UNITED STATES INTERNATIONAL TRADE COMMISSION

Give credit where credit is due: Tracing value added in global production chains

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Presentation outline

- Global value chain: nature and measures
- Conceptual framework
  - Model setup and three important matrices
  - Major value-added components of gross exports
- Empirical results
  - Graphically show positions of countries in global value chains
- Database improvements and limitations
  - Extensions of the GTAP database

Contributions

- Conceptual framework
  - Unified
    - Incorporates all major measures in the literature
    - Vertical specialization and value-added trade
  - Complete
    - Decomposes gross exports into value-added components
- Empirical results
  - Informative:
    - Highlight each country's upstream and downstream position
    - Caveat: Highlight differences but do not examine causes
- Database development
  - Improved measures of imported intermediate inputs and processing trade

Value chains, 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)
  - Single country: Hummels, Ishii, Yi (2001), Koopman et al (2008)
  - Asian regional chains: Pula and Peltonen (2009); Wang, Powers, and Wei (2009)
  - Global snapshot: Daudin, Rifflart, and Schweisguth (2010); Johnson and Noguera (2010)
  - Global time series: Erumban et al. (2010); Wang et al. (2010)

Global value chains: Multiple measures

- Hummels, Ishii, and Yi (2001) measures of vertical trade
  - VS: share of imported inputs in exports
  - VS1: share of exports sent indirectly through third countries
- Newer measures
  - VAX: domestic value-added in exports (Johnson and Noguera, 2010):
  - VS1*: domestic value-added that returns home (Daudin et al., 2010)
- Not previously unified in a fully specified framework

Value chains in a two-country world: Gross output

- 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* of intermediates from *r*

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

Production system in a two-country world

- In block matrix notation

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

- 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×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×1) vector of global use of *r*'s final goods

Value added in production

- 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×N) domestic value-added coefficient vector;
element v_{ri} = 1 – intermediate input share from all countries

u: (1×N) vector of ones

- **Value-added shares** matrix (2×2N)

$$VAS = VB = \begin{bmatrix} V_1B_{11} & V_1B_{12} \\ V_2B_{21} & V_2B_{22} \end{bmatrix}$$

VAS decomposes the value added in production of each sector in all countries

Value-added exports

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

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

- Use E (2N×2) to calculate national value-added exports

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

(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: Value added in many-country world

Production and trade system:

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

$$VAS = VB$$

$$VAS\_E = VBE$$

Matrix	Description	Dimension
X	Gross output	GN×1
Y	Final demand	GN×1
A	IO coefficient	GN×GN
E	Gross exports	GN×G
B	Leontief inverse	GN×GN
V	Direct value-added coefficient	G×GN
VAS	Value-added share	G×G
VAS_E	Value-added exports	G×G

G countries
N sectors

VAS_E incorporates all value-added measures

- Diagonal elements: Domestic value added in exports
- Off-diagonal elements: Foreign value added in exports
- Each column sums to unity
- Characterizes both direct and indirect value-added exports

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

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

Further decomposition of value-added exports

- Exports (N×1) include both intermediate and final goods
- Some intermediates are consumed in s; some are sent elsewhere

$$E_{rs} = \underbrace{Y_{rs}}_{\text{Final goods}} + \underbrace{A_{rs}X_{ss}}_{\text{Finished in s}} + \underbrace{A_{rs}\sum_{s\neq t}X_{st}}_{\text{Processed in s;}} \qquad (1)$$

Consumed in s; consumed elsewhere

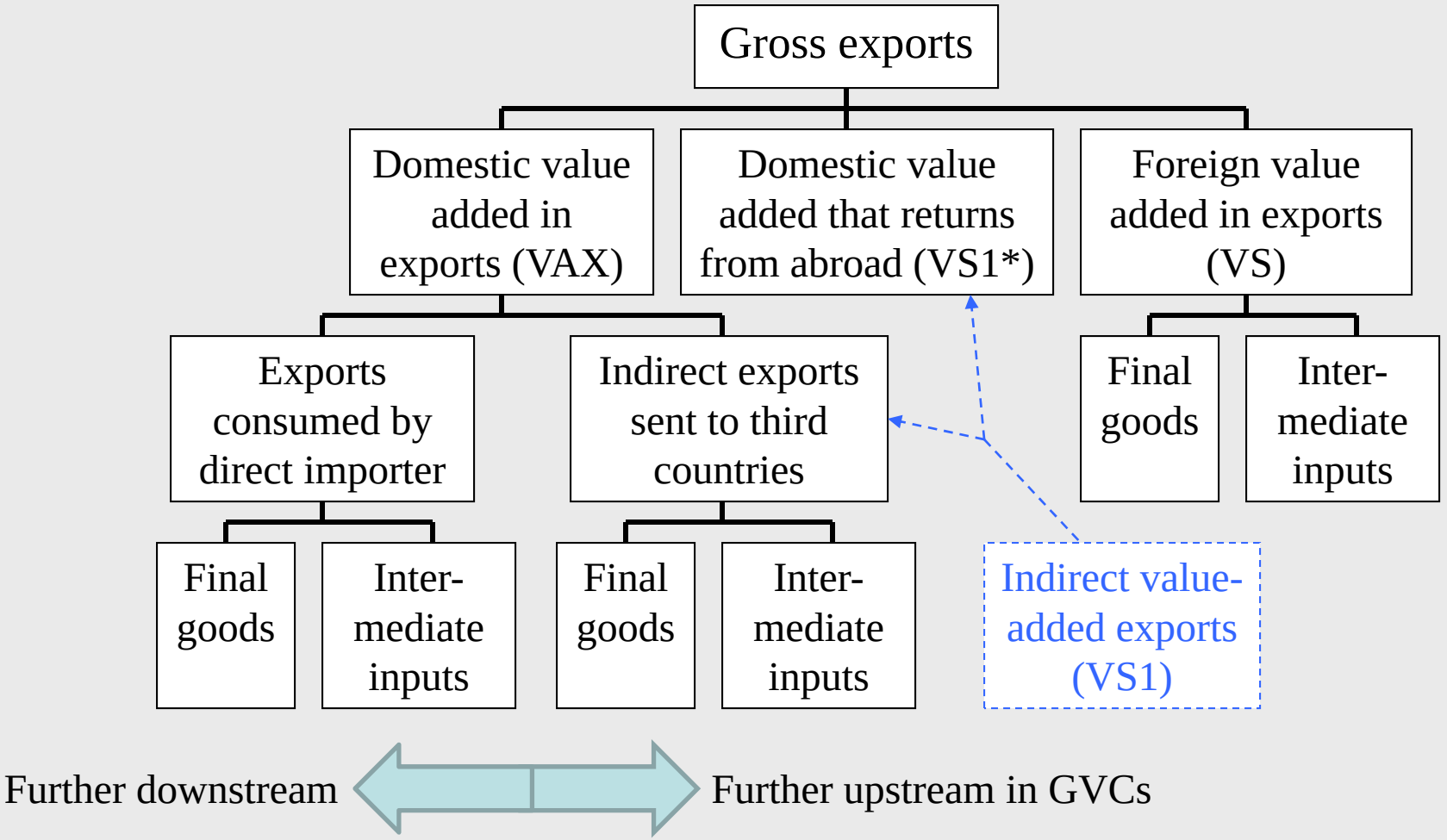
- DV measures the total domestic value-added embodied in *r*'s exports

