



Energy efficiency in Europe: trends, convergence and policy effectiveness

International Energy Workshop
Fondazione Cini, Venice , 17-19 June 2009

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Introduction:

- Motivation
- Energy use in Europe

Energy indicators:

- Energy Intensity
- Energy Efficiency

The convergence of energy intensities among EU countries

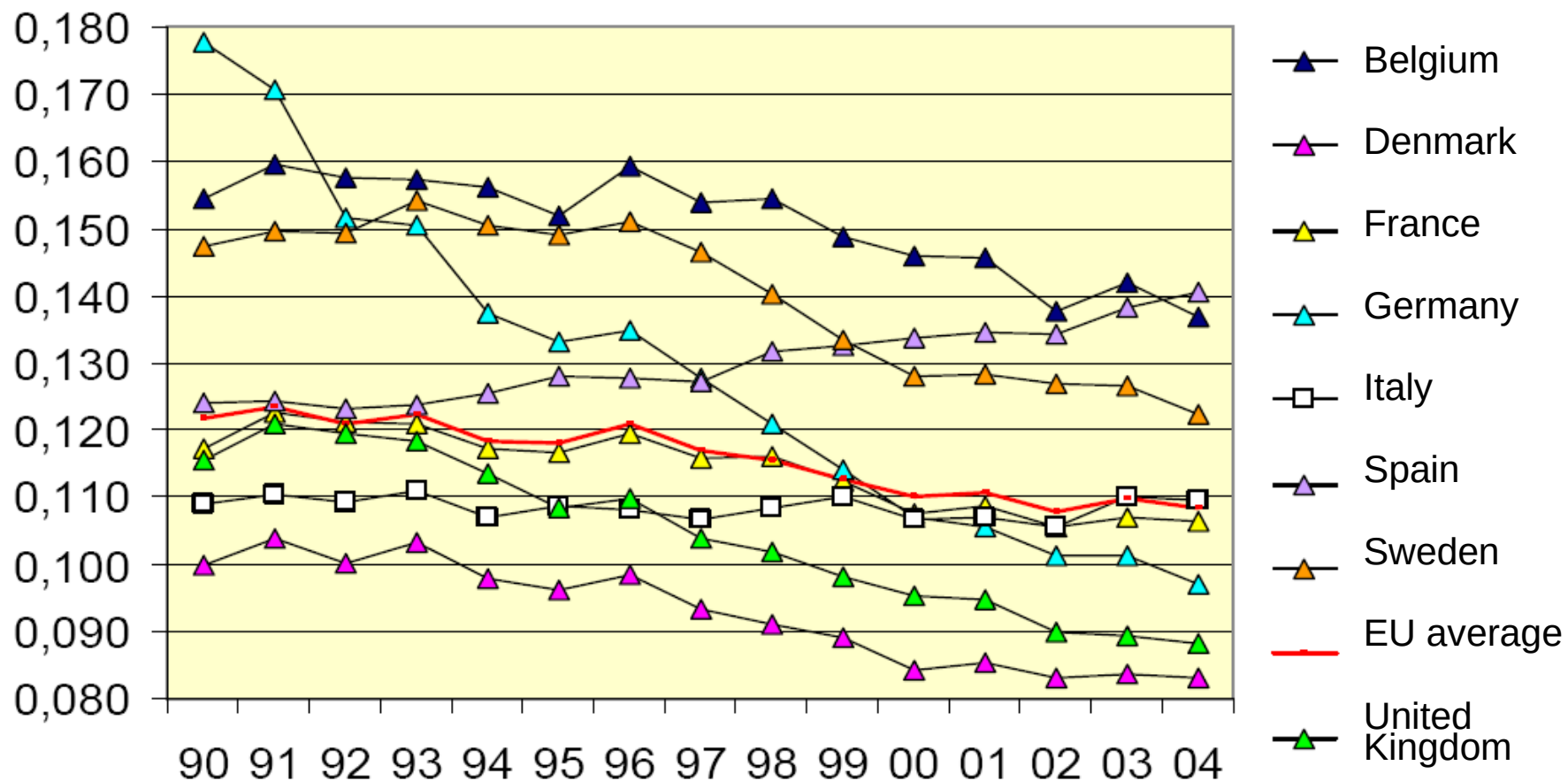
Energy policy and energy efficiency in Europe

