Give Credit Where Credit is Due:
Tracing Value Chains in Global Production Networks

Robert Koopman, William Powers and Zhi Wang
United States International Trade Commission
Shang-Jin Wei
Columbia University, CEPR, and NBER

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Presentation Outline

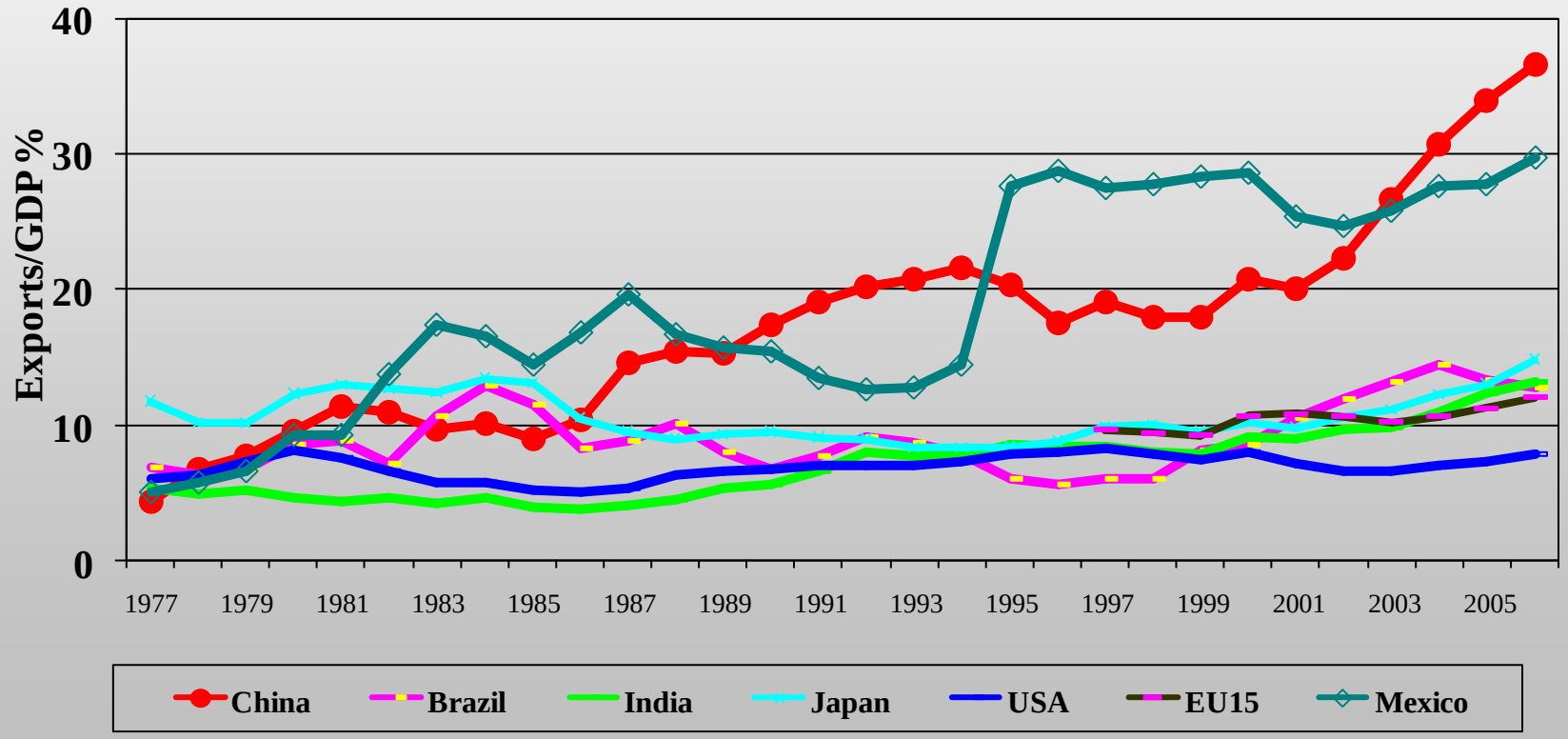
- Motivation
- Conceptual Framework
  - Transparent: block matrix formulation, only three matrixes
  - Complete: decompose gross exports and imports into value-added components, full consistent with official trade statistics
  - Comprehensive: integration of all existing measures in the literature
- Empirical Results
  - Highlight regional differences in supply chain participation
  - Demonstrate different patterns of integration in three world major trading blocs
  - Show differences in trade costs from multistage production
- Database improvement and Limitations
  - Why end-use classification is better than proportion assumption
  - What end-use classification can help, what it can't

Objective of This Paper

- Help national and international government agencies to find a feasible and cost effective way to remedy the problems in current official trade statistics;
- Bridge current custom trade statistical system and national account, to make measure of trade consistent with SNA standard. Develop a unified conceptual framework that incorporates all measures of value-added trade in the literature;
- Completely decompose each country's gross exports to and imports from the world into its value-added components, thus establishing a formal relationship between value-added measures of trade and officially reported trade statistics;
- Apply the new measure to evaluate the differences in economies' participation in global production chain, regional economic integration and trade cost of multi-stage production.

Gross Exports to GDP ratio is a misleading indicator of export dependence

Gross export/GDP for large economies in the world, 1977-2006



Messages from National and International Policy Makers

- "Traditional measurement of foreign trade alone no longer suffices to explain how the country fits into the world economy. … The time has come to explore new channels so that accounting and statistical systems can take account of the new geography of international trade in an economy which … has flattened under the influence of globalization and internationalization of production relations."
- "The challenge is to find the right statistical bridges between the different national accounting systems in order to ensure that international interactions resulting from globalization are properly reflected and to facilitate cross border dialogue between national decision makers"
- "The challenge is not only for statisticians, but also for the decision makers responsible for ensuring the proper conduct of domestic and international policy."

By Pascal Lamy, Oct. 15, 2010

Value Chain in Production Network from a product view to a global view

- What is a global value chain?
  - A system of value-added sources and destinations within a globally integrated production network

- Literature
  - Single product: Dedrick, Kraemer, and Linden (2008), ADB(2011)
  - Single country: Hummels, Ishii, Yi (2001), Koopman et al (2008)
  - Asian regional production network: Asian IO table (IDE-JETRO, 2000), Pula and Peltonen (2009); Wang, Powers, and Wei (2009)
  - Global snapshot: Daudin, Rifflart, and Schweisguth (2009); Johnson and Noguera (2009)
  - Global time series: WIOD (2010); Wang et al. (2010)

Value-added Contents of Trade: Existing measures

- Hummels, Ishii, and Yi (2001) measures of vertical trade
  - VS: imported contents embodied in a country's exports
  - VS1: Intermediate exports sent indirectly through other countries to final destination
- Newer measures
  - VAX: Ratio of domestic value-added in gross exports (Johnson and Noguera, 2009)
  - VS1*: domestic value-added in intermediates first exported then returns home (Daudin et al., 2009)
    - "reflected" exports
- Not unified in a fully specified transparent framework

Production and trade in a two-country world

- All output is used as an intermediate or final good at home or abroad

$$X_r = A_{rr}X_r + A_{rs}X_s + Y_{rr} + Y_{rs}$$

with N goods

X_r: (N×1) Gross output of country r

A_{rs}: (N×N) IO Coefficient matrix giving use in country s for intermediate inputs from country r

Y_{rs}: (N×1) Final demand: Country s's use of final goods and services from country r

Production and trade in a 2-country world

- In block matrix notations

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} Y_{11} + Y_{12} \\ Y_{21} + Y_{22} \end{bmatrix}$$

- Rearranging,

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} I - A_{11} & -A_{12} \\ -A_{21} & I - A_{22} \end{bmatrix}^{-1} \begin{bmatrix} Y_{11} + Y_{12} \\ Y_{21} + Y_{22} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}$$

where

B_{sr}: ($N \times N$) block Leontief inverse matrix, denoting the amount of total output in s required for a one-unit increase in final demand in country r

Y_r: ($N \times 1$) vector of global use of r's final goods

Value added Share Matrix in a 2-country world

- Direct domestic value added in production:

$$V_1 = u[I - A_{11} - A_{21}] \quad \text{and} \quad V_2 = u[I - A_{12} - A_{22}]$$

where

V_r: ($1 \times n$) domestic value-added coefficient vector;

element v_{ri} = 1 – intermediate input share from all countries

u: ($1 \times$n) vector of ones

- Value-added shares matrix (2×2N) decomposes value added in production of each sector in all countries

$$\text{VAS} = VB = \begin{bmatrix} V_1B_{11} & V_1B_{12} \\ V_2B_{21} & V_2B_{22} \end{bmatrix} \qquad V = \begin{bmatrix} V_1 & 0 \\ 0 & V_2 \end{bmatrix}$$

Value-added in gross exports

- Exports (2N×2) include both intermediate and final goods

$$E = \begin{bmatrix} E_1 & 0 \\ 0 & E_2 \end{bmatrix}$$

(See paper for value-added exports at the product level)

- Value-added exports matrix (2×2)

$$VAS\_E = VBE = \begin{bmatrix} V_1 B_{11} E_1 & V_1 B_{12} E_2 \\ V_2 B_{21} E_1 & V_2 B_{22} E_2 \end{bmatrix}$$

- Fully generalizable to a many-country world

$$X = (I - A)^{-1} Y = BY$$

$$VAS = VB$$

$$VAS\_E = VBE \quad (G \times G)$$

Unified all existing value-added measures

- Vertical specialization: both direct (VS) and indirect (VS1)
- Domestic value added in exports (VAX)
- Domestic value added in exports that returns home (VS1*)

Diagonal elements: domestic VA in exports
Off-diagonal elements: foreign value added in exports
Each column sum to unity

Domestic value added in exports (VAX ratio plus VS1*)

$$\text{VAS\_E} = VBE = \begin{bmatrix} V_1B_{11}E_1 & V_1B_{12}E_2 & V_1B_{13}E_3 \\ V_2B_{21}E_1 & V_2B_{22}E_2 & V_2B_{23}E_3 \\ V_3B_{31}E_1 & V_3B_{32}E_2 & V_3B_{33}E_3 \end{bmatrix}$$

