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"The Implications of the Global Value Chain Revolution for Input-Output Analysis: Next Steps"

Bart Los
(with thanks to Xianjia Ye and Luuk Appels)

University of Groningen, Groningen Growth and Development Centre

German Input-Output Workshop, Osnabrück, March 12-13, 2020

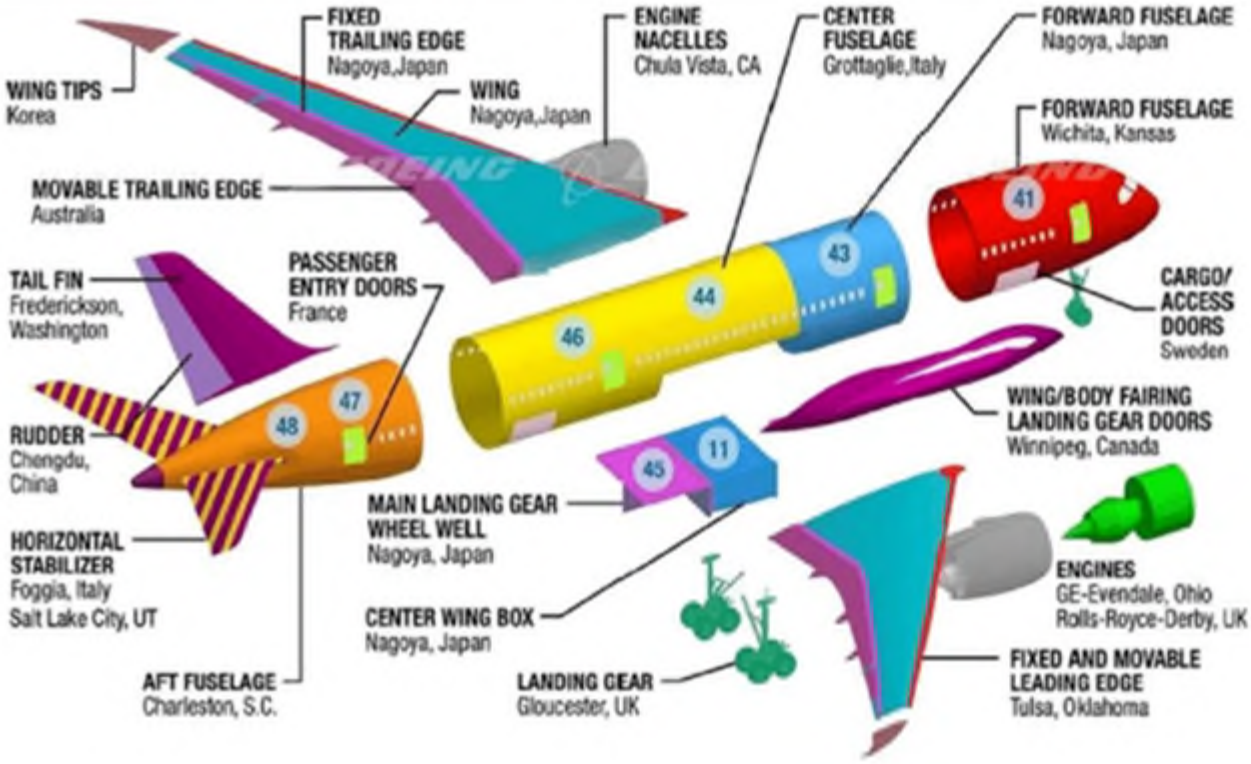
The Global Value Chain Revolution

BUSINESS

(*WSJ*, June 13, 2019)

Boeing 737 MAX Grounding Ripples Through Supply Chain

Trade tensions, lower airline profits and now MAX uncertainty threaten historic jetliner boom



About 600 suppliers of components all over the world suffer as well, and many of these have multiple subcontractors.

Source: econlife.com

The Global Value Chain Revolution

Value Chain: "All activities required to produce a final product" (this includes services activities)

(cf. Pasinetti, 1981, "vertically integrated sectors")

"International Fragmentation of Production Processes" (Arndt and Kierzkowski, 2001)

"Second Unbundling" (Baldwin, 2006)

Causes:

- Trade liberalization (WTO, EU Single Market, regional Free Trade Agreements)
- Continuing reductions in transportation costs (containerization, etc.)
- Internet technology (remote management of inventories and logistics)

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Two GVC-archetypes

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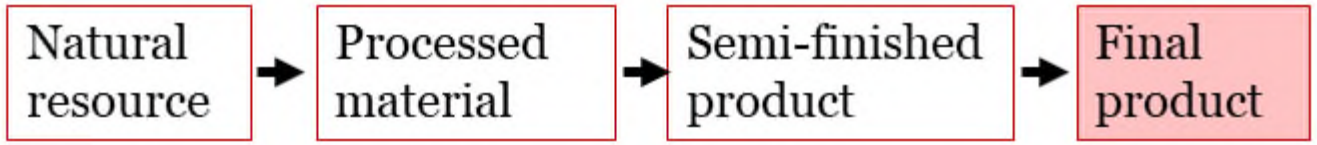
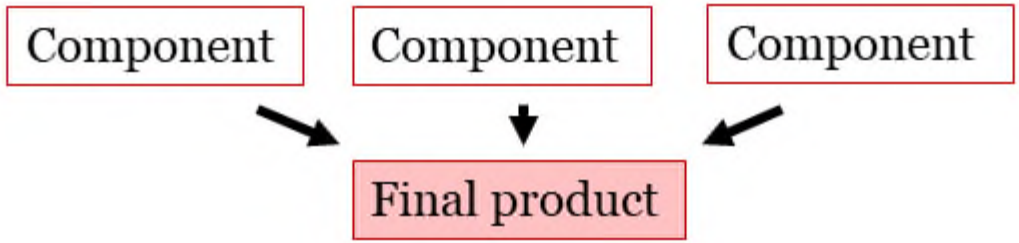
Snake:



Spider:



Baldwin and Venables (2013, *JIntEc*)

Reality: Mixes of both archetypes. "Snaky" aspects have made IO-analyses particularly relevant.

