International Organization 10 Years AMRO

Chapter 2.

A More Regionally Anchored ASEAN+3: The Transformation of Economic Linkages

Online Annexes

Johor-Singapore Causeway, Malaysia and Singapore

Table of Contents

Annex 1. Network Analysis for Global Value Chain 1
Annex 2. Global Value Chain: Conceptual Framework and Economy-level Trends 2
Annex 3. Economy-level Trends of Exports for Foreign Final Demand and Foreign Direct Investment 4
Annex 4. Dynamic Factor Model for Business Cycle Synchronization Analysis 12
Annex 5. Trade Integration and Business Cycle Synchronization Relationship Analysis 15
Annex 6. Cross-Economy Spillover Impact Estimation 17
Annex 7. Global Value Chain Position Framework 24

References 26

Annex 1. Network Analysis for Global Value Chain

Part I identified supply and demand hubs in the global value chain from importer and exporter perspectives by following the approach of Li and others (2019) on network analysis. Supply hubs in this analysis are defined as the economies from which most economies source most of their imports. Demand hubs are economies to which most economies direct most of their exports.

The network charts are constructed using value-added exports, based on the Borin and Mancini (2023) decomposition of global value chain indicators by source. Specifically, the VAX indicator is used, which measures an economy's domestic value added embodied in its exports that is absorbed abroad.

The size of the node represents the share of the economy's value-added exports or imports by other economies in the world's total value-added exports or imports. The thickness of the linkage represents the share of the value-added export or import flow between each trading partner in the world's total value-added export or import flow. The arrow of the linkage shows the direction of the trade flow. The supply hub network uses value-added import data, as it shows the trading pattern from the importer's perspective. Conversely, the demand hub network is based on the value-added export data, as it displays trading patterns from the exporter's perspective.

Similar to Li and others (2019), to simplify the visual, a linkage between the two economies appears if (1) economy A takes the largest share in economy B's value-added exports or imports, or (2) economy A comprises more than 25 percent of economy B's value-added exports or imports. The first criterion is the "Top one" threshold widely used in network analyses to identify the most important linkages. The second criterion is used to adjust the density of the network to avoid losing other important linkages.

Gross and sectoral value-added exports and imports are computed using the statistical package exvatools built by Feas (2024), based on the 35-sector classification of the Asian Development Bank Multiregional Input-Output Table at constant 2010 prices, covering 62 economies and the rest of the world from 2000 to 2024. The 62 economies are converted to ISO-2 names. The rest of the world node is omitted from the network charts for visual clarity.

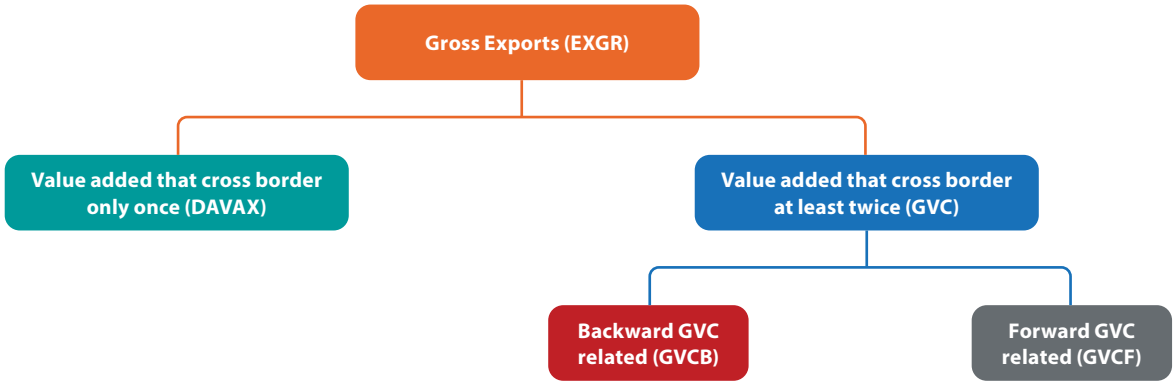
Annex 2. Global Value Chain: Conceptual Framework and Economy-level Trends

Part I documented the trend in Global Value Chain (GVC) related trade activities for the ASEAN+3 region, and Part II examined how increasing GVC participation is associated with more business cycle synchronization. The GVC indicators used in the chapter are constructed following the comprehensive value-added trade decomposition framework proposed by Borin and Mancini (2019), which decomposes gross exports according to the source or destination of the value added and the stages involved in trade.

As illustrated in Figure A2.1, gross exports (EXGR) are decomposed into domestic value added absorbed directly by the importing economy (DAVAX) and value added that crosses international borders at least twice (GVC). The value added captures production processes that involve multiple economies along the value chain and is a defining feature of global value chains. GVC-related trade can be further decomposed into backward GVC participation (GVCB), reflecting the use of foreign inputs in exports, and forward GVC participation (GVCF), reflecting domestic value added that is embodied in other economies' exports before reaching final demand. The indicators are constructed from the ADB Multiregional Input–Output Table at constant 2010 prices.

In addition to the regional comparisons shown in Part I, Figure A2.2 presents the GVC-related trade activities at the economy level, illustrating how the composition of gross exports has evolved under this decomposition framework. These charts highlight that, for most regional economies, the share of GVC-related trade in gross exports has increased over time.

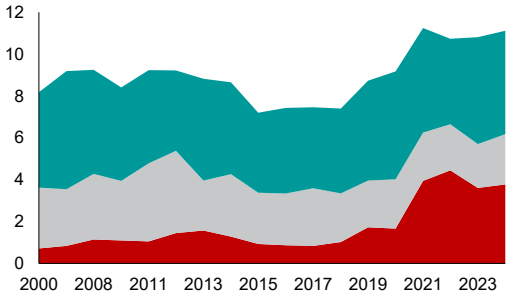
Figure A2.1 Conceptual Framework of GVC Indicators Decomposition



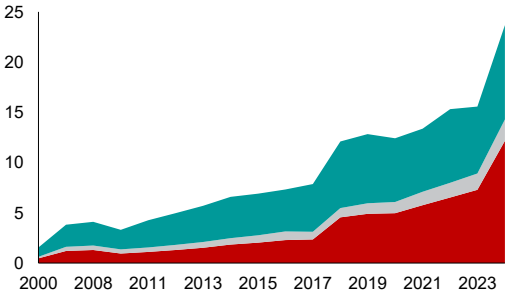
Source: Borin and Mancini (2019); AMRO staff.

Figure A2.2 Composition of Gross Exports for ASEAN+3 Economies between 2000 and 2024
(USD billions in 2010 prices)

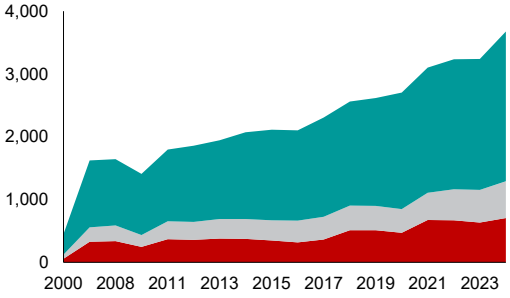
Brunei



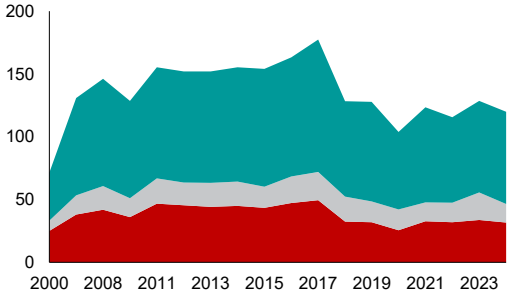
Cambodia



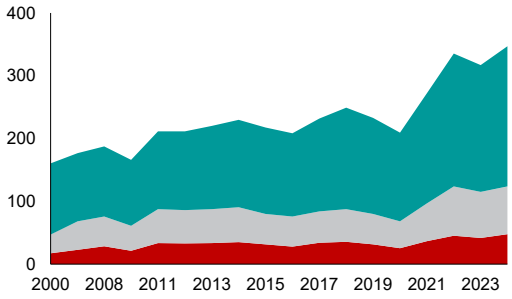
China



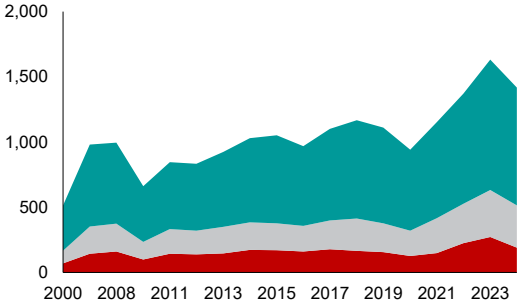
Hong Kong



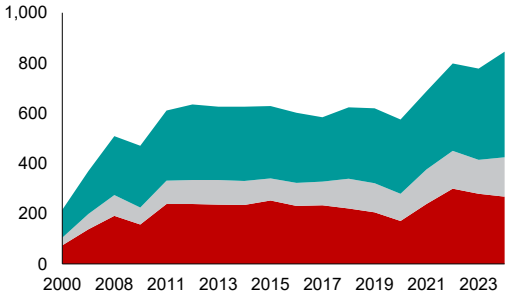
Indonesia



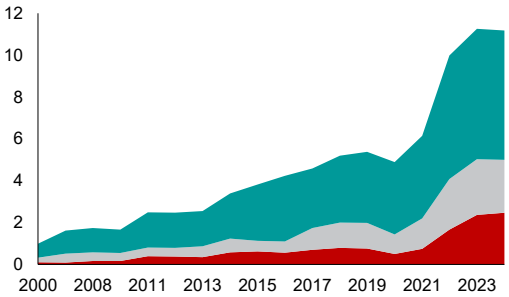
Japan



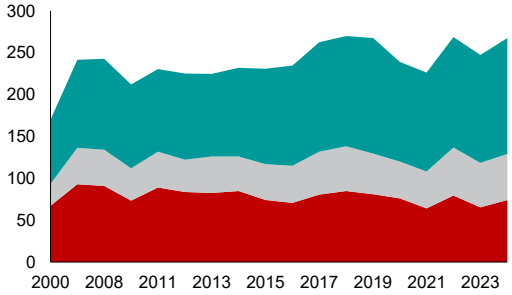
Korea



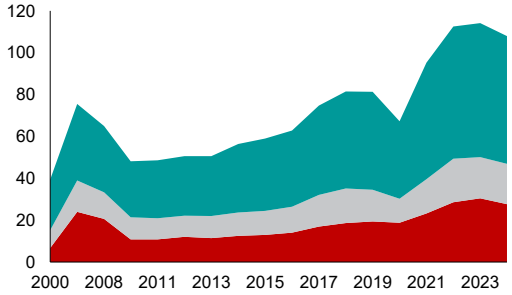
Lao PDR



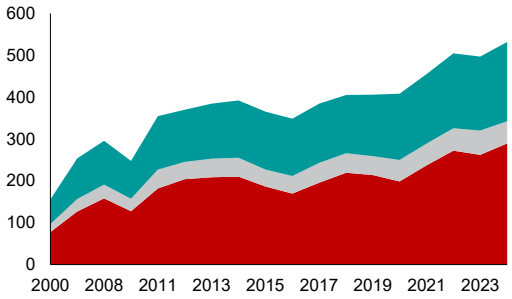
Malaysia



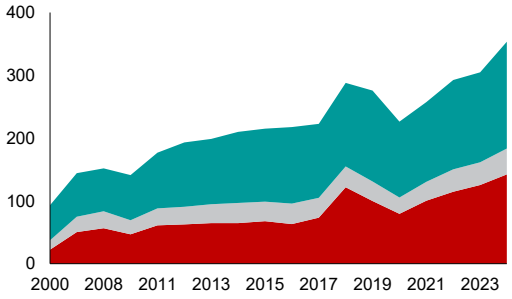
The Philippines



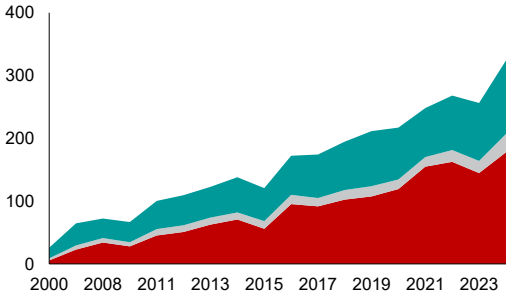
Singapore



Thailand



Vietnam



GVCB GVCF DAVAX

Source: Asian Development Bank Multiregional Input-Output Table; AMRO staff calculations.
Note: DAVAX = direct value-added exports that only cross borders once; GVC = global value chain; GVCB = backward GVC participation; GVCF = forward GVC participation. Excludes Myanmar due to data unavailability. Charts show data available for year 2000, 2007–2009, and 2011–2024.

Annex 3. Economy-level Trends of Exports for Foreign Final Demand and Foreign Direct Investment

Part I analyzed final demand destinations, which trace where exports ultimately serve consumption rather than intermediate use, of ASEAN+3. Figure A3.1 shows this trend for all 14 regional economies from two aspects – by selected economies (left panel) and by intraregional breakdown (right panel).

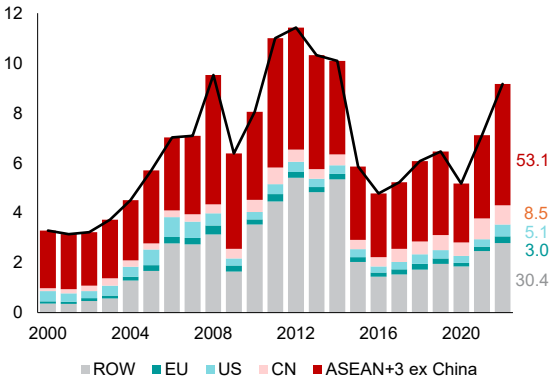
Part I also examined foreign direct investment (FDI) trends in ASEAN+3. Figure A3.2 presents a breakdown of FDI inflow sources from two perspectives – by selected economies (left panel) and by intraregional breakdown (right panel).