Indirect (VS1): Country 1's value added embodied in 2's and 3's exports

Direct (VS): Foreign value added from 2 and 3 embodied in country 1's exports

Gross exports decomposition in a 3-country world

- Exports (N× 1 matrix) include both intermediate and final goods

$$E_r = \sum_{s \neq r} E_{rs} = \sum_s (A_{rs} X_s + Y_{rs})$$

  - Some intermediates are consumed in s; some are sent elsewhere by s

--sent elsewhere--

$$E_{rs} = \underbrace{Y_{rs}}_{\text{Final goods}} + \underbrace{A_{rs} X_{ss}}_{\substack{\textit{Finished} \text{ in } s \\ \text{Consumed in } s}} + \underbrace{A_{rs} X_{sr}}_{\substack{\text{Processed in } s; \\ \text{send back to } r}} + \underbrace{\sum_{t \neq r,s} A_{rs} X_{st}}_{\substack{\text{Processed in } s; \\ \text{send to third countries}}} \quad (1)$$

Further decomposition of Value-added Exports

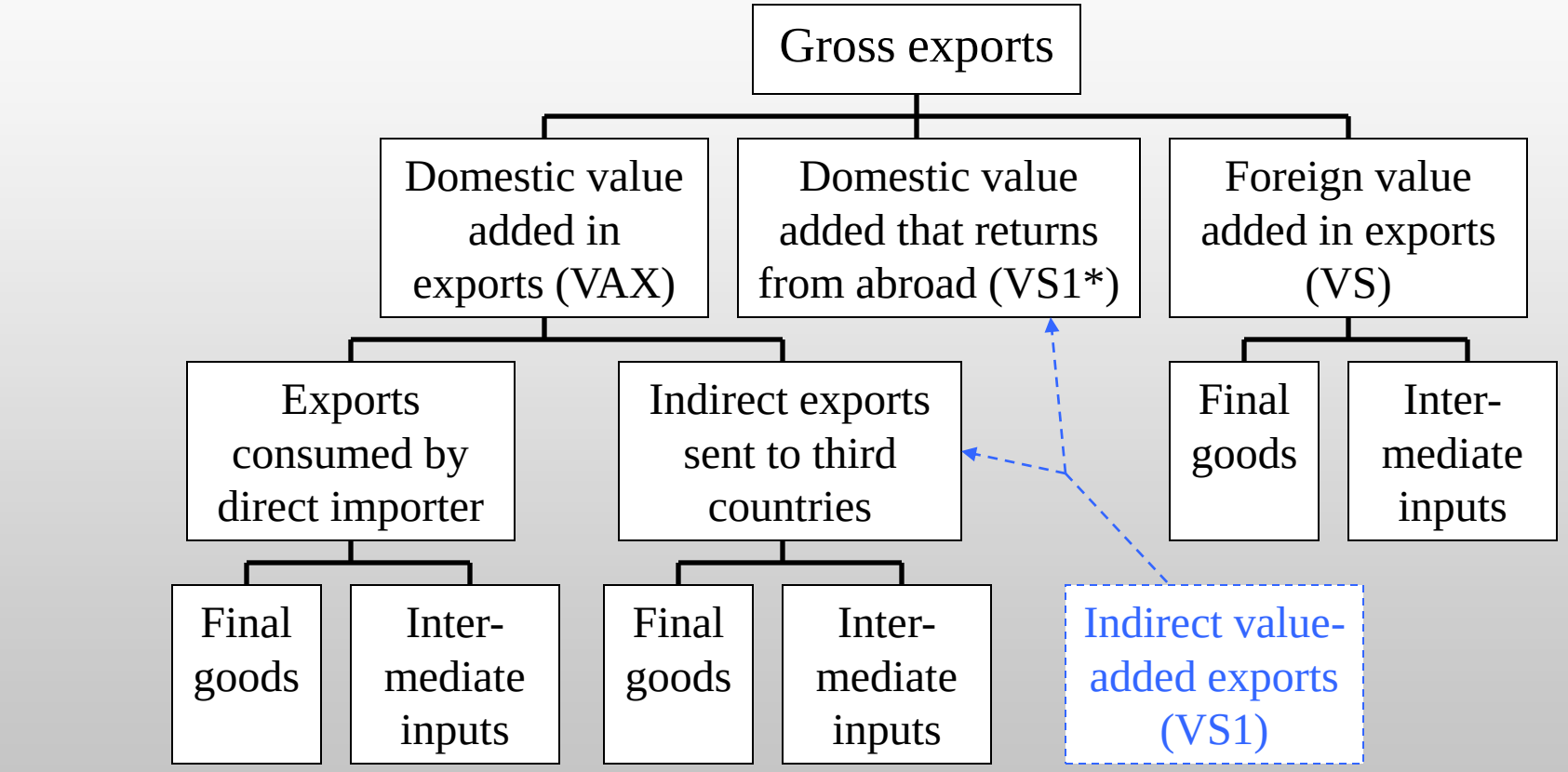
- DV measures the total domestic value-added embodied in country r's exports:

$$\mathrm{DV_r} = V_r B_{rr} E_r \qquad (2)$$

- Further decomposition of value-added exports: combine (1) and (2)

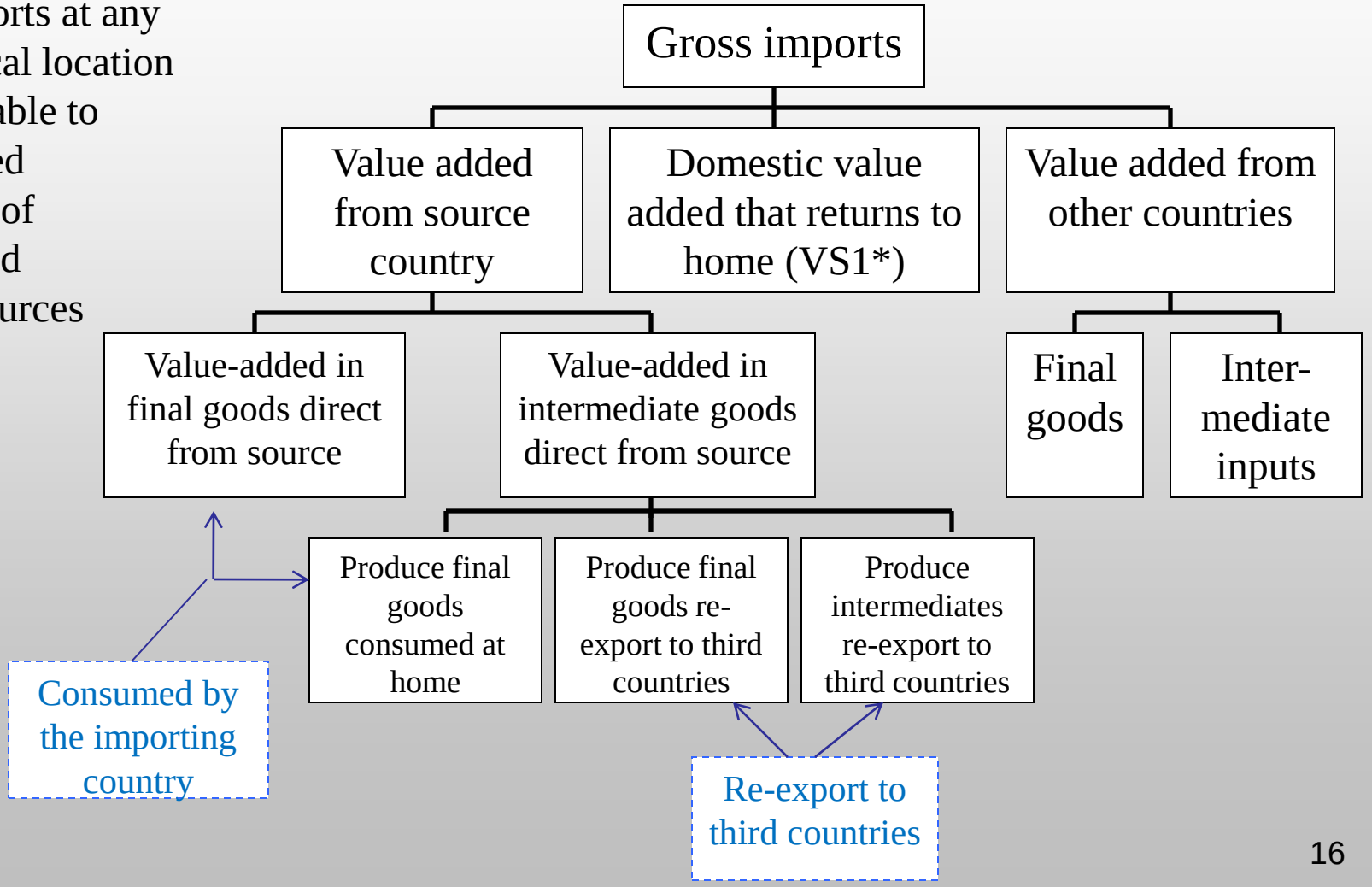
$$\mathrm{DV_{rs}} = V_r B_{rr} E_r = V_r B_{rr} \sum_{s \neq r} Y_{rs} + V_r B_{rr} \sum_{s \neq r} A_{rs} X_{ss}$$
$$+ V_r B_{rr} \sum_{s \neq r} A_{rs} X_{sr} + V_r B_{rr} \sum_{s \neq r} \sum_{t \neq s,r} A_{rs} X_{st}$$

