Slicing Up Global Value Chains:
Major trends in the cost structure of global production

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The need for vertically integrated production functions

- Production processes are fragmenting across industries and across borders.

- To understand effects on (uneven) growth in jobs and incomes we need to adapt the standard conceptualization of a production function:

One stage: Value added = F [K(dom), L(dom)]

Gross output = G [K(dom), L(dom), II(dom), II(for)]

Multi-stage: Final output = H [K(dom), L(dom), K(for), L(for)]

(NB This harks back at least to work by Pasinetti (1973))

PROBLEM: Observational equivalence of offshoring and biased technical change

	Before offshoring	*After offshoring*	
		Traditional approach	**GVC approach**
High-skilled design	35%	50%	35%
Low-skilled parts	35%	50%	35%
Low-skilled assembly	30%	Not observed	30%
		BIASED technical change	**NO** bias

Stylised example of <u>observed cost shares</u> in car production before and after offshoring (assuming no change in factor prices or quantities)

For traditional approach, see Goos, Manning and Salomons (AER,2014) or Michaels, Natraj and van Reenen (ReStat 2013)

The GVC approach

- Can we identify the factor inputs in Global Value Chains (GVCs)?

- The **GVC approach** (Timmer et al. *JEP*, 2014)
  - Starting point: **a *final* product identified by “country-industry of completion”**. This is the country-industry where the last stage of production takes place, (that is, before being sold to final user), e.g. GVC of German cars
  - **Factor content** of GVC determined by:
    - *last stage* based on industry-statistics on factor use
    - *previous stages* proxied by tracing backward linkages using Leontief’s trick in a global input-output model

An accounting framework

FROM: World input-output table

			Use by country-industries							Final use by countries			Total use
			Country 1			...	Country M			Country 1	...	Country M	
			Industry 1	...	Industry N	...	Industry 1	...	Industry N				
Supply from country-industries	Country 1	Industry 1											
		...											
		Industry N											
	...	...											
	Country M	Industry 1											
		...											
		Industry N											
Value added by labour and capital													
Gross output													

Input cost shares of industries (A)

F

v

$$G = v(I-A)^{-1}F$$

Leontief's trick: compute value added in all industries associated to final demand for a specific product

TO: GVC cost-share table

			Final products of a global value chain, identified by country-industry of completion							Value added
			Country 1			...	Country M			
			Industry 1	...	Industry N	...	Industry 1	...	Industry N	
Value added from country-industries participating in global value chains	Country 1	Industry 1								
		...								
		Industry N								
	...	...								
	Country M	Industry 1								
		...								
		Industry N								
Total final output value										World GDP

Factor cost shares of final products (G)

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Data

- The World Input-Output Database (www.wiod.org):
  - Annual Tables 1995-2011 including values of all flows of products across industries and countries
  - 40 countries (EU27 + 13 major economies) + Rest of the world
  - 35 industries per country
  - At basic prices, exchange rate converted into US$

- Based on benchmark national supply- and use-tables (**A**), combined with time-series on **v** and **F** from National accounts statistics, and bilateral trade data from official statistical sources (by use category).

- Socio-economic accounts including data on hours worked and wages by 3 skill types (educational attainment levels) and capital

Some stylised empirical trends based on WIOD research

TREND 1 European GVCs become truly global

(based on value added by country-of-origin, see Los et al., 2015). European chains contain increasing foreign value added, in particular from *outside* the EU.

