

# **NEW METHODOLOGY TO IDENTIFY AND MEASURE GLOBAL VALUE CHAINS: REVEALED TRADE LINKS AND INPUT-OUTPUT RELATIONSHIPS**

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# Presentation outline

1. Justification and objectives
2. Methodology
3. Data and Results
4. Conclusions

# Fragmentation of production

- Different stages of productive processes are now spread over different national jurisdictions
- Basic force: reduction in trade cost
  - Technological nature
    - Goods- containers and cargo unitization
    - Services- Information technologies and telecommunications
  - Policies liberalization
    - Trade : mix unilateral, preferential and multilateral agreement.
    - Investment: unilateral policies and preferential agreements

# LITERATURE AND TERMINOLOGY

- Description of the phenomena
  - new international division of labour (Fröbel et al., 1980),
  - multistage production (Dixit and Grossman, 1982),
  - slicing up the value chain (Krugman, 1995),
  - disintegration of production (Feenstra, 1998),
  - fragmentation (Arndt and Kierzkowski, 2001),
  - vertical specialization (Hummels et al., 2001; Dean et al, 2007),
  - global production sharing (Yeats, 2001),
  - offshore outsourcing (Doh, 2005)
  - integrative trade (Maule, 2006).
  - Trade in tasks (Grossman and Rossi-Hansberg, 2008)
- Permanent structures with this new type of trade and investment
  - Global commodity chains (Gereffi, 1994, Bair, 2009),
  - Global production networks (Borrus et al, 2000, Henderson et al, 2002),
  - International supply chains (Escaith et al, 2010), and supply chains trade (Baldwin, 2012)
  - Global value chains (GVCs), (Humphrey and Schmitz, 2002; Kaplinsky, 2005; Gereffi et al, 2005; Kawakami, 2011; Cattaneo et al, 2010)

# Trade modes

- Conventional trade -One country sells to another
  - Final goods (services) and
  - Intermediate goods (services) which will be elaborated for final consumption.
- Supply Chain Trade: Import to export. Typical case:
  - High tech manufactured firms combined know how with low salaries in developing countries to produce a good for the international market.
  - Main sectors: transport equipment; electrical and optical equipment ;and chemicals.

# Characteristics typical Global Value Chain case

- Technological asymmetry
  - Headquarter economies: US, Japan and Germany, new evolving Taipei and Korea
  - Factory economies: China, India, Turkey, Indonesia, Thailand, Poland
  - Micro perspective: leader firm MC/Supplier main components/Assembly/Leader firm (distribution product,..)

# Characteristics of typical GVCs case

- Regionalization
  - GVCs are mainly regional: Europe; North America; South East Asia.
- Policies requirements
  - trade policy package that includes a set of traditionally domestic issues but that are essential for a dynamic integration in GVCs.
  - Increase the exchange of intermediate goods but mostly increases knowledge sharing. This requires new disciplines and rules.

# How are GVC in others sectors with other countries participation?

- Trade in final goods are reduced in all sectors or trade in intermediate increases everywhere (Baldwin and Lopez Gonzalez, 2013)
- Sectors
  - Natural resources: Agricultural (Food and Raw materials); Fuels and minerals
  - Other matures manufactures (textiles and apparel )
  - Services (BPO, KPO)
- Have all the same characteristics?:
  - Developing countries could only participate as providers of low labor cost?
  - Technological asymmetries and governance of GVCs: these others networks could have many different shapes. **It will be useful to develop a typology of the different GVCs, considering, among other criteria:**
    - **the role played by the lead country (firm ) in the network.**
    - Type of regionalization of the different networks
    - Trade policy requirements



# Methodology: Three alternatives

- 1) National input-output tables into larger international (global and regional) input-output tables (IIOTs).
  - Coverage mainly developed countries and selected emerging markets.
- 2) Case studies at a level of specific sectors and /or firms tracking value chain at the highest level of disaggregation (product and firm). Needs new data and so it needs new surveys. Restricted to some countries.
- 3) Analyzed trade data to elaborate a global architecture of GVCs networks by type of product, using available information at a global and regional level. Global coverage.

	Weakness	Strenght
1) IIOTs	<ul style="list-style-type: none"> <li>• Harmonization problems among countries (developing countries is worst)</li> <li>• Level of aggregation</li> <li>• Assumptions to solve data problems- Proportionalitiy</li> </ul>	<ul style="list-style-type: none"> <li>• Consistency and balancing</li> <li>• Standard well know measures of IO literature applied to the global economy</li> </ul>
2) Case Studies- firms and sectors	<ul style="list-style-type: none"> <li>• Restrictions to generalize results to global economy</li> <li>• Cost of collecting new data</li> </ul>	<ul style="list-style-type: none"> <li>• Level of disaggregation</li> <li>• Value added origin and value added capture (origin of capital)</li> </ul>
3) Trade Data and Trade Policy	<ul style="list-style-type: none"> <li>•Consistency and balancing</li> <li>•Geographic distribution and flow of value added</li> <li>•Level of aggregation- could be difficult to link inputs and outputs.</li> </ul>	<ul style="list-style-type: none"> <li>• Systemic approach using trade and trade policy data: a) specialization indexes and Graph theory. b) gravity models.</li> </ul>

# GVCs a complex phenomenon to measure

- Each method has its own weakness and strength
- Restrictions in the availability of good information
  - In particular developing countries not good primary information (or too less) about international inter industrial relationships.
  - Use available data: opportunity and disaggregation level
- Measure and interpretation needs an eclectic approach that combine the different type of methods.

