Global value chains: Concepts and measurement

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*The views expressed are these of the author

Outline

- Motivation: Why it is important to analyse Global Value Chains (GVCs)?
- Main concepts and definitions:
  - -Gross vs value added trade
  - -Main GVC indicators
- Data and Measurement:
  - -Global Input-Output Tables and Leontieff representation
- Practical applications

Why it is important to analyse GVCs?

- Global value chains have emerged as dominant paradigms in production worldwide. Trade in intermediate goods (eg: parts and components) accounts for more than 50 percent of global trade
- While participation in GVCs might have come to a halt, production remains highly fragmented across countries
- Trade in GVCs key in the transmission of shocks across countries and for price formation
- Conventional trade statistics (balance of payment statistics and national accounts) not suitable to analyze GVCs
- New methods and data have emerged to monitor trade flows through the GVC

Main concepts

Gross vs value added trade: Definitions

➢ Gross trade

Traditional trade measures record goods and services on a gross basis, which is every time they cross a border. This includes the cost of inputs, plus the value added by each country

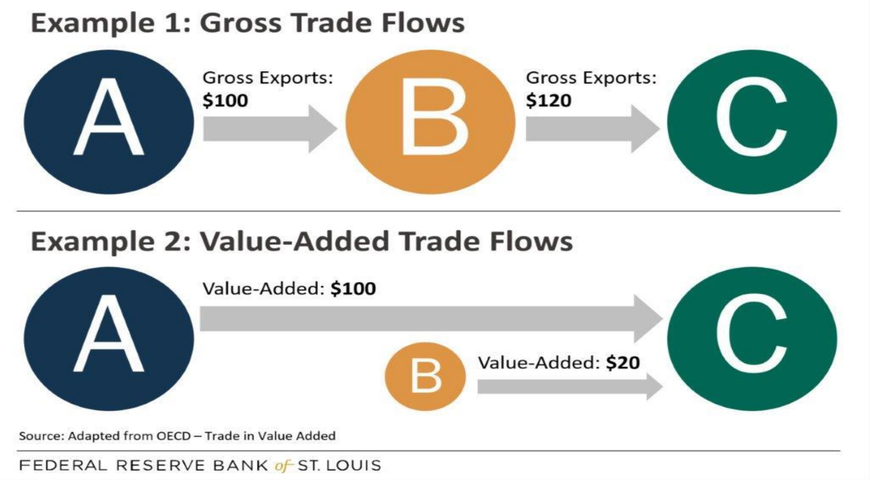
➢ Value added trade

Gross exports are broken down according to the country and industry of origin and destination of value added, such that value added is traced across borders and apportioned to the countries where it is produced. According to Borin and Mancini (2019), GVC trade includes all the traded items that cross at least two international borders, i.e. that are re-exported at least once before being finally consumed

➢ Global value chain (GVCs)

A series of stages involved in producing products and services that are sold to consumers, with each stage adding value (Antras, 2020). Within GVCs, different stages of the production process are located across different countries

