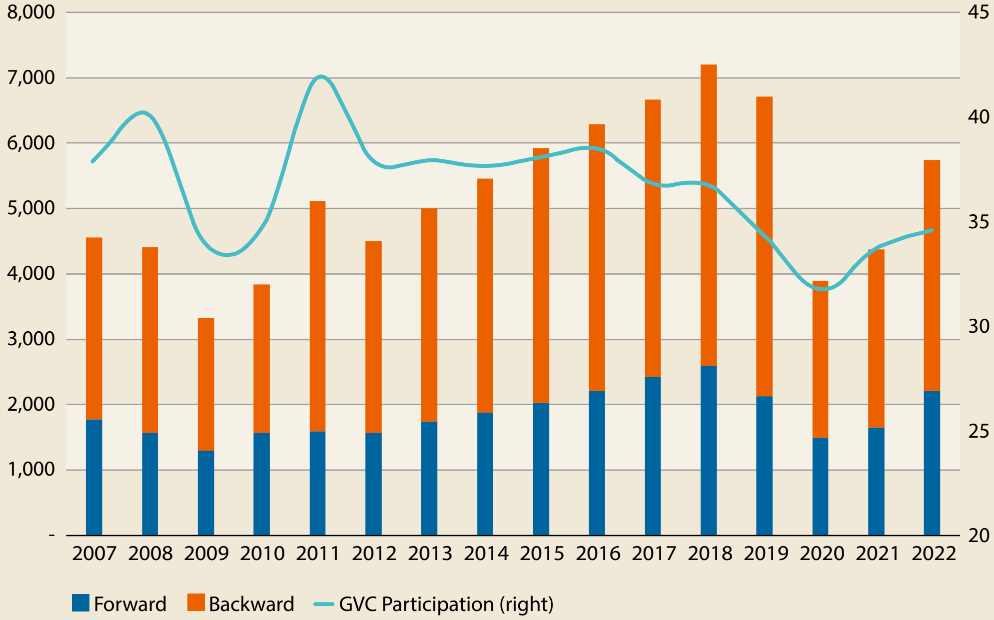


Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

(Unit: Million USD (left), percentage (right))



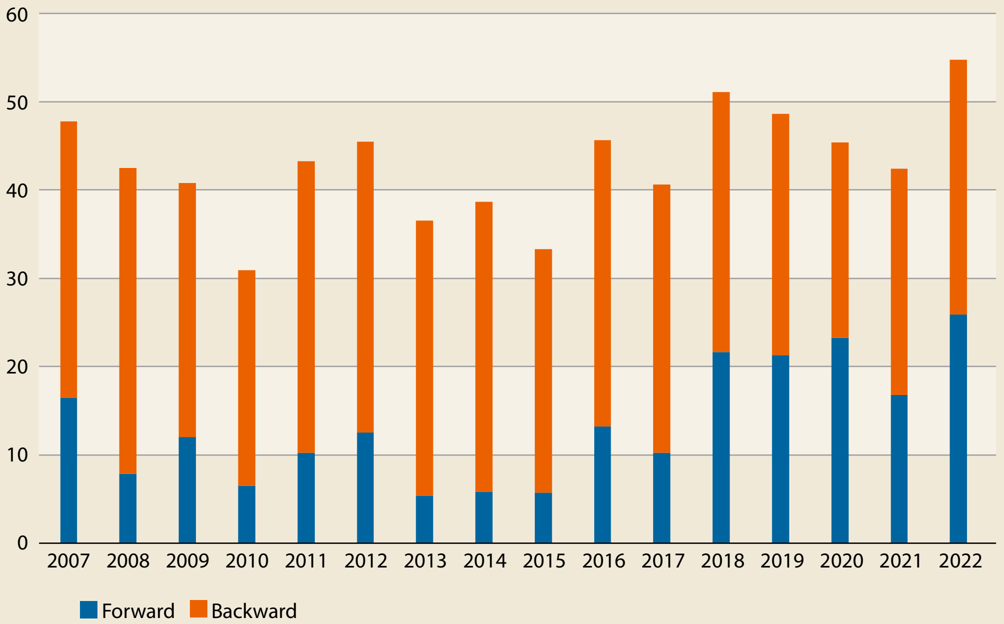
Source: ADB, MRIO Tables Database.

- In 2022, the electrical equipment and machinery industry contributed 3.33% of Sri Lanka's total value-added exports, of which nearly 54.7% involved in GVCs.

FIGURE 3

GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR

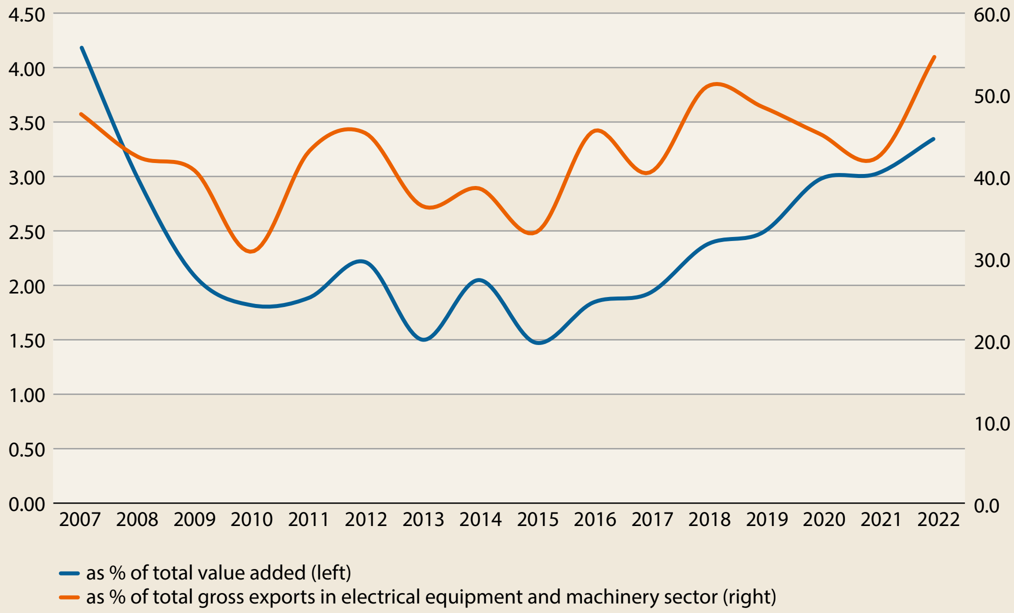
(Unit: Percentage)



Source: ADB, MRIO Tables Database.

