



Slicing Up Global Value Chains

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Aims of this study

- International production fragmentation (IPF): unbundling of production processes into “tasks” which are carried out in different countries.
- IPF has a long history (Feenstra 1998), but accelerated since the mid 1990s with global labour supply shock due to opening up of China and India.
- Aim of this explorative study to measure :
 - the trends in IPF for global production of manufacturing goods
 - patterns of factor income distributions within vertically integrated production (denoted by “global value chains”)
- Macro-economic equivalent of the product case studies, like of iPod, Dedrick et al, (2010)



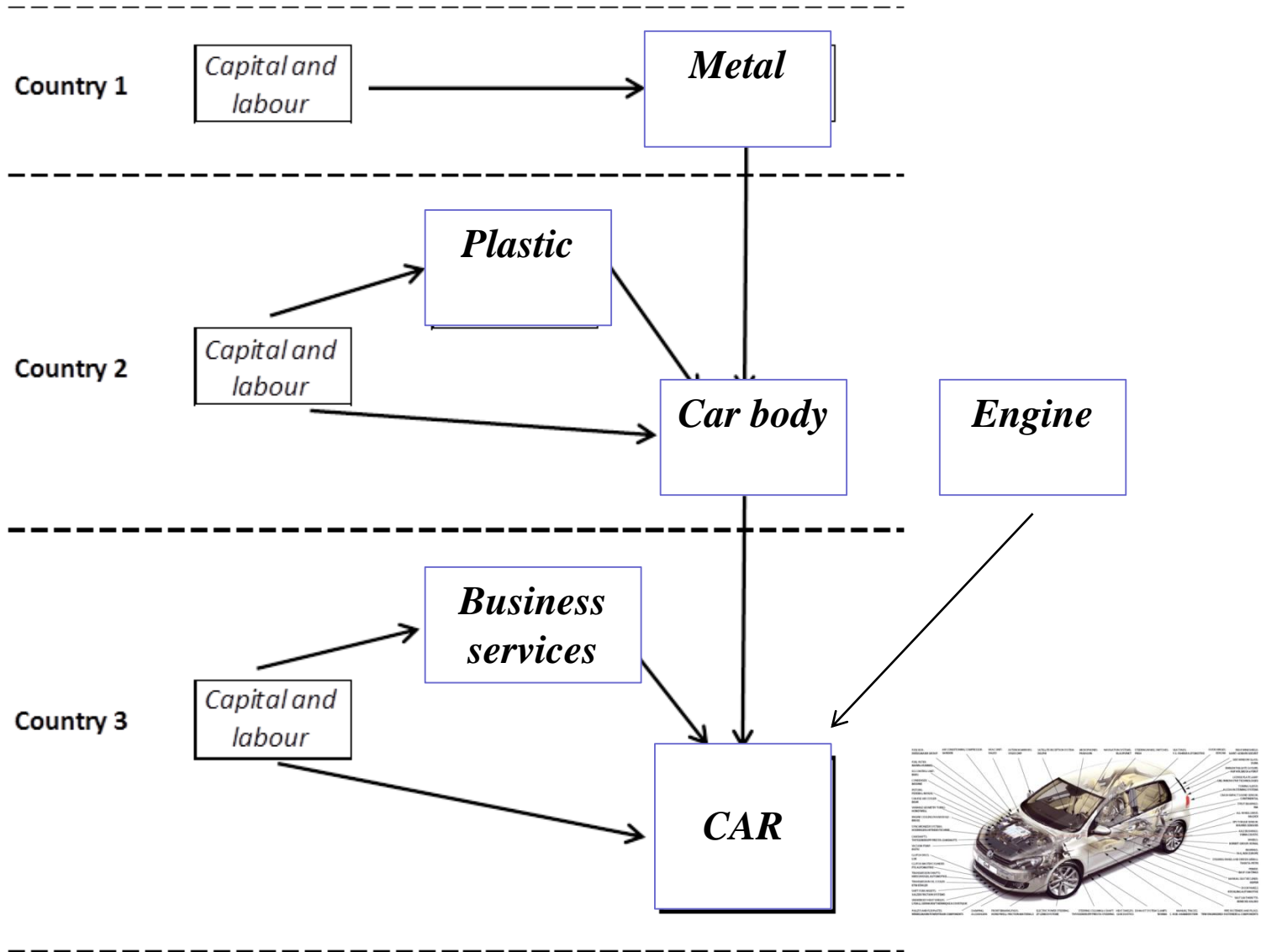
Main findings

- Basically an accounting exercise to provide stylised facts that can serve as starting point for deeper analysis of causes and consequences of IPF.

- We find four trends in global production of manufactures since 1995:
 1. International production fragmentation has increased rapidly
 2. Globally, increasing shares of value added by capital and high-skilled workers, and declining shares for low-skilled workers.
 3. Advanced countries specialise in high-skilled activities.
 4. Capital shares in emerging countries are increasing.