Gross trade vs value added trade: Example



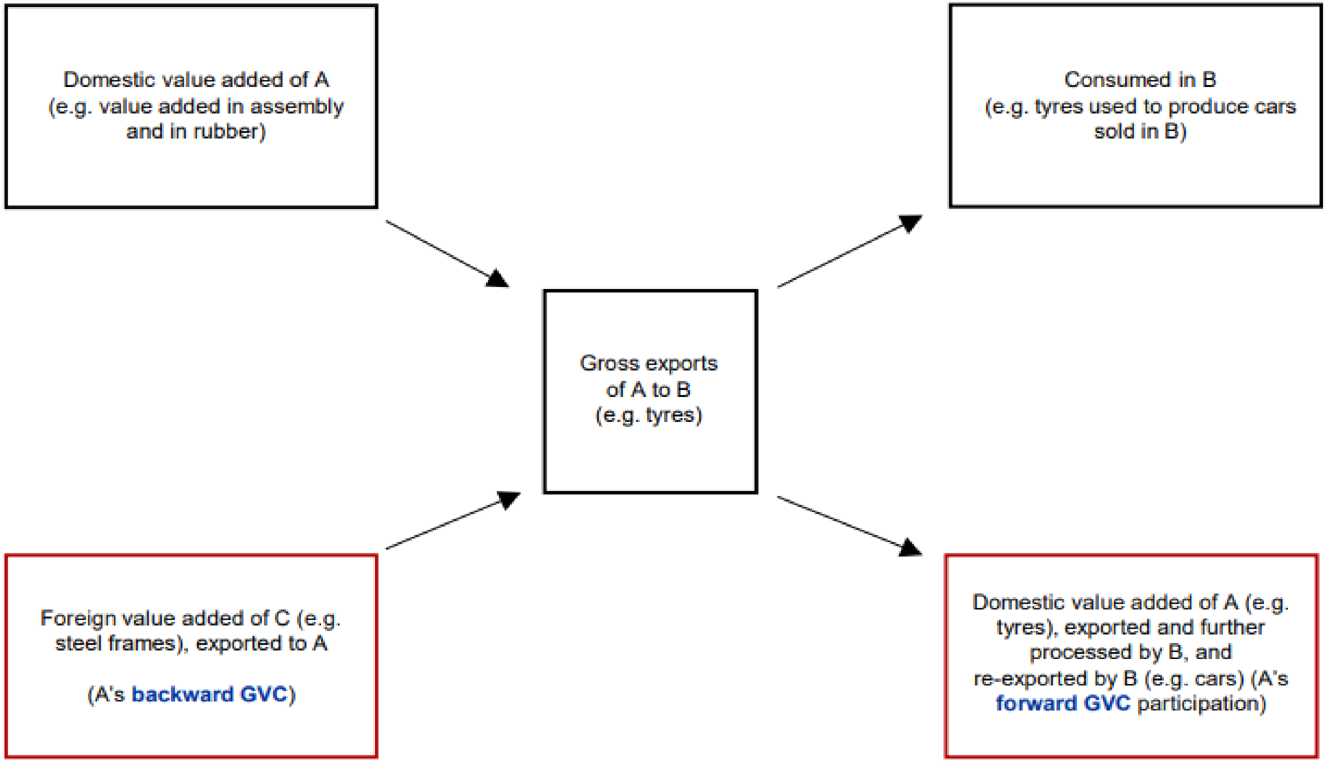
Deficit of country C with:	Gross Trade Deficit	Value-Added Trade Deficit
Country A	$0	-$100
Country B	-$120	-$20
World (Country A + Country B)	-$120	-$120

Gross trade vs value added trade: U.S. Trade Balance with Major Partners

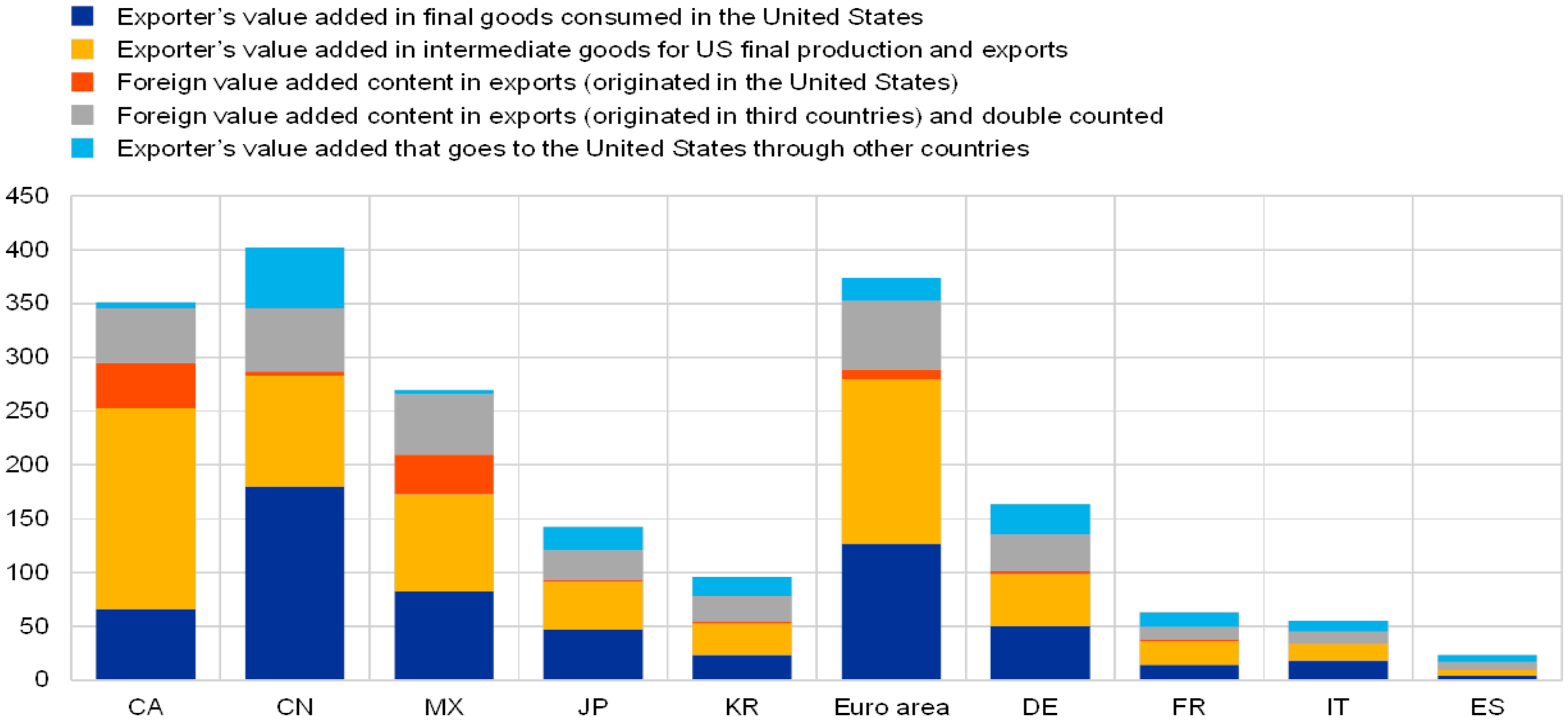
	Gross Trade Balance (in USD Billions)	Value-Added Trade Balance (in USD Billions)
Brazil	$18.5	$15.4
Canada	-$32.1	-$9.9
China	-$251.5	-$219.2
France	$4.8	$0.04
Germany	-$58.2	-$60.4
Hong Kong	$5.2	$3.6
India	-$61.2	-$49.0
Italy	-$32.4	-$25.3
Japan	-$26.4	-$33.3
Mexico	-$79.0	-$40.0
Netherlands	$15.4	$4.3
South Korea	-$11.8	-$21.9
U.K.	-$20.3	-$18.7