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

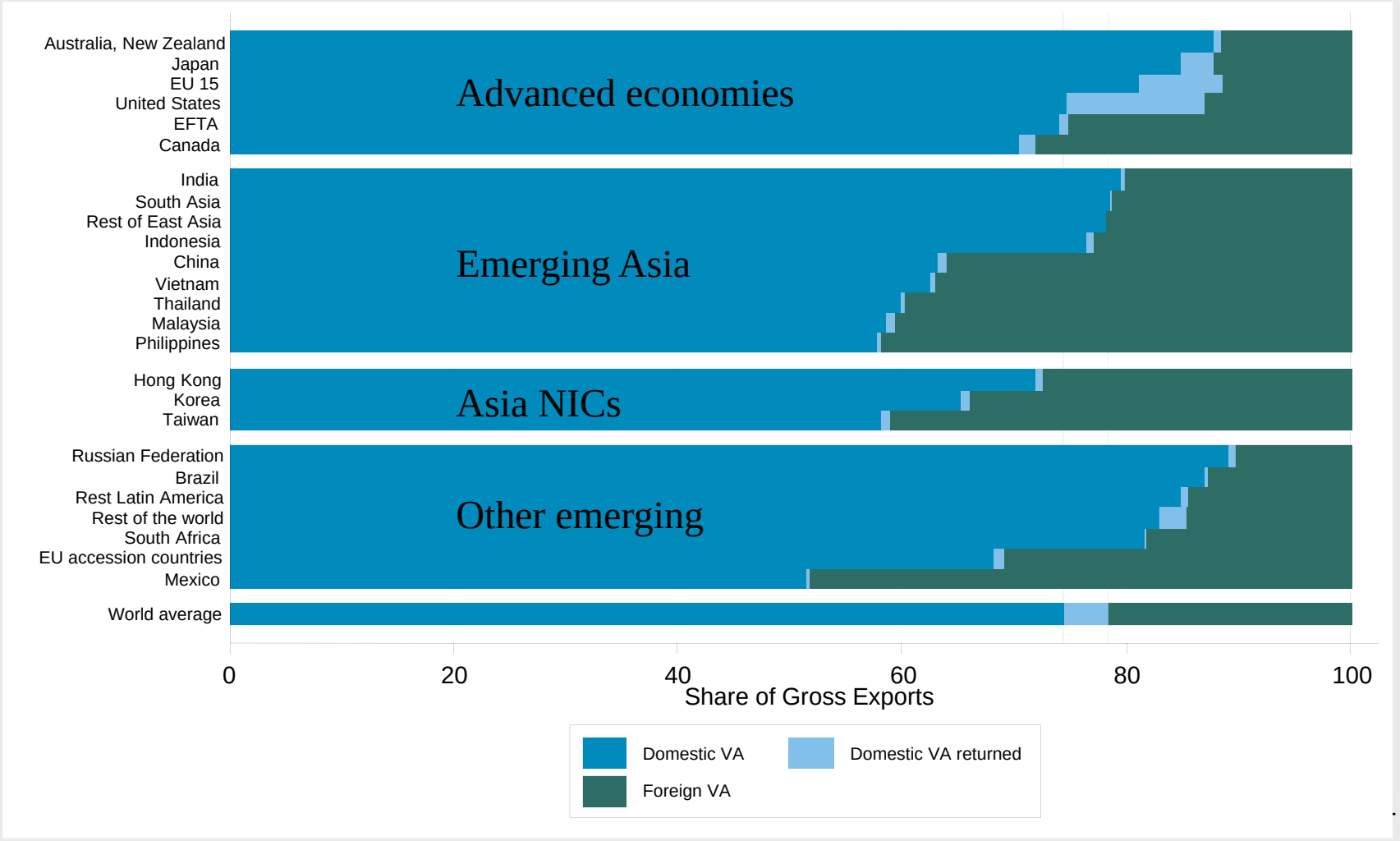
- Further decomposition of value-added exports: combine (1) and (2)