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Stylized WIOTs over Time

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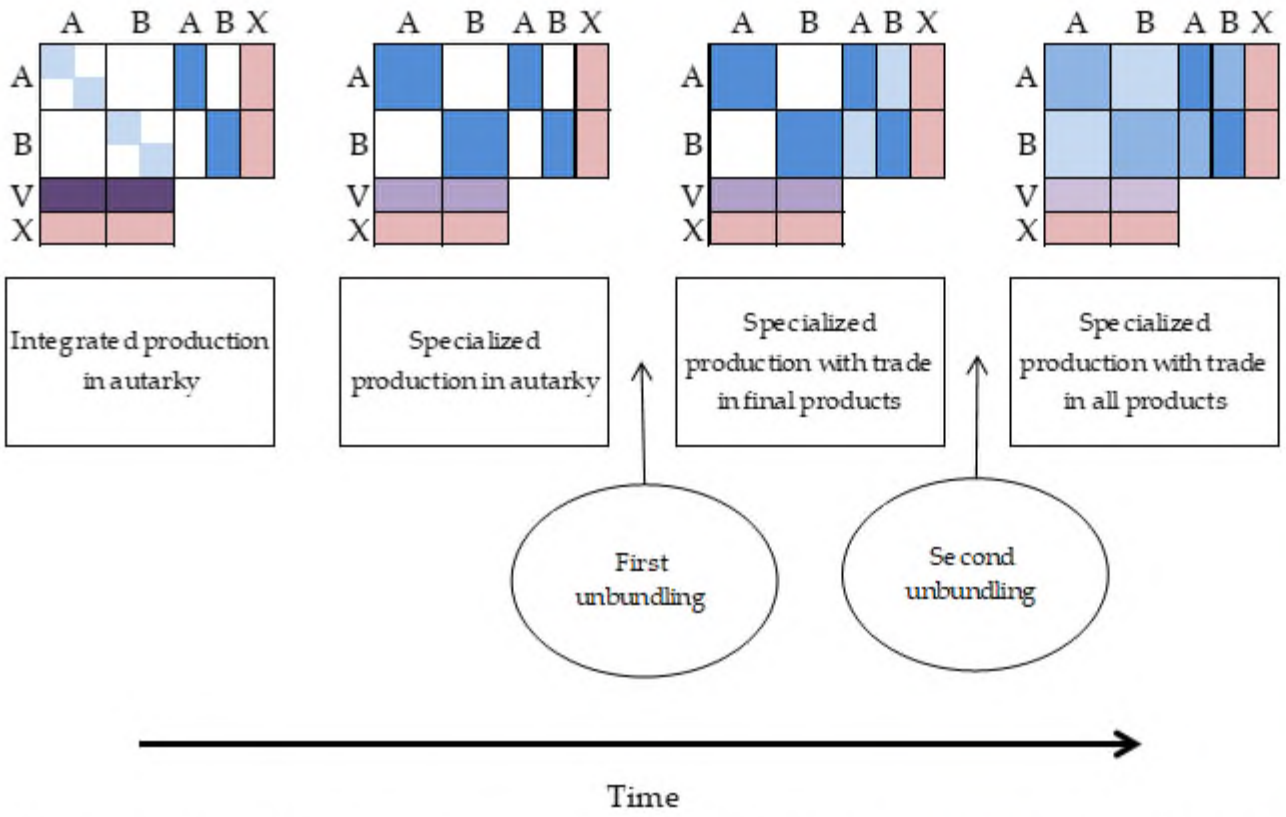

Two regions A and B, each consisting of two industries; V: value added; X: gross output; White cells contain zeros, dark cells contain positive values.

Source: Los (2018, Elgar Handbook of Input-Output Analysis, ed. Ten Raa)

GVC revolution reflected in IO tables:

- Value added to output coefficients shrank
- Domestic intermediate input coefficients shrank
- Imported intermediate input coefficients grew
- See next three slides for empirics

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The GVC Revolution (1995-2011)

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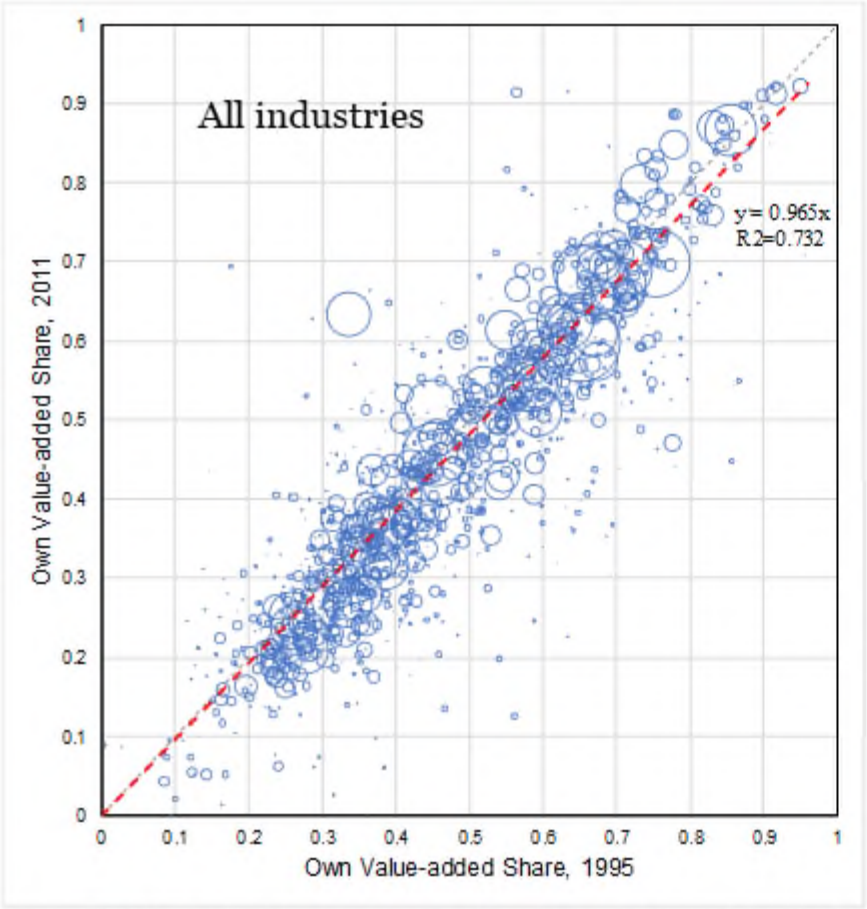