Source: OECD-WTO: Statistics on Trade in Value Added

GVC trade: Main indicators



Production chain linkages in exports to the United States (USD$)



Measurement and Data

Global Input-Output (GIOT) Tables

- National supply and use tables (SUTs) are matrices by product and industry showing how domestic production and imports of goods and services in an economy are used by industries for intermediate consumption and final use.
- National Input-output tables (IOTs) can be product-by-product or industry-by-industry matrices combining both supply and use tables into a single matrix. IOTs depict inter-industry or inter-product relationships within an economy. In economics, input-output models serve policy impact analyses
- GIOT represent an extension of national IOT/SUTs. They describe sales and purchases transactions across countries and industries, defining the nature and use of value added (intermediate and final) by the country of origin and destination
- GIOT are based on two main sources of data: (i) national accounts data and supply and use tables; and (ii) trade data (for goods and services) at nominal prices.
- A number of databases that enable analysis of trade through the lens of GVCs are now available. Regional tables are also being developed
- Global tables are generally published irregularly and updated with long lags

Global Input-Output Tables

Database	Data sources	Countries/Regions	Years	Sectors
WIOD	National supply use tables	43	2000-2014	56
OECD TIVA	National input-output tables	66	1995-2018	45
UNCTAD EORA	National and regional supply-use and I-O tables	190	1990-2021	26
ADB Multiregional IOT	National input-output tables	62	2000-2019	35
GTAP based	Input-output tables	140	2004, 2007, 2011, 2014	57
EU FIGARO	National and regional supply-use and I-O tables	28	2010-2020	64

Global Input-Output Tables: A stylized example

Exports from A to B of intermediates

Exports from A to B of final products

		Intermediate use		Final demand		Gross output
		Country A	Country B	Country A	Country B	
		Industry	Industry	Industry	Industry	
Country A	Industry	Intermediate use of domestic output	Intermediate use by B of exports from A	Final use of domestic output	Final use by B of exports from A	X_A
		+	+			
Country B	Industry	Intermediate use by A of exports from B	Intermediate use of domestic output	Final use by A of exports from B	Final use of domestic output	X_B
		+	+			
Value added		V_A	V_B			
		=	=			
Gross input		X_A	X_B			