Stylized Global Value Chain (GVC) of a car

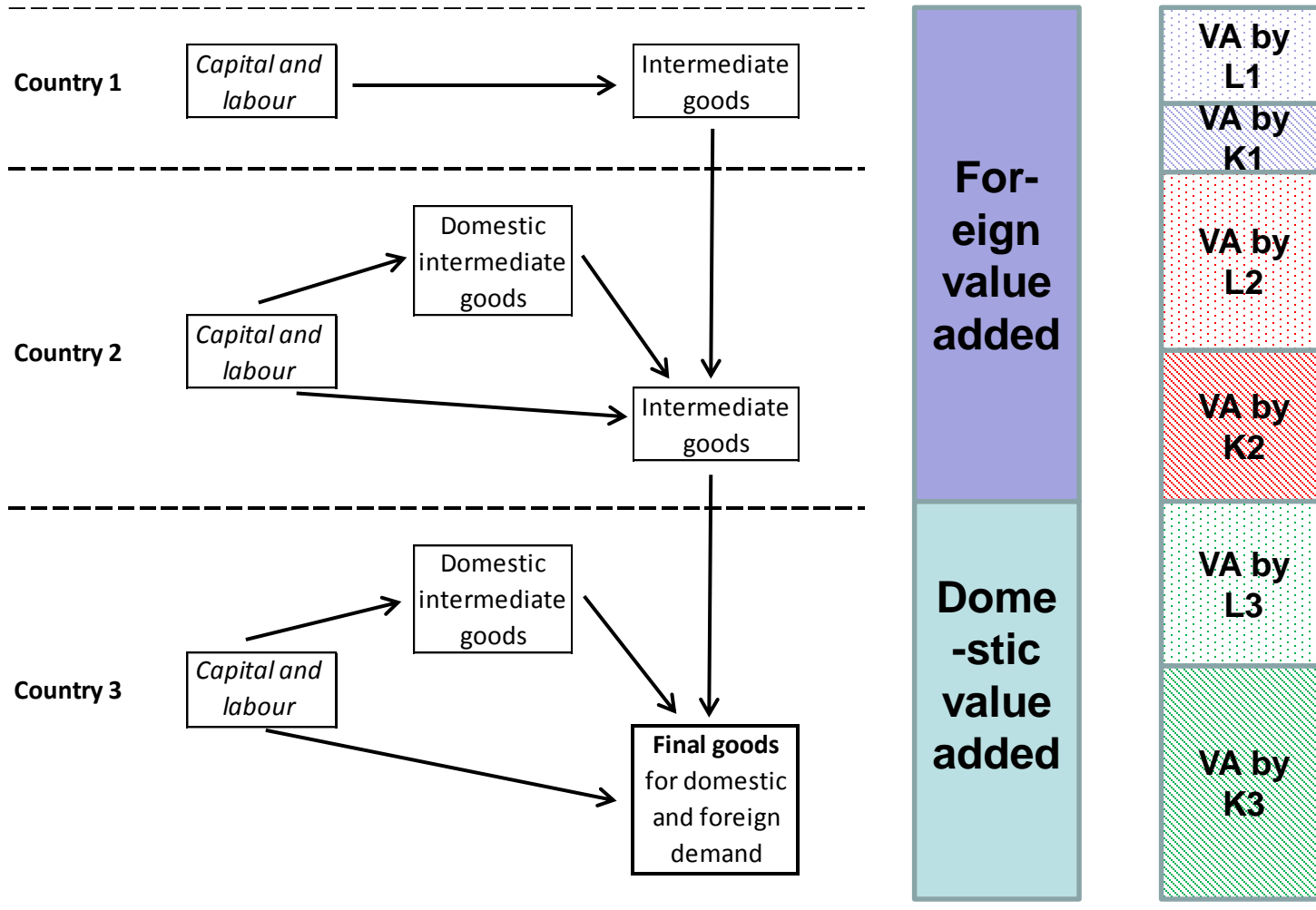




Factor content of a global value chain: graphical representation

Production process of a good

Value of good





Decomposition method

A set of $F(k,h)(x,c)$ can be found by:

$$\mathbf{F} = \mathbf{R}(\mathbf{I} - \mathbf{Z})^{-1}\mathbf{Y} \quad (2)$$

\mathbf{Y} matrix of final output of all products (i,j);

$F(k,h)(i,j)$ = quantity of production factor k located in country h , used in production of product (i,j)

\mathbf{Z} the matrix of intermediate input use of all products per unit of output for each product;

\mathbf{I} is identity matrix and $(\mathbf{I} - \mathbf{Z})^{-1}$ is the Leontief inverse ($= 1 + \mathbf{Z} + \mathbf{Z}^2 + \mathbf{Z}^3 + \dots$);

\mathbf{R} a matrix with direct factor requirements per unit of gross output of (x,c) with elements $[P(k,c)F(k,c)(x,c)] / [P(x,c)(Y(x,c) + Z(x,c))]$

(NB All matrices of the appropriate dimensions with elements in values)



Two new measures

1. The foreign value added share (FVAS) in a final product (x,c)

$$FVAS(x,c) = 1 - \sum_k P(k,c)F(k,c)(x,c) / P(x,c)Y(x,c) \quad (3)$$

This is an indicator of international production fragmentation

2. Factor k cost shares in vertical integrated production a final product (x,c)

$$FCS(k,x,c) = \sum_j P(k,j)F(k,j)(x,c) / P(x,c)Y(x,c) \quad (4)$$

These indicate the factor content of production of the product



Related literature

- Our method is based on Leontief's (1936) input-output decomposition technique, applied to a new industry-level database of global input-output transactions: World Input-Output Database (WIOD)

- Variations of this approach are also used in literature on
 - *vertical specialisation in trade*: Johnson and Noguera (2012, JIE) who extended Hummels, Iishi and Yi (2001, JIE) multi-regional.
 - *Value added content of exports*: Koopman, Wei and Zhang (2014, AER) and Bems, Johnson and Yi (2011, AER)
 - *Factor content of trade*: Reimer (2006, JIE) and Trefler and Zhu (2010, JIE)

- (Methods related to ecological footprinting, and alternatives such as CO₂ and endangered species (Manfred Lenzen, Nature 2013))



