Identifying hubs and spokes in global supply chains

with redirected trade in value added

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Arjan Lejour
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Outline

• Background and purpose
• Methodology
  • global input-output analysis
  • labelling trade in value added
  • definition of indicators
• Results
  • hubs in electronics and machinery
  • hubs in China, EU12 and EU15
  • summary of major hubs and major suppliers to the hubs
• Some conclusions
Background

• Hype in attention for trade in value added (WTO, World Bank, OECD, etc.)

• Inspiring articles:
  - *KPWW*: Koopman, R., Powers, W., Wang, Z. and Wei, S.-J. (2010), Give Credit where Credit is Due: Tracing Value Added in Global Production Chains, *NBER Working Paper 16426*

• Predecessor of our current paper is

• We bring the analysis further by
  - using a more focused country classification
  - adding 2007 data to the datasets for 2001 and 2004 used in *LRV*
  - and shifting the focus to hub and spoke identification
Purpose

• Can we retrieve meaningful information from global input-output tables about the most important hubs and spokes at the industry level?

• Some examples:
  - electronics production in China, South-East Asia and East Asia
  - motor vehicle assembly in EU12, Canada, Japan, etc.
  - airplane construction in USA and EU15

• We aim to identify at the industry level
  - the ‘hubs’ that convert intermediate output imports into final output exports
  - their most important suppliers and customers
  - and the regions that do not supply
**Approach**

- Take the datasets from GTAP for 2001, 2004 and 2007
  - these datasets link national input-output tables with bilateral trade statistics
  - 57 industries, 84 different countries/regions
- Construct global input-output tables from the datasets
  - main proportionality assumption: all incoming imports at the industry level are allocated to intermediate and final use in proportion to the row of the import matrix of the importer
    > hence, for example, German electronics imports from China and German electronics imports from the US are allocated to use categories in Germany in exactly the same proportions
- Derive suitable indicators that identify the hubs and spokes at the industry level
  - we base these on redirected trade in value added
Structure of the global input output tables

- For a three region world example with regions: \( e \) (EU), \( c \) (China), \( r \) (RoW) and \( w \) (World)

\[
\begin{bmatrix}
S_{ee} & S_{ec} & S_{er} & f_{ee} & f_{ec} & f_{er} & x_e \\
S_{ce} & S_{cc} & S_{cr} & f_{ce} & f_{cc} & f_{cr} & x_c \\
S_{re} & S_{rc} & S_{rr} & f_{re} & f_{rc} & f_{rr} & x_r \\
w'_e & w'_c & w'_r \\
x'_e & x'_c & x'_r
\end{bmatrix}
\]

- \( S \) is an (industry by industry) matrix of intermediate output deliveries, \( f \) a vector of final output deliveries by industry, \( x \) a vector of gross outputs by industry and \( w' \) a row vector of value added by industry.
Leontief arithmetic I (condensed notation)

We summarize the global table with

\[
\begin{bmatrix}
S & F & x \\
wx' & x' \\
\end{bmatrix}
\]

and define input coefficients for intermediates and value added as

\[
A(r,i,s,j) = S(r,s,i,j) / x(j) \quad \text{and} \quad v(r,j) = w(r,j) / x(j)
\]

Then

\[
x = Ax + f_w = (I - A)^{-1} f_w = Bf_w
\]

in which \(B\) denotes the global Leontief inverse and \(f_w\) is global final output use.
Leontief arithmetic II (condensed notation)

Defining the use of final output in country $r$ as $f_r$ and using the $\wedge$ symbol to denote a matrix with a vector on its main diagonal and zeroes elsewhere, consider

$$\Theta^r = \hat{\nu} \hat{B} \hat{f}_r$$

This matrix gives all values added that are required for the use of final output in country $r$. The row totals represent the values added from different sources that are needed for final output use in $r$ and the column totals are equal to this final output use.
Labelling required values added (three region world)

For China this matrix would become

\[
\Theta^c = \begin{bmatrix}
\hat{v}_e B_{ee} \hat{f}_{ec} & \hat{v}_e B_{ec} \hat{f}_{cc} & \hat{v}_e B_{er} \hat{f}_{rc} \\
\hat{v}_c B_{ce} \hat{f}_{ec} & \hat{v}_c B_{cc} \hat{f}_{cc} & \hat{v}_c B_{cr} \hat{f}_{rc} \\
\hat{v}_r B_{re} \hat{f}_{ec} & \hat{v}_r B_{rc} \hat{f}_{cc} & \hat{v}_r B_{rr} \hat{f}_{rc} \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
\hat{f}'_{ec} & \hat{f}'_{cc} & \hat{f}'_{re}
\end{bmatrix}
\]