Global Input-Output Tables: The EORA Tables

Year: 2000

		Country 1				Country 2				Country 3				Final Demand (FD) Matrix				
														Country 1	Country 2	Country 3		
	T matrix	Sector 1	Sector 2	Sector 3	Sector 4	Sector 1	Sector 2	Sector 3	Sector 4	Sector 1	Sector 2	Sector 3	Sector 4	Households	Households	Households	**Gross Output**	**Gross Exports**
Country 1	Sector 1	346	156	95	594	819	154	832	397	409	562	241	554	394	902	446	**6,901**	**5,316**
Country 1	Sector 2	354	443	7	908	42	92	561	839	470	770	83	368	514	694	512	**6,657**	**4,431**
Country 1	Sector 3	291	795	243	825	753	2	340	232	251	605	526	610	384	753	909	**7,518**	**4,980**
Country 1	Sector 4	637	259	289	813	500	716	947	645	856	221	898	41	91	653	301	**7,868**	**5,778**
Country 2	Sector 1	547	466	910	276	518	149	779	553	197	285	305	828	630	565	857	**7,864**	**5,300**
Country 2	Sector 2	752	936	822	638	611	496	98	924	608	689	872	972	847	209	37	**9,511**	**7,173**
Country 2	Sector 3	295	444	7	828	929	535	367	257	890	429	641	26	165	419	886	**7,117**	**4,610**
Country 2	Sector 4	113	518	791	459	79	748	254	218	586	673	424	157	800	355	501	**6,677**	**5,022**
Country 3	Sector 1	46	457	552	572	632	680	730	607	796	186	15	958	338	320	194	**7,082**	**4,934**
Country 3	Sector 2	962	96	544	96	675	113	711	337	787	571	241	211	479	14	608	**6,445**	**4,027**
Country 3	Sector 3	531	190	686	191	374	615	788	738	351	32	565	622	269	814	559	**7,326**	**5,197**
Country 3	Sector 4	857	776	897	18	915	482	308	458	253	145	982	270	700	822	729	**8,612**	**6,233**
																	89,578	
	VA matrix																	
Country 1	Value Added	1,172	1,120	1,676	1,648	-	-	-	-	-	-	-	-					
Country 2	Value Added	-	-	-	-	1,019	4,730	401	471	-	-	-	-					
Country 3	Value Added	-	-	-	-	-	-	-	-	626	1,278	1,532	2,995					
	Total input	**6,901**	**6,657**	**7,518**	**7,868**	**7,864**	**9,511**	**7,117**	**6,677**	**7,082**	**6,445**	**7,326**	**8,612**	**89,578**				

Global Input-Output Tables: Basic matrix algebra

- X=Gross Output matrix

- A =matrix of input-output coefficients, describing the units of intermediate goods needed to produce one unit of gross output in each sector and country

- AX=matrix of goods for intermediate use (the T matrix in the previous slide)

- Y=matrix of goods used for final demand (the FD matrix in previous slide)

$$X = AX + Y \qquad (1)$$

We can rearrange (1) such that:

$$X=BY\text{, where } B=(I-A)^{-1} \qquad (2)$$

Where B=Leontief inverse matrix, elements of which express the total output required both directly and indirectly to produce a unit of goods for final demand… $B=(I-A)^{-1}=A+A^1+A^2+A^3$…

Global Input-Output Tables: Basic matrix algebra

We can express a GG-country NN-sector production and trade system in equation (1) as a global-country input-output model (GG = 3 and NN = 4) as follows:

$$\begin{bmatrix} \sum_{r}^{G=3} \boldsymbol{X}_{1r} \\ \sum_{r}^{G=3} \boldsymbol{X}_{2r} \\ \sum_{r}^{G=3} \boldsymbol{X}_{3r} \end{bmatrix}_{12\times 1} = \begin{bmatrix} \boldsymbol{A}_{11} & \boldsymbol{A}_{12} & \boldsymbol{A}_{13} \\ \boldsymbol{A}_{21} & \boldsymbol{A}_{22} & \boldsymbol{A}_{23} \\ \boldsymbol{A}_{31} & \boldsymbol{A}_{32} & \boldsymbol{A}_{33} \end{bmatrix}_{12\times 12} \begin{bmatrix} \sum_{r}^{G=3} \boldsymbol{Y}_{1r} \\ \sum_{r}^{G=3} \boldsymbol{Y}_{2r} \\ \sum_{r}^{G=3} \boldsymbol{Y}_{3r} \end{bmatrix}_{12\times 1}$$

- where Xsr is a N×1 (4×1) vector that gives the gross output produced in country s and consumed in country r
- Ysr is a N×1 (4×1) vector that gives final goods produced in country s and consumed in country r
- Asr is a N×N (4×4) matrix of input-output coefficients. The B matrix can be written analogously to A, where Bsr is a N×N (4×4) block matrix, also called the total requirements matrix