TREND 2 Increasing cost shares of high-skilled workers and capital in GVCs

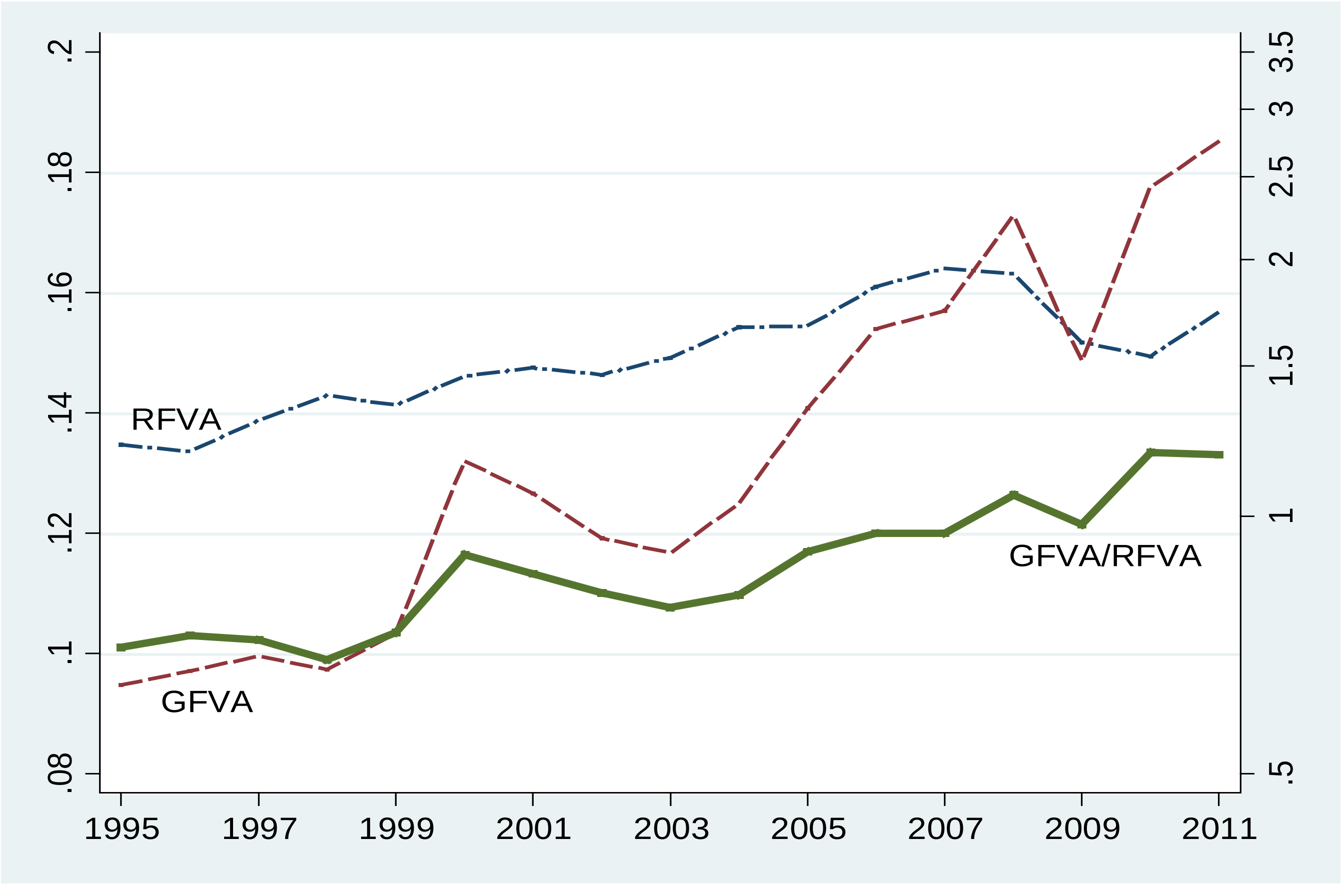
(based on value added by factor, see Timmer et al, 2014). This is driven by decline in relative price of low-skilled workers, and by SBTC (Timmer and Ye, 2015).

TREND 3 Functional specialisation in advanced countries in head-office *tasks*

(Based on cost shares of labour by occupation, see De Vries and Timmer, 2015).

NB Units of observation: GVCs of manufactured final products, 1995-2011

TREND 1.
European GVCs become truly global



Note: value added to products finalised in EU outside the "country-of-completion" but still within the EU (**RFVA**) and outside the EU (**GFVA**)
Expressed as share of value of all final manufacturing products completed in 25 EU countries (left-hand scale). *Source: Los et al. (JRS, 2015).*

TREND 2. Increasing cost shares of high-skilled and capital in global production

Table 2 Factor shares in global value chains of all manufactures.

