ENVIRONMENTAL INNOVATION IN INDUSTRY AND ENVIRONMENTAL TAX REFORM (ETR)

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by

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Research Questions on ETRs and innovation

- What is the effect of relative price changes on the direction of innovation?
- In particular, will ETR, by making environmentally intensive activities more expensive, stimulate innovation in the environmental industries?
- Will this result in environmental and economic improvement?
- Method:
  - Define innovation and understand how it occurs
  - Define environmental industries and estimate their size and economic importance
  - See whether there is any evidence that environmental industries to date have resulted in environmental improvement
  - See whether there is any evidence that ETRs to date have stimulated environmental industries
  - Research ongoing (so far inconclusive)

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Why is environmental innovation of interest?

- Two great social priorities
  - Competitiveness, growth, employment (Lisbon agenda)
  - Environmental threats, quality (Gothenburg, SDS, 6EAP)
- Historical experience is overwhelmingly of trade-off of environment for economic performance
  - Unsustainable, unacceptable threat
  - Unacceptable for trade off to work the other way round (not even prepared to accept reduced rate of economic growth)
- In this context environmental innovation must deliver
  - Improved environmental performance (over life-cycle, time-periods, multiple dimensions, rebound effects), and hopefully
  - Improved economic performance (output, welfare, employment, exports; over what time? over what scale (country, sector, firm, process, product)?
- What policy can stimulate environmental innovation? Can environmental tax reform (ETR)?

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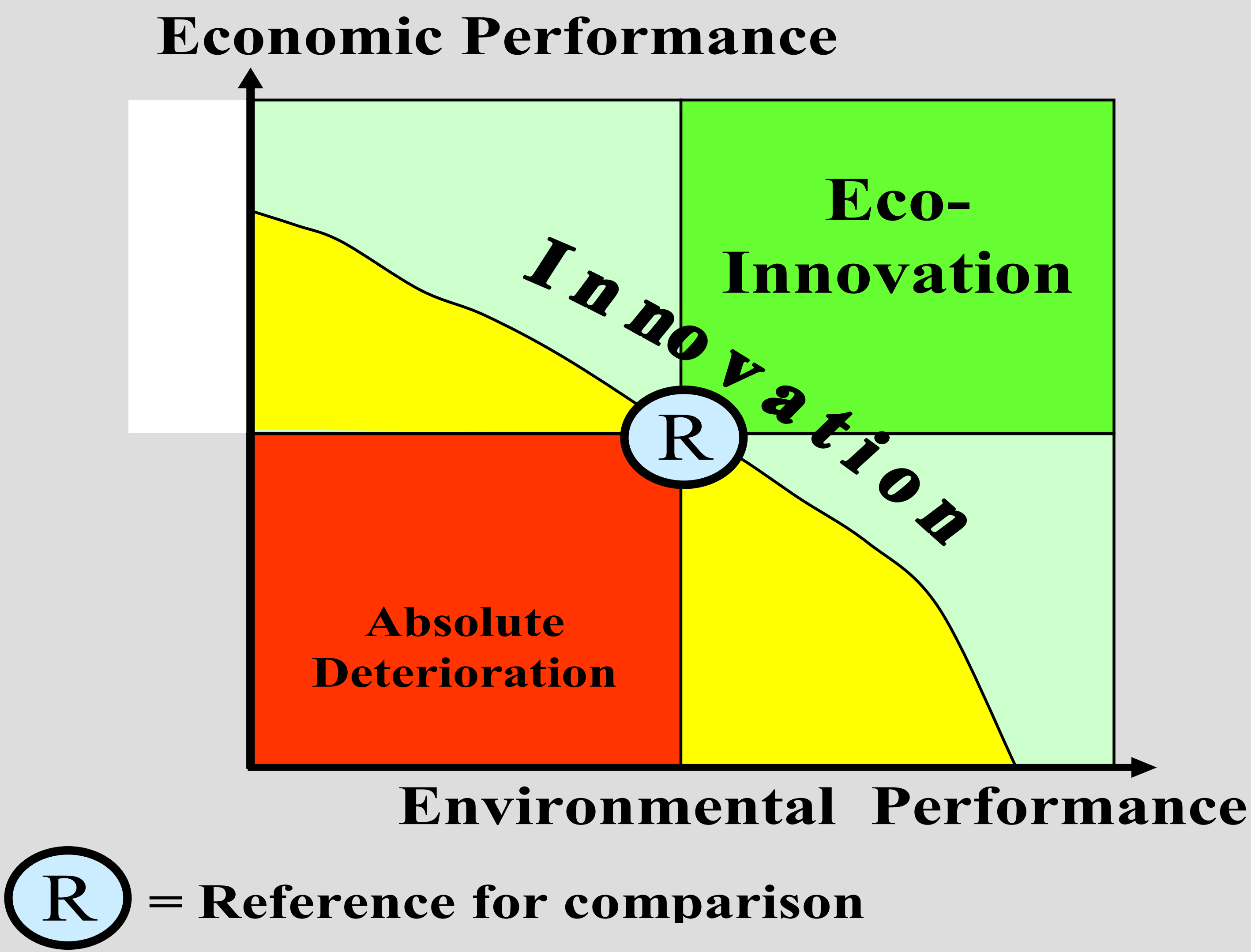
Eco-innovation as a subset of innovation

Cf. weak/strong sustainability (Source: G. Huppes, 2007)



ETR: impacts on firms and innovation

- Differences in energy costs: energy prices
  - Exchange rates
  - Energy import prices
  - Tariffication
  - Energy tax rates
- Revenue-recycling: winners as well as losers
  - Business taxes (e.g. SSCs, lower business costs)
  - Labour/capital distortionary taxes: double dividend (increased employment/output), tax interaction effect
- Innovation in taxed firms (Porter/van der Linde)
  - Cost-effective energy efficiency measures
  - X-inefficiencies in use of energy
  - Innovation-seeking/competitiveness of individual firms
- Market stimulation/innovation in environmental industries

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Theories of Innovation

- How does innovation take place; what are its signs; (how) can its pace or direction be changed by policy? What is the role/impact of changes in relative prices?
  - Propositional and prescriptive knowledge (Mokyr)
  - Technology push/market pull (Foxon/Carbon Trust)
  - Alignment/co-evolution of social sub-systems (Freeman & Louca):
  - Technological transitions/multi-level system change/niches, regimes, landscapes (Geels)
  - Kinds of innovation
    - Technological, organisational, business-related, social (Hauschildt)
    - Product & process, organisational, institutional (Horbach)

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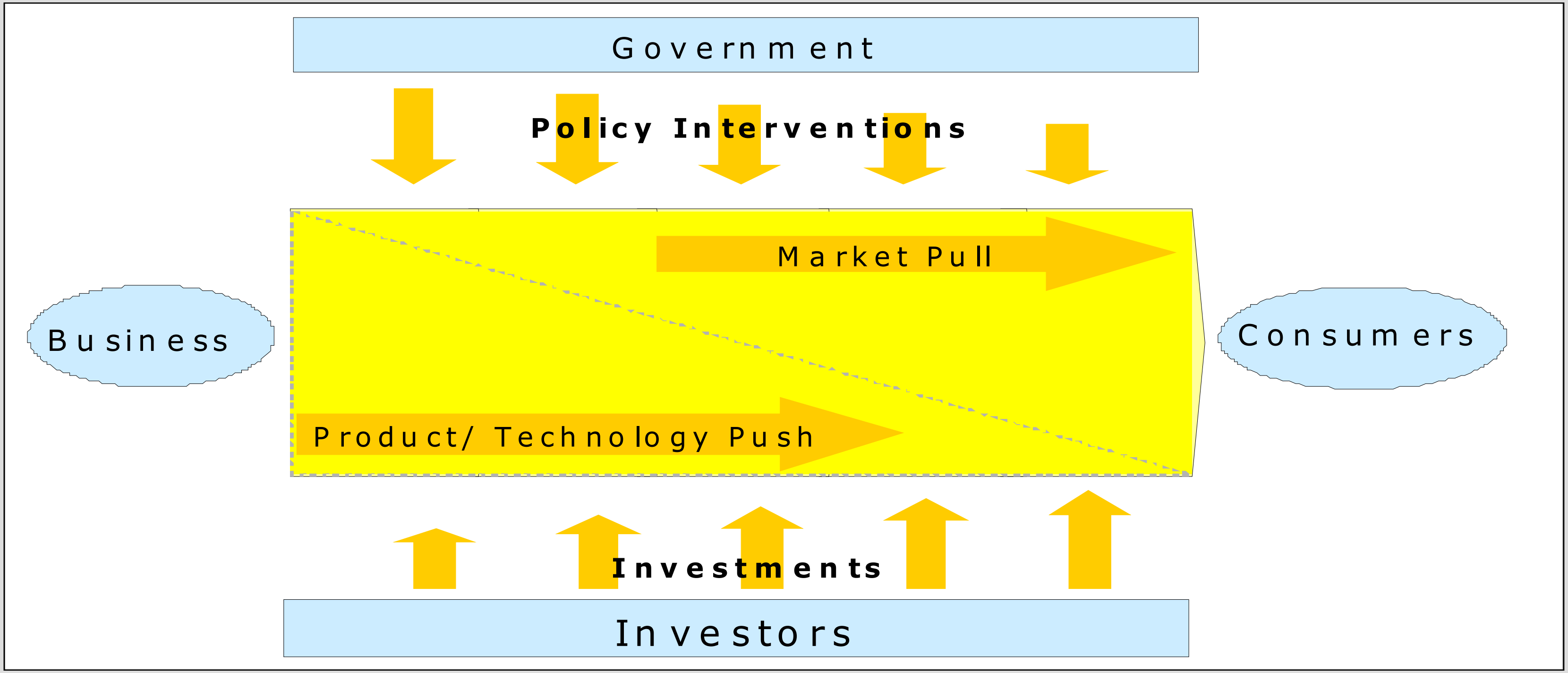
Three models of innovation/technical change/technological transition

(1) Roles of Innovation Chain Actors (Source: Foxon 2003, p.18, after Carbon Trust 2002)



- The innovation process involves the development and deployment of new technologies, products and services by business in order to meet the needs of consumers. To achieve this, funding is required from a variety of investors, such as insurance companies, banks, private equity houses and angel investors.
- In the early stages of the market, take-up is largely driven by the product/technology push. As consumer awareness builds, the rate of deployment is accelerated as consumer demand grows.
- Government can make various policy interventions at various stages of the innovation chain to overcome barriers to the development of various technologies, products and services.

