

# Competitiveness at the Country-Sector Level: New Measures Based on Global Value Chains

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*ESCoE Conference on Economic Measurement  
London, May 8, 2019*

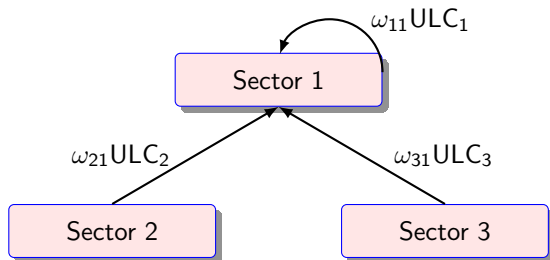
# Motivation

- Current account imbalances lead to renewed interest in the competitiveness of countries and industries
- Real effective exchange rates (REERs): commonly used to assess external competitiveness
- REERs as relative price- or cost-related indicators
- Unit labor costs (ULC): the common cost-related indicator
- Traditional REERs at the sectoral level neglect important aspects:
  - Inter-sectoral linkages: a sector's own labor costs constitute only a small share of total costs
  - The domestic value added contained in a sector's exports may have significantly declined over time relatively to its gross exports

# Our contribution

- Novel measure of the REER at the sectoral level, called “embodied real effective exchange rate” (EREER)
- EREER introduces two innovations in comparison to traditional sectoral relative unit labor cost (ULC) measures:
  - 1 “Embodied unit labor costs” (EULC) are proposed as a deflator: not only consider a sector’s own ULC but also take account of the ULC incorporated in the intermediate goods delivered to this sector
  - 2 Weights for competing sectors in trading partner countries are based on domestic value added embodied in bilateral sectoral gross exports

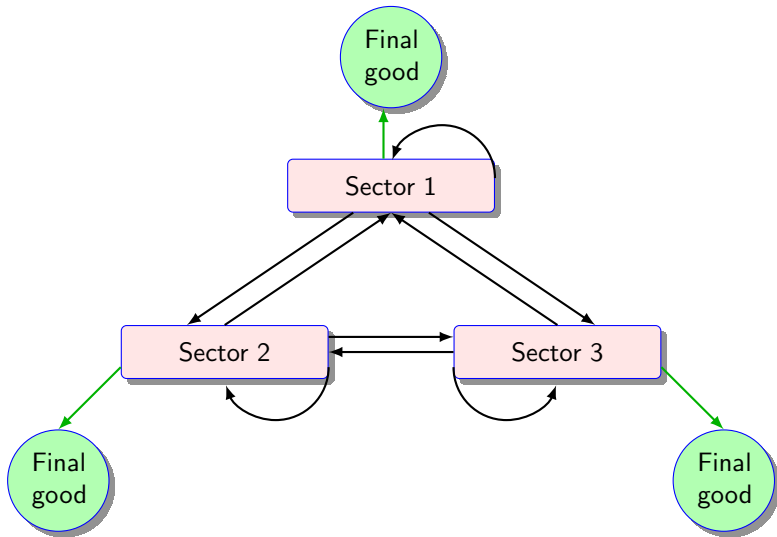
## Embodied unit labor costs (EULC):



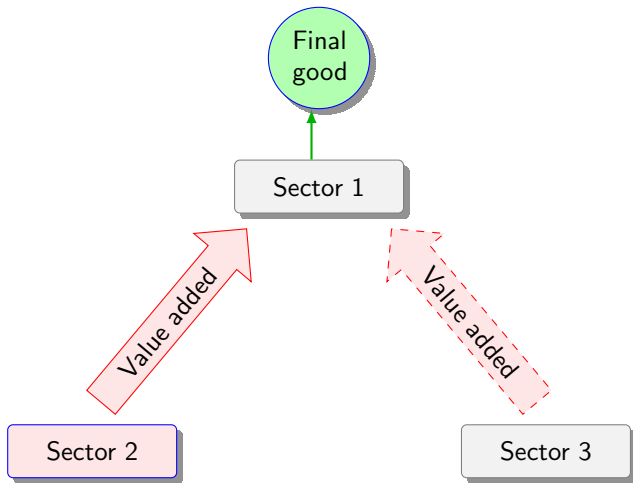
$$EULC_1 = \omega_{11}ULC_1 + \omega_{21}ULC_2 + \omega_{31}ULC_3$$


$\omega_{i1}$  : Value-added contribution of sector  $i$  to sector 1,  $i = 1, 2, 3$


## Inter-sectoral linkages (intermediate-goods flows):



## Value-added contribution of sector 2 to sector 1:



 Direct value-added contribution

 Indirect value-added contribution

# Outline

- 1 Introduction
- 2 Embodied unit labor costs (EULC)
- 3 Embodied real effective exchange rate (EREER)
- 4 Empirical application: competitiveness of German sectors
  - Data
  - Stylized facts for Germany
- 5 Conclusions

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# Input-output table

- $G$ : number of countries
- $H$ : number of sectors
- 4 parts of a global inter-country input-output (ICIO) table:
  1.  $(GH \times GH)$  matrix  $\mathbf{Z}$  of intermediate sales
  2.  $(GH \times G)$  matrix  $\mathbf{F}$  of final demand
  3.  $(GH \times 1)$  vector  $\mathbf{y}$  of value added
  4.  $(GH \times 1)$  vector  $\mathbf{q}$  of output

