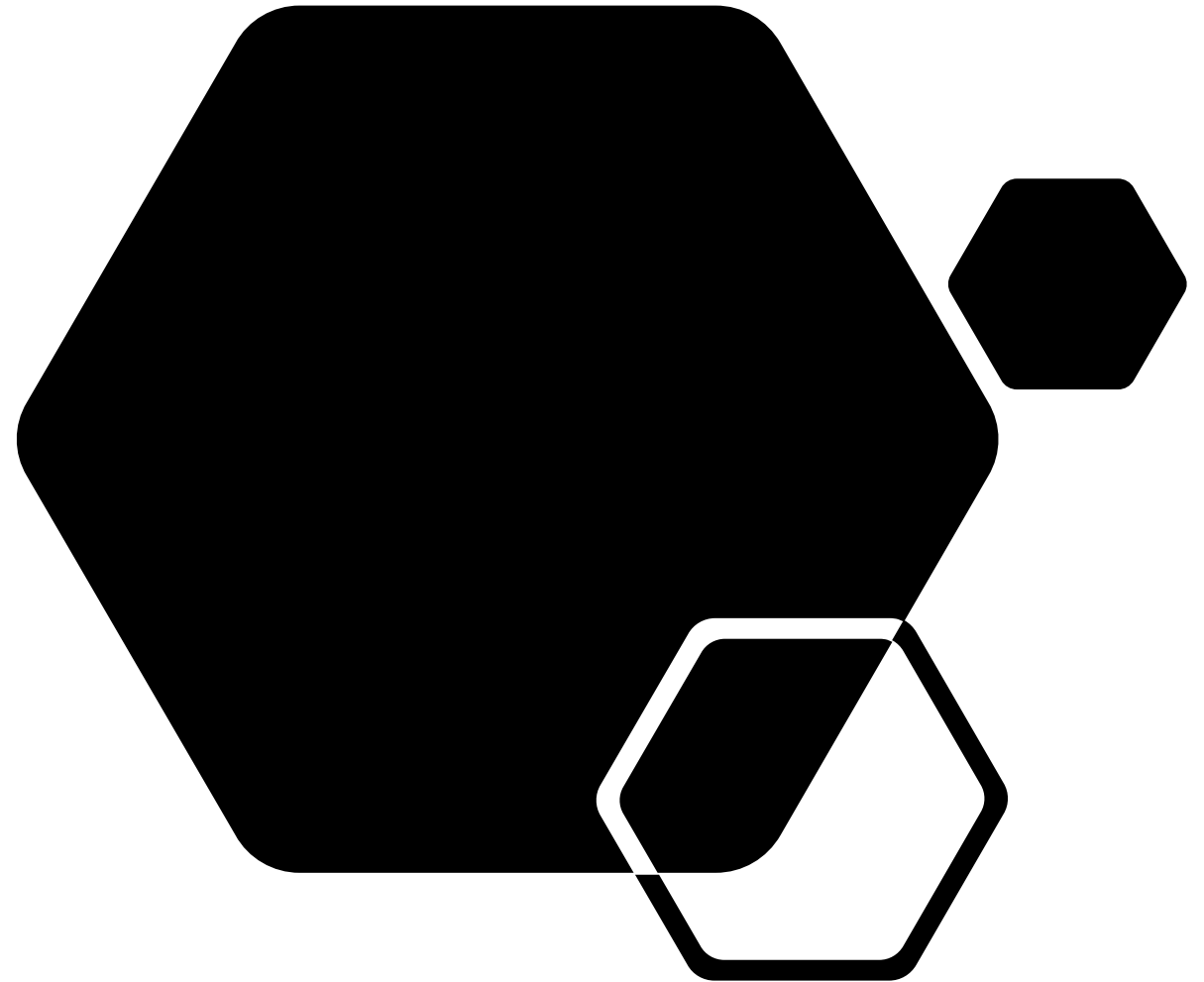
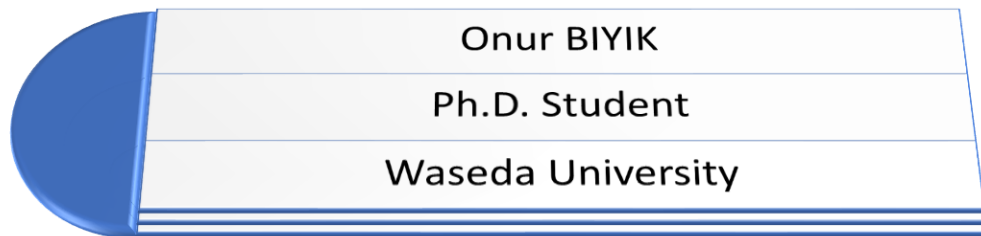


Double Counting in Mystery: Journey of Intermediate Products in Multi- Country Trade



Plan of Talk

1. Introduction and Motivation

2. The Model

- > Basic Matrix
- > Value-Added

3. VA in Export

- > DVA and FVA in two and N countries
- > Empirical Setting
- Data and Result

4. Knowledge spillover in GVC participation

- > Knowledge flow and Matrix
- > Empirical Setting
- Data and measures
- Regression speciation
- Result

5. Discussion of the Empirical Results

- Policy Discussion and Suggestions

6. Conclusion

Preamble

Multinational companies expanded around the world due to the cost-effectiveness of one's location.

Production processes of global firms have become increasingly complex

Procurement and assembly of multiple inputs from multiple countries

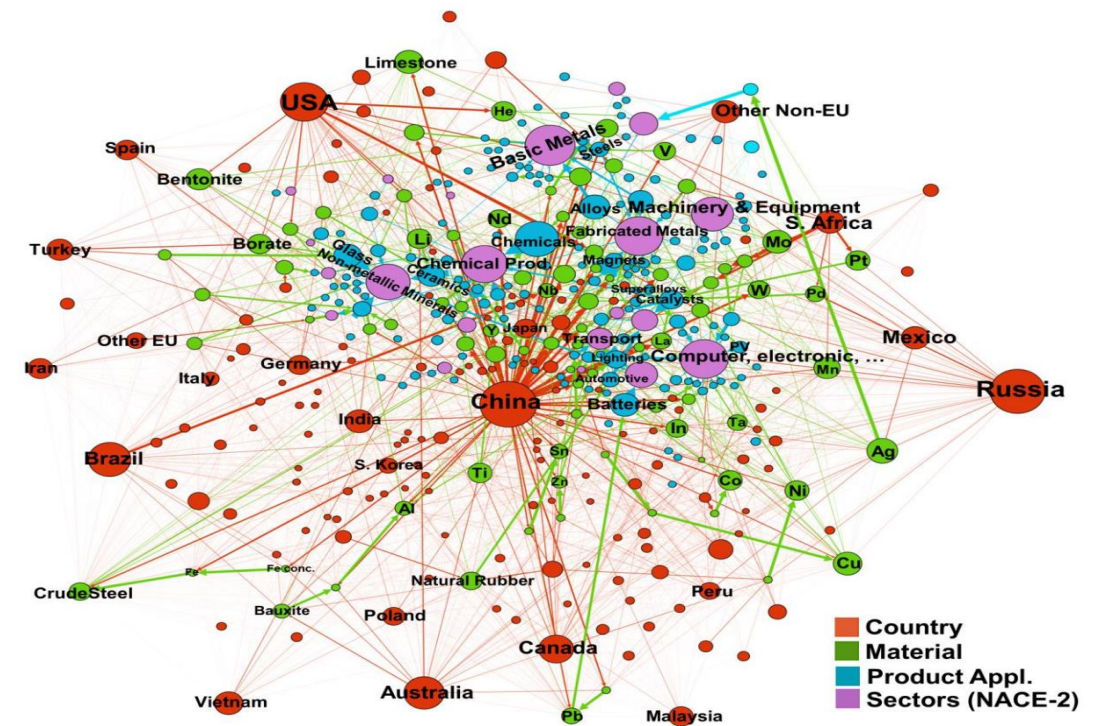
Global production lines feature (at least some element) of sequentiality

- Design > Wafer Fabrication > Assembly > Testing > Distribution

Sequentiality particularly relevant when production crosses national boundaries.

