

## **e-Business Study:**

# **ICT Impact on Energy Consumption: Empirical Analysis**

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**Energy & ICT Roundtable Discussion  
7 February 2008, Brussels**

An initiative of the



**European  
Commission**

# Overview Empirical Research

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- **Data selection / description**
- **Electricity / ICT capital ratios (Total / Chem. Ind.)**
- **Intermediate Energy Input (IIE) / ICT capital ratios\***
- **Time series IIE, IIM, IIS, LAB, CAP, CAPIT, CAPNIT\***
- **Model specifications**
- **First results**
- **Conclusions**

\* Metal Ind. (27t28), Chem. Ind. (24)

# Data Selection / Description

- **Primary interest in relationship between energy (electricity) and ICT capital stock**
- **Use of EUROSTAT database**
  - Electricity consumption data for descriptive analyses (e.g. ratio el.cons. / ICT cap.)
- **Use of EU KLEMS database**
  - Sufficiently long time series (panel data) available for few EU member countries
  - Dataset 1 (1980-2004) – 8 x 25 = 200 obs.:  
AUT, DNK, ESP, FIN, FRA, GER, ITA, ----, UK;
  - Dataset 2 (1980-2004) – 8 x 25 = 200 obs.:  
AUT, DNK, ESP, -----, FRA, GER, ITA, NL, UK;

# EU KLEMS Data Availability

(example: Basic Metals and Fabricated Metal Products)

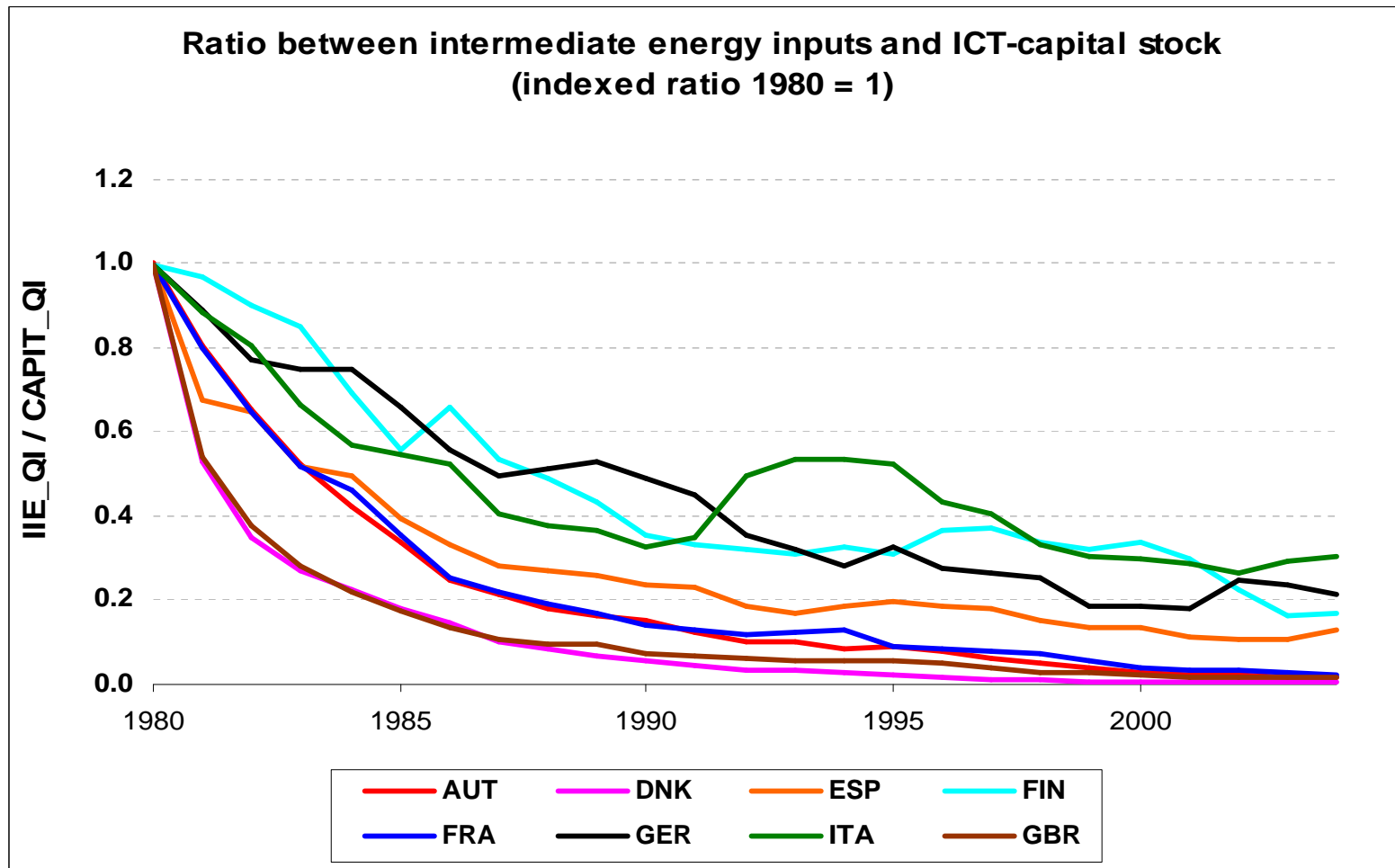
Country	IIE, IIM, IIS	IIE-QI, IIM-QI, IIS-QI	LAB, CAP	LAB-QI	CAP-QI	CAPIT, CAPNIT	CAPIT-QI, CAPNIT-QI
<b>Austria</b>	80-04	80-04	70-04	80-04 (27t28)	76-04 (27t28)	76-04(27t28)	76-04 (27t28)
<b>Belgium</b>	95-04	95-04	70-04(27t28)	86-04 (27t28)	70-04 (27t28)	70-04(27t28)	70-04 (27t28)
<b>Cyprus</b>	x	x	95-04	x	x	x	x
<b>Czech Republic</b>	95-04	95-04	95-04	95-05 (27t28)	95-04 (27t28)	95-04 (27t28)	95-04 (27t28)
<b>Denmark</b>	70-05	70-05	70-05	80-04 (27t28)	70-05 (27t28)	70-05 (27t28)	70-05 (27t28)
<b>Estonia</b>	00-02	x	95-04	x	x	x	x
<b>Finland</b>	70-04	70-04	70-04	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)
<b>France</b>	78-04	78-04	70-04	80-04 (27t28)	70-05 (27t28)	70-04 (27t28)	70-05 (27t28)
<b>Germany</b>	78-90(t), 91-04	78-90(t), 91-04	70-04	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)
<b>Greece</b>	95-99	95-99	70-04	x	x	x	x
<b>Hungary</b>	95-04	95-04	92-04	95-04 (27t28)	95-04 (27t28)	95-04 (27t28)	95-04 (27t28)
<b>Ireland</b>	x	x	70-04	x	x	x	x
<b>Italy</b>	70-91(t), 92-04	70-91(t), 92-04	70-04	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)
<b>Latvia</b>	x	x	95-04	x	x	x	x
<b>Lithuania</b>	x	x	95-04	x	x	x	x
<b>Luxembourg</b>	95-04	95-04	70-04	x	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)
<b>Malta</b>	00-01	x	95-04	x	x	x	x
<b>Netherlands</b>	81-86(t), 87-04	80-86(t), 87-04	70-04	79-04 (27t28)	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)
<b>Poland</b>	95-04	95-04	95-04	95-05 (27t28)	95-04 (27t28)	x	x
<b>Portugal</b>	x	x	70-04	x	x	x	x
<b>Slovak Republic</b>	95-05	95-05	95-05	95-05 (27t28)	x	x	x
<b>Slovenia</b>	95-04	x	95-04	95-04 (27t28)	95-04 (27t28)	95-04 (27t28)	95-04 (27t28)
<b>Spain</b>	80-04	80-04	70-04	80-04 (27t28)	70-05 (27t28)	70-04 (27t28)	70-05 (27t28)
<b>Sweden</b>	93-03	93-03	70-04	93-04 (27t28)	1993-2004	1993-2004	1993-2004
<b>UK</b>	70-04	70-04	70-04	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)	70-04 (27t28)
<b>EU-25</b>	x	x	95-04	x	x	x	x

# Ratio between electricity and ICT capital services, total and chemical industries, selected EU members (index ratio 1995= 1)

	Total Industries		Chemical Industries	
	2003	2004	2003	2004
<b>Austria</b>	0.3104	0.2981	0.3134	0.3064
<b>Denmark</b>	0.2304	0.2144	0.1685	0.1415
<b>Finland</b>	0.5524	0.5259	0.5672	0.5528
<b>France</b>	0.5253	0.5136	0.4517	0.3916
<b>Germany</b>	0.4081	0.3971	0.5092	0.5197
<b>Italy</b>	0.4921	0.4824	1.4101	1.8189
<b>Spain</b>	0.6125	0.6022	0.6031	0.6277
<b>UK</b>	0.2969	0.2763	0.3519	0.3444
<b>EU 15</b>	0.3967	0.3813	0.5044	0.4908