Method and Data

- **Method** : Input-output analysis (Miller and Blair, 2009)
- **Data**: World Input-Output Tables representing flows of goods and services across industries *and* countries, for 1995-2011 (www.wiod.org), based on:
 - Times-series of input-output tables benchmarked to national accounts
 - Bilateral trade classified by end-use
 - Capital and workers by three types of educational attainment levels
- Global value chain analysis done for **560 manufacturing products** (14 product groups times 40 countries-of-completion)



DATA: World Input-Output Tables

- **World Input-Output Table (WIOT)** represents flows of goods and services across industries *and* countries (40 countries and rest-of-the-world region), 1995-2008. Two data challenges in construction:

1. Times-series of input-output tables.

- Based on harmonised official benchmark national supply and use tables (34 industries and 59 product groups)
- Adjusted to, and interpolated with, industry output and main final demand time series from the National Accounts (RAS-like method)

2. Allocation of imports to three use categories

- using improved BEC-classification (based on COMTRADE HS 6-digit level) rather than standard proportionality assumption (Feenstra and Jensen, 2012)
- Breakdown of imports by country of origin, using bilateral trade statistics on goods and services (export shares by mirroring imports)

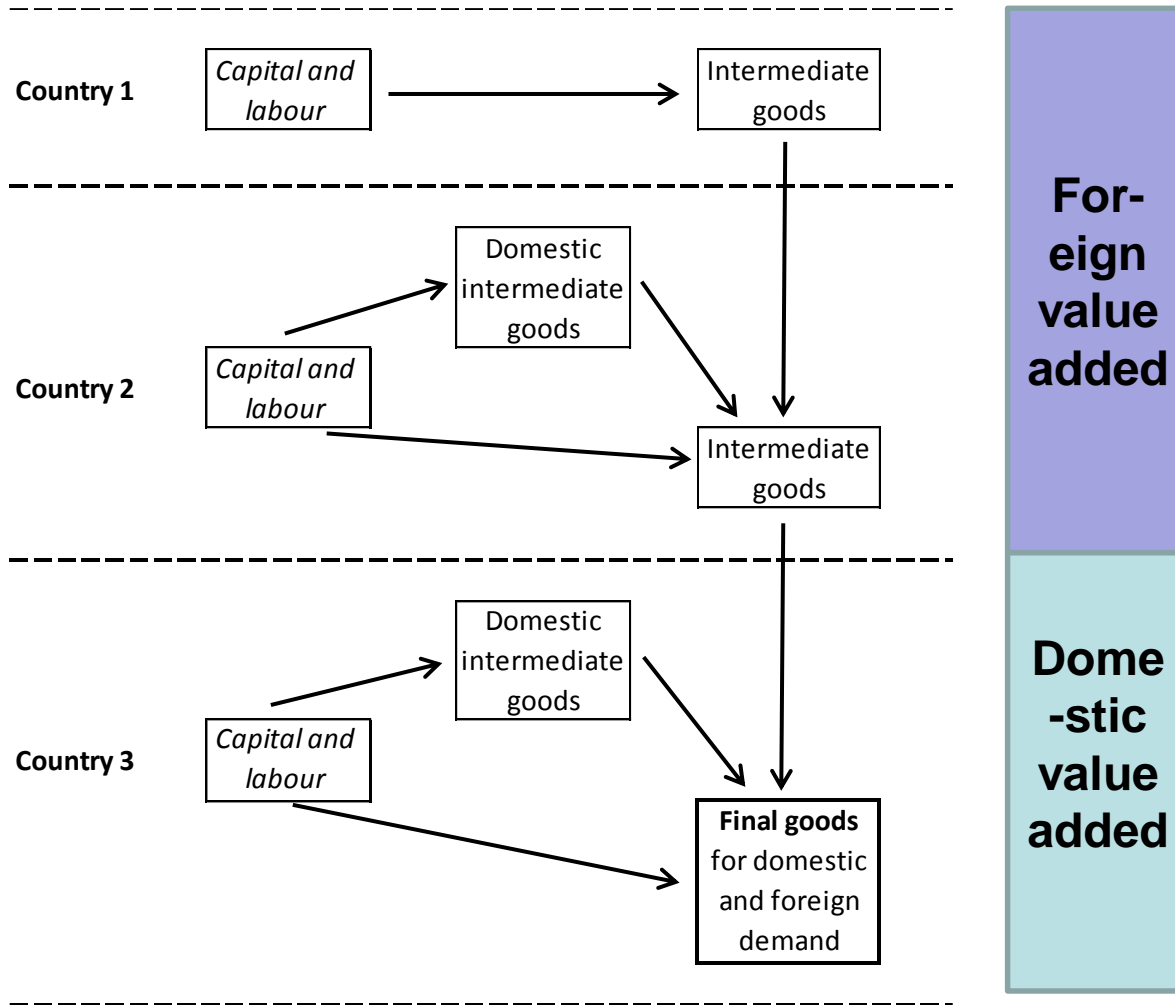


DATA: factor incomes by industry-country

- **Wages and quantities of labour** by skill type
 - Number of workers (incl. self-employed) by three skill types based on levels of educational attainment (ISCED classification)
 - Wages reflect total costs for employer, including imputed wage for self-employed workers (Gollin, JPE, 2002)
 - For advanced countries data taken from EU KLEMS database (see O'Mahony and Timmer, 2009)
 - Other countries: similar methodology based on country-specific labour force surveys and additional materials (Erumban et al., 2011)
- **Capital income** is defined as residual such that the accounting identity will hold:
 - capital income = *value added minus labour compensation*.
 - It reflects income to all capital assets, including intangibles