❖ when goods are exported and then it is impossible with available data sources to show where the goods are combined with other components and services

Figure1: Complex Global Supply Chain (Fragmentation of the Production Network)



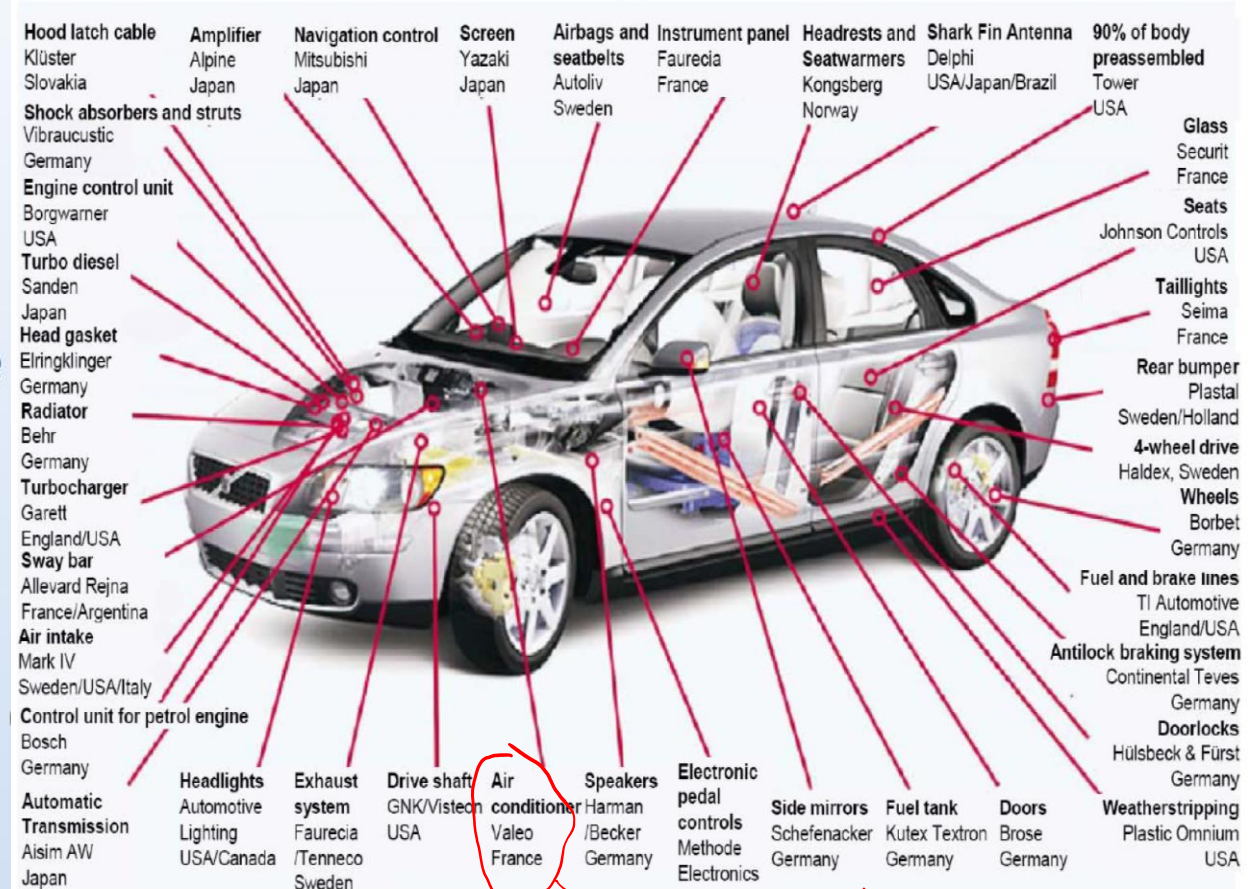
Source: Nuss and Ciuta (2018).

Fragmentation of the Volvo S40 production

Swedish multinational manufacturer

What are GVCs?

- GVCs are factories crossing borders
- Factories that used to be in one nation, in one city (say Detroit) are broken up into various stages of production and some of the stages are moved to nearby low-wage nations



Source: Ericsson Chairman Micheal Treschow

Handwritten red notes: "Gor - it - #1" and "it < G"

Research Question

➤ Background

- ✓ investigate where the VA was created (Koopman et al., 2014; Johnson, 2018) and the upstream effect of VA (Fally, 2012; Antràs et al., 2012; Antràs & Chor, 2013; Wang et al., 2017a),
- ✓ measuring the VA exchange rate (Bems & Johnson 2017), factor content (Trefler & Zhu, 2010), and international inflation spillovers (Auer et al., 2019)

➤ Research question:

1. What is the **challenge** of **measuring double-counting in relation to N-country model**?
2. What role does **the knowledge spillover** play in increased value-added production in the form of exports (its contribution to VA)?

Contribution

➤ Previous research

- ✓ similar to the approach of Koopman, et al. (2010; 2014), Johnson, (2018), Los et al., (2016), and Wang et al. (2017a; 2017b) concerning *double-counting*

➤ The limitation

- ❖ show *where products end*, or *which country/sector receives* these products in the GVC participation
 - 1) two-way gross export (Kuboniwa, 2016; Los, Timmer, & de Vries, 2016)
 - 2) three-way gross export among trade partners (Koopman, Wang, & Wei, 2014; Wang, Wei, & Zhu, 2013).
 - 3) *treats third partners as one unified country* and then segments product parts
- ❖ **The literature lacks an n-way of intermediate export/import in multi-countries.**

➤ This research

- ✓ reveal intermediate trade flow in *continuous integration of the GVC participation*
 - i. third country in more than three-way trade *leads to complex integration "paradox of intertwined trade"*.
- ✓ vertical (*upstream and downstream*) integrations
 - i. merges the (*knowledge*) spillover with GVC participation

The Model: Basic Matrix

$$X^r = A^{r1}X^1 + A^{r2}X^2 + \dots A^{rn}X^n + Y^{r1} + Y^{r2} \dots Y^{rn} \quad (1)$$

$$\begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & \dots & A_{1n} \\ A_{21} & A_{22} & \dots & A_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ A_{n1} & A_{n2} & \dots & A_{nn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} + \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} \quad \#(1.1)$$

$$X = AX + Y$$

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

$$\begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & \dots & B_{1n} \\ B_{21} & B_{22} & \dots & B_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ B_{n1} & B_{n2} & \dots & B_{nn} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} \quad \#(2)$$

the inputs from each sector meet in needed to produce a unit of output in each sector