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

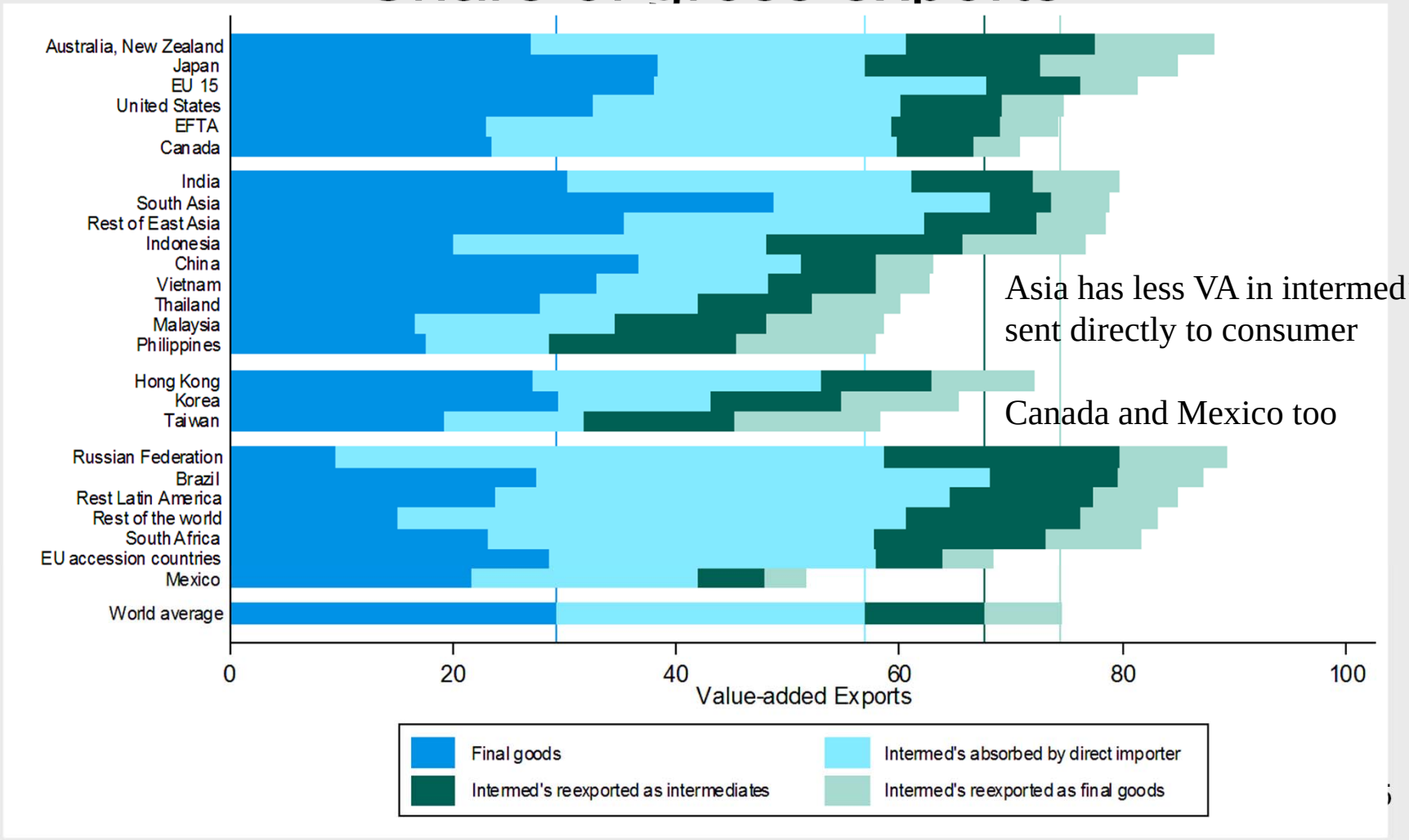
Complete decomposition of gross exports



Decomposition of gross exports