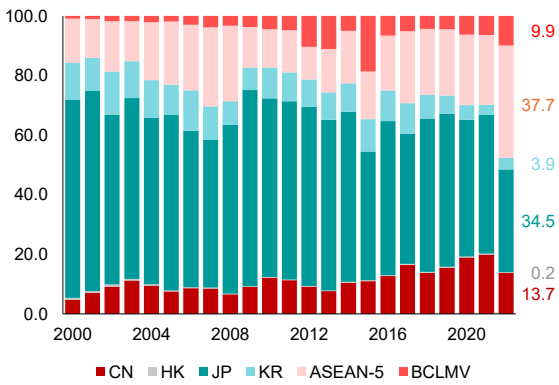
Figure A3.1 Exports of ASEAN+3 Economies for Foreign Final Demand

By Selected Economies
(USD billions; Percent share)

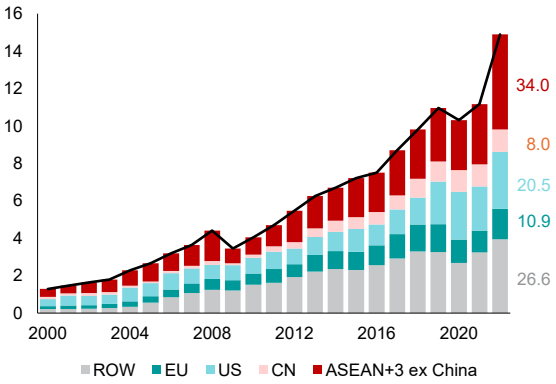
Intraregional Destination Breakdown
(Percent share)

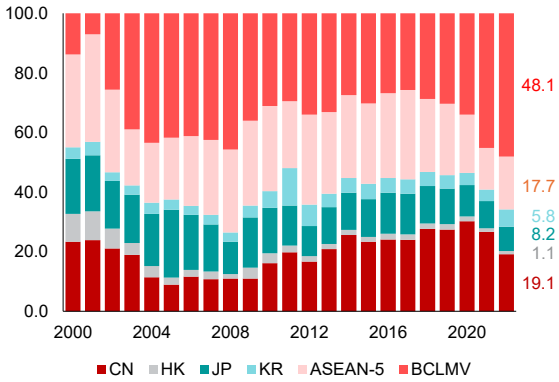
Brunei



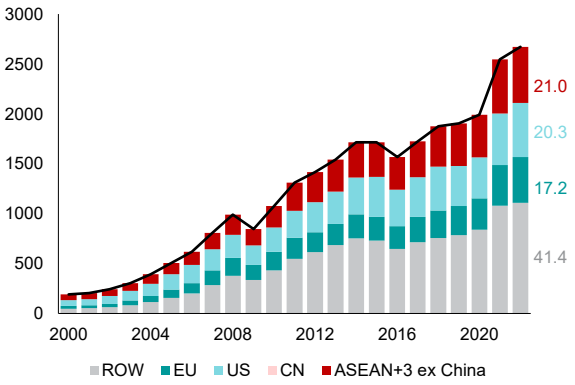


Cambodia





China



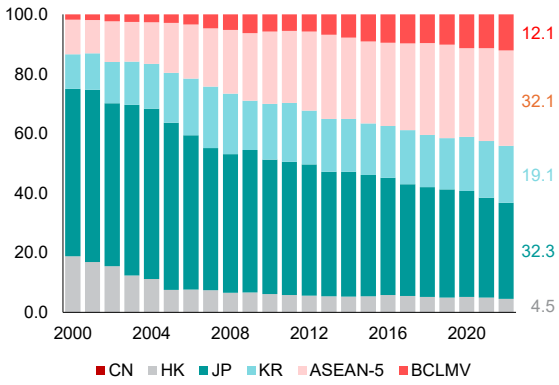
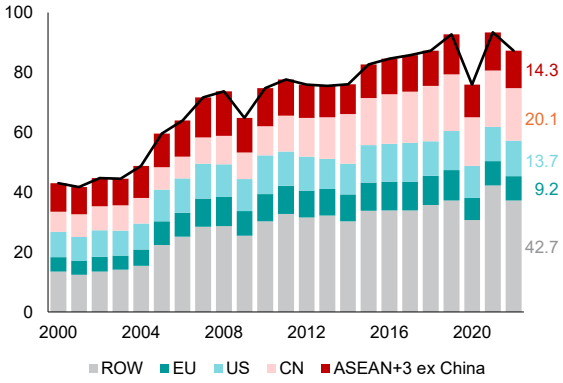


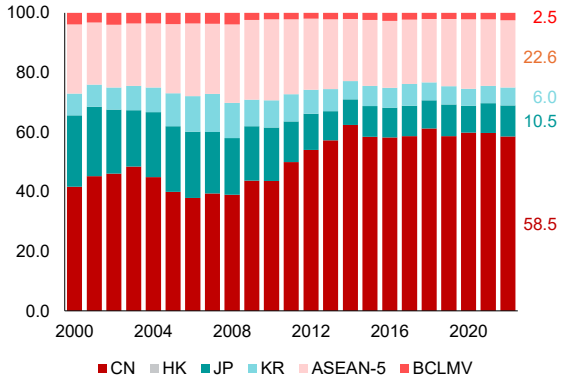
Figure A3.1 Exports of ASEAN+3 Economies for Foreign Final Demand (Continued)

By Selected Economies
(USD billions; Percent share)

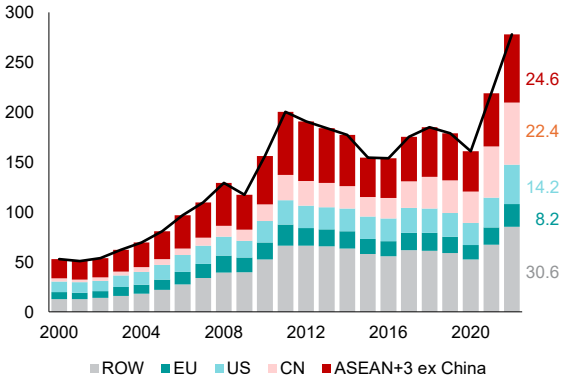
Intraregional Destination Breakdown
(Percent share)

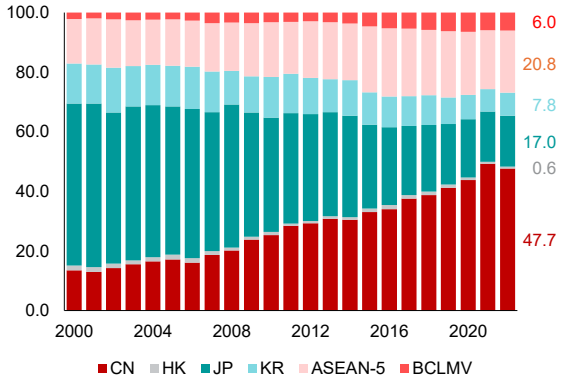
Hong Kong



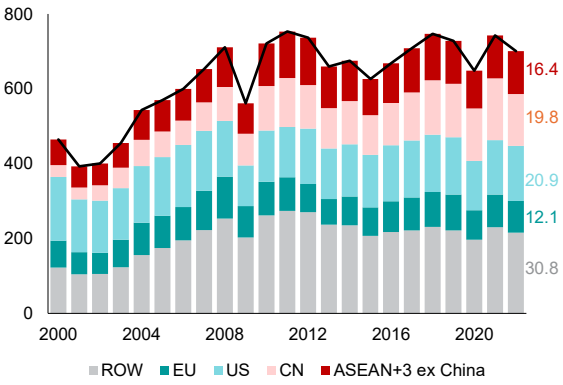


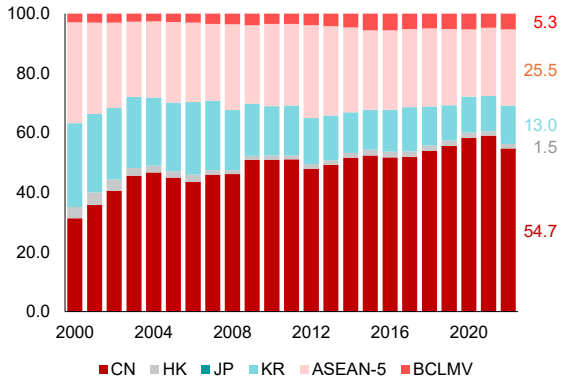
Indonesia



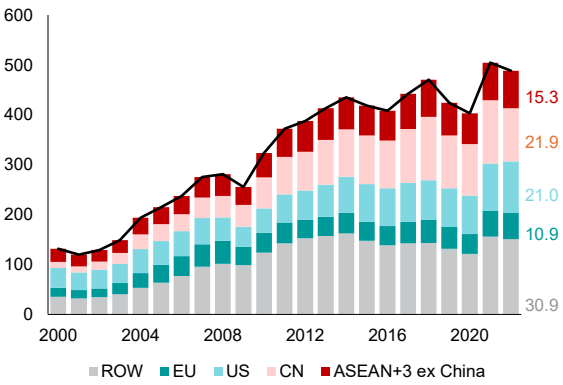


Japan





Korea



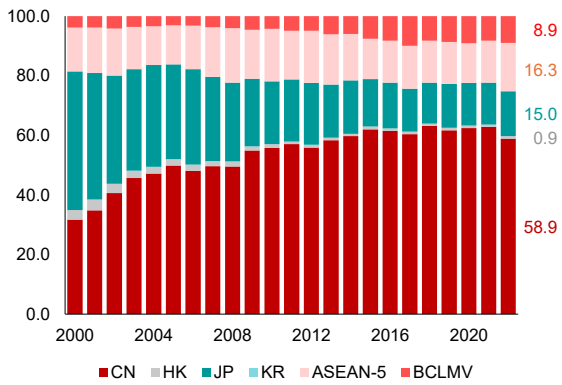
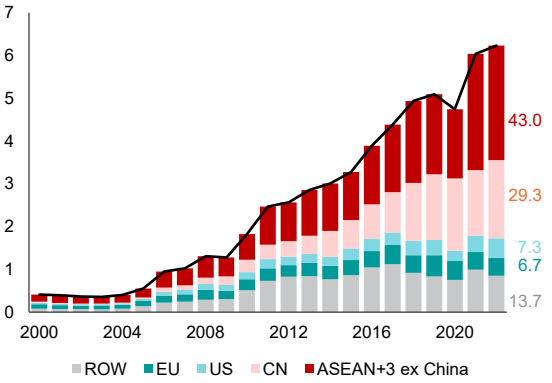


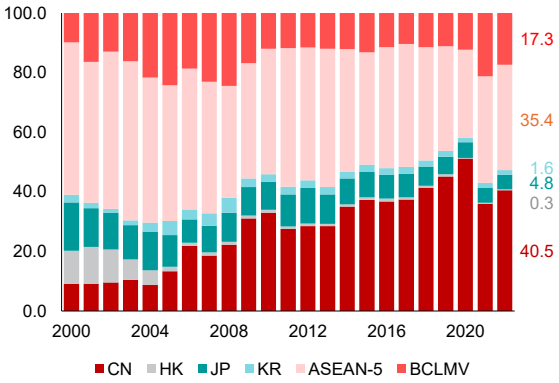
Figure A3.1 Exports of ASEAN+3 Economies for Foreign Final Demand (Continued)

By Selected Economies
(USD billions; Percent share)

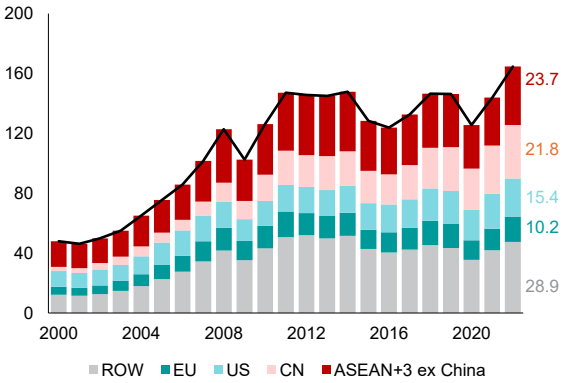
Intraregional Destination Breakdown
(Percent share)

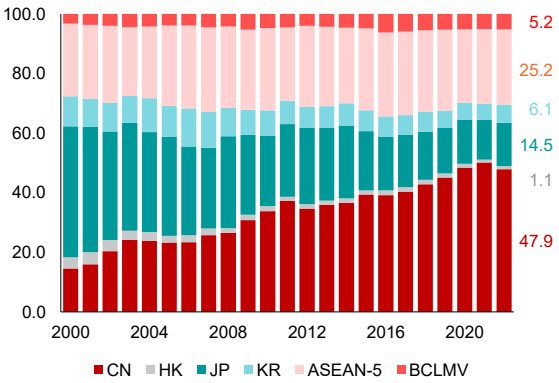
Lao PDR



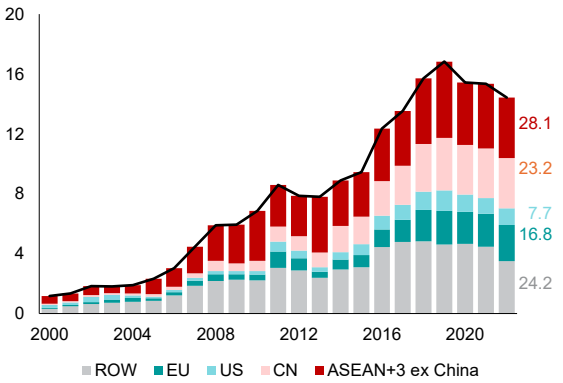


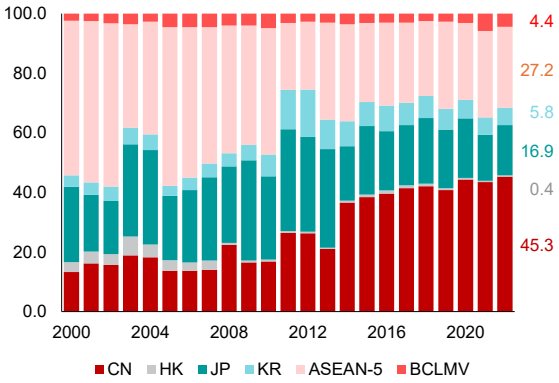
Malaysia



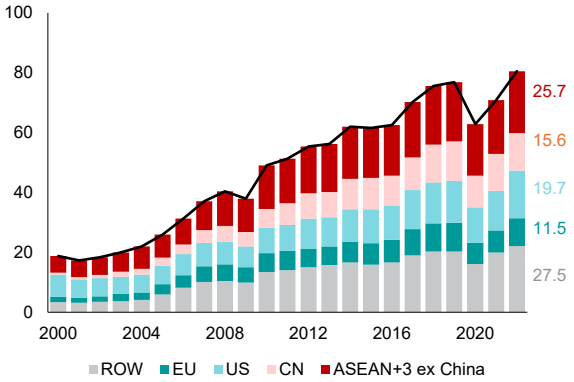


Myanmar





The Philippines



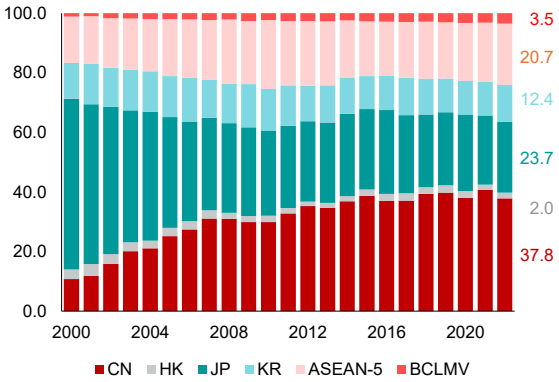
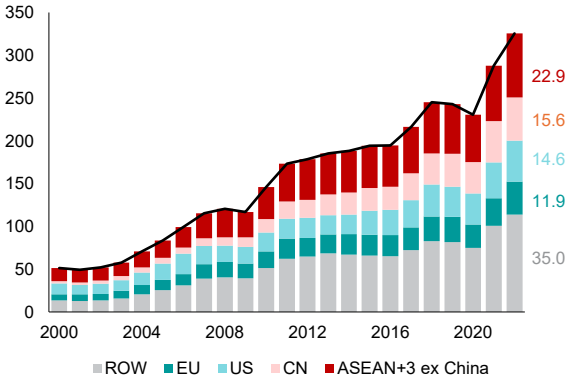