- ✓ $D^{rr} = (I - A_{ij}^{rr})$, $B = (I - A_{ij})$, $L_{12} [\cong D_{11}A_{12}D_{22}]$, and $B_{12} - L_{12} [F_{12} \cong (B_{11}A_{12}B_{22}) - (D_{11}A_{12}D_{22})]$
- ❖ decomposed the matrix $[B = B^{rr} + B^{rs} = D^{rr} + (B^{rr} - D^{rr}) + L^{rs} + (B^{rs} - L^{rs})]$

$$= \begin{bmatrix} D_{11} & 0 & \dots & 0 \\ 0 & D_{22} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & D_{nn} \end{bmatrix} + \begin{bmatrix} B_{11} - D_{11} & 0 & \dots & 0 \\ 0 & B_{22} - D_{22} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & B_{nn} - D_{nn} \end{bmatrix} + \begin{bmatrix} 0 & L_{12} & \dots & L_{1n} \\ L_{21} & 0 & \dots & L_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ L_{n1} & L_{n2} & \dots & 0 \end{bmatrix}$$

$$+ \begin{bmatrix} 0 & B_{12} - L_{12} & \dots & B_{1n} - L_{1n} \\ B_{21} - L_{21} & 0 & \dots & B_{2n} - L_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ B_{n1} - L_{n1} & B_{n2} - L_{n2} & \dots & 0 \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} \quad \#(4)$$

assumption is that there would be $r,s=1,2,\dots,N$ countries in which produce and input $r(i)$, $s(j)=1,2,\dots,n$ part and components

- X^r is N^n -by-1 output vector of Country r
- Y^r is N^n -by-1 final demand vector of Country r
- $A(A^{rr} + A^{rs})$ N^n -by- N^n (diagonal+off-diagonal) standard matrix of input-output coefficient
- $B = (I - A_{ij})$ is the interregional (Leontief inverse) matrix
- $D^{rr} = (I - A_{ij}^{rr})$ represents local equilibrium
- $(B^{rr} - D^{rr} = F^{rr})$ shows feedback effect
- L^{rs} represents bilateral spillover effect
- $B_{12} - L_{12} = F^{rs}$ feedback spillover effect from multilateral integration

Value Added as vXY

Total final demand ($\sum_{r=1}^n(Y^r) = \sum_{r=1}^n Y^{rr} + \sum_{s \neq r}^n E^{rs}$)

- **domestic final demand** ($\sum_{r=1}^n Y^{rr}$)
- **gross export** ($\sum_{s \neq r}^n E^{rs} = \sum_r^n E^r$)

$$T_v = \begin{bmatrix} v_1 D_{11} Y_{11} & 0 & \cdots & 0 \\ 0 & v_2 D_{22} Y_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & v_n D_{nn} Y_{nn} \end{bmatrix} + \begin{bmatrix} v_1 F_{11} Y_{11} & 0 & \cdots & 0 \\ 0 & v_2 F_{22} Y_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & v_n F_{nn} Y_{nn} \end{bmatrix} + \begin{bmatrix} 0 & v_1 L_{12} Y_{22} & \cdots & v_1 L_{1n} Y_{nn} \\ v_2 L_{21} Y_{11} & 0 & \cdots & v_2 L_{2n} Y_{nn} \\ \vdots & \vdots & \ddots & \vdots \\ v_n L_{n1} Y_{11} & v_n L_{n2} Y_{22} & \cdots & 0 \end{bmatrix} \\ + \begin{bmatrix} 0 & v_1 F_{12} Y_{22} & \cdots & v_1 F_{1n} Y_{nn} \\ v_2 F_{21} Y_{11} & 0 & \cdots & v_2 F_{2n} Y_{nn} \\ \vdots & \vdots & \ddots & \vdots \\ v_n F_{n1} Y_{11} & v_n F_{n2} Y_{22} & \cdots & 0 \end{bmatrix} \\ + \left[\begin{bmatrix} v_1 D_{11} E_1 & 0 & \cdots & 0 \\ 0 & v_2 D_{22} E_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & v_n D_{nn} E_n \end{bmatrix} + \begin{bmatrix} v_1 F_{11} E_1 & 0 & \cdots & 0 \\ 0 & v_2 F_{22} E_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & v_n F_{nn} E_n \end{bmatrix} + \begin{bmatrix} 0 & v_1 L_{12} E_2 & \cdots & v_1 L_{1n} E_n \\ v_2 L_{21} E_1 & 0 & \cdots & v_2 L_{2n} E_n \\ \vdots & \vdots & \ddots & \vdots \\ v_n L_{n1} E_1 & v_n L_{n2} E_2 & \cdots & 0 \end{bmatrix} \right. \\ \left. + \begin{bmatrix} 0 & v_1 F_{12} E_2 & \cdots & v_1 F_{1n} E_n \\ v_2 F_{21} E_1 & 0 & \cdots & v_2 F_{2n} E_n \\ \vdots & \vdots & \ddots & \vdots \\ v_n F_{n1} E_1 & v_n F_{n2} E_2 & \cdots & 0 \end{bmatrix} \right] \quad \#(5.1)$$

Value-Added in Export as (T_v^E)

$$T_v^E = \begin{bmatrix} v^r B^{rr} & v^r B^{rs} & \cdots & v^r B^{rn} \\ v^s B^{sr} & v^s B^{ss} & \cdots & v^s B^{sn} \\ \vdots & \vdots & \ddots & \vdots \\ v^n B^{nr} & v^n B^{ns} & \cdots & v^n B^{nn} \end{bmatrix} \begin{bmatrix} E_{k^*}^r & 0 & \cdots & 0 \\ 0 & E_{k^*}^s & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & E_{k^*}^n \end{bmatrix} = \begin{bmatrix} v^r B^{rr} E_{k^*}^r & v^r B^{rs} E_{k^*}^s & \cdots & v^r B^{rn} E_{k^*}^n \\ v^s B^{sr} E_{k^*}^r & v^s B^{ss} E_{k^*}^s & \cdots & v^s B^{sn} E_{k^*}^n \\ \vdots & \vdots & \ddots & \vdots \\ v^n B^{nr} E_{k^*}^r & v^n B^{ns} E_{k^*}^s & \cdots & v^n B^{nn} E_{k^*}^n \end{bmatrix} \quad (5.1^*)$$

- **v is the n-by-n diagonal** of the VA portion
- **Y is the n-by-n diagonal** of the final demand, representing the **location/place** in which VA is produced

DVA FVA

Domestic Value Added in Export

DVA in Two countries

$$DVA^r = v^r B^{rr} Y^{rs} + v^r B^{rr} (A^{rs} X^s) \quad \text{product stages} \quad (6)$$

$$= v^r (D^{rr} + F^{rr}) Y^{rs} + v^r (D^{rr} + F^{rr}) (A^{rs} X^s)$$

we extend the intermediate product function of **future consumption**: $X^s = [B^{ss} + B^{sr}](Y^{ss} + Y^{sr} + [A^{sr} X^r])$.