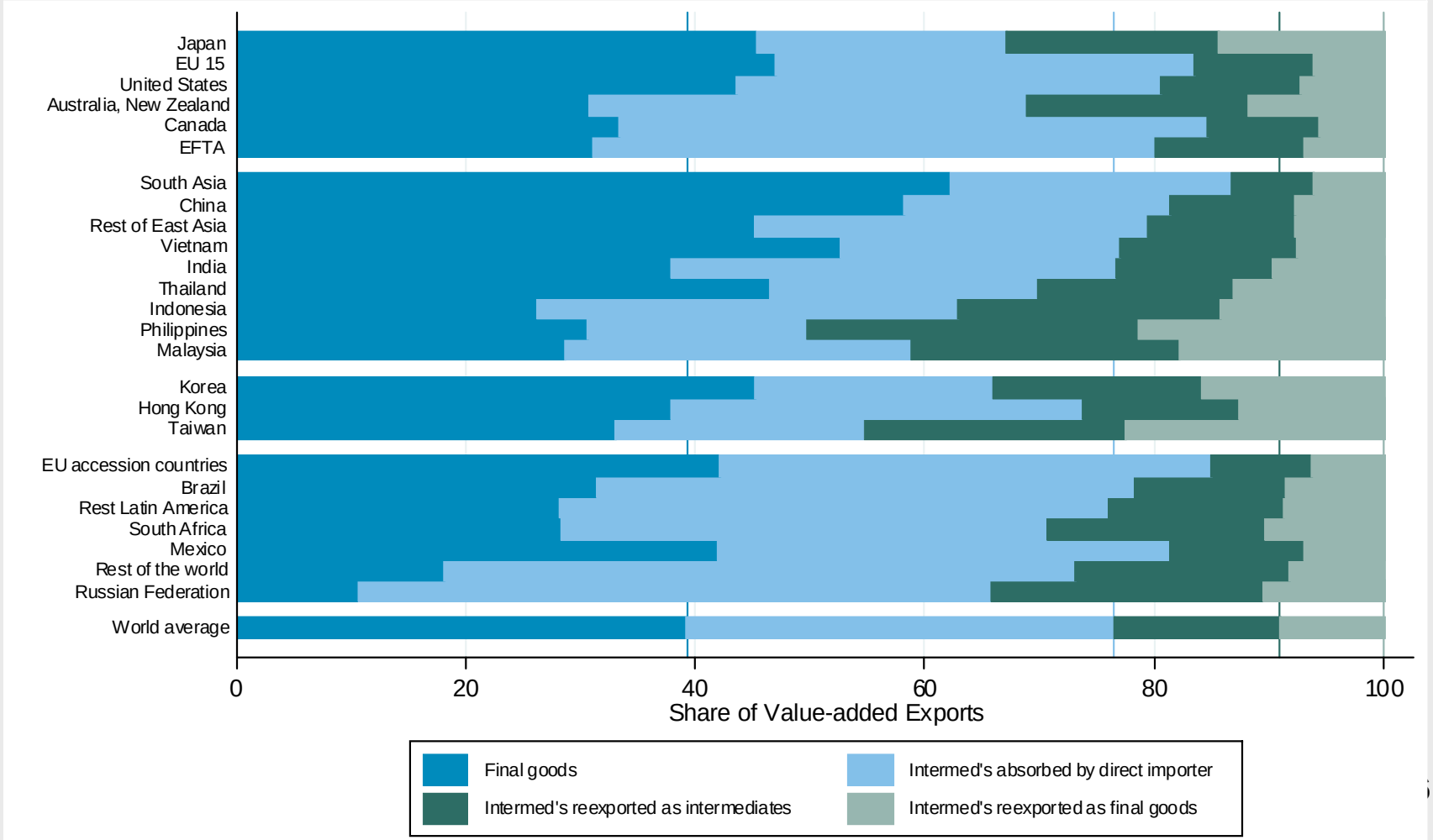
Domestic value-added components: Share of gross exports



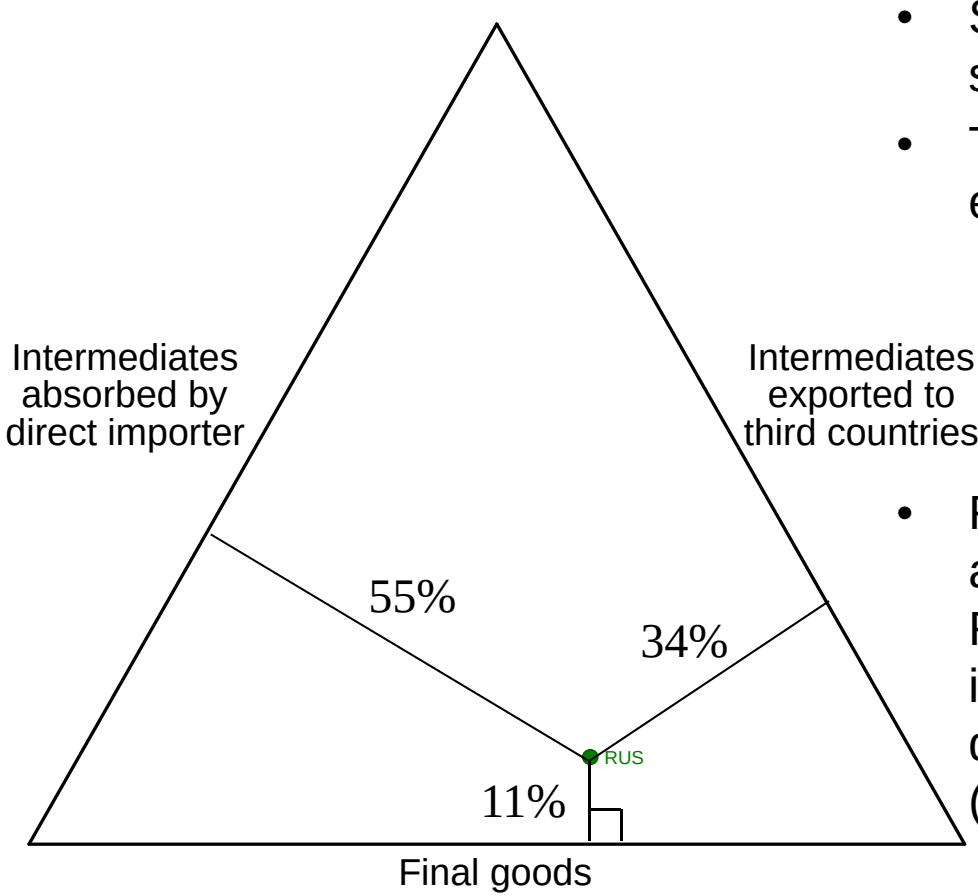
Asia has less VA in intermed's sent directly to consumer