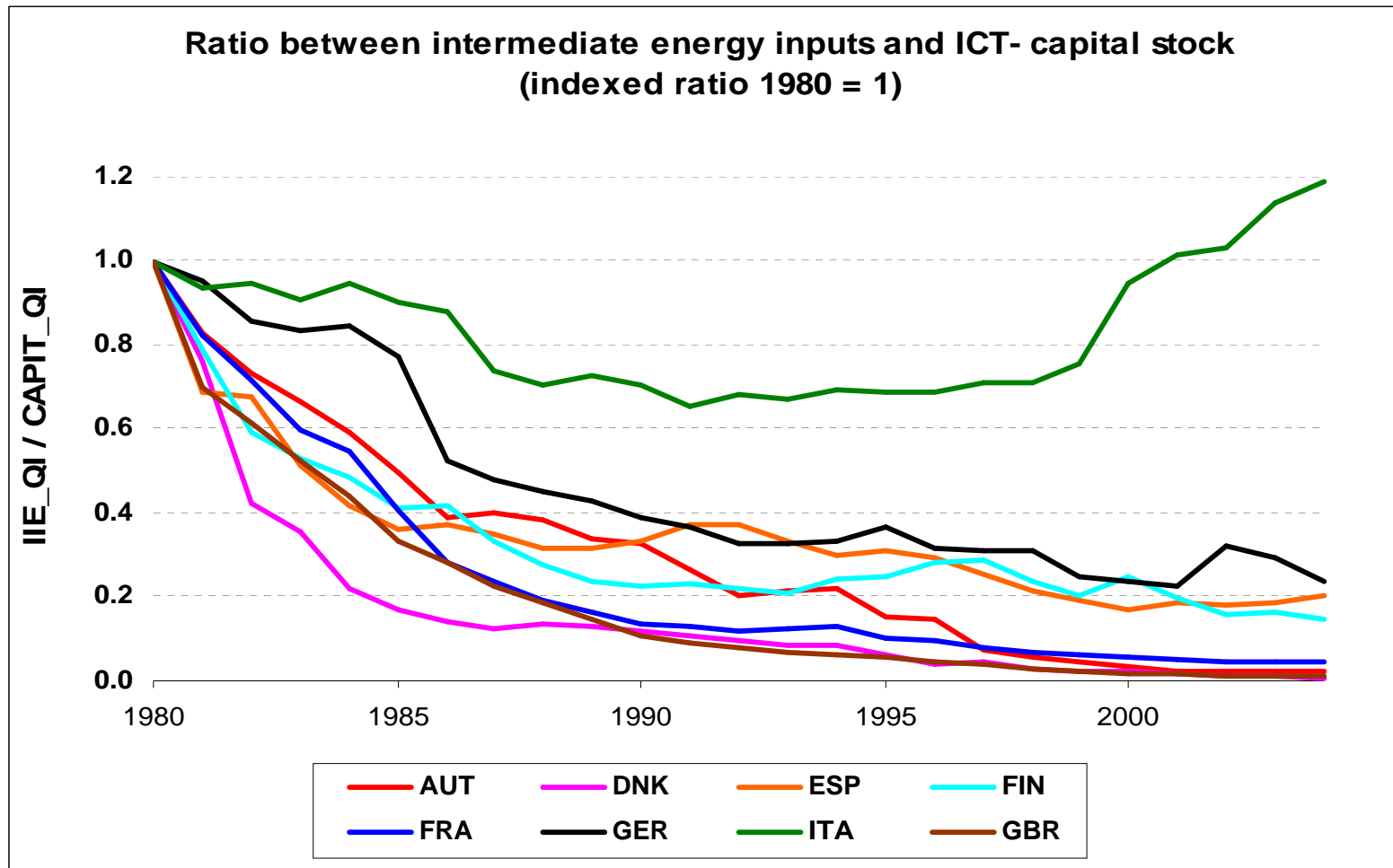
Source: EUROSTAT, EUKLEMS

# Basic Metals and Fabricated Metal Products: Ratio IIE / ICT capital



Source: Euklems

# Chemicals and Chemical Industries: Ratio IIE / ICT capital

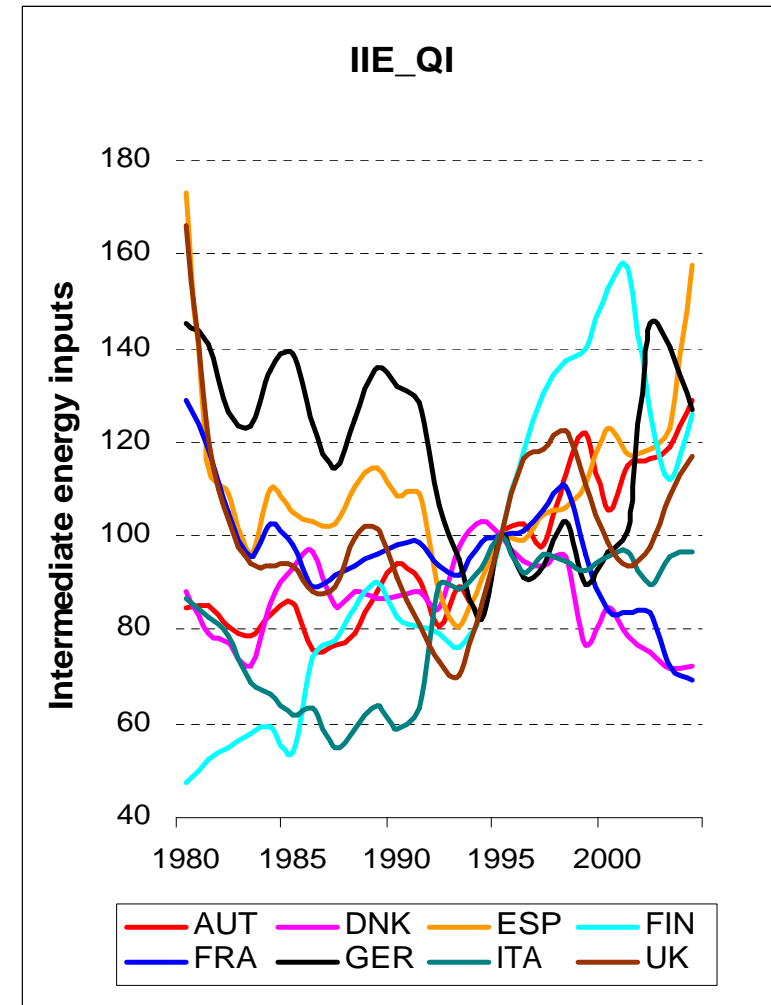
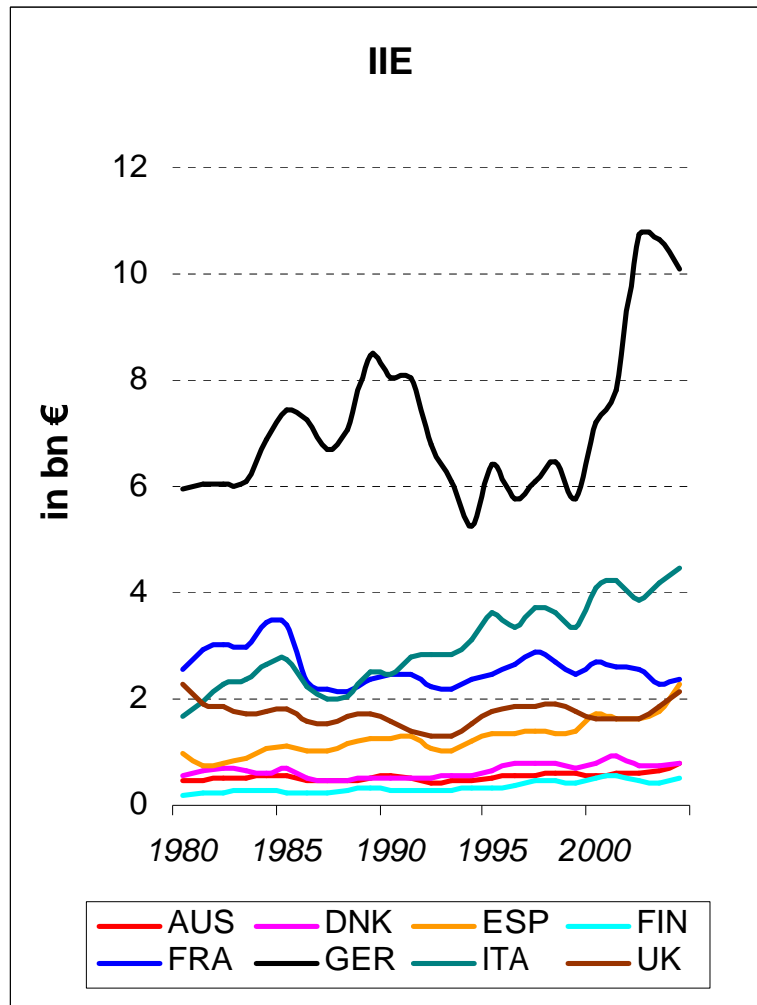