	1995	2008	2008 minus 1995
Total value added (billion US$), by	**6,586**	**8,684**	**2,098**
capital (%)	40.9	47.4	6.5
high-skilled labor (%)	13.8	15.4	1.5
medium-skilled labor (%)	28.7	24.4	-4.2
low-skilled labor (%)	16.6	12.8	-3.8

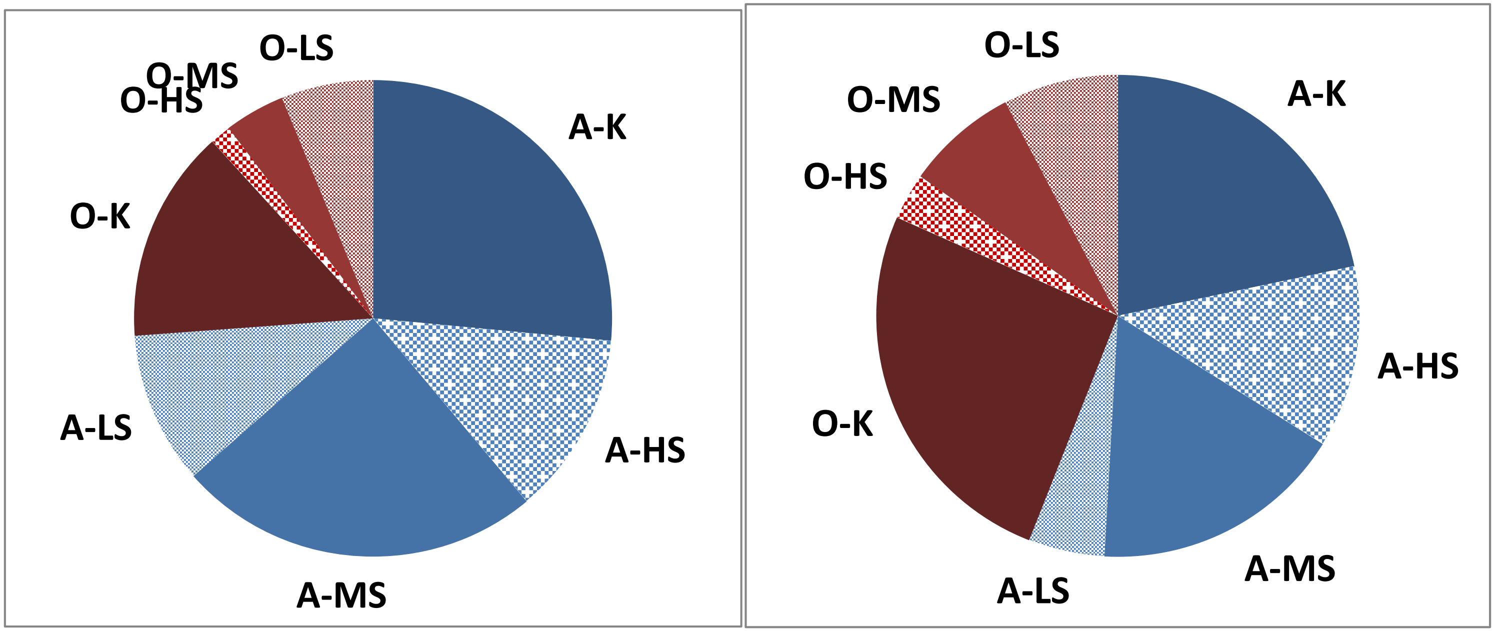
Note: Shares of production factors in total value added, based on all global value chains of manufactures. Shares add up to 100 percent. Value added is at basic prices (hence excluding net taxes, trade and transport margins on output). It is converted to US$ with official exchange rates and deflated to 1995 prices with the US CPI. Figures may not add due to rounding.

Source: Table 2 from Timmer et al, *Journal of Economic Perspectives*, 2014

TREND 2. ...in advanced (A) as well as other (O) countries

Figure 1 Factor shares in global value chains of manufactures, by region.