Panel analysis of the effects of policies and measures on energy efficiency

Conclusions

Motivation

Direct observation of energy intensity trends in Europe seem to suggest



Final energy intensity of GDP for selected EU Countries (ktep/€)

Energy consumption in Europe : An Overview (1/2)

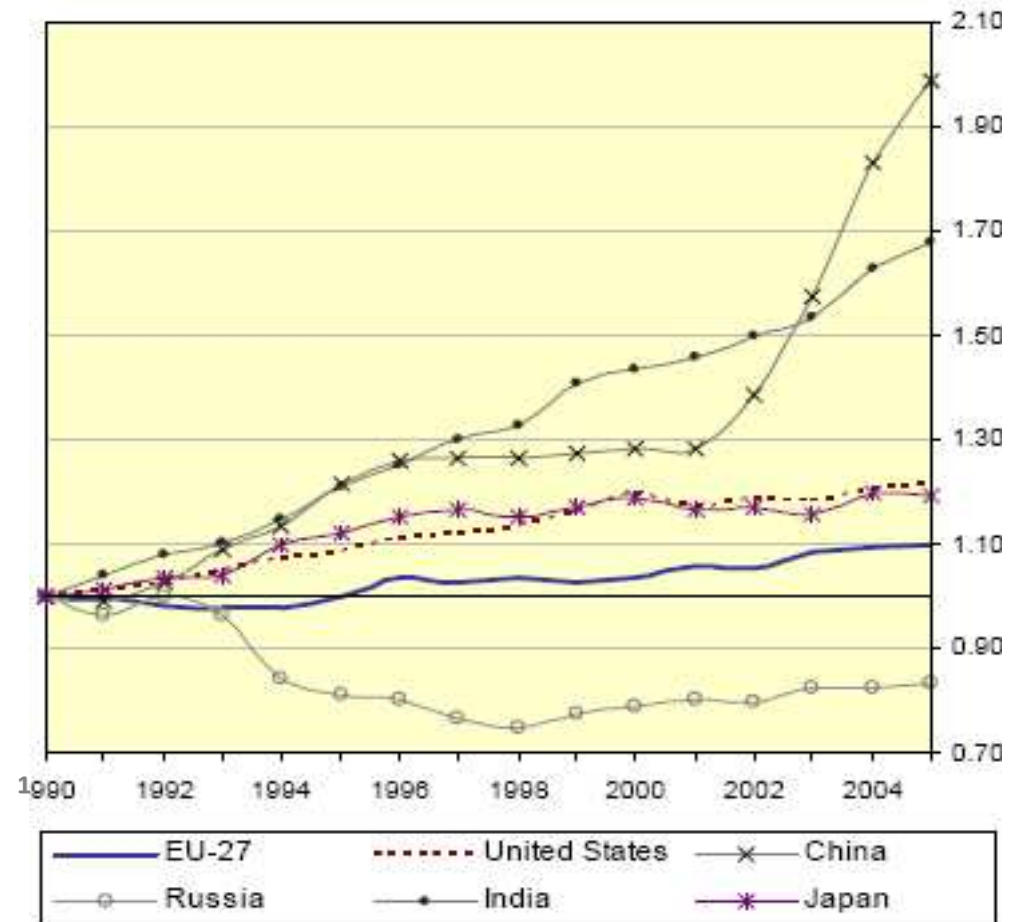
Comparison of EU and the Rest of the World.
Gross-Inland Energy Consumption (1990=1).

European Consumption

- From 1990 to 1996: consumption decreases slightly;
- Since 1996: consumption has smoothly increased;

Other Economies.

- Consumption has significantly increased especially in developing and emerging countries (China and India, *in primis*)



Energy consumption in Europe : An Overview (2/2)

Energy Consumption by Fuel.