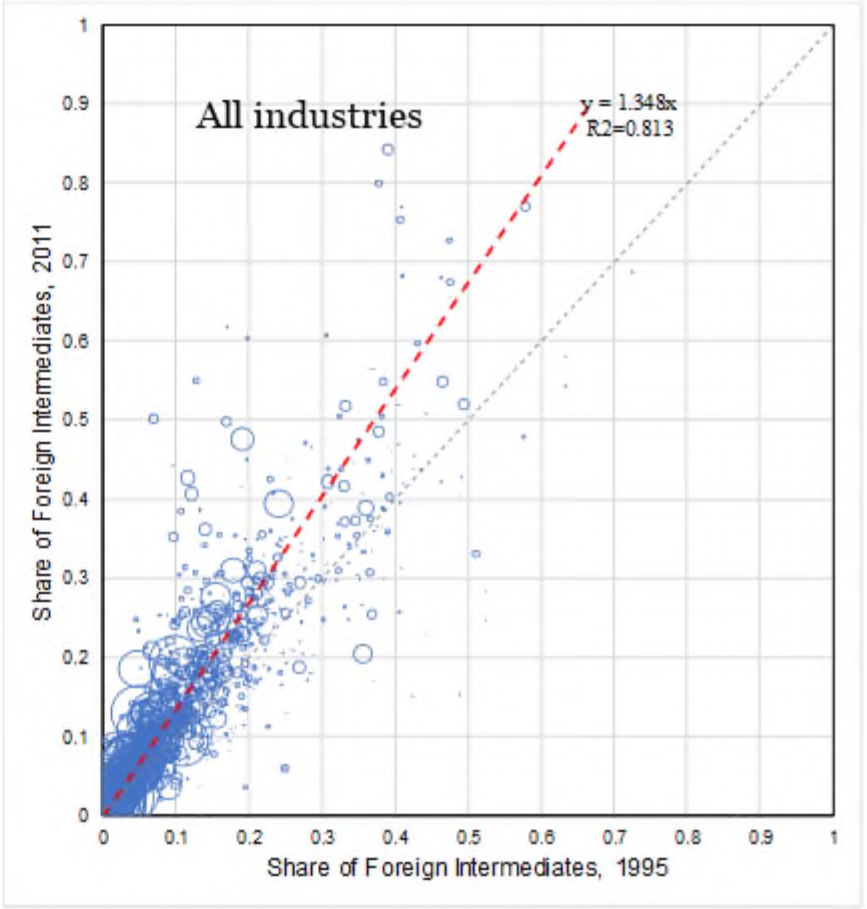

Note: Red line: weighted regression line through the origin; Dashed line: 45-degrees line; Circle areas proportional to 1995 output.
Source: Own calculations, based on WIOD-2013 release (Timmer et al., 2015)

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The GVC Revolution (1995-2011)

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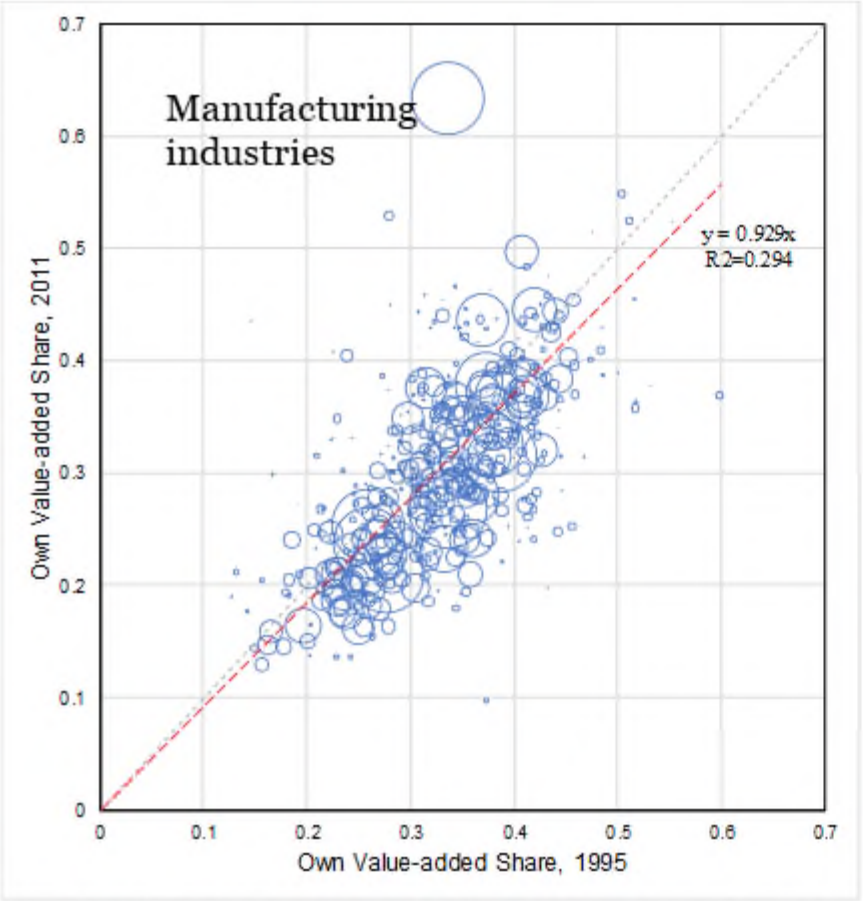

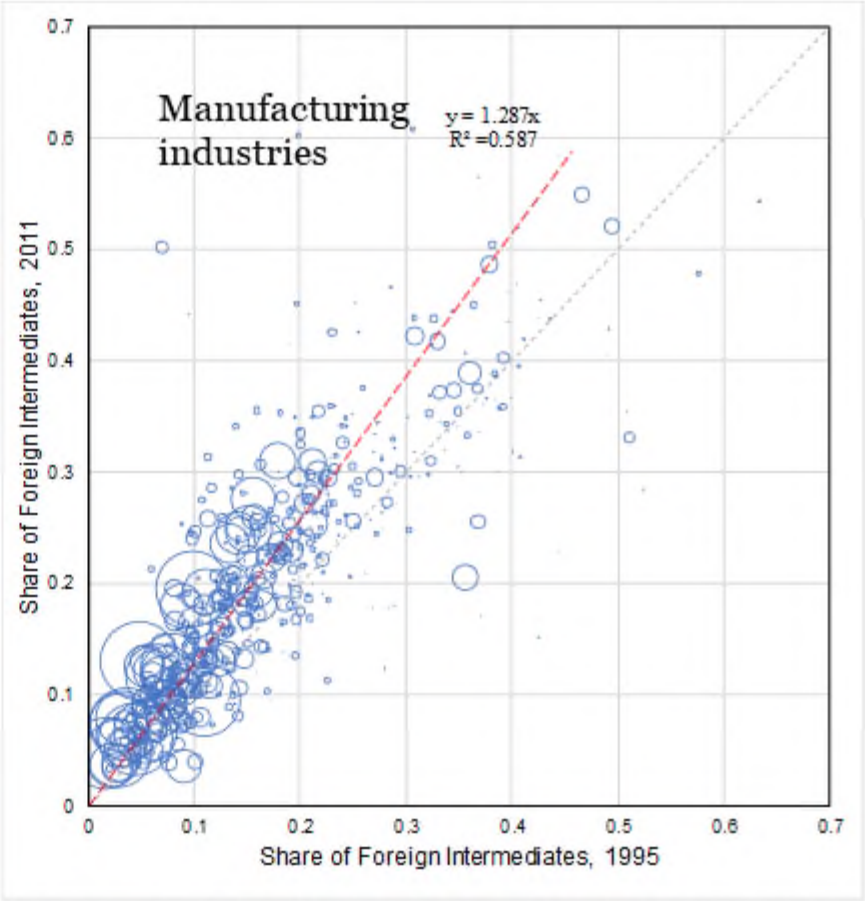

Note: Red line: weighted regression line through the origin; Dashed line: 45-degrees line; Circle areas proportional to 1995 output.
Source: Own calculations, based on WIOD-2013 release (Timmer et al., 2015)