PROPOSITION 1: $D^{rr} A^{rs} D^{ss}$, $B^{rr} A^{rs} B^{ss}$, and $F^{rr} A^{rs} F^{ss}$ can replace with L^{rs} , B^{rs} , and F^{rs} , respectively, under condition 1 and Walras' law (see Los et al. (2016) and Johnson (2018))

$$DVA^r = v^r B^{rr} Y^{rs} + v^r [(B^{rs} + B^{rr} A^{rs} B^{sr}](Y^{ss} + Y^{sr} + [A^{sr} X^r])$$

$$DVA^s = v^s B^{ss} Y^{sr} + v^s [(B^{sr} + B^{ss} A^{sr} B^{rs}](Y^{rr} + Y^{rs} + [A^{rs} X^s])$$

$$\rightarrow DVA^r = v^r (D^{rr} + F^{rr}) Y^{rs} + v^r (L^{rs} + F^{rs} + \underbrace{B^{rr} A^{rs} B^{sr}}_{\downarrow})(Y^{ss} + Y^{sr} + [A^{sr} X^r]) \quad (6.1)$$

$$B^r A^s B^{sr} = (D^{rr} + F^{rr}) A^{rs} B^{sr}$$

PROPOSITION 2: products in r stimulated by s multilevel integration are to present downstreamness ($D^{rr} A^{rs} B^{sr} = \lambda^{rs}$). Products in s stimulated by demand from r multinational integration are to present upstreamness ($F^{rr} A^{rs} B^{sr} = \delta^{rs}$). $\Downarrow$

$$DVA^r = v^r (D^{rr} + F^{rr}) Y^{rs} + v^r (\lambda^{rs} + L^{rs} + \delta^{rs} + F^{rs})(Y^{ss} + Y^{sr} + [A^{sr} X^r])$$

$$DVA^s = v^s (D^{ss} + F^{ss}) Y^{sr} + v^s (\lambda^{sr} + L^{sr} + \delta^{sr} + F^{sr})(Y^{rr} + Y^{rs} + [A^{rs} X^s]) \quad (6.2)$$

DVA as a method of absorbing in foreign and domestic countries (see Koopman et al., 2010; 2014).

Equation (6.2) can be transferred,

$$DVA^r = v^r (D^{rr} + F^{rr}) Y^{rs} + v^r (\lambda^{rs} + L^{rs} + \delta^{rs} + F^{rs}) [A^{rs} X^{ss} + A^{rs} X^{sr}] \quad (6.2^*)$$

- $E^{rs} = Y^{rs} + A^{rs} X^s$
- Y^{rs} : final goods in r export to s
- $A^{rs} X^s$: intermediate goods in r export to s

❖ Vertical integration triggers spillovers by GVC

❖ upstream suppliers through relationship-specific interactions/investments affect the incentives of suppliers in downstream stages (see Alfaro et al. (2019) for more details) regarding sequential complements/substitutes in the production process.

- $(A^{rs} X^{ss})$ intermediated absorbed in s
- $(A^{rs} X^{sr})$ processed and exported back to r

DVA in N countries

$$DVA^r = v^r B^{rr} E^{rs} + v^r B^{rr} \sum_{l \neq r, s}^n E^{rl}$$

$$v^r B^{rr} E^{rs} = v^r B^{rr} Y^{rs} + v^r \{\lambda^{rs} + L^{rs} + \delta^{rs} + F^{rs}\} \left(A^{rs} X^{ss} + A^{rs} X^{sr} + \sum_{l \neq r, s}^n A^{rs} X^{sl} \right) \quad (8)$$

$$DVA^l = \sum_{l \neq r, s}^n v^l \sum_{l \neq r, s}^n X^l = \sum_{l \neq r, s}^n v^l \left(\sum_{l \neq r, s}^n (B^{ll} E^{lr}) + \sum_{l \neq r, s}^n (B^{ll} E^{ls}) + \sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n (B^{ll} E^{lt}) \right), t \in l = \{t-1, t, \dots, n\}$$

$$= \left(\sum_{l \neq r, s}^n v^l \right) \left(\sum_{l \neq r, s}^n (B^{ll} Y^{lr}) + \sum_{l \neq r, s}^n (B^{ll} A^{lr} X^r) + \sum_{l \neq r, s}^n (B^{ll} Y^{ls}) + \sum_{l \neq r, s}^n (B^{ll} A^{ls} X^s) + \sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n B^{ll} Y^{lt} + \sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n B^{ll} A^{lt} X^t \right) \quad (8.1)$$

To extend the $\sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n B^{ll} Y^{lt} + \sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n B^{ll} A^{lt} X^t$ based on equation 6.2*

$$\left(\sum_{l \neq r, s}^n v^l \right) \left[\sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n B^{ll} Y^{lt} + \sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n B^{ll} A^{lt} X^t \right]$$

$$= \left(\sum_{l \neq r, s}^n v^l \right) \left(\sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n \left[B^{ll} Y^{lt} + B^{ll} A^{lt} X^{tt} + B^{ll} A^{lt} X^{tr} + B^{ll} A^{lt} X^{ts} + B^{ll} A^{lt} X^{tl} + \sum_{k \neq r, s, l, t}^n B^{ll} A^{lt} X^{tk*} \right. \right.$$

$$\left. \left. + \dots + \sum_{k \neq r, s, l, t}^n \dots \sum_{x \in n} B^{ll} A^{lx} X^{x*} \right] \right), \quad k, x \in t = [k-1, k, k+1, \dots, n] \quad \#(8.2)$$

BOX 2: Sector-Country Pairs in GVC Participation

To estimate the stage of traveling products, this paper modifies the integration of intermediate trade flow. As we defined r as a country ($r, s \in \mathcal{R}$), i as sector ($i, j \in \mathcal{I}$), and k as sector-country pairs $\{k[r(i), s(j)] \in \mathbb{K}\}$; thus, intermediate flow at sector-country pairs present $P^n(k^n, k^{n-1}, \dots, k^1, r)$, where inputs are sold from k^n to the sequence $k^{n-1} \rightarrow k^{n-2} \rightarrow \dots \rightarrow k \rightarrow r$ (Japan). This stage of GVC participation in production activities can illustrate that intermediate flow at sector-country pair can explain how many inputs are sold from k^n to r . For example, produced products in k^{n-1} are sold to k^{n-2} , so on and so forth, until the products arrive at k^1 and are put into final goods that are shipped and sold to consumers in r . To illustrate sector-country pairs in GVC participation at bilateral integration in the last two stages. VA can be written,

$$VA = \sum_{n=2}^{\infty} \dots \sum_{k \in \mathbb{K}} VA^n(k^n | k^2, k, r)$$

However, this becomes more complicated when intermediate inputs flow at multilateral integration (see equation 8.1). Theoretical frameworks of highly stylized sequential production do not characterize asymmetries across production stages (see Alfaro et al. (2019) for firm-level solutions). This is because the production activities of transactions among countries are not easily observed. However, de Gortari (2019) reports that this challenge can be solved by specializing input in the roundabout model (US, MEX, CAN).

✓ $(\sum_{l \neq r, s}^n A^{rs} X^{sl})$ is processed and exported to third countries

✓ straightforward due to a single country's relationship with n countries

❖ how do third countries distribute their export with partners (r and s) and within third countries in relation to complex/continuous production processes in multi-level integration?