(2) Co-evolution of social sub-systems

- Need for co-evolutionary alignment between different interacting sub-systems (Freeman & Louca 2001)
  - Science, technology, economy, politics, culture
  - Application to Kondratiev cycles

- **The Physical Dimension**, which deals with the physical issues involved in the production/storage/distribution/end use of the good or service under consideration, and has the following components:
  - *Science* the physically possible
  - *Technology* physical realisation of the physically possible
  - *Infrastructure* physical (including technical) support and diffusion of the physical realisation

- **The Socio-Economic Dimension**, which deals with the interests and drivers that push technical change along: *entrepreneurs* (and profits), *consumers* (and preferences), and *public policy* pressures, and has the following components:
  - *Economics* issues of allocation, distribution, competition
  - *Institutions* legal, financial, regulatory, planning frameworks
  - *Political Drivers* social perceptions driving political priority (security of supply, environmental issues) and the planning system, and the policy instruments through which these perceptions are implemented
  - *Culture* social perceptions driving social acceptability, consumer demand

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(3) Technological Transitions (1)

- Change in socio-technical configuration (Geels 2002, pp.94-5)
  - Economics: price, performance, user preferences
  - Sociology: actors, interactions, institutions, context (also related to existing technology/socio-technical configuration)
  - Socio-technical: large technical systems, networks
- Regime stability/’lock-in’: learning by using; network externalities; economies of scale; increasing informational returns; deployment of complementary technologies (Arthur 1988, p.591)

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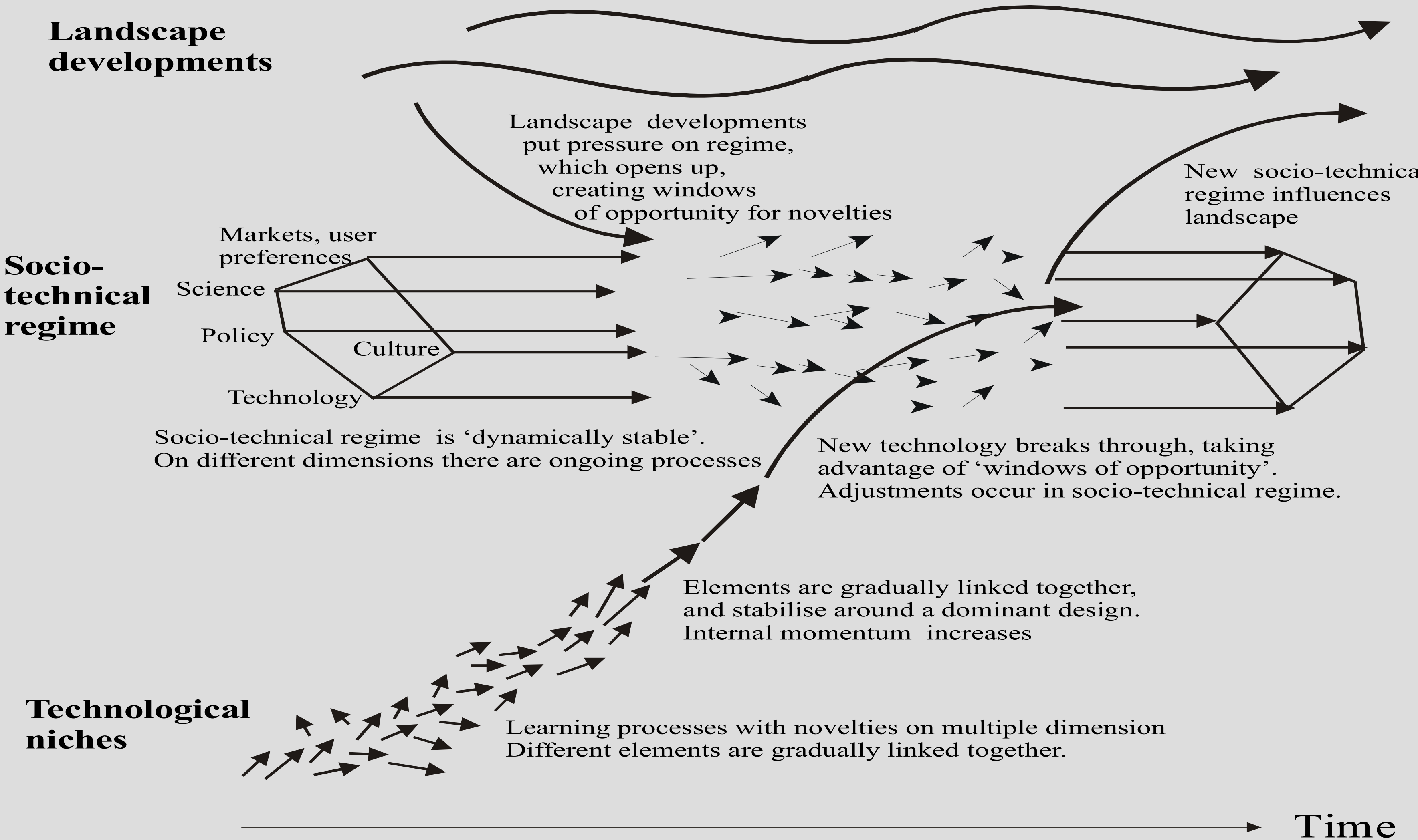
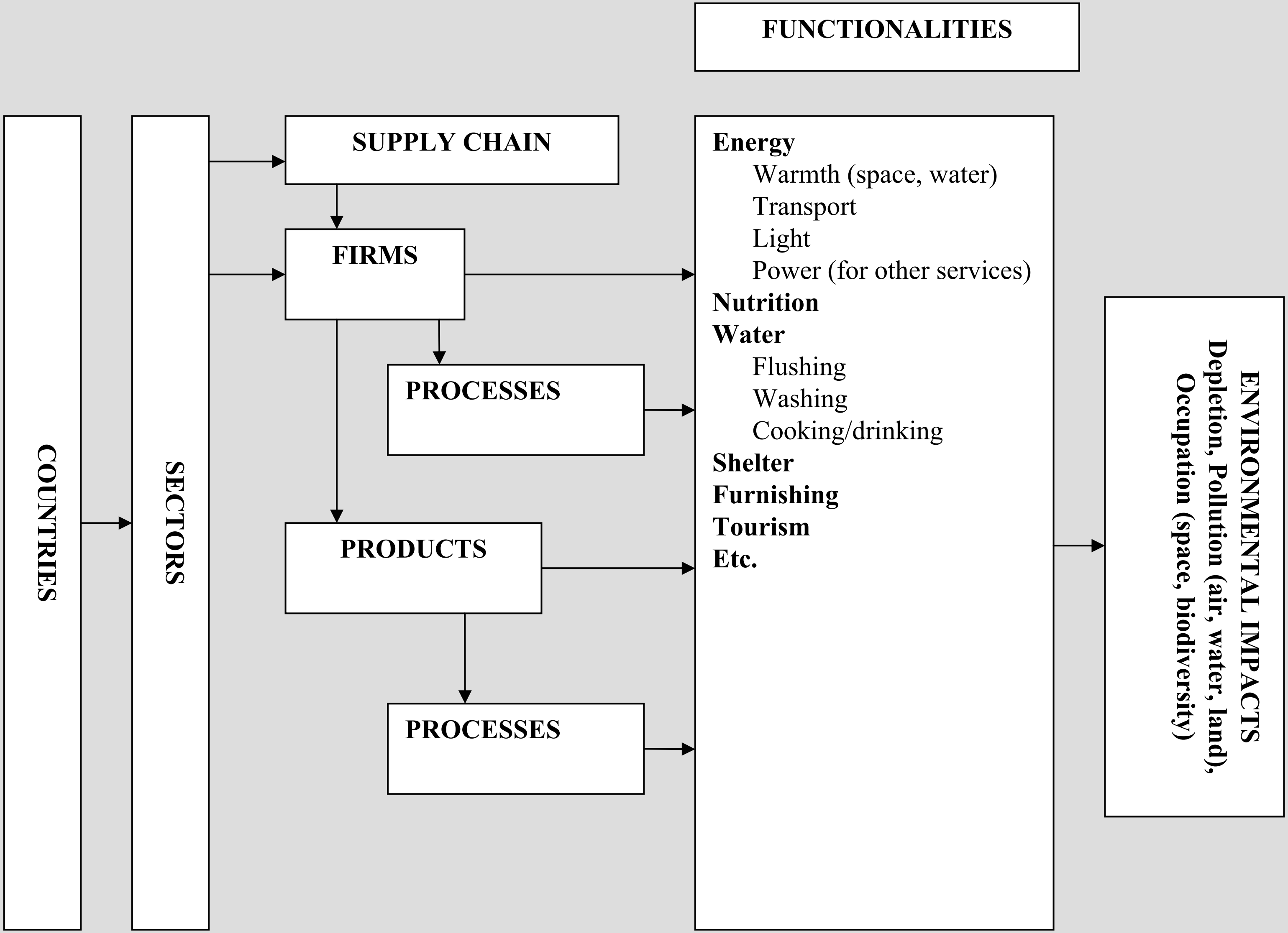
The development of niches