(a) 1995 **(b) 2008**

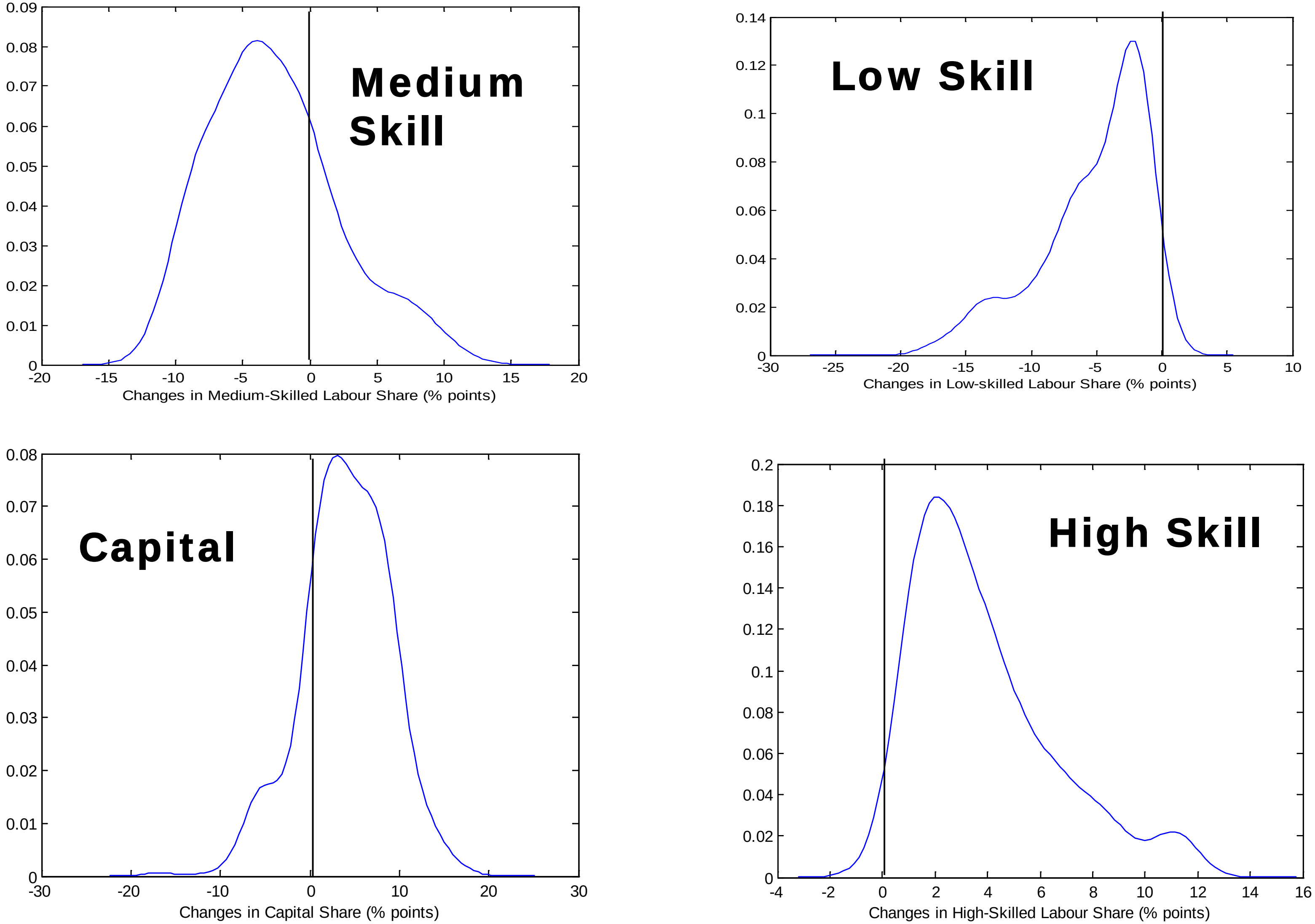


Note: Shares of production factors in total value added in a region, based on all global value chains of manufactures. Value added by a region is sum of value added by labour (low- (LS), medium- (MS), and high-skilled (HS) workers) and capital (K) on the domestic territory. Advanced countries (A) include Australia, Canada and the United States; Japan, South Korea and Taiwan; and all fifteen countries that joined the European Union before 2004. O indicates value added in all other countries in the world.

Source: Based on Table 2 from Timmer et al. (2014).

Kernel distributions of changes in factor income shares in 252 GVCs between 1995 and 2007

(12 manufacturing product groups from 21 advanced countries)



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Cost share changes driven by FBTC or substitution?