Table: The structure of a global ICIO table

Use \ Supply		Use by country-industries							Final use by countries			Total use
		Country 1			...	Country G			Coun.1	...	Coun.G	
		Ind.1	...	Ind.H	...	Ind.1	...	Ind.H				
Coun.1	Ind.1	$z_{11}^{11}$	...	$z_{11}^{1H}$	...	$z_{1G}^{11}$	...	$z_{1G}^{1H}$	$f_{11}^1$	...	$f_{1G}^1$	$q_1^1$
	...	...	...	...	...	...	...	...	...	...	...	...
...	Ind.H	$z_{11}^{H1}$	...	$z_{11}^{HH}$	...	$z_{1G}^{H1}$	...	$z_{1G}^{HH}$	$f_{11}^H$	...	$f_{1G}^H$	$q_1^H$
	...	...	...	...	...	...	...	...	...	...	...	...
Coun.G	Ind.1	$z_{G1}^{11}$	...	$z_{G1}^{1H}$	...	$z_{GG}^{11}$	...	$z_{GG}^{1H}$	$f_{G1}^1$	...	$f_{GG}^1$	$q_G^1$
	...	...	...	...	...	...	...	...	...	...	...	...
	Ind.H	$z_{G1}^{H1}$	...	$z_{G1}^{HH}$	...	$z_{GG}^{H1}$	...	$z_{GG}^{HH}$	$f_{G1}^H$	...	$f_{GG}^H$	$q_G^H$
		...	...	...	...	...	...	...	...	...	...	...
Value added		$y_1^1$	...	$y_1^H$	...	$y_G^1$	...	$y_G^H$				
Gross output		$q_1^1$	...	$q_1^H$	...	$q_G^1$	...	$q_G^H$				

# First building block of EULC

**Leontief inverse** matrix of “total requirement coefficients”:

$$\mathbf{B} = (\mathbf{I}_{GH} - \mathbf{A})^{-1}, \quad \text{with } \mathbf{A} \equiv \mathbf{Z} \cdot \text{diag}(\mathbf{q}^{-1})$$

$$\mathbf{B} = \begin{pmatrix} \mathbf{B}_{11} & \mathbf{B}_{12} & \cdots & \mathbf{B}_{1G} \\ \mathbf{B}_{21} & \mathbf{B}_{22} & \cdots & \mathbf{B}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{B}_{G1} & \mathbf{B}_{G2} & \cdots & \mathbf{B}_{GG} \end{pmatrix}, \quad \text{with } \mathbf{B}_{ij} \equiv \begin{pmatrix} b_{ij}^{11} & \cdots & b_{ij}^{1H} \\ \vdots & \ddots & \vdots \\ b_{ij}^{H1} & \cdots & b_{ij}^{HH} \end{pmatrix}$$

# Second building block of EULC

**Sectoral direct value-added shares:**

$$\mathbf{V} = \mathbf{I}_{GH} - \text{diag}(\mathbf{A}' \cdot \mathbf{e}_{GH})$$

$$= \begin{pmatrix} \mathbf{V}_1 & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \mathbf{V}_2 & \cdots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{V}_G \end{pmatrix}, \text{ with } \mathbf{V}_i \equiv \begin{pmatrix} v_i^1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & v_i^H \end{pmatrix},$$

where  $v_i^m = y_i^m / q_i^m$



# EULC

- $\mathbf{V} \cdot \mathbf{B}$ : value added contributions of all domestic and foreign sectors to the final good of a particular sector
- **Sectoral EULC**: weighted sum of ULC ( $\mathbf{u}$ ) with weights based on  $\mathbf{V} \cdot \mathbf{B}$ :

$$\mathbf{u}^{\text{emb}} \equiv \mathbf{\Omega}' \cdot \mathbf{u}, \quad \text{with} \quad \mathbf{\Omega} \equiv \mathbf{V} \cdot \mathbf{B} \quad (1)$$

- EULC can be justified with a Leontief-type model

# Domestic EULC

- Focus on the domestic EULC in the computation of EREER in the next step: contributions of domestic sectors only are taken into account
- In the relative comparisons across the same sectors in different countries, domestic EULC should capture country's "own" competitiveness
- Correct record of the domestic contribution still requires global input-output tables
- Domestic contributions are extracted from the matrix  $\mathbf{V} \cdot \mathbf{B}$
- Domestic contributions are finally reweighted to obtain weights summing up to one

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# Traditional REER

- Real effective exchange rate (REER): measure of relative prices expressed in the same currency
- National REER extended to the sectoral level for country  $i$  and sector  $n$ :

$$\varepsilon_i^n = \prod_{\substack{j=1, \\ j \neq i}}^G \left( \frac{d_i^n}{d_j^n} \right)^{\gamma_{ij}^n}, \quad i = 1, \dots, G, \quad n = 1, \dots, H, \quad (2)$$