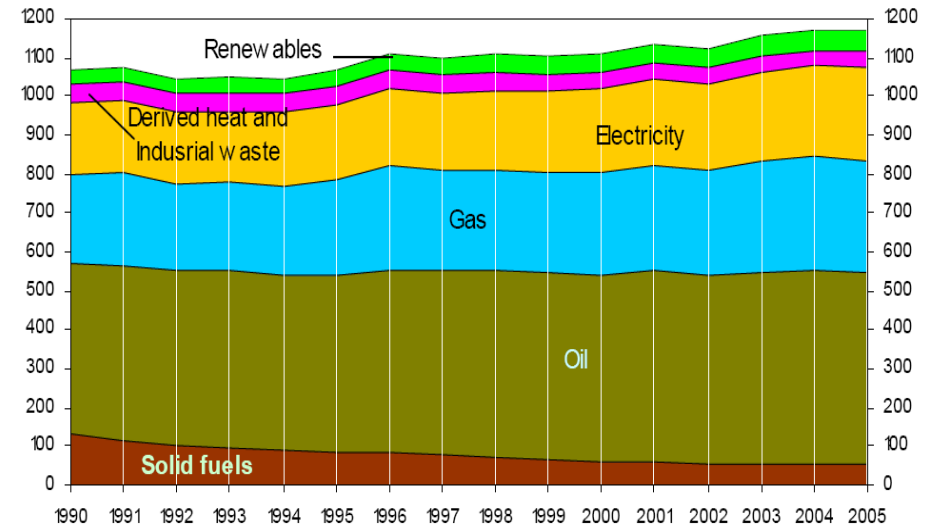
Energy mix mainly composed by oil, gas and electricity;
Solid fuels, renewables and industrial waste: limited share of total consumption.

Energy Consumption by Sector.

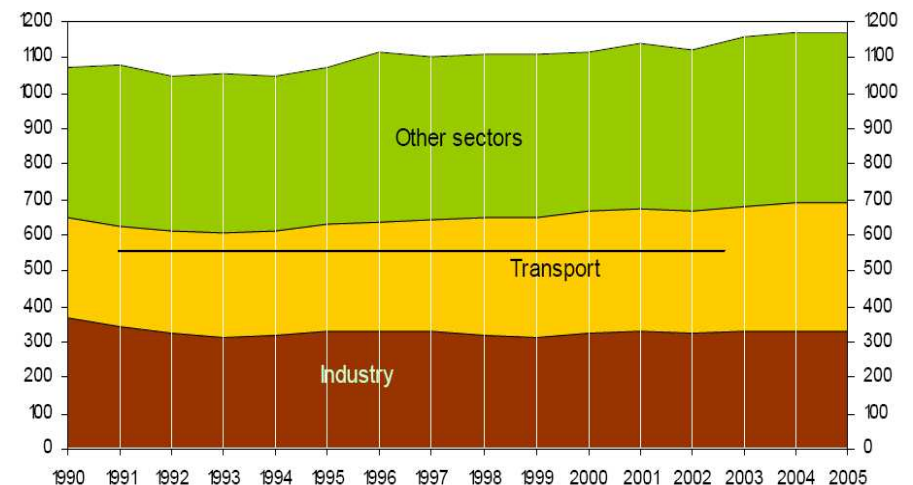
Largest share of total final energy consumption: households and service sectors (“other sectors”).

Final Energy Consumption EU27, Mtoe

a) by Fuel.



b) by Sector.



Energy Intensity.

Definition: ratio between final energy consumption and Gross Value Added (GVA). It is an economic measure of the energy requirement that a country, or one of its industries, needs to fulfil for its production;

General trend in the EU 15: the average value (as well the dispersion of countries) has decreased progressively during the last 25 years;

However, in Spain, since energy final consumption has grown more than the GDP, energy intensity has increased.

Energy Indicators (2/4)

Energy Intensity in the EU-15 Countries and Norway, 1980-2004.

ENERGY INTENSITY						
3-year Average Centered on 1981			3-year Average Centered on 1992		3-year Average Centered on 2003	
1 st Quartile	EL	0.097	DK	0.099	DK	0.082
	IT	0.109	IT	0.106	UK	0.084
	ES	0.111	UK	0.108	IE	0.087
	UK	0.120	AT	0.112	NO	0.100
2 nd Quartile	DK	0.121	ES	0.113	FR	0.102
	PT	0.121	FR	0.118	IT	0.104
	AT	0.127	DE	0.121	DE	0.105
	FR	0.135	NO	0.122	AT	0.111
3 rd Quartile	NO	0.147	EL	0.128	SE	0.119
	IE	0.147	IE	0.129	NL	0.131
	DE	0.152	PT	0.132	ES	0.133
	SE	0.168	SE	0.144	EL	0.136
4 th Quartile	NL	0.195	NL	0.147	LU	0.155
	LU	0.202	LU	0.175	PT	0.156
	BE	0.203	BE	0.176	BE	0.173
	FI	0.215	FI	0.213	FI	0.179
Average =		0.148			0.134	
Median =		0.141			0.125	
St. Dev =		0.038			0.031	
Minimum =		0.097			0.082	
Maximum =		0.215			0.179	

Energy Efficiency.

