Measures of Upstreamness and Downstreamness Defined on Exports

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Objective

- Develop measures of position and length that fit better with specialization along global value chains
- Compare results with benchmark measures
- Describe specialization along the value chain targeting directly international trade

Motivation

Current measures of Upstreamness (U) and Downstreamness (D) exhibit limitations:

- Antràs and Chor (2018) and Miller and Termushoev (2017) (AC-MT) consider all production, but most of it is not related to trade
  - do not offer a single measure of position linking both U and D
  - U and D exhibit strong positive correlation
- Wang et al (2017a,b) divides world production according to its share in domestic activities, traditional trade activities and global value chains, and focus in the latter
  - their split do not account as GVC the last stage, so ends of chains (i.e. assemblers) are unconsidered
  - their measure of position is a ratio not defined over the same flow

References: U and D defined over production

Antràs and Chor (2018) and Miller and Termushoev (2017) define the
Output Upstreamness as the distance from production to final demand: The average
number of stages that production faces until it is included in a final good or service

$$OU = \hat{X}^{-1}(I + 2A + 3A^2 + \dots)Y = \hat{X}^{-1}BBY = \hat{X}^{-1}B\hat{X}u^T = Hu^T$$

Where:

X is Production

Y is Final demand

A is Leontief Matrix

B is Leontief inverse matrix

H is Ghosh inverse matrix

u is a row vector of ones

References: U and D defined over production

Antràs and Chor (2018) and Miller and Termushoev (2017) define the
Input Downstreamness as the distance from factors to production: The average number
of times that value added is included in production.

$$ID = Va(I + 2J + 3J^2 + \dots)\hat{X}^{-1} = VaHH\hat{X}^{-1} = u\hat{X}H\hat{X}^{-1} = uB$$

Where:

X is Production
Va is Value Added
J is Ghosh Matrix
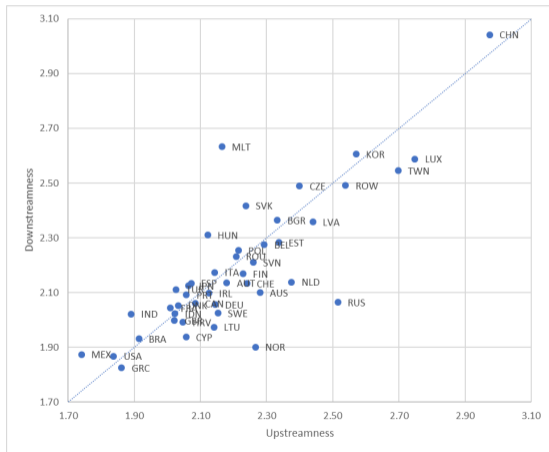B is Leontief inverse matrix
H is Ghosh inverse matrix
u is a row vector of ones
V is a vector with ratio of Value Added to exports

References: U and D defined over production

AC-MT description of position in GVC is useless: "puzzling" positive correlation

AC-MT Measures of Upstreamness and Downstreamness at a country level. Year 2014
Source: Own elaboration based in WIOD.

References: U and D over value-added only in GVCs

Wang et al (2017b) start from the matrix of value added included in the production of final goods: $\hat{V}B\hat{Y}$, and then apply the logic of AC-MT to define U and D:

- The ratio between production and value added is the average length of each ij.

$$\frac{\hat{V}BB\hat{Y}}{\hat{V}B\hat{Y}}$$

- Their U for total output is the ratio between the row sums of both terms: Forward perspective

$$U_W^{Tot} = \frac{\hat{V}BB\hat{Y}u^T}{\hat{V}B\hat{Y}u^T} = \frac{\hat{V}BBY}{\hat{V}BY}$$

- Their D for total output is the ratio between column sums: Backward perspective

$$D_W^{Tot} = \frac{u\hat{V}BB\hat{Y}}{u\hat{V}B\hat{Y}} = \frac{VBB\hat{Y}}{VB\hat{Y}}$$

References: U and D over value-added only in GVCs

Wang et al (2017b) uses Wang et al (2017a) to split domestic activities, traditional trade activities and global value chains and counts average length in each term and each perspective:

$$\hat{V}B\hat{Y} = \hat{V}L\hat{Y}^D + \hat{V}L\hat{Y}^F + \hat{V}LA^F B\hat{Y}$$