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The New Normal? (2011-2014)

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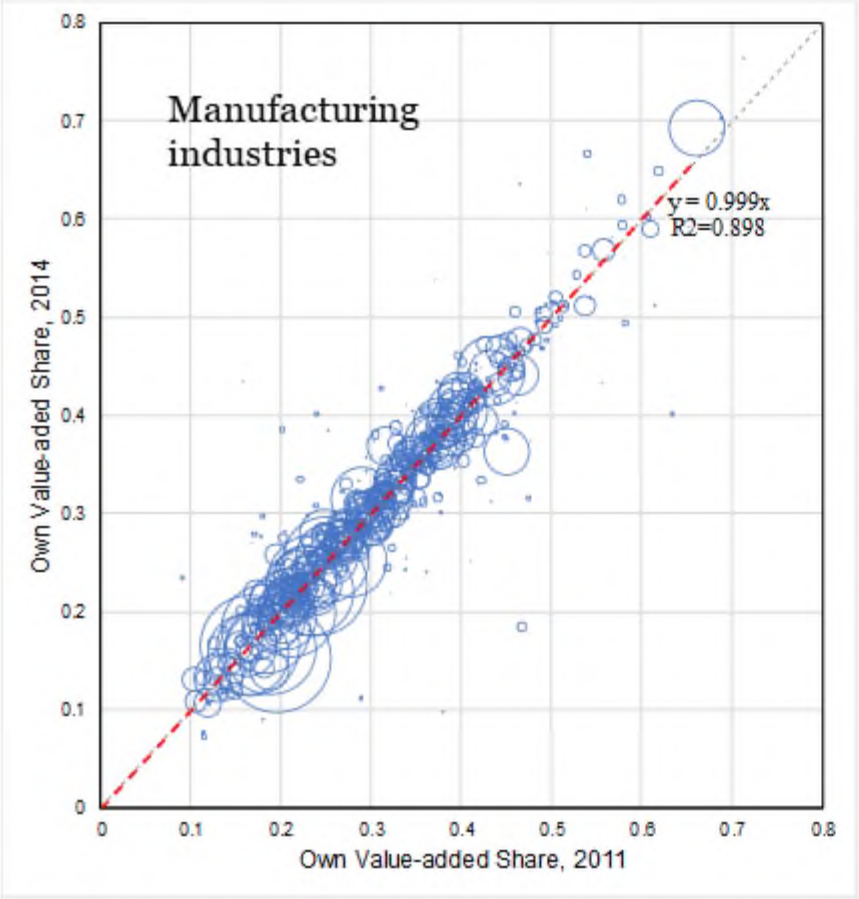

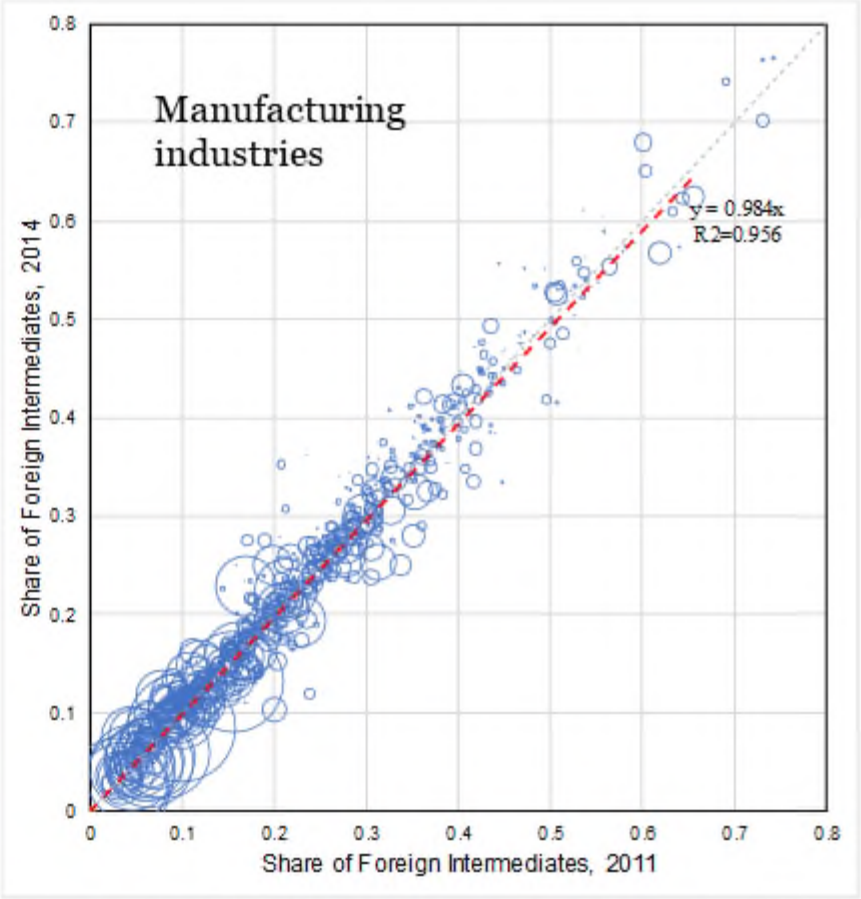

Note: Red line: weighted regression line through the origin; Dashed line: 45-degrees line; Circle areas proportional to 2011 output.
Source: Own calculations, based on WIOD-2016 release (Timmer et al., 2016)

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Sidestep: Trade in Intermediate Products