Definition: EE is measured as the variation of energy consumption for unit of product with respect to a base year. A downward trend indicates a progressive improvement of the country's energy efficiency.

Several countries have achieved significant improvements in terms of energy efficiency ,*due to*

1. modernization of the energy system,
2. introduction of natural gas,
3. renewal of the car park etc.)

Energy Indicators (4/4)

Percentage Change of Total Energy Efficiency in the EU-15 Countries and Norway, 1980-2004.

TOTAL (% change in EE Index over period)				
1980 - 2004		1980 - 1992		1992 - 2004
EL	-30.8%	-16.8% DK	PT	-17.9%
IE	-28.1%	-16.0% IE	EL	-17.8%
DK	-23.7%	-15.8% EL	IE	-14.4%
PT	-21.7%	-13.0% SE	BE	-14.3%
SE	-21.2%	-11.2% AT	AT	-10.0%
AT	-20.1%	-8.1% DE	SE	-9.4%
DE	-14.9%	-5.6% FI	NO	-9.4%
NO	-12.7% Median	-5.2% FR	DK	-8.3%
FR	-12.4%	-5.2% IT	FR	-7.6%
FI	-11.8%	-4.7% PT	DE	-7.4%
IT	-6.6%	-4.1% ES	FI	-6.6%
NL	-5.5%	-3.7% NO	UK	-2.8%
UK	-4.9%	-2.8% NL	NL	-2.7%
BE	-2.4%	-2.1% UK	IT	-1.5%
ES	0.0%	-1.0% LU	ES	4.3%
LU	52.4%	13.9% BE	LU	54.0%
Average =	-10.3%	-6.3%		-4.5%
Median =	-12.6%	-5.2%		-7.9%
St. Dev =	0.191	0.075		0.167
Minimum =	-30.8%	-16.8%		-17.9%
Maximum =	52.4%	13.9%		54.0%

E.I. Convergence: definitions

Two Different Definitions of Convergence.