# Objectives

- Develop a new methodology to measure trade in GVC
  - combining trade data and IO information.
  - increase coverage of countries and time sample
- Build the basic data to be able to track the sequence of stages of product transformation in the trade net at high level of disaggregation
- Define an index of GVC participation
- Characterize trade with this new tools between particular regions and trade blocs

# Organization presentation

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# New tools for a new methodology

- Modern empirical methodology that describes international trade as a net that links countries with products (bipartite net) .
- See:
  - Hausmann, R. e Hidalgo, C., 2009. The Building Blocks of Economic Complexity.
  - Hidalgo, C.A., Klinger, B., Barabási, A.L., Hausmann, R., 2007. [The product space conditions the development of nations.](#)

# “New” tools for the new methodology

- Previous result proximity among products in the:
  - Export space
- Generalize the methodology to link inputs with outputs using export and import data simultaneously.
  - Export-import space.
- Similar idea in Amador and Cabral (2008).  
“Vertical specialization across the world: a relative measure”.

# Trade Specialization: Two Bipartite Networks

- Trade Bipartite Network ( $\mathcal{T}$ ) is defined by:
  - Two groups of nodes: products ( $\mathcal{P}$ ) and countries ( $\mathcal{C}$ )
  - Edges ( $\mathcal{E}$ ) that connect products with countries
$$\Rightarrow \mathcal{T} = \{\mathcal{P}, \mathcal{C}, \mathcal{E}\}$$
- Edge connects a country with a product
  - When product  $i$  has a share in country  $j$  trade (import or exports) that is sufficiently greater ( $\underline{u}_1$ ) than the world average (Balassa)
- Two matrix summarize trade specialization: **M** for imports and **X** for exports (**T=M,X**)
  - Products are in rows and countries in columns
  - Binary entries (value 1 if there is an edge and 0 if there is not)



# Three stages

- Trade revealed link between input and outputs at product level
- Input Output relationship expanded to the product dimension
- Combination of both information produces to different dyads:
  - country of destiny  $c$  imports a product  $j$  to be incorporated in a certain export product  $i$ .
  - *country of origin  $c'$  exports a product  $i$  which uses some import product  $j$*

# 1 stage: proximity inputs (I) and outputs (E)

- Revealed link by trade between an export product and an import one (number of countries both are associated)

$$E_{PxP} = XM' = \left[ e_{ij} \right]$$

- Probability of have RCA in product  $i$  conditional of have a specialization in import product  $j$

$$P(x_i = 1 | m_j = 1) = \frac{P(x_i = 1 \cap m_j = 1)}{P(m_j = 1)} = XM' [D(m^p)]^{-1} = \left[ \frac{e_{ij}}{\sum_c m_{jc}} \right]$$

- Unconditional probability of export product  $i$

$$P(x_{ic} = 1) = \left[ \frac{\sum_c x_{ic}}{C} \right]$$

# 1 stage: proximity inputs (I) and outputs (E)

- Conditional over unconditional probability revealed a link between import a product  $j$  an export product  $i$

$$\begin{aligned}
 E^n_{PxP} &= \frac{P(x_{ic} = 1 | m_{jc} = 1)}{P(x_{ic} = 1)} = \frac{P(x_{ic} = 1 | m_{jc} = 1)P(m_{jc} = 1)}{P(x_{ic} = 1)P(m_{jc} = 1)} = \frac{P(x_{ic} = 1 \cap m_{jc} = 1)}{P(x_{ic} = 1)P(m_{jc} = 1)} = \\
 &= C [D(x^p)]^{-1} XM' [D(m^p)]^{-1} = \left[ \frac{Ce_{ij}}{\sum_c x_{ic} \sum_c m_{jc}} \right]
 \end{aligned}$$

- A link enough high

$$E^b_{PxP} = \left[ \begin{array}{l} e^b_{ij} = 1, \text{ if } \left[ \frac{Ce_{ij}}{\sum_c x_{ic} \sum_c m_{jc}} \right] > \underline{u}, \\ e^b_{ij} = 0 \text{ otherwise} \end{array} \right]$$

## 2 stage: Input Output relationship

- Disaggregated Input Output Matrix  $A_{S \times S} = [a_{ss'}]$
- Link between sectors greater than certain threshold

$$A_{S \times S}^b = \begin{bmatrix} a_{ss'}^b = 1 & \text{if } a_{ss'} > \underline{a}_{ss'} \\ a_{ss'}^b = 0 & \text{otherwise} \end{bmatrix}$$

- Correlations table from sectors to products and expansion of the input-output table

$$\bar{A}_{P \times P} = \left[ \bar{a}_{ji} = a_{ss'} \text{ if } j \in s, i \in s' \right]$$

$$\bar{A}_{P \times P}^{-b} = \begin{bmatrix} \bar{a}_{ji} = 1 & \text{if } a_{ss'}^b = 1, j \in s, i \in s'; \\ \bar{a}_{ji} = 0 & \text{otherwise} \end{bmatrix}$$

# 3 stage: Combination

- Connection between export product  $i$  and import product  $j$  revealed by international trade and IO relationship

$$G_{PxP} = E^b \circ \bar{A}^b = \left[ g_{ij} = e_{ij}^b \bar{a}_{ij}^b \right]$$

– where  $\circ$  is the Hadamard operator

- Participation of each country  $c$  in GVC

$$E^c = x_c m_c = \left[ x_{ic} m_{jc} \right] = \left[ e_{ij}^c \right]$$

$$G^c = G \circ E^c = \left[ g_{ij} e_{ij}^c \right] = \left[ g_{ij}^c \right]$$

- ✓ Rows: export product  $i$  linked with some import input  $j$
- ✓ Columns: import input  $j$  linked with some export product  $i$