Row sums

\[
\begin{bmatrix}
w_e (f_c) \\
w_c (f_c) \\
w_r (f_c)
\end{bmatrix}
\]

Column sums

Which we label as

\[
\begin{bmatrix}
G^c_e & D^c_e & R_{er}^c \\
R_{ce}^c & - & R_{cr}^c \\
R_{re}^c & D_r^c & G_r^c
\end{bmatrix}
\]

We label the entries to distinguish four different claims on value added for the use of final output in China:

- \( G \): values added for direct final output imports
- \( D \): intermediate values added for Chinese final output that is used in China
- \( R \): intermediate values added diverted into China
- \( R^* \): values added reflected back to China
Labelling required values added (three region world)

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\end{bmatrix} \]

Row sums

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w_r (f_c)
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\end{bmatrix} \]

Column sums

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w_c(f_c) \\
w_r(f_c)
\end{bmatrix}
\]

which we label as

\[
\begin{bmatrix}
G_e^c & D_e^c & R_{er}^c \\
R_{ce}^c & - & R_{cr}^c \\
R_{re}^c & D_r^c & G_r^c
\end{bmatrix}
\]

Row sums
Column sums

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Labelling required values added (three region world)

For China this matrix would become

\[ \Theta^c = \begin{bmatrix} \hat{v}_e B_{ee} f_{ec} & \hat{v}_e B_{ec} f_{cc} & \hat{v}_e B_{er} f_{rc} \\ \hat{v}_c B_{ce} f_{ec} & \hat{v}_c B_{cc} f_{cc} & \hat{v}_c B_{cr} f_{rc} \\ \hat{v}_r B_{re} f_{ec} & \hat{v}_r B_{rc} f_{cc} & \hat{v}_r B_{rr} f_{rc} \end{bmatrix} \]

We label the entries to distinguish four *different* claims on value added for the use of final output in China:

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- **D**: intermediate values added for Chinese final output that is used in China
- **R**: intermediate values added diverted into China
- **R\(^*\)**: values added reflected back to China

\[ \begin{bmatrix} G_e^c & D_e^c & R_{er}^c \\ R_{ce}^c & - & R_{cr}^c \\ R_{re}^c & D_r^c & G_r^c \end{bmatrix} \]
Labelling required values added (three region world)

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\hat{v}_r B_{re} f_{ec} & \hat{v}_r B_{rc} f_{cc} & \hat{v}_r B_{rr} f_{rc}
\end{bmatrix} \]

which we label as

\[ \begin{bmatrix}
G^c_e & D^c_e & R^c_{er} \\
R^c_{ce} & D^c_r & G^c_r
\end{bmatrix} \]

We label the entries to distinguish four different claims on value added for the use of final output in China:

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Three perspectives of value added trade

- Let $\Gamma^\rho_{rs}$ denote bilateral value added exports from country $r$ via redirector $s$ to final destination $\rho$
- Then we can look at value added trade from three different angles
  - Traditional: from origin to redirector $\Gamma^w_{rs}$
    > trade statistics
  - Trade in value added: from origin to final destination $\Gamma^\rho_{rw}$
    > bilateral value added trade balance
  - Neglected thus far: from redirector to final destination $\Gamma^\rho_{ws}$
    > decomposition of bilateral value added balance into contributions via redirectors
- The literature thus far has focused on the first and second perspective; our focus is on the first and third perspective
Focus on the redirector and on national value added

- $\Gamma_{rs}^w$ provides the incoming spokes into the redirector and

- $\Gamma_{ws}^\rho$ gives us the outgoing spokes from the redirector

- What value added should we choose?
- Our choice is

\[ \Gamma_{rs}^\rho (t, j) : \text{all national value added needed for final } j\text{-output} \]

- Most authors use

\[ \Gamma_{rs}^\rho (i, t) : i\text{-value added needed for total final output} \]
Bilateral value added intermediate imports

China’s bilateral imports from the EU into Chinese final \( j \)-output production

\[
e_{ec}(j) = \Gamma_{ec}^w(t, j) = d^c_e(j) + r^r_{ec}(j) + r^*_{ec}(j)
\]

The general form of this equation is the basis for our hub and spoke indicators.