✓ define third countries DVA^l in export content

✓ introduce (n-2) countries' trade with (n-3) countries

Let's arrange the X^r with equation (8.1)

$$DVA^r = v^r \left[\underbrace{B^{rr}Y^{rs} + B^{rr}A^{rs}X^s}_{E^r} + B^{rr} \sum_{l \neq r,s} Y^{rl} + B^{rr} \sum_{l \neq r,s} A^{rl}X^{lt*} + B^{rr} \sum_{l \neq r,s} \sum_{t \neq r,s,l} A^{rl}X^{lt*} \right]$$

✓ $\sum_{l \neq r,s}^n \sum_{t \neq r,s,l}^n A^{rl}X^{lt*}$ that processed and exported to t (intermediate absorbed in (n-3) countries) from l countries (n-2).

reach out to draw equation (8.3)

$$v^r B^{rr} \sum_{l \neq r,s}^n E^{rl} = v^r B^{rr} \sum_{l \neq r,s} Y^{rl} + v^r \left[\sum_{l \neq r,s} (\lambda^{rl} + L^{rl} + \delta^{rl} + F^{rl}) \right] \left[\sum_{l \neq r,s} A^{rl}X^{lr} + \sum_{l \neq r,s} A^{rl}X^{ls} + \sum_{l \neq r,s} A^{rl}X^{ll} + \sum_{l \neq r,s} \sum_{t \neq r,s,l} A^{rl}X^{lt} \right] \quad (8.3)$$

The number of (t) countries' continued trade integration with others can be written

$$= v^r B^{rr} \sum_{l \neq r,s} Y^{rl} + v^r \left[\sum_{l \neq r,s} (\lambda^{rl} + L^{rl} + \delta^{rl} + F^{rl}) \right] \left[\sum_{l \neq r,s} A^{rl}X^{lr} + \sum_{l \neq r,s} A^{rl}X^{ls} + \sum_{l \neq r,s} A^{rl}X^{ll} + \sum_{l \neq r,s} \sum_{t \neq r,s,l} A^{rl}X^{lt*} + \dots \right. \\ \left. + \sum_{l \neq r,s} \sum_{t \neq r,s,l} \sum_{k \neq r,s,l,t} \dots \sum_{x \in n} A^{lx}X^{x*} \right] \quad (8.4^*)$$

the number of (t) countries have trade integration with r, s, l , and $(t - 1)$ countries.

build DVA by combining equations (8) and (8.3) (as can be interpreted Japan (r), Africa (s), and $\sum_{l \neq t}^n ROW$ (l)),

this process continues until intermediate goods finalize their journey to be final goods that are shipped and sold to consumers in x as

$$DVA^r = v^r [D^{rr} + F^{rr}] \left(Y^{rs} + \sum_{l \neq r,s} Y^{rl} \right) + v^r \{ \lambda^{rs} + L^{rs} + \delta^{rs} + F^{rs} \} \left(A^{rs}X^{ss} + A^{rs}X^{sr} + \sum_{l \neq r,s} A^{rs}X^{sl} \right) \\ + v^r \left(\sum_{l \neq r,s} \{ \lambda^{rl} + L^{rl} + \delta^{rl} + F^{rl} \} \right) \left(\sum_{l \neq r,s} \left[A^{rl}X^{ll} + A^{rl}X^{lr} + A^{rl}X^{ls} + \sum_{t \neq r,s,l} A^{rl}X^{lt} \right] \right) \quad \#(9)$$

FVA in Two countries

$$\begin{aligned} FVA^r &= v^s B^{sr} E^{rs} = v^s (B^{sr})(Y^{rs} + [A^{rs}X^s]) \\ &= v^s B^{sr} Y^{rs} + v^s B^{sr} (A^{rs} X^s) - v^s B^{sr} Y^{rs} = v^s [(L^{sr} + F^{sr})(A^{rs} X^s)] \end{aligned} \quad (10)$$

FVA in N countries

$$\begin{aligned} FVA^r &= v^s B^{sr} E^{rs} + \sum_{l \neq r, s}^n (v^l) \sum_{l \neq r, s}^n (B^{lr} E^{rl}) \\ &= v^s (L^{sr} + F^{sr})(Y^{rs} + A^{rs} X^s) + \left(\sum_{l \neq r, s}^n (v^l) \sum_{l \neq r, s}^n (L^{lr} + F^{lr}) \right) \left(\sum_{l \neq r, s}^n Y^{rl} + \sum_{l \neq r, s}^n A^{rl} X^{l*} + \sum_{l \neq r, s}^n \sum_{t \neq r, s, l}^n A^{rl} X^{lt} \right) \quad \#(11) \end{aligned}$$

- Is it clear to eliminate the return home part?
- ✓ the return home part becomes impossible to track and then eliminate (see equations (8.1; 8.2; 8.4))
- ❖ Use equation (5.1*) to estimate optimal contribution to sectoral output

equations (8.2; 8.4) show that we cannot track intermediate export and the origin of goods

this process continues until intermediate goods finalize their journey to be final goods that are shipped and sold to consumers in x as

Estimation Techniques in line with the theory-consistent empirical work

Input-Output (I/O) Database

- Input-Output (I/O) databases are most commonly used to examine GVC, DVA FVA
- developed a GTAP-MRIO table based on Peters et al. (2011) and Walmsley et al. (2014)
- aggregated data relies on 3 regions (countries) and 4 sectors.

Result1 from I/O

- ✓ sectoral distribution of international **sectoral linkages**, which leads overestimate VA in some conditions, is to display around **1.5%** if the average product crosses the border only **twice as return the origin of the product home**
- consistent with WB's (2020) estimation such as 1.7% for Germany and so on

Table 1: Contribution of Sectoral Linkages (Sourcing-Side) to Sectoral Outcome (%)

		$\sum_{r=1}^3 \sum_{i=1}^4 v_i^r$	$\sum_{r=1}^3 \sum_{i=1}^4 B_i^{rr}$	$\sum_{r,s=1.1}^3 \sum_{i=1}^4 B_i^{rs}$	$\sum_{r=1}^3 \sum_{i=1}^4 D_i^{rr}$	$\sum_{r=1}^3 \sum_{i=1}^4 F_i^{rr}$	$\sum_{r,s=1.1}^3 \sum_{i=1}^4 L_i^{rs}$	$\sum_{r,s=1.1}^3 \sum_{i=1}^4 F_i^{rs}$
Japan	AGR	0.380	99.82%	0.18%	99.7869%	0.0317%	0.1544%	0.0270%
	MN	0.230	99.59%	0.41%	99.4859%	0.1010%	0.3567%	0.0565%
	MANF	0.277	96.31%	3.69%	95.6490%	0.6629%	3.1278%	0.5603%
	SRV	0.594	98.73%	1.27%	98.5112%	0.2178%	1.0931%	0.1779%
Japan Average		0.482	98.46%	1.54%	98.1812%	0.2750%	1.3178%	0.2260%
Africa	AGR	0.714	99.29%	0.71%	99.2368%	0.0573%	0.6073%	0.0986%
	MN	0.620	86.62%	13.38%	85.8669%	0.7522%	9.1372%	4.2437%
	MANF	0.311	98.20%	1.80%	98.0210%	0.1804%	1.4086%	0.3900%
	SRV	0.562	97.64%	2.36%	97.4777%	0.1656%	1.7048%	0.6519%
ROW	AGR	0.473	87.11%	12.89%	86.9739%	0.1404%	12.7568%	0.1289%
	MN	0.383	56.66%	43.34%	56.2998%	0.3644%	42.9900%	0.3458%
	MANF	0.269	66.80%	33.20%	66.2941%	0.5048%	32.7256%	0.4754%
	SRV	0.555	75.90%	24.10%	75.5691%	0.3336%	23.7739%	0.3235%
All Average		0.459	84.73%	15.27%	84.4182%	0.3166%	14.6248%	0.6404%

Note: v is the proxy of VA in total output. This analysis relies on the Leontief inverse matrix (see equation 5.2)

Source: GTAP 10A MRIO Database, author's estimation.