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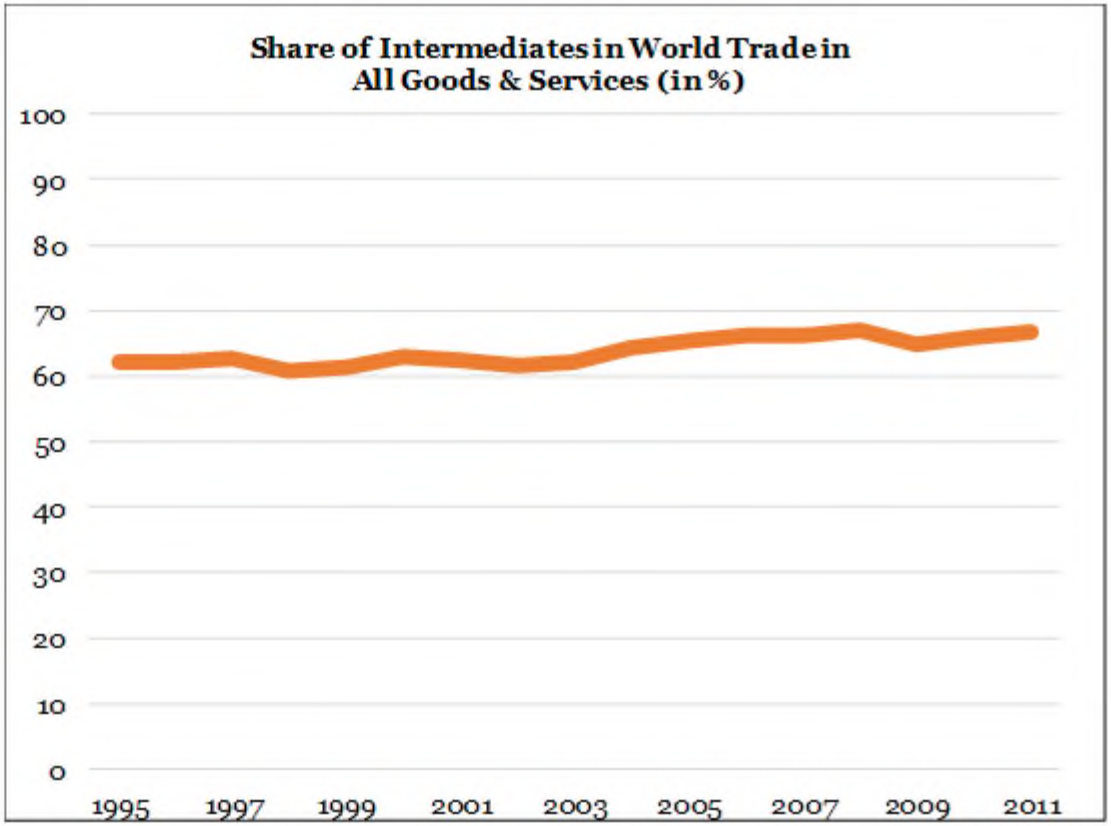
Common mistake: GVC-revolution would have implied marked increase in share of intermediates trade in total trade

This share grew by only 7 %-points over 1995-2011.

Assembly activities also offshored, to benefit from economies of scale: Trade in final products grew as well.



Source: Own calculations, based on WIOD-2013 release (Timmer et al., 2015)
Note: Trade within RoW considered as within-country transactions.

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GVCs: Renewed Interest in Input-Output

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Examples from major mainstream economics outlets:

- Johnson and Noguera (2012, *JIntEc*; 2017, *REStat*)
- Antras and Chor (2013, *Ectrica*)
- Koopman, Wang and Wei (2014, *AER*)
- Timmer et al. (2014, *JEconPersp*)
- Costinot and Rodriguez-Clare (2014, *Elsevier Handbook of Int'l Econ*)
- Caliendo and Parro (2015, *REStud*)
- Reijnders and de Vries (2018, *JDevEc*)
- Auer et al. (2019, *REStat*)

Etc. etc.

In grey: "Non-standard IO"

The IO-community missed several boats… We should be more relevant than just as data constructors.

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Three Potential 'Close-to-Home' Steps

1. Focus on 'something' to value added ratios rather than on 'something' to gross output ratios;
2. Different set-up of SDAs quantifying the effects of change in technology and trade on 'something';
3. More attention to activities/tasks/functions/occupations, rather than to industries and products.

1. and 2. would imply improvements without new data,
3. requires data that have recently become available.

1. Focus on *Value Added* in the Denominator of Coefficients, rather than *Gross Output*

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CO2 Emission Coefficients

09/04/2020

Electrical and Optical Equipment Industry 2007
(source: WIOD-2013 release)

	CO2/x	CO2/v	v/x
AUS	0.0157	0.0345	0.46
AUT	0.0060	0.0146	0.41
BEL	0.0115	0.0286	0.40
BRA	0.0296	0.0887	0.33
CAN	0.0447	0.1221	0.37
CHN	0.0145	0.0828	0.17
CZE	0.0066	0.0354	0.19
GER	0.0081	0.0198	0.41

CO2 in kiloton

v: value added in mln$

x: gross output in mln$

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According to conventional indicator: AUS-Elec and CHN-Elec about equally dirty.

But CHN emits much more per $ of VA (and relies much more on intermediates)

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In Europe similar result for CZE-Elec and GER-Elec.

Given that v/x tended to decline during GVC-revolution, this has implications for interremporal comparisons as well (SDA).

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SDA and Emission Coefficients

09/04/2020

1995
(Trade in Final Products)

		D			
		M	S	F	x
D	M	10	10	80	100
	S	10	10	80	100
imp		0	0		
	w	80	80		
	x	100	100		
	c	40	40		

2010
(GVC Trade)

		D			
		M	S	F	x
D	M	15	15	120	150
	S	15	15	120	150
imp		20	20		
	w	100	100		
	x	150	150		
	c	50	50		

In green: CO2 emissions;
All numbers hypothetical

SDA and Emission Coefficients

Basic SDA example: "What explains the economywide increase of CO2 emissions from 80 to 100 units?"

Standard approach: 1) cleaner/dirtier production processes (**k**); 2) changes in the intermediate input coefficients (**L**); 3) changes in final demand (**f**).

$$c_{2010} - c_{1995} = (\Delta\mathbf{k})'\mathbf{Lf} + \mathbf{k}'\Delta\mathbf{Lf} + \mathbf{k}'\mathbf{L}\Delta\mathbf{f}$$

Using arithmetic averages of 'polar decompositions' (Dietzenbacher and Los, 1998):

$\Delta\mathbf{k}$: -16.67; $\Delta\mathbf{L}$: 0.00; $\Delta\mathbf{f}$: 36.67

SDA and Emission Coefficients

But have technologies become cleaner indeed?? "Own" pollution is generated by activities, not by purchased inputs. Emissions per $ of value added remained constant…

GVC approach: 1) changes in emission to VA coefficients ($\mathbf{k}^*$); 2) changes in fragmentation ($\mathbf{v}$, VA to GO ratios); 3) changes in intermediate input coefficients ($\mathbf{L}$); 4) changes in final demand ($\mathbf{f}$).

$$c_{2010} - c_{1995} = (\Delta\mathbf{k})'\hat{\mathbf{v}}\mathbf{L}\mathbf{f} + \mathbf{k}'\Delta\hat{\mathbf{v}}\mathbf{L}\mathbf{f} + \mathbf{k}'\hat{\mathbf{v}}\Delta\mathbf{L}\mathbf{f} + \mathbf{k}'\hat{\mathbf{v}}\mathbf{L}\Delta\mathbf{f}$$

Result: $\Delta\mathbf{k}^*$: 0.00; $\Delta\mathbf{v}$ -16.67; $\Delta\mathbf{L}$: 0.00; $\Delta\mathbf{f}$: 36.67

International fragmentation led to lower domestic emissions, rather than cleaner production!