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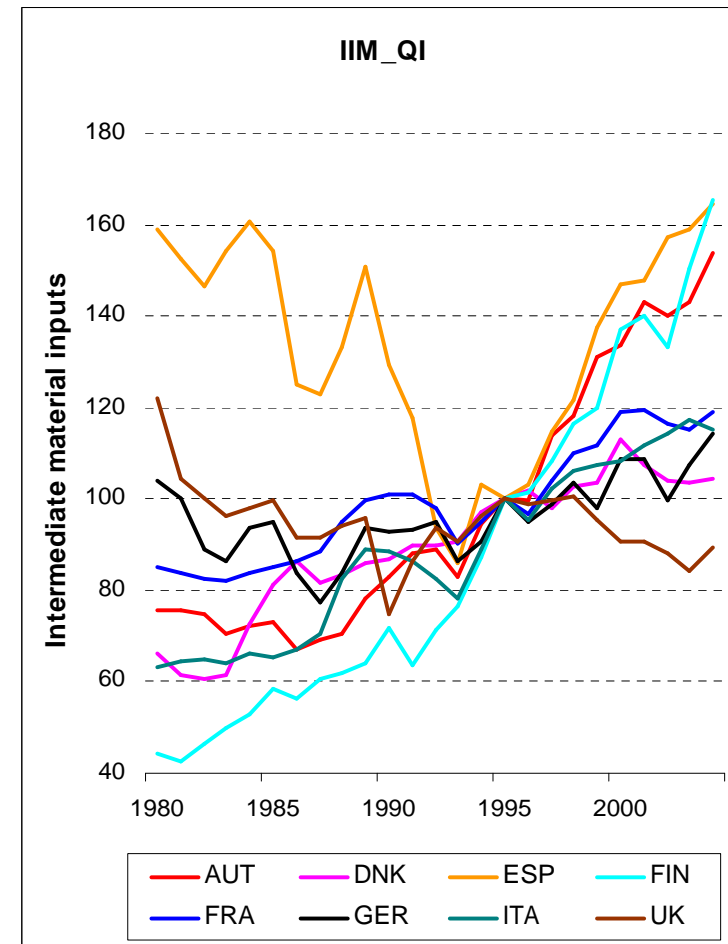
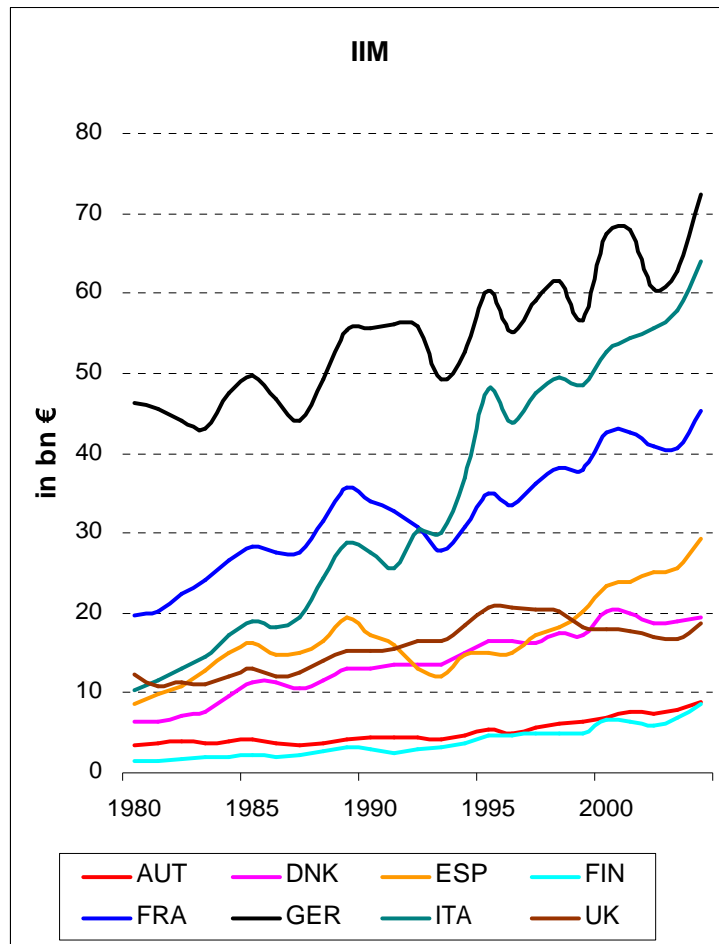
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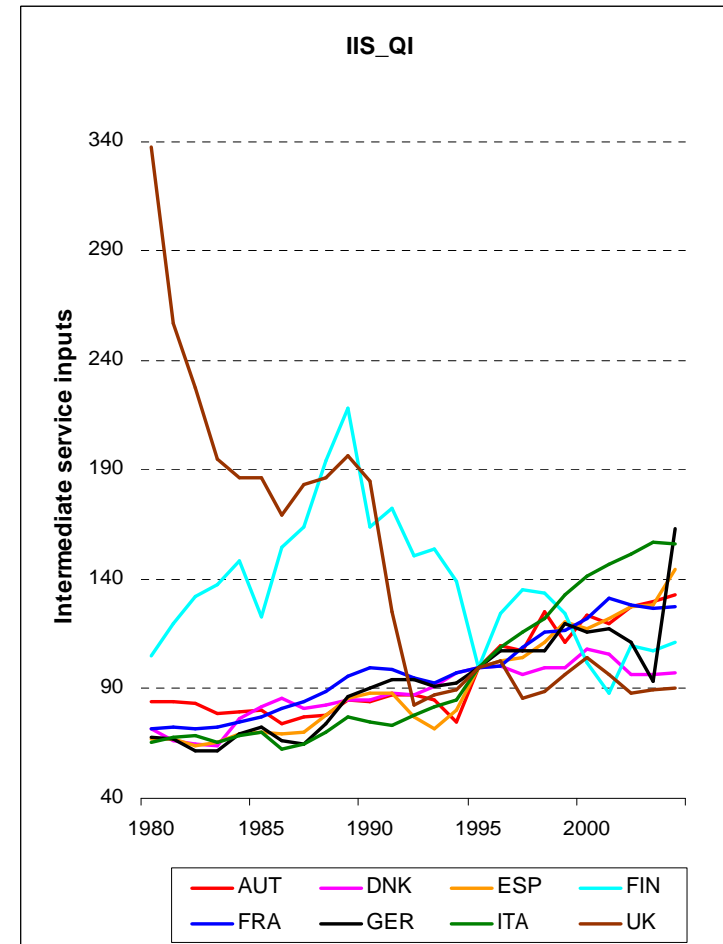
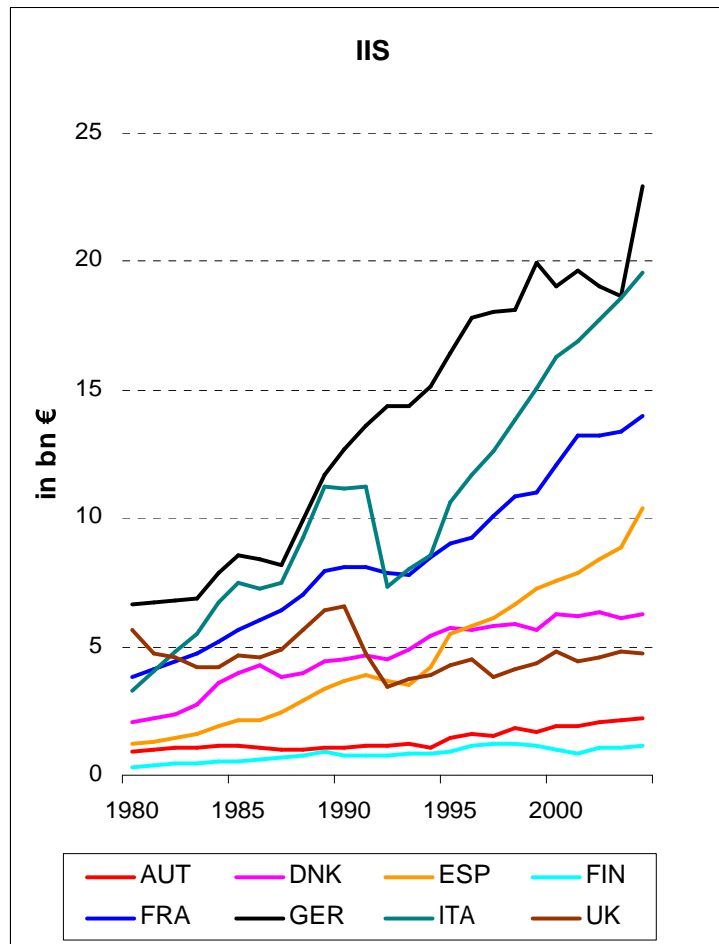
# Basic Metals and Fabricated Metal Products: Intermediate energy inputs (at current purchasers' prices and volume)



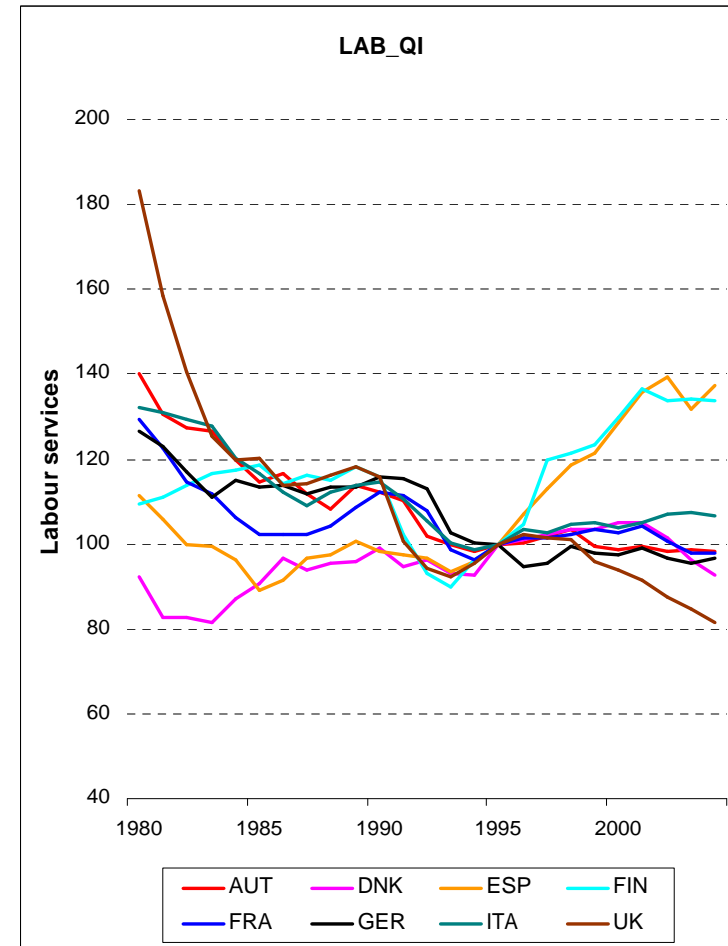
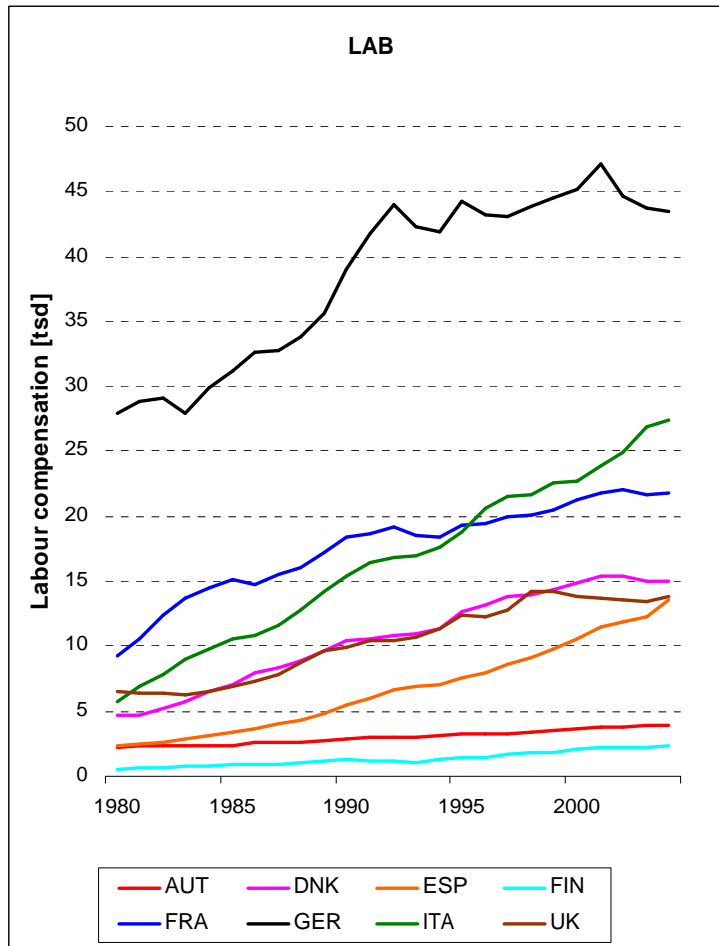
# Basic Metals and Fabricated Metal Products: Intermediate material inputs (at current purchasers' prices and volume)