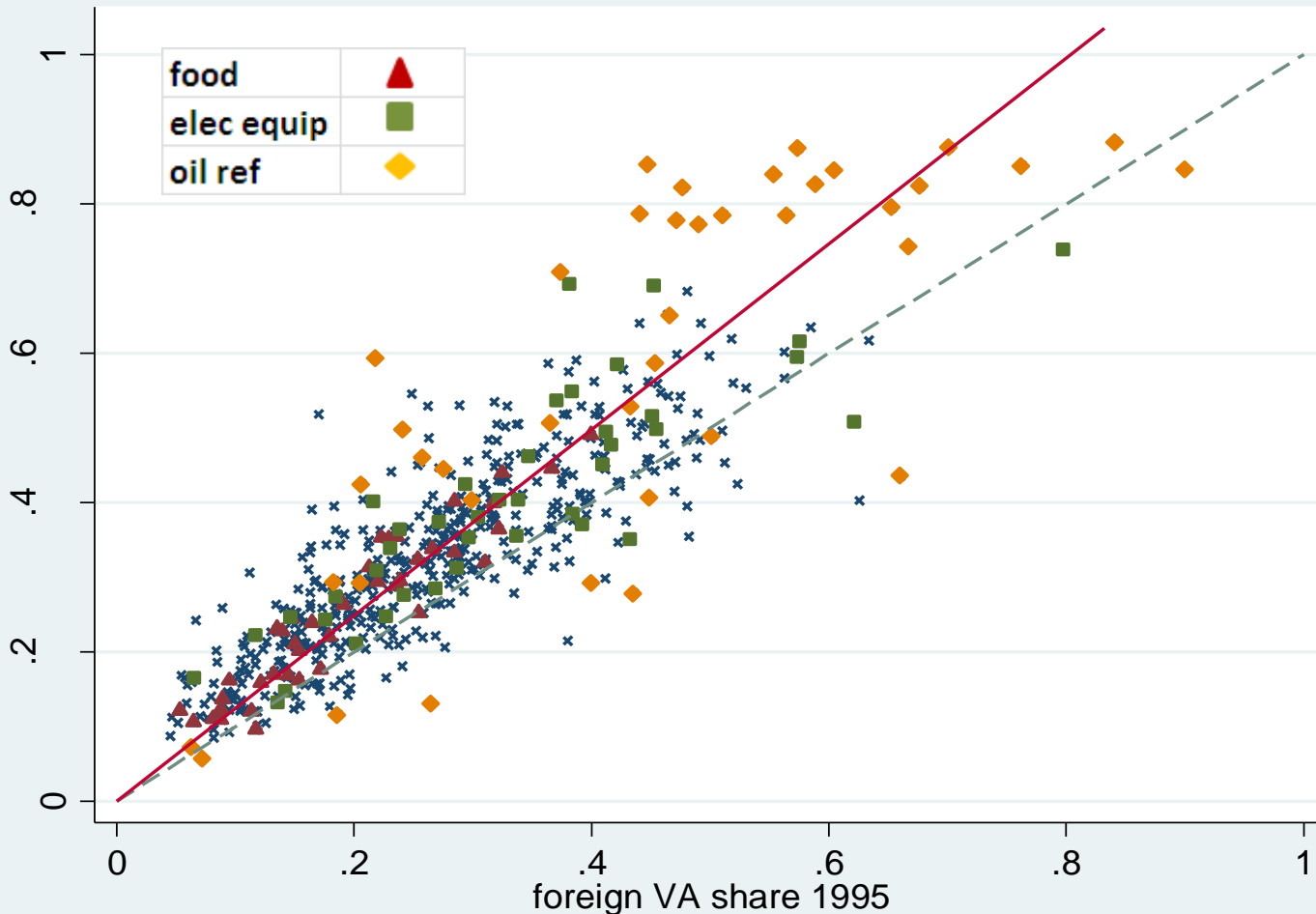


Factor content of a global value chain: graphical representation





Increasing fragmentation between 1995 and 2008



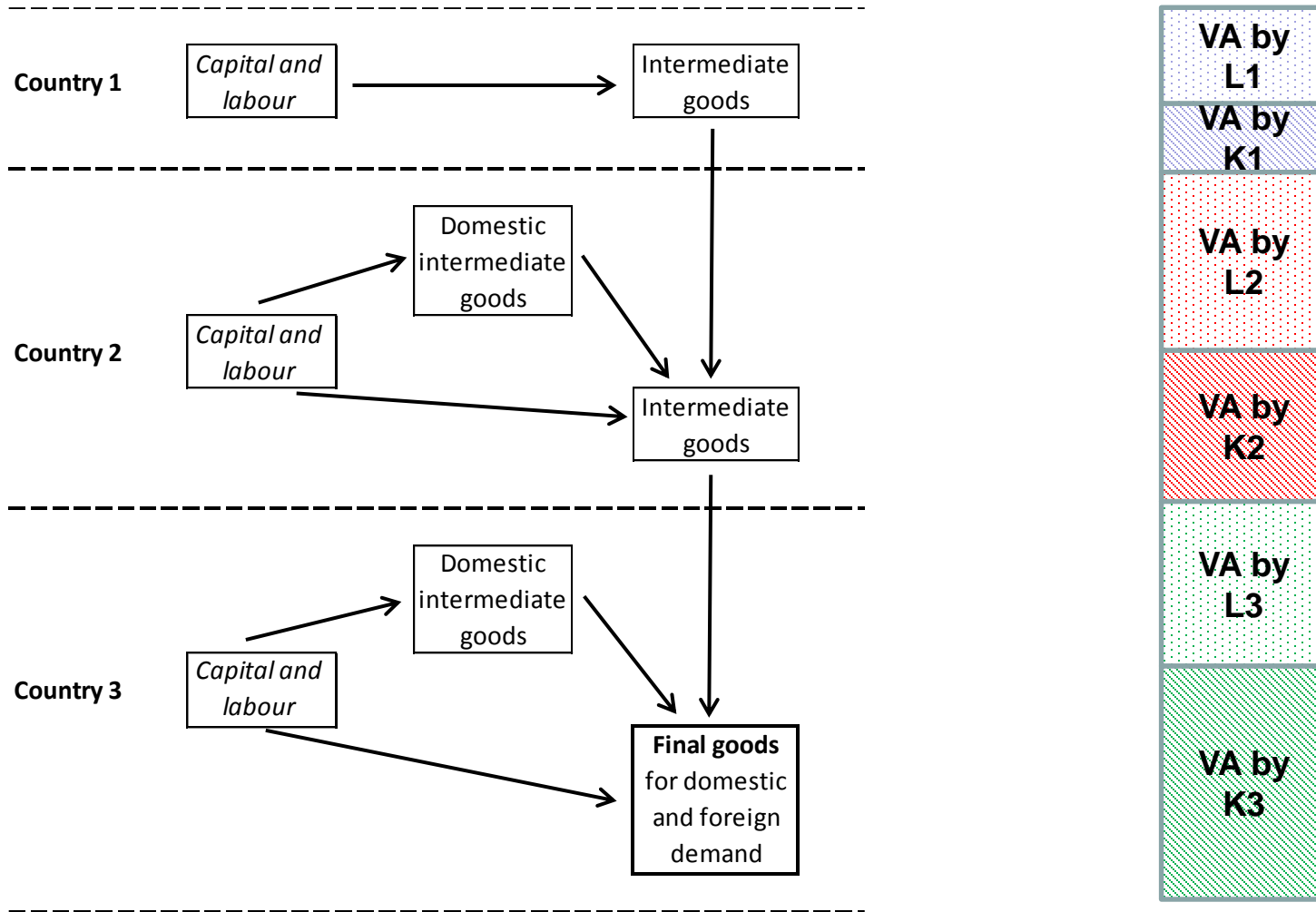
Foreign value added share in final output of each of 14 manufacturing industries in 40 countries