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS

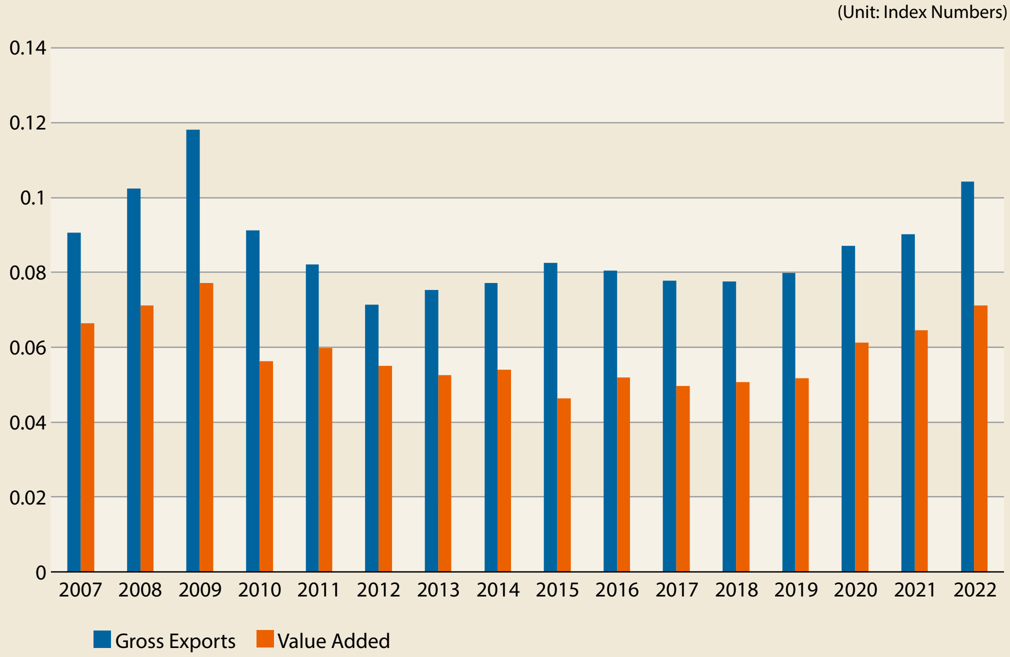


Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Sri Lanka reported an export concentration in gross exports of approximately 0.11, indicating growth from 2018. Similarly, the export concentration in value-added exports was close to 0.07 in 2022, demonstrating an increase from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Sri Lanka's domestic R&D stock and ICT productivity appear to have increased slightly. However, the knowledge spillover appears to have decreased significantly. Despite Sri Lanka's weak macroeconomy, it appears to be affected by the downgrade of its credit rating by continuing quantitative easing policies. Political unrest has also increased due to the massive protests that occurred. However, there is also a green light with the IMF approving Sri Lanka's Extended Fund Facility (EFF), so it is necessary to observe the trend.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Sri Lanka
Domestic R&D stock growth (2018)	5.725
Foreign R&D stock growth (2020)	-28.759
ICT industry labor productivity growth (2020)	1.898
Human capital growth (2019)	-0.105

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

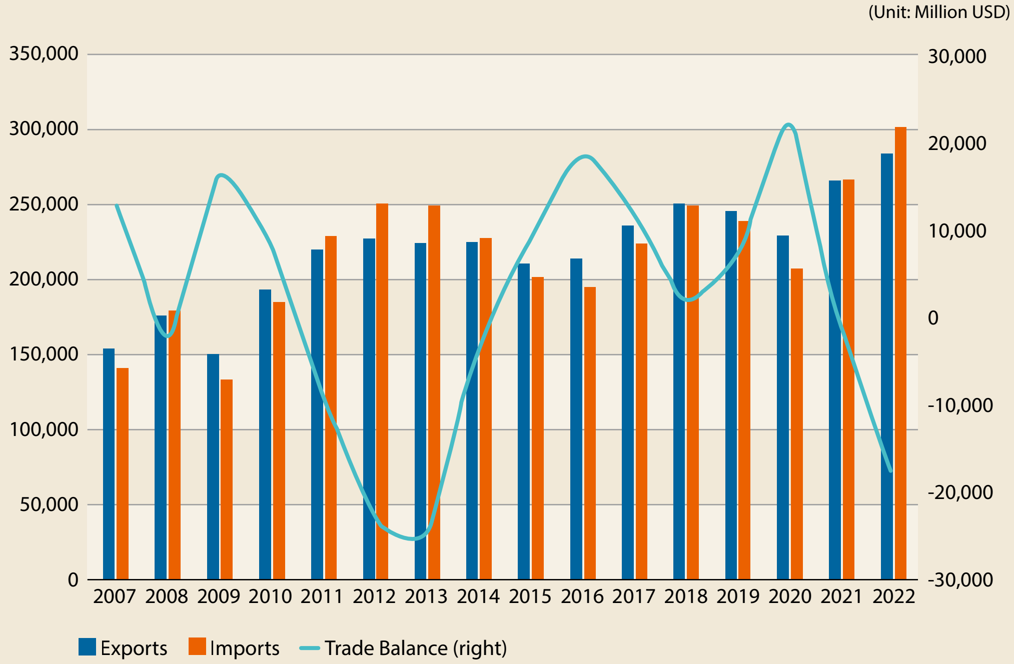
COUNTRY PROFILE: THAILAND

- Thailand total exports amounted to USD283,862 million, while imports accounted at USD301,411 million in 2021, recording a trade deficit of USD17,548 million. According to the BACI-CEPII database, in 2021 the main exports were machinery and electrical equipment (34.6%), transport-related goods (13.6%), and refined petroleum and chemicals (13.4%). In 2022, main export partners were China, the United States, Japan, Malaysia, and the United Arab Emirates. (UN Comtrade).