(Geels 2002a, Figure 3.6, p.110, 2005)



Delivering eco-innovation



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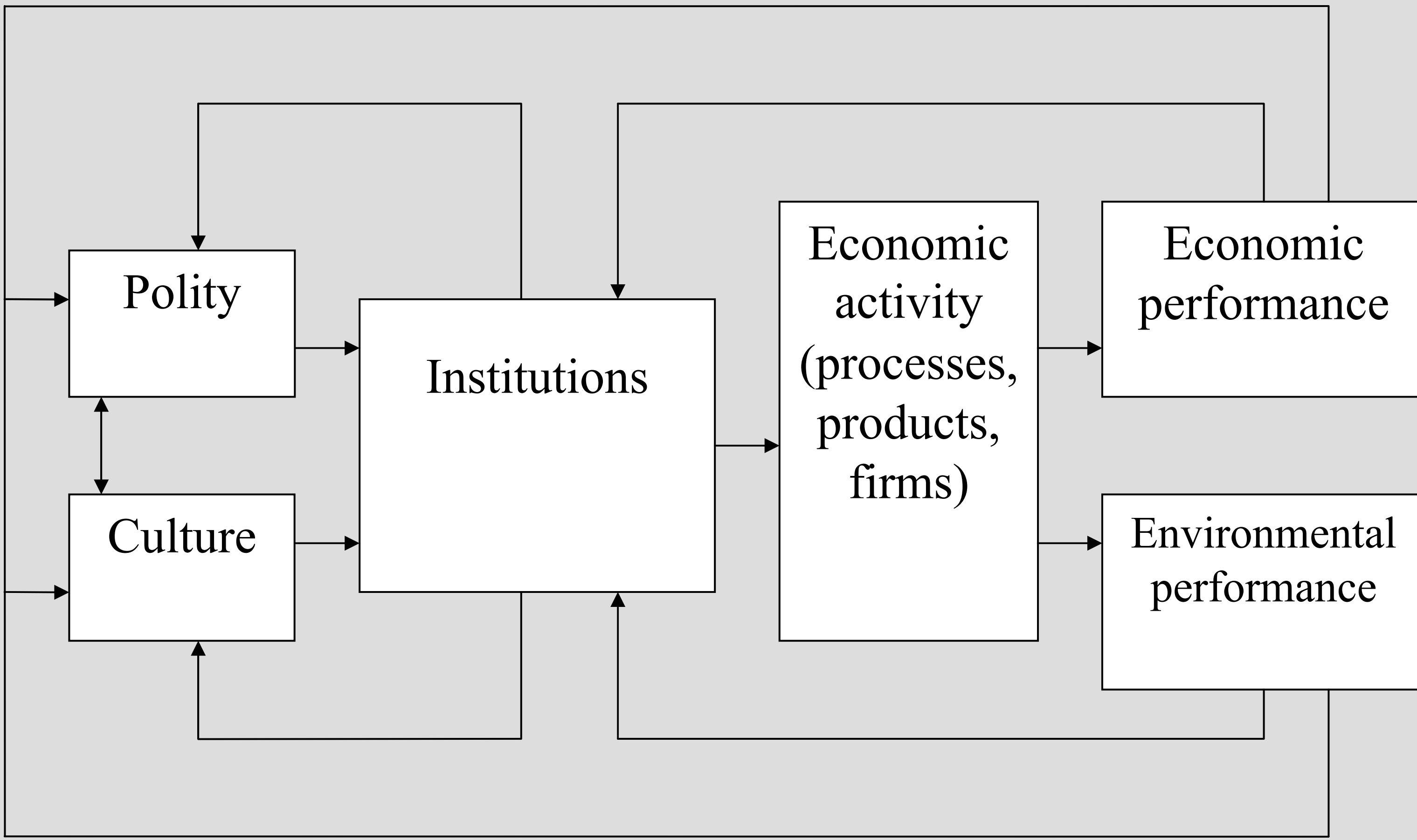
The Socio-Economic Cultural System in Dynamic Evolution



Environment Industries

'The environmental goods and services industry consists of activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use.' (OECD/ Eurostat 1999)

- **Pollution management group:** Includes Air pollution control; Wastewater management; Solid waste management; Remediation and clean-up of soil and water; Noise and vibration abatement; Environmental monitoring, analysis and assessment
- **Cleaner technologies and products group:** Activities which improve, reduce or eliminate environmental impact of technologies, processes and products (e.g. fuel-cell vehicles)
- **Resource management group**: Prime purpose of activities not environmental protection (e.g. energy saving, renewable energy plant)

• Economic significance of environment industries estimated from environmental protection expenditures (EPE) in the above categories.

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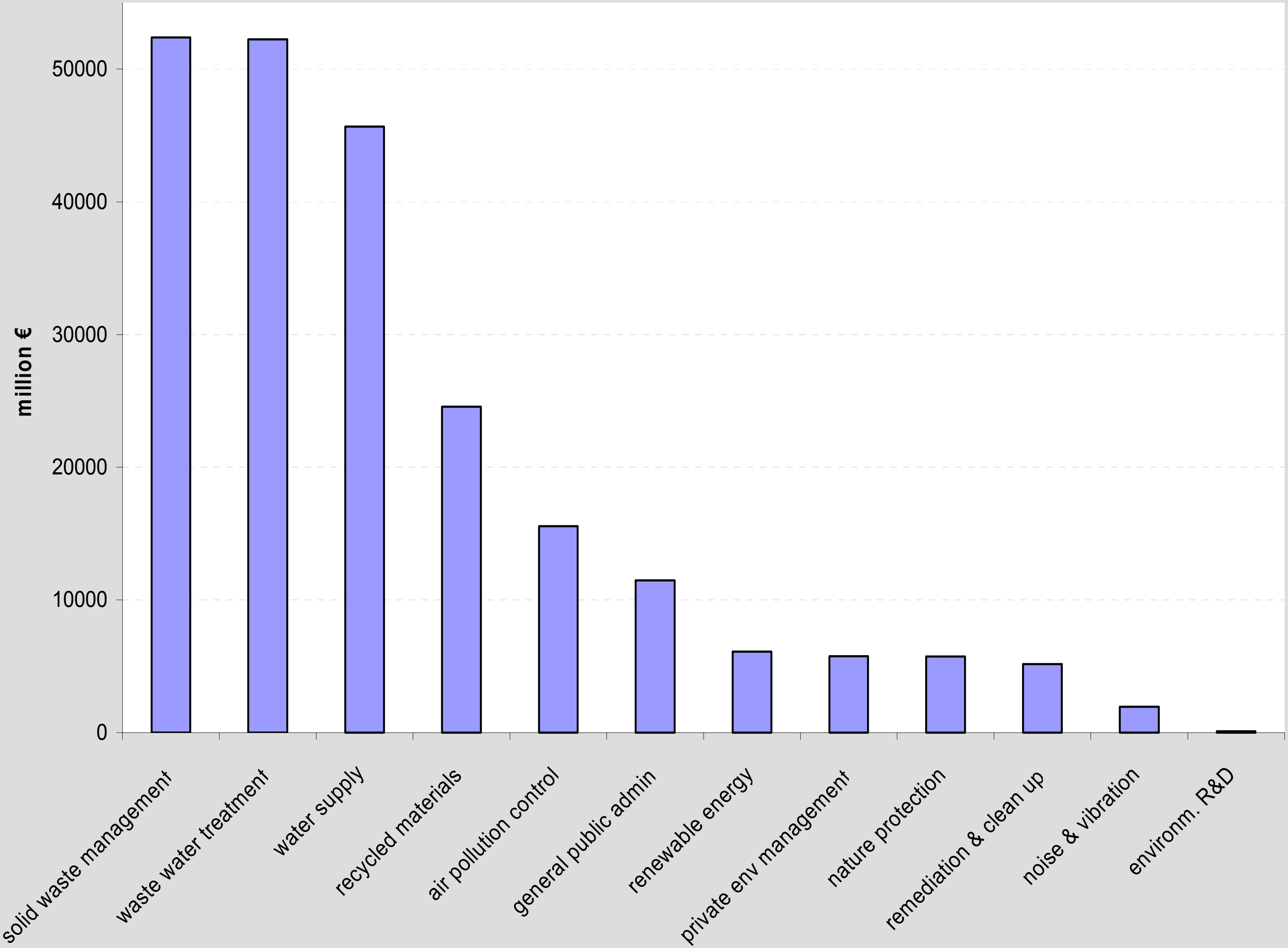
Eco-industry turnover in 2004, EU-25