Global Input-Output Tables: Basic matrix algebra

From ICIO Tables we can retrieve the T matrix, which provide inter-industry flow of inputs across sectors and countries. It can be expressed as:

$$\boldsymbol{T} = \begin{bmatrix} \sum_{r}^{G=3} \boldsymbol{T}_{1r} \\ \sum_{r}^{G=3} \boldsymbol{T}_{2r} \\ \sum_{r}^{G=3} \boldsymbol{T}_{3r} \end{bmatrix}_{12\times1}$$

We can the calculate each element Asr of matrix A, by dividing the corresponding element of matrix T with the corresponding element of the X vector of gross output

$$Asr = TsrXs$$

or in matrix form

$$A = T \oslash \begin{bmatrix} \boldsymbol{X}' \\ \vdots \\ \boldsymbol{X}' \end{bmatrix}_{12\times1} \qquad (3)$$

Once matrix A is recovered, it is easy to calculate B, using the Leontief inverse in equation (2)

Global Input-Output Tables: Basic matrix algebra

- To calculate the main indicators of GVCs we also need to recover the matrix of value-added shares

- It can be obtained by summing across rows of the A matrix, putting these elements on the diagonal of a squared matrix and subtracting it from an identity matrix of size GN×GN (12×12), as follows:

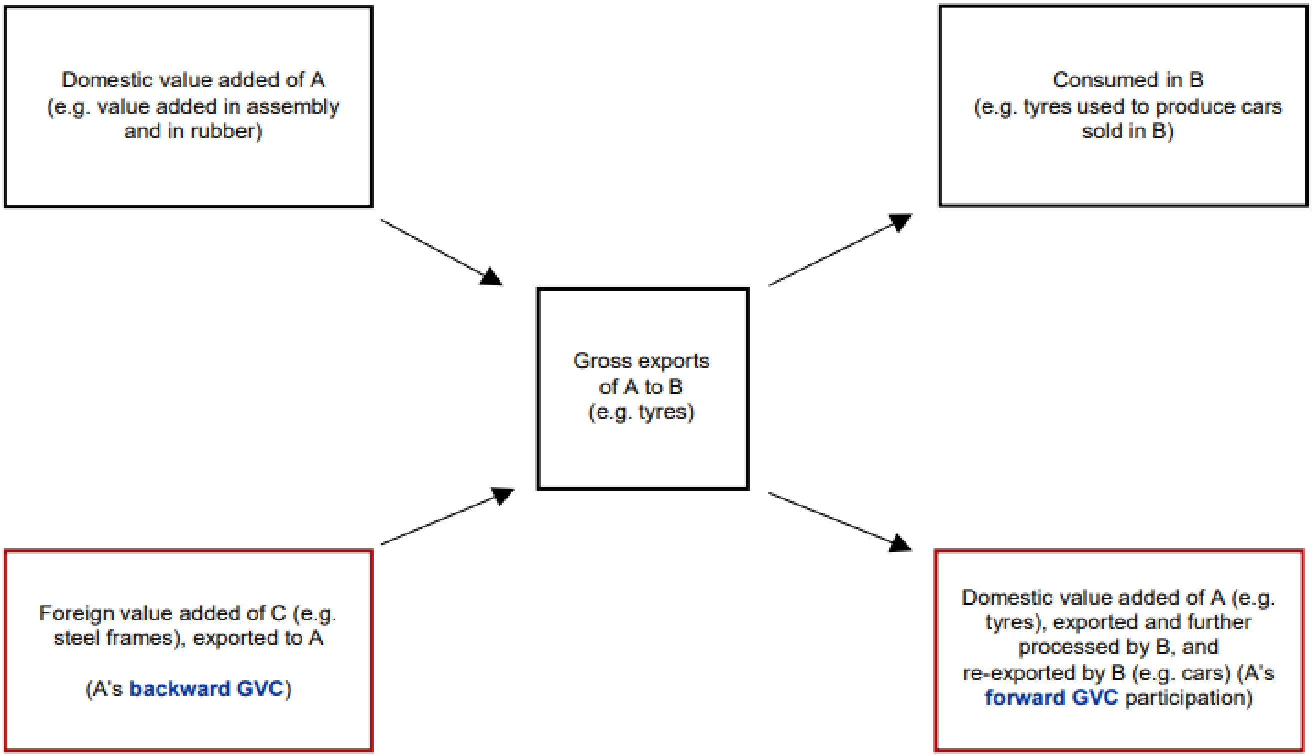
$$\hat{\boldsymbol{V}} = I_{12\times12} - diag\left(\sum_{s}^{GN=12} \boldsymbol{A}_{s1} \cdots \sum_{s}^{GN=12} \boldsymbol{A}_{s12}\right)$$

$$\hat{\boldsymbol{V}} = \begin{bmatrix} \hat{v}_1 & 0 & \cdots & 0 \\ 0 & \hat{v}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{v}_{GN=12} \end{bmatrix}$$