- Regarding GVC participation, Thailand exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

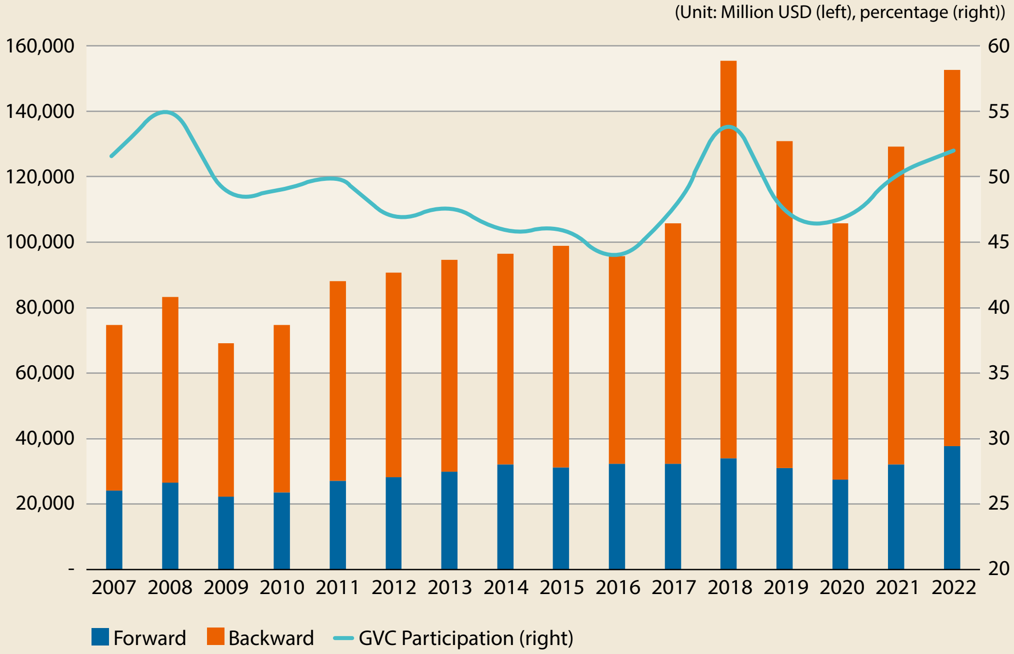
TRENDS OF TRADE



Source: IMF, Direction of Trade Statistics.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

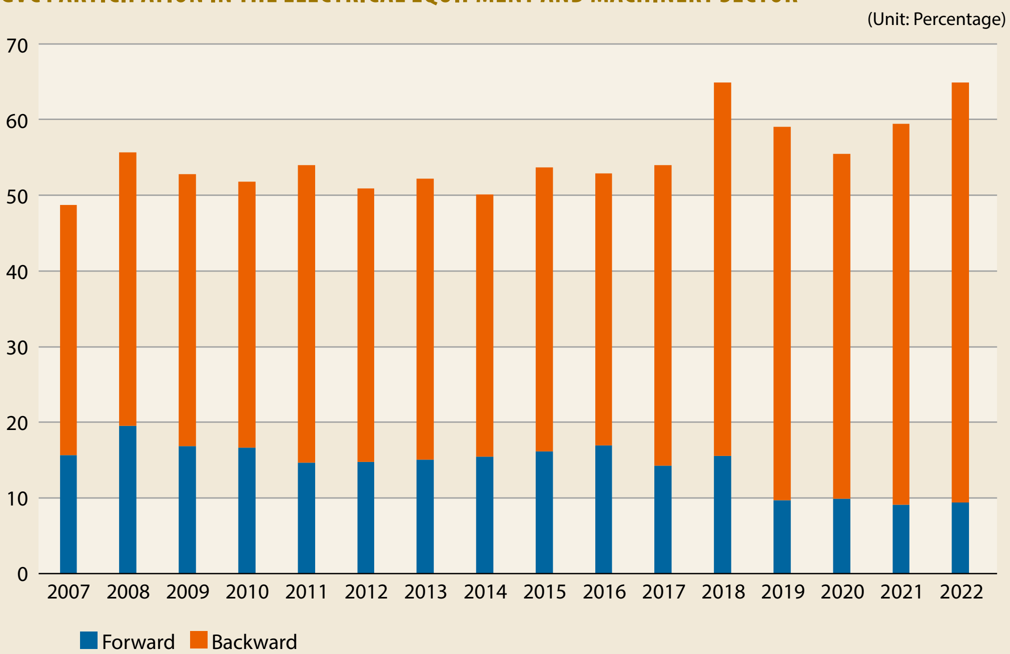


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 10% of Thailand's total value-added exports, of which nearly 65% involved in GVCs, with relatively higher backward GVC participation.

FIGURE 3

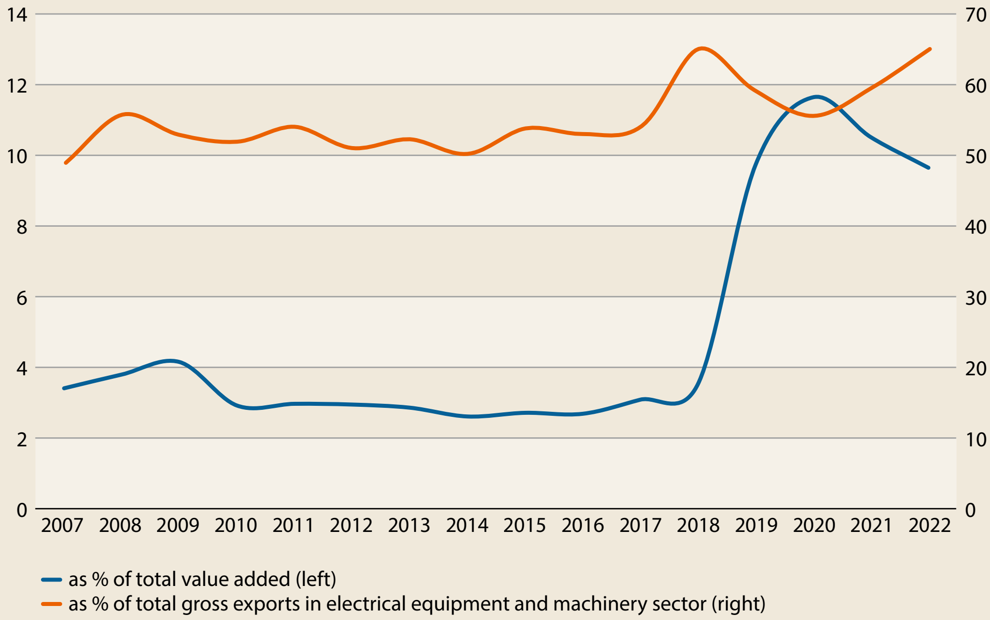
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database.