$d_i^n$ : sectoral deflator for country  $i$ , e.g. ULC

$d_j^n$ : sectoral deflator for country  $j$ , e.g. ULC

$\gamma_{ij}^n$ : bilateral sector-level weight (weight attached to the deflator of sector  $n$  in a foreign country  $j$ )

- Weights  $\gamma_{ij}^n$  are usually based on gross exports

# Embodied REER (EREER)

Features of the proposed measure:

- **Deflator:** domestic EULC at the sectoral level
- **Weights for trading partners:** gross export weights are replaced by an appropriate value-added counterpart

Problems with gross exports:

- Vertical specialization: gross exports contain foreign value added embodied in intermediates
- “Pure double counting”: multiple counting of the same value added embodied in intermediates

# Value-added weights

Challenges in the construction of appropriate value-added weights:

1 Sectoral dimension:

- **Backward-linkage measure:** value added of all domestic sectors in gross exports of a particular sector  
in contrast to
- **Forward-linkage measure:** value added of a particular sector in gross exports of all domestic sectors

▶ Illustration

2 Bilateral dimension of trade flows:

# Value-added weights

Challenges in the construction of appropriate value-added weights:

- 1 Sectoral dimension
- 2 Bilateral dimension of trade flows:
  - Well-established measure: value-added exports
  - Our proposed measure:  
**domestic value added in gross exports that is absorbed abroad**

▶ Illustration

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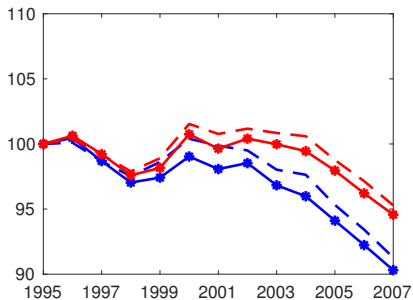


# Original data

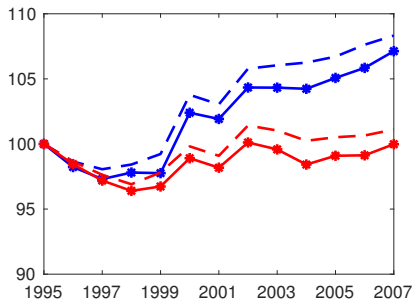
## World Input-Output Database (WIOD): Release 2013

- 1995–2011
- 40 countries: 27 members of the EU (as of 1 January 2007) and 13 other major economies  
+ rest of the world (RoW)
- 35 industries mostly at the two-digit ISIC Rev. 3 level

# REER and EREER: Germany



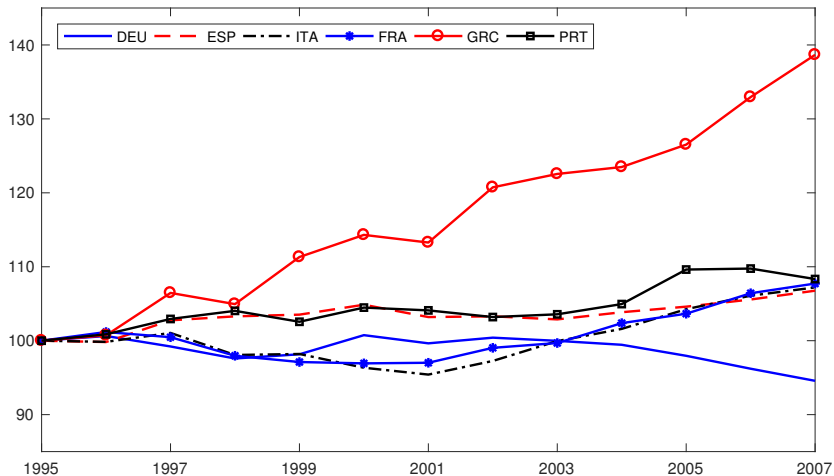
(a) Tradable manufacturing



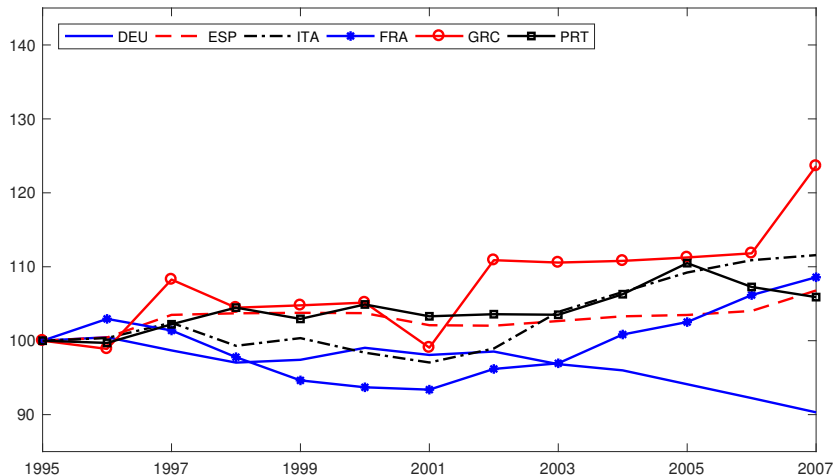
(b) Tradable services

Note: blue solid line: REER based on ULC; red solid line: REER based on EULC;  
line with markers: value-added weights; line without markers: gross-export weights

# EREER: tradable manufacturing



# REER: tradable manufacturing



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# Conclusions

- We propose sectoral EULC as a more appropriate sectoral cost indicator than ULC
- Based on domestic sectoral EULC, we propose sectoral EREER as a new REER indicator at the sectoral level
- The weights for a sector's foreign competitors are based on the domestic value-added embodied in this sector's bilateral gross exports to the respective country that is ultimately absorbed abroad.