Complete Decomposition of Gross Exports

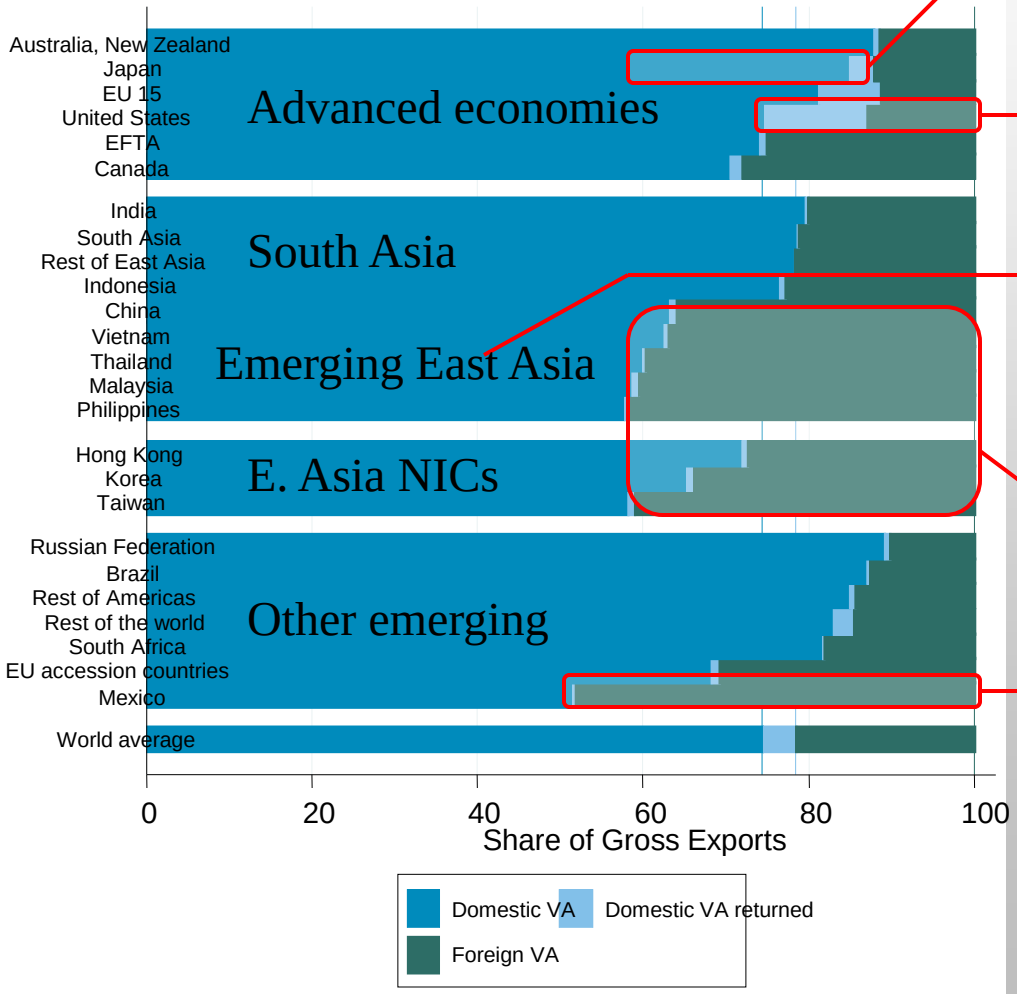


Complete Decomposition of Gross Imports

Gross imports at any geographical location should be able to decomposed to the sum of value-added from all sources



Value-added Exports: Key differences by region



Japan sends much of its VA exports to final suppliers indirectly through third countries (see table 3)

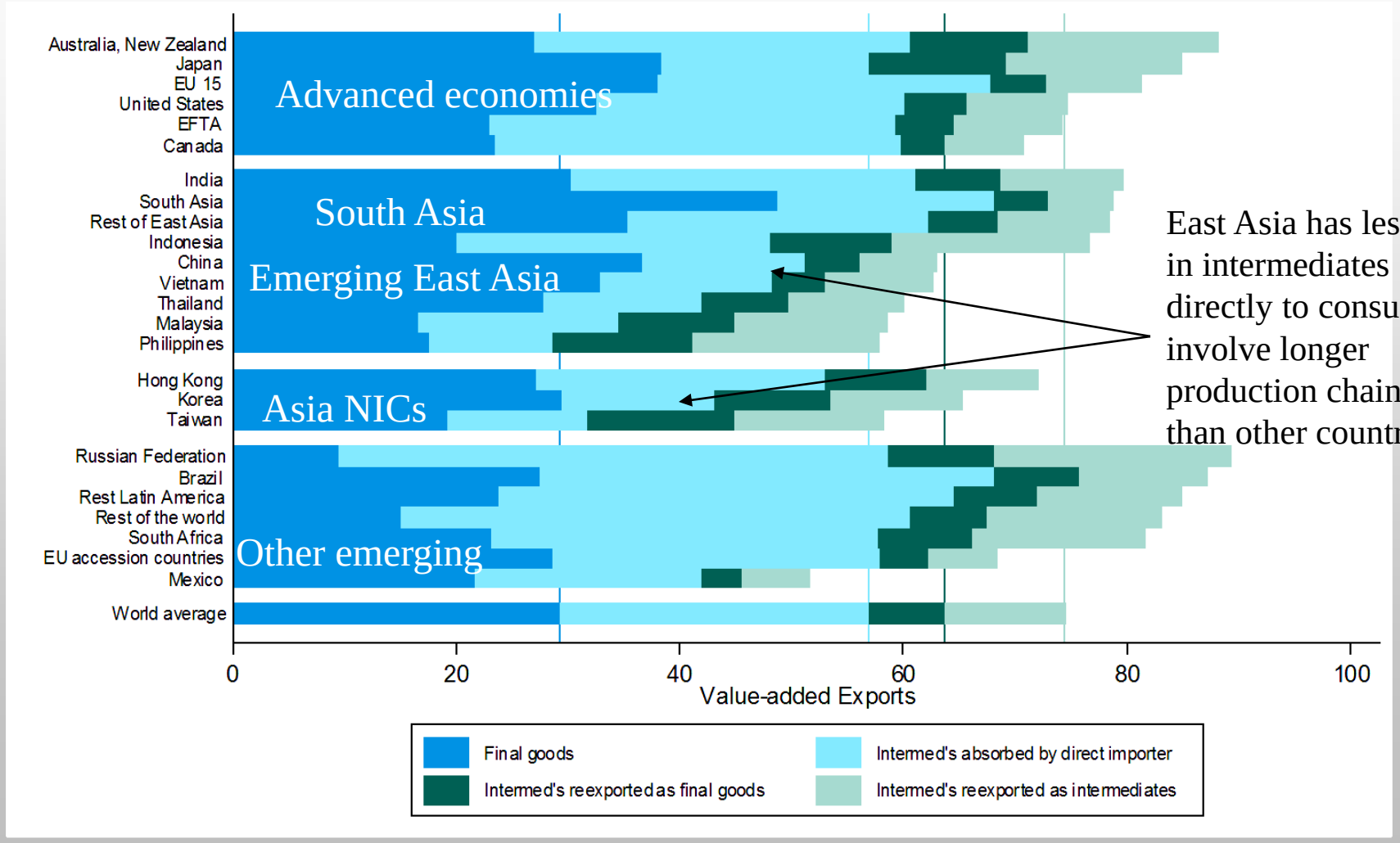
US uses lots of imported inputs in its exports; imported VA supplied by Canada, Mexico, and US itself

E. Asia has the longest chains–little of its VA exports is absorbed by direct importer (see table 3)

East Asia has the most foreign content in its own exports

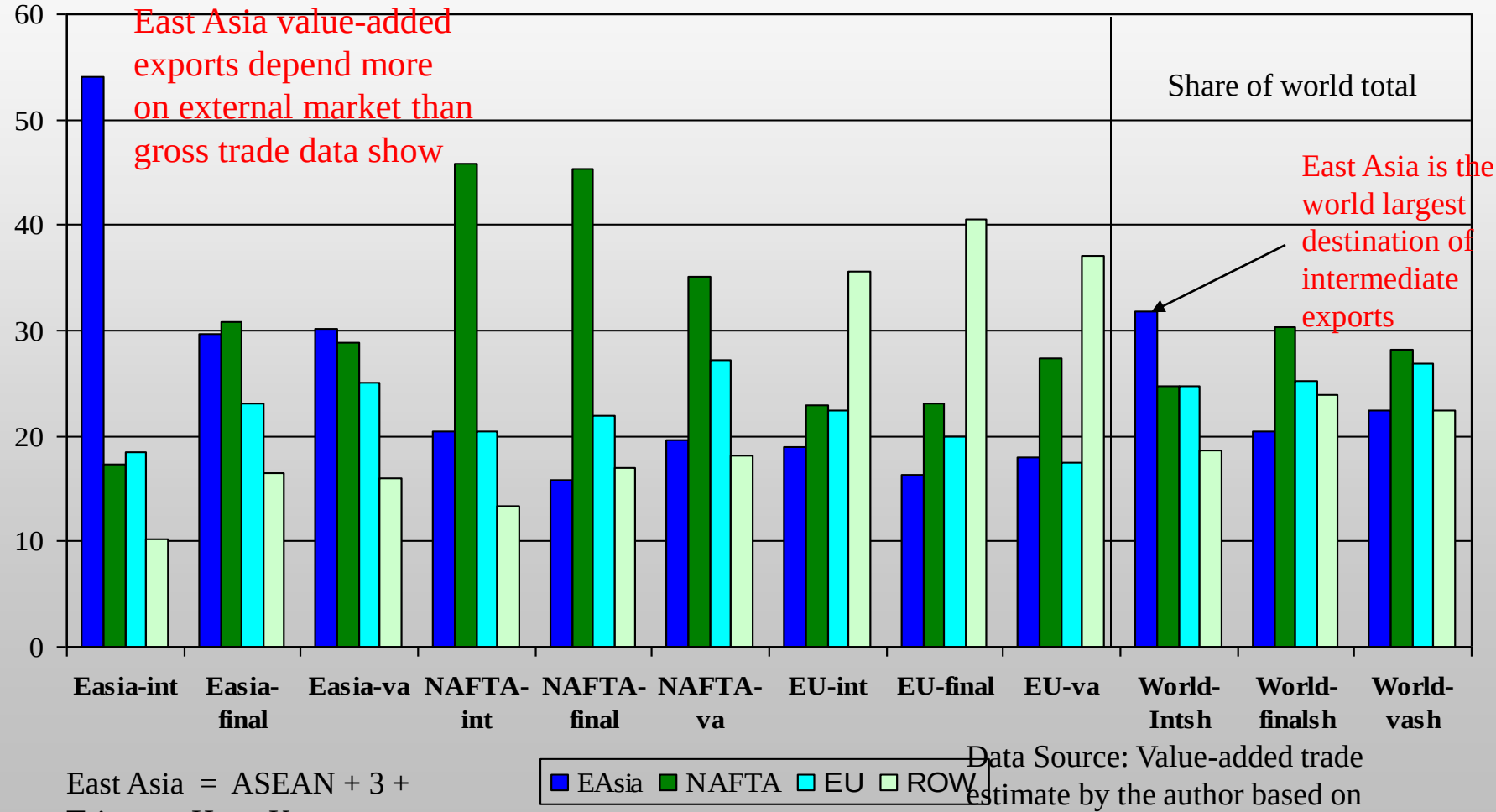
Integration in NAFTA makes Mexico an outlier among non-Asian economies