Canada and Mexico too

Domestic value-added components: Share of domestic value added



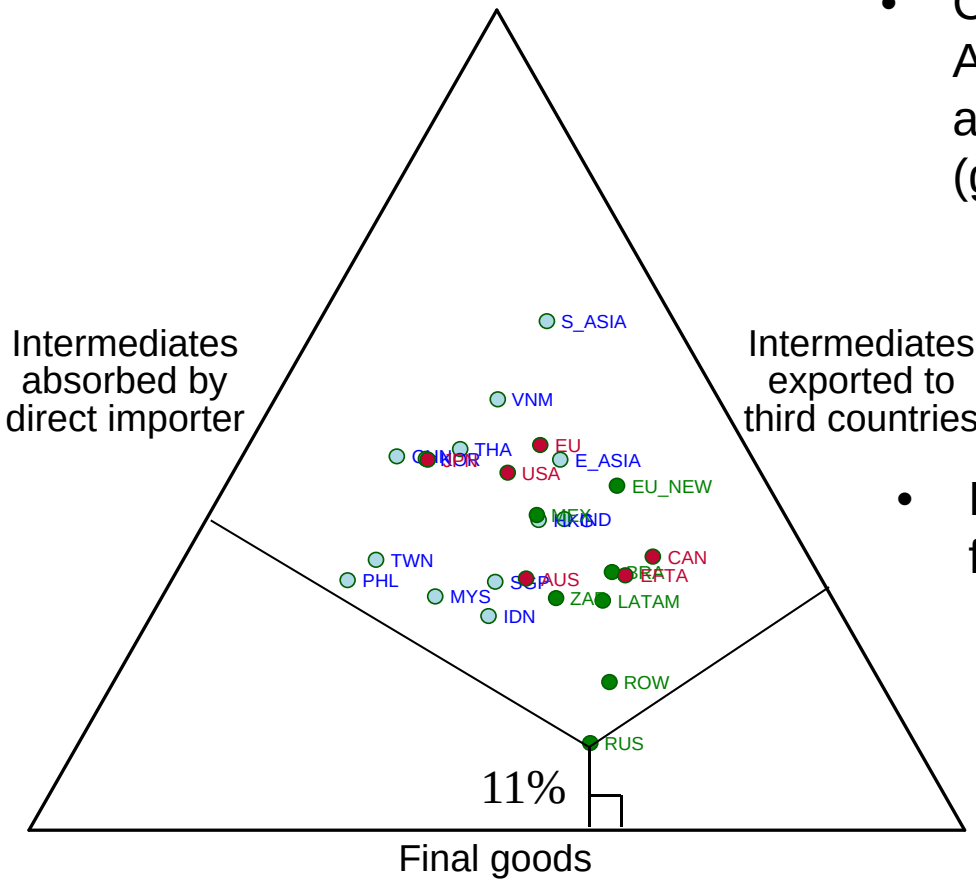
Intermediates and final goods, shares of domestic value-added exports



- Sum of distance to sides is same for all points in triangle
- Triangle can represent shares of each component in DVA exports

- For example, final goods account for only 11% of Russia's DVA exports, and intermediates absorbed by direct exporter acct for 55% (reliance on energy exports)

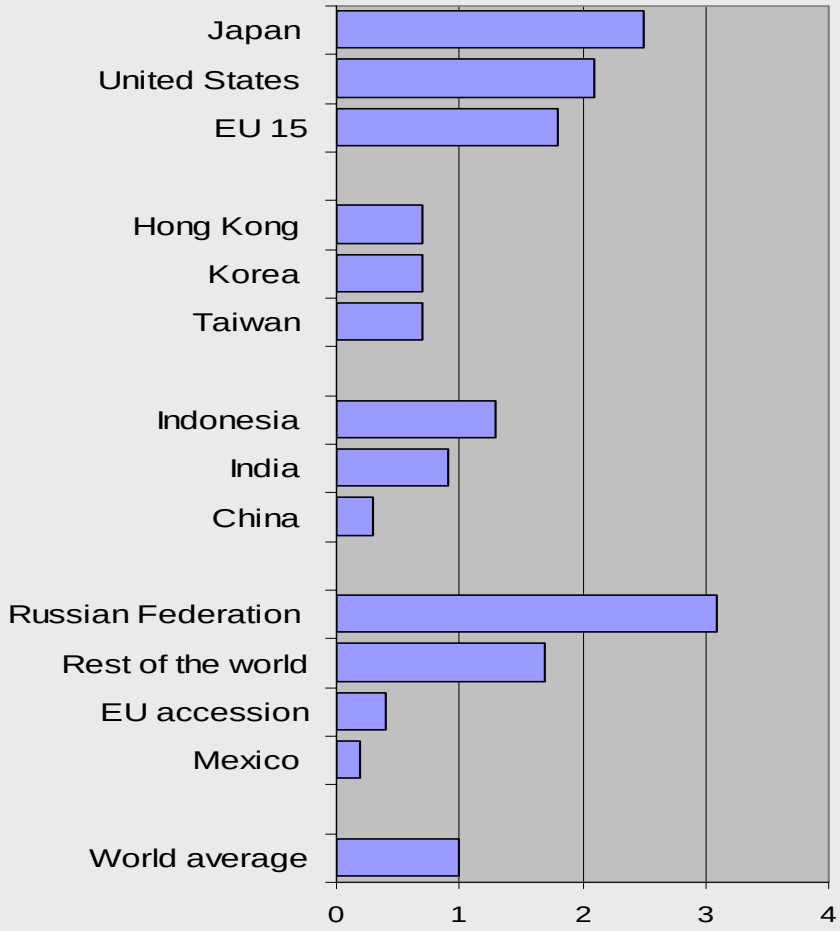
Intermediates and final goods, shares of domestic value-added exports



- Colors indicate country grouping: Advanced (red), Asian emerging and NIC (blue), Other emerging (green)