# Conclusions

## Results for German sectors:

- EREERs suggest a smaller increase in international competitiveness of German tradable manufacturing than standard REERs (as opposed to tradable services)
- Standard REERs underestimate (overestimate) the increase in German cost competitiveness in tradable manufacturing relative to Greece (other countries)
- Value-added weights point to larger increases in international competitiveness in German tradable manufacturing and tradable services

# Conclusions

## Relevance:

- Debates on global imbalances and international disputes about wage dumping: standard ULC and REER may be misleading for assessing competitiveness and deriving policy recommendations
- The proposed concepts can be extended for other research questions, e.g. the impact of offshoring on production and employment
- The proposed measures are not only compatible with the WIOD but all kinds of global inter-country input-output data



Thank you for your attention!

# Theoretical justification for EULC

- Gross-output production of sector  $n$  in country  $j$ :

$$q_j^n = \min \left\{ \frac{1}{v_j^n} y_j^n, \frac{1}{a_{1j}^{1n}} z_{1j}^{1n}, \frac{1}{a_{1j}^{2n}} z_{1j}^{2n}, \dots, \frac{1}{a_{ij}^{mn}} z_{ij}^{mn}, \dots, \frac{1}{a_{Gj}^{Hn}} z_{Gj}^{Hn} \right\}$$

- Efficient production:

$$q_j^n = \frac{1}{v_j^n} y_j^n = \frac{1}{a_{ij}^{mn}} z_{ij}^{mn}, \quad i = 1, \dots, G, m = 1, \dots, H$$

- Value-added production:

$$y_j^n = \lambda_j^n L_j^n,$$

$L_j^n$ : labor input,  $\lambda_j^n$ : labor productivity

- Intermediate goods and final goods of a sector are sold at the same price  $p_j^n$
- Zero-profit condition:

$$p_j^n = v_j^n u_j^n + \sum_{i=1}^G \sum_{m=1}^H a_{ij}^{mn} p_i^m,$$

$u_j^n \equiv w_j^n / \lambda_j^n$ : unit labor costs

- Price vector  $\mathbf{p} = (p_1^1, \dots, p_G^H)'$ :

$$\mathbf{p} = \mathbf{A}' \cdot \mathbf{p} + \mathbf{V} \cdot \mathbf{u} = (\mathbf{V} \cdot \mathbf{B})' \cdot \mathbf{u} = \mathbf{\Omega}' \cdot \mathbf{u}$$

- Matrix  $\mathbf{\Omega}$  delivers weights for the calculation of EULC of each sector

# Domestic EULC

- Weighting matrix  $\tilde{\Omega}$ :

$$\tilde{\Omega} = \begin{pmatrix} \tilde{\Omega}_{11} & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \tilde{\Omega}_{22} & \cdots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \tilde{\Omega}_{GG} \end{pmatrix}, \text{ with } \tilde{\Omega}_{ii} \equiv \begin{pmatrix} \tilde{\omega}_{ii}^{11} & \cdots & \tilde{\omega}_{ii}^{1H} \\ \vdots & \ddots & \vdots \\ \tilde{\omega}_{ii}^{H1} & \cdots & \tilde{\omega}_{ii}^{HH} \end{pmatrix},$$

where

$$\tilde{\omega}_{ii}^{mn} = \frac{v_i^m b_{ii}^{mn}}{\sum_{m=1}^H v_i^m b_{ii}^{mn}} \quad \text{and} \quad \sum_{m=1}^H \tilde{\omega}_{ii}^{mn} = 1$$

- Domestic EULC for sector  $n$  in country  $i$ :

$$\tilde{u}_i^n = \sum_{m=1}^H \tilde{\omega}_{ii}^{mn} u_i^m$$

# Domestic EULC in sectoral aggregates: illustration

Domestic EULC in aggregate manufacturing sector  $man$ :

$$\tilde{u}_i^{man} = \sum_{m=1}^H \tilde{\omega}_{ii}^{m,man} u_i^m, \quad \text{with}$$

$$\tilde{\omega}_{ii}^{m,man} = \frac{\sum_{n \in I_{man}} v_i^m b_{ii}^{mn} f_i^n}{\sum_{m=1}^H \sum_{n \in I_{man}} v_i^m b_{ii}^{mn} f_i^n}$$

$\tilde{\omega}_{ii}^{m,man}$ : weight of ULC in sector  $m$  to EULC in manufacturing

$I_{man}$ : set of individual sector indices belonging to manufacturing

$f_i^n = \sum_{j=1}^G f_{ij}^n$ : final goods of sector  $n$  in country  $i$  for the use in all  $G$  countries

# Domestic EULC in sectoral aggregates

- First component: matrix  $\Psi$

$$\Psi = (\mathbf{V} \cdot \tilde{\mathbf{B}}) \cdot \text{diag}(\mathbf{F} \cdot \mathbf{e}_G)$$

- Second component: aggregation matrix  $\mathbf{R}$

$$r^{m\hat{n}} = \begin{cases} 1 & \text{if } m \in I_{\hat{n}} \\ 0 & \text{else,} \end{cases}$$

where  $I_{\hat{n}}$  denotes the index set containing the indices of sectors assigned to the sectoral aggregate  $\hat{n} = 1, \dots, \hat{H}$ .