Knowledge spillover in GVC participation

- ❖ GVC can be one of the important channels of knowledge spillovers that drive up innovation/productivity, see equation (6.2/6.2*)
- (i) high intensity between foreign firms and domestic suppliers (World Bank (WB), 2020; Piermartini & Rubínová, 2021)
- (ii) (efficient) production of the outsourced inputs of which foreign outsourcing firms will eventually be the consumer (Baldwin & Lopez, 2015).

transmitted through

- 1) international trade in final, intermediate, and capital goods,
- 2) FDI
- 3) migration of educated people
- 4) publications in technical journals and
- 5) foreign technology payments

➤ PROPOSITION 4: Knowledge flow relying on the production process among sector-country pairs at multilateral integration is to display jointly marginal distributional impact.

❖ We created the knowledge flow model based on Bottazzi and Peri (2003).

$$\sum \eta_{ij}^{rs} = \sum C_j^s \prod_{s \neq r} IMP_{ij}^{rs} \quad (12)$$

GVC initializers become more productive, and this better performance accumulates over time. (Baldwin and Yan, 2014)

$\zeta_{r(i)s(j)}^{\dagger}$ (the production stages of continuum inputs): $1 + (\eta_{ij}^{rs})^1 + (\eta_{ij}^{rs})^2 + \dots (\eta_{ij}^{rs})^{\dagger-1}$

$$\zeta_{r(i)s(j)}^{\dagger} = \begin{bmatrix} 1, & \sum \eta_{ij}^{rs} = 0 \\ \frac{1}{1 - \eta_{ij}^{rs}}, & 0 < \sum \eta_{ij}^{rs} < 1 \end{bmatrix}, \quad \dagger \approx \infty$$

Supply chain crosses
country's border 2
Supply chain crosses
country's border 3
Supply chain
crosses
country's
border n times
(12.1)

- η_{ij}^{rs} is knowledge flow in relation to distribution probability in export
- IMP is the international knowledge spillovers embodied in trade goods
- C is the other variables, which have an impact on knowledge flow in regions
- $\zeta_{r(i)s(j)}^{\dagger}$ in line with supplier and consumer lengths (see Dietzenbacher et al. (2005) and Antràs et al. (2012) for average propagation lengths)

Employed the logic of Treffer and Zhu (2010) and Koopman et al. (2010) to merge the knowledge flow with GVC participation

$$\zeta_{T_v}^{\dagger} = \begin{bmatrix} \zeta_r^{\dagger} & 0 & \dots & 0 \\ 0 & \zeta_s^{\dagger} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \zeta_n^{\dagger} \end{bmatrix} \begin{bmatrix} v^r B^{rr} E_{k^*}^r & v^r B^{rs} E_{k^*}^s & \dots & v^r B^{rn} E_{k^*}^n \\ v^s B^{sr} E_{k^*}^r & v^s B^{ss} E_{k^*}^s & \dots & v^s B^{sn} E_{k^*}^n \\ \vdots & \vdots & \ddots & \vdots \\ v^n B^{nr} E_{k^*}^r & v^n B^{ns} E_{k^*}^s & \dots & v^n B^{nn} E_{k^*}^n \end{bmatrix} = \begin{bmatrix} \zeta_r^{\dagger} v^r B^{rr} E_{k^*}^r & \zeta_r^{\dagger} v^r B^{rs} E_{k^*}^s & \dots & \zeta_r^{\dagger} v^r B^{rn} E_{k^*}^n \\ \zeta_s^{\dagger} v^s B^{sr} E_{k^*}^r & \zeta_s^{\dagger} v^s B^{ss} E_{k^*}^s & \dots & \zeta_s^{\dagger} v^s B^{sn} E_{k^*}^n \\ \vdots & \vdots & \ddots & \vdots \\ \zeta_n^{\dagger} v^n B^{nr} E_{k^*}^r & \zeta_n^{\dagger} v^n B^{ns} E_{k^*}^s & \dots & \zeta_n^{\dagger} v^n B^{nn} E_{k^*}^n \end{bmatrix} \quad (5.1^{**})$$

Estimation Techniques in line with the theory-consistent empirical work

Patent Panel Database

- The patent citation data between 2001 and 2010 from PATSTAT
- trade data at the International Standard Industrial Classification 4-digit level from UN Comtrade
- Others from CEPII GeoDist

1. knowledge flow classification of patents and industry classifications of trade goods were merged (Schmoch et al., 2003)
2. The dataset covers 14 East Asian countries

paper's logic is in line with Bottazzi and Peri (2003) who found that knowledge spillovers decay with distance

➤ Our empirical models followed by Nabeshima et al. (2018) are determined

$$\ln\left(\sum \eta_{ij}^{rs}\right) = \beta_0 + \beta_1 IMP_{ij}^{rs} + \beta_2 Control_{rs} + \alpha_t + \chi_{ij} + \varepsilon_{rs} \quad (Rg.1)$$

$$\ln\left(\sum \eta_{ij}^{rs}\right) = \exp[\beta_0 + \beta_1 IMP_{ij}^{rs} + \beta_2 Control_{rs} + \alpha_t + \chi_{ij}] + \varepsilon_{rs} \quad (Rg.2)$$

- $\ln(\sum \eta_{r(i)s(j)})$ represents the log of the number of patent citations, which accounts for all applicants in country r to country s in industry ij in year t, as a percentage of knowledge flow
- IMP_{ij}^{rs} represents bilateral trade flow of imports
- Control variables present a log of Distance-based on each country's capital, as well as a dummy of the Language and Border
- χ_{ij} captures sector-fixed effect and α_t captures year-fixed effect.