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS



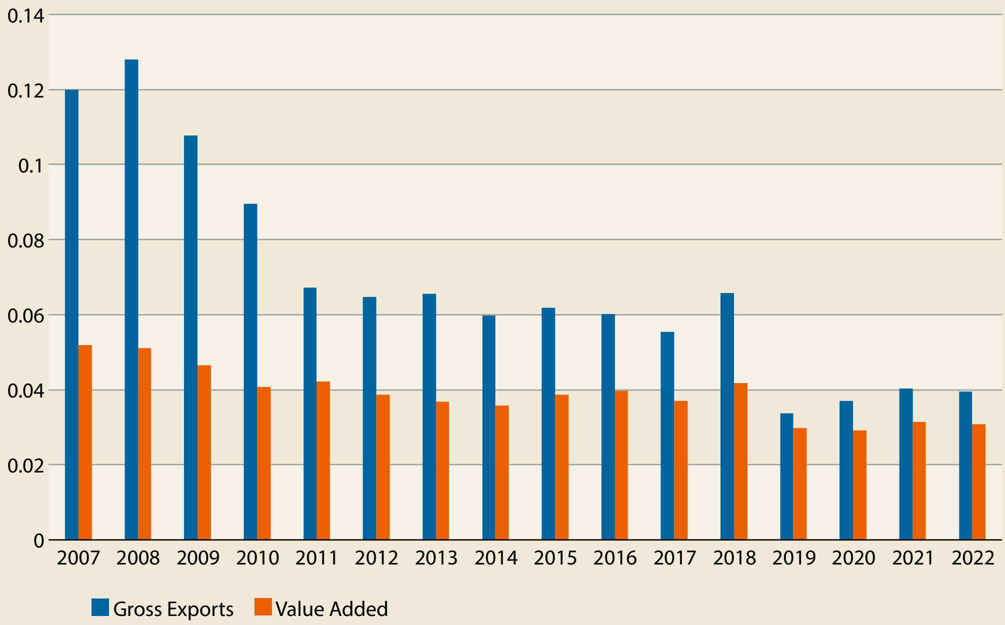
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Thailand documented an export concentration in gross exports of approximately 0.04, showing growth from 2018. Conversely, the export concentration in value-added exports was close to 0.03 in 2022, indicating a decline from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Thailand's domestic R&D stock and ICT productivity appear to have increased. However, the knowledge spillover appears to have decreased slightly. Thailand's total investment and foreign direct investment both decreased due to the influence of COVID-19, but investment appears to have recovered, centered on the domestic investment. In particular, ICT productivity also appears to have increased due to the increase in investment in Thailand's largest export industry, the ICT sector.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Thailand
Domestic R&D stock growth (2020)	15.367
Foreign R&D stock growth (2020)	-5.754
ICT industry labor productivity growth (2018)	6.146
Human capital growth (2019)	1.081

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

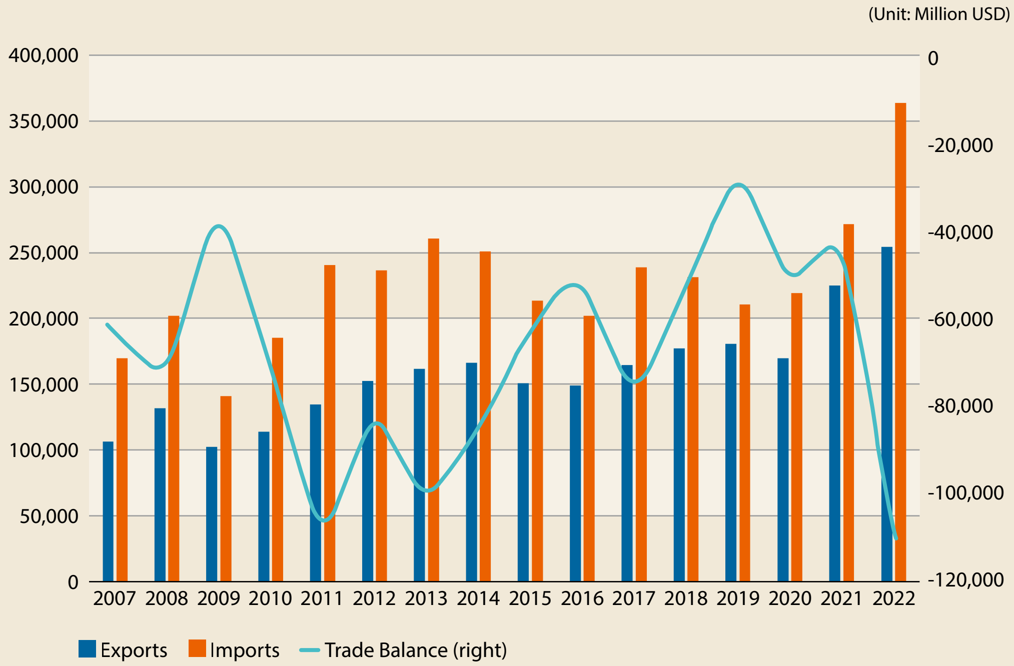
COUNTRY PROFILE: TURKIYE

- Turkiye total exports amounted to USD254,169 million, while imports accounted at USD363,710 million in 2021, recording a trade deficit of USD10,954 million. According to the BACI-CEPII database, in 2021 the main exports were nonmetallic mineral metals (15.1%), textiles, apparel and footwear (15.6%) and machinery and electrical equipment (15.1%). In 2022, its main export partners were Russia, Germany, China, the United States, and Italy. (UN Comtrade).