- Joint aggregation of sectors for all countries:

$$\mathbf{R}^* = \mathbf{I}_G \otimes \mathbf{R} \tag{3}$$

# Domestic EULC in sectoral aggregates

- Matrix of value-added contributions of all sectors to sectoral aggregates in all countries:

$$\Psi^* = \Psi \cdot R^*$$

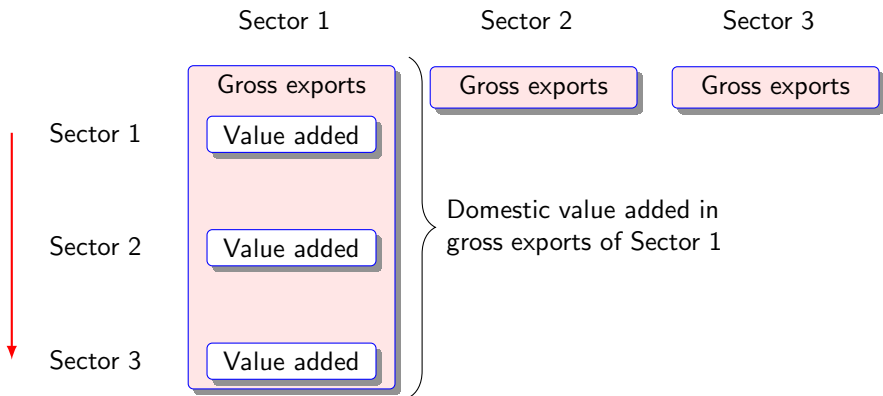
- Vector of domestic EULC for the sectoral aggregates for all  $G$  countries:

$$\tilde{\mathbf{u}}^{agg} = (\tilde{\Omega}^{agg})' \cdot \mathbf{u}, \quad (4)$$

with

$$\tilde{\Omega}^{agg} \equiv \Psi^* \cdot [\text{diag}(\mathbf{e}'_{GH} \cdot \Psi^*)]^{-1}$$

## Illustrative example: backward linkages in sectoral gross exports





## Illustrative example: domestic value added in gross exports of Country 1 to Country 2

# The proposed value-added concept

**Domestic value added in sector-level bilateral gross exports that is absorbed abroad** (*Wang et al., 2013*)

$$\begin{aligned} \tilde{\mathbf{x}}_{ij} = & (\mathbf{e}_H \cdot \mathbf{V}_i \cdot \mathbf{B}_{ii})' \circ \mathbf{f}_{ij} \\ & + (\mathbf{e}_H \cdot \mathbf{V}_i \cdot \mathbf{L}_{ii})' \circ \left( \mathbf{A}_{ij} \sum_{\substack{g=1, \\ g \neq i}}^G \sum_{\substack{k=1, \\ k \neq i}}^G \mathbf{B}_{jg} \mathbf{f}_{gk} \right), \end{aligned} \quad (5)$$

- First term corresponds to final goods exports of sector  $n$  in country  $i$  to country  $j$
- Second term corresponds to intermediate goods exports of sector  $n$  in country  $i$  to country  $j$  used in country  $j$  to produce:
  - final goods that are consumed either in country  $j$  or in a third country
  - intermediate goods eventually used in production of final goods in a third country that are consumed in any country except country  $i$

# Value-added weights in EREER

- Simple weights:

$$\tilde{\gamma}_{ij}^n = \frac{\tilde{x}_{ij}^n}{\sum_{g=1}^G \tilde{x}_{ig}^n},$$

where  $\tilde{x}_{ij}^n$  denotes an  $n$ -th element of  $\tilde{\mathbf{x}}_{ij}$ , see eq. (5)

- Overall weights composed of export double weights and import weights:

$$\tilde{\gamma}_{ij}^n = \alpha_i^n \tilde{\gamma}_{ij}^{(x),n} + (1 - \alpha_i^n) \tilde{\gamma}_{ij}^{(im),n}, \quad \alpha_i^n = \frac{\sum_{g=1}^G \tilde{x}_{ig}^n}{\sum_{g=1}^G \tilde{x}_{ig}^n + \sum_{g=1}^G \tilde{x}_{gi}^n}$$

# Value-added weights in EREER

- Import weights:

$$\tilde{\gamma}_{ij}^{(im),n} = \frac{\tilde{x}_{ji}^n}{\sum_{g=1}^G \tilde{x}_{gi}^n}$$