Further Decomposition of Value-added Exports, 2004



Manufacturing Export Destination of the 3 Trading Blocks

- *Intermediates, final goods and value-added exports, 2004, %*

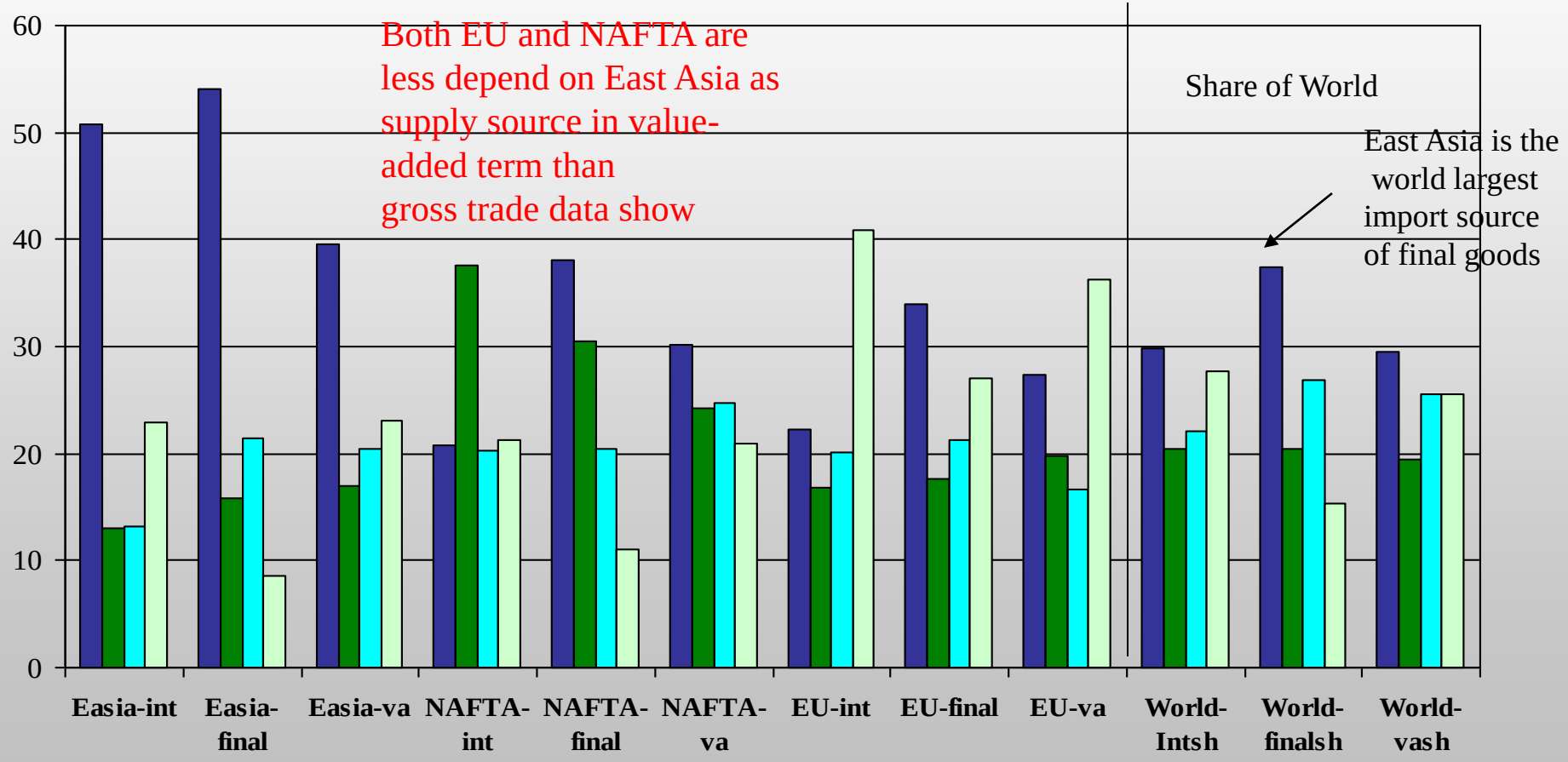


East Asia = ASEAN + 3 + Taiwan + Hong Kong

Data Source: Value-added trade estimate by the author based on version 7 GTAP database

Manufacturing Import Sources of the 3 Trading Blocks

- *Intermediates, final goods and value-added imports, 2004, %*



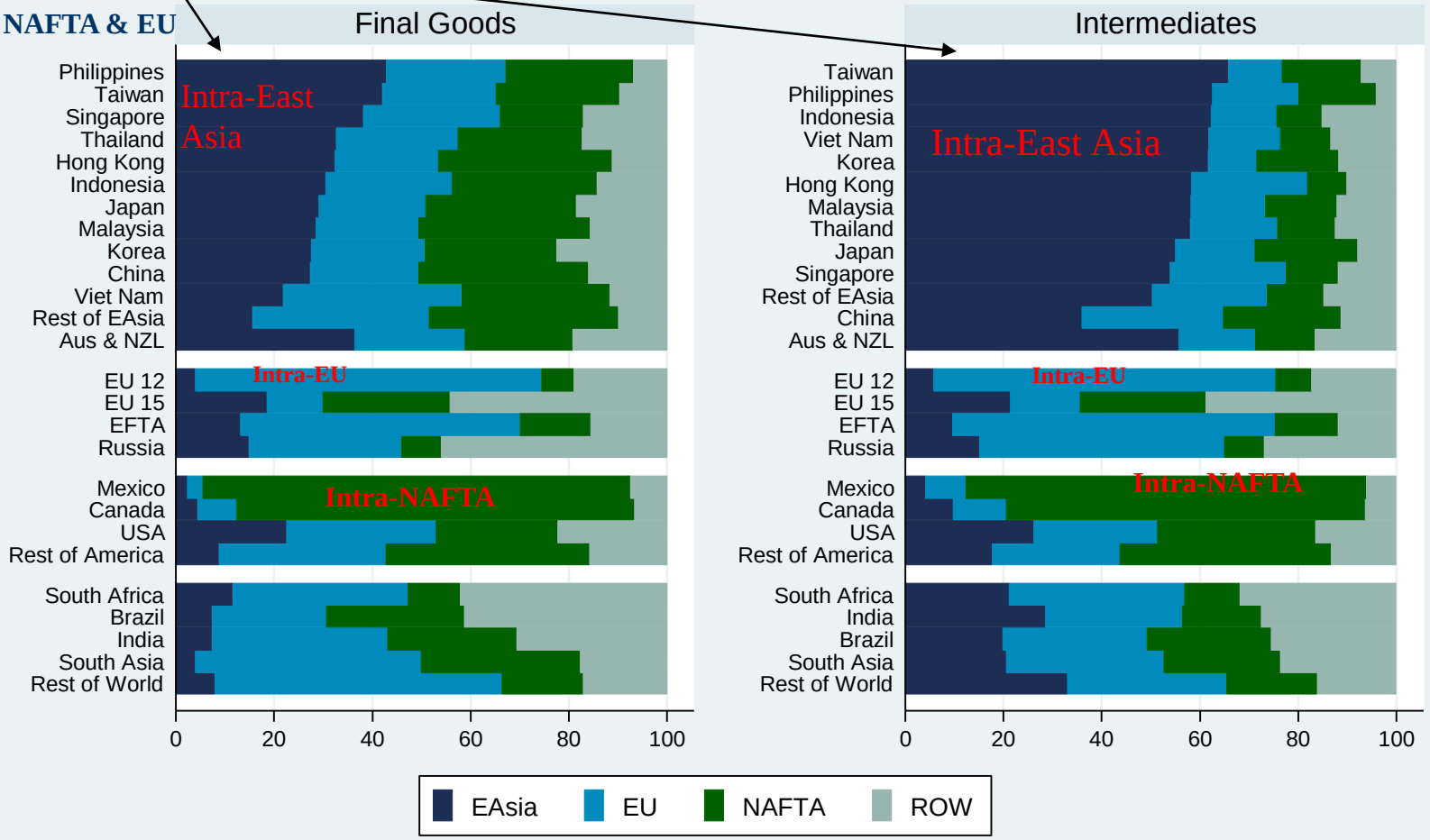
East Asia = ASEAN + 3 + Taiwan + Hong Kong

Data Source: Value-added trade estimate by the author based on version 7 GTAP database

Three Major Trading Blocks In the World (1)

