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Patterns of variability in the structure of global value chains: a network analysis

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Agenda

- The current debate on GVCs

- The measurment problem: possible network indicators

- Data and results

- Conclusion and policy implications

The current debate

A change in trends?

- slowdown of international trade after two crises;
- after a long period of growing relevance, GVCs diffusion stopped;
- tendency toward regionalization of trade ;
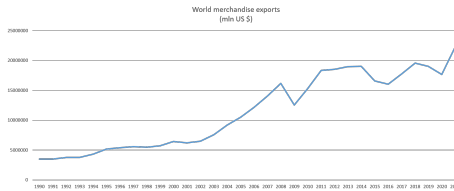- new tendency toward "near-shoring".

Figure: Trend in world trade Source: WTO data

Motivations and aims

- Debate on changes in GVCs;

- Longer or shorter, global or regional ?

- How far the 'great unbundling' can go?

- How to measure the length of Global Value Chains?

- **Aim of this paper**: to assess whether global value chains have been expanding or shrinking in past years, proposing a measure of GVCs extension and answering questions such as:

  - For a given sector (i.e. a country/industry pair), has the GVN increased its size over time?
  - For a given industry, has the GVN of different countries evolved with different patterns over time?
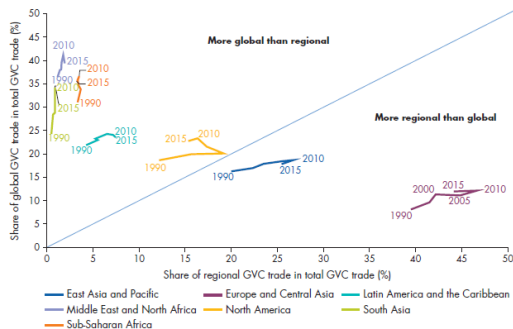
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Declining relevance of GVCs?
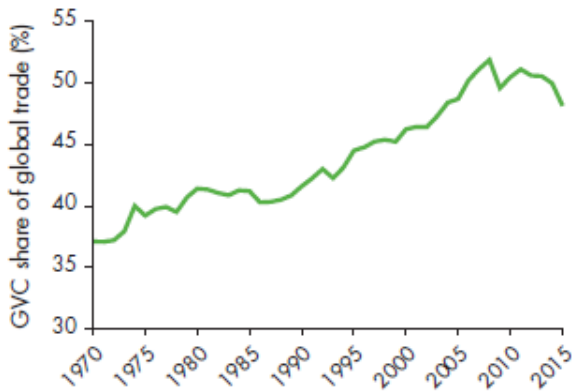
Sources: WDR 2020 team, using data from Eora26 database; Borin and Mancini (2015, 2019); and Johnson and Noguera (2017). See appendix A for

Figure: Share of GVCs trade in world exports. Source: WB, WDR 2020

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Shortening Value Chains?

Figure: Source: WB, WDR 2020

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Measuring the length of GVCs

Broad definition of GVCs: a series of stages required to produce a good or a service to be sold to consumers, with each stage adding value and with at least two stages taking place in different countries (e.g. Antras 2020). Consistent with various configurations and different structures of GVCs, "spider-like" or "snake-like" (Baldwin and Venables 2013).

How to measure such structures?

- **Antras et al. 2012**: the number of steps to go from a certain product to a final good;

- **De Backer and Miroudot 2013**: explore some structural properties also with network analysis;

- **Piccardi et al. 2018**: identify GVCs as communities in the WIOD network;

- **Antras and de Gortari 2020**: take geography into account by analysing the centrality of a country according to its geographical position.

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GVCs as networks

A network (or graph) is a pair $G = (V, E)$, where
V is the set of *nodes*, in our case each sector (a given industry in a given country) is a node;
E is the set of *edges*, and an edge from node i to node j means that sector i contributes to sector j by providing inputs, the weight $w_{ij} > 0$ associated to the edge is the amount of input.
$N = |V|$ and $L = |E|$ are, respectively, the number of nodes and edges.
The network structure is fully described by the $N \times N$ *adjacency matrix* A, weighted or unweighted.

The **Global Value Network** is built by starting from the target sector and then by proceeding backward by adding *levels*: the first level contains all sectors directly contributing to the target; the second level all sectors directly contributing to the first level (but not to the target), etc.. .
We decided to truncate the GVNs at the third level, as this appeared as the best trade-off.

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Distances on networks: Shortest path and Communicability (1)

In a network, a path connecting i to j is a *shortest path* if its length – measured in number of edges – is minimal among all the paths from i to j.

Shortest path distance: d_{ij} is the length of a shortest path connecting i and j; it only takes integer values. When the network is connected (i.e. all pairs i, j are connected) we can define the **average distance** as

$$d = \frac{1}{N(N-1)} \sum_{\substack{i,j \\ i \neq j}} d_{ij} \tag{1}$$

It is a global property of the network, representing how far, on average, two nodes are from each other.