- Double export weights:

$$\begin{aligned} \tilde{\gamma}_{ij}^{(x),n} = & \left( \frac{\tilde{x}_{ij}^n}{\sum_{g=1}^G \tilde{x}_{ig}^n} \right) \left( \frac{v_j^n}{v_j^n + \sum_{\substack{g=1, \\ g \neq i}}^G \tilde{x}_{gj}^n} \right) \\ & + \sum_{\substack{k=1, \\ k \neq i,j}}^G \left( \frac{\tilde{x}_{ik}^n}{\sum_{g=1}^G \tilde{x}_{ig}^n} \right) \left( \frac{\tilde{x}_{jk}^n}{v_k^n + \sum_{\substack{g=1, \\ g \neq i}}^G \tilde{x}_{gk}^n} \right) \end{aligned}$$

# EREER in sectoral aggregates

- EREER in a sectoral aggregate  $\hat{n}$ :

$$\tilde{\epsilon}_i^{\hat{n}} = \prod_{\substack{j=1, \\ j \neq i}}^G \left( \frac{\tilde{u}_i^{\hat{n}}}{\tilde{u}_j^{\hat{n}}} \right)^{\tilde{\gamma}_{ij}^{\hat{n}}}$$

- EULC for the sectoral aggregate  $\hat{n}$  in countries  $i$  and  $j$  is extracted from the vector of EULC for sectoral aggregates, see eq. (4)

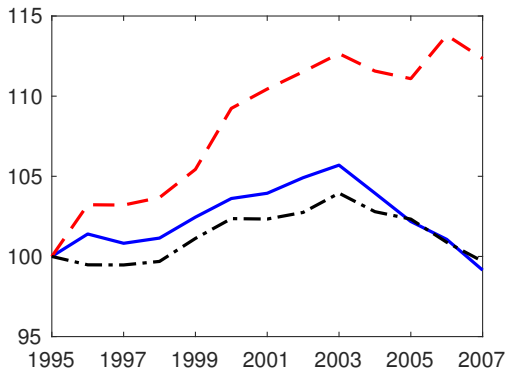
# EREER in sectoral aggregates

- The weights  $\tilde{\gamma}_{ij}^{\hat{n}}$  are based on  $\tilde{x}_{ij}^{man}$ : the domestic value added in gross exports of the whole manufacturing sector from country  $i$  to  $j$  that is absorbed abroad
- $\tilde{x}_{ij}^{\hat{n}}$  is extracted from the matrix:

$$\tilde{\mathbf{X}}^{agg} = (\mathbf{R}^*)' \cdot \tilde{\mathbf{X}}, \quad \tilde{\mathbf{X}} = \begin{pmatrix} \mathbf{0} & \tilde{\mathbf{x}}_{12} & \cdots & \tilde{\mathbf{x}}_{1G} \\ \tilde{\mathbf{x}}_{21} & \mathbf{0} & \cdots & \tilde{\mathbf{x}}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\mathbf{x}}_{G1} & \tilde{\mathbf{x}}_{G2} & \cdots & \mathbf{0} \end{pmatrix},$$

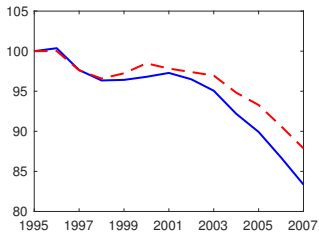
where column vectors  $\tilde{\mathbf{x}}_{ij}$  from matrix  $\tilde{\mathbf{X}}$  are computed according to eq. (5), and  $\mathbf{R}^*$  is the aggregation matrix, see eq. (3)

# Wages in German sectoral aggregates

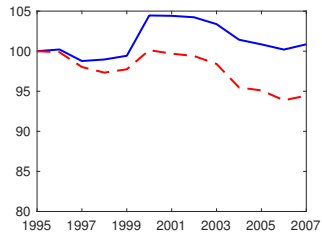


**Figure:** Real hourly wages in three German sectoral aggregates; red dashed line: tradable manufacturing, black dash-dot line: tradable services, blue solid line: nontradable sectors.