2. Different Set-Ups of SDAs aimed at Disentangling Effects of Technology and Trade

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Technology or Trade? SDA

1995

		D		H		D	H	
		M	S	M	S	F	F	x
D	M	10	10	0	0	60	20	100
	S	10	10	0	0	60	20	100
H	M	0	0	10	10	20	60	100
	S	0	0	10	10	20	60	100
	w	80	80	80	80			
	x	100	100	100	100			
	c	40	40	60	60			

Era: Trade in Final Products

2010

		D		H		D	H	
		M	S	M	S	F	F	x
D	M	15	15	0	0	85	35	150
	S	15	15	0	0	85	35	150
H	M	10	10	15	15	15	65	130
	S	10	10	15	15	15	65	130
	w	100	100	100	100			
	x	150	150	130	130			
	c	50	50	70	70			

Era: GVC Trade

In green: CO2 emissions; D: Hypothetical GER; H: Hypothetical HUN; M: Manufacturing; S: Services

Technology or Trade? SDA

Common approach (e.g. v/d Linden and Oosterhaven, 1995, *ESR*):

$$c = \mathbf{k}'(\mathbf{I} - [\mathbf{T}^{\mathbf{A}} \therefore \mathbf{A}^{*}])^{-1}[\mathbf{T}^{\mathbf{F}} \therefore \mathbf{F}^{*}] \qquad \therefore : \text{Cell-by-cell multiplication}$$

Five potential sources of changes in CO2 emissions. Those related to trade are contained in the **T**-matrices. t_{risj} indicates the share of country r in the inputs of industries i in the production process of country s's industry j.

Captures BMW switching from purchasing German banking services to British banking services, implying less emissions in GER.

Technology or Trade? SDA

Two (related) problems:

1. BMW might also have offshored part of its own activities to HUN (GVC trade characterized by substitution of own value added by foreign intermediate inputs; see 'factoryless manufacturers'; Bernard and Fort, 2015, *AER*). An effect of trade, but not considered as such.

2. If BMW offshores its polluting metal products manufacturing activities to HUN, but maintains its R&D and accounting departments in GER, the lower emissions in GER show up as outcomes of technological progress… But it is due to new opportunities to trade.

Alternative Approach

GVC table: $G = \hat{\mathbf{k}}\mathbf{L}\widehat{\mathbf{Fe}}$ **e**: column vector with ones

Meaning: $g_{ri,sj}$ stands for the emissions of industry i in country r, needed for the production of final product j completed in country s.

See table on next slide

Tables for two periods in time can be compared using SDA techniques.

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Alternative Approach

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G10		D		H		ci
		M	S	M	S	
D	M	45	5	0	0	50
	S	5	45	0	0	50
H	M	7	7	49.5	6.5	70
	S	7	7	6.5	49.5	70
	cg	64	64	56	56	240
	f	120	120	80	80	

cg: CO_2 emitted in GVC for final products completed by the country-industry in the column header;

ci: CO_2 emitted by country-industry in the row header (cf. cells in green on slide 20).

Ratios between cg and f indicate how much CO_2 is emitted anywhere in the world in the production of a final product, irrespective of whether a BMW is produced from scratch to car in Germany or not;

Ratios between a cell and its corresponding column sum indicates to what extent a country-industry is an important location of emitting activities in the production of a BMW or not.

Alternative Approach

Next step: SDA based on two GVC tables rather than based on MRIOs

See Reijnders and De Vries (2018, *JDevEc*)

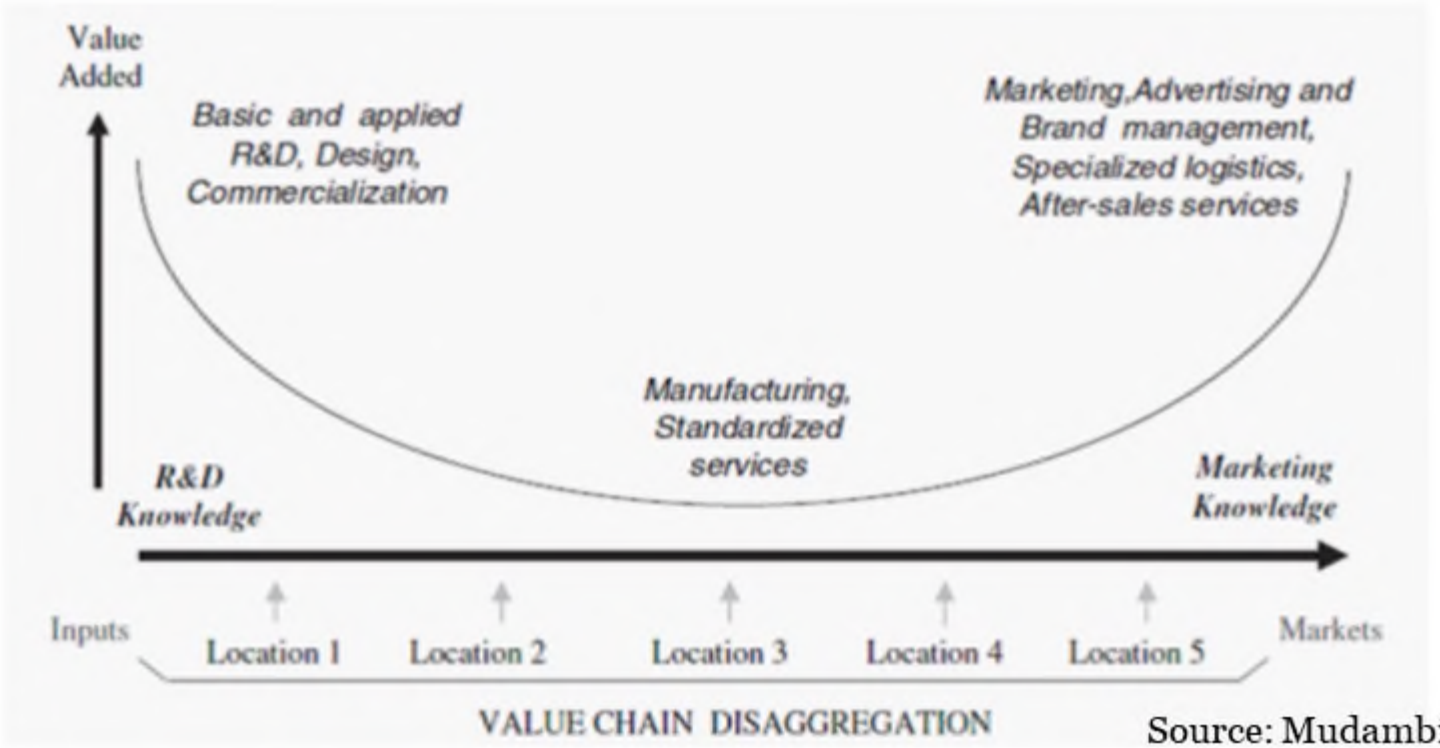
Determinants driving emissions in GER:

(1) Changes in worldwide final demand;
(2) Changes in composition of worldwide final demand (w.r.t. types of products demanded and w.r.t. country-of-completion);
(3) Changes in GVC-specific emission technologies;
(4) Shares of GER in emissions within GVCs.