Econometric framework

Explaining the changes in the cost shares using standard translog cost framework (following Baltagi and Rich, 2005 and Hijzen et al. 2005). For each GVC :

$$\ln C(\boldsymbol{p}_t, y_t, t) = \alpha + \sum_{i\in F} \beta_i \ln p_{it} + \frac{1}{2}\sum_{j\in F}\sum_{i\in F} \gamma_{ij} \ln p_{it} \ln p_{jt} + \beta_Y \ln y_t + \frac{1}{2}\sum_{i\in F} \gamma_{iY} \ln p_{it} \ln y_t + \frac{1}{2}\gamma_{YY}(\ln y_t)^2 + \beta_T t + \frac{1}{2}\sum_{i\in F} \gamma_{iT} t \ln p_{it} + \frac{1}{2}\gamma_{TT} t^2$$

System of cost equations

Under standard assumptions cost share equations can be derived. We have **four factors** and drop the equation for capital.

$$S_{Lt} = \beta_L + \gamma_{LL}\ln(p_{Lt}/p_{Kt}) + \gamma_{LM}\ln(p_{Mt}/p_{Kt}) + \gamma_{LH}\ln(p_{Ht}/p_{Kt}) + \gamma_{LY}\ln y_t + \gamma_{Lt}\,\mathrm{t}$$
$$S_{Mt} = \beta_M + \gamma_{ML}\ln(p_{Lt}/p_{Kt}) + \gamma_{MM}\ln(p_{Mt}/p_{Kt}) + \gamma_{MH}\ln(p_{Ht}/p_{Kt}) + \gamma_{MY}\ln y_t + \gamma_{Mt}\,\mathrm{t}$$
$$S_{Ht} = \beta_H + \gamma_{HL}\ln(p_{Lt}/p_{Kt}) + \gamma_{HM}\ln(p_{Mt}/p_{Kt}) + \gamma_{HH}\ln(p_{Ht}/p_{Kt}) + \gamma_{HY}\ln y_t + \gamma_{Ht}\,\mathrm{t}$$

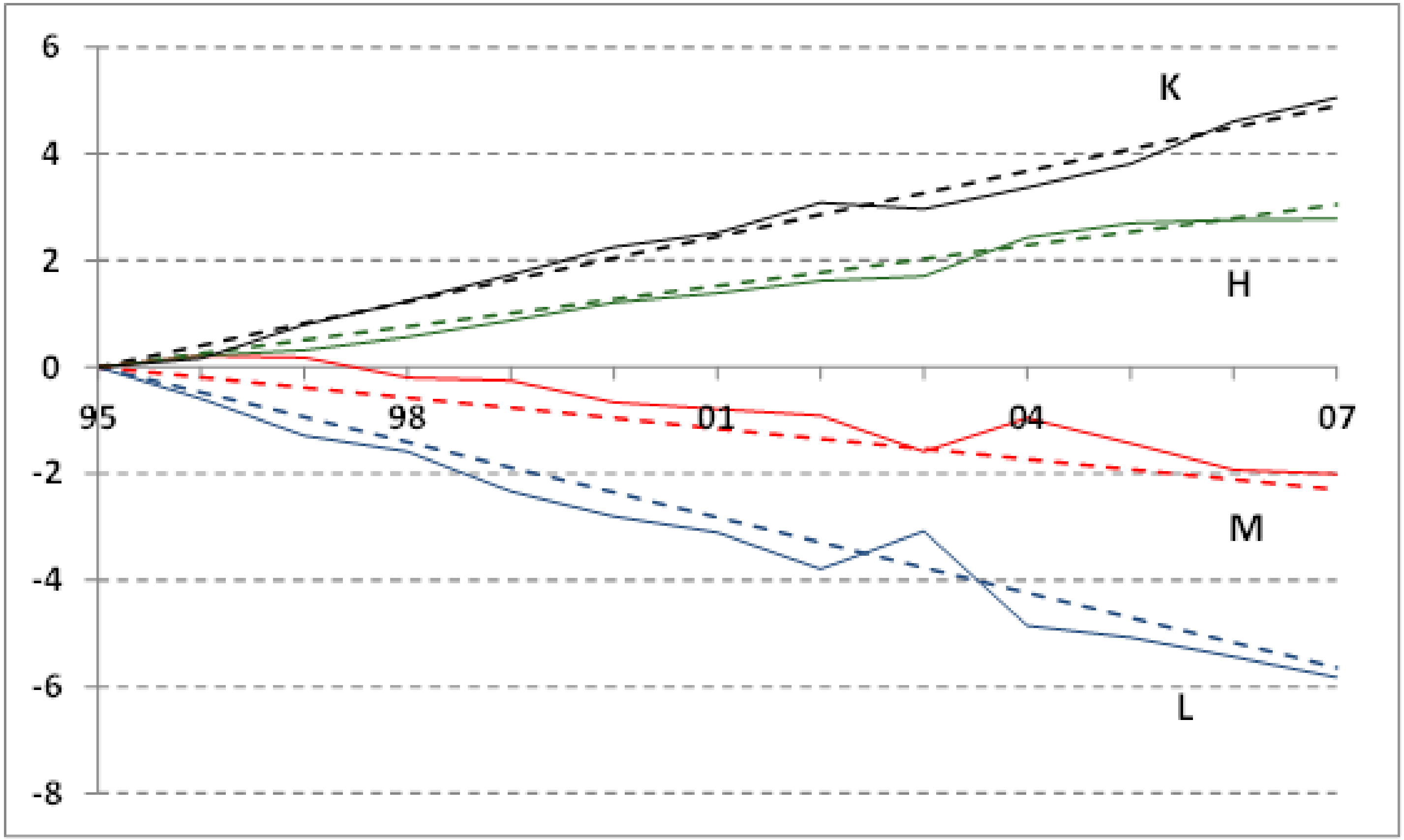
- ISUR estimation with cross-restrictions on elasticities.
- FBTC is modelled as linear trend and as a set of time-dummies (Baltagi and Griffin *JPE* 1988)
- Panel data: 252 product GVCs (12 product groups for 21 advanced countries) for 13 years
- NB Factor prices are averaged across countries using weights that are GVC-specific.