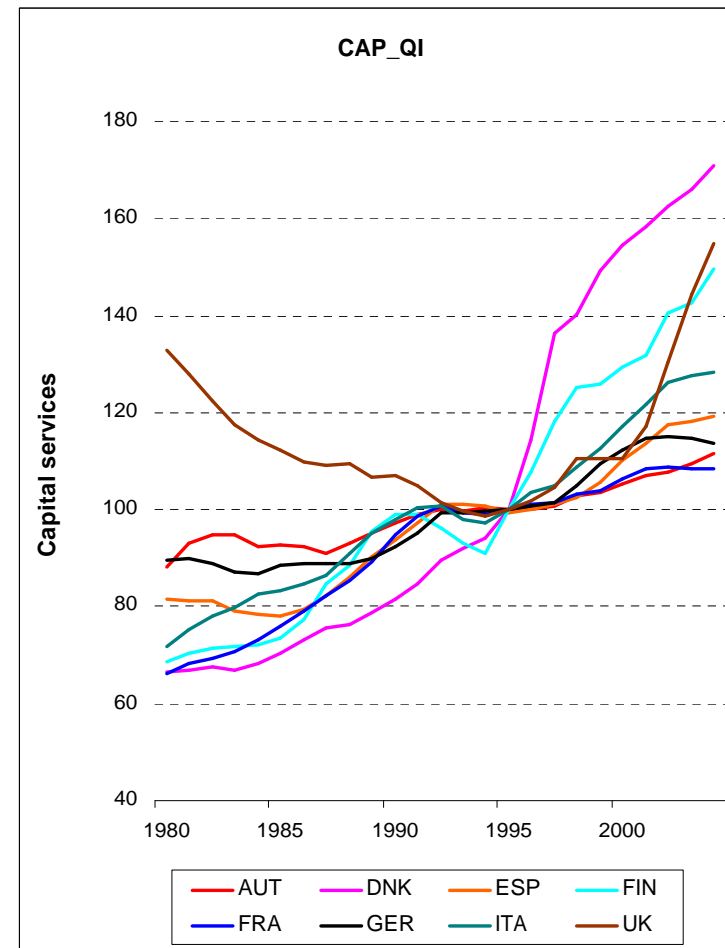
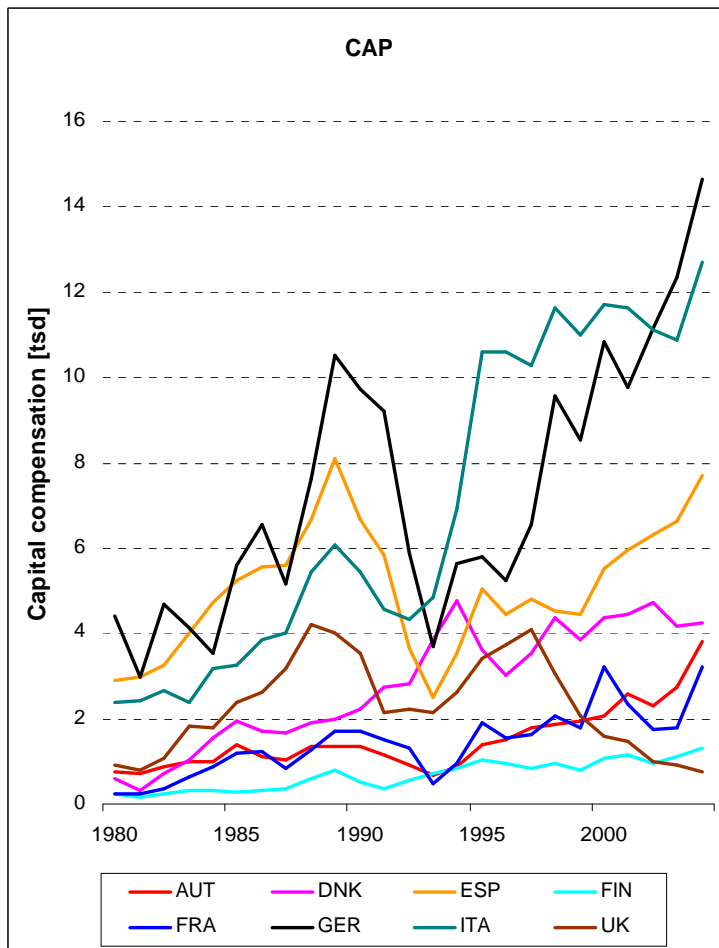
# Basic Metals and Fabricated Metal Products: Intermediate service inputs (at current purchasers' prices and volume)



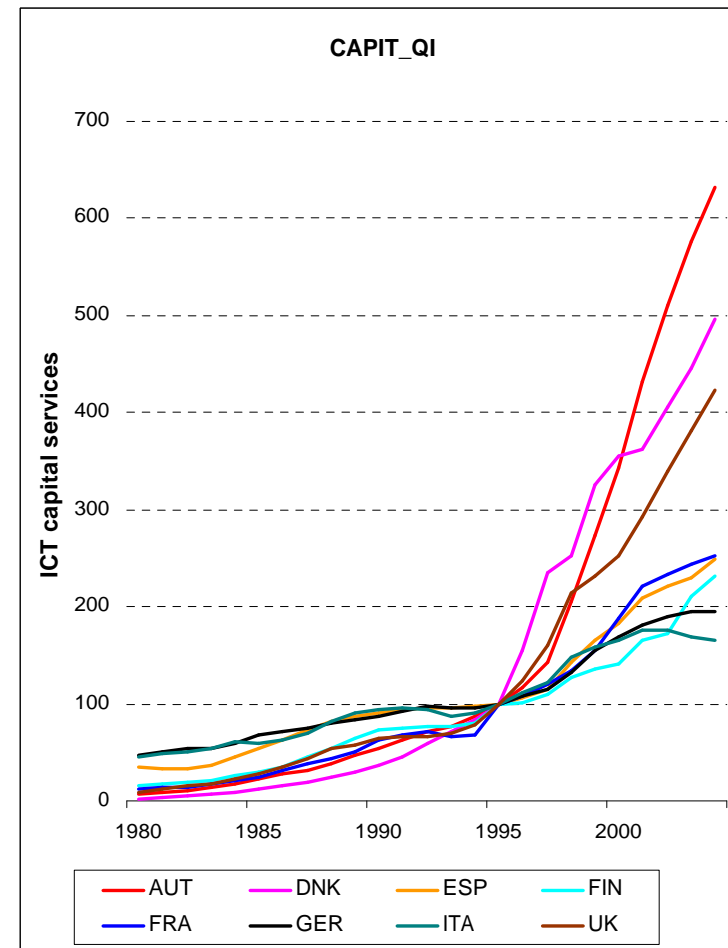
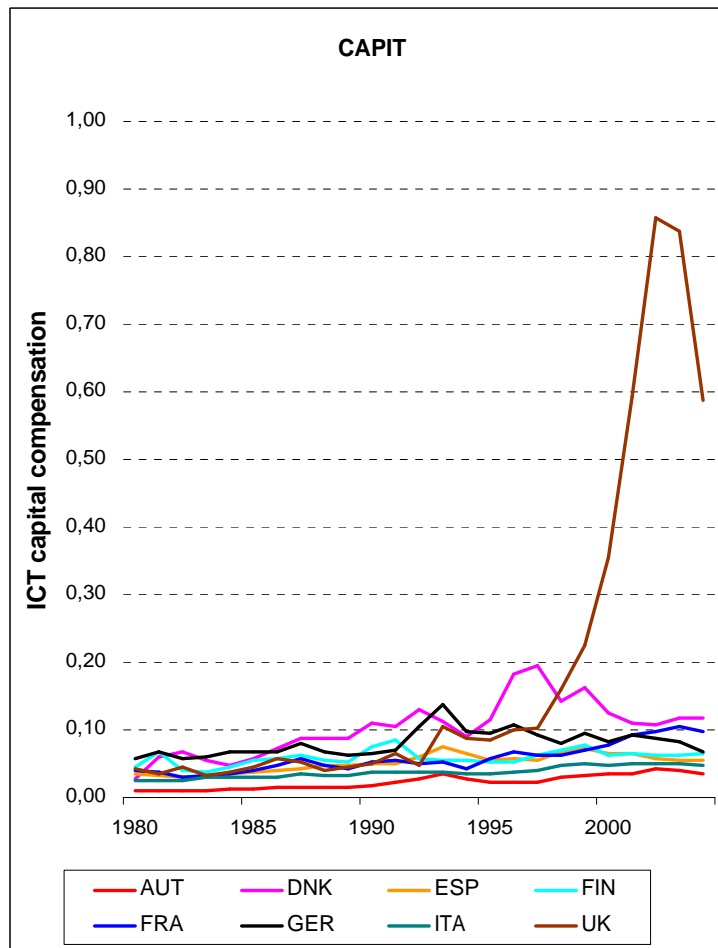
# Basic Metals and Fabricated Metal Products: Labour compensation and services



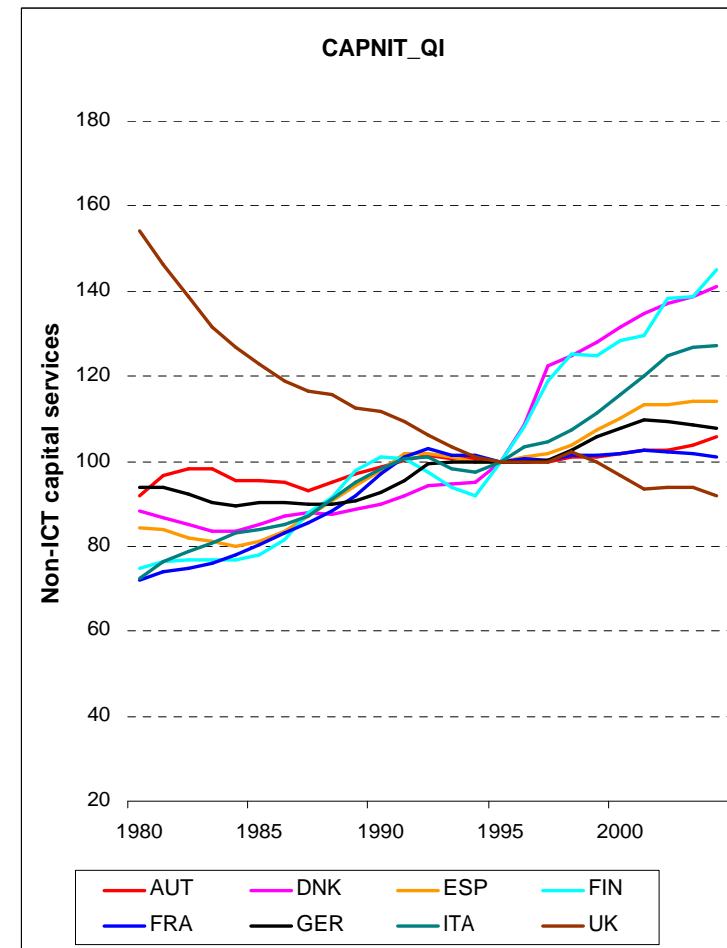
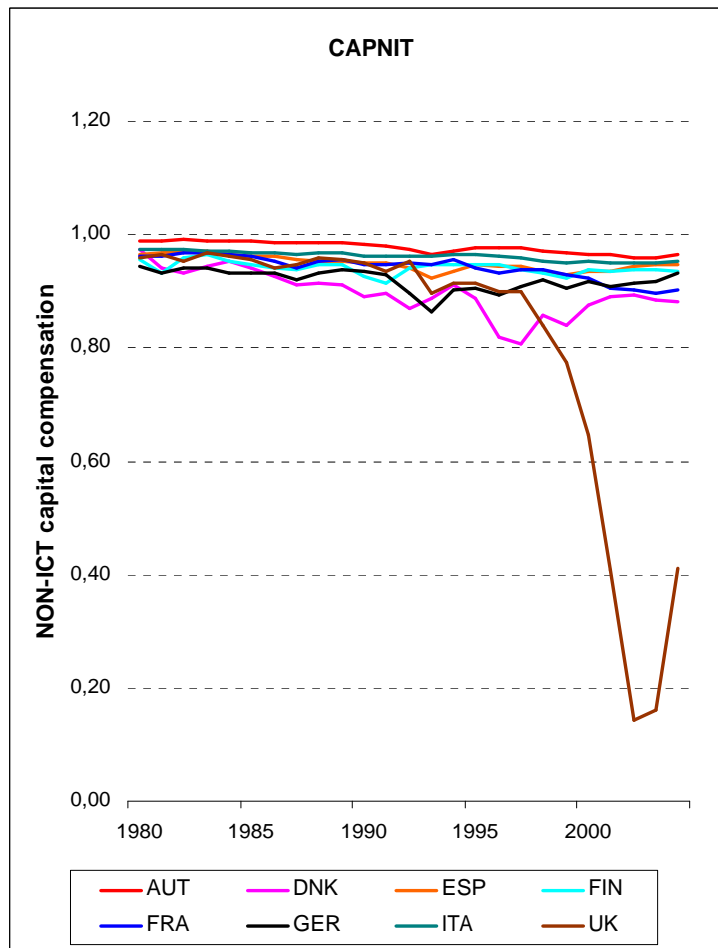
# Basic Metals and Fabricated Metal Products: Capital compensation and capital services