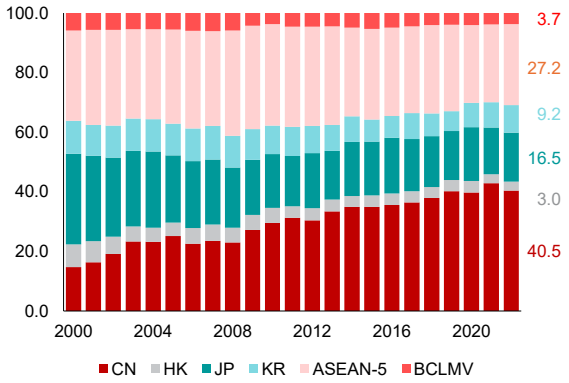
Figure A3.1 Exports of ASEAN+3 Economies for Foreign Final Demand (Continued)

By Selected Economies
(USD billions; Percent share)

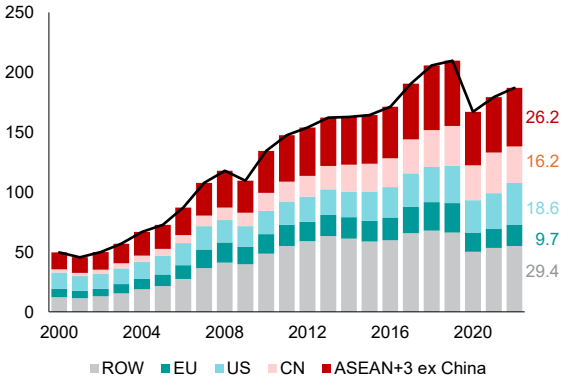
Intraregional Destination Breakdown
(Percent share)

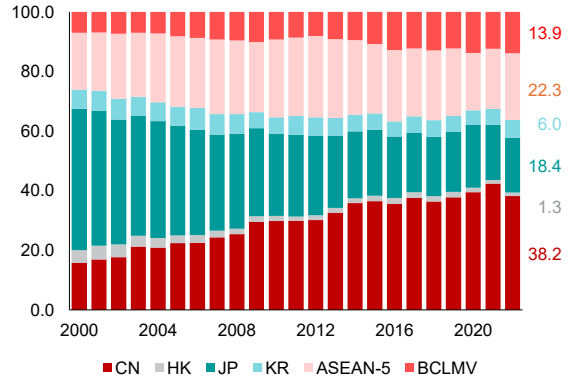
Singapore



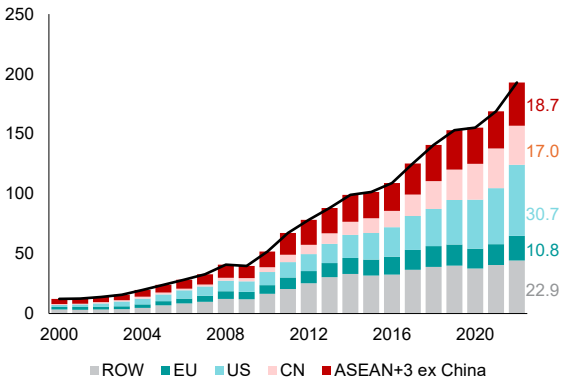


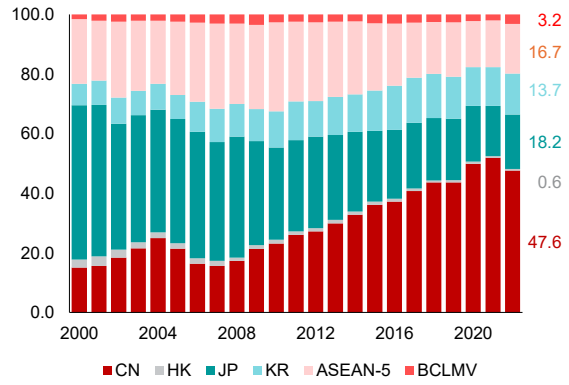
Thailand





Vietnam





Source: Organisation for Economic Co-operation and Development Trade in Value-Added Database; AMRO staff calculations.
Note: CN = China; EU = EU-27 member economies; US = United States; ROW = Rest of the world. The colored data labels represent each economy's domestic value-added embodied in each partner economy's final demand as a share of its total domestic value-added in foreign final demand. Percent share totals may not sum to 100 due to rounding.

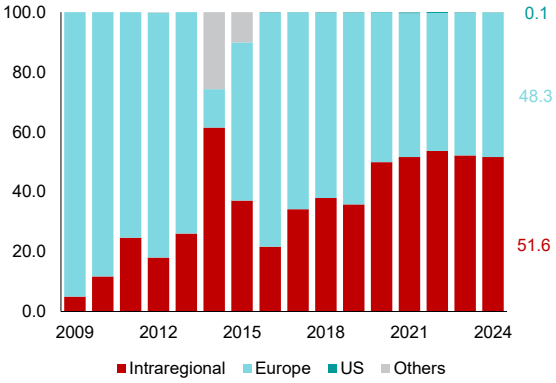
Source: Organisation for Economic Co-operation and Development Trade in Value-Added Database; AMRO staff calculations.
Note: HK = Hong Kong; JP = Japan; KR = Korea; ASEAN-5 = Indonesia, Malaysia, the Philippines, Singapore, and Thailand; BCLMV = Brunei, Cambodia, Lao PDR, Myanmar, and Vietnam. The colored data labels represent each intraregional partner's share of the total intraregional final demand for value-added from ASEAN+3 economies. Percent share totals may not sum to 100 due to rounding.

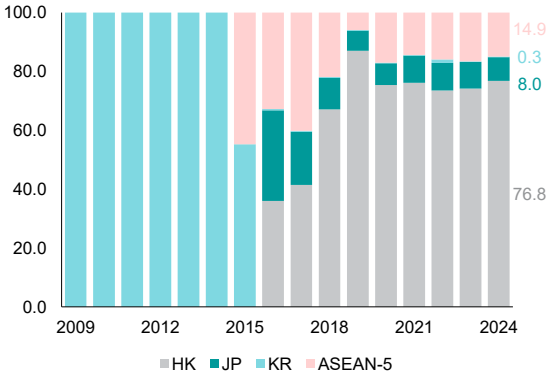
Figure A3.2 ASEAN+3 FDI Inflow Pattern by Source

By Selected Economies
(Percent share)

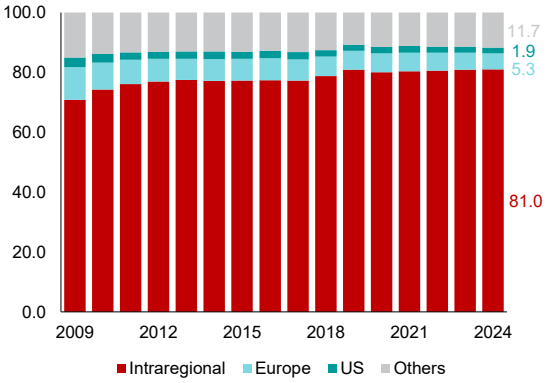
Intraregional FDI Inflow Breakdown
(Percent share)

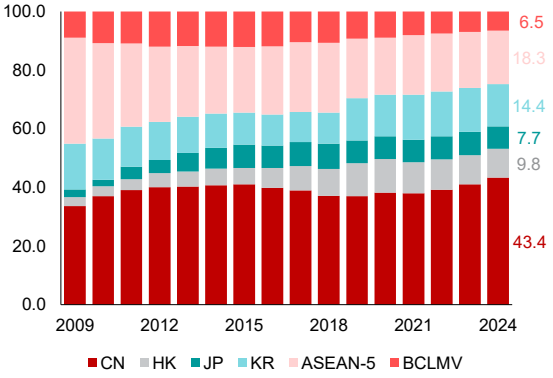
Brunei



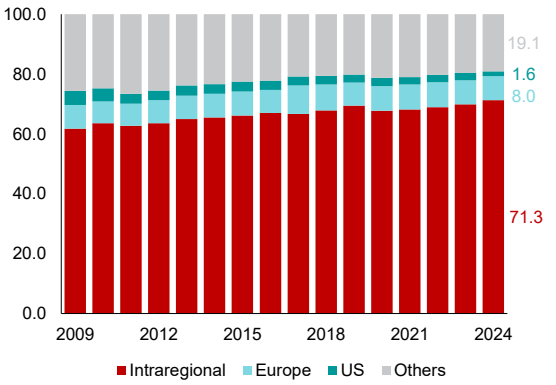


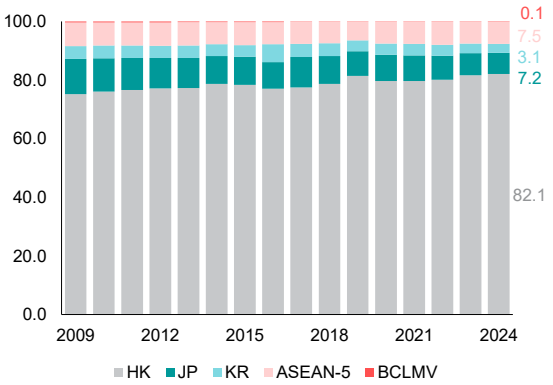
Cambodia



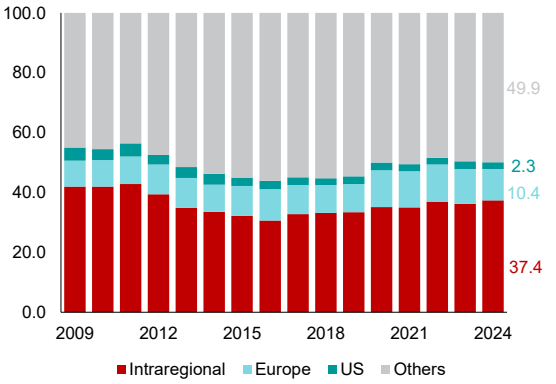


China





Hong Kong



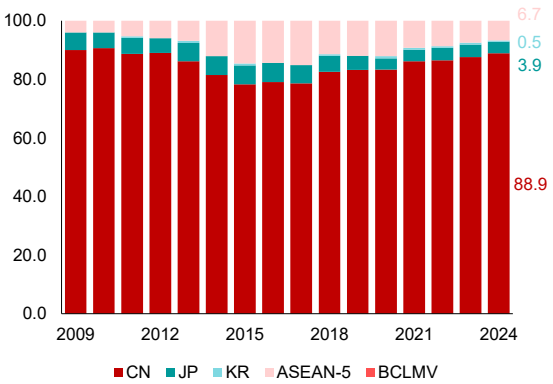
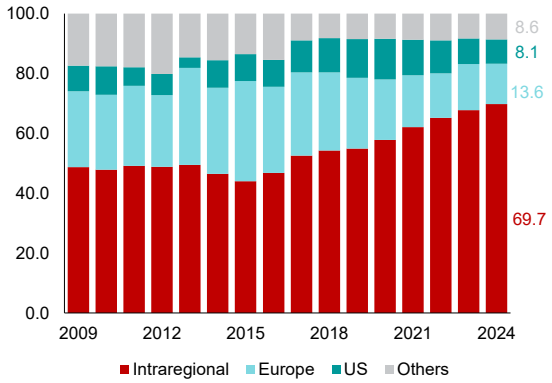


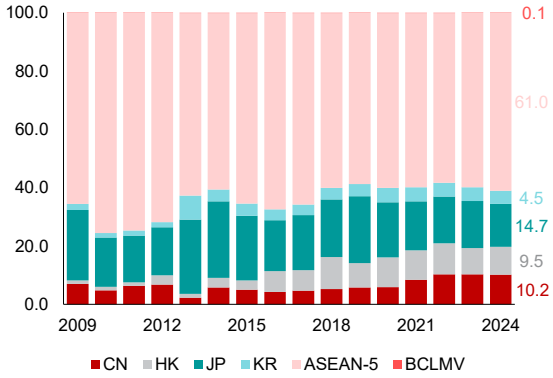
Figure A3.2 ASEAN+3 FDI Inflow Pattern by Source (Continued)

By Selected Economies
(Percent share)

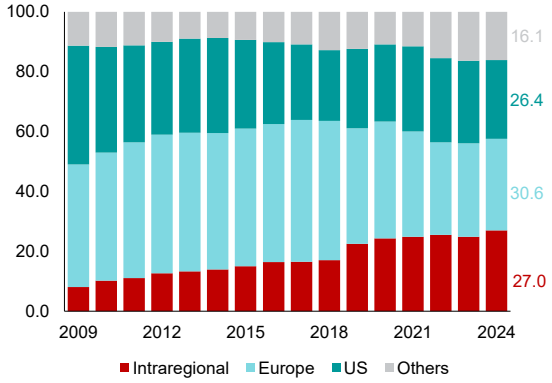
Intraregional FDI Inflow Breakdown
(Percent share)