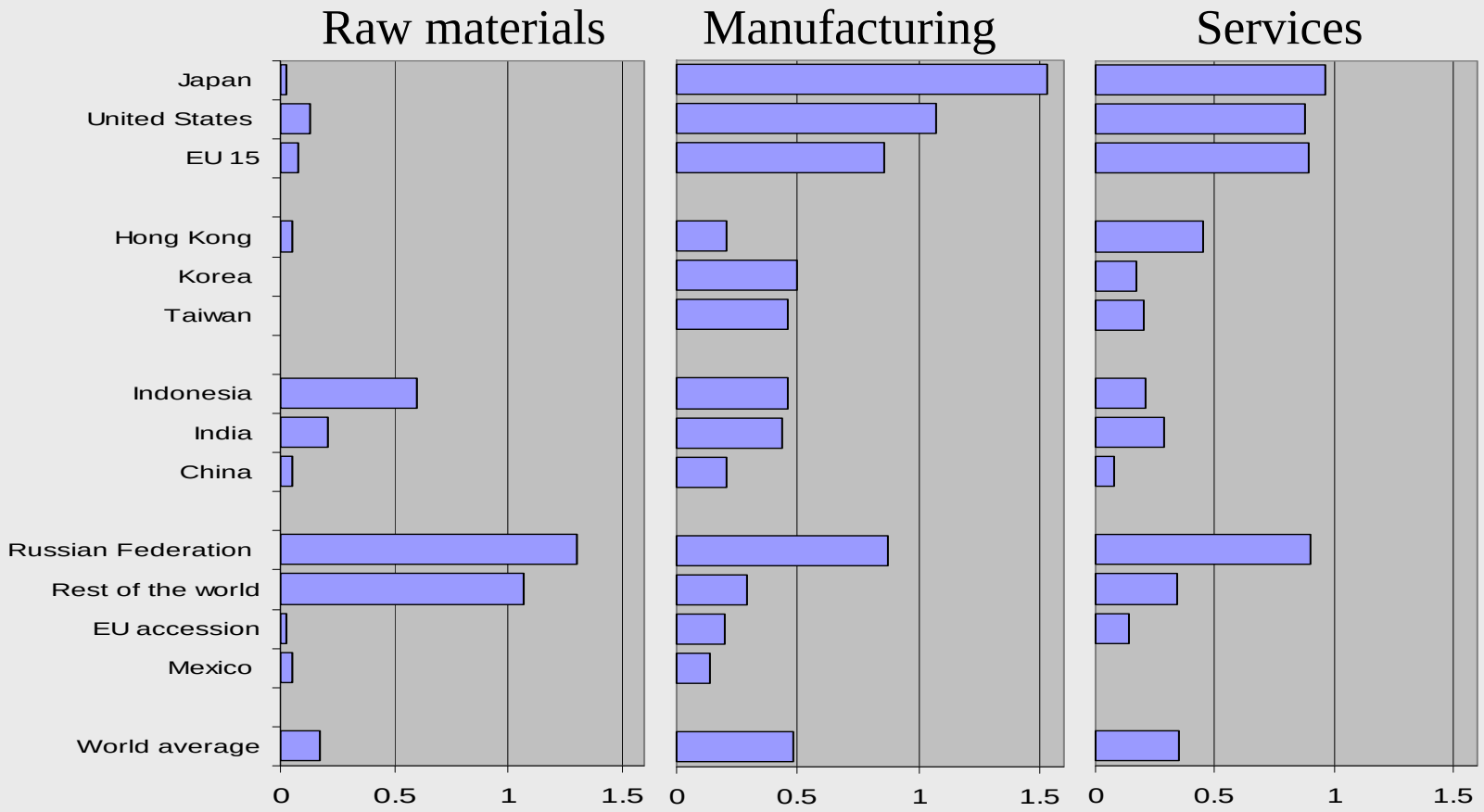
- Emerging Asia differs markedly from other emerging countries
  - More final goods
  - Lower intermeds to direct consumer

Structure of value-added exports: VS1/VS



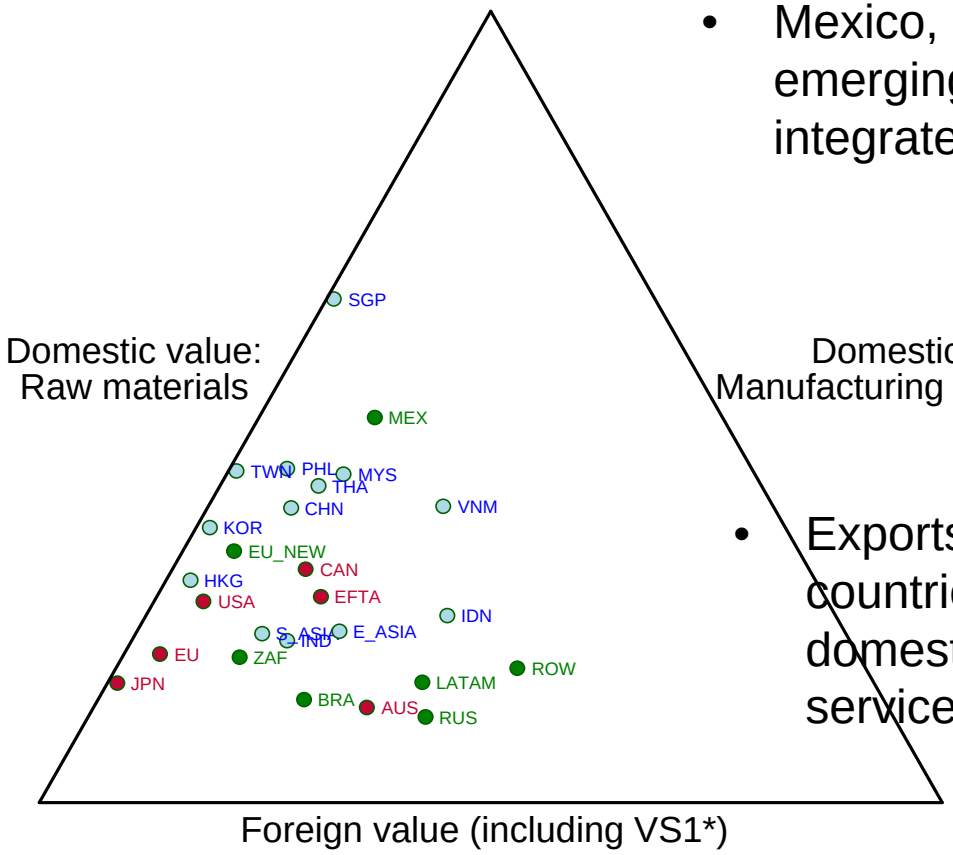
- Measures position in GVC
  - Ratio of indirect intermediates exports to foreign content of exports
  - Higher values: more upstream
    - Greater value sent indirectly
    - Less foreign value in imports
- Shows that Asia is different
- But has problems
  - Doesn't distinguish raw material exporters from large developed countries
  - Not a perfect measure of integration: Both VS1 and VS are high for some countries