Results: base line

Table 3 Regression results, 1995-2007.

Variable	Pooled ISUR Coef	std. E		Fixed Effect ISUR coef	std. E		Fixed Effect with year dummies coef	std. E	
β_L	0.1972	0.0115	***	0.1566	0.0103	***	0.1602	0.0103	***
β_M	-0.0006	0.0132		-0.0623	0.0121	***	-0.0765	0.0122	***
β_H	0.0036	0.0110		-0.2065	0.0099	***	-0.2049	0.0100	***
γ_{LL}	0.1310	0.0033	***	0.0316	0.0024	***	0.0275	0.0024	***
γ_{LM}	-0.1125	0.0028	***	0.0109	0.0024	***	0.0116	0.0024	***
γ_{LH}	-0.0002	0.0022		-0.0047	0.0018	**	-0.0016	0.0019	
γ_{MM}	0.2514	0.0053	***	0.0743	0.0047	***	0.0771	0.0049	***
γ_{MH}	-0.0693	0.0046	***	-0.0096	0.0038	**	-0.0121	0.0039	**
γ_{HH}	0.0809	0.0051	***	0.0655	0.0038	***	0.0650	0.0038	***
γ_{LY}	-0.0007	0.0007		-0.0005	0.0006		-0.0012	0.0005	*
γ_{MY}	-0.0024	0.0006	***	-0.0022	0.0006	***	-0.0017	0.0006	**
γ_{HY}	0.0045	0.0004	***	0.0020	0.0005	***	0.0022	0.0005	***
γ_{LT}	-0.0026	0.0003	***	-0.0052	0.0001	***	-		
γ_{MT}	-0.0043	0.0003	***	-0.0016	0.0001	***	-		
γ_{HT}	0.0037	0.0002	***	0.0032	0.0001	***	-		
Country Dummies		NO			YES			YES	
Product Dummies		NO			YES			YES	
Year Dummies		NO			NO			YES	
Number of observations		3258			3258			3258	
R^2 - *LS*		0.4237			0.9437			0.9467	
R^2 - *MS*		0.4320			0.9193			0.9215	
R^2 - *HS*		0.1650			0.8733			0.8748	

Figure 2 Cumulative factor bias in technological change, 1995-2007



Capital

High skill

Medium

Low skill

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TC bias against medium-skilled workers in GVC is related to ICT use

Table 7 Alternative regression model results, 1995-2007.