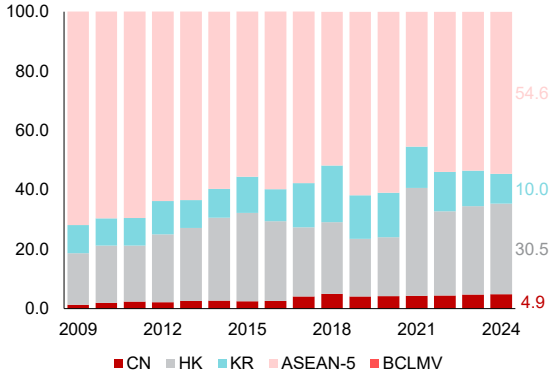
Indonesia



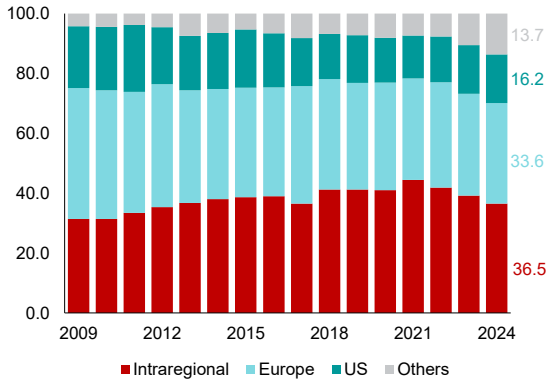


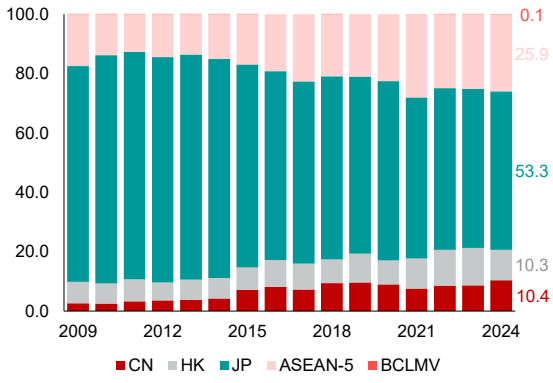
Japan



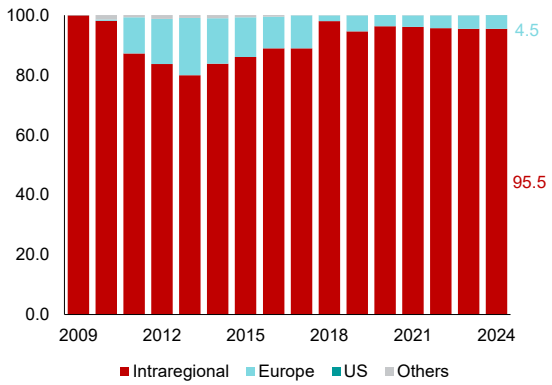


Korea





Lao PDR



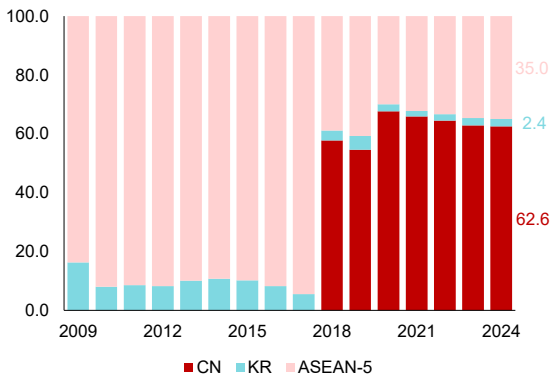
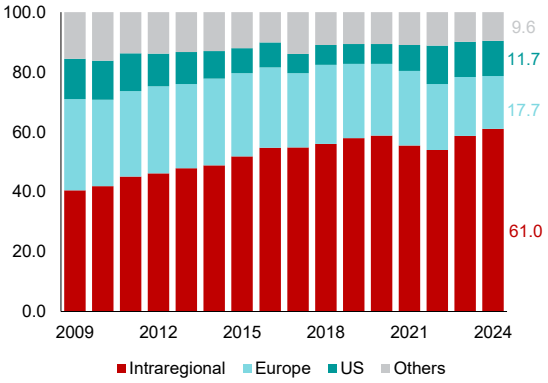


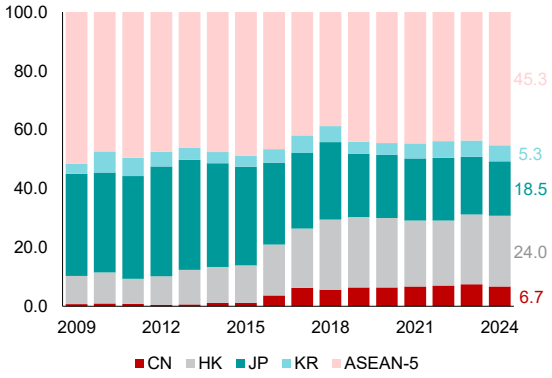
Figure A3.2 ASEAN+3 FDI Inflow Pattern by Source (Continued)

By Selected Economies
(Percent share)

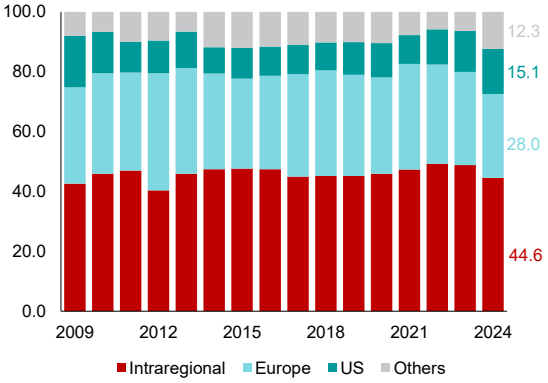
Intraregional FDI Inflow Breakdown
(Percent share)

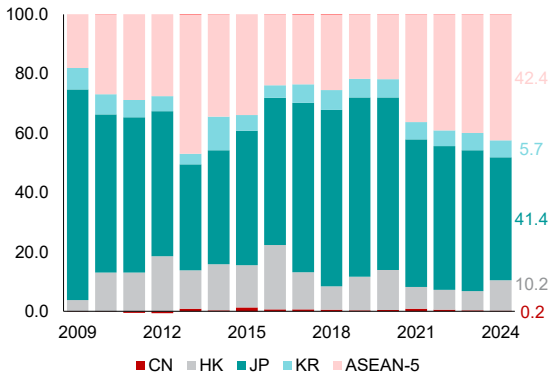
Malaysia



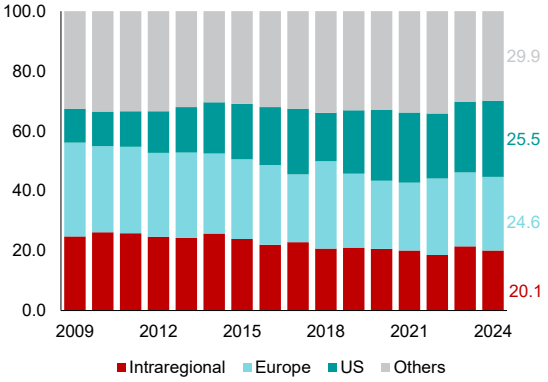


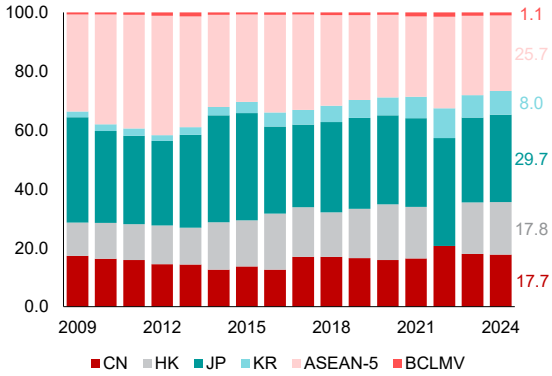
The Philippines



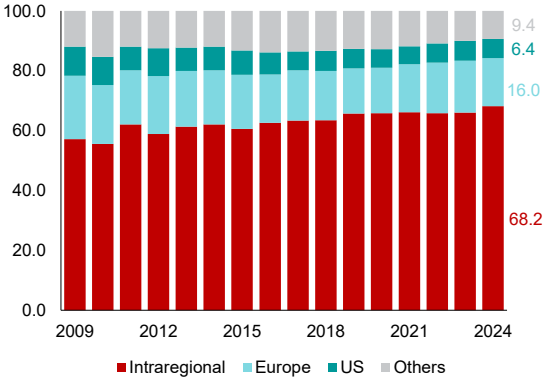


Singapore





Thailand



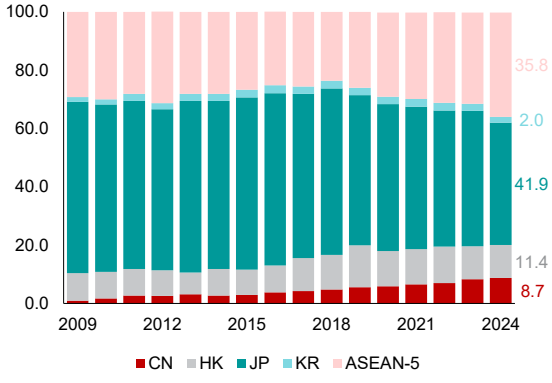
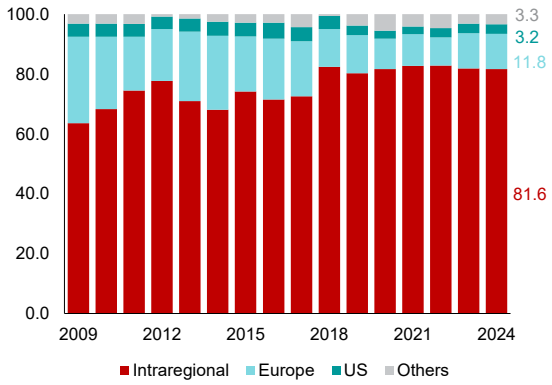


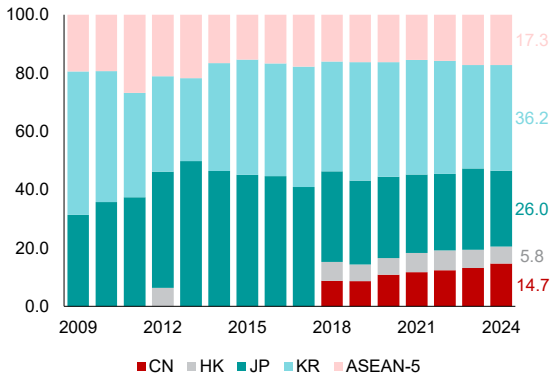
Figure A3.2 ASEAN+3 FDI Inflow Pattern by Source (Continued)

By Selected Economies
(Percent share)

Vietnam



Intraregional FDI Inflow Breakdown
(Percent share)



Source: International Monetary Fund Coordinated Direct Investment Survey; AMRO staff calculations.
Note: CN = China; HK = Hong Kong; JP = Japan; KR = Korea; US = United States; ASEAN-5 = Indonesia, Malaysia, the Philippines, Singapore, and Thailand; BCLMV = Brunei, Cambodia, Lao PDR, Myanmar, and Vietnam; FDI = Foreign direct investment; Others = Rest of the world. The colored data labels represent the percent share of total FDI inflow stock. Percent share totals may not sum to 100 due to rounding.

Annex 4. Dynamic Factor Model for Business Cycle Synchronization Analysis

Part II analyzed global and regional business cycle synchronization across economies using a multilevel dynamic factor model (DFM), following the framework proposed by He and Liao (2012). The approach decomposes real GDP growth fluctuations into global, regional, and economy-specific components and is applied across the full sample and selected subperiods.

Real GDP growth y for economy *i*, belonging to region *k*, at time *t*, denoted $y_{i,t}$, is modelled as:

$$y_{i,t} = \lambda_i^g g_t + \lambda_i^k f_{k,t} + u_{i,t}$$

where g_t is a global factor common to all economies, $f_{k,t}$ is a region-specific factor common to economies within region *k*, and $u_{i,t}$ captures idiosyncratic, economy-specific fluctuations. The coefficients λ_i^g and λ_i^k represent economy-specific loadings on the global and regional factors. The full sample includes 174 economies from the World Bank's annual real GDP dataset, classified into 8 regions according to United Nation's region classification.

The global and regional factors are assumed to follow autoregressive processes:

$$g_t = \Phi_g g_{t-1} + \eta_t^g, \quad f_{k,t} = \Phi_k f_{k,t-1} + \eta_t^k$$

with mutually orthogonal innovations. The idiosyncratic component is assumed to be uncorrelated across economies and over time.

The model is estimated using a sequential factor-extraction strategy. First, a single global factor is extracted from the full panel of real GDP growth rates using a dynamic factor model with one factor and one lag, estimated by quasi-maximum likelihood. Second, for each region, a regional factor is extracted using only economies belonging to that region. To ensure that regional factors capture purely region-specific co-movements, each regional factor is obtained as the residuals by regressing the raw regional factor on the global factor.

The baseline sample begins in 2000 and extends to the most recent available year, 2024. To examine changes in synchronization over time, the analysis is conducted for three subperiods: 2000–2007, 2008–2015, and 2016–2024. The crisis years affected by the global financial crisis (2008, 2009) and COVID-19 (2020, 2021) are removed from the sample.

To quantify the relative importance of global and regional forces, output-growth variance is decomposed as follows:

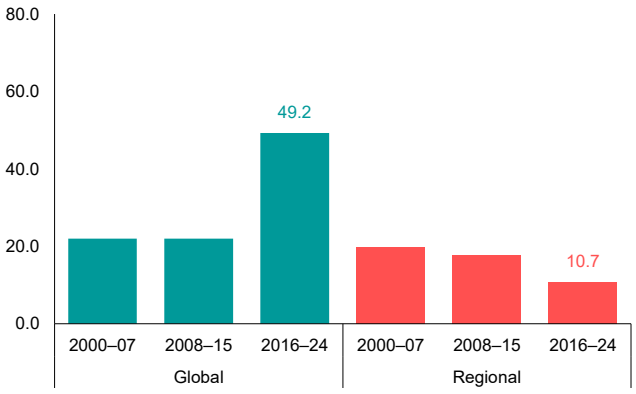
$$Var(y_{i,t}) = Var(\lambda_i^g g_t) + Var(\lambda_i^k f_{k,t}) + Var(u_{i,t})$$

For each economy, real GDP growth is regressed on the estimated global and regional factors, and the variance shares attributable to each component are computed. These variance shares are then averaged across economies within each region and reported by subperiod. A higher regional variance share indicates stronger intraregional business-cycle synchronization, while a higher global variance share indicates greater exposure to global business-cycle fluctuations. Figure A4.1 shows the results by major regions.