Multiplying the V matrix with B and the matrix of gross exports, we get the matrix Tv including value added shares. For the general GG-country NN-sector case, this is given by:

$$\boldsymbol{T}_v = \begin{bmatrix} \hat{v}_1 & 0 & \cdots & 0 \\ 0 & \hat{v}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{v}_{GN} \end{bmatrix} \begin{bmatrix} \boldsymbol{B}_{11} & \boldsymbol{B}_{12} & \cdots & \boldsymbol{B}_{1G} \\ \boldsymbol{B}_{21} & \boldsymbol{B}_{22} & \cdots & \boldsymbol{B}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{B}_{G1} & B_{G2} & \cdots & \boldsymbol{B}_{GG} \end{bmatrix} \begin{bmatrix} e_1 & 0 & \cdots & 0 \\ 0 & e_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & e_{GN} \end{bmatrix} \quad (4)$$

What are the components of GVC trade?



Computing GVCs indicators

		Country A		RoW		Output value added
		Manuf	Services	Manuf	Services	
Country A	Manuf	7.7	0.4	0.5	0.1	8.7
	Services	0.5	3.3	0.3	0.1	4.2
RoW	Manuf	0.5	0.2	9.9	0.8	11.4
	Services	0.3	0.1	1.3	5.0	6.7
Exports		9	4	12	6	

Computing GVC indicators

Value added used to produce gross exports

		Country A
		Manuf
Country A	Manuf	7.7
	Services	0.5
RoW	Manuf	0.5
	Services	0.3
Exports		9

Domestic value added of A in gross exports 91%

Imported value added to produce gross exports (backward participation) 9%

Value added sold to produce gross exports

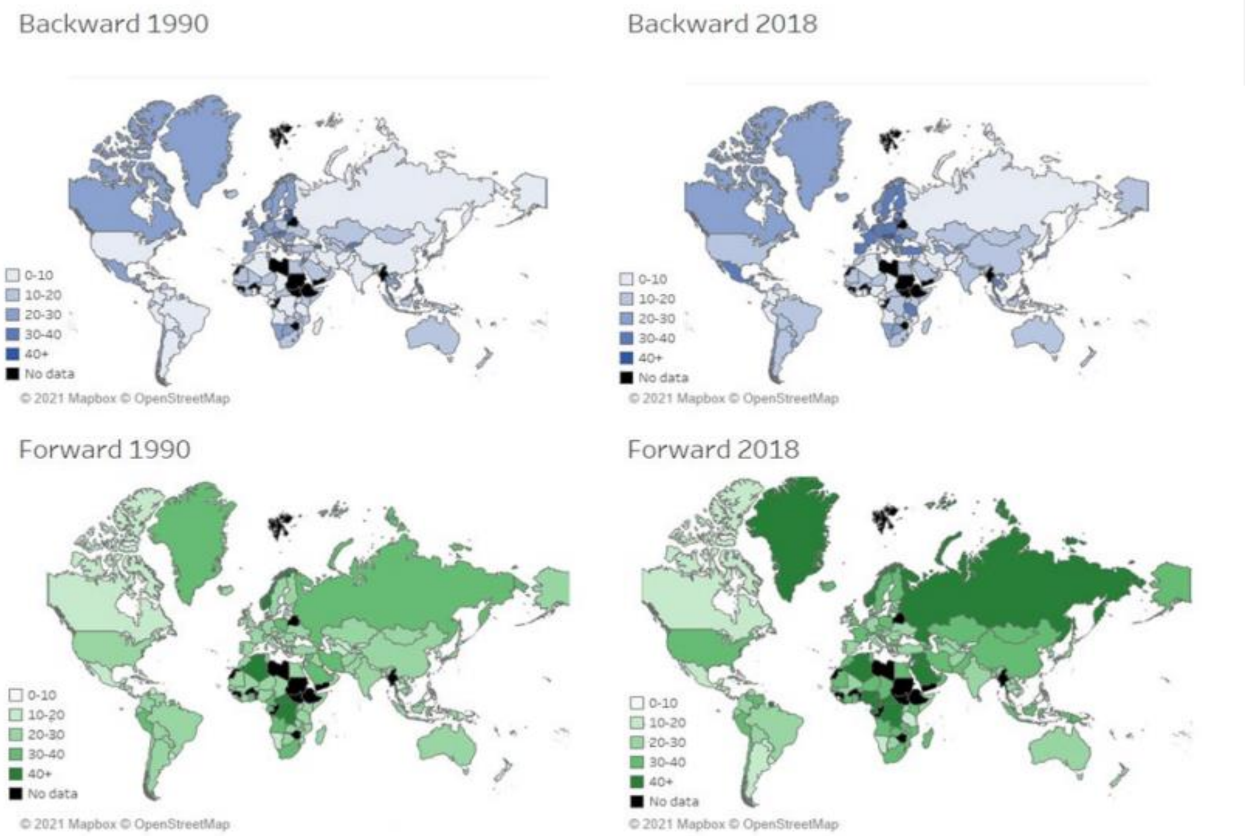
		Country A		RoW		Output value added
		Manuf	Services	Manuf	Services	
Country A	Manuf	7.7	0.4	0.5	0.1	8.7