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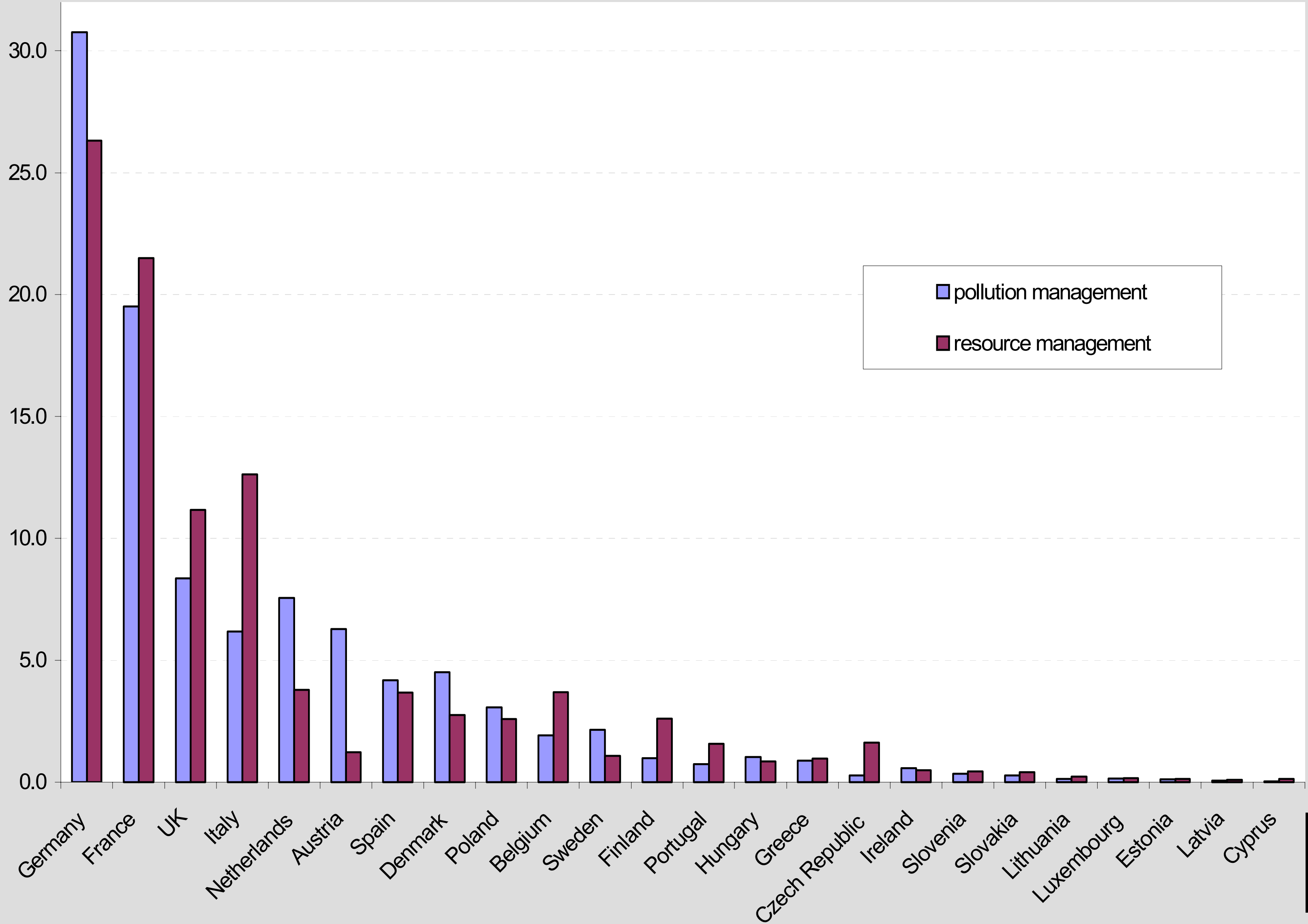
Eco-industry turnover as % of EU-25



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Turnover (£ million) and employment in the environment industry in the UK

Sector	**2000***	**2005****
Water & wastewater treatment	7334	9400
Waste management	4600	8100
Env. consultancy services	600	1230
Air pollution control	907	583
Other	523	523
Contaminated land remediation	638	494
Cleaner technology & processes		177
Noise & vibration control	77	369
Renewable energy	200	290
Env. monitoring & instrument.	100	189
Marine pollution control		22
Research & development		
Energy management		2648
Total	**14979**	**24025**

Sector		**2004****
Water industry		**50,000**
	provision of services	28,000
	sewage	22,000
Waste management		**69,000**
	collection	52,000
	recycling	17,000
Renewable energy		**6,370**

* Source: 'Global Environmental Markets and the UK Environmental Industry', DTI and DEFRA 2002

** Source: 'Emerging markets in the environmental sector', UKCEED for DTI and DEFRA 2006

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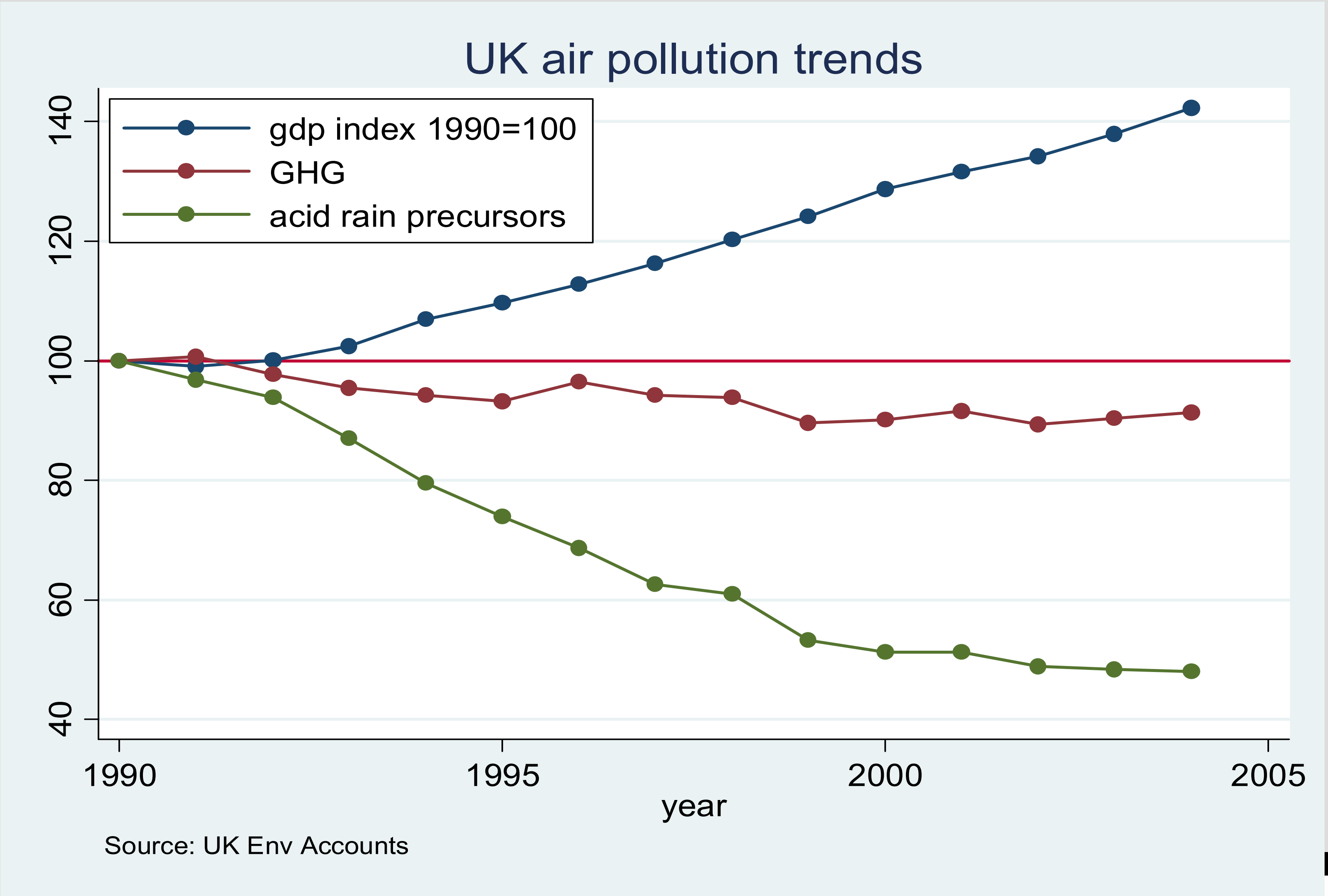
Decoupling indicators for the UK



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Sectoral decoupling of emissions and water demand

SIC	Sector	Acid rain prec.	GHG	Water demand
1	Agriculture	R	R	A
10	Mining	A	A	R
15	Food	A	R	A
17	**Textiles**	**N since 1997**	**N**	
20	Wood	N*	N*	A
21	Paper	A	R	
23	**Coke**	A	**N**	
24	Chemicals	A	A	R
25	**Plastics (inc.Rubber)**	A	**N**	
26	Non-met. Minerals	A	R	
27	Basic metals	A	R	A
29	**Machinery**	A	**N since 1999**	
32	Electrical equip.	A	**A (N since 2000)**	
34	Transport	A	R	
36	Other manufacturing	A	A	A
40	**Energy production**	A	**N**	**A (N after 1995)**
	Engineering			A
45	Construction			A

A…. Absolute decoupling
R… relative decoupling
N… increase in intensity
* Caveat: unexplained jump in data in 1999.

Average EPE by sector and medium, 2000-2004 (constant £ mio.)