Sectoral VS1 to total VS ratios



- Clearly delineates type of indirect exports
- But are services really so similar to manufacturing across countries?

Domestic and foreign value-added shares of gross exports



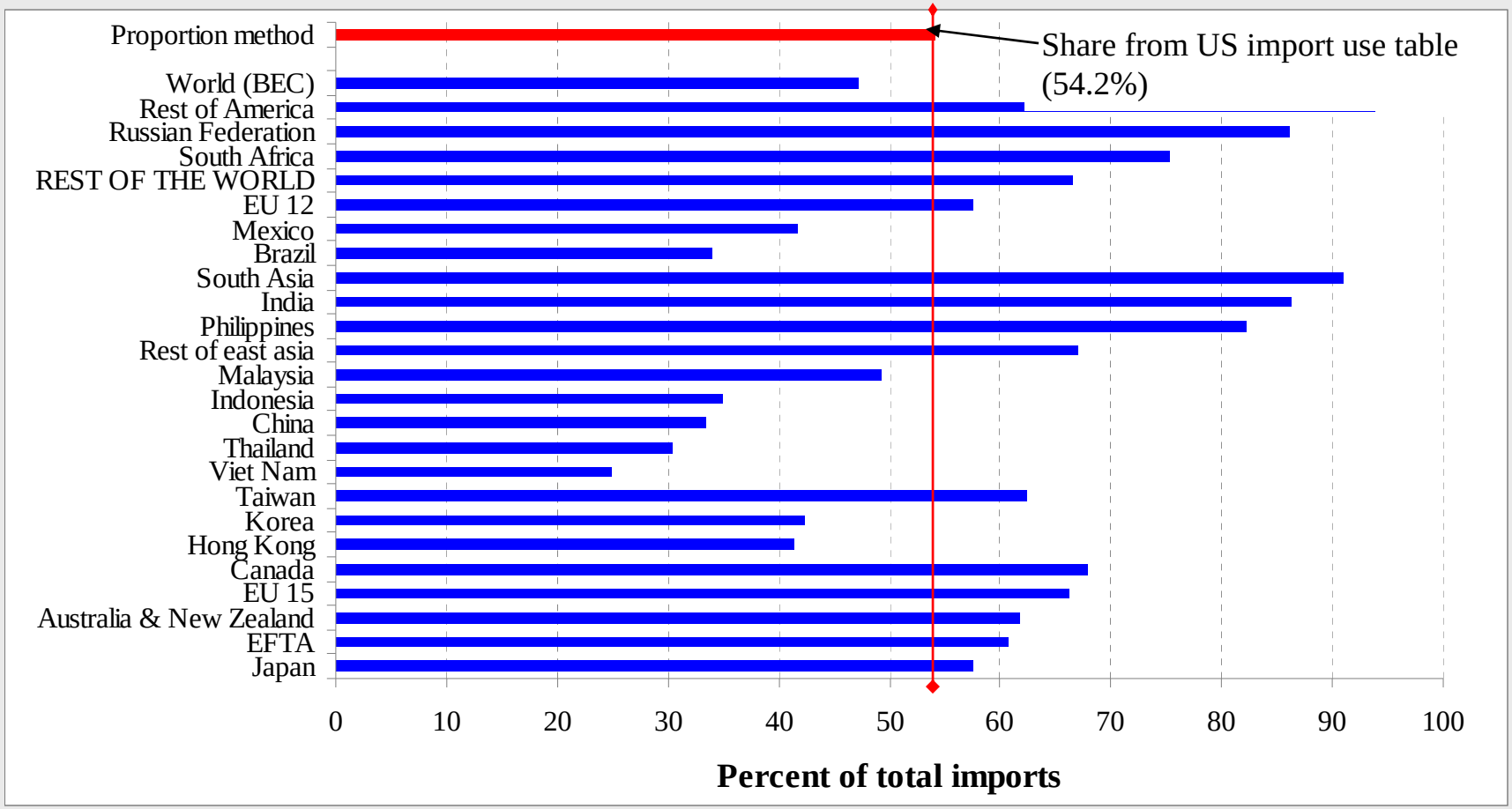
- Mexico, EU accession, and emerging Asia are most tightly integrated into GVCs
- Exports by major advanced countries are predominantly domestic manufacturing and services value added