Figure A4.1. Variance in Real Growth of Major Regions Explained by Factors
(Percent share of total variance)

Full Sample Period (2000–2024)

Africa



Excluding Crisis Years

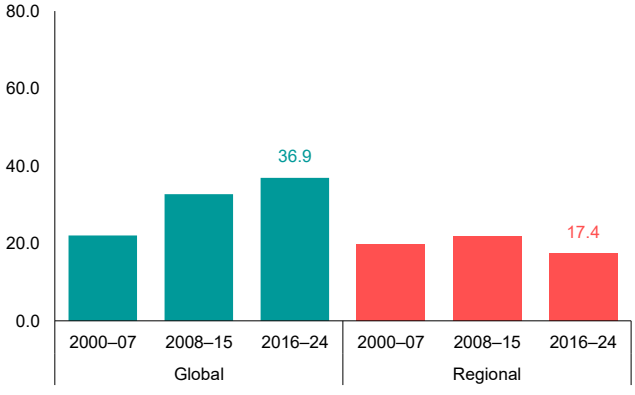
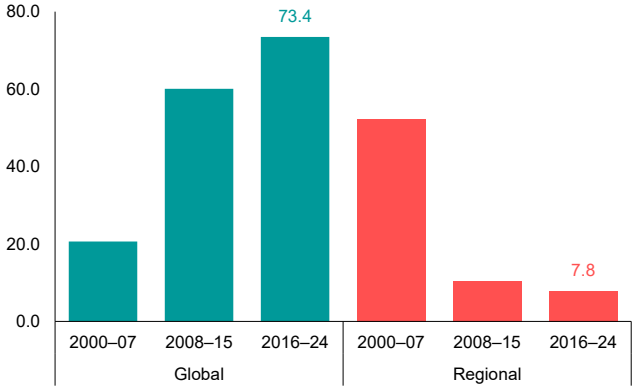


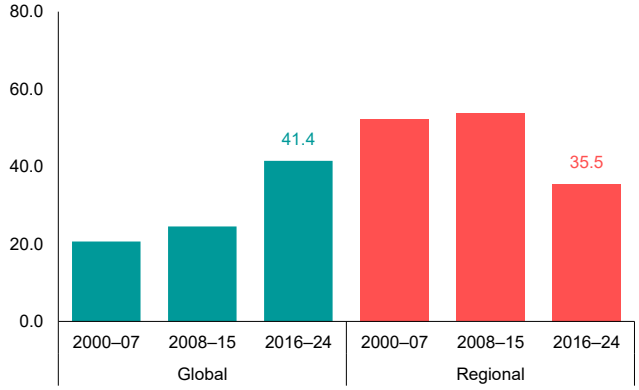
Figure A4.1. Variance in Real Growth of Major Regions Explained by Factors (Continued)
(Percent share of total variance)

Full Sample Period (2000–2024)

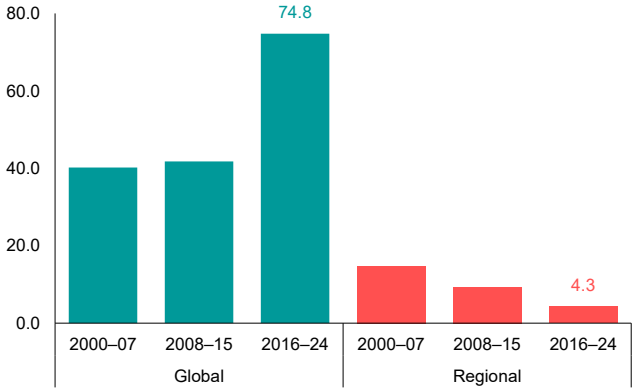
Excluding Crisis Years

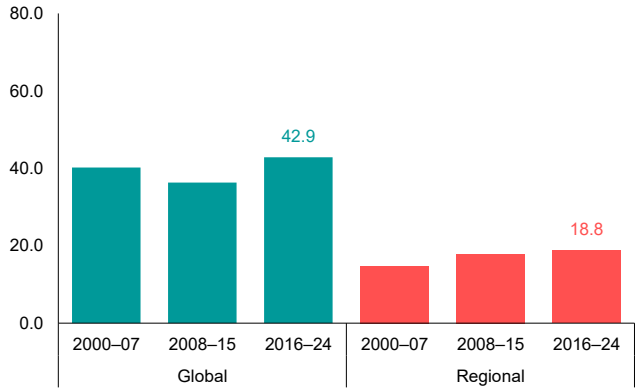
European Union



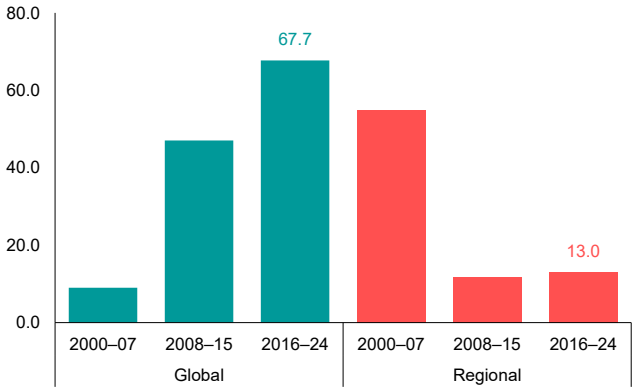


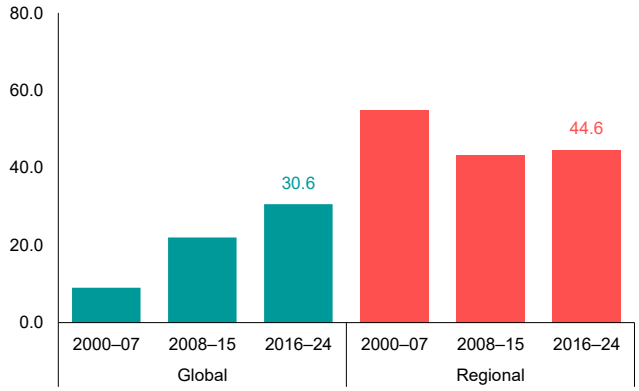
Latin America and the Caribbean



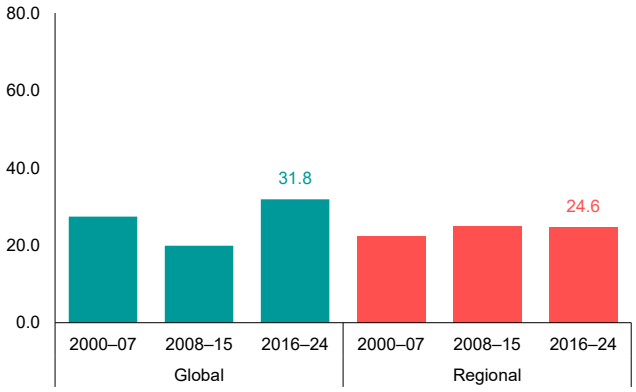


Northern America





Oceania



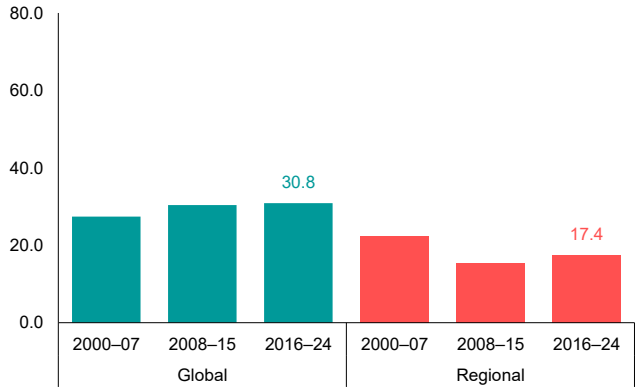
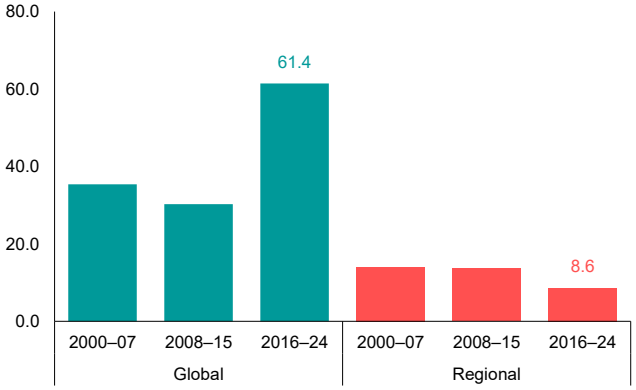


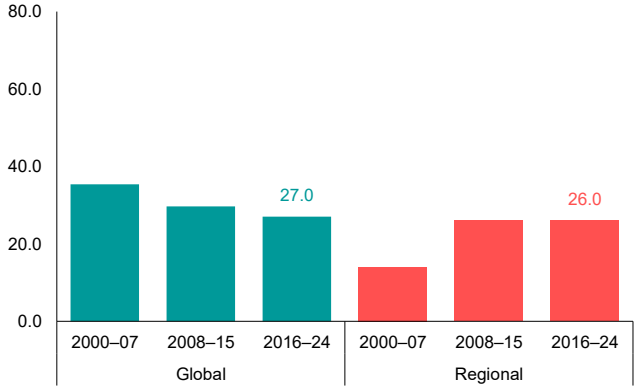
Figure A4.1. Variance in Real Growth of Major Regions Explained by Factors (Continued)
(Percent share of total variance)

Full Sample Period (2000–2024)

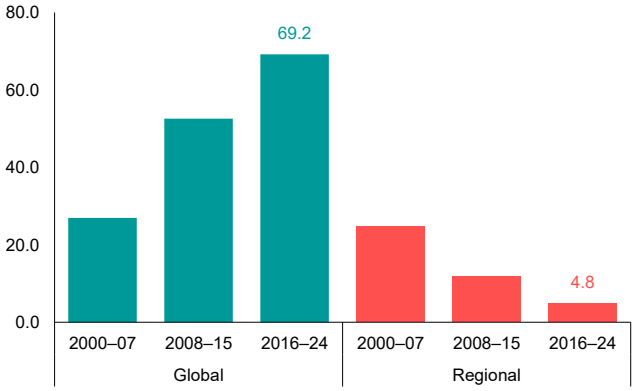
Excluding Crisis Years

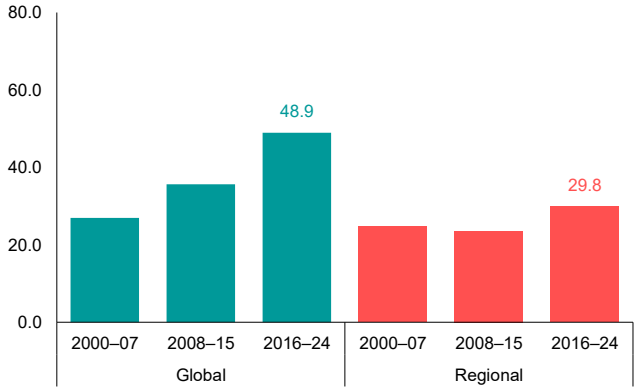
Other Asia





Other Europe





Source: United Nations, World Bank; AMRO staff calculations.
Note: Regional grouping follows the United Nations' region classification. The crisis years correspond to years affected by the global financial crisis (2008, 2009) and COVID-19 (2020, 2021).

Annex 5. Trade Integration and Business Cycle Synchronization Relationship Analysis

Part II examined the relationship between trade integration and business cycle synchronization across ASEAN+3 economies. The analysis first constructed the bilateral panel dataset and conducted panel regression analysis on two samples: a full bilateral sample covering all economy pairs in ASEAN+3, and a subsample focusing on China and its partner economies.

Business cycle synchronization is measured using an instantaneous quasi-correlation index constructed from real GDP growth rates. Following Abiad and others (2013), and Duval and others (2014), the quasi-correlation of real GDP growth rates of the economy i and j in year *t*, $QCORR_{ij,t}$ is computed as:

$$QCORR_{ij,t} = \frac{(g_{i,t} - g_i^*) * (g_{j,i} - g_j^*)}{\sigma_i^g * \sigma_j^g}$$

where $g_{i,t}$ denotes the output growth rate of the economy *i* in year *t*, g_i^* and σ_i^g represent the mean and standard deviation of the output growth rate of the economy *i*, respectively, during the sample period. The growth rate is measured as the first difference of the log of real GDP.

The panel regression involves a set of bilateral integration measures, constructed at the economy-pair level.

- *Global value chain (GVC) trade linkages*
  Measures the share of bilateral trade linkages, which consist of GVC backward participation and GVC forward participation, over the sum of bilateral gross exports. The variable is constructed from the Asian Development Bank Multiregional Input-Output Table at constant 2010 prices.

- *Trade complementarity*
  Captures the extent to which one economy's export structure aligns with its partner's import structure. The variable is obtained from the World Integrated Trade Solution Trade Indicators.

- *Foreign direct investment (FDI) integration*
  Measures the share of bilateral FDI stock positions over the sum of the two economies' GDP. The variable is constructed from the International Monetary Fund (IMF) Coordinated Direct Investment Survey investment position data.

- *Portfolio financial integration*
  Measures the sum of bilateral investment holdings (equity and debt securities) over the sum of GDP. The variable is constructed from the IMF Coordinated Portfolio Investment Survey investment position data.

- *Structural and institutional differences*
  GDP per capita gap from World Bank proxies differences in income levels and production structures. The governance gap is constructed as the absolute difference in two economies' regulatory quality indicators from the World Governance Indicators.

The baseline panel consists of annual bilateral observations across ASEAN+3 economies. The main integration variables are included with a one-year lag, reflecting the delayed transmission of real and financial linkages to business cycle co-movement.

For the full bilateral sample, the following fixed-effects specification is estimated:

$$QCORR_{ij,t} = \beta X_{ij,t-1} + \mu_{ij} + \lambda_t + \varepsilon_{ij,t}$$

where $X_{ij,t-1}$ is a vector of lagged bilateral integration measures, μ_{ij} are pair fixed effects capturing time-invariant characteristics specific to each economy pair, and λ_t are year fixed effects controlling for common global shocks. All continuous regressors are standardized, and standard errors are clustered at the bilateral pair level.

A subsample is constructed to include only bilateral pairs involving China. In this subsample, each observation represents business cycle synchronization between China and another ASEAN+3 economy, and all explanatory variables are constructed as measures of China-partner integration. Table A5.1 shows the results of the regression analysis.