SIC	Air	Water	Waste	R&D	EPE
Chemicals	113	140	286	32	635
Food	54	159	266	7	556
Energy prod.	141	175	23	4	499
Basic metals	90	105	81	12	353
Mining	48	64	40	10	264
Machinery	22	119	48	15	249
Paper	23	100	67	3	226
Transport equip.	35	68	43	9	210
Plastic	43	77	27	3	177
Coke	23	25	42	6	142
Non-met min.	38	41	21	3	122
Electrical equip.	25	31	25	2	106
Textiles	15	28	51	1	103
Other man.	12	43	14	4	78
Wood	9	33	8	1	57
Average	**46**	**81**	**69**	**7**	**252**
Total	**691**	**1208**	**1042**	**112**	**3777**

Source: DEFRA, 2006

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Average emissions intensity and EPE intensity, 2000-2004

SIC	GHG	acid rain prec	EPE air	EPE total
	tonnnes per £ mio GVA		£ th. per £ mio. GVA	
energy prod.	12711	64	9.9	35
coke	7429	40	8.8	56
non-met min.	2810	13.1	6.6	21
wood	1683	8.6	3.3	21
basic metals	1801	5.4	5.4	21
chemicals	1745	4.2	8.7	49
plastic	716	3.5	5.1	21
mining	1262	3	1.9	10
textiles	574	2.3	2.3	18
food	495	1.8	2.4	24
other man.	433	1.8	1.8	11
paper	288	0.8	1.1	10
transport equip.	218	0.7	2	12
machinery	119	0.4	1	12
electrical equip.	178	0.4	2	9
average	**2164**	**10**	**4**	**22**
sdev	**3449**	**18**	**3**	**14**

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Regression results

	OLS: ACID RAIN PREC.		OLS: GHG	
explanatory var.	**coeff. ***	**t-stat**	**coeff.***	**t-stat**
EPE_air intensity	0.1267	1.14	13.21	1.04
dummy SIC 15	-0.0012	-0.87	**-0.77**	-4.79
dummy SIC 17	-0.0008	-0.55	**-0.69**	-4.29
dummy SIC 20	**0.0054**	3.81	**0.40**	2.48
dummy SIC 21	-0.0021	-1.48	**-0.96**	-5.96
dummy SIC 23	**0.0361**	22.54	**6.08**	33.02
dummy SIC 24	0.0003	0.2	**0.39**	2.15
dummy SIC 25	0.0001	0.06	**-0.59**	-3.53
dummy SIC 26	**0.0095**	6.34	**1.49**	8.63
dummy SIC 27	0.0019	1.32	**0.49**	2.94
dummy SIC 29	-0.0025	-1.78	**-1.13**	-7.00
dummy SIC 32	-0.0026	-1.86	**-1.08**	-6.72
dummy SIC 34	-0.0023	-1.66	**-1.05**	-6.48
dummy SIC 36	-0.0012	-0.83	**-0.83**	-5.13
dummy SIC 40	**0.0599**	35.97	**11.34**	59.29
dummy 2001	-0.0004	-0.46	0.06	0.6
dummy 2002	-0.0007	-0.74	0.07	0.7
dummy 2003	-0.0005	-0.58	0.15	1.43
dummy 2004	-0.0012	-1.33	0.15	1.51
constant	0.0033	2.74	1.15	8.27
Number of obs	75		75	
R-squared	0.98		0.99	

* Bold coefficients are significant at the 10% level or higher.

Conclusions from Regression

- No support for the hypothesis that higher sectoral EPE intensity will lead to lower sectoral emissions intensity.
- A number of the sector dummies were highly significant for the GHG regression (much less so for the acid rain precursors)
- Variation in GHG intensities across sectors and time is explained almost entirely by the sector dummies and not by variations in sector EPE
- Much lower spread of acid rain prec. intensities and the fact that far fewer of the sector dummies were significant in the regression may indicate the greater effect of EPE air on acid rain prec. than on GHGs
- However, measurement error, low response rates, endogeneity of EPE (i.e. sectors with higher emission intensities will tend to be required to spend more on EPE), omitted variable bias (e.g. structural change), due to lack of relevant data

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ETRs in Europe

- Denmark, Finland, Germany, Netherlands, Sweden and UK
- Different tax base (energy, CO2, sectors), tax rates, revenue recycling, exemptions because of competitiveness fears
- Paper presented at 7GETC, Ottawa, forthcoming
- COMETR project – modelling by Cambridge Econometrics

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Energy cost shares in selected sectors (2000)

Share of energy tax to energy expenditure - first row
Share of total energy costs to total costs – second row

NACE classification: 24.1: basic chemicals; 26.5: cement; 27.1-3: iron and steel

Sector	UK	GER	DK	NL	FIN	SW	SL
24.1	0.8%	5.9%	8.0%	6.3%	12.6%	3.3%	6.9%
	12.8%	7.7%	5.2%	6.1%	13.7%	5.4%	8.7%
26.5	0.3%	4.6%	4.1%	8.2%	n.a.	10.3%	14.8%
	16.0%	26.6%	17.7%	6.6%	n.a.	19.2%	n.a.
27.1-3	1.3%	5.4%	8.5%	16.1%	21.3%	19.1%	6.2%
	18.7%	12.1%	5.3%	16.4%	15.0%	8.2%	16.8%

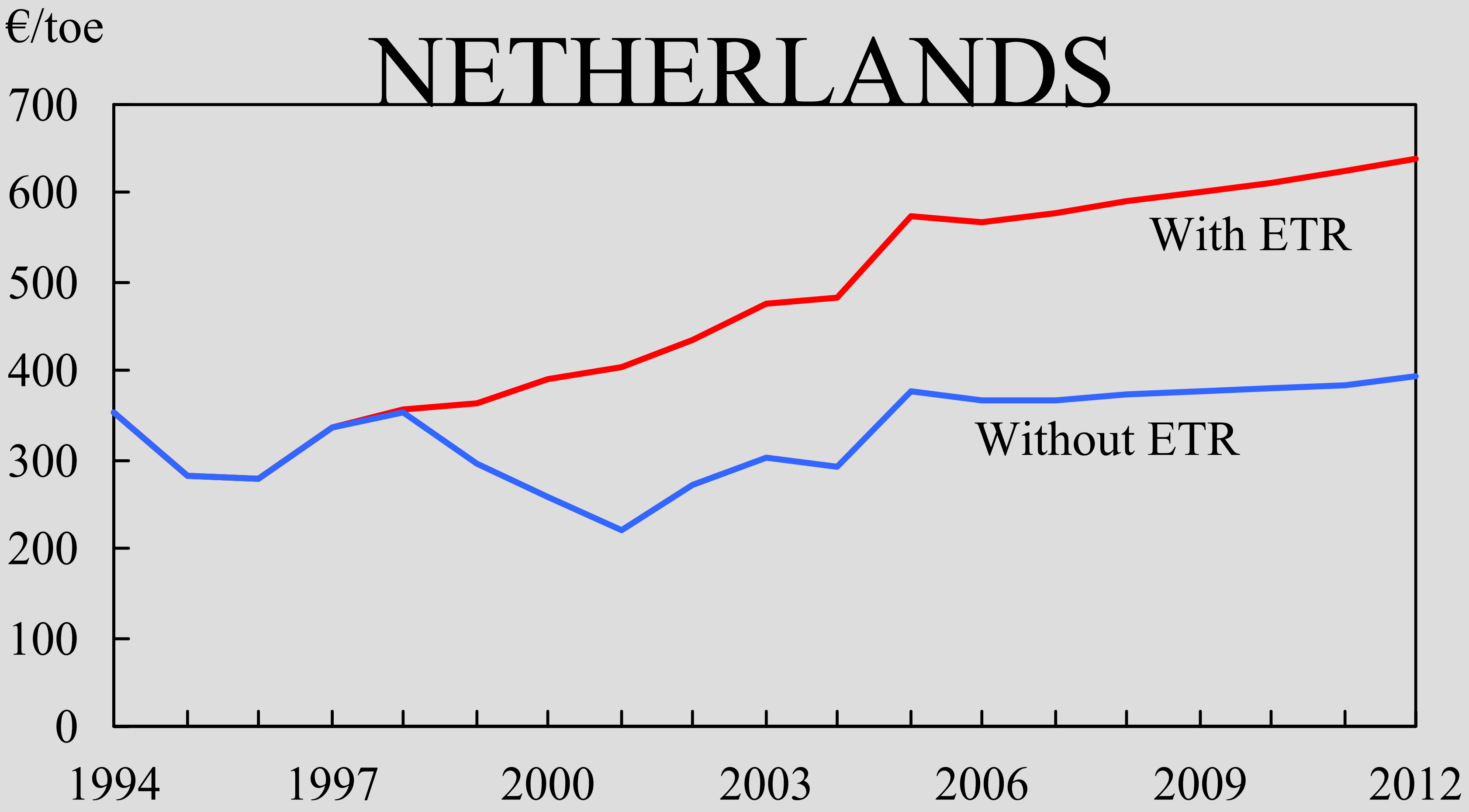
Prices in sector 27.1-3 ferrous metals (iron and steel): natural gas and electricity
(EUR/GJ)

		Natural gas price	Natural gas – ex tax price	share of taxes - natural gas	Electricity price	Electricity price – ex tax price	share of taxes – electricity
UK	2002	3.5	3.3	5.3%	14.2	13.6	3.9%
GER	2002	5.4	4.8	11.5%	14.3	13.3	7.0%
DK	2002	4.1	3.4	16.5%	13.9	13.1	5.3%
NL	2002	4.2	3.9	7.5%	9.4	9.3	1.3%
FIN	2001	4.9	4.4	9.8%	11.1	9.9	10.6%
SW	2002	5.8	4.8	18.0%	8.0	8.0	0%