Country A value added used to produce its own exports 92.6%

Country A value added used by other countries to produce their exports (Forward participation) 7.4%

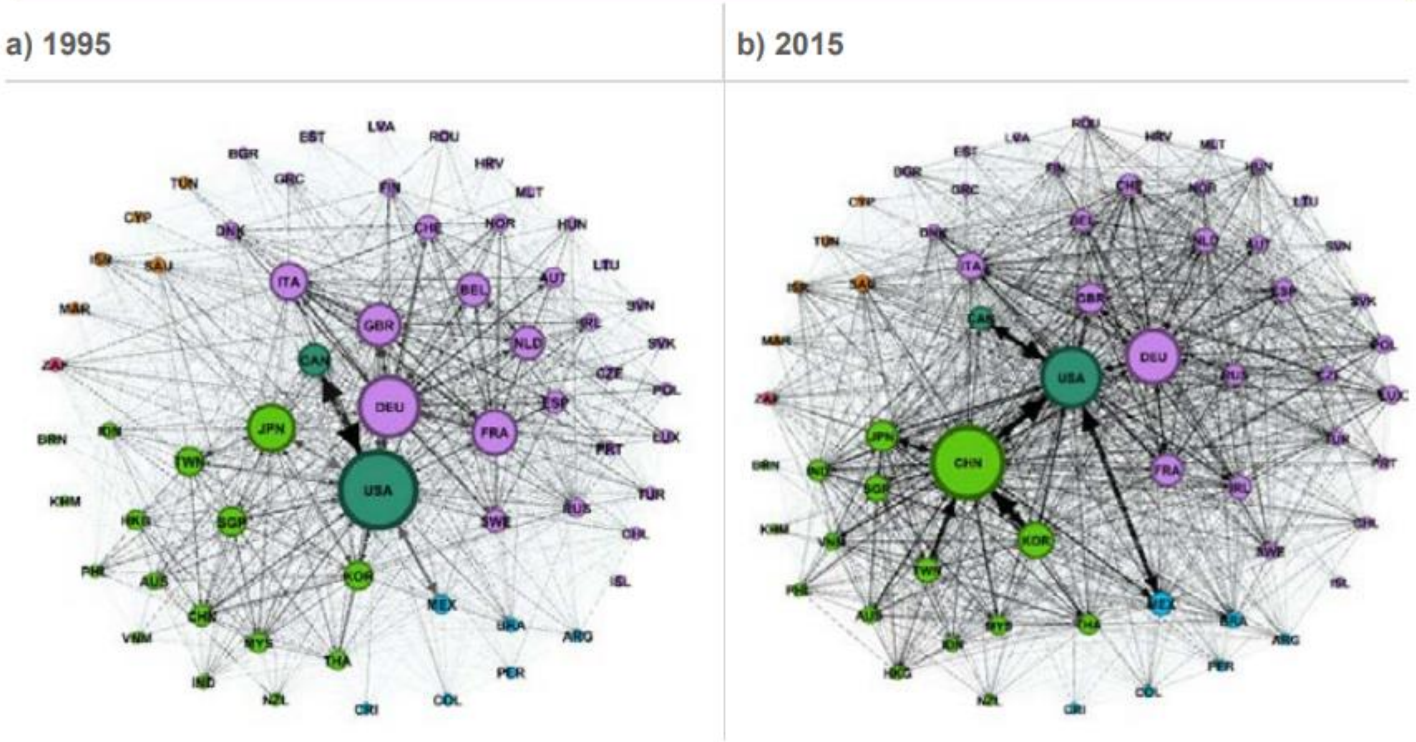
Applications

Backward and Forward GVC participation



Source: OECD and ECB computations.
Notes: Indexes of GVC participation are shared of gross exports