It specifies the claims on EU value added for China’s final output production and splits these in those for Chinese final output exports \((r\text{ and } r^*)\) and those for China’s own final output use \((d)\)
Hub and spoke indicators for final $j$-output

We propose two indicator pairs at the industry level:

• China as a redirector:
  - China’s share in redirecting foreign intermediate value added as a percentage of its foreign intermediate value added imports (redirection as % China’s imports)
  - redirection as % of globally redirected value added trade for industry $j$

• China as a supplier to foreign redirectors:
  - China’s share of domestic intermediate value added that is redirected by other countries as a percentage of China’s domestic intermediate value added exports (% of exports that is redirected)
  - redirected Chinese exports as a % of globally redirected value added for industry $j$
Country classification in results

EU15: Old member states
EU12: New member states
OWE: Other western Europe
OEE: Russia and other eastern Europe
IND: India
CHH: China and Hong Kong
EAS: East Asia
SEA: South-East Asia
JPN: Japan
USA: United States of America
ONA: Other Nafta
ROW: Rest of World
Industry classification in results

AGO: Agriculture and raw materials
ENG: Energy
LTM: Low-tech manufacturing
MLM: Medium-low tech manufacturing
CRP: Chemical, rubber and plastic products
MVH: Motor vehicles and parts
OTN: Transport equipment nec
OME: Machinery and equipment nec
ELE: Electronic equipment
TRA: Transport
OBS: Business services
OCS: Other commercial services
OSR: Other services
Aggregation and the share of redirected value added trade

• Aggregation over industries does not affect the composition of value added trade

• Aggregation over countries reduces the share of redirected value added trade and increases the shares of $D$ and $G$
  
  - Example: aggregation over EU member states
    
    $\rightarrow$ all internal EU trade will be classified as $D$: domestic value added needed for EU final output used in the EU
    
    $\rightarrow$ all EU imports that were diverted by EU-countries to other EU countries will be classified as $G$
    
    $\rightarrow$ all EU exports that were diverted by EU-countries before leaving the EU will be classified as $G$ as well
Intermediate value added trade as % of global value added trade for final $j$-output, 2007
Redirected value added as % of global intermediate value added exports for final j-output, 2007
Redirected value added as % of global intermediate value added exports for j-output, 2007
Redirection of foreign value added for electronics, 2007

% of globally redirected value added

% of intermediate value added imports

Redirector: EU15 EU12 OWE OEE China India EAS SEA Japan USA ONA RoW

0 20 40 60 80 100

0 5 10 15 20 25 30 35 40
Redirection of domestic value added for electronics, 2007

% of globally redirected value added

% of intermediate value added exports

EU15  EU12  OWE  OEE  China  India  EAS  SEA  Japan  USA  ONA  RoW
Origins of redirected value added for electronics, 2007
Final destinations of redirected value added for electronics, 2007

% of globally redirected value added

Final destination:
- eu15
- eu12
- owe
- oee
- chh
- ind
- eas
- sea
- jpn
- usa
- ona
- row

CPB Netherlands Bureau for Economic Policy Analysis
WIOD, 25 April 2012
Hubs and Spokes
Redirection of foreign value added for machinery, 2007

% of globally redirected value added

% of intermediate value added imports

EU15  EU12  OWE  OEE  China  India  EAS  SEA  Japan  USA  ONA  RoW
Redirection of domestic value added for machinery, 2007
Origins of redirected value added for machinery, 2007

% of globally redirected value added

Origin:
- eu15
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- eas
- sea
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- ona
- row

CPB Netherlands Bureau for Economic Policy Analysis
Hubs and Spokes
WIOD, 25 April 2012
Final destinations of redirected value added for machinery, 2007
China as a redirector, 2001-2007
EU12 as a redirector, 2001-2007

% of globally redirected value added

% of intermediate value added imports
EU15 as a redirector, 2001-2007

% of globally redirected value added vs. % of intermediate value added imports

- MLM
- VHM
- 2001
- 2004
- OME
- 2007
- ITM
- AGO

CPB Netherlands Bureau for Economic Policy Analysis
Hubs and Spokes
WIOD, 25 April 2012
## Summary table of important redirectors, 2007

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### Criteria used:
- share of redirected value added > 20% of intermediate value added imports
- share of redirected value added > 8% of globally redirected value added
### Summary table of important suppliers, 2007

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Criteria used:
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Some conclusions

- Our analysis yields meaningful results on vertical specialisation at the industry level that are robust over time and are easily recognized as making sense.
- We contribute to the literature with:
  - the direct labelling of bilateral trade in value added
  - focus on first and third perspective for value added trade
  - explicit treatment of international transport margins
- Yet, the approach has some weaknesses:
  - the proportionality assumption in constructing global input-output tables
  - we do not distinguish yet whether the ‘hubs’ identified are production hubs or trading hubs (re-exporters of ‘almost final’ output)
- Future research might focus on:
  - extensions of the analysis
    - longer time series
    - components of value added
  - the benefits of ‘being connected’