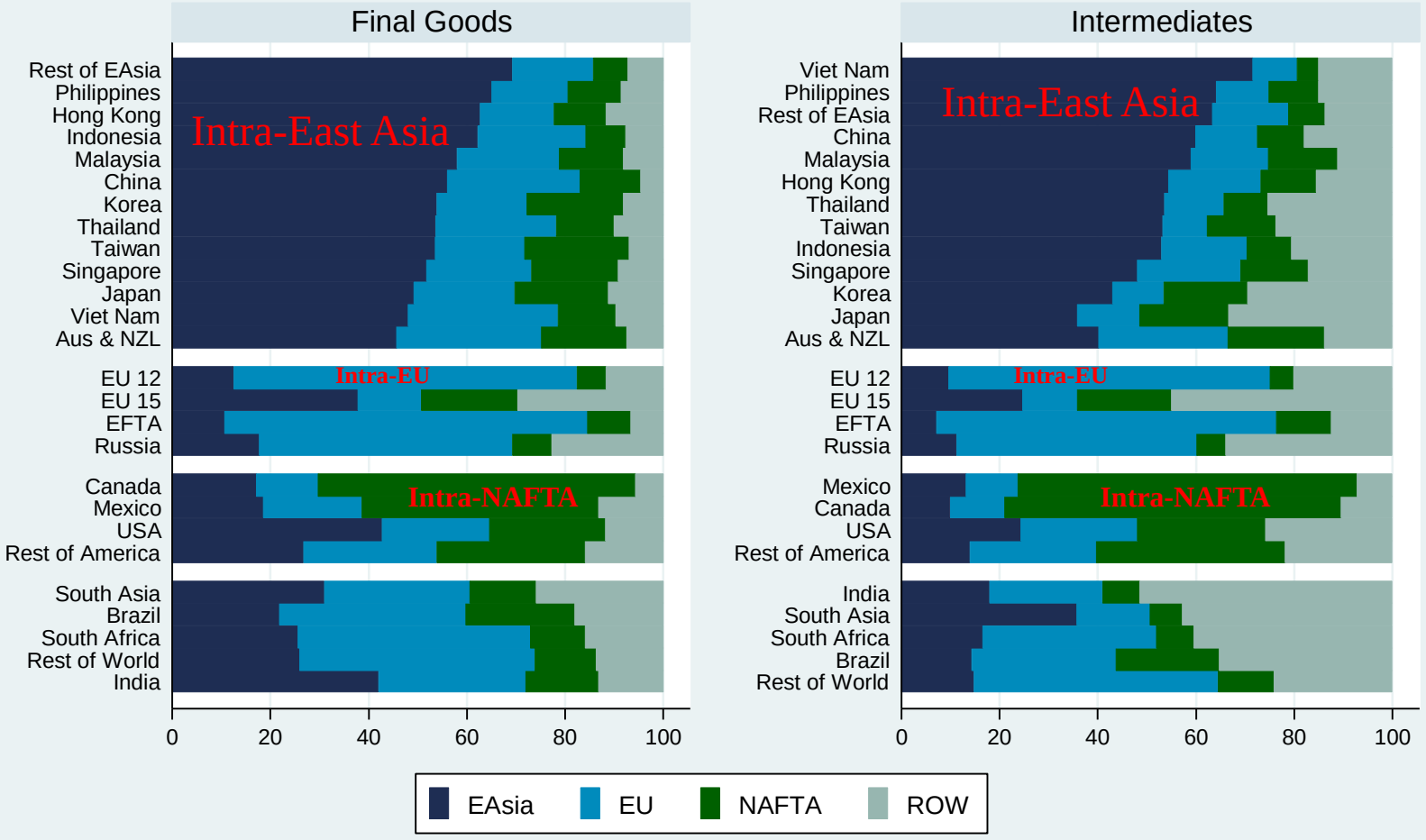
- *Manufacturing exports dependence, 2004, %*

The integration pattern of East Asia is different from NAFTA & EU



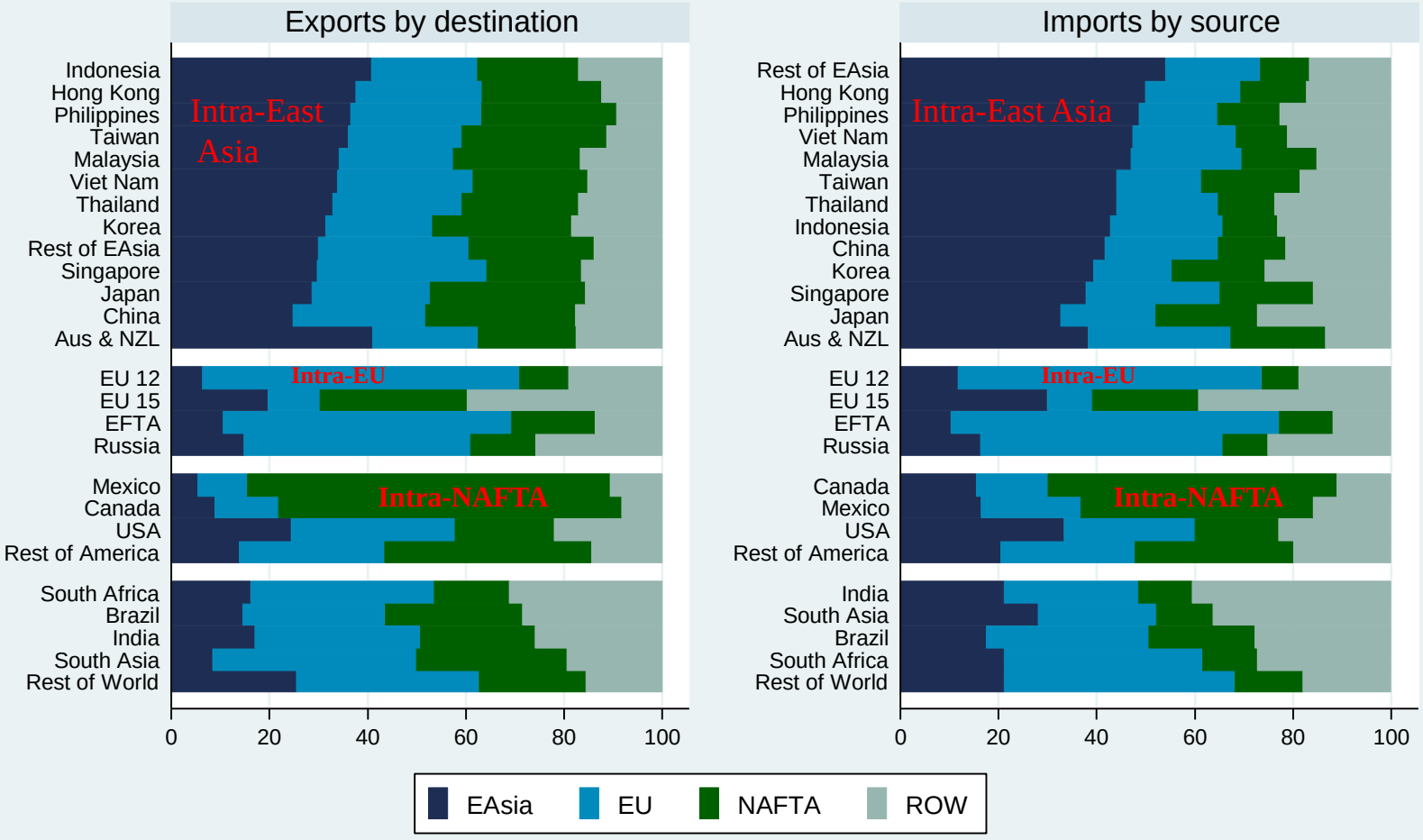
Three Major Trading Blocks In the World (2)

- *Manufacturing imports dependence, 2004, %*



Three Major Trading Blocks In the World (3)

- *Manufacturing value-added trade dependence, 2004, %*

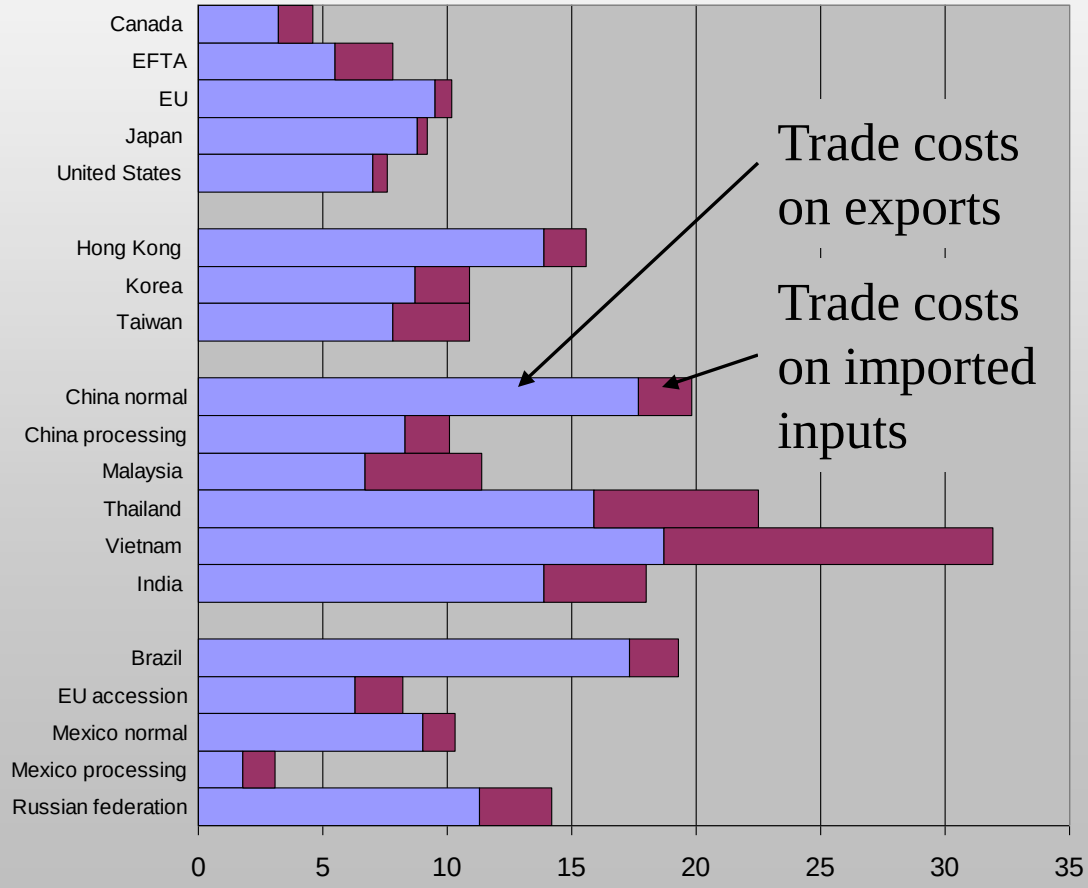


What is Special for East Asia as a Trading Bloc

- Very high intra-regional dependence on intermediate trade in manufacturing sectors
- About 70% final manufacturing exports depend on external demand
- Two major hubs in the production network: Japan and China, one upstream and one downstream, at very different stage of economic development
- Deeply integrated with vertical specialized or segmented global production chain