# Typology of bilateral trade according to the participation in GVC of the origin country $c$ and the destination country $z$ in product $i$

		Exporting (origin) country ( $c$ )	
		$g_{i,c}^c = 0$	$g_{i,c}^c > 0$
Importing (destination) country ( $z$ )	$g_{i,z}^z = 0$	<p><b>Conventional trade.</b> Export country (<math>c</math>) does not use imported inputs to export (<math>i</math>) and the import country (<math>z</math>) does not use it to export any other product.</p>	<p><b>Final absorption trade.</b> Export country (<math>c</math>) uses imported inputs to export (<math>i</math>) and the import country (<math>z</math>) does not use it to export any other product.</p>
	$g_{i,z}^z > 0$	<p><b>Basic trade.</b> Export country does not use imported inputs to export (<math>i</math>) and the import country uses it to export other product(s).</p>	<p><b>Intermediate trade.</b> Export country (<math>c</math>) uses imported inputs to export (<math>i</math>) and the import country (<math>z</math>) uses it to export other product(s).</p>

# Trade and GVC

- $t_{cz}^i$  - imports from country  $z$  of country of origin  $c$  in product  $i$
- Aggregation by import country

$$t_{.z}^C = \sum_c \sum_{i \in C^{cz}} t_{cz}^i \quad t_{.z}^B = \sum_c \sum_{i \in B^{cz}} t_{cz}^i$$

$$t_{.z}^F = \sum_c \sum_{i \in F^{cz}} t_{cz}^i \quad t_{.z}^I = \sum_c \sum_{i \in I^{cz}} t_{cz}^i$$

- Aggregation by export country

$$t_{c.}^C = \sum_z \sum_{i \in C^{cz}} t_{cz}^i \quad t_{c.}^B = \sum_z \sum_{i \in B^{cz}} t_{cz}^i$$

$$t_{c.}^F = \sum_z \sum_{i \in F^{cz}} t_{cz}^i \quad t_{c.}^I = \sum_z \sum_{i \in I^{cz}} t_{cz}^i$$

# GVC indexes

- Imports and GVC  $t_{.z}^G = t_{.z}^B + t_{.z}^I$

$$I_z^1 = \frac{t_{.z}^G}{t_{.z}}$$

$$I_z^2 = \frac{t_{.z}^I}{t_{.z}^G}$$

- Exports and GVC  $y_c^G = y_c^F + y_c^I$

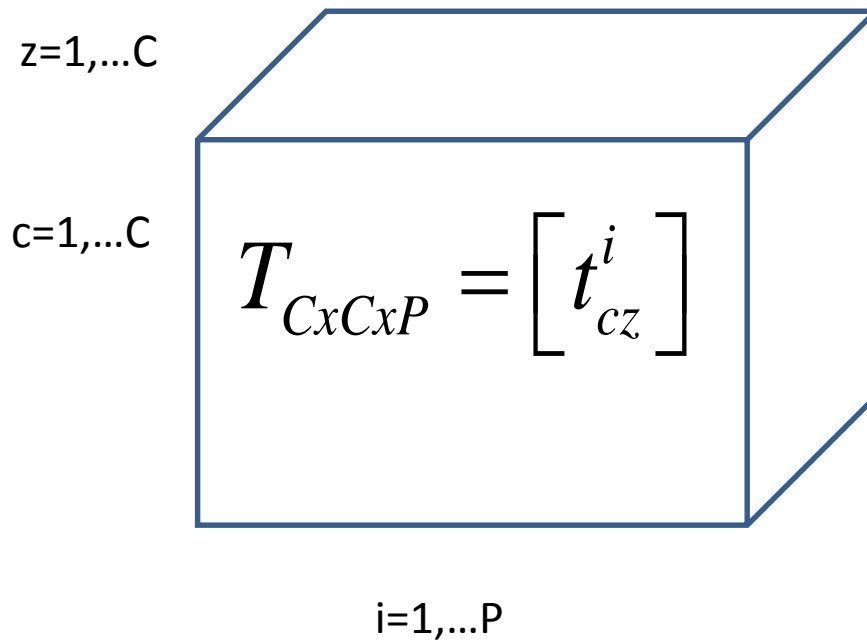
$$E_c^1 = \frac{t_c^G}{t_c}$$

$$E_c^2 = \frac{t_c^I}{t_c^G}$$

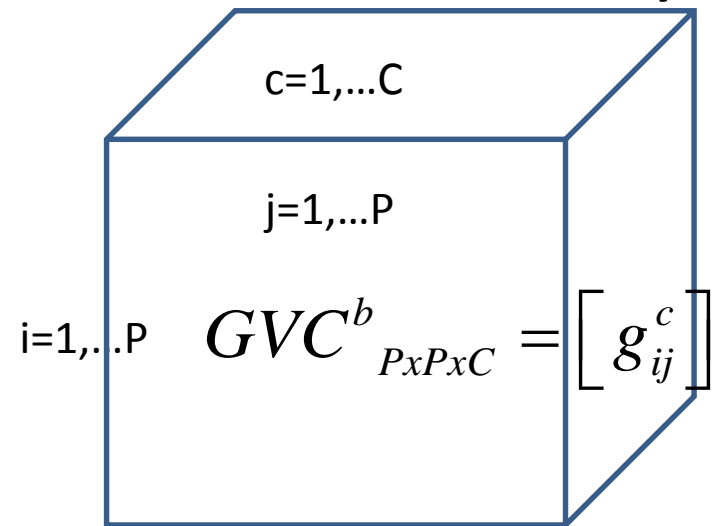


# Bilateral trade and GVC

- Trade in value



## GVC net binary



# Bilateral trade and GVC

- Import matrix one for each country  $c$ :

$$T^c_{Px1} = \begin{bmatrix} t^c_{jz} \end{bmatrix}$$

- Vector of imports of country  $c$

$$t^c_{Px1} = T^c i_c = \begin{bmatrix} t^c_{j.} \end{bmatrix} = \begin{bmatrix} \sum_z t^c_{jz} \end{bmatrix}$$