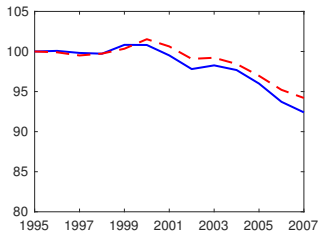
# ULC and EULC: Germany



(a) Tradable manufacturing



(b) Tradable services

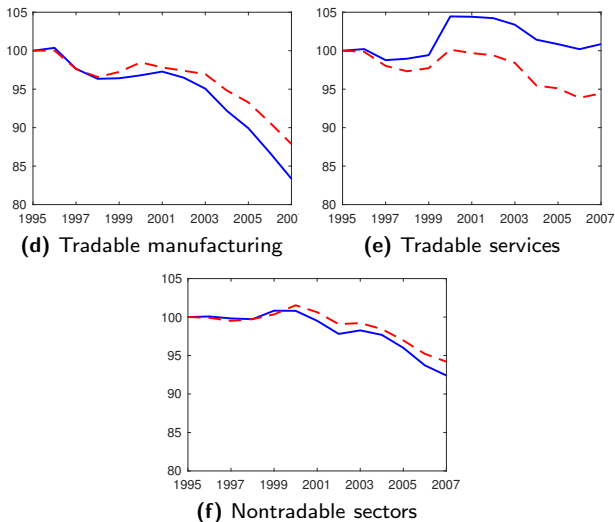


(c) Nontradable sectors

Note: blue solid line: ULC; red dashed line: EULC

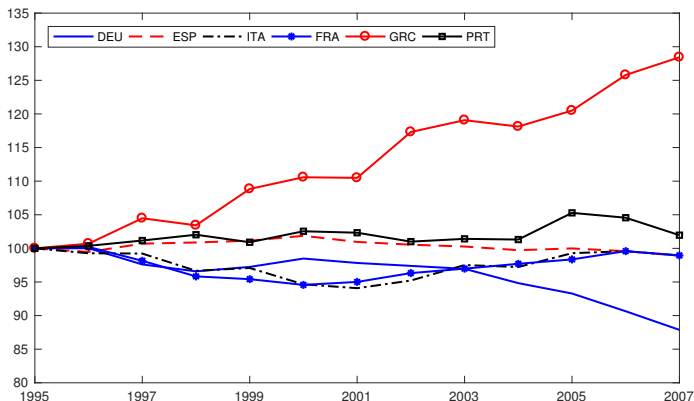


# ULC and total EULC: Germany



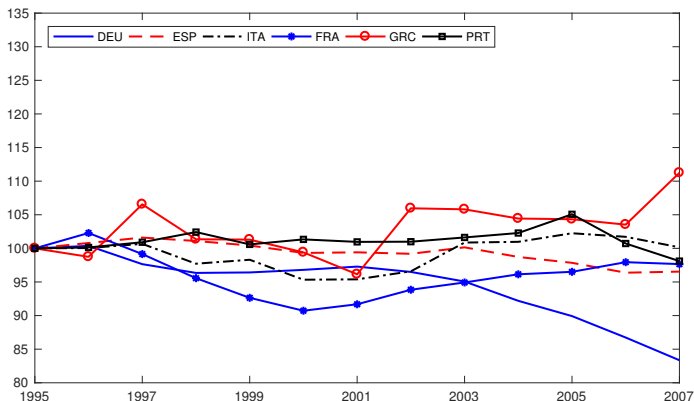
**Figure:** ULC (blue solid line) and total EULC (red dashed line) in three German sectoral aggregates

# EULC: tradable manufacturing



**Figure:** EULC in tradable manufacturing in Germany compared with selected euro area countries; German classification of sectoral aggregates is applied to all countries.

# ULC: tradable manufacturing



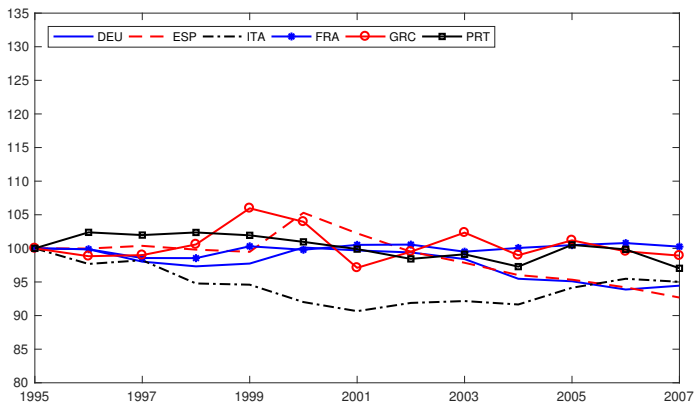
**Figure:** ULC in tradable manufacturing in Germany compared with selected euro area countries; German classification of sectoral aggregates is applied to all countries.

# EULC and ULC: international comparison

## Tradable manufacturing:

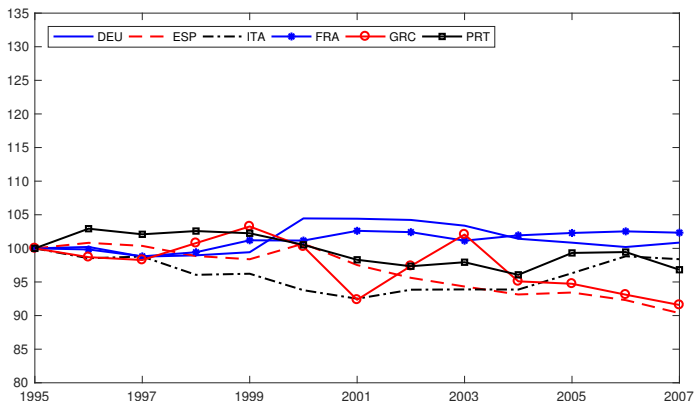
- Germany: EULC declined, especially from 2003 onwards
- Other countries except Greece: EULC stayed in 2007 at about the same level as in 1995
- Greece: EULC increased strongly between 1995 and 2007
- Greece: the largest difference between ULC and EULC (explained, among others, by a very strong increase in ULC in nontradable sectors)

# EULC: tradable services



**Figure:** EULC in tradable services in Germany compared with selected euro area countries; German classification of sectoral aggregates is applied to all countries.