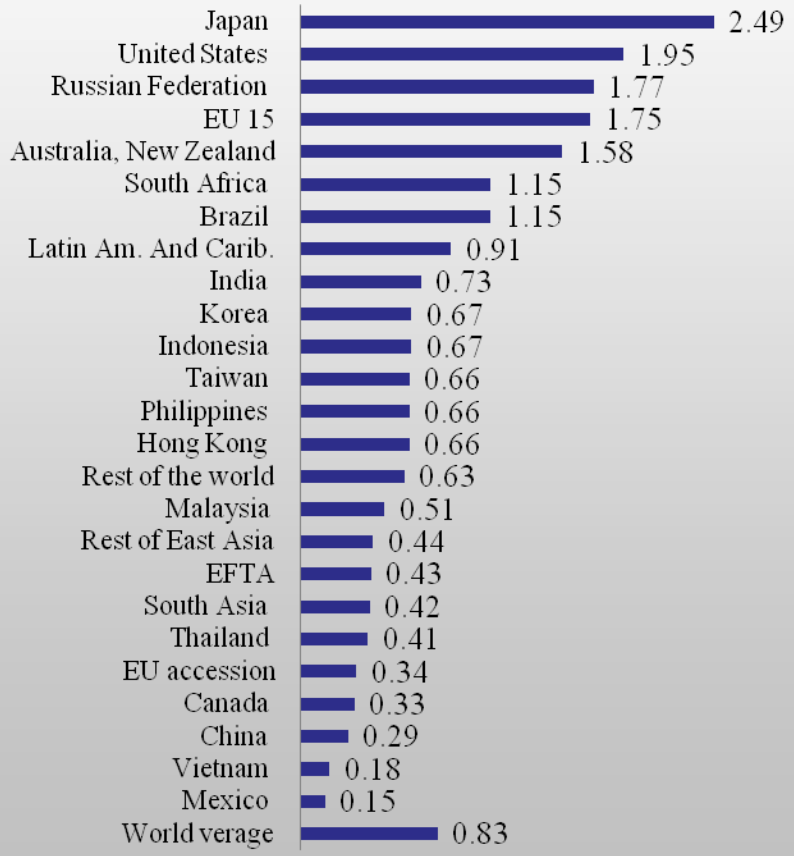
Trade costs of multistage production

Trade costs (tariff + transport), as a share of export value

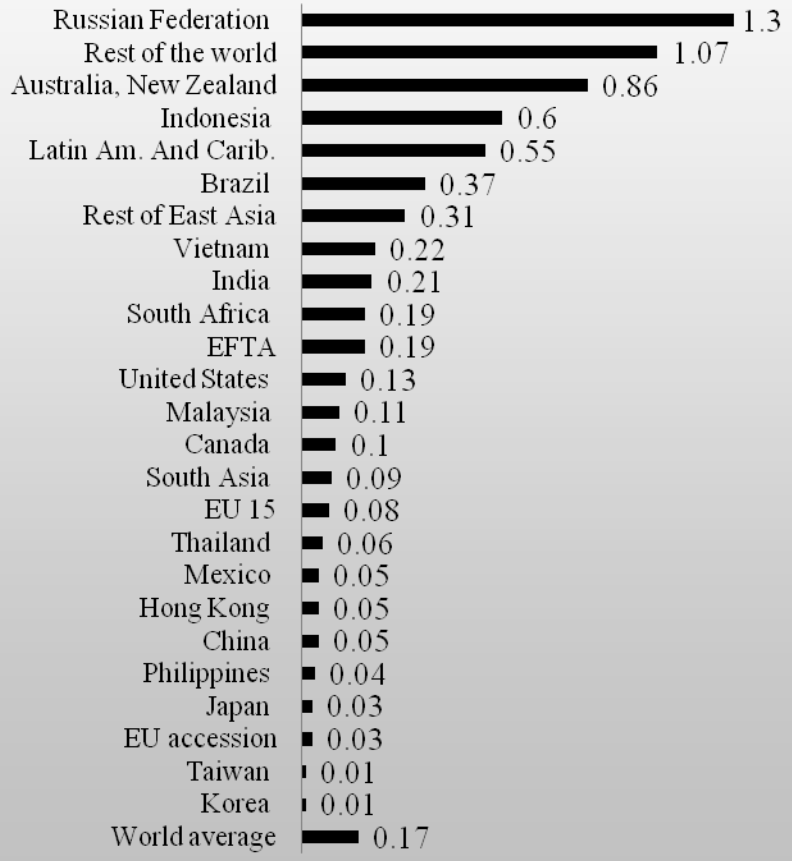


- East Asia pays a price for its long chains and relatively high tariffs
- Advanced economies have low foreign content and, hence, low costs