Table A5.1 Panel Regression Results for Full Sample and China-pair Sample

Variables	Fixed Effects Panel Regression of Business Cycle Synchronization	
	Full sample	China-pair sample
Lagged GVC trade linkage	0.461** (0.216)	1.535** (0.630)
Trade complementarity	0.298 (0.197)	1.055 (1.179)
Lagged FDI integration	0.180*** (0.063)	0.318** (0.153)
Lagged portfolio integration	-0.049 (0.120)	-0.565 (0.627)
GDP per capita gap	-0.039 (0.517)	0.118 (0.626)
Lagged governance gap	0.086 (0.157)	-0.239 (0.851)

Source: AMRO staff calculations.
Note: FDI = Foreign direct investment; GVC = Global value chain. *p<0.1; **p<0.05; ***p<0.01. All regressors are standardized, and standard errors are clustered at the bilateral pair level.

Annex 6. Cross-Economy Spillover Impact Estimation

Part II showed the spillover impact of a final demand shock in China and the United States on other ASEAN+3 economies using a Multiregional Input–Output (MRIO) framework, following Eklou and others (2024). The approach isolates direct production-network transmission channels operating through trade in intermediate and final goods, abstracting from macroeconomic feedback, price adjustments, and policy responses.

Total gross output is given by

$$x = Ax + y$$

where

- A is the global matrix of input coefficients,
- y is the vector of final demand by economy and use category.

Solving yields the standard Leontief form:

$$x = (I - A)^{-1} y$$

Value added is obtained using a diagonal matrix of value-added coefficients $\hat{v}$, giving value added generated by final demand:

$$VA = \hat{v} (I - A)^{-1} y$$

This formulation allows value added to be fully attributed to the economy and sector where it is generated, regardless of where final demand originates. All simulations focus on the domestic value added generated by each economy, using the Asian Development Bank MRIO tables at constant 2010 prices, covering 62 economies and the rest of the world from 2000 to the latest year available, 2024.

The analysis considers exogenous shocks to final demand in selected economies and regions:

- A 10 percent decline in final demand in China or the United States; and
- A 10 percent decline in final demand in ASEAN+3 subregions (ASEAN+3 excluding China, ASEAN-5, BCLV, and Plus-3 excluding China).

Shocks are applied across relevant final demand components (consumption, investment, government spending, and inventories), holding input coefficients and production technology fixed.

The framework does not endogenize behavioral responses, such as substitution across suppliers, exchange-rate adjustments, or countercyclical policy reactions. As such, the results should be interpreted as first-round, partial-equilibrium spillovers operating through existing production networks.

For each shock scenario, the impact on an economy i is measured as the change in domestic value added relative to its baseline GDP:

$$\Delta GDP_i = \frac{\Delta VA_i}{GDP_i}$$

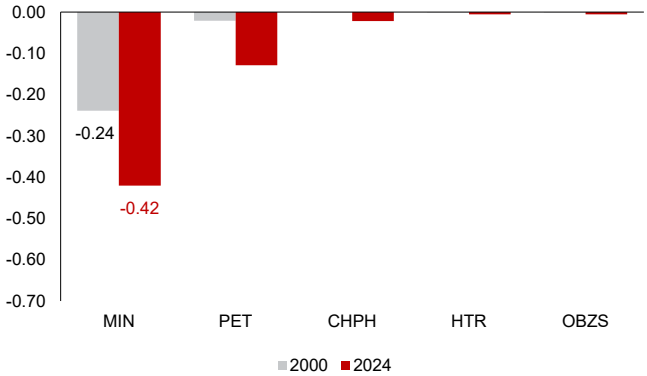
Sectoral impacts are computed analogously, allowing aggregation to subregional totals by summing value added and GDP across member economies before forming ratios. This aggregation ensures internal consistency: regional impacts reflect the weighted contribution of member economies rather than simple averages.

The sectors follow ADB's MRIO 35-sector definitions, which have direct correspondence to the International Standard Industrial Classification (ISIC) 3.1 definitions (Table A6.1). Impacts from major partners' final demand shocks on each ASEAN+3 economy's most affected sectors are shown. Figure A6.1 shows the result for each regional economy.

Figure A6.1. Impact on Sectoral Value Added of ASEAN+3 Economies due to a 10-percent Final Demand Shock from Major Partners in 2000 and 2024
(Percent of GDP)

Brunei

China Final Demand Shock



US Final Demand Shock

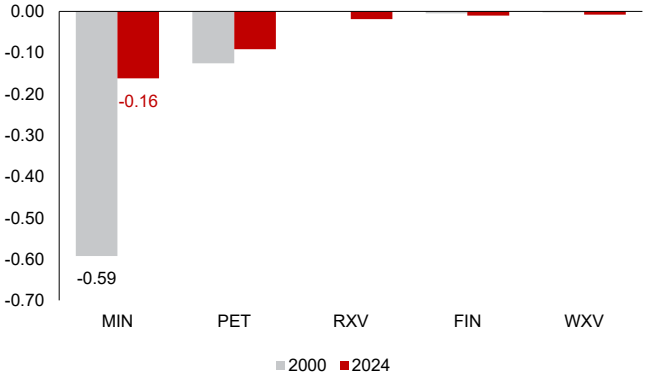
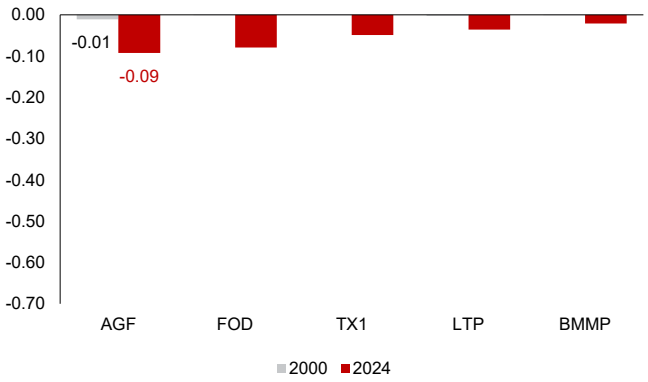


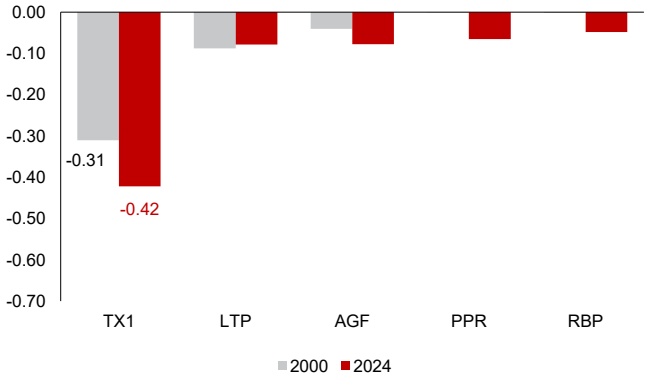
Figure A6.1. Impact on Sectoral Value Added of ASEAN+3 Economies due to a 10-percent Final Demand Shock from Major Partners in 2000 and 2024 (Continued)
(Percent of GDP)

Cambodia

China Final Demand Shock

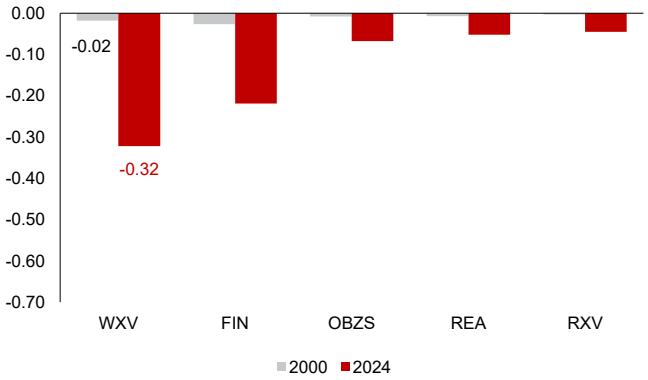


US Final Demand Shock

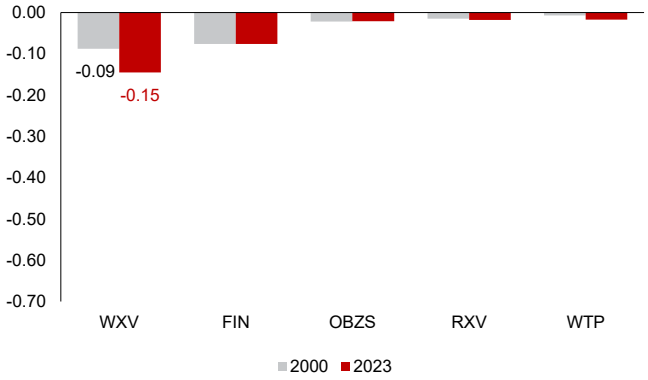


Hong Kong

China Final Demand Shock

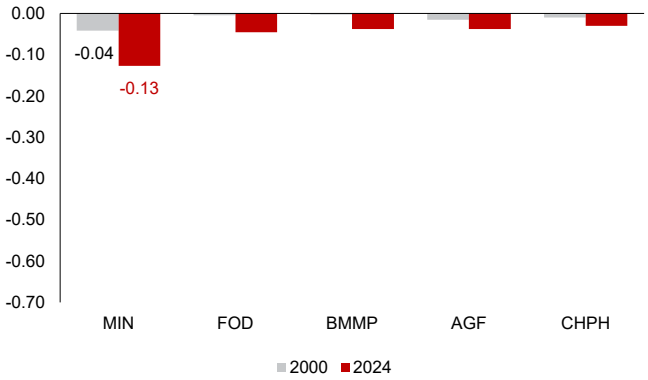


US Final Demand Shock

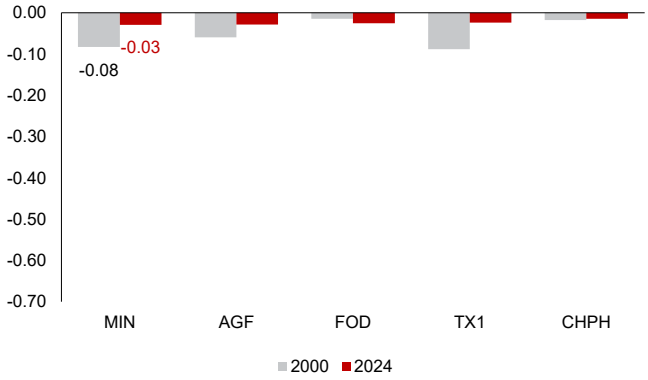


Indonesia

China Final Demand Shock

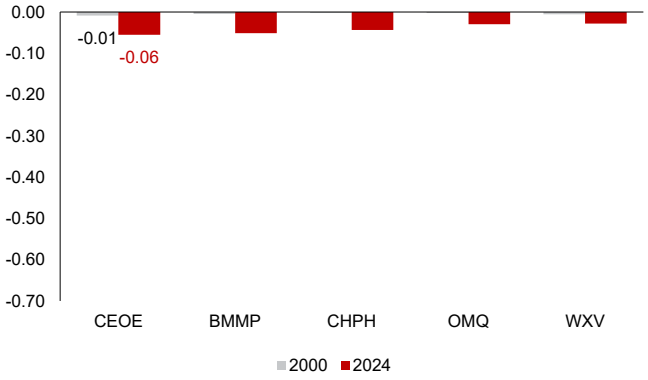


US Final Demand Shock



Japan

China Final Demand Shock



US Final Demand Shock

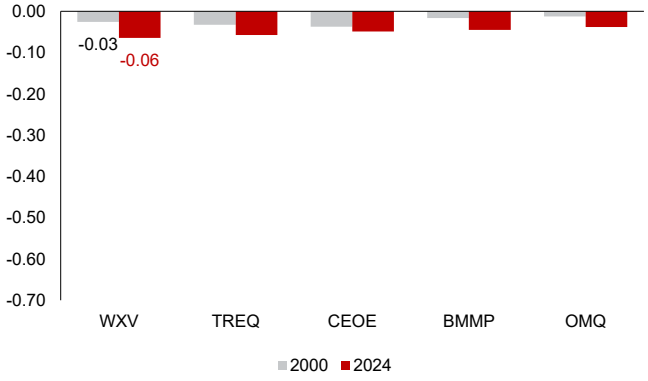
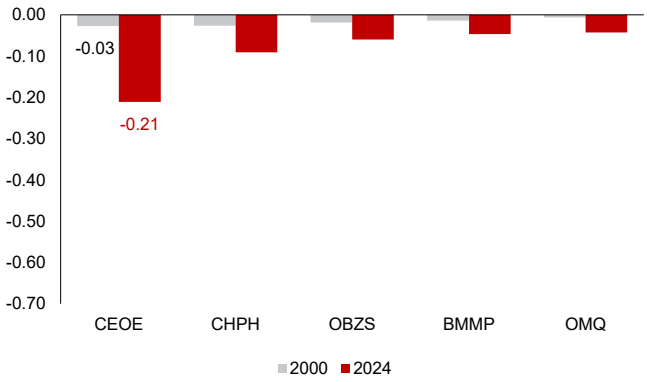


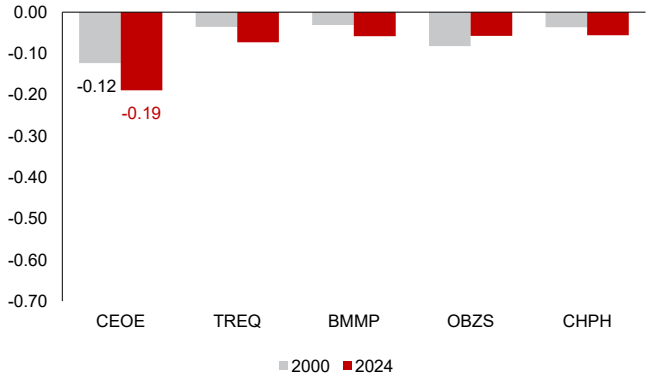
Figure A6.1. Impact on Sectoral Value Added of ASEAN+3 Economies due to a 10-percent Final Demand Shock from Major Partners in 2000 and 2024 (Continued)
(Percent of GDP)