❖ Patenting data are non-negative; thus, we employed Negative Binomial Regression (NBReg) and Poisson Pseudo-likelihood regression with Multiple Levels of fixed effects (PPML)

(i) NBReg: Negative Binomial Regression

(ii) PPML: Silva and Tenreyro (2006;2010): naïve method

Result2

- Knowledge spillover displays between 0.018% and 0.643% for all East Asian countries
- $\zeta_{r(i)s(j)}^+$ for average in Japan accounts for $1 + 0.058 + (0.058)^2 + \dots + (0.058)^\infty$ due to the continuous integration in the multilateral trade,

✓ Traveling goods regarding production stages contribute more by 1.6% ($1.54 \times 1.058 = B\zeta$) to 154% ($1,54 \times 10000/9942$) as twice and infinity times

✓ Its contribution to VA as twice or infinity (see equation 5.1**) result in boosting extra by 0.8% ($0.48 \times 1.54 \times 1.058 = vB\zeta$) to 72% ($0.48 \times 1,54 \times 10000/9942$)

Table 2: Pooled Estimates of $\ln(\sum \eta_{ij}^{rs})$ Citation/Knowledge Flow (%)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Import</i>	0.000175*** (5.39e-05)	0.000239*** (4.58e-05)	0.000258*** (4.29e-05)	0.00643*** (0.00140)	0.000575*** (0.000204)	0.00126*** (0.000192)	0.000721* (0.000417)	0.000700*** (0.000172)
<i>Lalpha</i>				5.364*** (0.0746)				
<i>Constant</i>	29.81*** (1.393)	33.75*** (1.029)	35.98*** (1.040)	39.66*** (2.539)	95.54*** (21.78)	104.1*** (5.776)	25.37** (9.995)	111.0*** (20.95)
→ <i>Estimator</i>	PPML	PPML	Poisson	NBReg	PPML	PPML	PPML	PPML
→ <i>Region</i>	All	All	All	All	Japan	Japan	Japan	Japan
→ <i>Sector</i>	All	All	All	All	All	Agri	Mining	Manufact
<i>Regression</i>	Rg.2	Rg.2	Rg.1	Rg.1	Rg.2	Rg.2	Rg.2	Rg.2
<i>Period</i>	2001-10	2001-10	2001-10		2001-10	2001-10	2001-10	2001-10
<i>ContVar</i>	✓	✓	✓	✓	✓	✓	✓	✓
<i>Year Dummy</i>	✓	✓						
<i>Sector Dmmy</i>	✓							
<i>Cluster-ID</i>	✓	✓	✓	✓	✓	✓	✓	✓
→ <i>Observations</i>	64,949	68,060	68,060	68,060	5,280	240	140	4,800
<i># Countries</i>	14	14	14	14	13	13	13	13
<i>Pseudo R2</i>	0.4952	0.2731		0.0271	0.6243	0.7732	0.8239	0.6587

Note: (1)***, **, * represent significance at 1%, 5% and 10% level respectively; (2) standard errors in parentheses. NBReg and PPML stand for, respectively, Negative Binomial Regression and Poisson pseudo-likelihood regression with multiple levels of fixed effects. ContVar includes Distance, Language, and Border. Sector classified product codes of 1-2 for Agriculture, 9 for Mining, 3-8 and 10-44 for Manufacturing, and 5 for Service, see Appendix Table 1 in Nabeshima et al. (2017). We could not estimate citation in the service sector in Japan due to the "0" standard deviation (min and max 0). Cluster-ID stands for technological influence among the heterogenized sector-county pairs (Eaton, & Kortum, 2002); Thus, this applies to the spillover effect on heterogenous sector-country pairs as a contribution within a country and among countries.

Source: Patent Panel dataset, author's estimation.

Discussion of the Empirical Results

➤ What did we study in this work?

- ✓ challenge of the Double counting and knowledge spillover with GVC participation

➤ What is the challenge of measuring double-counting?

- ✓ theoretically reveal intermediate trade flow in continuous integration of the GVC participation, "paradox of intertwined trade".
- ✓ the optimal double-counting coefficient is about 1.54 % in terms of (single) country-level data.

- i. to imply Koopman et al. (2014), sectoral linkages becomes very small coefficient (versa the great unbundling!! Factor Asia/EU/America)

➤ What role does the technological spillover effect play?

- ✓ Traveling goods regarding production stages contribute more by 1.6% ($1.54 \times 1.058 = B\zeta$) to 154% ($1.54 \times 10000/9942$)

- i. Its contribution to VA as twice or infinity (see equation 5.1**) result in boosting extra by 0.8% ($0.48 \times 1.54 \times 1.058 = vB\zeta$) to 72% ($0.48 \times 1.54 \times 10000/9942$)

➤ To compare this paper's result with the existed studies

1. Consistent with theoretical and empirical results “*more productive firms should integrate more inputs*” in production stages (Alfaro et al., 2019)
 2. Global supply chain shocks (no intermediates trade) result in decreasing (national) GDP lowered by 3% to 70% (Caliendo and Parro, 2015)
- ✓ shock, (labor shortage due to covid), that affects VA rather than the production, (their) gains from trade are most like to diminish by 0.8% to 72%,

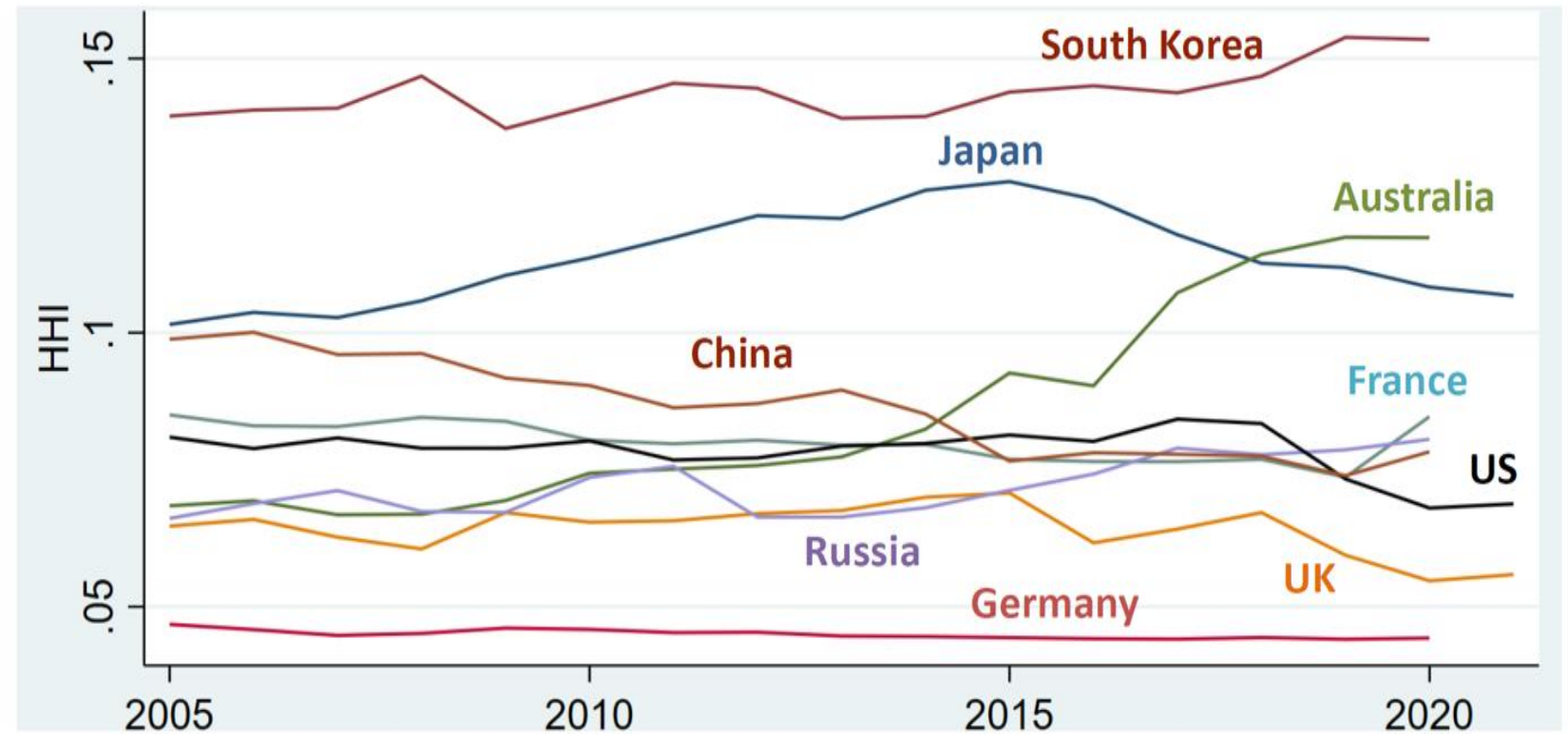
❏ Note

- ❖ the role of GVC in international knowledge spillovers is essential for gauging the impact on economic growth!