Where superscripts D and F accounts for domestic and international splitting of A and Y and $L = (I - A^D)^{-1}$
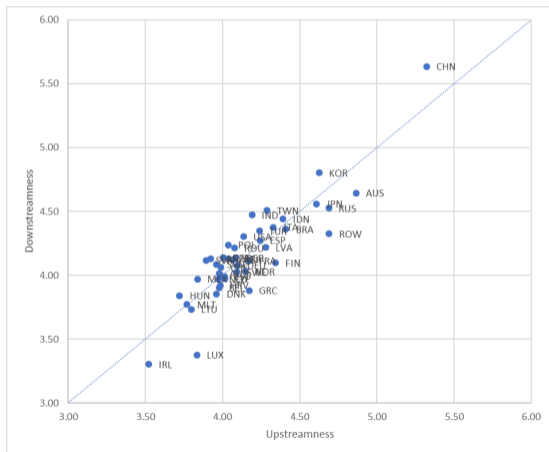
They focus in length of last term:

$$AL_{gvc} = \frac{\hat{V}LLA^F B\hat{Y} + \hat{V}LA^F BB\hat{Y}}{\hat{V}LA^F B\hat{Y}}$$

But there can be trade related to GVCs in $\hat{V}L\hat{Y}^F$ and not all value of $\hat{V}LA^F B\hat{Y}^D$ is GVCs in the perspective of the user country

References: U and D over value-added only in GVCs

Wang et al (2017b) measurement of U and D in GVC does not solve the issue

Wang et al (2017b) measures of Upstreamness and Downstreamness at a country level for GVC component. 2014 *Source:* Own elaboration based in WIOD.

Position and Length defined on Exports

- Previous measures rely on production or value-added, and they account for production many times in both directions:
  - as distance to final demand (U)
  - as distance from value added (D)
- This paper departs from a decomposition of gross exports
  - Borin and Mancini (2019), Koopman et al (2014), Los and Timmer (2020), Wang Wei and Zhu (2013)
- Does not trace value-added and double-counting, but the number of stages
- Avoids considering production not related to trade, which is behind positive correlation between U and D of previous measures

Position and Length defined on Exports

Two measures are defined for gross exports and three direct combination of these gives measures of length and position of exports in global value chains:

1. **Distance from exports to final demand: Upstreamness**
   Gross exports are divided according to their use:

   $$E = Y^F + A^F BY = Y^F + A^F (I - A)^{-1} Y = Y^F + A^F (I + A + A^2 + A^3 + \dots) Y$$

   U_E is defined as the distance from exports to final demand. When exports are already final, the distance is 0.

   $$U_E = 0 * Y^F + A^F (1 * I + 2 * A + 3 * A^2 + 4 * A^3 + \dots) Y = A^F (BB) Y$$

   Comparable Upstreamness must be defined in relative terms.

   $$u_E = \frac{U_E}{E} = \frac{A^F BBY}{E}$$

Position and Length defined on Exports

2. Distance from exports to primary factors: Downstreamness

D tracks the origin of the value added incorporated into a country's gross exports. Any output vector can be split using VB to identify the sector of origin of the value added (Borin and Mancini, 2019).

$$E^T = VB\hat{E} = V(I - A)^{-1}\hat{E} = V(I + A + A^2 + A^3 + A^4 + \dots)\hat{E}$$

D_E counts the times that value added is included in production until it is included in the exports. The VA directly included in exports is counted once, the VA directly included in the inputs that exporters use is counted twice, and so on.

$$D_E = V(1 * I + 2 * A + 3 * A^2 + 4 * A^3 + 5 * A^4 + \dots)\hat{E} = V(BB)\hat{E}$$

Again, comparable Downstreamness must be defined in relative terms.

$$d_E = \frac{D_E}{E^T} = \frac{VBB\hat{E}}{E^T}$$

Position and Length defined on Exports

2. Distance from exports to primary factors: Downstreamness

To characterize better the D of a country (sector), it would be useful to distinguish between the length from factors explained by the domestic linkages from the length "imported" in the foreign inputs (Wang et al, 2017b)

$$D_E = VBB\hat{E} = D_{E_{dom}} + D_{E_{int}}$$

Where:

$$D_{E_{dom}} = VLL\hat{E} + VBA^F LL\hat{E}$$

and

$$D_{E_{int}} = VBBA^F L\hat{E}$$

Position and Length defined on Exports

3. Length of chains in which exports are involved

$$LC = D_e^T + U_e$$

- The length of chain of a country sector *ns* is defined as the average distance from primary factors to final demand involving exports of country sector *ns*.
- Is the average number of times that value-added included in a export is counted in production until it is consumed by final users.
- The minimum length of a chain is 1, when all value-added is included by the exporter of a final good.