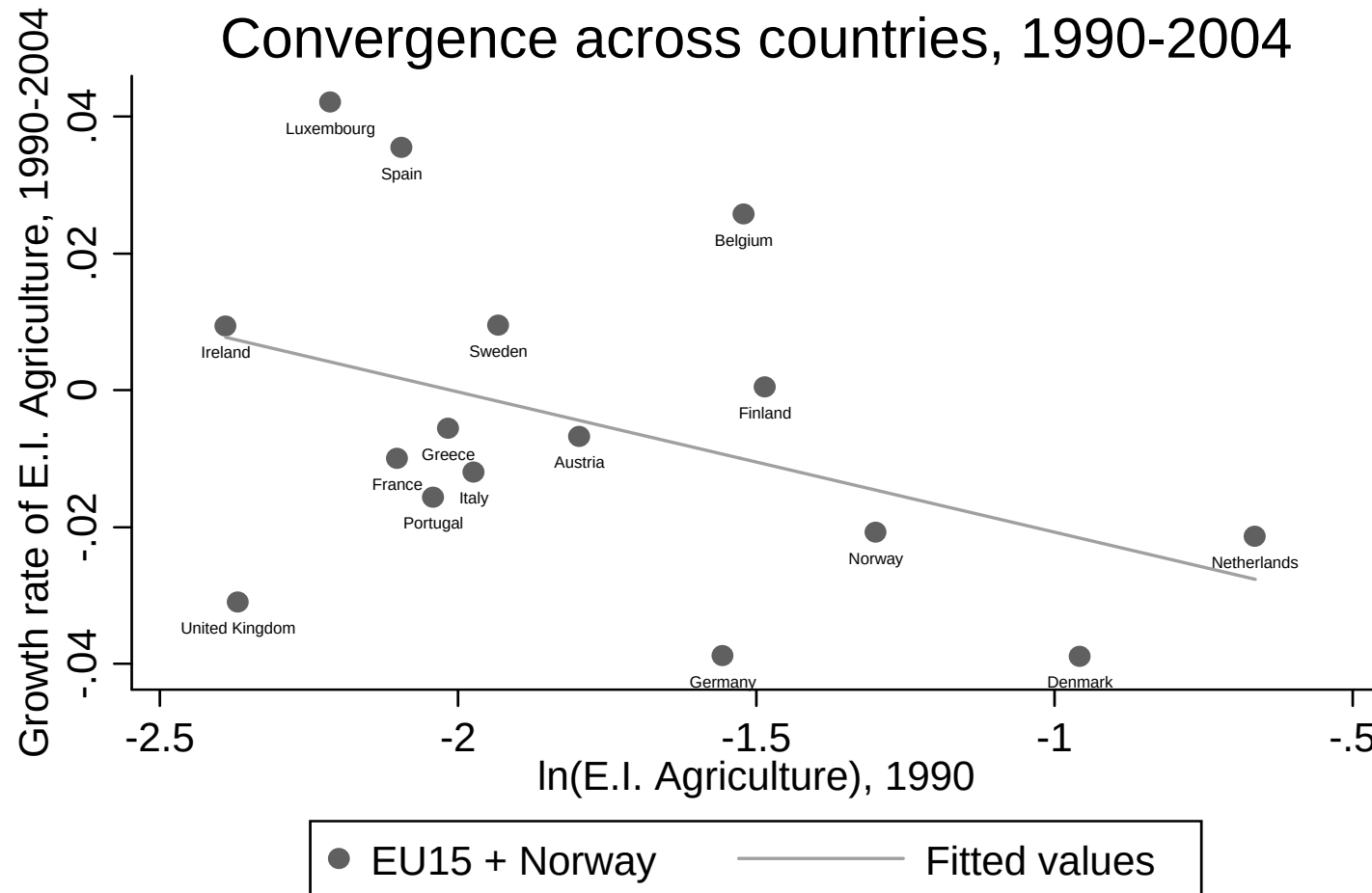
β – convergence: situation in which poorer countries are growing faster than richer ones