Policy Discussion and Suggestions

- geographically diversified supply chains are **more innovative due to learning new knowledge from distant partners** (Iino et al., 2021; Nabeshima et al., 2018).
 - policies that encourage **diversification of foreign suppliers' lower volatility** by reducing the exposure to individual economies (Baldwin & Freeman, 2021)
1. the diversity of goods as well as markets, which not only **boosts its welfare/GDP** but also **improves recovery dynamism** from any negative shocks.
-
- **But there are still high costs of management and face-to-face for firms (leading to unbundling!)**

Figure 2: Concentration Index (HHI) of Partner Countries in Intermediate-Good Imports



Source: International Trade Center-TradeMAP regarding UN Comtrade.

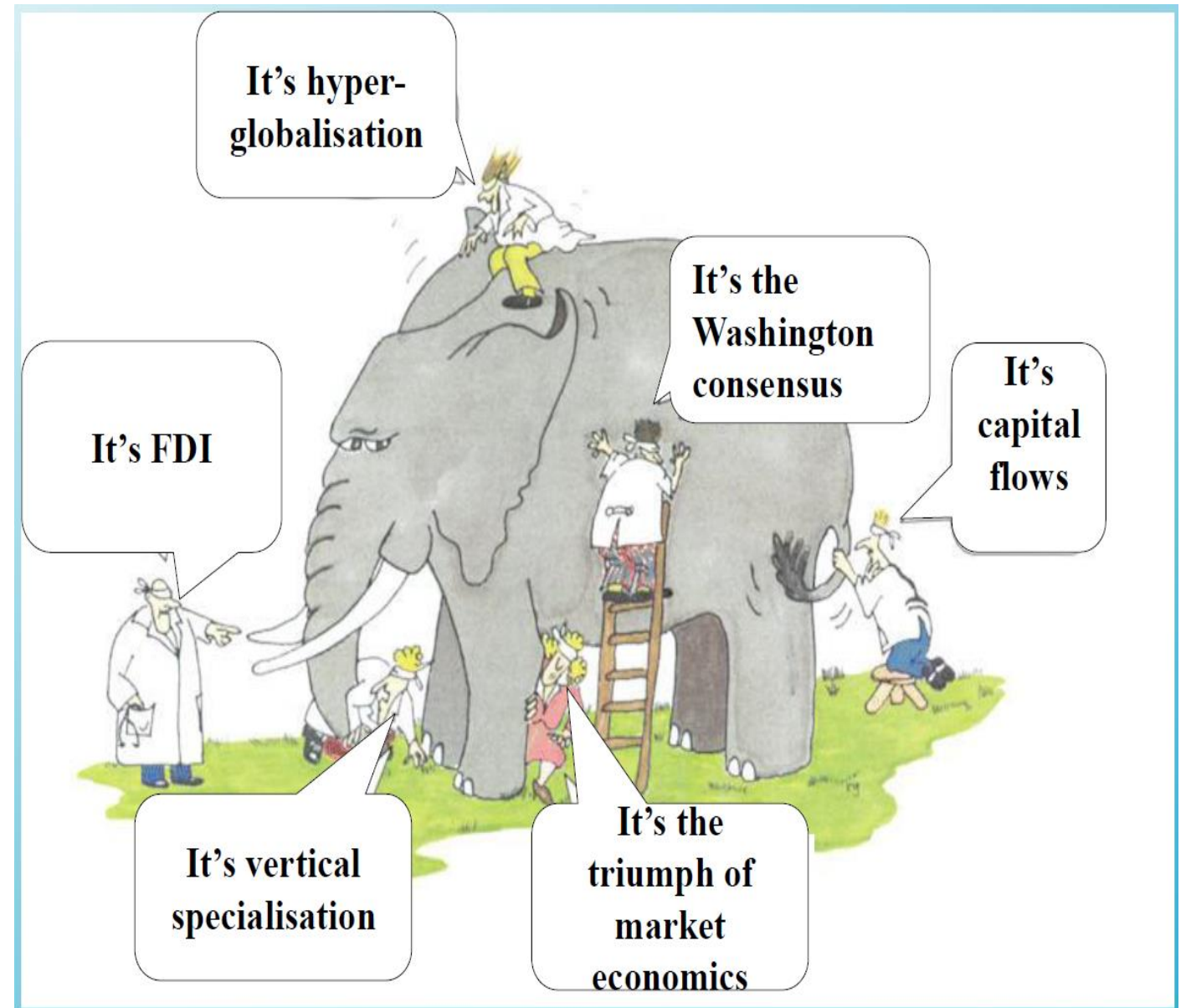
How to solve current challenges?

COVID-19, Global warming, the US-China trade war, and the Russian-Ukrainian war?

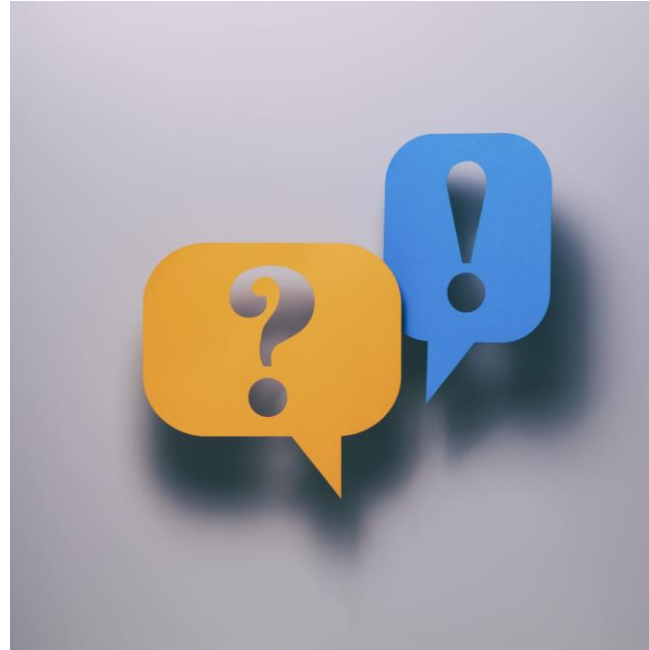
GVC distortion

From 2018: nation-specific conflict
2) it's beyond firm decision

- ✓ building **greater global governance** (WTO and UN) and cooperation will be long run solution for **distortion of adjustment** from agglomeration of GVC in specific region and **any conflicts**.
- ✓ **Tariff and TFA** under WTO
- Otherwise, there **is import-related negative** spillover effect such as **cost-push inflation** under macro-economic uncertainty/instability



Thank you!



- Q&A
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