Solid line is OLS with significant slope of 1.20.

NB Output is at basic (ex-factory gate) prices

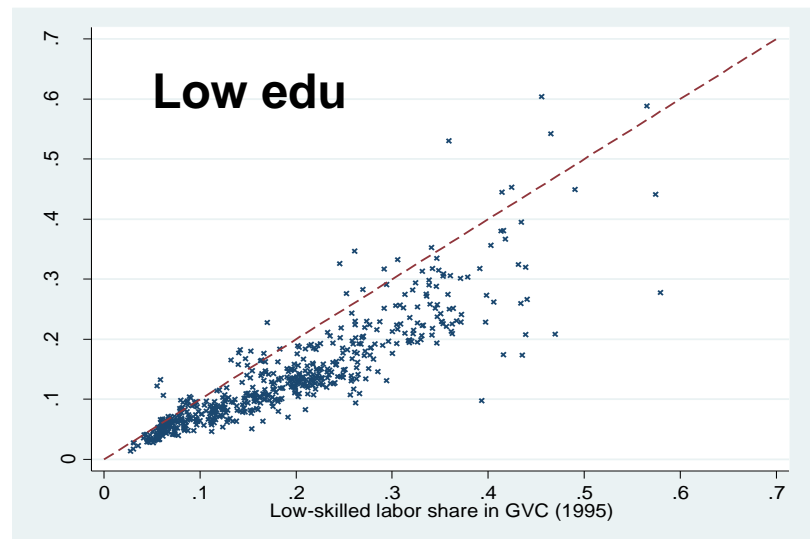
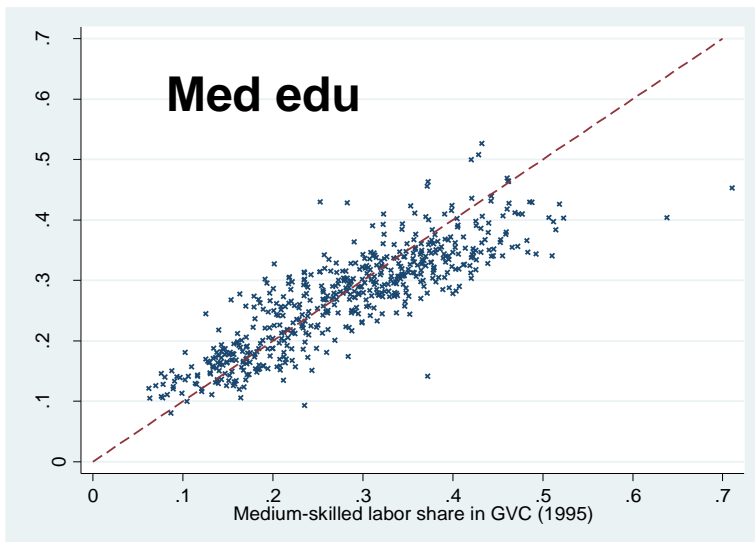
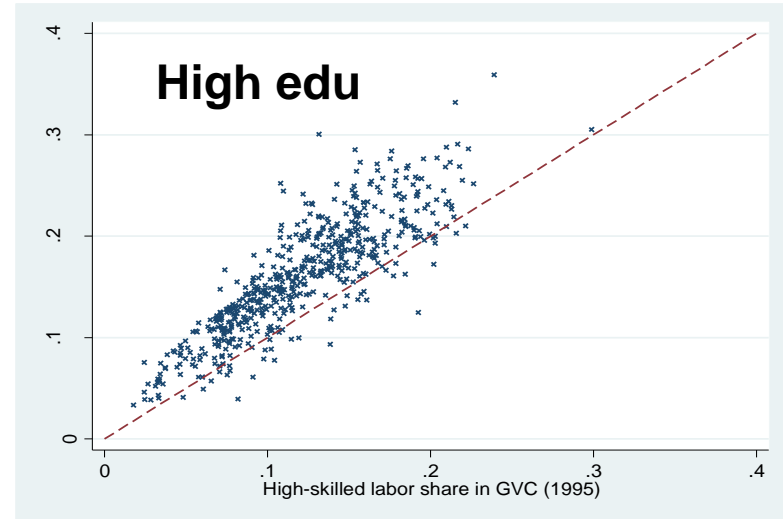
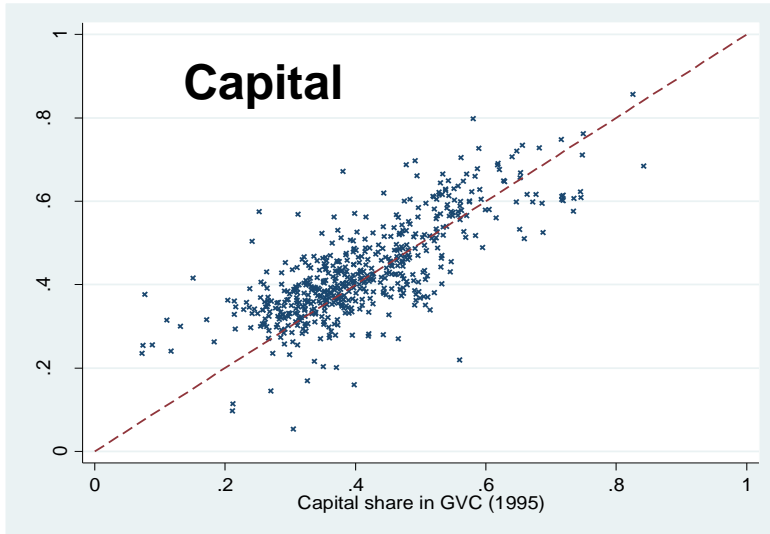