Findings: energy taxes, energy prices

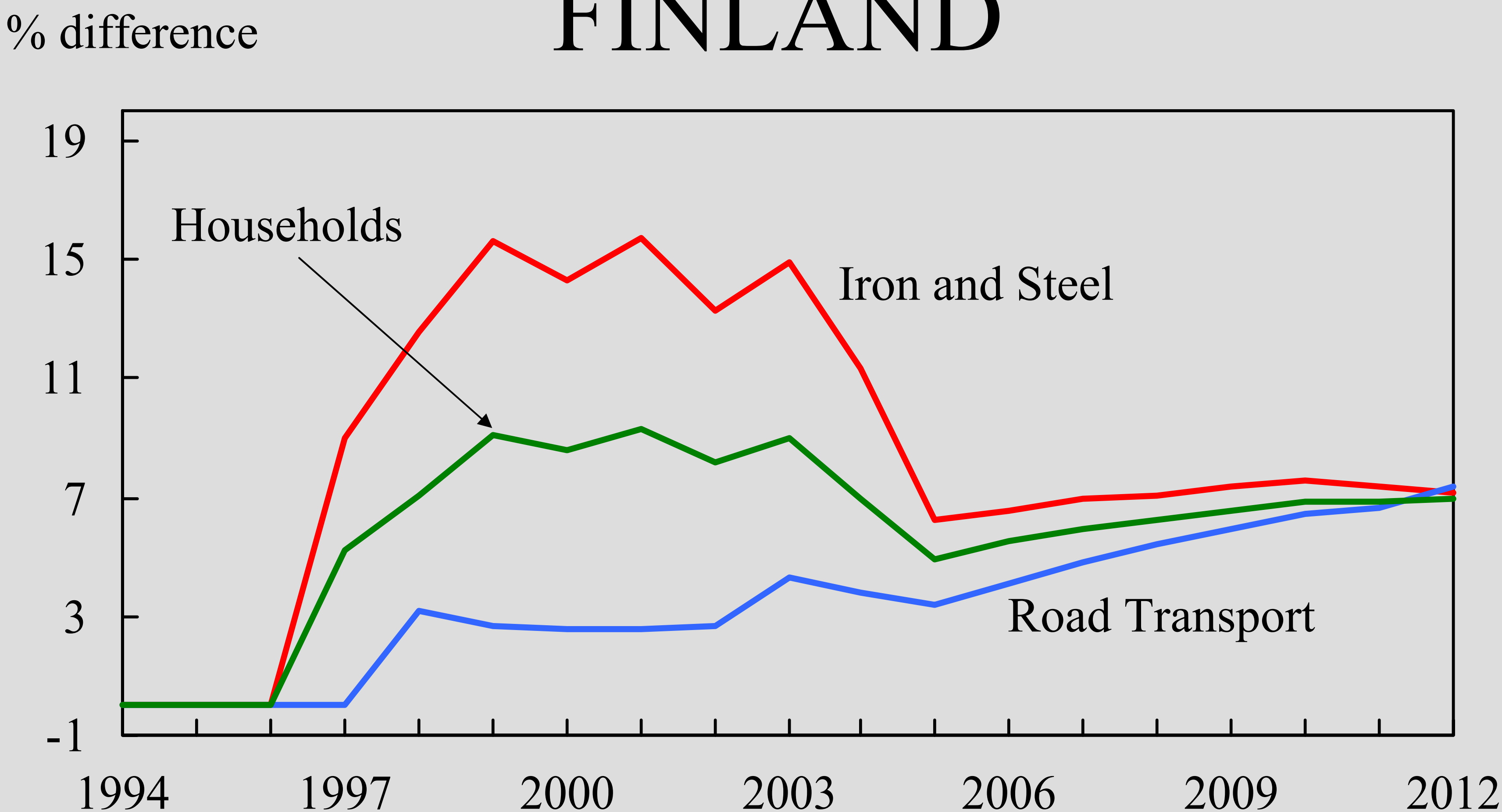
- *Taxation partly determines the price of energy products and electricity* (2003/96/EC Directive – point 13)
- Differences in energy tax burden between economic sectors and countries – BUT also major differences in pre-tax energy prices
- Share of energy taxes to total costs is generally low – with some exceptions
- Total energy costs depends on energy mix
- Significance of energy taxes has been further eroded during the past years as a result of increases in world market prices of energy products and the simultaneous 'freeze' of energy tax rates

ETR: AVERAGE HOUSEHOLD ENERGY PRICES IN THE NETHERLANDS



Source(s) : CE.