- Regarding GVC participation, Turkiye exhibits a relatively higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

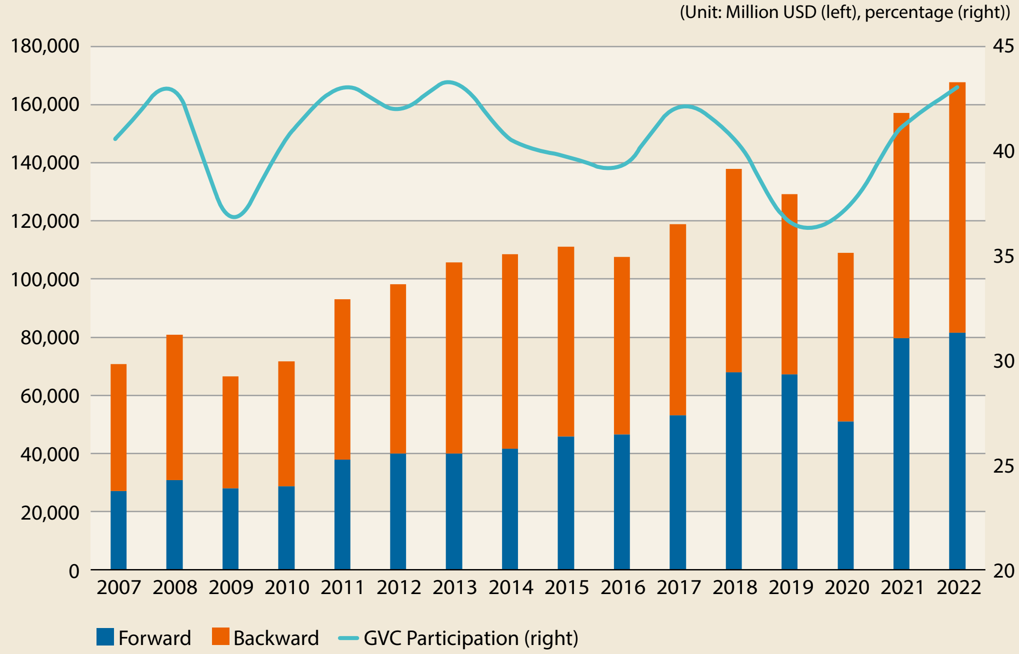
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

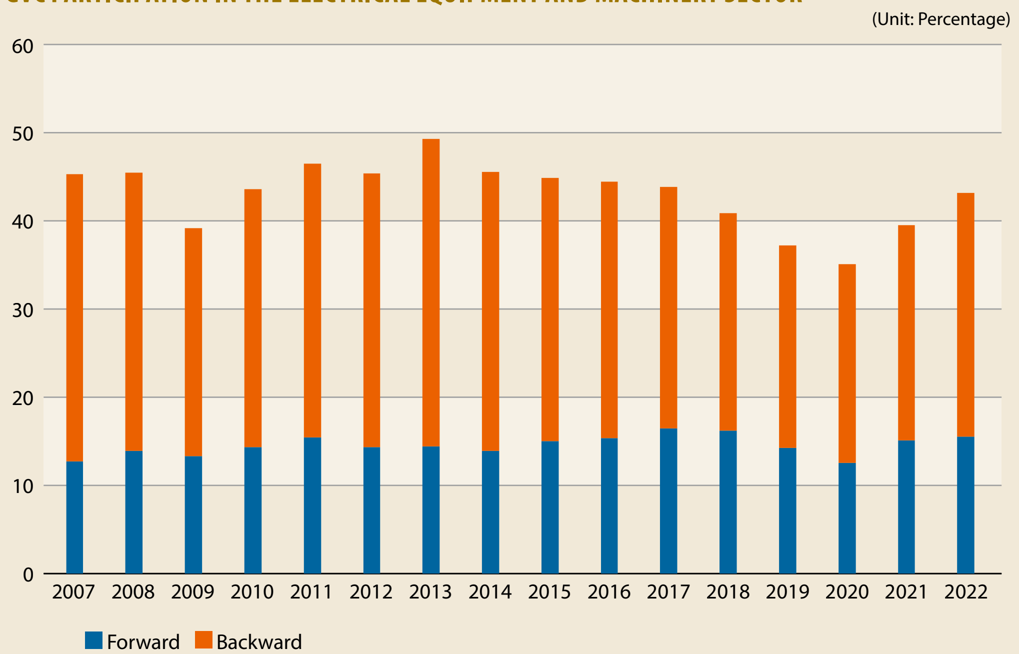


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 14% of Turkiye's total value-added exports, of which nearly 43% involved in GVCs, with a relatively higher backward GVC participation.

FIGURE 3

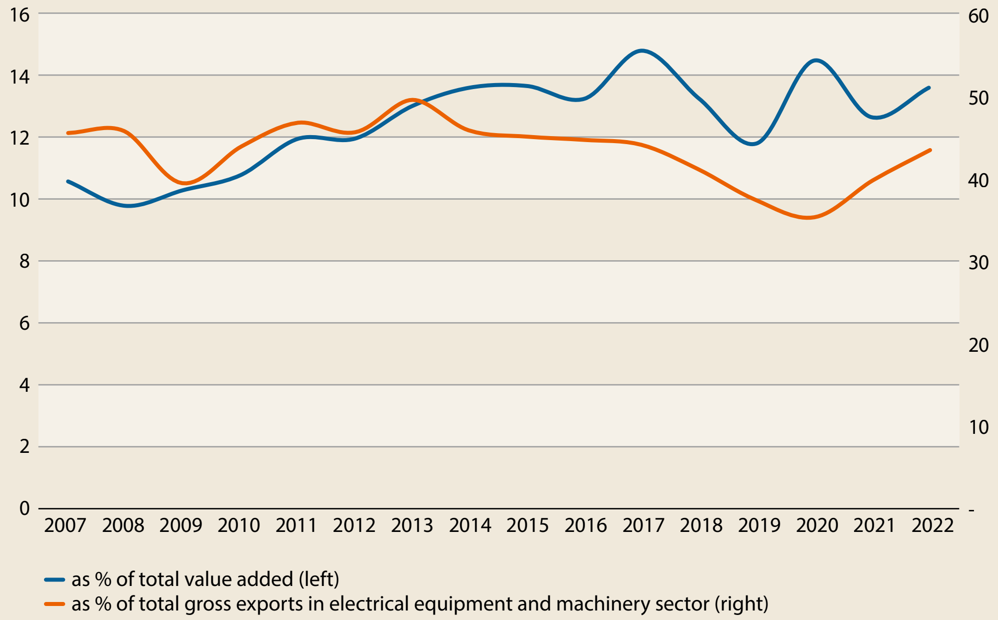
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS



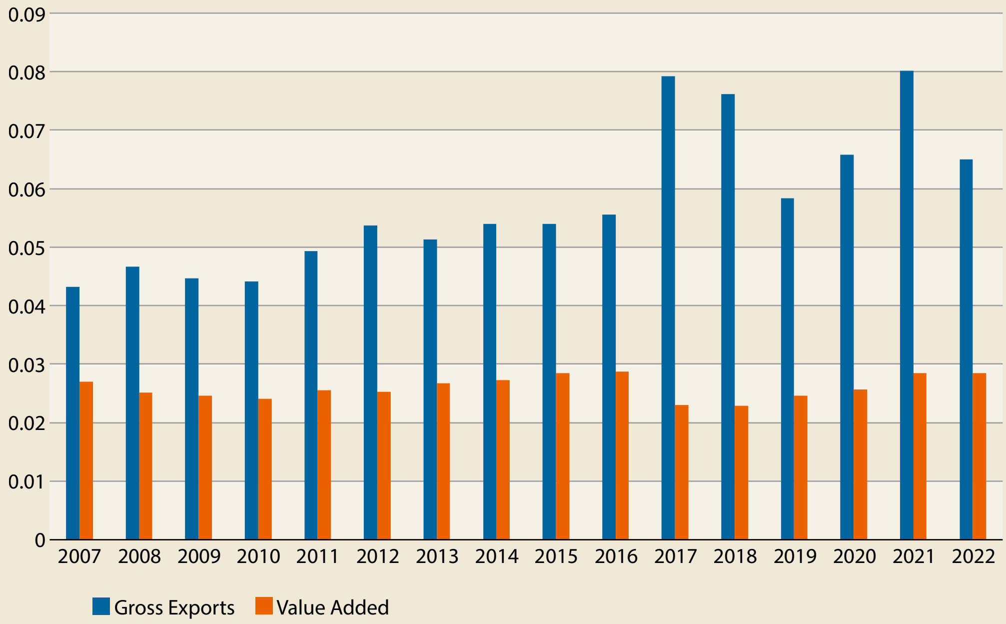
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Turkiye reported an export concentration in gross exports of approximately 0.07, displaying fluctuations since 2018. On the other hand, the export concentration in value-added exports was close to 0.03 in 2022, indicating growth from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Turkiye's domestic R&D stock and knowledge spillover appear to have increased. On the other hand, ICT productivity appears to have decreased slightly. Turkiye's major industries are automobiles, construction, and tourism, and even in terms of investment, the ICT sector does not account for a large proportion. The recovery of the Turkish economy requires the recovery of the tourism industry. Meanwhile, Turkiye's internal economic situation is unstable due to political turmoil, the weak lira, and high inflation, and the external situation appears to be bad due to the outbreak of conflict in the Middle East. However, with the re-election success of Rep Tayyip Erdogan, the trend of economic recovery needs to be observed.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Turkiye
Domestic R&D stock growth (2020)	8.617
Foreign R&D stock growth (2020)	3.572
ICT industry labor productivity growth (2020)	-3.067
Human capital growth (2019)	1.412

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

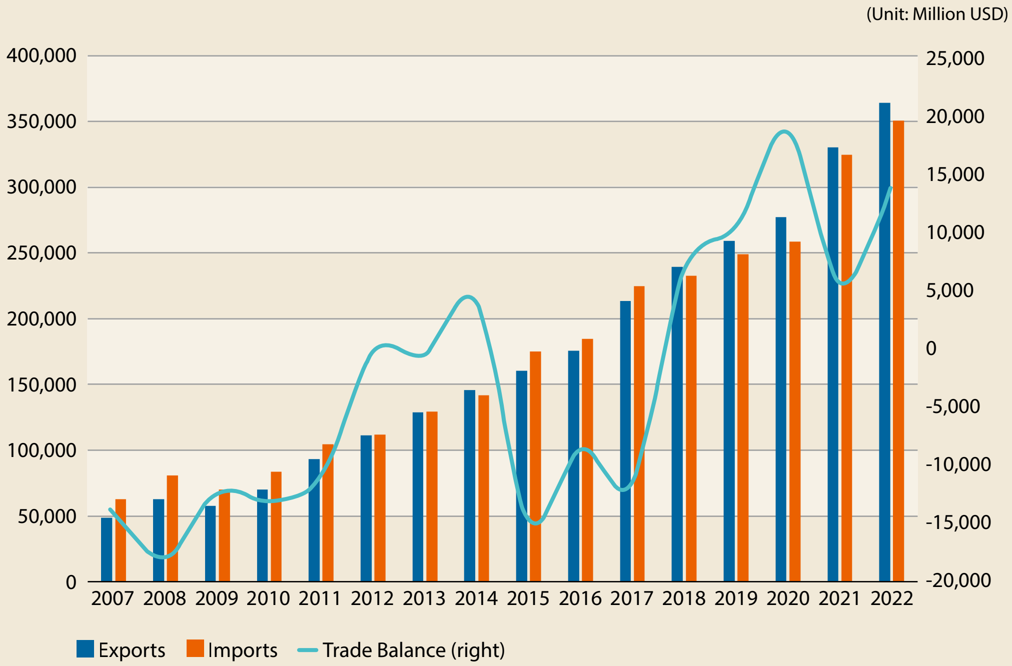
COUNTRY PROFILE: VIETNAM

- Vietnam total exports amounted to USD364,262 million, while imports accounted at USD350,869 million in 2021, recording a trade surplus of USD13,392 million. According to the BACI-CEPII database, in 2021 the main exports were machinery and electrical equipment (48.8%), textiles, apparel and footwear (18.6%) and nonmetallic mineral metals (7.5%). In 2022, main export partners were China, the United States, the Republic of Korea, Japan, and Thailand (UN Comtrade).

- Regarding GVC participation, Vietnam exhibits a higher degree of backward participation than forward participation, indicating a larger proportion of foreign value added across all industries.