$$\log(x_{i,T}/x_{i,0}) = \alpha + \beta \log(x_{i,0}) + \varepsilon_{i,t},$$

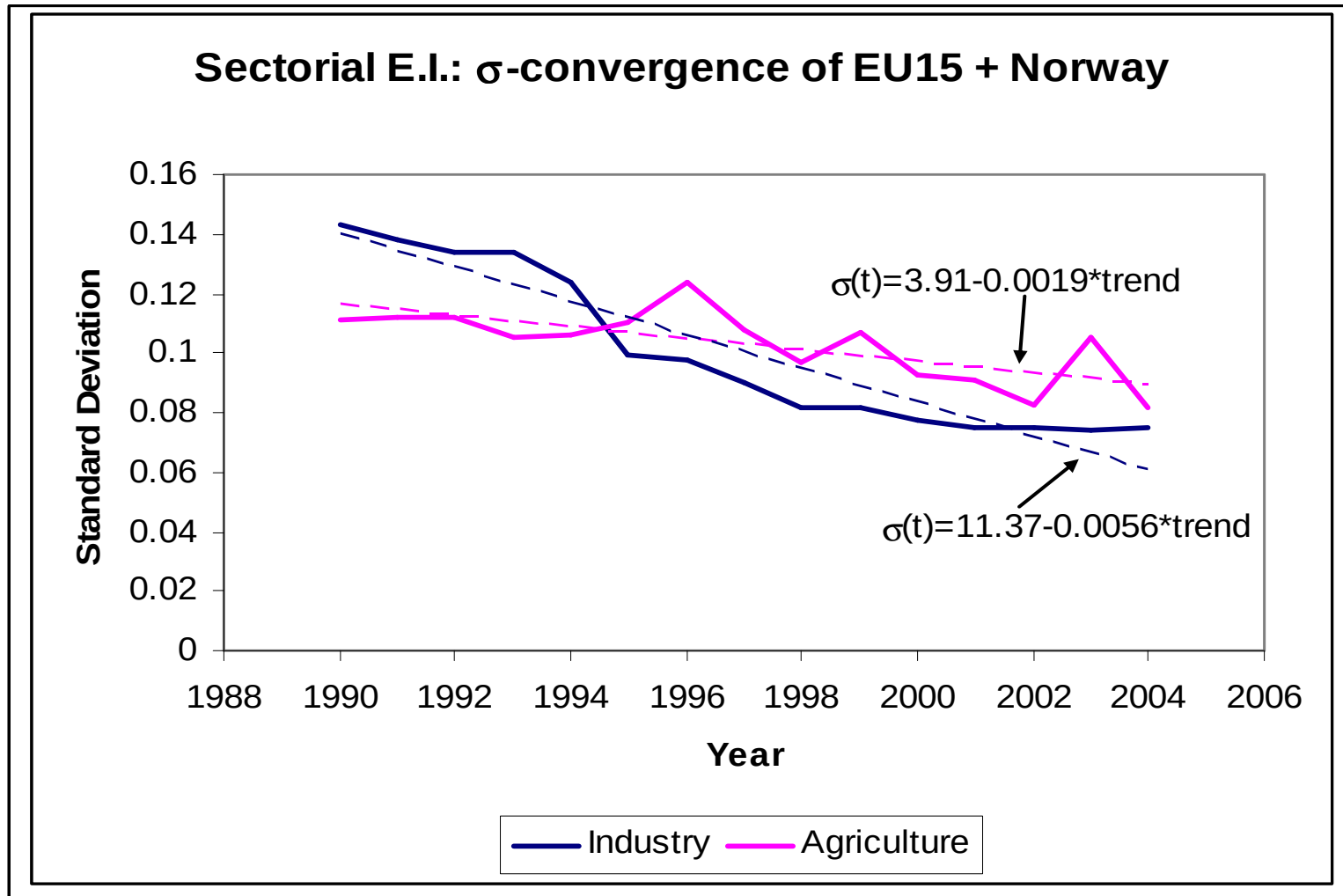
(β has to be negative).

σ – convergence: a group of economies are σ -converging if the dispersion of their per-capita real GDP tends to decrease over time: $\sigma_{t+T} < \sigma_t$