Korea

China Final Demand Shock

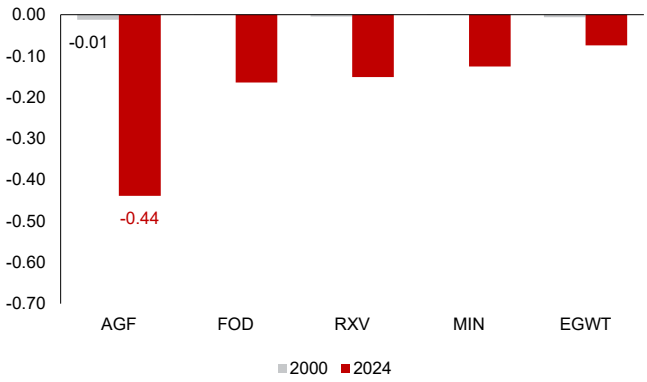


US Final Demand Shock

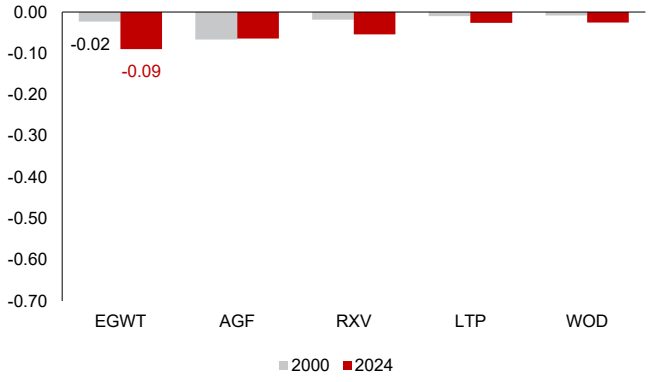


Lao PDR

China Final Demand Shock

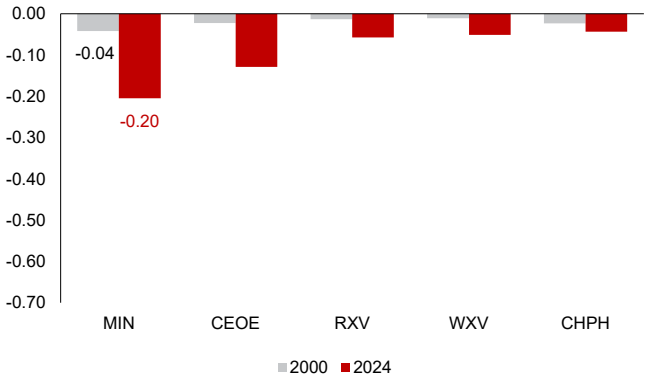


US Final Demand Shock

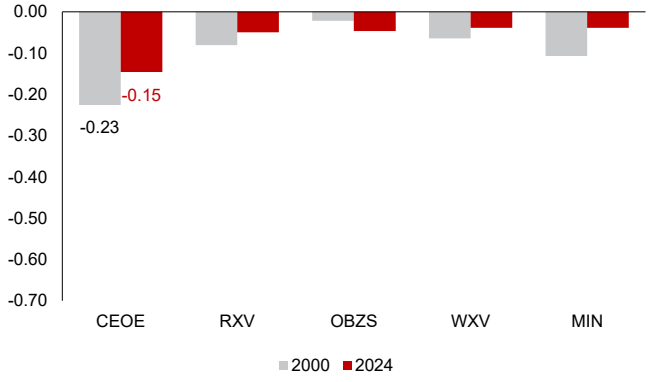


Malaysia

China Final Demand Shock

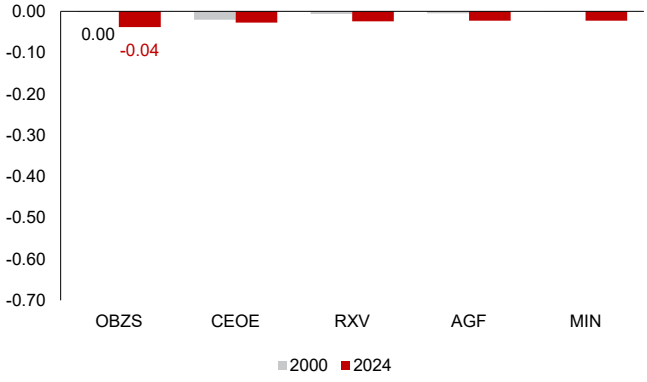


US Final Demand Shock



The Philippines

China Final Demand Shock



US Final Demand Shock

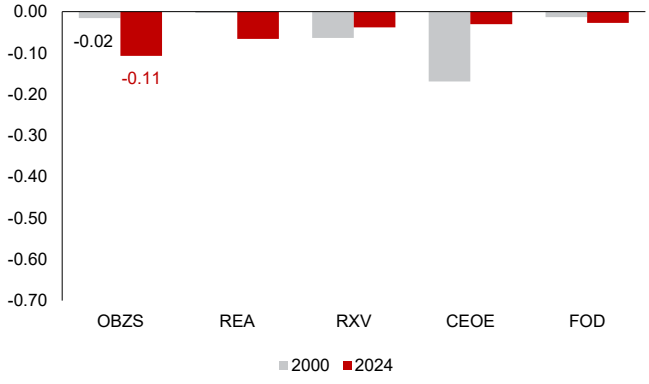
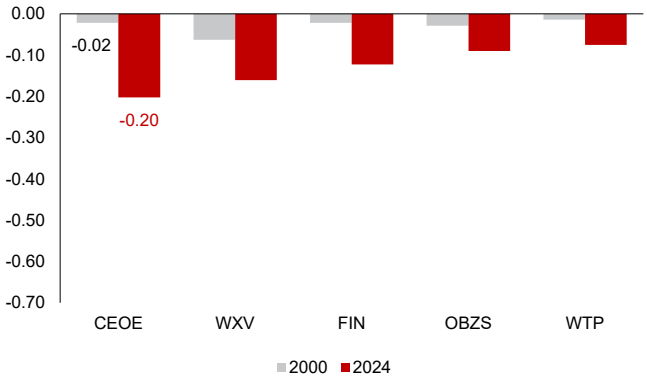


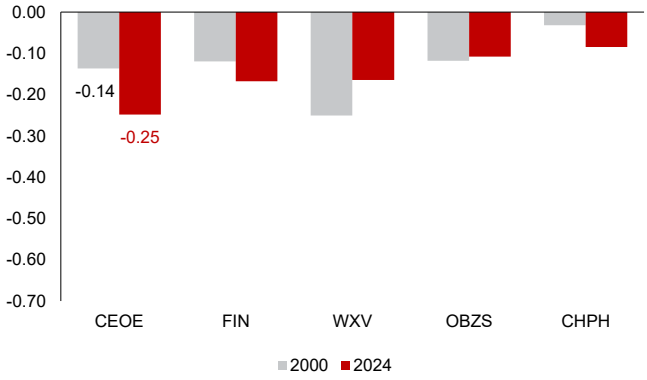
Figure A6.1. Impact on Sectoral Value Added of ASEAN+3 Economies due to a 10-percent Final Demand Shock from Major Partners in 2000 and 2024 (Continued)
(Percent of GDP)

Singapore

China Final Demand Shock

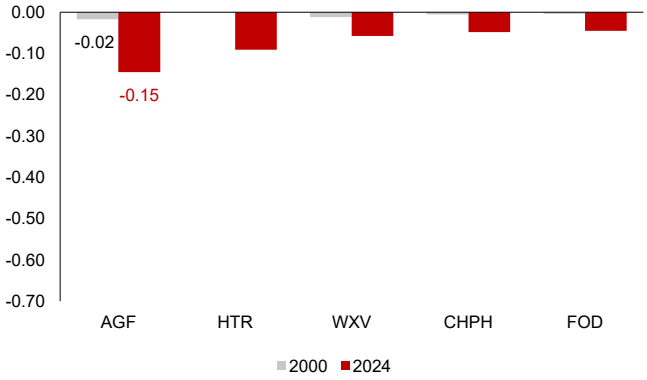


US Final Demand Shock

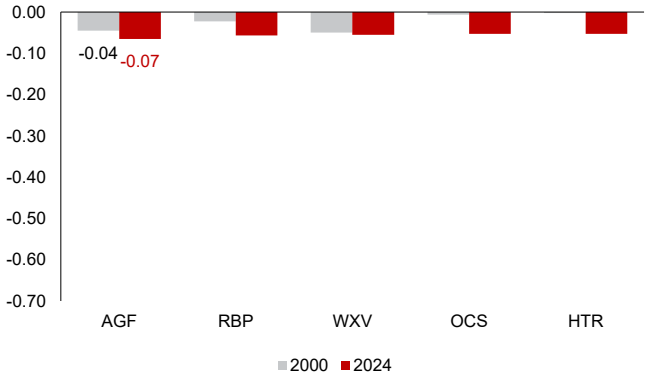


Thailand

China Final Demand Shock

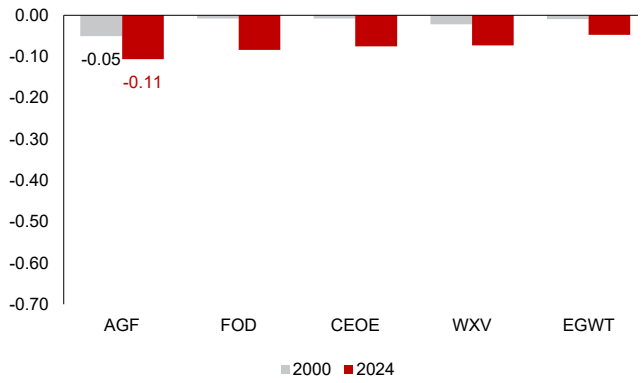


US Final Demand Shock

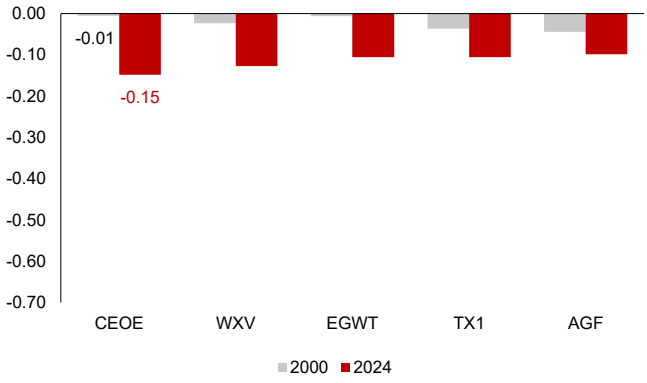


Vietnam

China Final Demand Shock

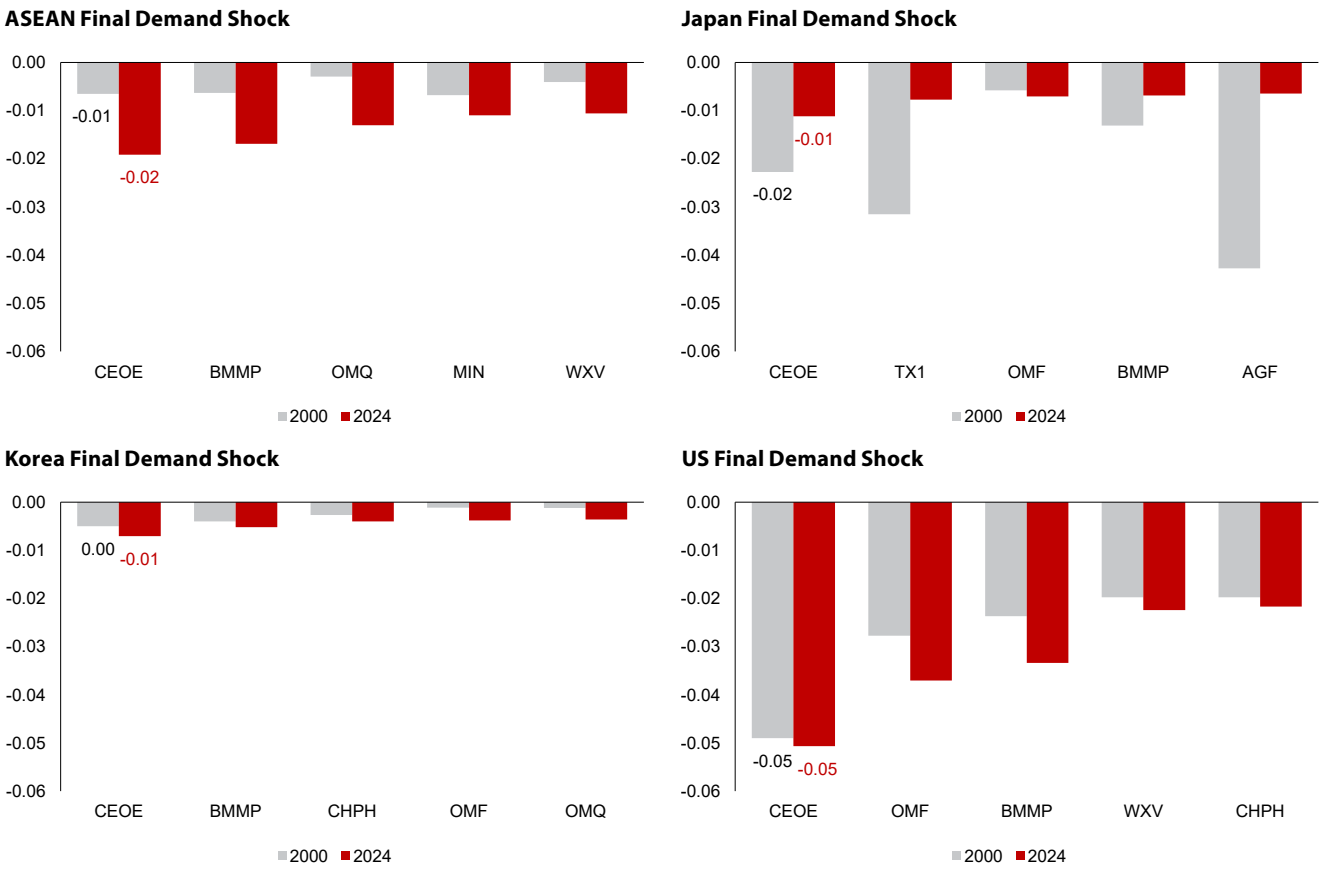


US Final Demand Shock



Source: Asian Development Bank Multiregional Input-Output Table; AMRO staff calculations.
Note: US = United States. Excludes Myanmar due to data unavailability. See Table A6.1 for the definition of the sectors.

Figure A6.2. Impact on Sectoral Value Added of China due to a 10-percent Final Demand Shock from Major Partners in 2000 and 2024
(Percent of GDP)



Source: Asian Development Bank Multiregional Input-Output Table; AMRO staff calculations.
Note: US = United States. The ASEAN regional aggregate excludes Myanmar due to data unavailability. See Table A6.1 for the definition of the sectors.