FIGURE 1

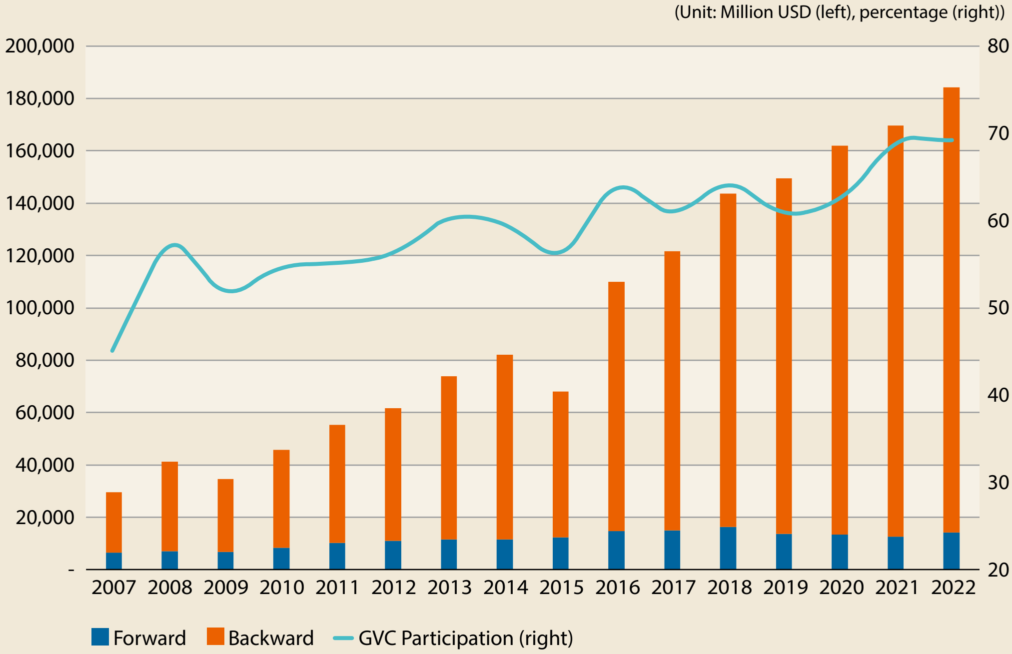
TRENDS OF TRADE



Source: IMF, DOTS.

FIGURE 2

TRENDS IN GVC PARTICIPATION (ALL INDUSTRIES)

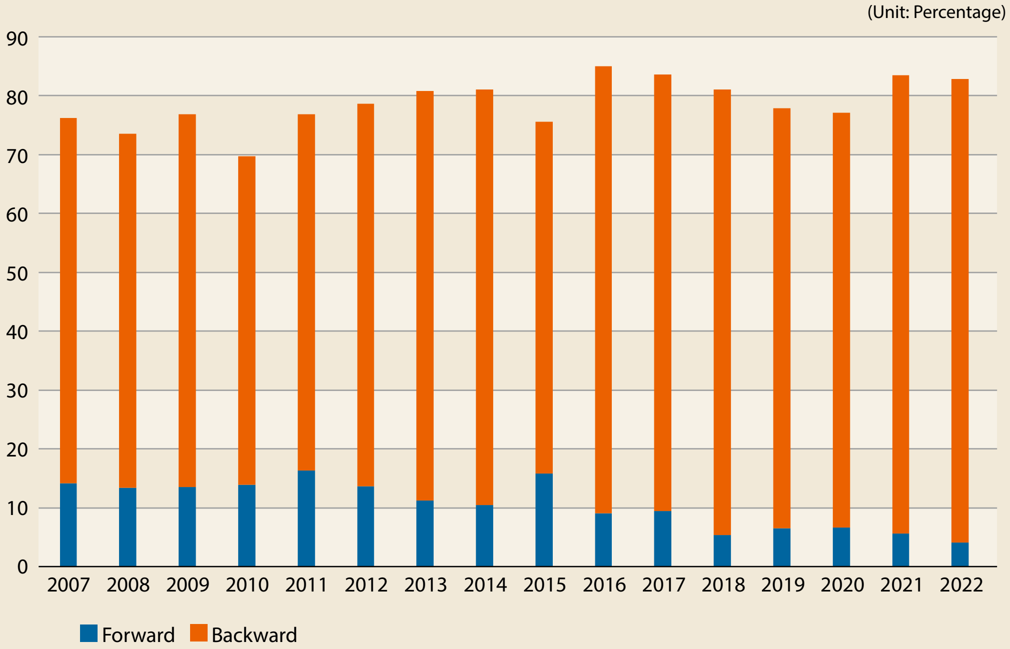


Source: ADB, MRIO Tables Database

- In 2022, the electrical equipment and machinery industry contributed 16% of Vietnam's total value-added exports, of which nearly 83% involved in GVCs, and relatively higher backward GVC participation.