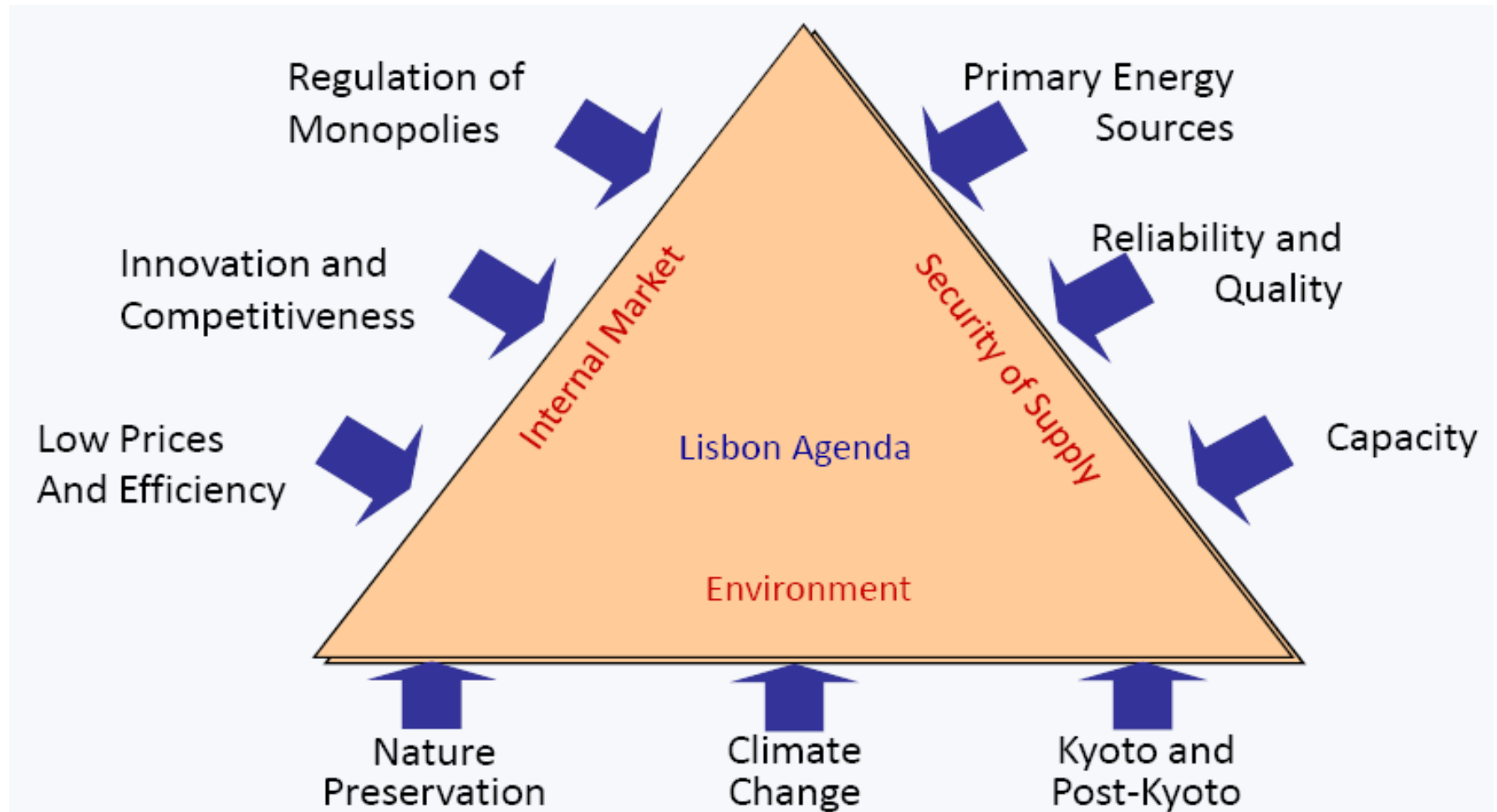
E.I. Convergence: β – convergence.



E.I. Convergence: σ – convergence.



Energy Policy in the EU (1/2)



Source: Bellmans (2009)

Energy Policy in the EU (2/2)

Security of supply, sustainability and competitiveness are not independent objectives;

Need to have a consensus view about the current situation and a (long-run) policy to deal with it.

The Green Paper (2006) “A European strategy for sustainable, competitive and secure energy” [COM(2006) 105 final]:

- Identifies priority areas and lists proposals to meet and fine-tune three core objectives:
 1. Increasing **security** of supply;
 2. ensuring the **competitiveness** of European economies and the availability of affordable energy, and;
 3. promoting environmental **sustainability** and combating climate change.

The “20-20-20” objectives : By 2020

- 20% reduction in CO₂ emissions
- 20% increase in renewable source share in TPES
- 20% increase in energy efficiency

EU policies promoting energy saving and efficiency

Energy efficiency is identified as a key ingredient to improve self-sufficiency and reducing GHG emissions.

GP on “Energy Efficiency or doing more with less” (2005):

- to cut energy consumption by 20% by 2020.
 - ⇒ to reduce the dependency on imported oil and gas
 - ⇒ to reduce the energy bill by an estimated 100 billion euro every year.

The EU has proposed directives and regulations concerned with areas where there is potential for energy savings:

- End-use Efficiency & Energy Services;
- Energy Efficiency in Buildings;
- Eco-design of Energy-Using Products;
- Energy Labeling of Domestic Appliances;
- Combined Heat and Power (Cogeneration).

Panel analysis of policy effectiveness in Europe (1/5)

Data sources: Odyssee, Energy Information Agency (EIA), and OECD data (dep.variables); the policies were obtained from the MURE database. The economic time series per country were obtained from Eurostat, the World Development Indicators (WDI) and Odyssee databases.

Dependent variables: overall energy intensity (EI) and energy efficiency (EE) indexes + sectoral indexes: transport; household and industry.

16 Countries : EU15+NO.

Time dimension: 1980 to 2004.

384 observations

Static, fixed effect models (dynamic models did not yield stable results).

Dummies per policy sub-type : the dummy variable equalled 1 if any of the policies of the same sub-type was in place in the country in a given year.