Broad Sector Structure of Value-added Exports
VS1/VS Ratios



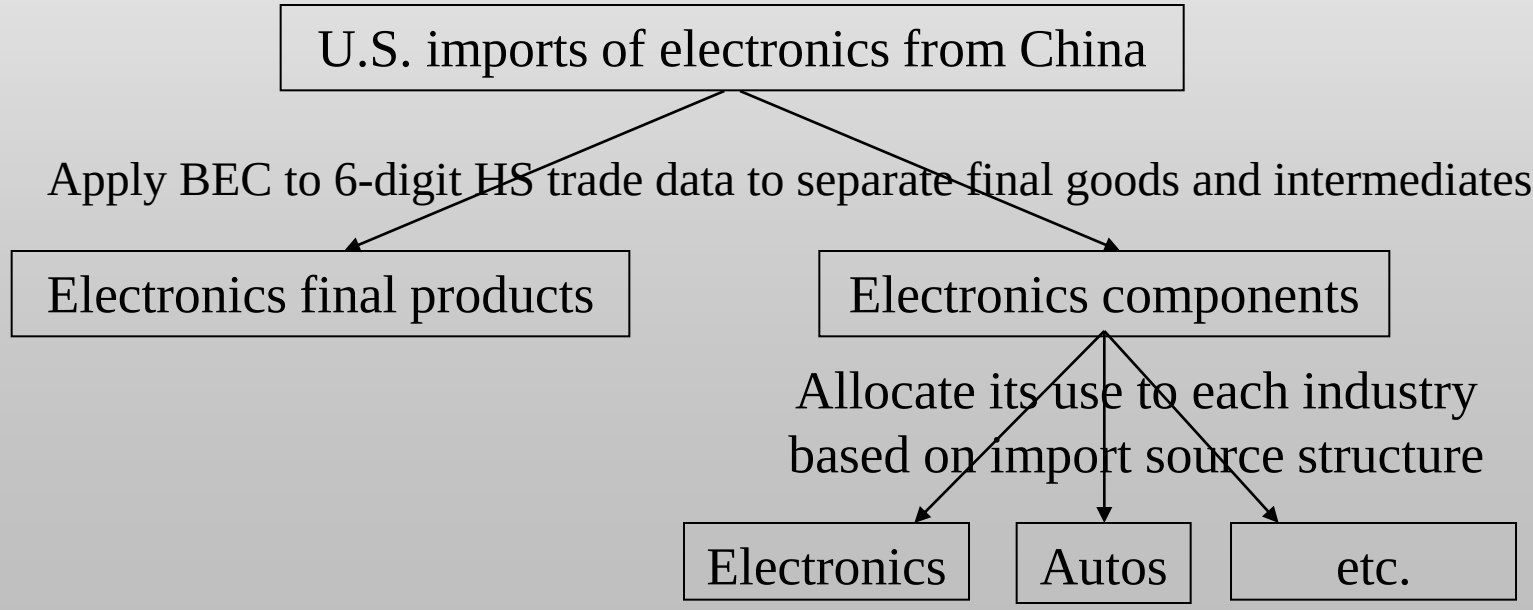
Manufacture and Services



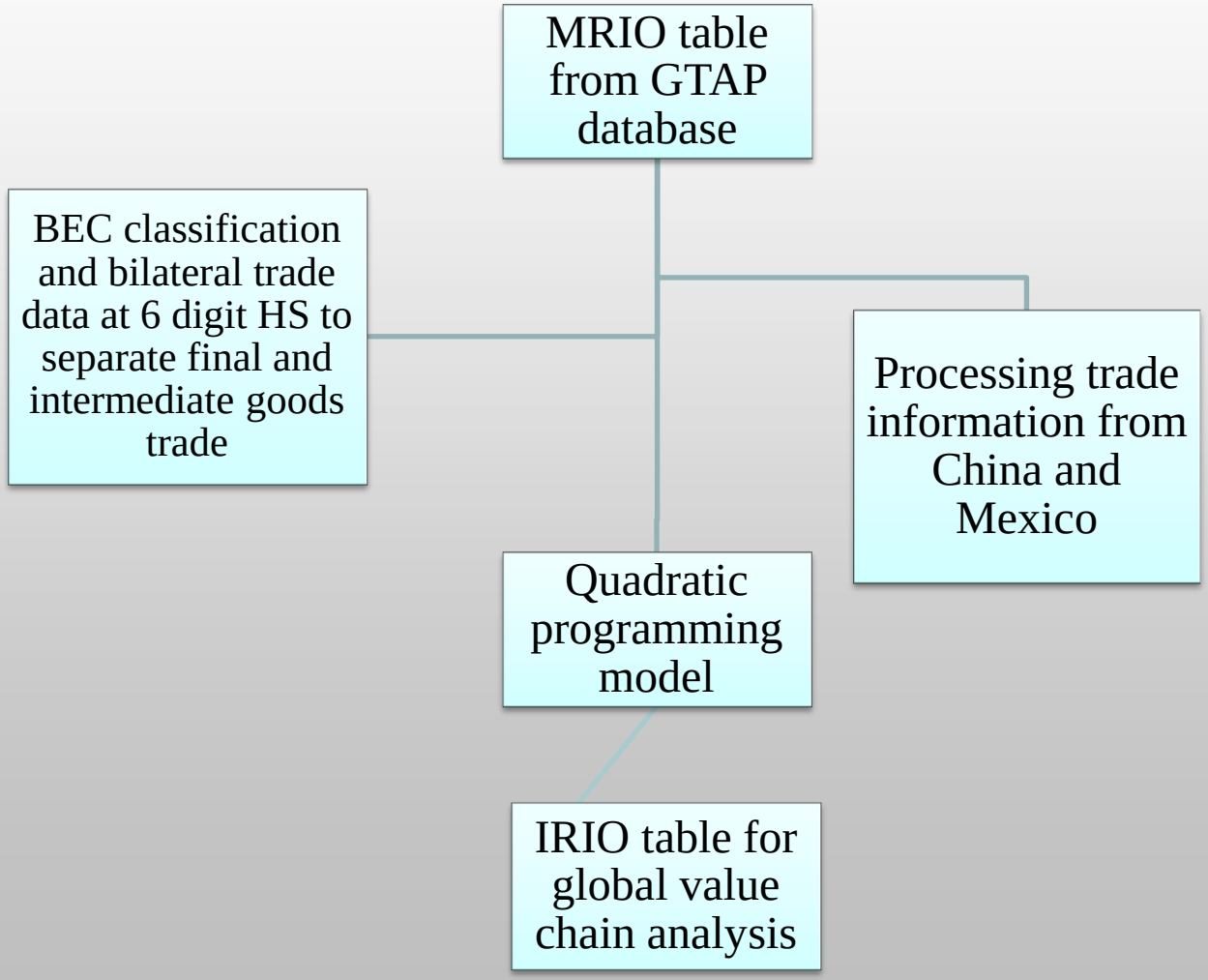
Raw Materials

Data Base Improvement: MRIO to IRIO

- Start with 2004 GTAP global trade and production database
- Add additional detail on source and use of intermediate inputs and final goods, Use end-use categories of detailed trade data (HS6) to improve imported intermediate use coefficients
- Add detail on processing imports for Mexico and China

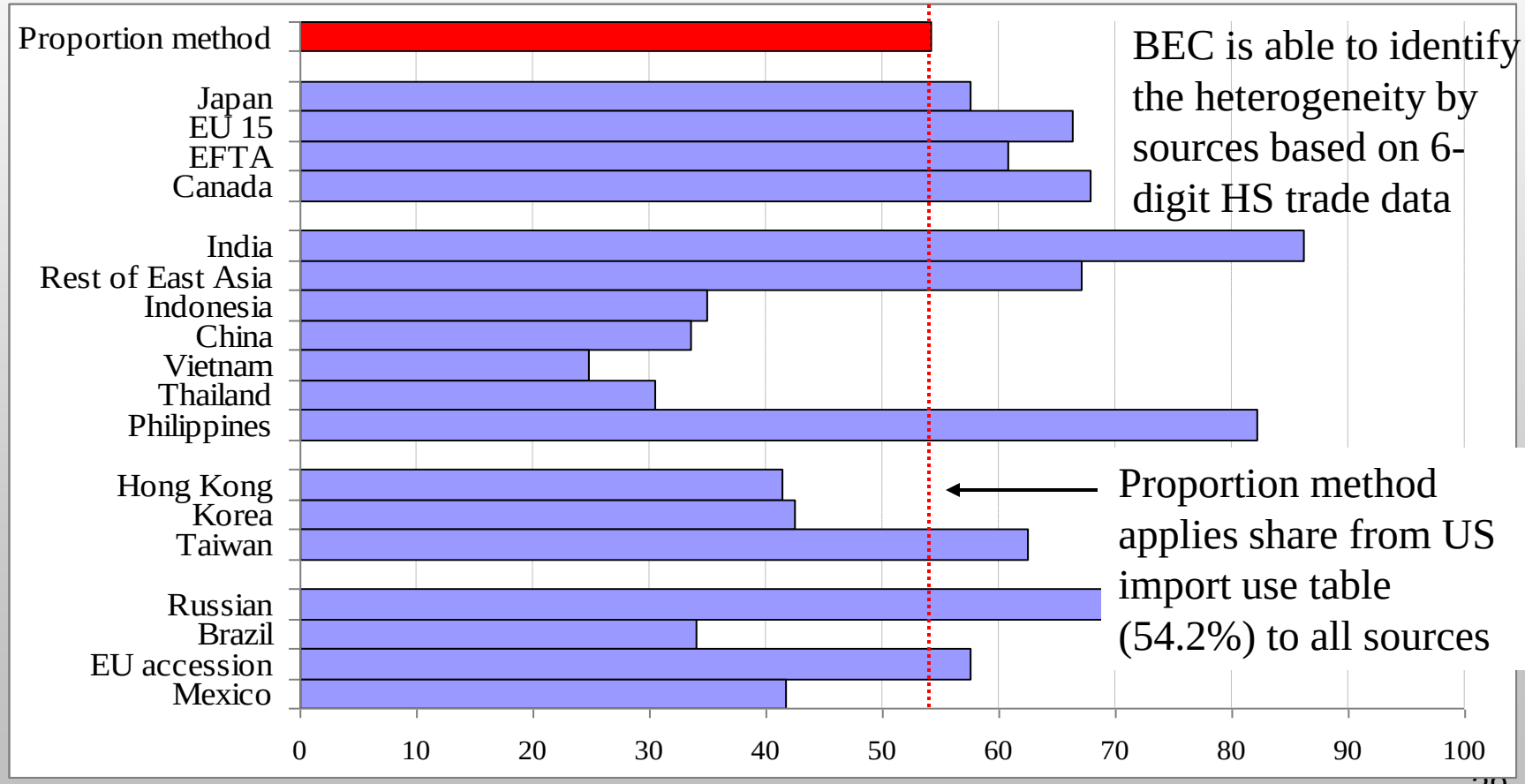


Database Construction: MRIO to IRIO Tables



Why BEC is Better than Proportional Assumption

Intermediate share of U.S. electronic machinery imports, by source



What end-use classifications can help

- Intermediate goods identified from gross trade flows are the row sum of each block matrix A_{rs} in the IO coefficient matrix A.
- End use classification such as BEC distinguishes intermediate inputs from final goods in imports from each source in each sector, thus can help improve the accuracy of IO coefficients in IRIO table by giving better row total control for each block matrix in A.
- End-use classifications improve estimates of intermediate inputs entering the importing country from each sources, therefore is better than the alternative: Proportional method assumes the intermediate share in imports from each source country are the same so it will bias the value-added estimates from each source country, even in aggregate.

What end-use classifications can't help

- Still have to assume proportionality to allocate intermediate inputs to each industry *within the importing country*
  - Required data not reported by most national statistical agencies
  - Problem noted by Committee on Economic Statistics of the American Economic Association (Feenstra et al., 2010)
- Industry-level estimates of value-added trade based on such IRIO table may be unreliable with unknown biases, despite their theoretical tractability
- More reliable data collected by national and international agencies are needed to overcome this limitation.

Conclusions

- New trade measure in value-added framework
  - Generalizes and harmonizes all measures in the literature
  - Accounts for the entirety of gross trade, establishing a formal relationship between value-added measures of trade and official trade statistics.
  - Provides new detail on regional differences in supply chain activity and trade costs
- It is now possible to measure trade in value-added terms consistent with official statistics, this will open the possibility for SNA to accept the concept of value-added trade without dramatically change current Custom trade data collection practice.

Limitations

- By design, this study is an ex post accounting exercise, we use IRIO table not as a model but as an accounting framework to decompose gross trade. The bias caused by fixed coefficient assumption will be smaller than that in a simulation exercise.
- It does not examine the causes and the consequences of value-added trade and global production network. Although an accurate accounting of value added by source country is a necessary step toward a better understanding of these issues. We hope the new measure could be widely used in analytical work in comparison with gross trade data.

Model Setup and Notations

G countries, N industry world

Production System :

$$X = (I - A)^{-1} Y = BY$$

Value-added Share Matrix:

$$VAS = VB$$

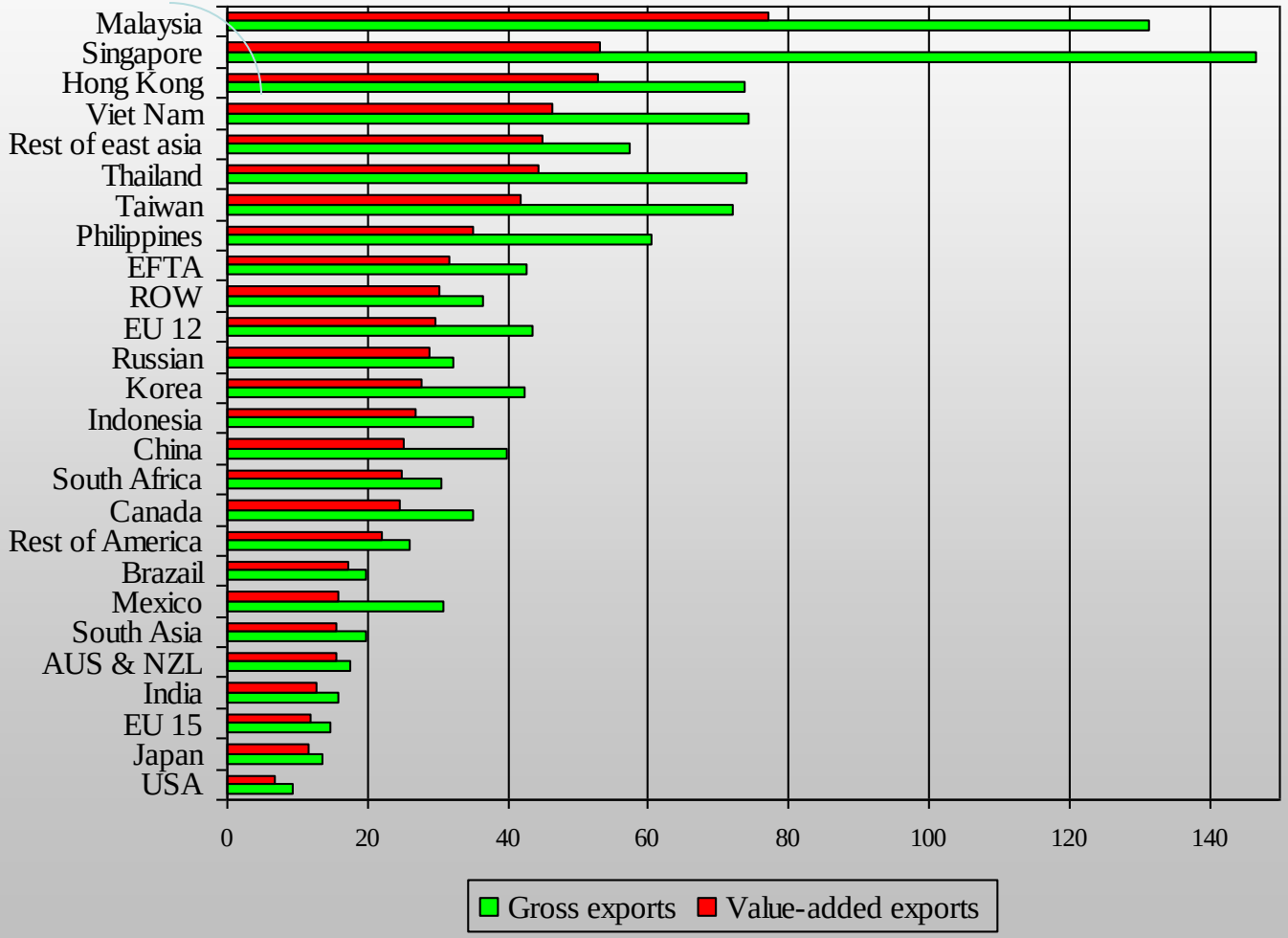
Value-added Trade Matrix:

$$VAS\_E = VB\hat{E}$$

Notation	Matrix Name	Dimension
X	Gross output	GN×1
Y	Final demand	GN×1
A	IO coefficient	GN×GN
$\hat{E}$	Gross exports	GN×GN
B	Leontief inverse	GN×GN
V	Direct value-added coefficient	G×GN
VAS	Value-added share	G×GN
VAS_E	Value-added exports	$G \times GN_{34}$

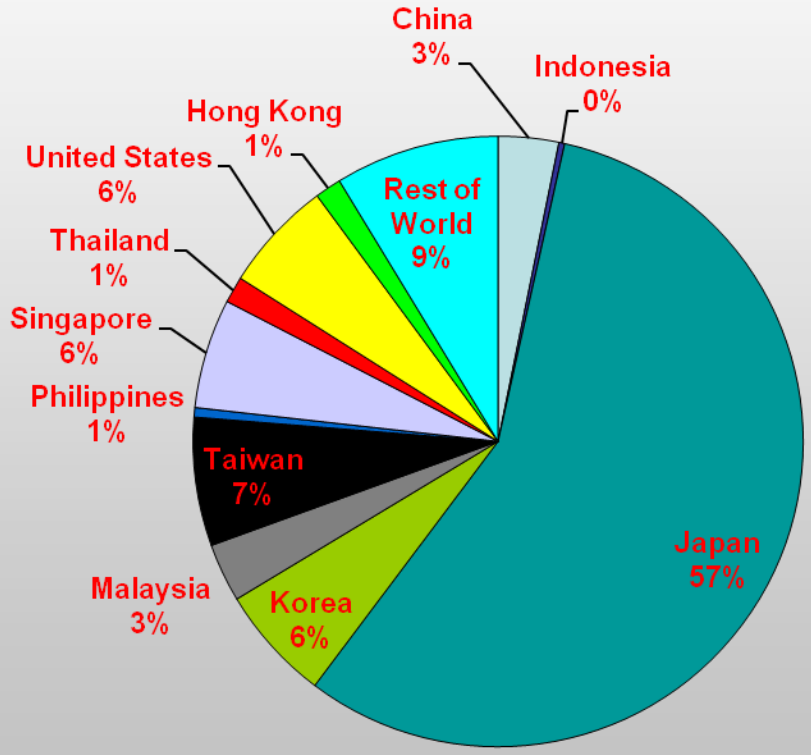
Exports Dependence

- *Gross and value-added exports as % of GDP, 2004*

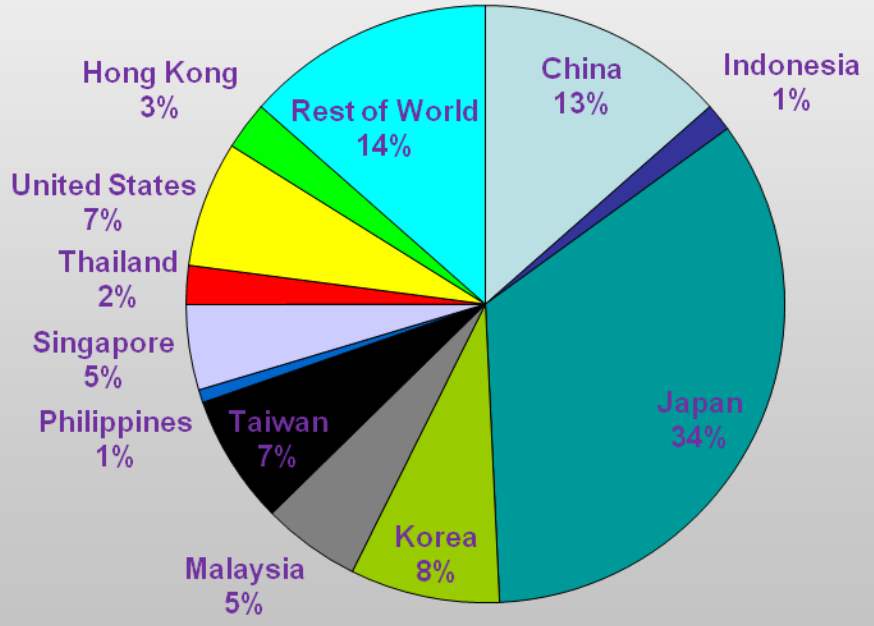


Data Source: Value-added trade estimate by the author based on version 7 GTAP database

Net Value Added Contribution by Source to Electronics Products Made in East Asia Sold at the U.S. Market



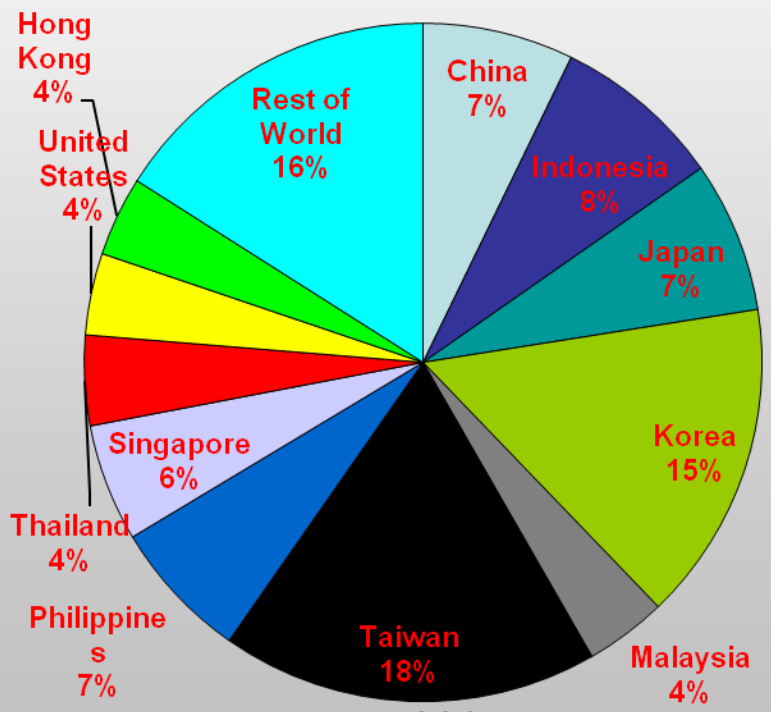
1990

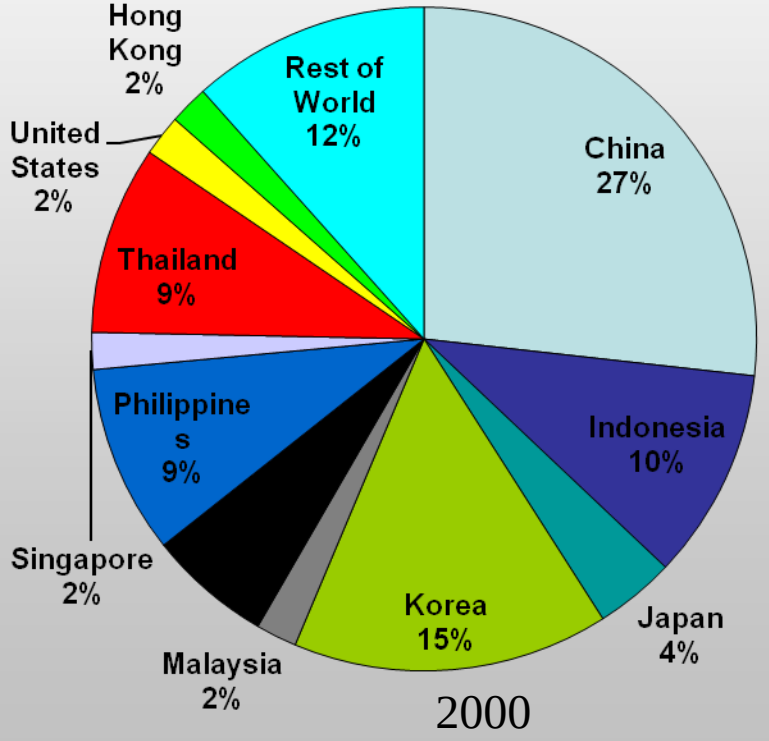


2000

Source: Author's estimate based on Asian IO table compiled by IDE of Japan

Net Value Added Contribution by Source to Wearing Apparel Made in East Asia Sold at the U.S. Market





Source: Author's estimate based on Asian IO table compiled by IDE of Japan