Factor content of a global value chain: graphical representation



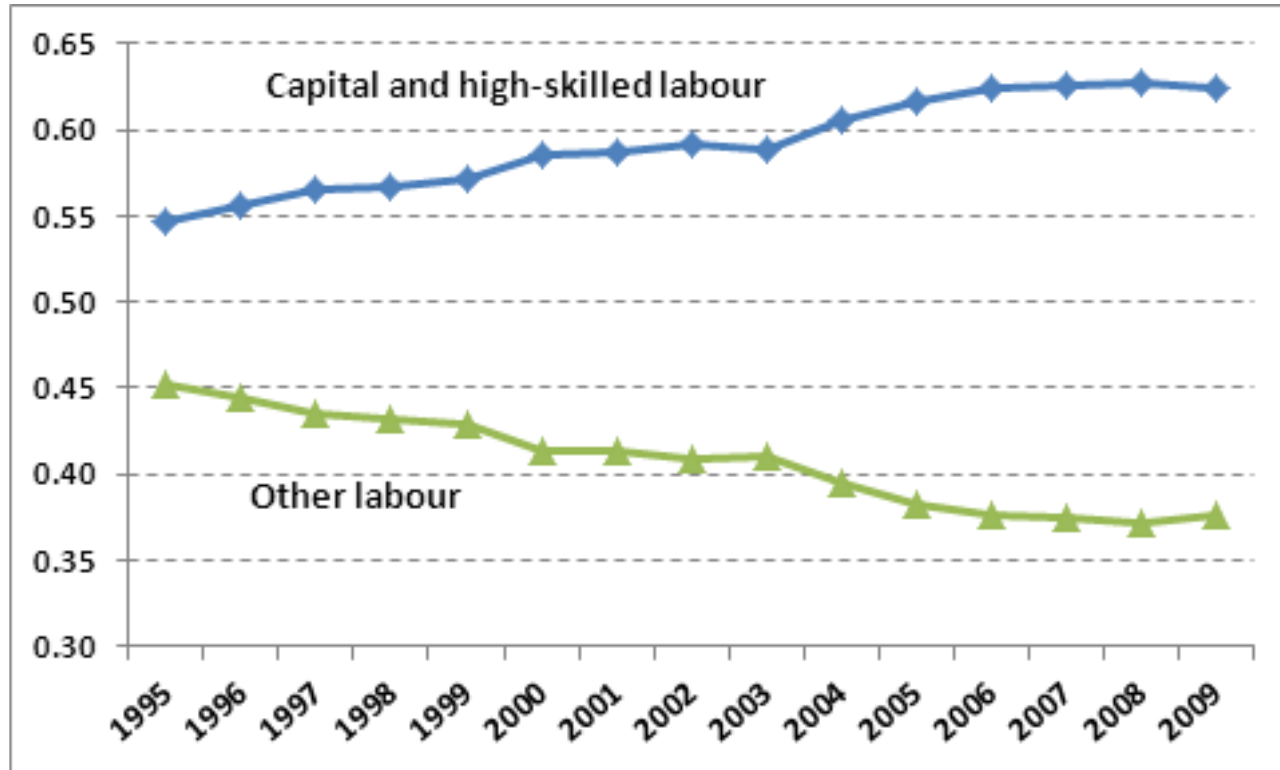


Factor shares in value added of 560 global value chains of manufactures





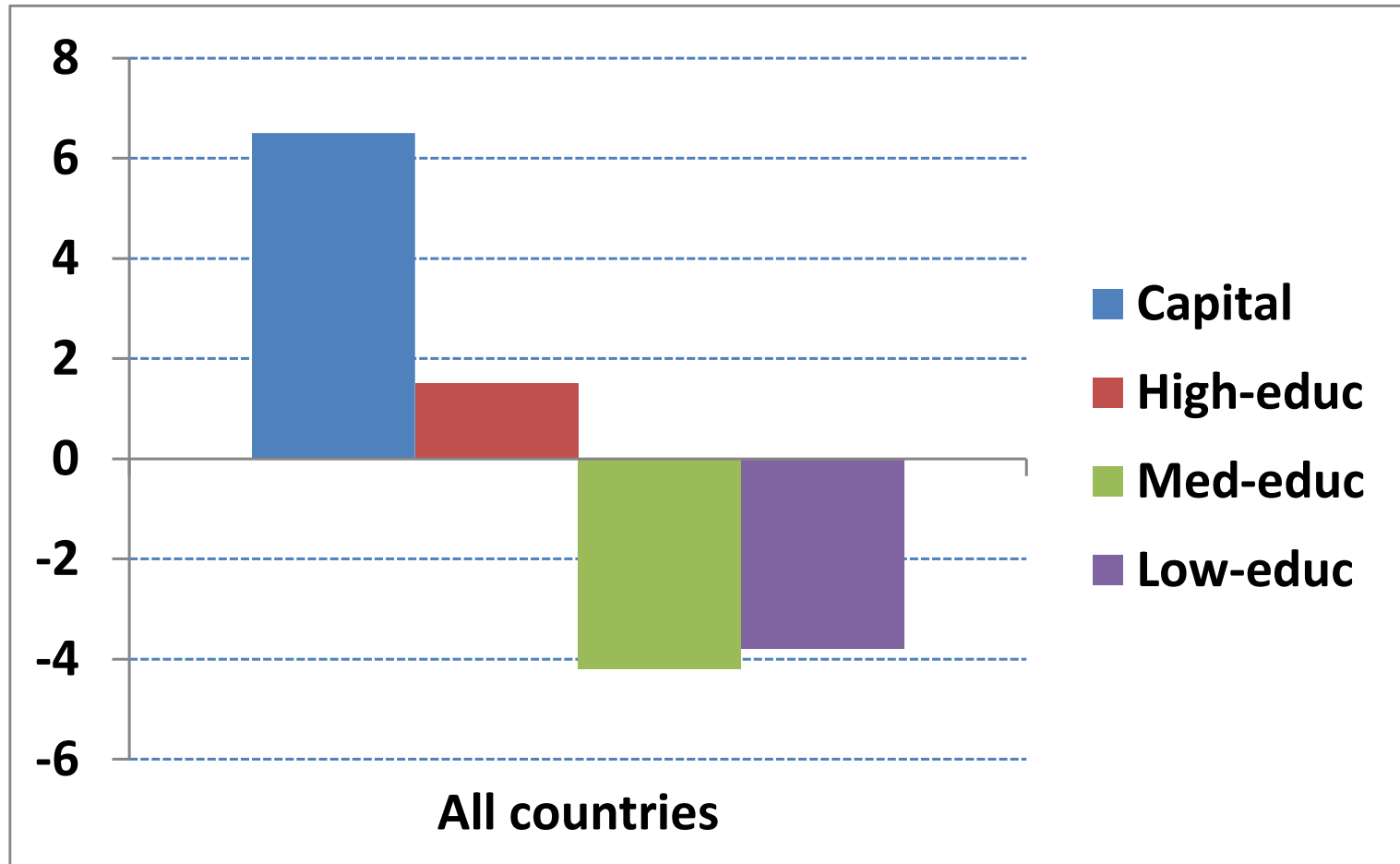
FACT 2 Increasing value added by capital and high-skilled labor, globally