- Export matrix one for each country  $z$ :

$$T^z_{Px1} = \begin{bmatrix} t^z_{ic} \end{bmatrix}$$

- Vector of exports of country  $z$

$$t^z_{Px1} = T^z i_c = \begin{bmatrix} t^z_{i.} \end{bmatrix} = \begin{bmatrix} \sum_c t^z_{ic} \end{bmatrix}$$

# Bilateral trade and GVC

- Share import input  $j$  to export product  $i$  by country  $c$  as a proportion of total import of product  $j$  by country  $c$

$$IS^c_{PxP} = \left[ D(t^c) \right]^{-1} \bar{A}' D(t^{z'=c}) = \left[ \frac{\bar{a}_{ij} t_i^{z'=c}}{t_j^c} \right] = \left[ s_{ij}^c \right]$$

- We combine the participation of  $c$  in GVC ( $G^c = \left[ g_{ij}^c \right]$ )

$$GI^c_{PxC} = (IS^c \circ G^c) T^c_{PxC} = \left[ \sum_j s_{ij}^c g_{ij}^c t_{jz}^c \right] = \left[ gi_{iz}^c \right]$$

- country  $c$  total imports from country  $z$  needed to export product  $i$  by  $c$ .

# Bilateral trade and GVC

- Bilateral export share (country  $c$  to country  $t$  of product  $i$ ) as a proportion of total export of product  $i$  by country  $c$

$$ES_{PxC}^c = \left[ D(t^{z'=c}) \right]^{-1} T^{z=c} = \left[ \begin{array}{c} t_{it}^{z'=c} \\ t_{i.}^{z=c} \end{array} \right]$$

- Aggregate  $z$  import contents of  $c$  exports of product  $i$  to bilateral export to country  $t$

$$GVC_{CxC}^c = (GI^c)' (ES)^c = \left[ \sum_i \sum_j s_{ij}^c g_{ij}^c t_{jz}^c es_{it}^c \right]$$

- GVC matrix of each country  $c$  measures the amount of imports from country  $z$  incorporated in exports of country  $c$  in total exports to country  $t$ .

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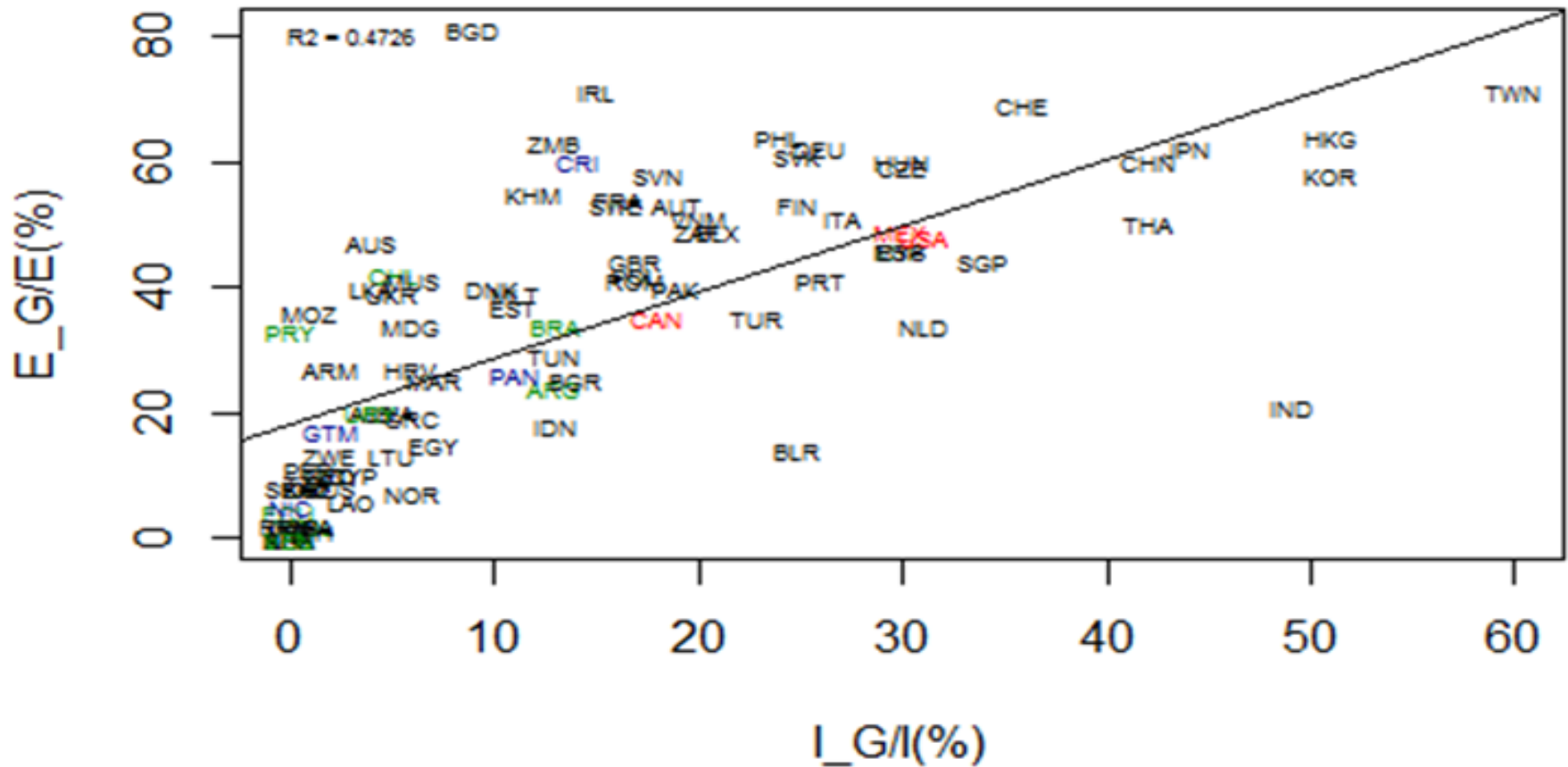
# Data