Coefficients can be computed from GVC tables.

3. More Attention for Activities / Functions / Occupations, rather than Conventional Industry Labels

"Smile Curves" (Shih, 1996, *Acer Foundation*)



Source: Mudambi (2008)

Horizontal axis: from pre-production functions (left) to post-production functions (right)

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"Smile Curves" (IO-style)

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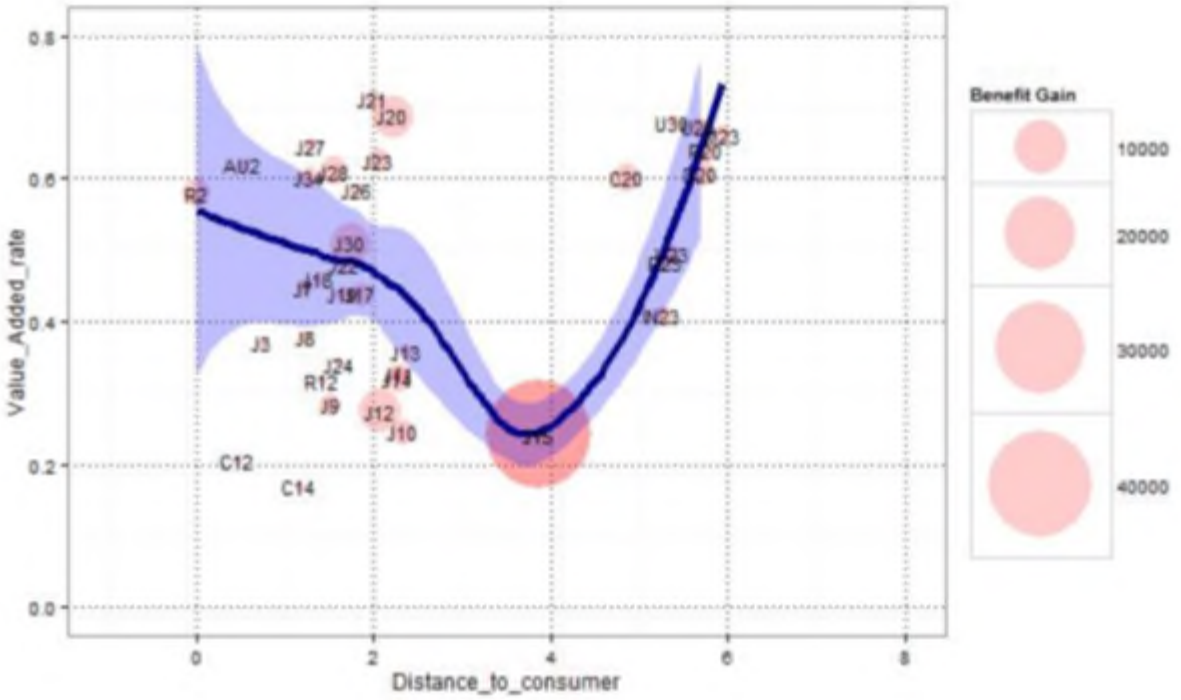

Source: Ye, Meng, Wei (2015)

Horizontal axis: from upstream sectors (left) to downstream sectors (right). Completely different thing…

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Functional Specialization

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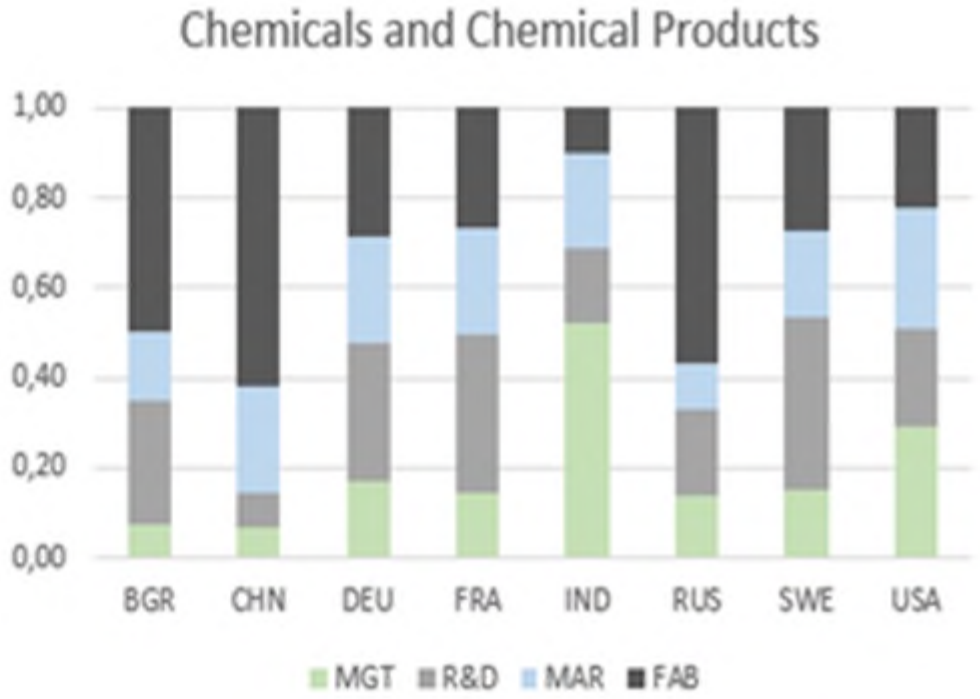
Business functions:

- *Management*: e.g. financial managers, HR managers
- *R&D*: e.g. engineers, computing professionals
- *Marketing*: e.g. sales persons, client information clerks
- *Fabrication*: e.g. assemblers, machine operators



Vertical axis: shares of functions in total labor income earned in this industry

Source: Appels (2020), based on data from Timmer et al. (2019)