Note: The graph shows value added by factors as share of global final manufactures output.



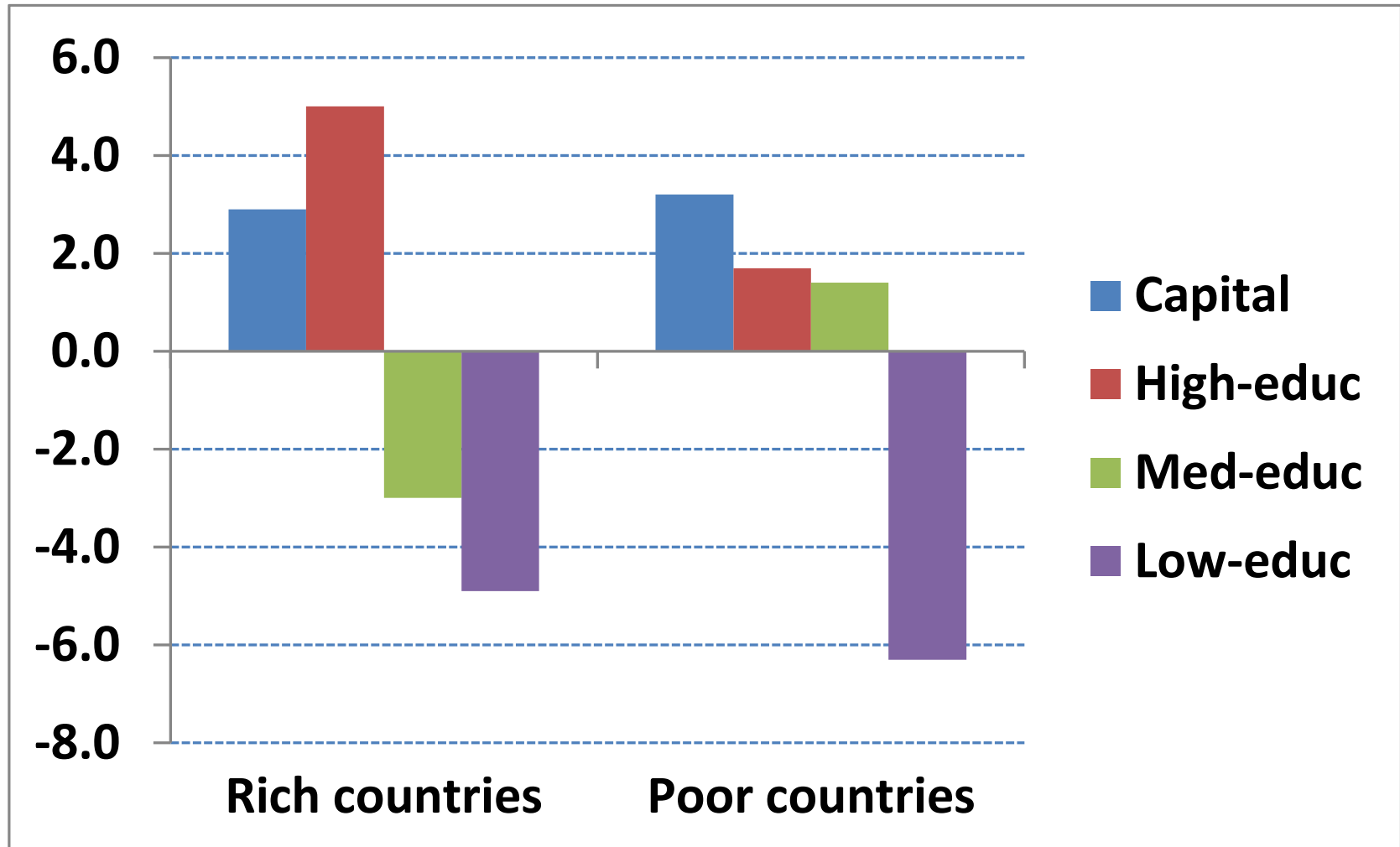
Increasing income share (%) for capital and high-edu workers: at global level (all 560 GVCs), 1995-2008