- BACI Average trade 2009-2014, HS 2002, 6 digits
  - Source: CEPII
- Commodity by Industry Matrix (385x385), Commodity-by-Commodity Direct Requirements (385x385), after Redefinitions Table, year 2007, 6 digit BEA codes
  - Source: US Bureau of Economic Analysis.
- Correlations table HS to BEA built from 2 sources:
  - HS-NAICS (Pierce & Schott, 2009)
  - NAICS-BEA (Bureau of Economic Analysis)
- Trade facilitation sources (Enrique)

# First approach to the results

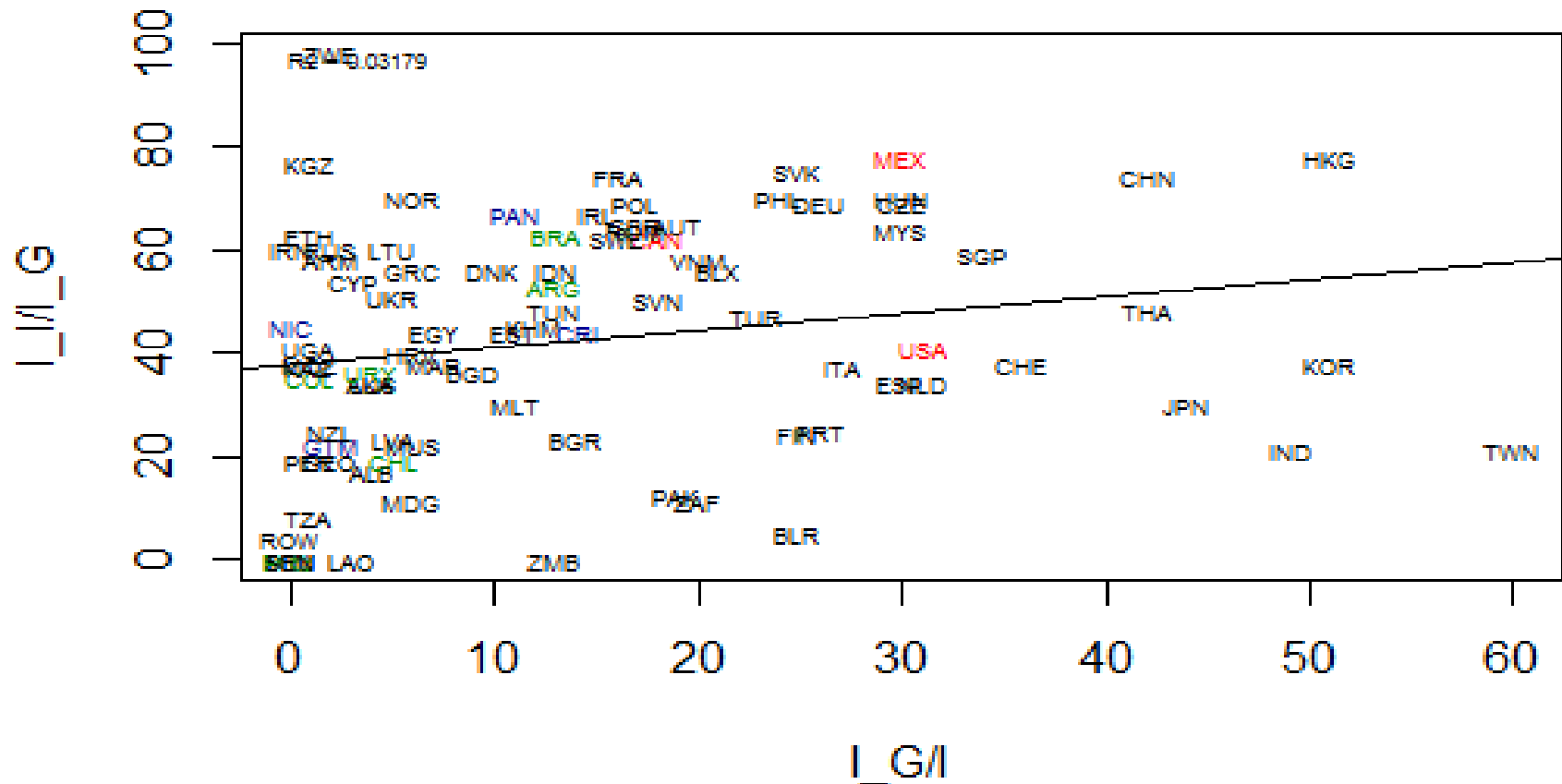
- Checking preliminary results to analyze the consistency of the methodology
- Particular case LA participation in GVC.
- We link a HS 6 digit product (#5218) with a country of destiny (#92)