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Distances on networks: Shortest path and Communicability (2)

Communication between nodes takes place through all possible routes connecting the nodes. The *communicability* G_{ij} between nodes i, j takes into account all walks of any length k starting at node i and ending at j, with the weight $1/k!$ giving higher weight to shorter walks:

$$G_{ij} = \sum_{k=0}^{\infty} \frac{(A^k)_{ij}}{k!} = (e^A)_{ij}. \tag{2}$$

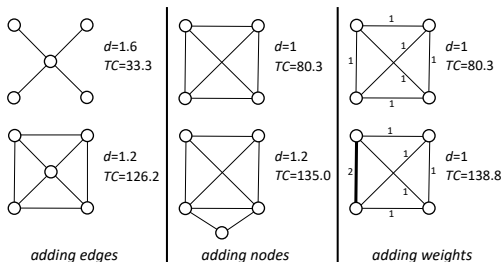$(A^k)_{ij}$ is the number of walks of length k from node i to j.

The **total network communicability**, a global measure characterizing the whole network, is defined as the sum of all node-to-node communicabilities G_{ij} :

$$TC = \sum_{i,j=1}^{N} G_{ij}. \tag{3}$$

In a weighted network, the communicability is similarly defined from the weighted adjacency matrix.

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Comparing shortest path and communicability

The figure exemplifies the effect on the average distance *d* and on the total communicability *TC* of network perturbations.

adding edges   adding nodes   adding weights

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Distances on GVNs: adding geography

To grasp the geographical dimension of GVNs, we introduce a
geointegrated weight v_{ij}:
for the edge $i \rightarrow j$, this is the product of the value of the flow w_{ij} and of
the geographical distance d_{ij} in km between the countries associated to
sectors (i, j).
The rationale is to weight the distance that all components of a GVC
have to travel before being assembled into the final product, not only
their quantity.

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Data and GVNs definition

- WIOD database (2018): yearly data 2005-2015 for 69 countries, 36 industries; a country/industry pair will be denoted as *sector*

- We extract from WIOD the GVN of a given *target sector* in a given year, i.e. the network representing its GVC in that year.

- The GVN is built by starting from the target sector and then by proceeding backward by adding *levels*;

- In order to make years comparable, we normalized the matrix Z by the total trade amountand we normalize data for the total trade in any given sector in order to compare sectors: we multiplied all entries of Z by $10^5/x_i$, if i is the target sector.

- We performed the GVN construction with three different methods, based on alternative filtering strategies. The three methods revealed a strong similarity among them, thus, for brevity, we only present the results obtained with the method of **Sector contribution**.

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Building GVNs

- *Sector contribution* : After defining the target node i, all edges $j \rightarrow i$ directed to i are included in the network, if weight $w_{ji} > \alpha x_i$, where x_i is the total amount of contributions received by the target sector i, and $\alpha = 0.003$.

- Then the same procedure is repeated treating all the existent nodes as the target one, up to the third level.

- In summary, this method includes all edges with non negligible weight and all sectors connected to them.

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Selected sectors

- Textiles, wearing apparel, leather and related products (D13T15): China (CHN) and Italy (ITA).
- Motor vehicles, trailers and semi-trailers (D29): Germany (DEU) and United States (USA).
- Computers and electronics (D26): China (CHN) and United States (USA).
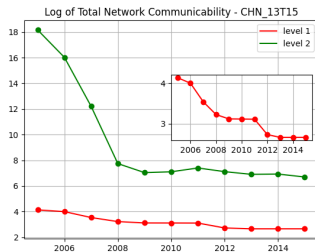- Other sectors analyzed in the paper.

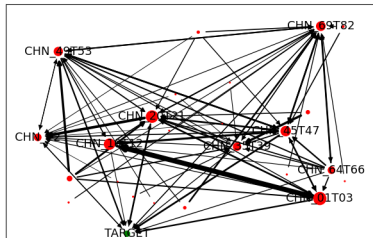These are sectors that could show a different evolution over time.

Figure 1.10 GVC participation by sector, 1995 and 2011

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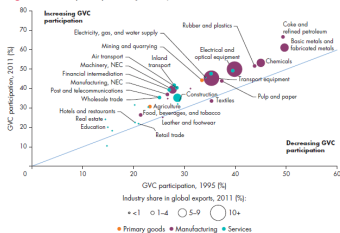
Textile, apparel and leather GVN: China 2005 - 2015

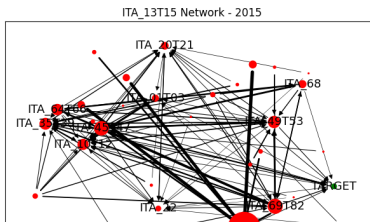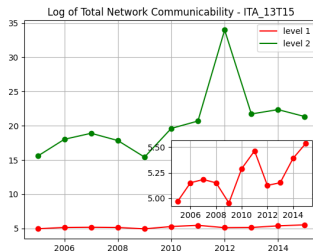GVC of China's textile industry from 2005 to 2015 has considerably reduced its size.