Note: Percentage change in factor income shares in 560 global value chains of manufactures, by region. Source: Timmer et al. (2014, Table 3)



both in rich and poor countries !



Note: Percentage change in factor income shares in 560 global value chains of manufactures, by region. Source: Timmer et al. (2014, Table 3)



Possible determinants of factor value added shares

From production theory: change in cost shares can be explained by:

- changes in factor prices,
- substitution elasticities across all factors in all countries and
- factor-biased technical change

Some loose suggestions:

- Declining costs of international fragmentation has increased substitution possibilities of low-skilled labour across countries
- Prices of natural resources increased + limited substitution possibilities
- Declining ICT prices + complementarity of ICT and high skills
- Expansion of demand for final products with large fixed capital costs (e.g. brand names or software system) in imperfect sales markets



Concluding remarks

- This paper proposed a new method to identify and analyse the factor content of vertically integrated production at a macro-economic level.
- Based on the new world input-output database (WIOD) we found three trends in GVCs of manufactures:
 1. International production fragmentation has increased rapidly
 2. Globally, increasing shares of value added by capital and high-skilled workers, and declining shares for low-skilled workers.
 3. Advanced countries specialise in high-skilled activities.
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More information

- For more information, see accompanying WIOD working papers “Fragmentation, Income and Jobs” and “Slicing up Global Value Chains” (downloadable from wiod website).

- **WIOD database**
 - Is publicly available at www.wiod.org
 - Offers many more opportunities for analysis, e.g. also includes environmental accounts
 - Is a proto-type database as many statistical challenges remain and will need coordinated international effort to bring forward as now put forward by e.g. OECD/WTO Trade in value added project.



Background studies

- Timmer, Marcel P., Bart Los, Robert Stehrer and Gaaitzen J. de Vries (2013). “Fragmentation, Incomes and Jobs. An Analysis of European Competitiveness.” **Economic Policy** 28(76):613–661.
- Los, B., M.P. Timmer and G.J. de Vries (2014), “How global are Global Value Chains? A New Approach to Measure International Fragmentation”, early view, **Journal of Regional Science**, DOI: 10.1111/jors.12121
- Timmer, M.P., A.A. Erumban, B. Los, R. Stehrer and G.J. de Vries (2014), "Slicing Up Global Value Chains", **Journal of Economic Perspectives**, Spring 2014, DOI: 10.1257/jep.28.2.99



Additional material



A stylized world input-output table

	Intermediate use (<i>S</i> columns per country)			Final use (<i>C</i> columns per country)			Total
	1	...	<i>N</i>	1	...	<i>N</i>	
S Industries, country 1	\mathbf{Z}^{11}	$\mathbf{Z}^{1\cdot}$	\mathbf{Z}^{1N}	\mathbf{F}^{11}	$\mathbf{F}^{1\cdot}$	\mathbf{F}^{1N}	\mathbf{x}^1
...	$\mathbf{Z}^{\cdot 1}$	$\mathbf{Z}^{\cdot\cdot}$	$\mathbf{Z}^{\cdot N}$	$\mathbf{F}^{\cdot 1}$	$\mathbf{F}^{\cdot\cdot}$	$\mathbf{F}^{\cdot N}$	\mathbf{x}^{\cdot}
S Industries, country <i>N</i>	\mathbf{Z}^{N1}	$\mathbf{Z}^{N\cdot}$	\mathbf{Z}^{NN}	\mathbf{F}^{N1}	$\mathbf{F}^{N\cdot}$	\mathbf{F}^{NN}	\mathbf{x}^N
Value added	$(\mathbf{w}^1)'$	$(\mathbf{w}^2)'$	$(\mathbf{w}^N)'$				
Output	$(\mathbf{x}^1)'$	$(\mathbf{x}^2)'$	$(\mathbf{x}^N)'$				