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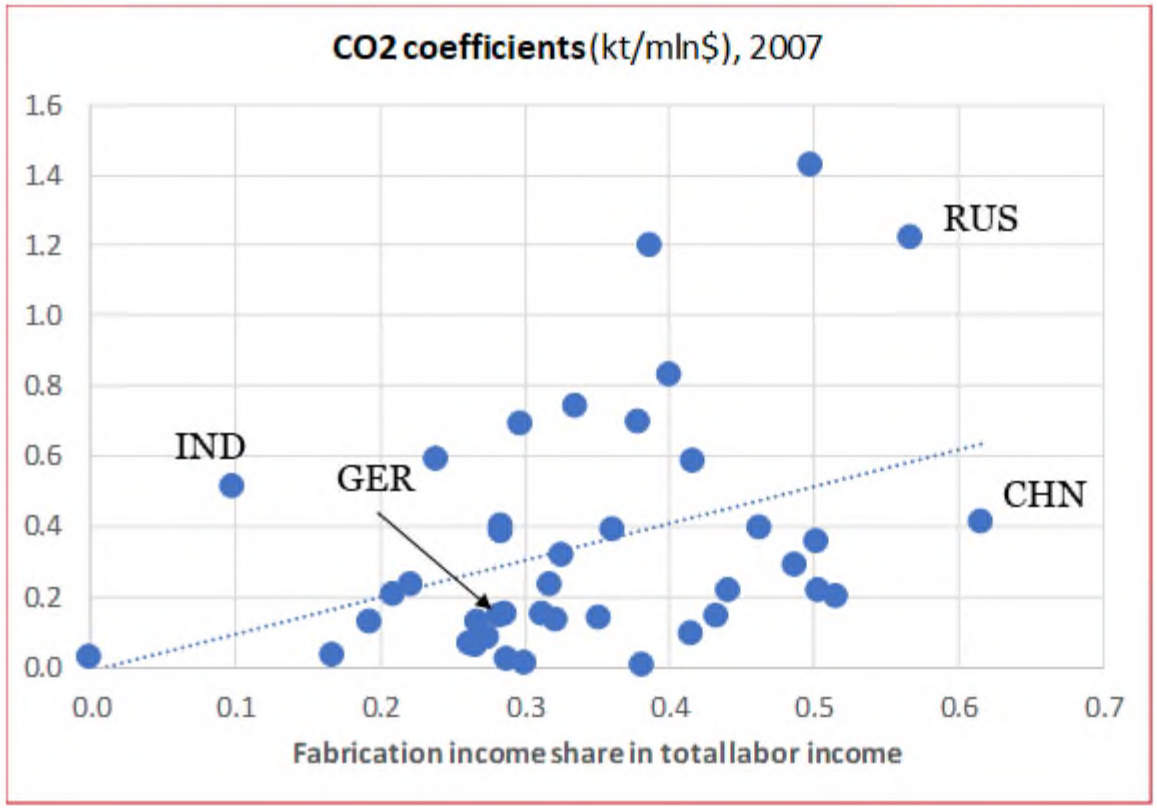
Functional Specialization and CO2 emissions

09/04/2020

Chemicals 2007

(source: WIOD-2013 release and Timmer et al., 2019)



RUS Chem is dirtier than CHN Chem, despite similar share of fabrication;

CHN's Chem and GER's Chem are not comparable. Office work in GER, fabrication in CHN.

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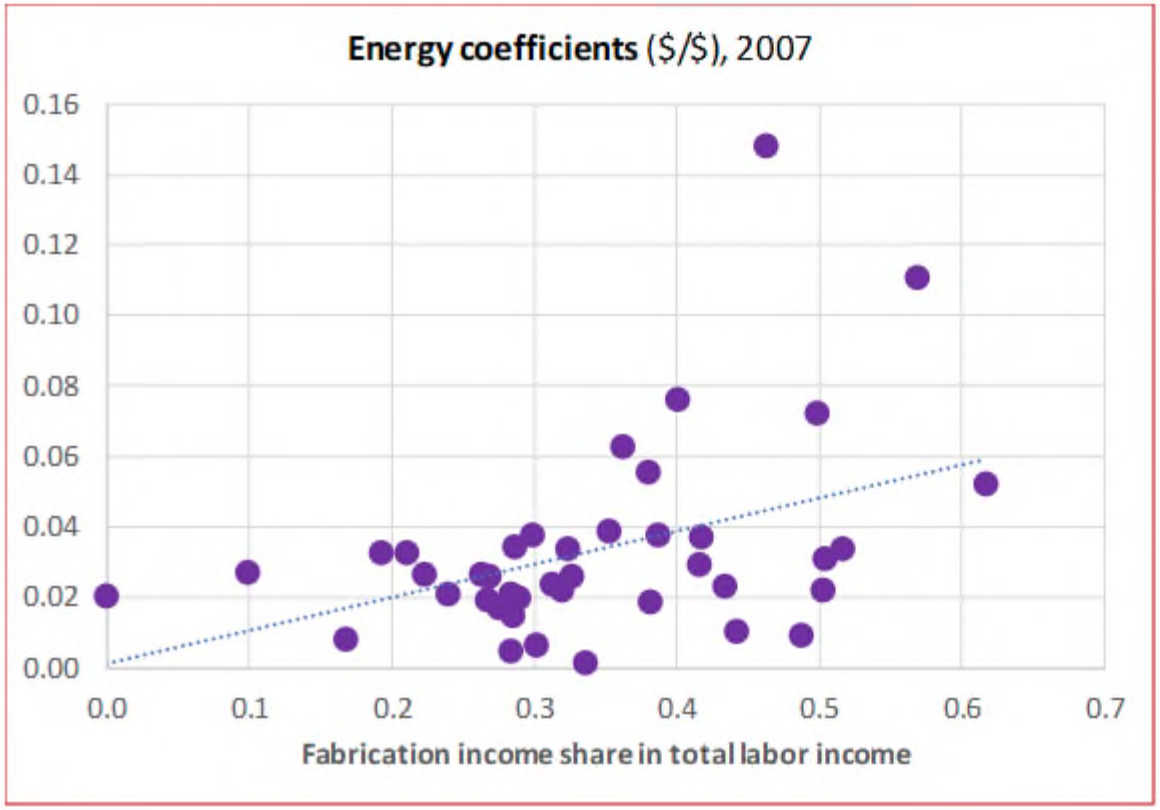
Functional Specialization and Energy Use

09/04/2020

Chemicals 2007

(source: WIOD-2013 release and Timmer et al., 2019)



Domestic technology assumption even more implausible than before GVC revolution: it does not only assume the same technologies, but also the same functions, which is at odds with why GVCs emerged

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(Somewhat Provocative) Reflections

- GVC revolution has made IO analysis more relevant, since performance of a country depends on role in network of GVCs
- IO community has contributed to increased popularity by constructing much-needed global IO databases;
- Methods have not been improved sufficiently (focus in this presentation on incremental innovations) to remain at the frontier;
- IO community should be more open to developments in other subfields (e.g. international trade, growth). We should do more than measuring.

Thanks for your attention!

(Questions and comments are welcome at b.los@rug.nl)