Table A6.1. ADB MRIO Table Sector Names and ISIC Definitions

S/N	Sector Code	ADB MRIO Table Sector Names	ISIC definitions
1	**AGF**	Agriculture, Hunting, Forestry and Fishing	Agriculture, hunting; fishing, aquaculture; forestry, logging
2	**MIN**	Mining and Quarrying	Extraction of crude petroleum and natural gas; mining of coal, lignite, metal ores, uranium and thorium ores; extraction of peat
3	**FOD**	Food, Beverages and Tobacco	Food products and beverages; tobacco products
4	**TX1**	Textiles and Textile Products	Textiles; wearing apparel; dressing and dyeing of fur
5	**TX2**	Leather, Leather products and Footwear	Tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear
6	**WOD**	Wood and Products of Wood and Cork	Wood and products of wood and cork, except furniture; articles of straw and plaiting materials
7	**PPR**	Pulp, Paper, Printing and Publishing	Paper and paper products; publishing, printing and reproduction of recorded media
8	**PET**	Coke, Refined Petroleum and Nuclear Fuel	Coke, refined petroleum products and nuclear fuel; manufacture of coke oven products
9	**CHPH**	Chemicals and Chemical Products	Basic chemicals and chemical products; detergents; fertilizers; man-made fibers; paints; pesticides; plastics; pharmaceuticals
10	**RBP**	Rubber and Plastics	Rubber and plastics products; rubber tires and tubes
11	**NMM**	Other Non-Metallic Mineral	Glass and glass products; ceramic products; articles of concrete, cement and plaster; stone

S/N	Sector Code	ADB MRIO Table Sector Names	ISIC definitions
12	**BMMP**	Metal and metal products	Basic metals; fabricated metal products, except machinery and equipment; structural metal products, tanks, reservoirs and steam generators
13	**OMQ**	Machinery, Nec	Engines and turbines, except aircraft and vehicles; pumps, compressors, taps and valves; ovens and furnaces; lifting and handling equipment; domestic appliances; weapons and ammunition
14	**CEOE**	Electrical and Optical Equipment	Electrical machinery and apparatus; electric motors, generators, and transformers; medical, precision and optical instruments; office, accounting and computing machinery; radio, television and communication equipment and apparatus
15	**TREQ**	Transport Equipment	Motor vehicles, trailers and semi-trailers; ships; aircraft and spacecraft; railway and tramway locomotives
16	**OMF**	Manufacturing, Nec; Recycling	Furniture; jewelry and related articles; musical instruments; sports goods; games and toys; recycling
17	**EGWT**	Electricity, Gas and Water Supply	Collection, purification and distribution of water; electricity, gas, gaseous fuels, steam and hot water supply
18	**CON**	Construction	Construction; renting of construction or demolition equipment with operator
19	**WRV**	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
20	**WXV**	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	Wholesale trade and commission trade of agricultural products, household goods, fuels, metals and metal ores, construction materials, machinery and equipment, computers and electronic equipment
21	**RXV**	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	Retail trade of food, beverages and tobacco, pharmaceutical and cosmetic goods, textiles and leather goods, household appliances, hardware, pains and glass, second-hand goods; repair of personal and household goods
22	**HTR**	Hotels and Restaurants	Hotels, restaurants, bars, camping sites and other provision of short-stay accommodation
23	**LTP**	Inland Transport	Land transport; transport through pipelines, railways, freight transport by road
24	**WTP**	Water Transport	Inland, sea and coastal water transport
25	**ATP**	Air Transport	Air transport
26	**STO**	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	Supporting and auxiliary transport activities; activities of travel agencies; cargo handling; storage and warehousing
27	**PTL**	Post and Telecommunications	Post and telecommunications
28	**FIN**	Financial Intermediation	Financial intermediation; insurance and pension funding, except compulsory social security; monetary intermediation; central banking; financial leasing
29	**REA**	Real Estate Activities	Real estate activities with own or leased property; real estate activities on a fee or contract basis

S/N	Sector Code	ADB MRIO Table Sector Names	ISIC definitions
30	**OBZS**	Renting of M&Eq and Other Business Activities	Advertising; architectural, engineering and other technical activities; business and management consultancy activities; computer and related activities; data processing; hardware consultancy; software publishing, consultancy and supply; legal, accounting, tax consultancy; renting of machinery and equipment; research and development
31	**GOV**	Public Admin and Defense; Compulsory Social Security	Public administration and defense; compulsory social security
32	**EDU**	Education	Education
33	**HHS**	Health and Social Work	Health and social work; veterinary activities
34	**OCS**	Other Community, Social and Personal Services	Activities of membership organizations; hairdressing and other beauty treatment; motion picture and video production and distribution; recreational, cultural and sporting activities
35	**PVH**	Private Households with Employed Persons	Activities of private households as employers of domestic staff; undifferentiated goods-producing activities of private households for own use; undifferentiated service-producing activities of private households for own use

Source: Asian Development Bank.
Note: The corresponding International Standard Industrial Classification (ISIC) 3.1 activity descriptions are shortened and similar activities are grouped together, without altering sectoral coverage.

Annex 7. Global Value Chain Position Framework

Part III provided a stylized framework to illustrate economies' global value chains (GVC) positions across two dimensions: value-added content and concentration risk (Figure 2.24).

Value-added content is measured by the share of value-added exports from higher value-added sectors in total value-added exports. The higher value-added sectors are defined as industries with high research and development (R&D) intensity, following the Organisation for Economic Co-operation and Development taxonomy in 2016. Under this approach, sectors are ranked by R&D intensity measured as business R&D expenditure relative to sector value added (Table A7.1). This exercise focuses on high- and medium-high value-added sectors.

The concentration risk is measured by adapting the Inomata and Hanaka (2024) "pass-through frequency (PTF)" approach. The PTF is a frequency-based measure of supply-chain exposure to geographic concentration risk in global production networks. It measures the number of times a given supply chain transacts with suppliers in a particular economy (and industry) throughout the production process – the average number of times production paths "pass through" the targeted supplier economy – industry on the way to the end producer. Notably, PTF complements volume-based metrics by capturing how often a supplier economy's industry appears along production paths – not how much is sourced from it. This helps flag potential chokepoints that may be repeatedly involved across stages, even if their value share is not large.

For example, Figure A7.1 contrasts exposure metrics based on volume and frequency. Volume-based measures identify dependencies based on where the largest share of flows is sourced – under this approach, producing economy G's specific product's supply chain appears most concentrated in economy B, which accounts for the largest value flow. By contrast, the frequency-based PTF indicator captures how often a supplier appears along production paths; under this lens, economy D emerges as the key chokepoint because production paths pass through D most frequently, implying that disruptions there can propagate across multiple downstream stages.

PTF is derived from the OECD's inter-country input–output framework, which traces multistage production linkages across economies and industries. The released indicator is organized in four dimensions as follows:

- *Prd_cou* denotes the end producer economy
- *Prd_ind* denotes the end producing industry
- *Sup_cou* denotes the supplying economy
- *Sup_ind* denotes the supplying industry

In order to obtain an economy-level measure that is comparable across producing economies, sector PTF values are aggregated to a single concentration index for each producing economy. Specifically, for each producing economy, PTF exposures are first summed across all producing and supplying industries for each supplier economy, yielding a vector of total exposures from the producer to all supplier economies. Table A7.2 provides an example of China's top five supplier economies.

These exposures are then converted into an economy-level PTF measure using the Herfindahl-Hirschman Index (HHI), a standard concentration metric widely used across various analytical contexts to summarize concentration in shares. The index is constructed by squaring each supplier economy's share in the producing economy's total PTF exposure and summing across suppliers:

$$PTF\_HHI_i = \sum_j \left(\frac{\sum_p \sum_s PTF_{i,p,j,s}}{\sum_j \sum_p \sum_s PTF_{i,p,j,s}}\right)^2 \quad (1)$$

where

- PTF_HHI_i denotes the HHI value of the end producer economy *i*
- $PTF_{i,p,j,s}$ denotes the pass-through frequency value for the end producer economy *i* in the producing industry *p*, with respect to the supplying economy *j* in the supplying industry *s*.

The computed *PTF_HHI* values are then normalized by following the equation below to map the GVC concentration of each economy onto a consistent scale:

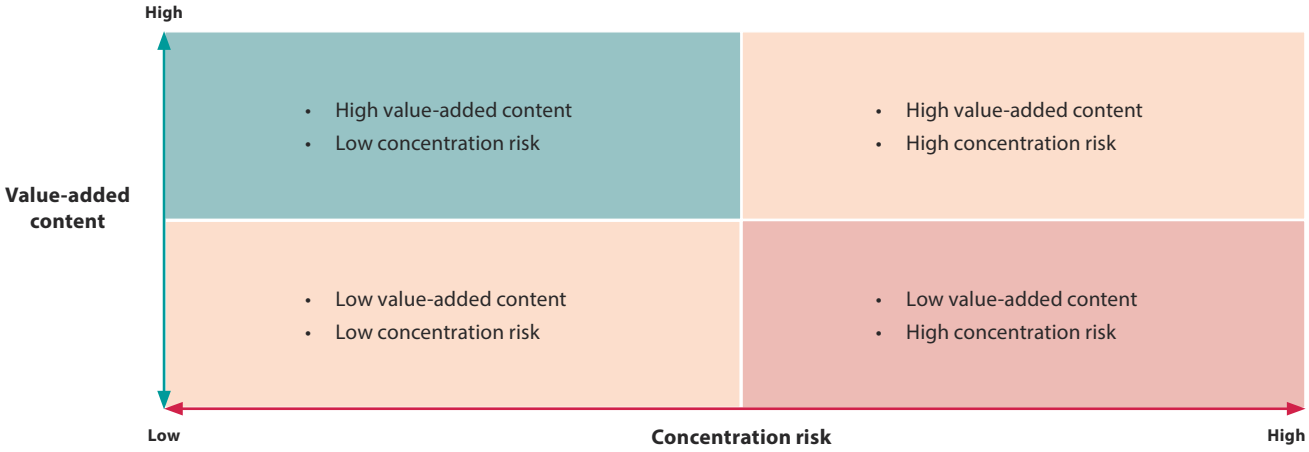
$$PTF\_HHI_{i\_norm} = \frac{PTF\_HHI_i - \overline{PTF\_HHI}}{\sigma_{PTF\_HHI}} \quad (2)$$

where

- $\overline{PTF\_HHI}$ denotes the global average value of *PTF_HHI*
- σ_{PTF_HHI} denotes the global standard deviation of *PTF_HHI*

The normalized $PTF\_HHI_{i\_norm}$ value thus indicates how many standard deviations an economy *i* is concentrated relative to the world average, which is 0 on a scale. A higher $PTF\_HHI_{i\_norm}$ indicates that the producing economy *i*'s supply-chain engagement is more concentrated in just a few supplier economies, while a lower $PTF\_HHI_{i\_norm}$ suggests a more diversified supplier footprint.

Figure 2.24. Global Value Chain Position Framework



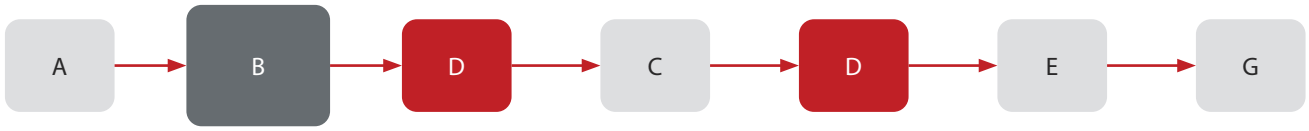
Source: AMRO staff.

Table A7.1. List of High and Medium-High Value-added Sectors

Sector Code	MRIO Table Sector Names	R&D Intensity
CEOE	Electrical and Optical Equipment	High
CHPH	Chemicals and Chemical Products	High
OBZS	Renting of M&Eq and Other Business Activities	High
TREQ	Transport Equipment	High
OMQ	Machinery, Nec	Medium-high

Source: Organisation for Economic Co-operation and Development; AMRO staff.
Note: The sectors have been mapped to the Asian Development Bank's Multiregional Input-Output (MRIO) table sector classification.

Figure A7.1. Supply Chain Path of End Producer Economy G, Electronics Sector



Source: Inomata and Hanaka (2024); AMRO staff illustration.
Note: Each upstream box represents a supplier economy and a stage in the production process, and the size of each box is proportional to the value-added contributed by that supplier at that stage to the specific production of economy G. The Figure is illustrative and does not correspond to any specific economies.

Table A7.2. China's Top 5 Supplier Economies by PTF Value in 2020

Sup_cou	PTF Value
Germany	26,756.5
Korea	23,937.5
Singapore	19,182.3
Taiwan, Province of China	18,411.2
Japan	17,880.4

Source: Organisation for Economic Co-operation and Development Pass-Through Frequency (PTF) Database; AMRO staff calculations.
Note: This shows that, across all sectors, China interacts with Germany the most in its production process, followed by Korea and Singapore, as of 2020, which is the latest PTF indicator available point.

References

Abiad, Abdul, and others. 2013. "Dancing Together? Spillovers, Common Shocks, and the Role of Financial and Trade Linkages," Chapter 3. *World Economic Outlook*. Washington, DC. October.

Borin, Alessandro, and Michele Mancini. 2019. "Measuring what Matters in Global Value Chain and Value-added Trade." Policy Research Working Paper No. 8804. World Bank. Washington, D.C. April 11.

Borin, Alessandro, and Michele Mancini. 2023. "Measuring what Matters in Value-added Trade." Economic Systems Research, Taylor & Francis Journals, vol. 35 (4): 586–613, October.

Duval, Romain, and others. 2014. "Trade Integration and Business Cycle Synchronization: A Reappraisal with Focus on Asia." IMF Working Paper No. 1452. International Monetary Fund, Washington, DC.

Eklou, Kodjovi, and others. 2024. "Spillovers from China's Growth Slowdown to the Singapore Economy." IMF Selected Issues Papers SIP/2024/041. International Monetary Fund, Washington, DC. August.

Feas, Enrique. 2024. *Exvatools: Value Added in Exports and Other Input-Output Table Analysis Tools*. September. *https://CRAN.R-project.org/package=exvatools*.

He, Dong, and Wei Liao. 2012. "Asian Business Cycle Synchronization." Pacific Economic Review 17 (1): 106–135.

Inomata, Satoshi, and Tesshu Hanaka. 2024. "Measuring Exposure to Network Concentration Risk in Global Supply Chains: Volume versus Frequency." Structural Change and Economic Dynamics 68 (1): 177–193.

Li, Xin, and others. 2019. "Recent Patterns of Global Production and GVC Participation." Chapter 1 in *Global Value Chain Development Report 2019: Technological Innovation, Supply Chain Trade, and Workers in a Globalized World*. Washington, DC: World Bank. *http://documents.worldbank.org/curated/en/384161555079173489*.

Organisation for Economic Co-operation and Development (OECD). 2016. OECD Science, Technology and Industry Working Papers, Volume 2016, Issue 4. Paris.