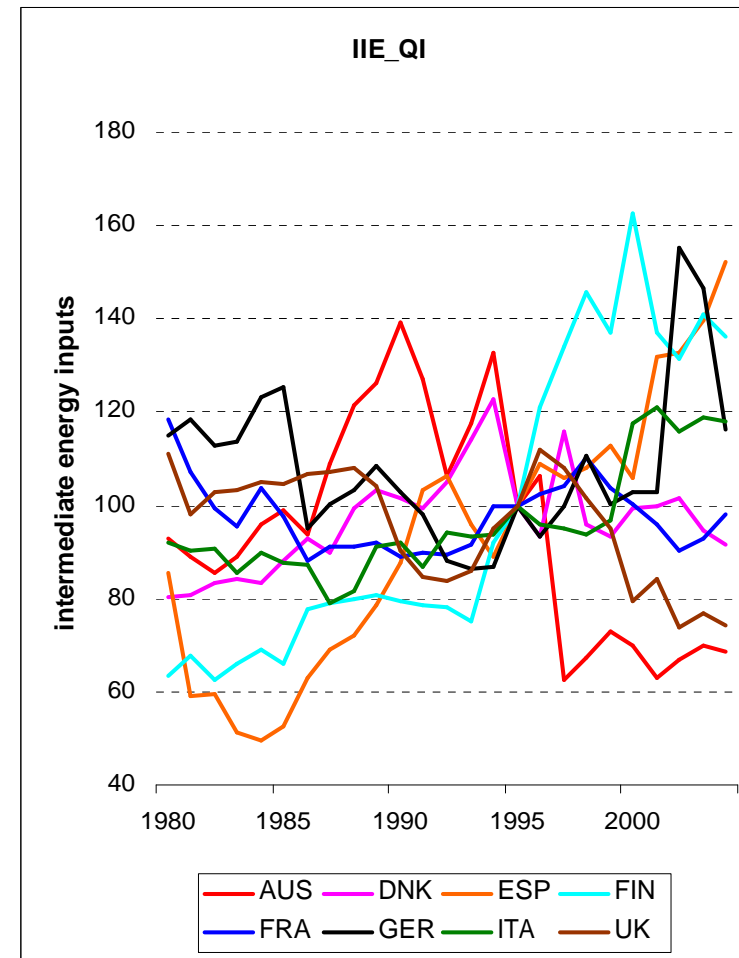
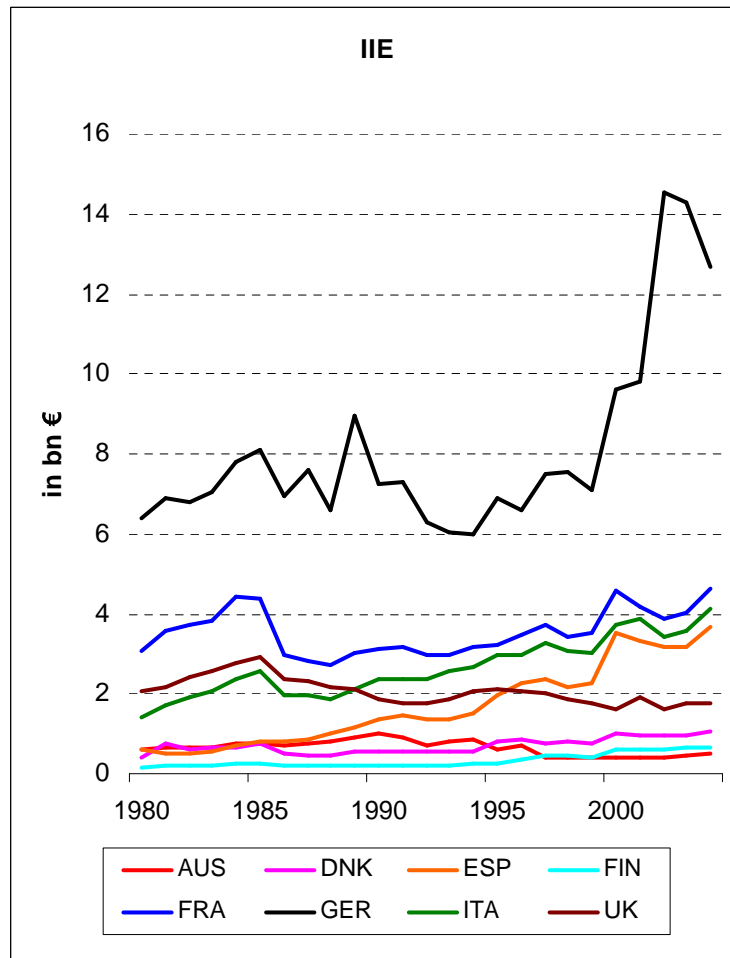
# Basic Metals and Fabricated Metal Products: ICT capital compensation and capital services



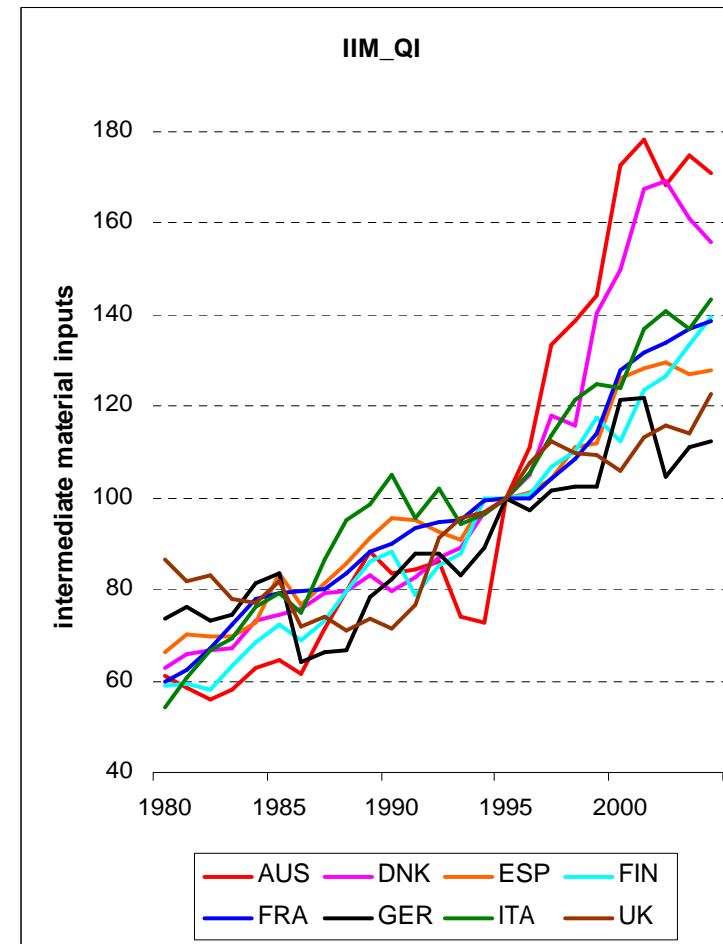
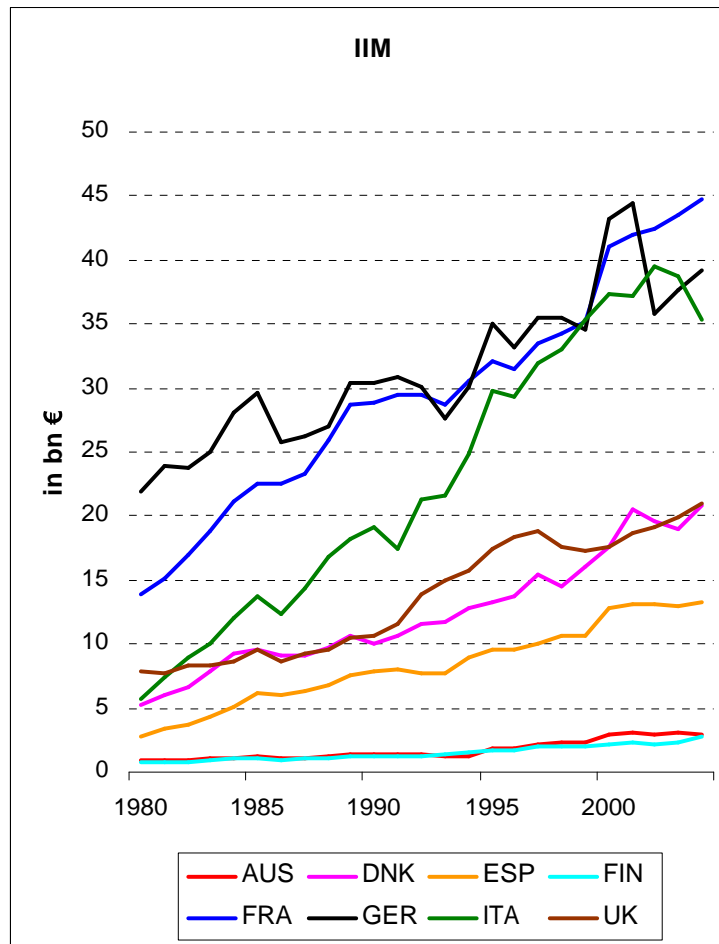
# Basic Metals and Fabricated Metal Products: Non-ICT capital compens. and capital services