Variable	Base Model	Include ICT	MFP adjusted	Expanding products
γ_{LT}	-0.0052 0.0001***	-0.0045 0.0001***	-0.0056 0.0001***	-0.0045 0.0001***
γ_{MT}	-0.0016 0.0001***	-0.0001 0.0002	-0.0017 0.0001***	-0.0018 0.0001***
γ_{HT}	0.0032 0.0001***	0.0037 0.0001***	0.0033 0.0001***	0.0024 0.0001***
$\gamma_{L,ICT}$		-0.0035 0.0008***		
$\gamma_{M,ICT}$		-0.0145 0.0010***		
$\gamma_{H,ICT}$		-0.0024 0.0007***		
Obs.	3258	2003	3258	6184
R^2 - LS	0.9437	0.9512	0.9421	0.9145
R^2 - MS	0.9193	0.9172	0.9169	0.9224
R^2 - HS	0.8733	0.9019	0.8711	0.9018

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3. Functional specialisation

- To better understand the nature of specialisation taken place in various countries, one needs information on **activities/tasks**

- Additional database constructed with **occupation of workers** (hours and wages), see De Vries and Timmer, mimeo, 2015.
- Based on 4-digit occupation description (ISCO 1988) from *LFS and SES* for EU, *OES* for US (cross walks for SOC 2000 and 2010) and *Population census* plus *wage structure surveys* for Japan.

- Division of occupations into
  - **Head Office**: R&D, Management, Logistics, Marketing, and Back office occupations
  - **Production occupations**: other including fabrication of intermediates and assembly.

Example of functional specialisation in German car GVC

Table 1. Functions in the German transport equipment GVC

	1995	2008	2008 - 1995
All HQ activities, of which:	*52.4*	*49.8*	*-2.7*
Management	6.5	6.4	-0.2
Back office	17.1	11.9	-5.2
R&D	15.6	17.3	1.6
Logistics	4.5	5.9	1.4
Marketing	8.7	8.3	-0.4
Production activities	*31.0*	*21.8*	*-9.2*
Total value added by workers in Germany	**83.5**	**71.6**	**-11.9**
Total value added by workers abroad	**16.5**	**28.4**	**11.9**

Notes: Decomposition of final output of the transport equipment manufacturing industry in Germany (ISIC rev. 3 industries 34 and 35) based on equation (4). Numbers may not sum due to rounding. *Sources*: Authors' calculations based on World Input-Output Database (November 2013 release) and occupation database.

TREND 3 Functional specialisation in advanced countries

Table 3. Functional distribution of value added in GVCs of manufactures

		Head quarter activities						Production activities
		MANA	BACKO	RD	LOG	MAR	Total	
1999	EU 15	8.5	14.3	15.2	9.2	14.7	61.9	38.1
	United States	10.5	6.2	11.9	22.1	18.8	69.6	30.4
	Japan	4.7	6.5	7.1	10.4	19.6	48.4	51.6
2008	EU 15	10.1	14.7	17.9	11.2	14.3	68.1	31.9
	United States	9.7	5.1	18.7	20.0	19.5	72.9	27.1
	Japan	3.6	7.9	8.0	11.0	22.2	52.7	47.3
2008 minus 1999	EU 15	1.7	0.4	2.6	1.9	-0.4	6.2	-6.2
	United States	-0.8	-1.2	6.8	-2.2	0.6	3.3	-3.3
	Japan	-1.1	1.4	0.9	0.6	2.6	4.3	-4.3

Notes: MANA: management; BACKO: back office; RD: Research and Development; LOG: logistics; MAR: marketing.

Sources: Authors' calculations based on World Input-Output Database (November 2013 release) and occupation database.

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Caveats and Future

- A WIOT is a synthetic database and constructed by combining various primary databases. Several assumptions in the construction process had to be made and various weaknesses in the data remain (see Timmer et al. 2015). This includes:
  - Imports by use category allocation.
  - Rest-of-the-world region and mirror-flows
  - Arms-length trade in services (Francois and Hoekman 2010)
  - Technology heterogeneity across firms (e.g. Koopman et al. 2012; Ottaviano, Altomonte, 2009)
  - Invisible trade: intra-firm intangibles (see e.g. Atalay, Hortaçsu, and Syverson, 2014)
  - Exports and imports for processing: the new challenge of SNA 2011

- **Future developments**
  - OECD/WTO *Tiva* project
  - Business functions survey (e.g. Brown and Sturgeon, 2013)
  - Firm-level information (see this conference)

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References to WIOD research

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- **For data access: www.wiod.org**