# Global imports and Global exports, 2009-2014 averages (%)

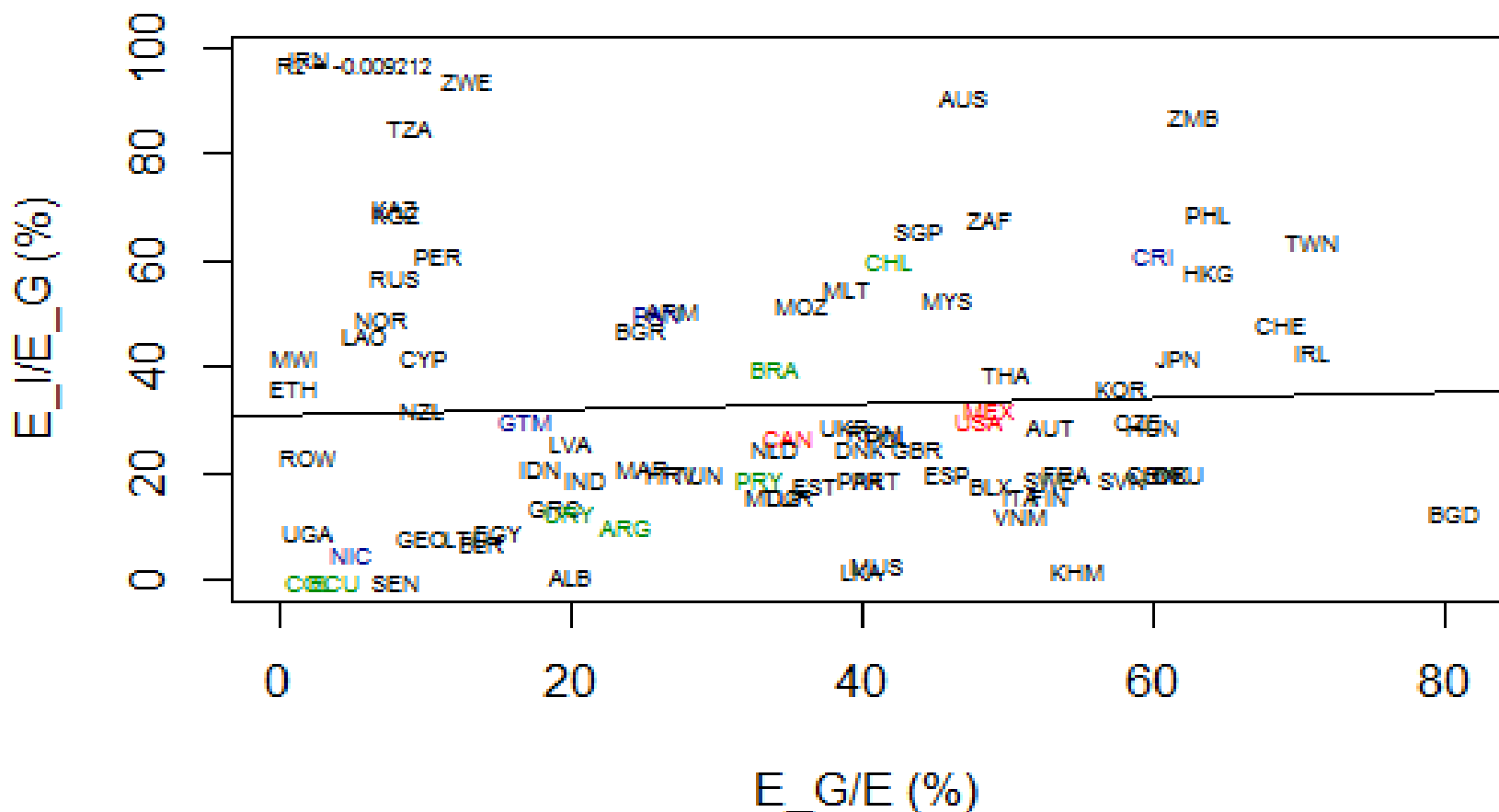




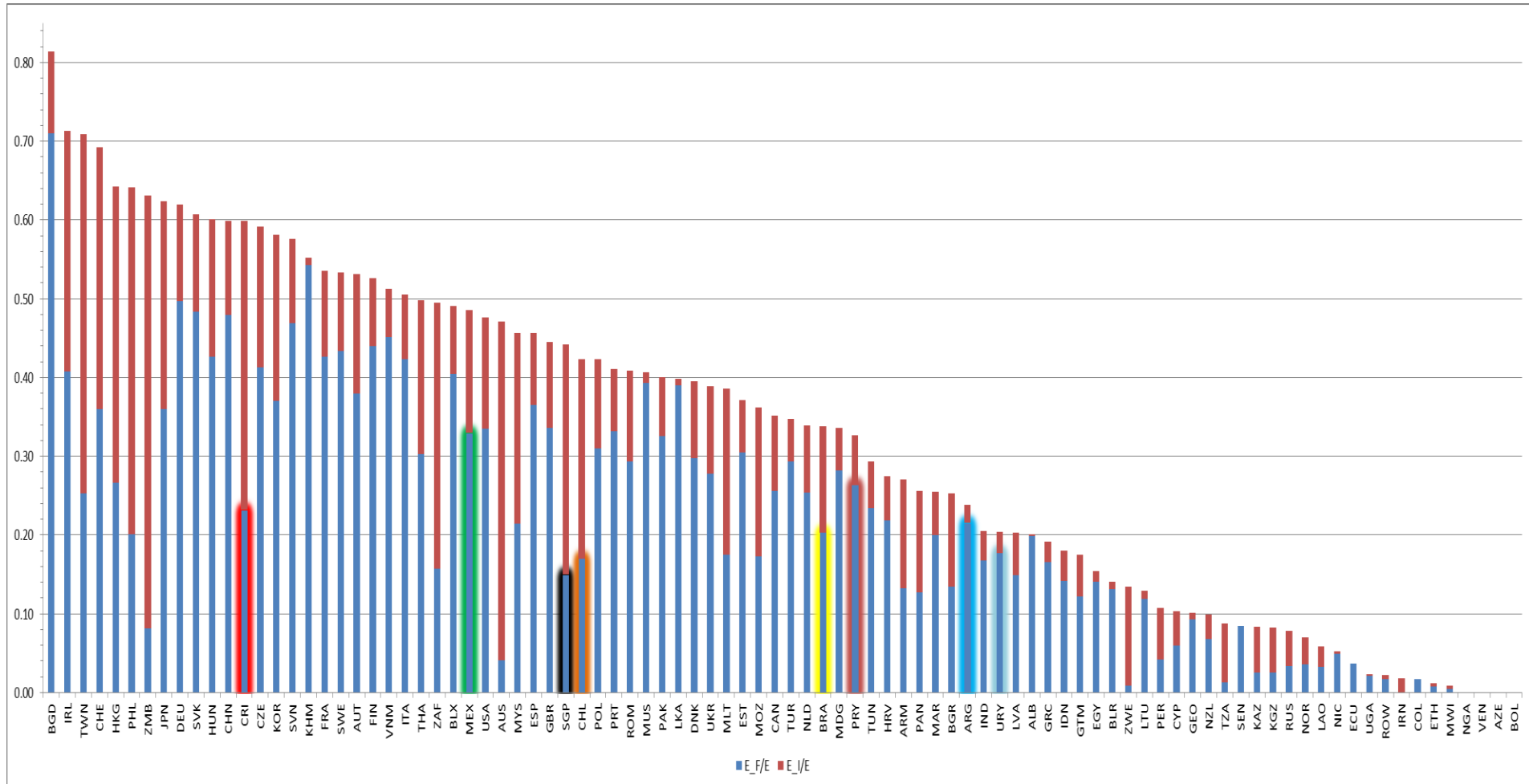
# Share of global and intermediate GVC imports, 2009-2014 averages (%)