Position and Length defined on Exports

4. Relative Position

RP is the share of total length of chain explained by the Downstreamness.

$$RP = \frac{D_e^T}{LC}$$

5. Balanced Relative Position

BRP accounts for the different ranges of U and D and is comparable with Wang et al (2017b) RP

$$BRP = \frac{D_e^T}{U_e + 1}$$

Comparison of measures

	Measure	2000	2004	2008	2012	2014	Annual growth
				Chain length measures. Selected years from 2000-2014			

Comparison of measures

Chain length measures. Selected years from 2000-2014

	Measure	2000	2004	2008	2012	2014	Annual growth
Reference in literature	AC-MT Total	2.01	2.04	2.19	2.26	2.31	1.0%
	Wang et al.: Total	1.93	1.94	2.06	2.10	2.13	0.7%
	Wang et al: Domest	1.69	1.67	1.71	1.75	1.78	0.4%
	Wang et al: GVC	4.01	4.05	4.24	4.37	4.43	0.7%
Based in Gross Exports	Upstreamness	1.32	1.35	1.53	1.60	1.62	1.5%
	Downstreamness	2.29	2.34	2.46	2.52	2.55	0.8%
	Length	3.61	3.69	3.99	4.12	4.16	1.0%

Source: Own elaboration based in WIOD version 2016

Total Upstreamness and Downstreamness

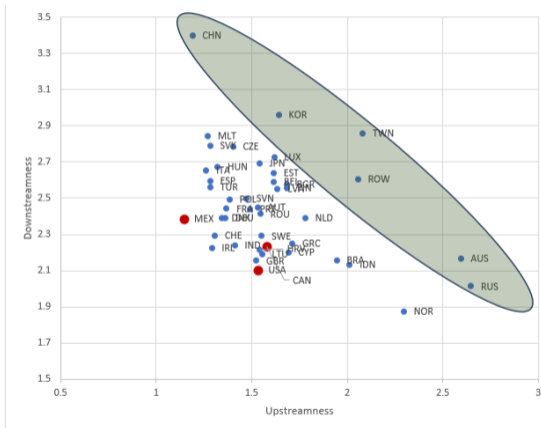Negative correlation between U and D, consistent with specialization.
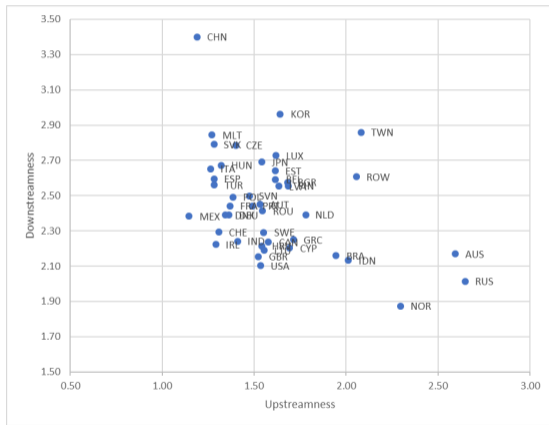
Upstreamness and Downstreamness of Exports- 2014
Source: Own elaboration based in WIOD.