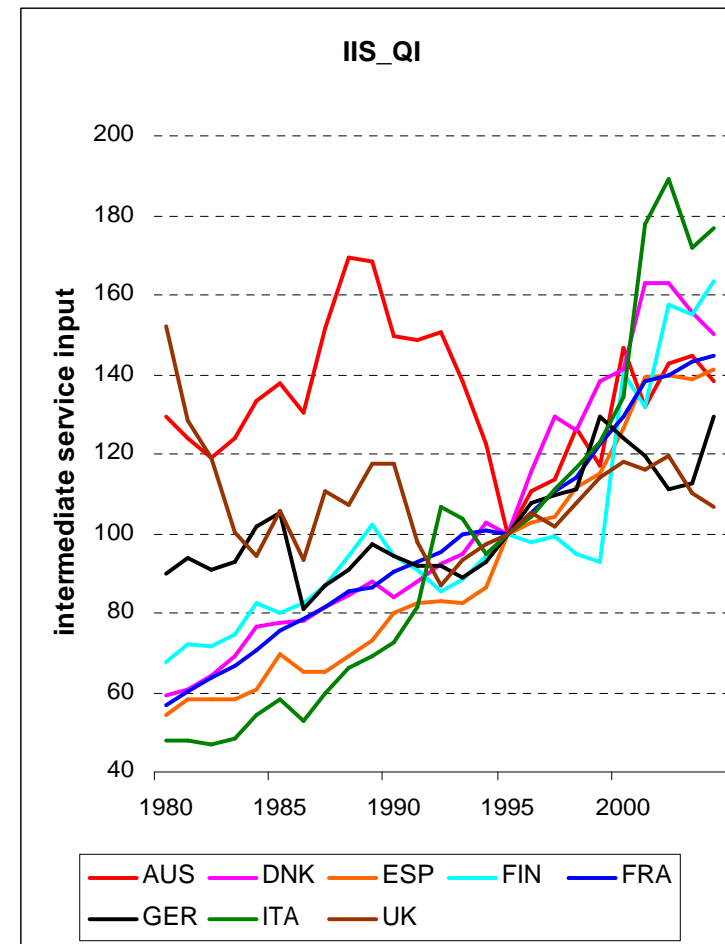
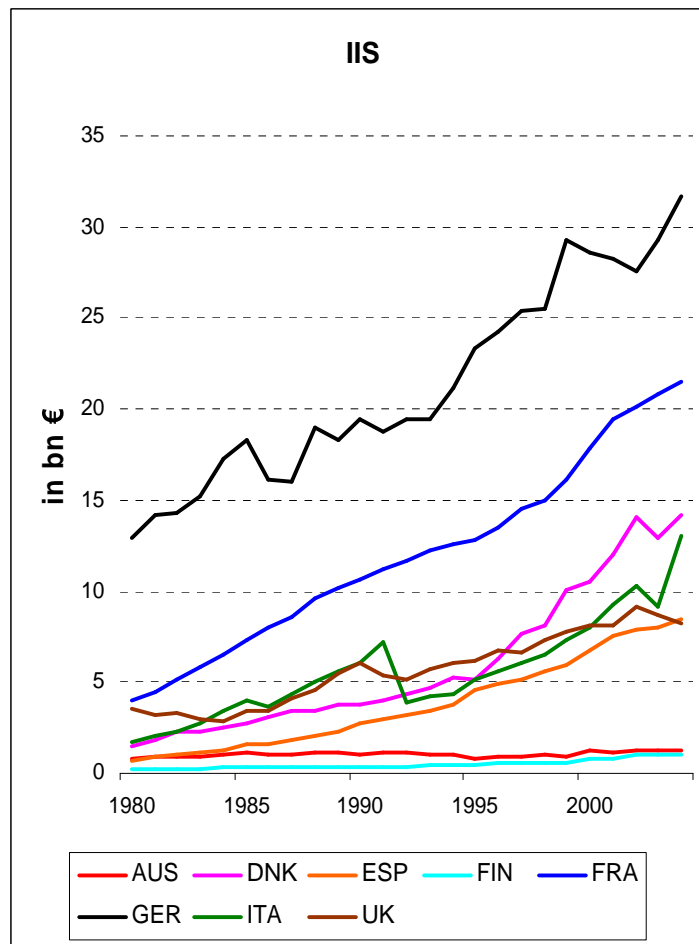
# Chemicals and chemical industries: Intermediate energy inputs (at current purchasers' prices and volume)



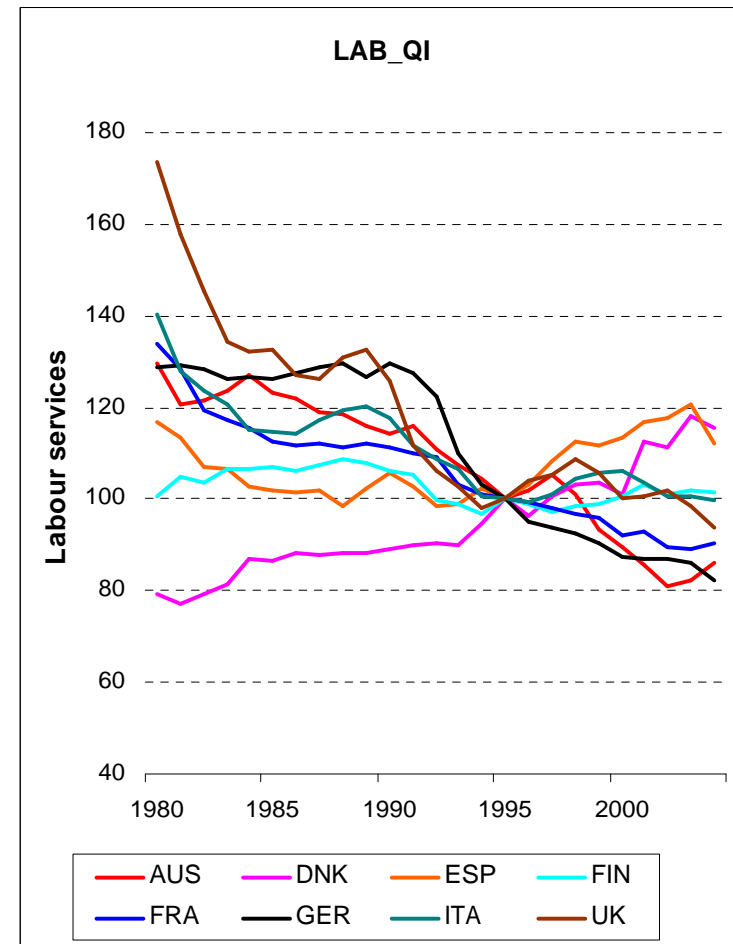
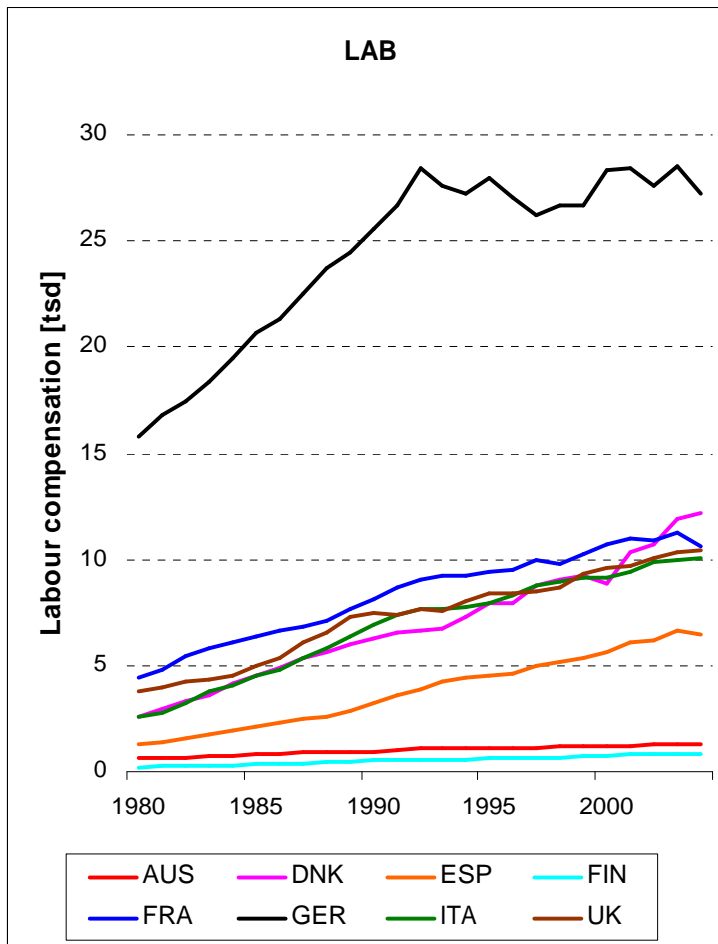
# Chemicals and chemical industries: Intermediate material inputs (at current purchasers' prices and volume)



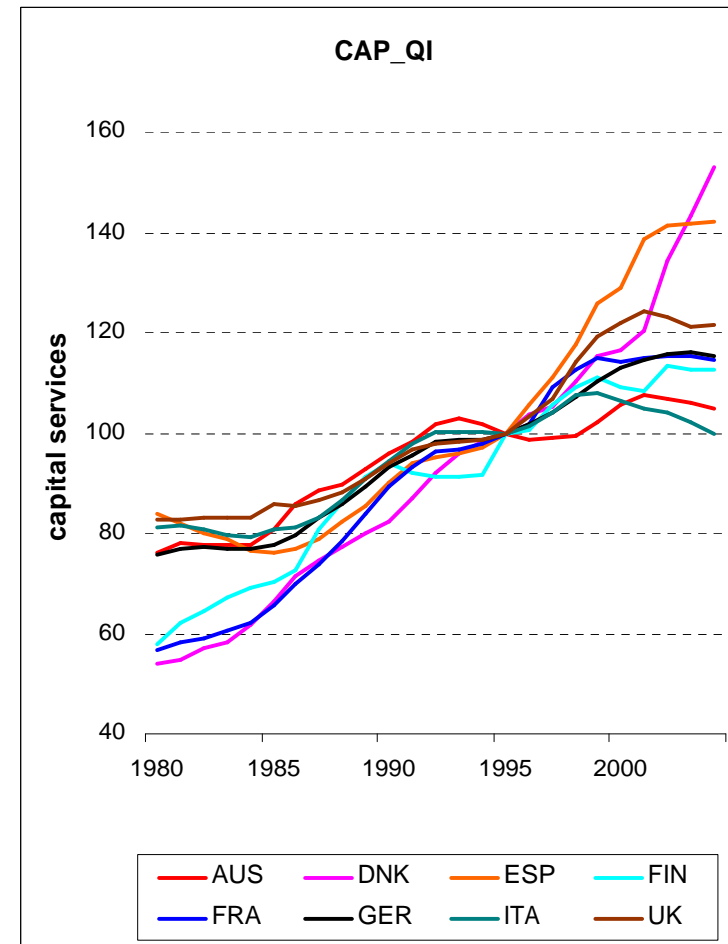
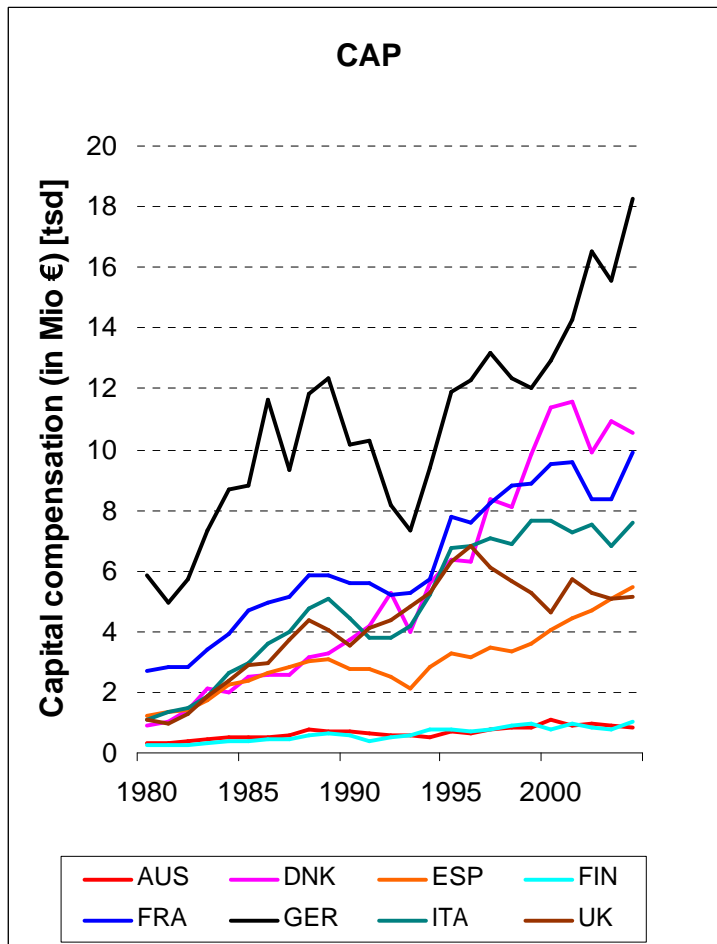
# Chemicals and chemical industries: Intermediate service inputs (at current purchasers' prices and volume)