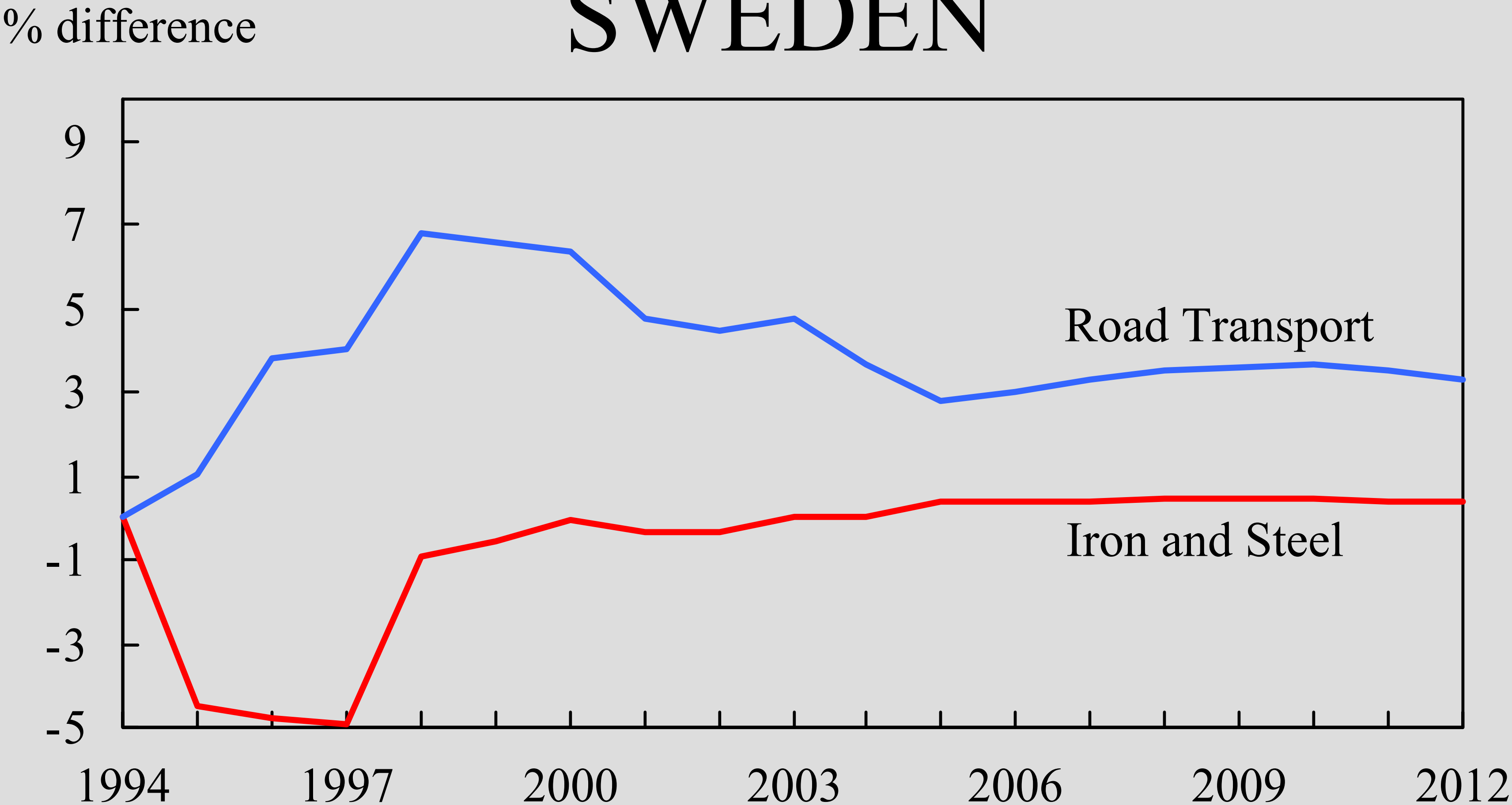
CHART 7.19: THE EFFECTS OF ETR: AVERAGE FUEL PRICES IN FINLAND



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

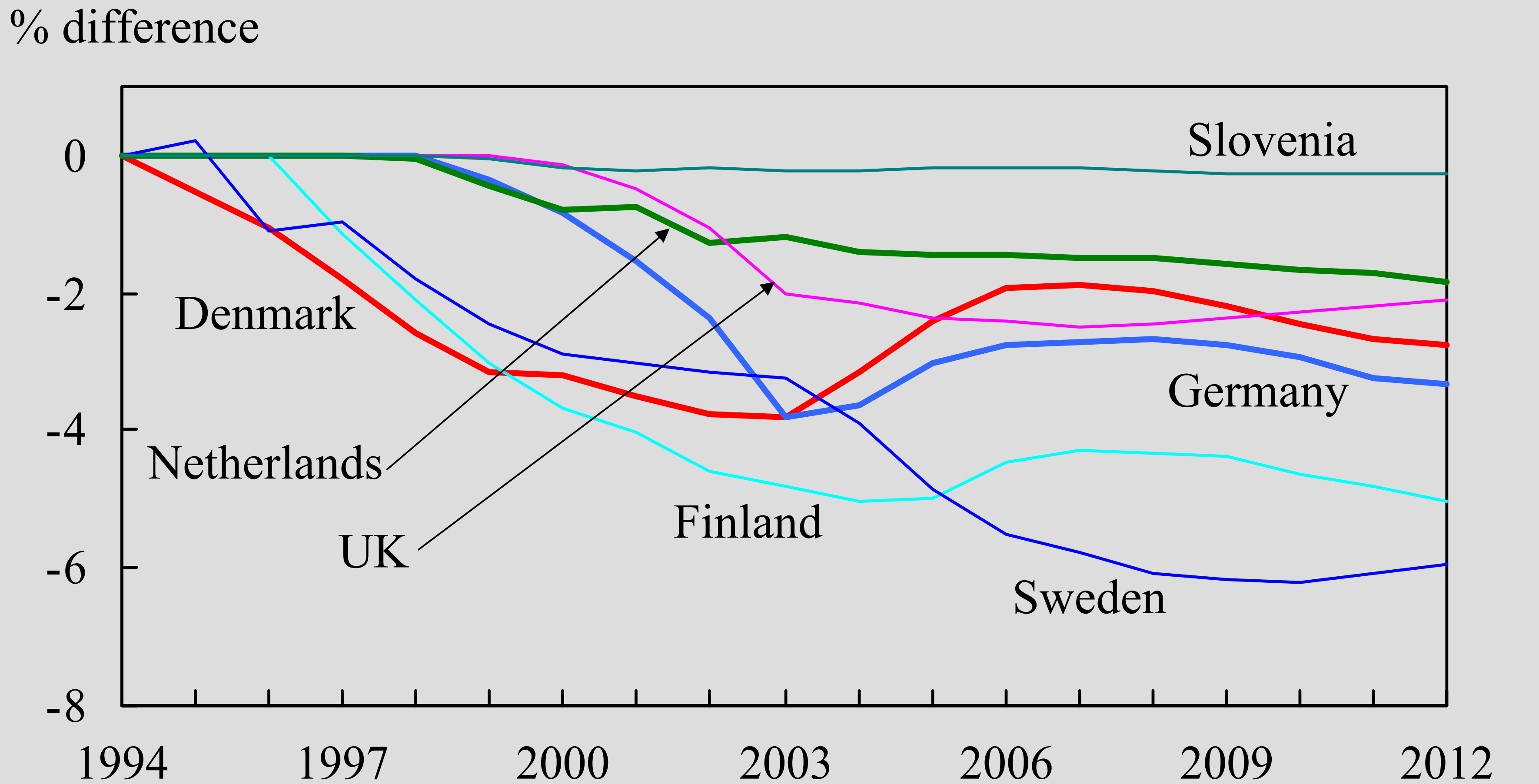
CHART 7.22: THE EFFECTS OF ETR: AVERAGE FUEL PRICES IN SWEDEN



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

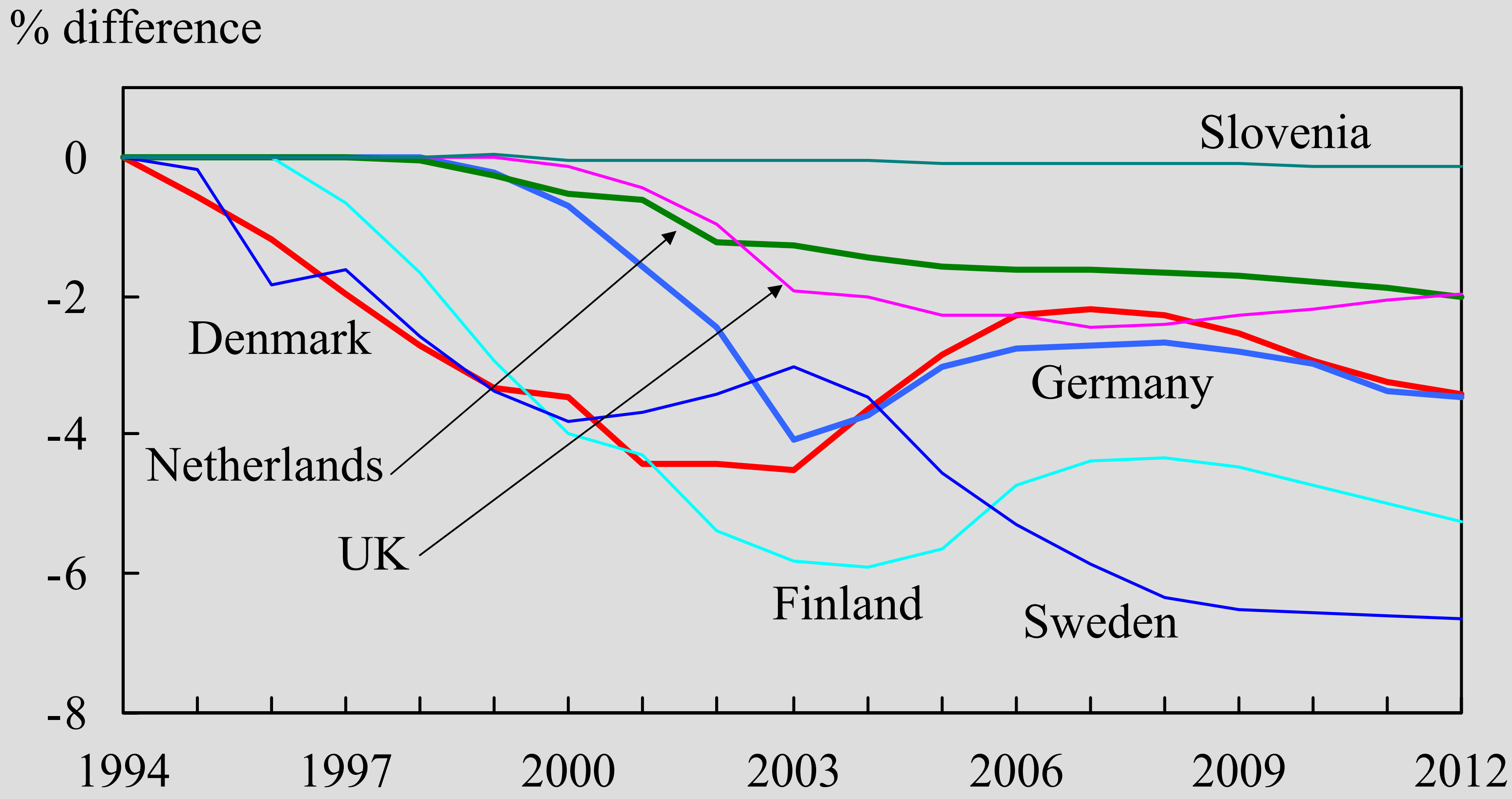
CHART 7.3: THE EFFECT OF ETR ON TOTAL FUEL DEMAND



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

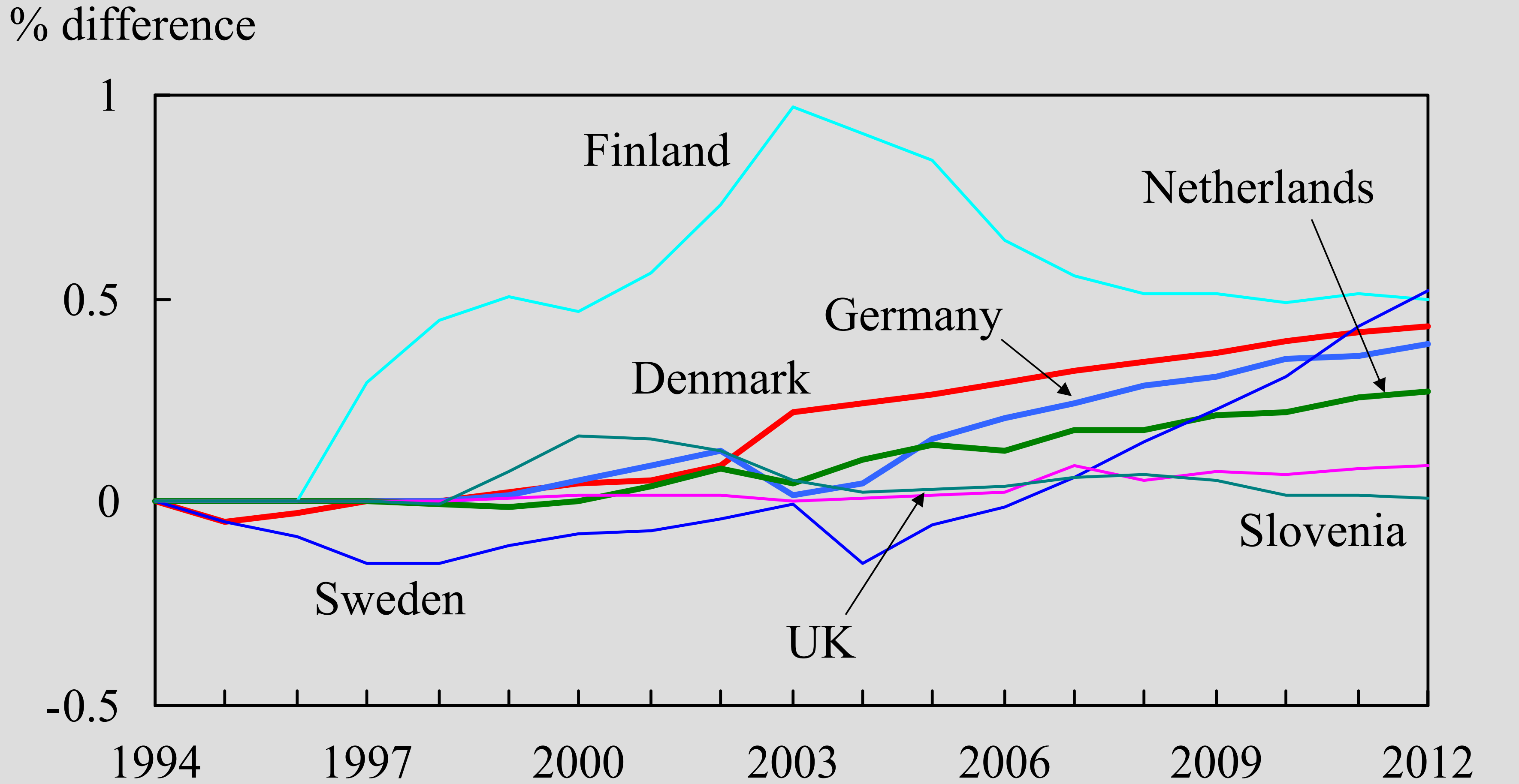
CHART 7.4: THE EFFECT OF ETR ON GHG EMISSIONS