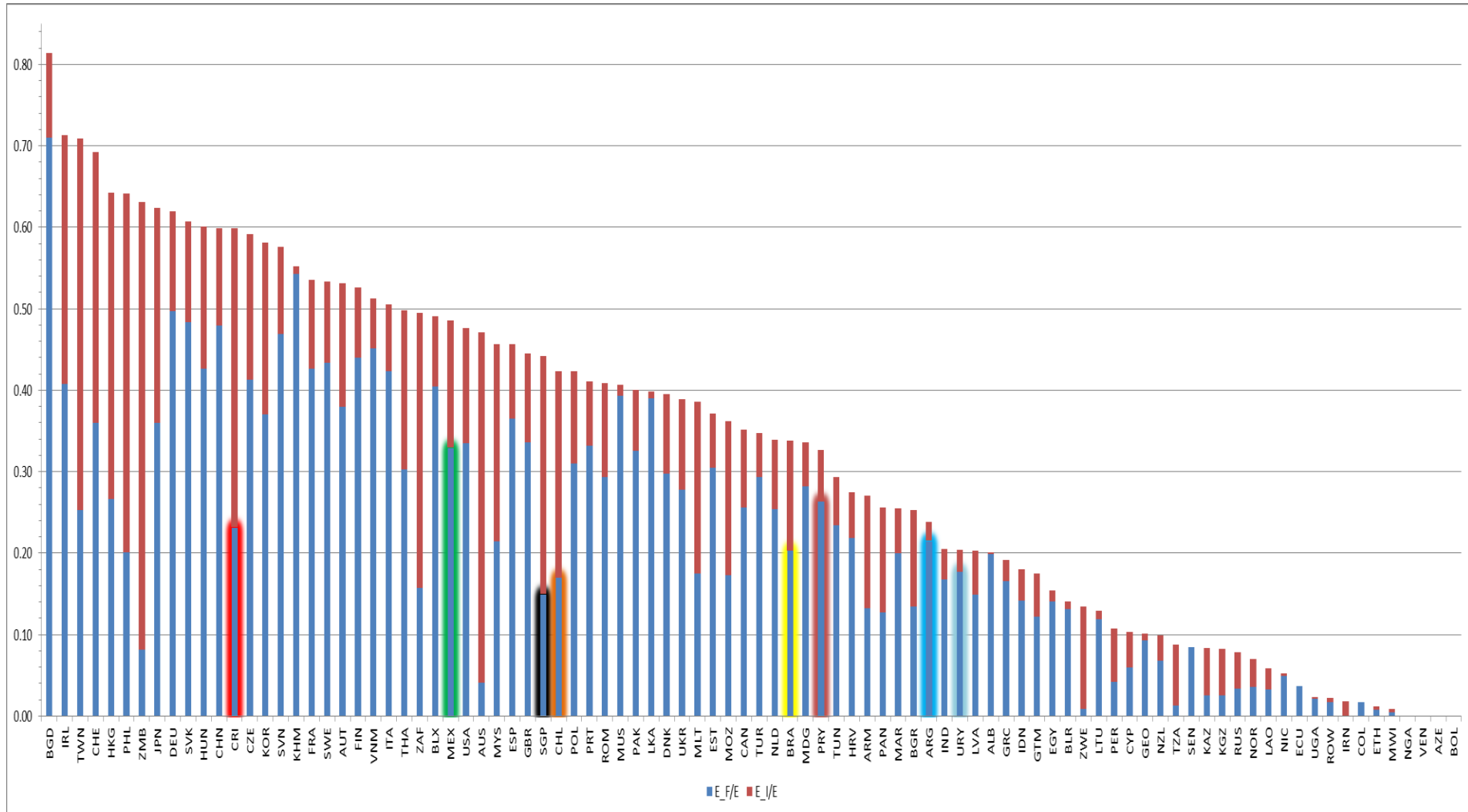
# Share of global and intermediate GVC exports, period 2009-2014 (%)