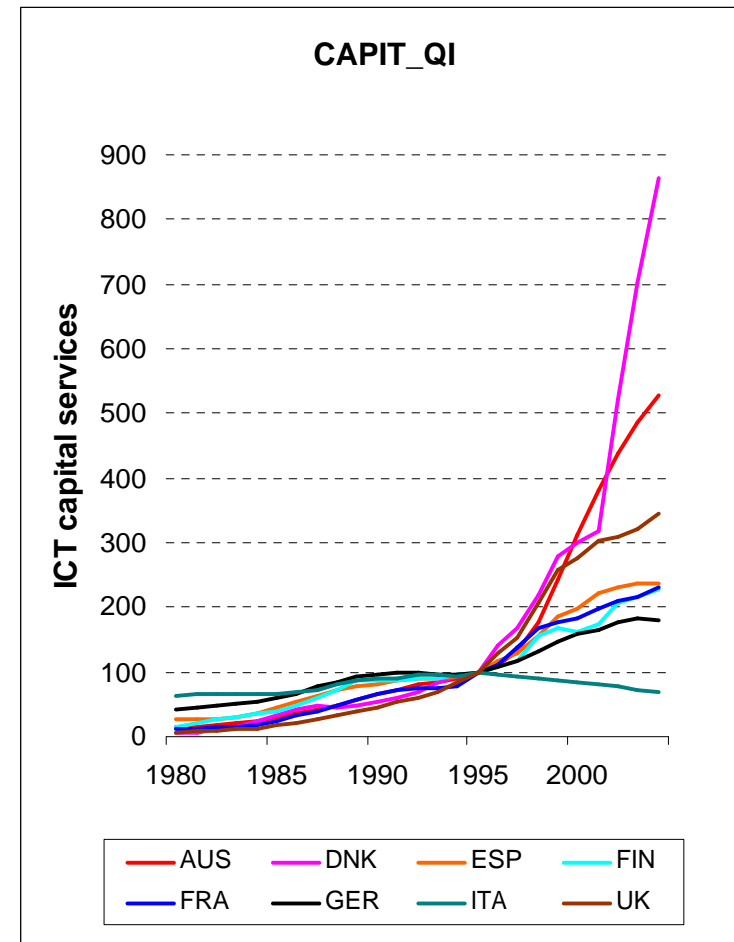
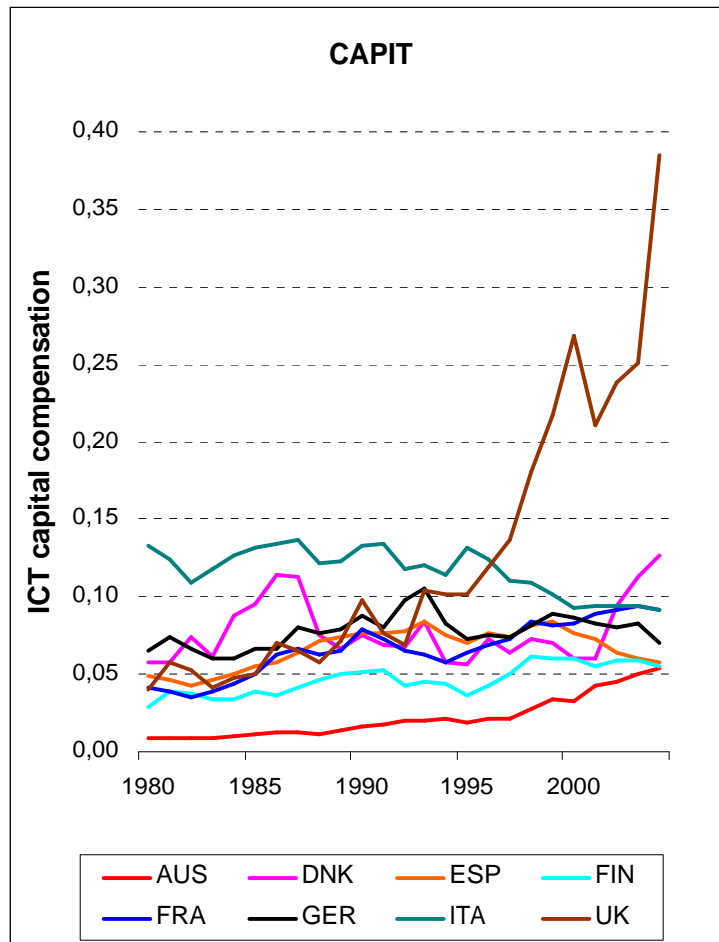
# Chemicals and chemical industries: Labour compensation and services



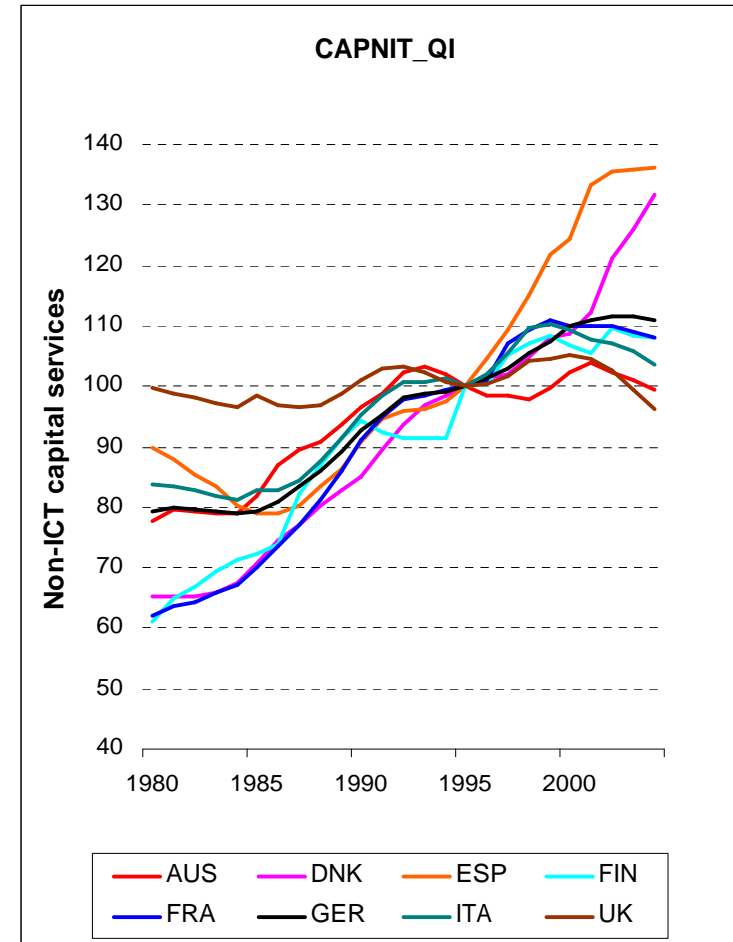
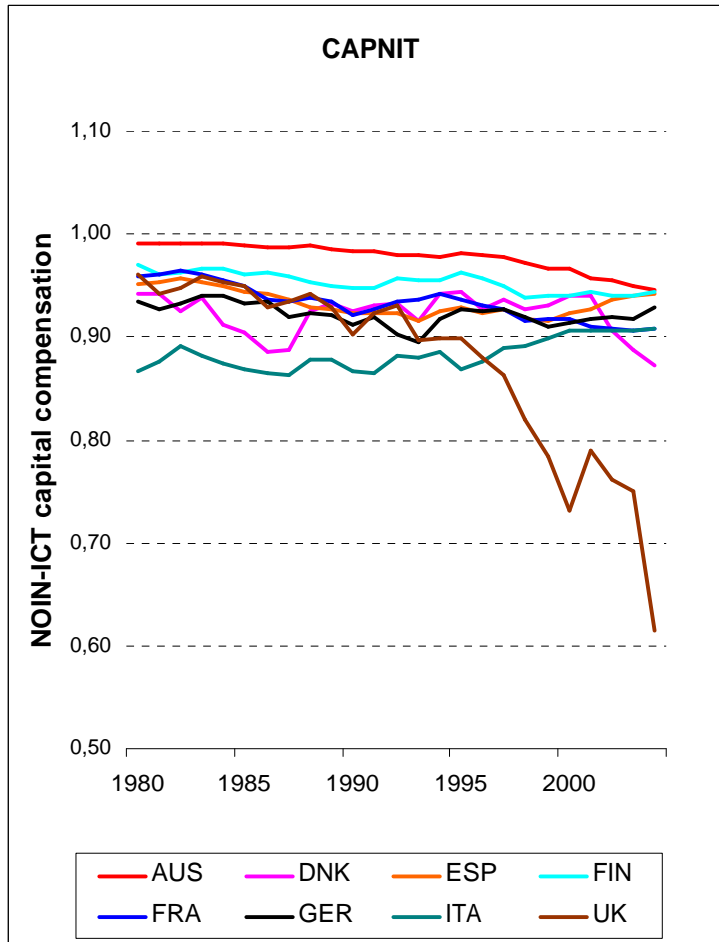
# Chemicals and chemical industries: Capital compensation and capital services