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

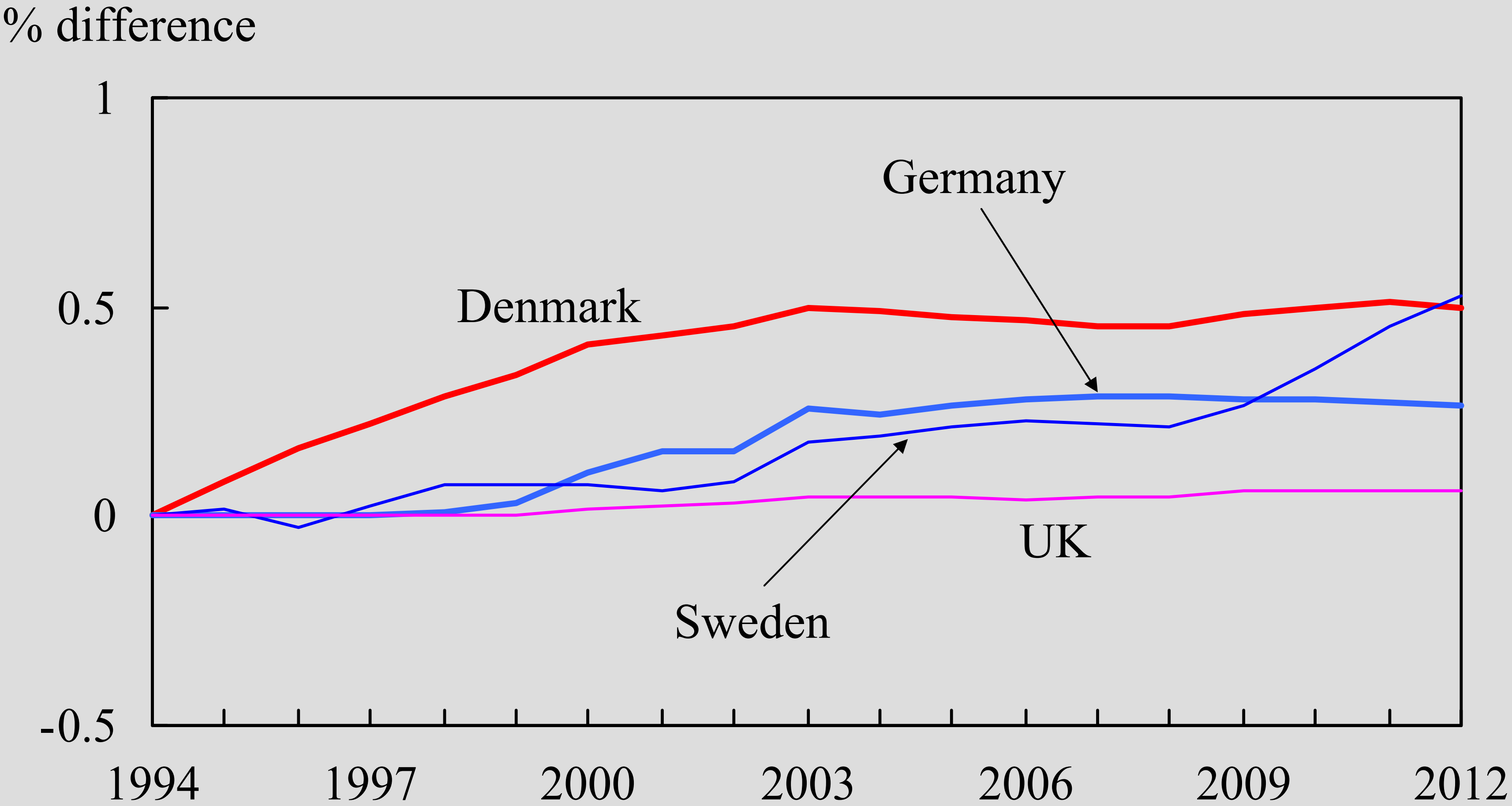
CHART 7.5: THE EFFECT OF ETR ON GDP



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

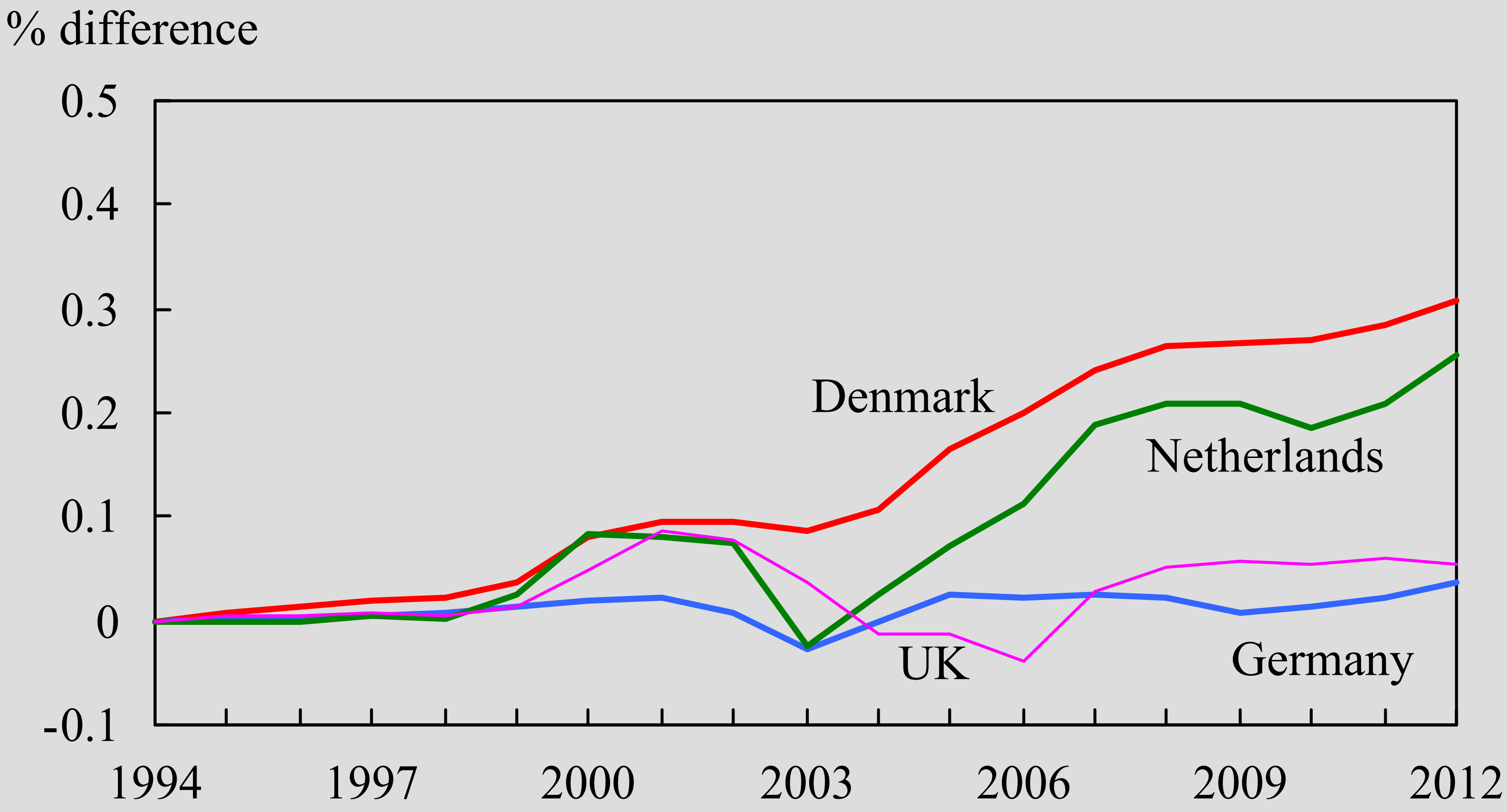
CHART 7.6: THE EFFECT OF ETR ON EMPLOYMENT



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

CHART 7.33: THE EFFECT OF ETR ON EXPORTS



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

Interim Conclusions on ETRs in Europe and innovation

- No obvious correlation between sectoral environmental protection expenditures and sectoral environmental intensities
- EPE may have reduced range of emission intensities between sectors BUT problems of data (definition, time series)
- ETRs have been small-scale and generally only had a small effect on prices in sectors where energy costs are significant
- Modelling suggests that ETR can be a source of economic and environmental improvement at macro level
- Further research ongoing to see whether this result can be given meso-foundations in respect of eco-industries (e.g. see if econometric analysis can detect any relation between more substantial ETRs and stimulation of eco-industries)

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