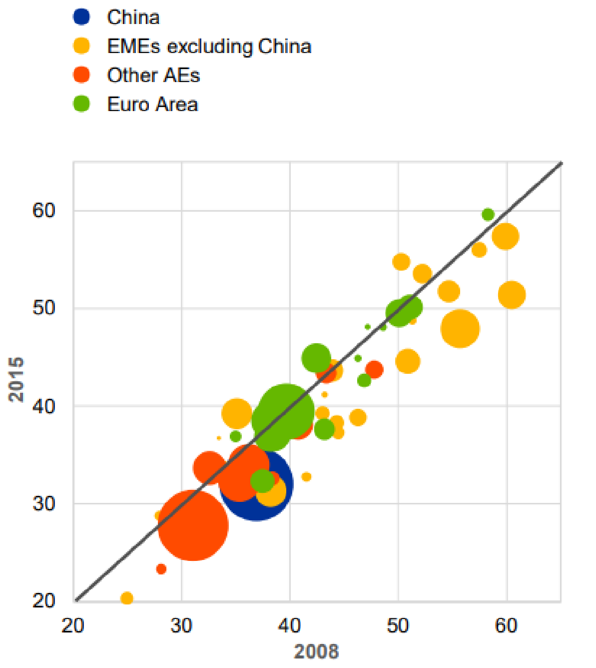
GVC Networks

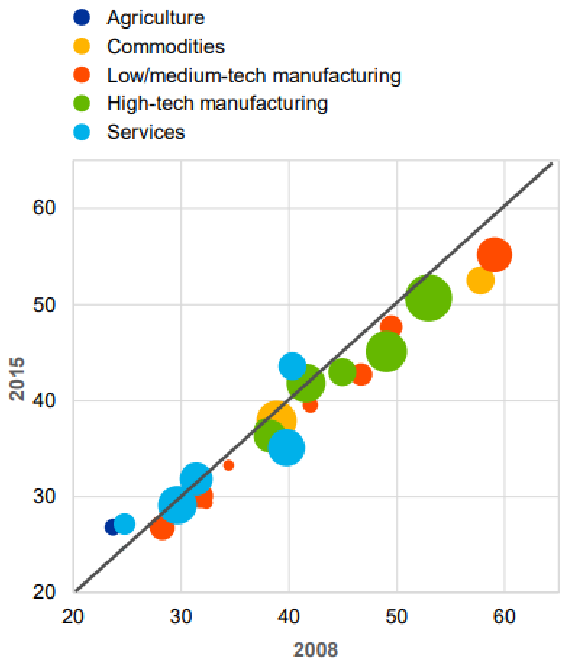


Source: OECD, TDM and ECB computations.
Notes: The value of the index goes from 0 to 100. The higher the value, the higher the country's participation in GVC, i.e., trade in intermediate products is more prevalent in total trade and the production process is more fragmented. The tracker is calculated as the share of intermediate generic products (as defined by the BEC5 classification by the UN) on total exports

GVC participation by country and sector

(percentage shares of gross exports)





Source: OECD and ECB computations. Notes: The size of the bubble refers to the share of each individual group of countries and sectors in gross exports in 2015. EMEs stand for Emerging economies.

Additional Reading

- *Belotti et al. "Economic Analysis with Inter-Country Input-Output Tables in Stata", World Bank, World Development Report 2020 https://documents1.worldbank.org/curated/en/587121582136569876/pdf/icio-Economic-Analysis-with-Inter-Country-Input-Output-Tables-in-Stata.pdf*
- *Martins Guilhoto, J., C. Webb and N. Yamano (2022), "Guide to OECD TiVA Indicators, 2021 edition", OECD Science, Technology and Industry Working Papers, No. 2022/02, OECD Publishing, Paris, https://doi.org/10.1787/58aa22b1-en.*
- *World Bank. 2020. World Development Report 2020 : Trading for Development in the Age of Global Value Chains. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/32437*
- *Robert Koopman & William Powers & Zhi Wang & Shang-Jin Wei, 2010. "Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains," NBER Working Papers 16426, National Bureau of Economic Research, Inc.*
- *Cigna Simone, Vanessa Gunnella & Quaglietti, Lucia, 2022. "Global value chains: measurement, trends and drivers," Occasional Paper Series 289, European Central Bank.*