Total Upstreamness and Downstreamness

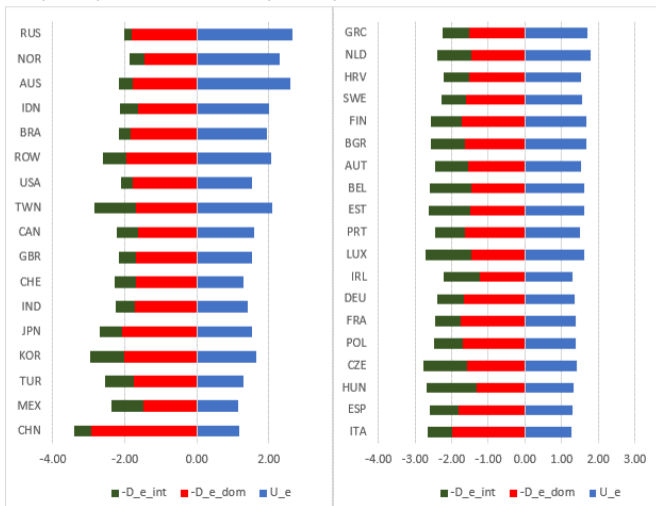Factory-Asia is more fragmented. Factory-America shows lower length

Upstreamness and Downstreamness of Exports- 2014
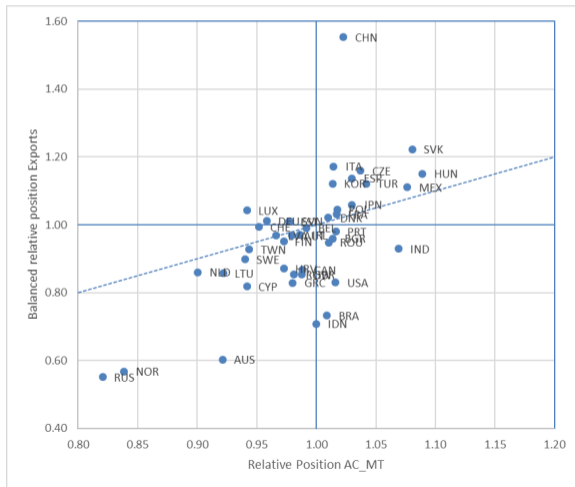*Source:* Own elaboration based in WIOD.

Length and Position in GVCs

International ($D_{e\,int}$) and Domestic ($D_{e\,dom}$) Downstreamness and Upstreamness (U_e)

- Most D of China is due to domestic linkages
- Mexico exhibit very short chains, on every segment

Comparison of position in GVC

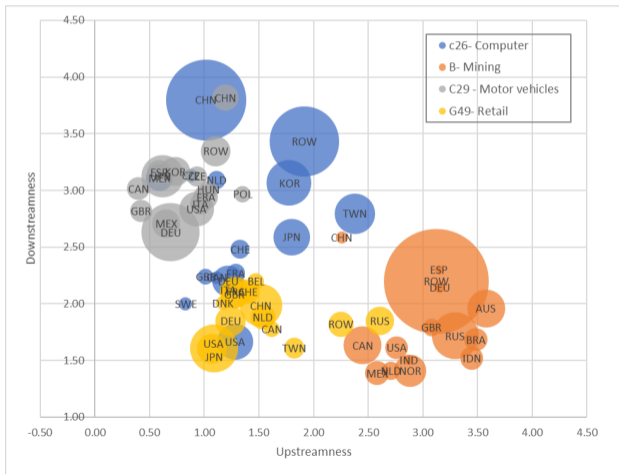Balanced RP of Exports and Ratio of U to D according to AC-MT. Year 2014

- Positive association indicates concordance
- Brazil, USA and India are Downstream according to AC-MT but Upstream when only exports are considered

Source: Own elaboration based in WIOD.

Description at country-sector level

U and D: 4 main sectors and 10 main countries

- GVC of Computer products is the most specialized
- USA performs low U and D in most GVCs

Conclusions

- Current well-known measures for Upstreamness, Downstreamness, length and position in GVC do not generate the appropriate description of specialization of countries
- Focusing directly on gross export decomposition (both forward and backward-looking) gives rise to intuitive and consistent measures
- There is a strong negative correlation between U and D, and countries within regional factories tend to have the same length
- In the peak of fragmentation (2000-2014) there has been a rise in the length of chains both upstream and downstream, but in international trade the distance to final demand increased more than the distance to primary factors
- China participates in the lengthiest international chains, especially as a downstream producer. Unlike other D countries, its measures rely on domestic content instead of foreign
- Unlike measures based in production, USA, Canada, Brazil and India specialize in upstream stages when exports are the basis of measures.

Main References

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