Database development: Estimating a global Inter-Region IO table

- Start with 2004 GTAP global trade and production database
- But, IRIO requires additional detail on source and use of intermediate inputs and final goods (elements of A_{rs})
- Add detail on processing imports for Mexico and China
- Use detailed trade data (HS 6-digit) to improve imported intermediate use coefficients
  - UN Broad economic classification (BEC) distinguishes intermediate inputs from final goods in imports from each source in each sector
  - Proportional method assumes the intermediate share in imports from each source is the same as in U.S. domestic supply

Why BEC is better than proportional assumption

Intermediates as a share of U.S. electronic machinery imports, 2004



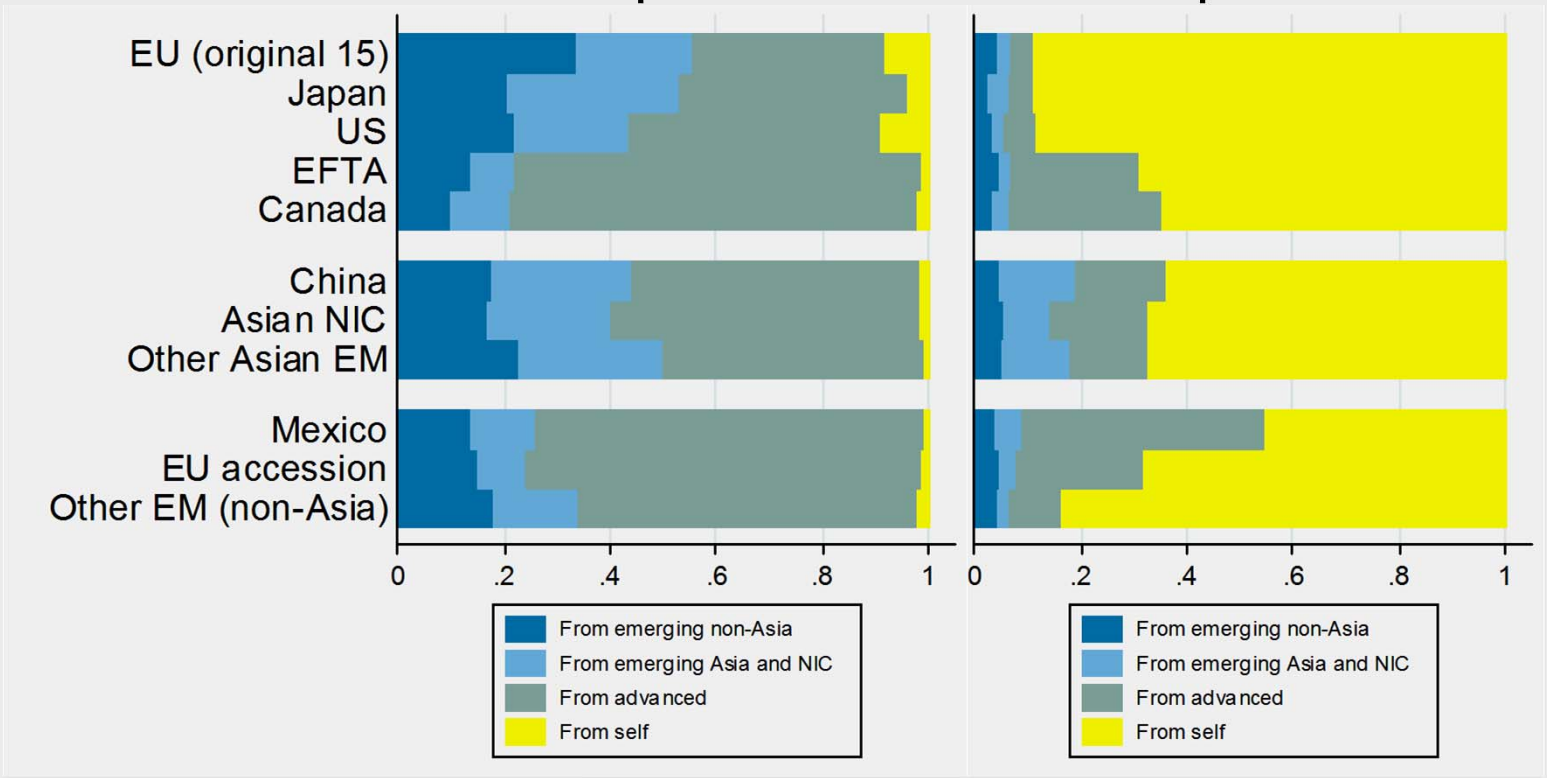
The role of end use classifications and their limitations

- End use classifications such as BEC can improve the accuracy of IO coefficients in IRIO table by giving better row total control for each block matrix in A.
- Proportionality assumptions must still be used to allocate intermediate inputs to each industry *after they enter the importing country*.
  - Industry-level estimates of value-added trade may be unreliable, despite their theoretical tractability
  - More reliable data collected by national agencies are needed to overcome this limitation.

Conclusions

- Big picture fairly complete
  - Can account for entirety of global gross exports
  - Can account for all value-added measures
  - See clear differences in regional integration
    - Asia > North America > Europe
- Next steps
  - Empirical analysis: determinants of differences
  - Better metrics of supply chain participation
  - Extension to sector-level analysis
    - Further estimation of imported intermediate use by sector

Value-added in imports and exports by source



- Imports: Major advanced countries similar to each other and to Asia
- Exports: Major advanced countries similar to each other but not to NICs