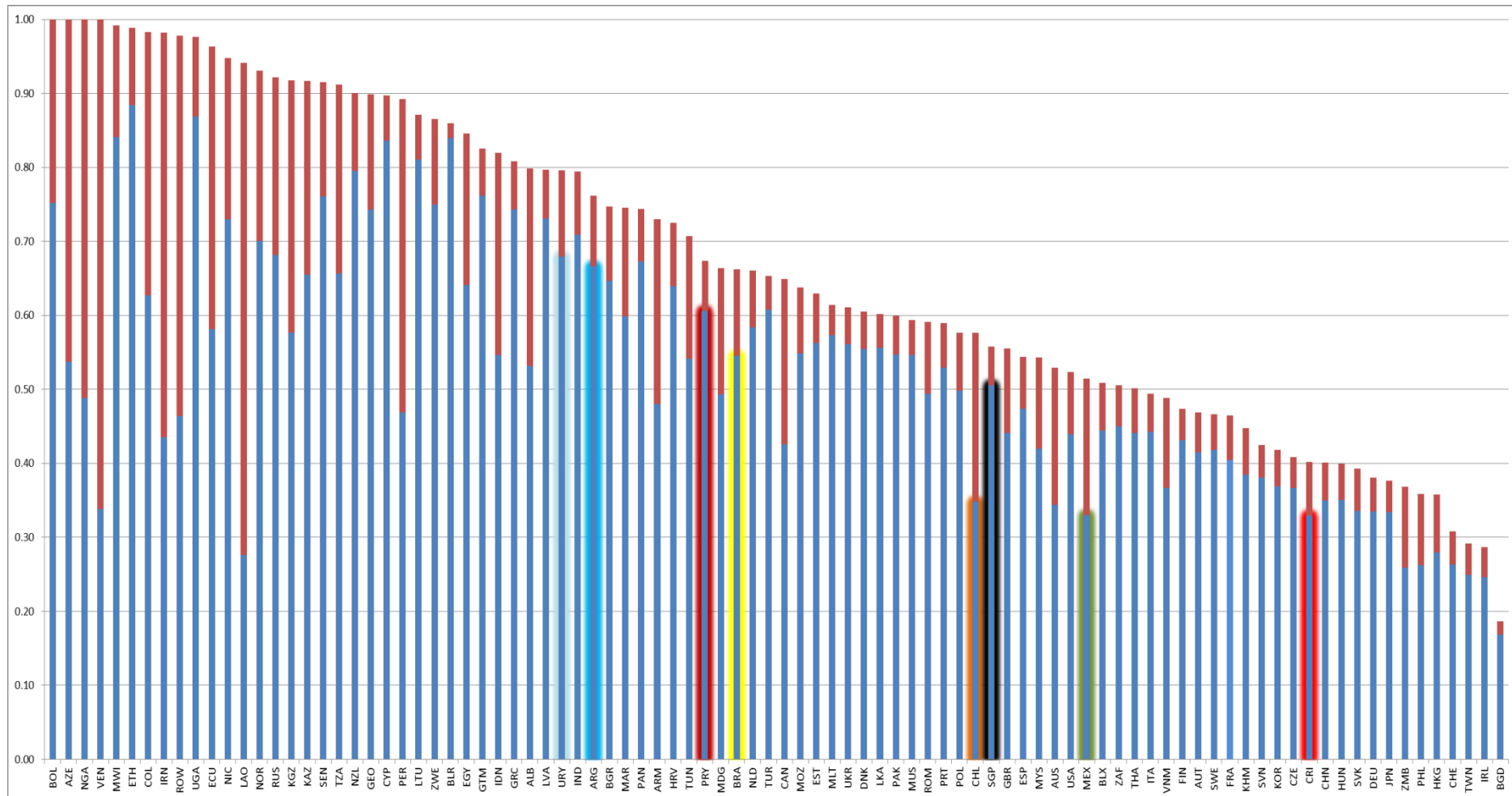
# GVC participation $(I_G/I+E_G/E)/2$ , average 2009-2014 (%)



# GVC Export participation $(E_F+E_I)/E=E_G/E$ , average 2009-2014 (%)



# Conventional and basic exports ( $E_C + E_B$ )/ $E$ ), average 2009-2014 (%)



# Countries tipology according with rol in GVC, coverage +90% E\_G

		Exportaciones en CGV		
		Finales	Intermedios	Ambos
Importaciones en CGV	Básicos	BGD, FIN, PRT, MUS, PAK	ZMB, ZAF, AUS, CHL	TWN, JPN
	Intermedios	DEU, SVK, CHN, FRA, SWE, VNM, GBR, POL, ROM	HKG, PHL	IRL, HUN, CZE, AUT, MEX
	Ambos	SVN, KHM, ITA, BLX, ESP, DNK, LKA	CRI	CHE, KOR, THA, MYS, USA, SGP

# Conclusions

- New Methodology
  - Revealed links between input and outputs in international trade combining trade data with IO relationships.
  - increase the coverage of countries and sectors to analyses GVC.
  - could be applied over yearly data
- First preliminary evidence of the consistency of the methodology:
  - styles facts are aligned with previous results in the literature.

# Main basic unity to identify GVC

- Final objective is tracking an input (and its value added) over the trade net
- The idea is that trade data could reveal that sequence. How? Using network techniques in the analysis of international trade.
- This first approach builds the basic information that allows to do this task in the FUTURE!!!



**Thank you**  
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