Log of Total Network Communicability - CHN_13T15

CHN13T15 - Network - 2015

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Textile, apparel and leather GVN: Italy 2005 - 2015

The GVN of the Italian textile slightly increased its size, as a
geographically distant country (China) became an increasingly important
supplier.

Log of Total Network Communicability - ITA_13T15

ITA_13T15 Network - 2015

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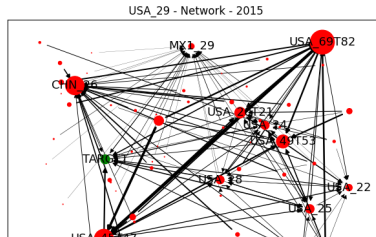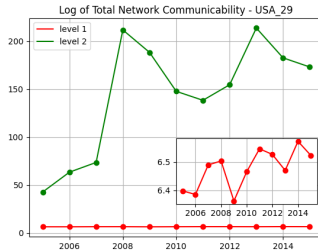○○○○○○

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Motor vehicles GVN: Germany 2005 - 2015

Change of gear in the German motor vehicles sector strategy: the GVC shortened until 2008 and then enlarged again

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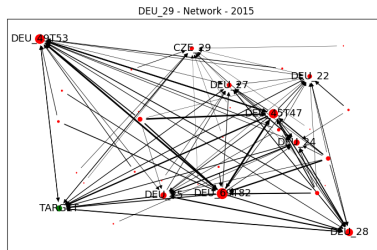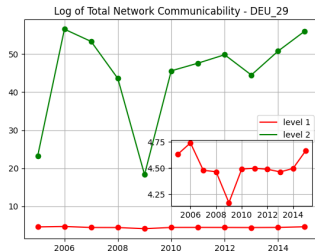
Motor vehicles GVN: USA 2005 - 2015

In the USA, the GVN has communicated better over the years, re-organization of the motor industry included a better organization of the foreign supply chains.

Log of Total Network Communicability - USA_29

USA_29 - Network - 2015

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Computers and electronics GVN: China 2005 - 2015

China's electronics sector decreased trade with geographically distant countries, the GVN has reduced its size over time.

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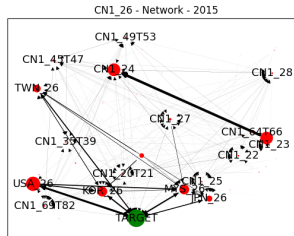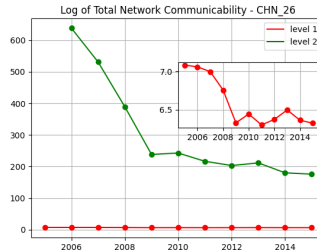
Computers and electronics GVN: USA 2005 - 2015

Irregular pattern for the USA GVN, following business cycle.

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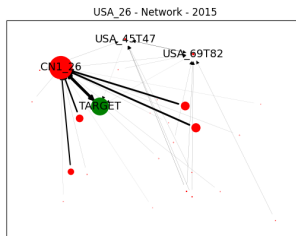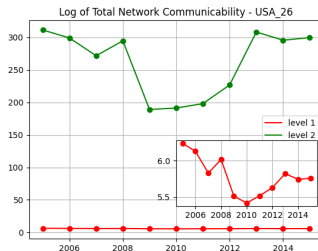
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Main findings

- Difficult to infer a general trend in the evolution of GVNs from the analysis;

- Growing 'size' of GVNs in some industry/country, and shrinking in others;

- Crucial role of China in many patterns;

- GVNs adapt and react to shocks.

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Conclusions

- Measuring GVCs size or length is not only a matter of counting steps, as their structure changes over time.

- Network analysis proves to be a useful tool to better understand the structure and evolution of Global Value Networks.

- Results do not suggest that radical shifts are in place: the general resilience of GVNs, especially in the first level of connections, confirms the hypothesis of the importance of the "relational approach" in GVCs .

- The analysis confirms the high adaptability of GVCs to the changing world.

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Policy implications

- GVNs seem long-lasting and industrial policies should take them explicitly into account.
- Given the resilience and adaptability of GVNs, policies to shape them seem difficult to put in place.
- Re-shoring or near-shoring appears to be quite costly, especially for well-established GVNs.