# Chemicals and chemical industries: ICT capital compensation and capital services



# Chemicals and chemical industries: Non-ICT capital compens. and capital services



# Econometric model specifications studied so far (EU KLEMS data)

- Explaining intermediate energy input by IT- and non-IT capital stock, and a trend variable (ad hoc model)

$$\log(IIE\_Qi_t) = \alpha_0 + \beta_T \cdot t + \beta_{IT} \log Capit\_Qi_t + \beta_{NIT} \log Capnit\_Qi_t$$

- Cobb-Douglas production functions (rel. to hours worked)

$$\log(GO\_Qi_t) = \alpha_0 + \beta_{IIE,t} \log(IIE\_Qi_t) + \beta_{IIM,t} \log(IIM\_Qi_t) + \beta_{IIS,t} \log(IIS\_Qi_t) \\ + \beta_{CIT,t} \log(Capit\_Qi_t) + \beta_{CNIT,t} \log(Capnit\_Qi_t) + \beta_T time$$

$$\log(GO\_Qi_t) = \alpha_0 + \beta_{IIE,t} \log(IIE\_Qi_t) + \beta_{IIM,t} \log(IIM\_Qi_t) + \beta_{IIS,t} \log(IIS\_Qi_t) \\ + \beta_{CIT,t} \log(Capit\_Qi_t) + \beta_{CNIT,t} \log(Capnit\_Qi_t) \\ + \log(IIE\_Qi_t) * \log(Capit\_Qi_t) + \log(IIE\_Qi_t) * \log(IIE\_Qi_t) \\ + \log(Capit\_Qi_t) * \log(Capit\_Qi_t) + \beta_T time$$

# First econometric estimation results

(Ad-hoc model; Chemicals and Chemical Industries, Austria only)

Dependent Variable: LNIIEQI

Method: Least Squares

Date: 02/03/08 Time: 10:43

Sample: 1980 2004

Included observations: 25

$LNIIEQI=C(1)+C(2)*TIME +C(3)*LNCAPIQI + C(4)*LNCAPIQI$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-10.27653	2.878961	-3.569528	0.0018
C(2)	-0.049397	0.035492	-1.391770	0.1786
C(3)	-0.071760	0.220425	-0.325553	0.7480
C(4)	3.473648	0.621579	5.588426	0.0000
R-squared	0.713082	Mean dependent var		4.523467
Adjusted R-squared	0.672094	S.D. dependent var		0.251129
S.E. of regression	0.143805	Akaike info criterion		-0.895077
Sum squared resid	0.434275	Schwarz criterion		-0.700057
Log likelihood	15.18846	Durbin-Watson stat		1.427903

# First econometric estimation results

(Cobb Douglas, CRS; Basic Metals and Fabricated Metal Products)

Dependent Variable: LGO\_QI\_WH

Method: Least Squares

Date: 02/05/08 Time: 12:13

Sample: 2 201

Included observations: 200

$LGO\_QI\_WH = C(1) + C(2)*LIIE\_QI\_WH + C(3)*LIIM\_QI\_WH + C(4)*LIIS\_QI\_WH + C(5)*LCAPIT\_QI\_WH + C(6)*LCAPNIT\_QI\_WH + C(7)*TIME$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.003117	0.029127	0.107008	0.9149
C(2)	0.235795	0.034582	6.818432	0.0000
C(3)	0.540614	0.037861	14.27878	0.0000
C(4)	0.042228	0.023882	1.768195	0.0786
C(5)	0.027101	0.012825	2.113051	0.0359
C(6)	0.160761	0.042591	3.774497	0.0002
C(7)	0.000559	0.001698	0.329093	0.7424

R-squared	0.995097	Mean dependent var	-1.555569
Adjusted R-squared	0.994944	S.D. dependent var	1.166318
S.E. of regression	0.082931	Akaike info criterion	-2.107250
Sum squared resid	1.327357	Schwarz criterion	-1.991809
Log likelihood	217.7250	Hannan-Quinn criter.	-2.060533
F-statistic	6527.859		
Prob(F-statistic)	0.000000		

# First econometric estimation results

(Cobb-Douglas, CRS; Basic Metals and Fabricated Metal Products)

Dependent Variable: LGO\_QI\_WH (deletion of insignificant coeff.)

Method: Least Squares

Date: 02/05/08 Time: 13:30

Sample: 2 201

Included observations: 200

$$\text{LGO\_QI\_WH} = \text{C}(1) + \text{C}(2) * \text{LIIE\_QI\_WH} + \text{C}(3) * \text{LIIM\_QI\_WH} + \text{C}(5) * \text{LCAPIT\_QI\_WH} + \text{C}(6) * \text{LCAPNIT\_QI\_WH}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.012468	0.010403	1.198577	0.2321
C(2)	0.233899	0.034103	6.858601	0.0000
C(3)	0.530079	0.037326	14.20151	0.0000
C(5)	0.030953	0.006982	4.433522	0.0000
C(6)	0.212327	0.028934	7.338340	0.0000

R-squared	0.995008	Mean dependent var	-1.555569
Adjusted R-squared	0.994905	S.D. dependent var	1.166318
S.E. of regression	0.083250	Akaike info criterion	-2.109266
Sum squared resid	1.351445	Schwarz criterion	-2.026808
Log likelihood	215.9266	Hannan-Quinn criter.	-2.075896
F-statistic	9716.053		
Prob(F-statistic)	0.000000		

# First econometric estimation results

(Cobb-Douglas, CRS; Chemicals and Chemical Industries)

Dependent Variable: LGO\_QI\_WH

Method: Least Squares

Date: 02/05/08 Time: 11:56

Sample: 2 201

Included observations: 200

LGO\_QI\_WH=C(1) + C(2)\*LIIE\_QI\_WH + C(3)\*LIIM\_QI\_WH + C(4)

\*LIIS\_QI\_WH + C(5)\*LCAPIT\_QI\_WH + C(6)\*LCAPNIT\_QI\_WH + C(7)\*TIME

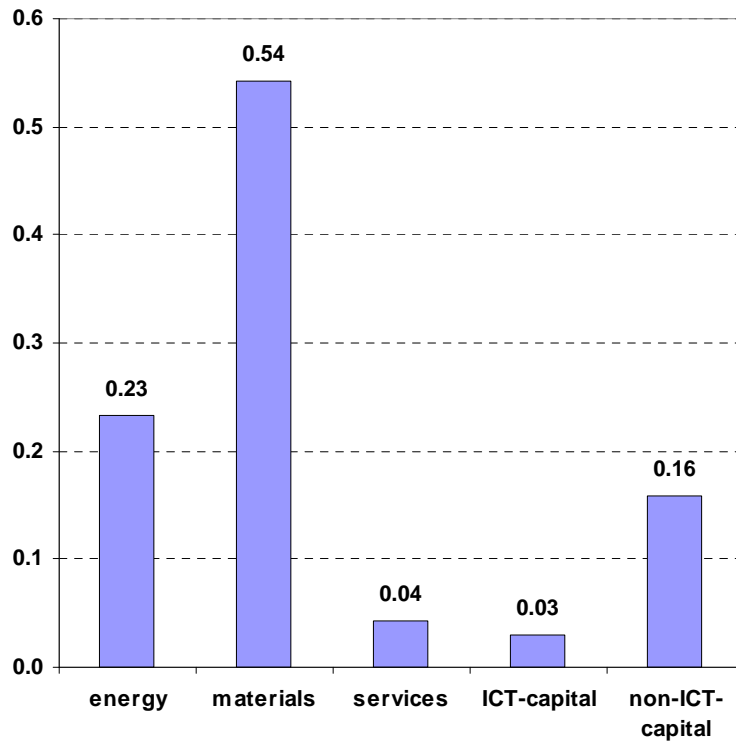
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.037757	0.174603	5.943509	0.0000
C(2)	0.110100	0.020095	5.479039	0.0000
C(3)	0.340530	0.031873	10.68391	0.0000
C(4)	0.238203	0.018624	12.79028	0.0000
C(5)	0.070925	0.008135	8.718476	0.0000
C(6)	0.238628	0.041569	5.740470	0.0000
C(7)	0.003758	0.001604	2.342959	0.0201

R-squared	0.998521	Mean dependent var	-0.665223
Adjusted R-squared	0.998475	S.D. dependent var	1.255243
S.E. of regression	0.049022	Akaike info criterion	-3.158714
Sum squared resid	0.463813	Schwarz criterion	-3.043273
Log likelihood	322.8714	Hannan-Quinn criter.	-3.111997
F-statistic	21713.47		
Prob(F-statistic)	0.000000		

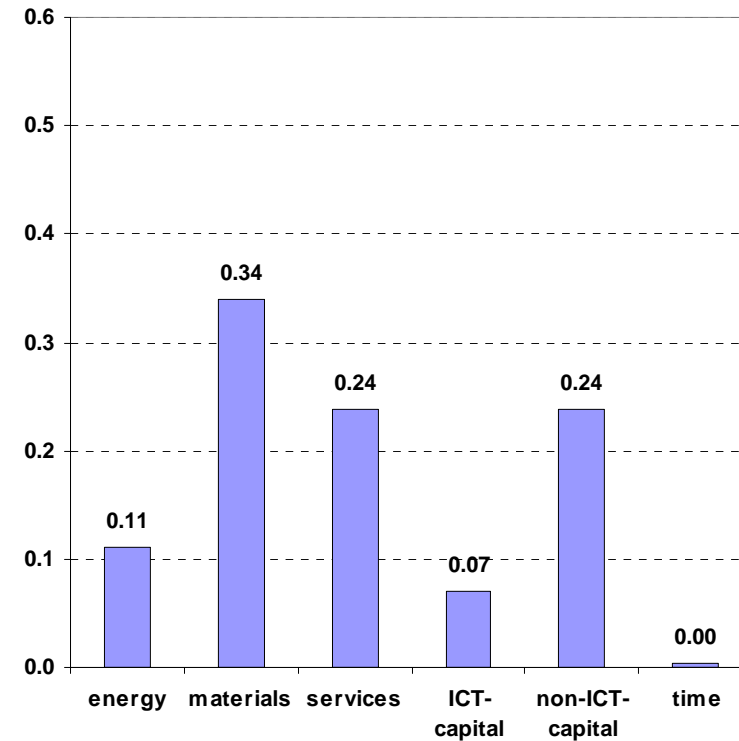
# Output elasticities by input factor

(Cobb Douglas, CRS; Metals and Chemicals Industries)

output elasticities in the metals industry



output elasticities in the chemicals industry



# (Preliminary) Conclusions

## Metals industry:

- Output elasticity of materials (0.54) is much higher than that for energy (0.23)
- output elasticity of ICT capital is the lowest of all (0.03), and less than a fifth of the non-ICT capital output elast.

## Chemicals industry:

- Output elasticity of materials – although lower than for the case of the metals industry – is highest of all (0.34), followed by services and non-ICT capital
- Output elasticity of energy (0.11) is much lower than for the metals industry (less than half)
- Output elasticity of ICT capital is lower than that for energy, but higher than in the metals industry