# ULC: tradable services



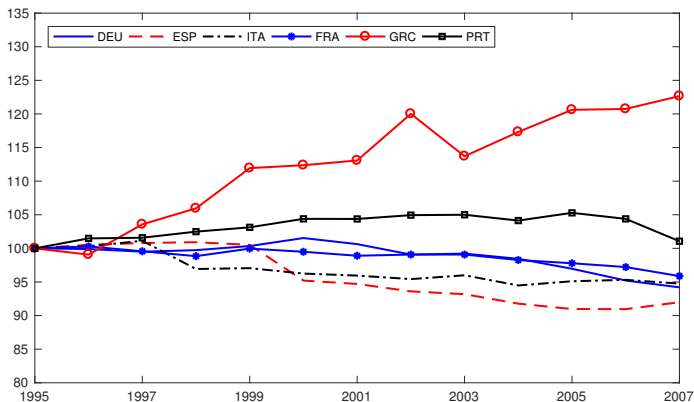
**Figure:** ULC in tradable services in Germany compared with selected euro area countries; German classification of sectoral aggregates is applied to all countries.

# EULC and ULC: international comparison

## Tradable services:

- Germany: the development of EULC is more in line with that in other countries than for tradable manufacturing
- Germany: large difference between ULC and EULC
  - Standard ULC increased in Germany, whereas they declined for the other euro area countries (with the exception of France)
  - EULC in Germany declined more strongly than in the other euro area countries (with the exception of Spain)

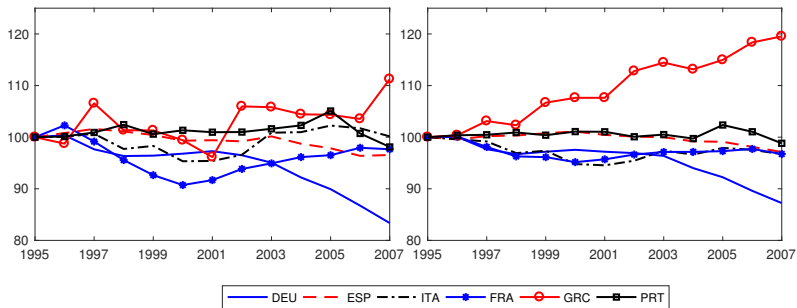
# EULC: international comparison



**Figure:** EULC in nontradable sectors in Germany compared with selected euro area countries; German classification of sectoral aggregates is applied to all countries.

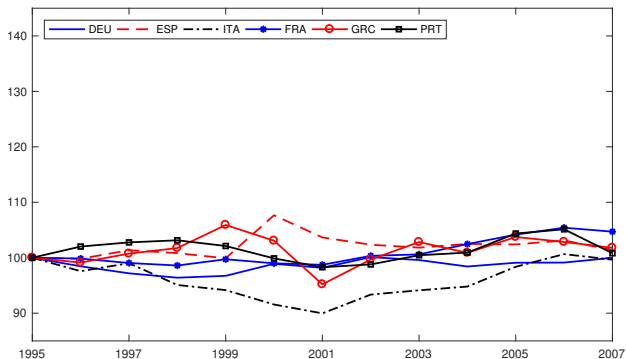


# Total EULC and ULC: international comparison



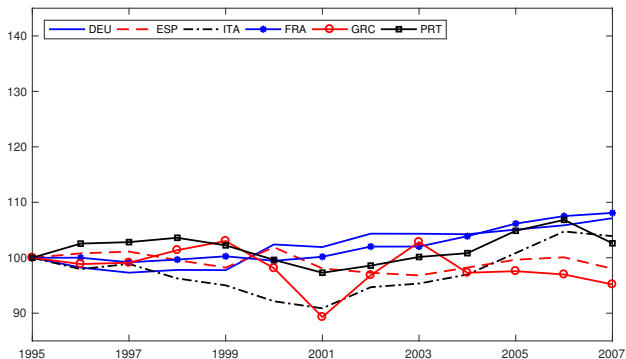
**Figure:** ULC (left panel) and EULC (right panel) in German tradable manufacturing and other selected euro area countries

# EREER: tradable services



**Figure:** EREERs in tradable services in Germany compared with selected euro area countries; German classification of sectoral aggregates is applied to all countries. EREERs are based on EULC and have been computed using overall value-added weights with double export weights.

## REER: tradable services



**Figure:** REERs in tradable services in Germany compared with selected euro area countries; German classification of sectoral aggregates is applied to all countries. REERs are based on ULC and have been computed using overall value-added weights with double export weights.

# EREER and REER: international comparison

## Tradable services:

- Development of EREERs is quite similar across countries:
  - In 2007, EREERs are at the roughly same level as in 1995 in the case of all countries except France
  - For France, EREERs increased slightly relatively to the level in 1995
- Different conclusions about competitiveness when looking at standard REERs:
  - Germany and France show the worst performance (increase of 7 percent and 8 percent, respectively)
  - Greece shows the best performance (decline of 5 percent)