FIGURE 3

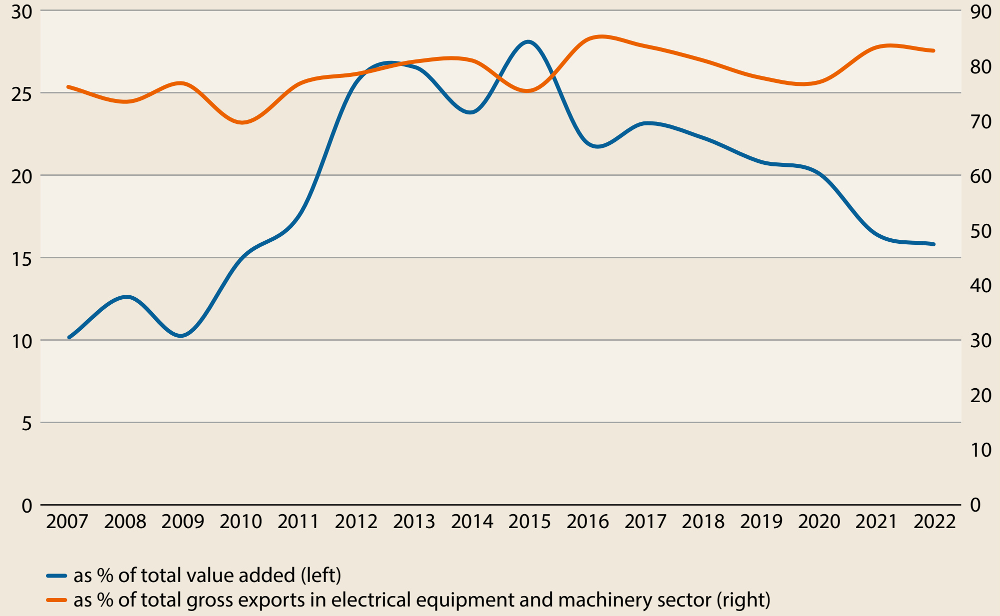
GVC PARTICIPATION IN THE ELECTRICAL EQUIPMENT AND MACHINERY SECTOR



Source: ADB, MRIO Tables Database

FIGURE 4

ELECTRICAL EQUIPMENT AND MACHINERY SECTOR AS PERCENTAGE OF TOTAL VALUE ADDED IN GROSS EXPORTS



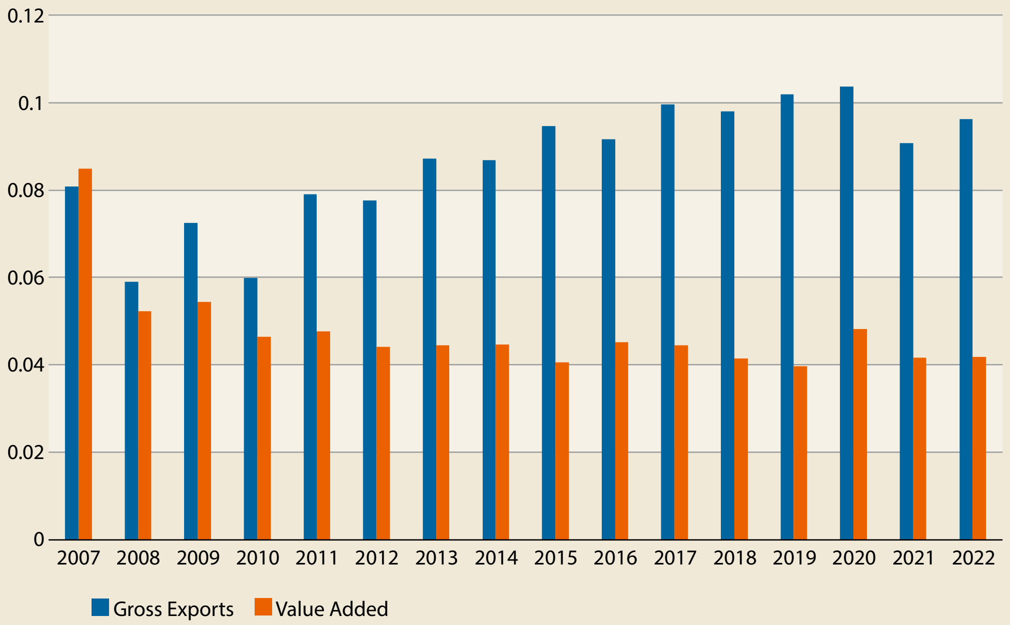
Source: Authors' calculations based on the ADB's MRIO Tables Database (Online). [https://www.adb.org/what-we-do/data/regional-input-output-tables]

- In 2022, Vietnam documented an export concentration in gross exports of approximately 0.1, maintaining stability since 2018. Similarly, the export concentration in value-added exports was close to 0.04 in 2022, showing no significant change from 2018.

FIGURE 5

TRENDS IN EXPORT CONCENTRATION (HHI INDEX)

(Unit: Index Numbers)



Source: ADB, MRIO Tables Database.
Note: Export concentration index is derived from the Herfindahl-Hirschman index. Indices with a score close to zero indicate a diversified portfolio of products and indices close to one indicate high concentration on few products.

- Vietnam's domestic R&D stock and knowledge spillover appear to have increased. However, ICT productivity appears to have decreased slightly. Vietnam introduced the Doi Moi policy, a reform and open policy, and steadily recorded economic growth of more than 3%. In addition, Bloomberg analyzed that Vietnam was the country with the smallest economic impact from COVID-19 in the ASEAN region. Accordingly, investment is expected to increase as the global production chain recovers.

TABLE 1

KEY INDICATORS RELATED TO KNOWLEDGE SPILLOVER

YoY, %

	Vietnam
Domestic R&D stock growth (2019)	10.761
Foreign R&D stock growth (2020)	6.881
ICT industry labor productivity growth (2020)	-4.770
Human capital growth (2019)	1.918

Source: Authors' calculation. For more information regarding data sources and methodology please refer to Chapter 3.

LIST OF ACRONYMS

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
CAGR	Compound Annual Growth Rate
CGE	Computable general equilibrium
CH method	Coe and Helpmann model
DAVAX	Domestic value added directly absorbed by partner economy
DVA	Domestic value added
E&M	Electrical Equipment and Machinery
Espillover	Electrical Equipment Spillover
FDI	Foreign Direct Investment
FPD	Foreign Portfolio Investment
FVA	Foreign value added
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GTAP	Global Trade Analysis
GVBS	Backward GVC Share
GVC	Global Value Chain
GVFS	Forward GVC Share
HHI	Herfindahl-Hirschman Index
ICIO	Inter Country Input Output
ICT	Information Communication Technology
IMF	International Monetary Fund
IP	Intellectual Property
IPR	Intellectual Property Rights
KSP	Knowledge Sharing Program
LP method	Lichtenberg and van Pottelsberghe de la Potterie method
MNC	Multinational Corporation
MRIO	Multiregional Input Output Database
MSpillover	Machinery Productivity Spillover
NIS	National Technology Innovation System

ODA	Official Development Assistance
PDC	Pure Double Counting
PWT	Penn World Table
R&D	Research and Development
REF	Domestic value added reexported by partner economy and eventually absorbed by home economy
REX	Domestic value added reexported by partner economy and eventually value added absorbed abroad
SMEs	Small Medium Enterprises
TFP	Total Factor Productivity
TVET	Technical and Vocational Education and Training
UNIDO	United Nations Industrial Development Organization
VAX	Value-added exports
WB	World Bank
WDI	World Development Indicators
WITS	World Integrated Trade Solution

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APO PRODUCTIVITY OUTLOOK 2024

Electrical Equipment and Machinery, Global Value Chain (GVC) and Knowledge Spillover

KDI