Estimation strategy: include all potential determinants and policies with their lags and excluding from the model those variables with coefficients not statistically significant. The process was repeated until we obtained a set of statistically significant variables and policies with the expected signs.

In the case of P&Ms coefficients we expect a negative sign, that is, when the policy is in place (dummy=1) it implies EE / EI improvements.

Panel analysis of policy effectiveness in Europe (2/5)

Dependent Variables	Significant Regressors						
EE all sectors	Energy Price	GDP/capita	R&D	---	---	---	---
EE industry	Energy Price	GDP/capita	R&D	Share of industry	Energy production	Electricity from coal	---
EE transport	Energy Price	---	---	---	Trade	---	---
EE household	Energy Price	GDP/capita	---	Share of service	Trade	Capital formation	---
EI all sectors	Energy Price	GDP/capita	R&D	Share of industry	---	---	---
EI industry	Energy Price	GDP/capita	R&D	Share of industry	Energy production	---	---
EI other sectors	Energy Price	GDP/capita	R&D	---	---	---	---
EI transport	Energy Price	GDP/capita	R&D	---	---	---	---

Dependent Variables	Significant Regressors (P&Ms)						
EE all sectors	PMhht2	PMhht12	PMtrT10	PMinT8	PMteT2	PMteT5	PMccT1
EE industry	PMinT2	PMinT5	PMinT8	PMccT3	PMccT7		
EE transport	PMtrT6	PMtrT10					
EE household	PMhht2	PMhht6	PMhht8	PMhht12	PMccT1	PMccT4	
EI all sectors	PMhht6	PMhht7	PMhht11	PMinT8	PMteT5	PMccT7	
EI industry	PMinT1	PMinT8					
EI other sectors	PMhht7	PMhht11	PMhht12	PMccT7			
EI transport	PMtrT6	PMtrT9	PMccT7				

Panel analysis of policy effectiveness in Europe (3/5)

The price of energy has a small but significant effect on improving energy efficiency, reducing energy intensity in all sectors and for the aggregate level of the economy. However, the 'elasticities' are small. For example, a ten percent increase in the price of energy net of inflation increases aggregate energy efficiency by 0.16 percent only and reduces energy intensity by 0.26 percent. The one important price elasticity we find is for households. A ten percent increase in energy prices results in a 1.2 percent increase in energy efficiency.

The effects of increases in GDP are mixed. In some cases GDP increases result in more efficiency and lower intensity; in other cases the reverse holds. There are about an equal number of positive effects as there are negative ones.

The effects of R&D expenditure on energy efficiency and intensity are disappointing. We do not generally find improvements in efficiency and intensity when R&D increases.

Panel analysis of policy effectiveness in Europe (4/5)

Sectors	EFFECTIVE P&Ms	
INDUSTRY	Mandatory Standards Soft loans. Information, education and training.	       
RESIDENTIAL	Heating regulations. Subsidies and tax exemptions Soft loans. DSM.	       
TRANSPORT	Tax exemptions and accelerated depreciation. Social Planning. Traffic management.	       

Legend: EE only

EE & EI

EI only

Panel analysis of policy effectiveness in Europe (5/5)

In terms of aggregate **energy efficiency**, **energy intensity** (or **both**) the effective measures are:

- regulations for heating systems and cross-cutting household sector specific policies (mainly eco-taxes);
- social planning in transport such as car sharing, increased load factors for goods, commuter plans for companies;
- **information, education and training in industry, which includes voluntary labelling, audits;**
- regulations for building equipment, which includes minimum standards for boilers;
- **grants and subsidies in the tertiary sector**, which includes investment in renewable energy sources, CHP;
- **cross-cutting financial measures** (e.g. funds for RES);
- **soft loans for the household sector.**

Conclusions (1/2)

There is a sensible catching-up of less performing countries in terms of reducing energy intensity, particularly in the agricultural and in the industrial sector (β -convergence).

However, there is non conclusive evidence that the dispersion among countries is reducing (σ -convergence), although this holds mostly for the last 4-5 years analysed.

The convergence of among European countries (EU15 + Norway) can offer guidance for fine-tuning energy policies within the EU. Extending this analysis to other countries could improve the coordination and cooperation between the EU and crucial partners.

Conclusions (2/2)

The panel analysis of energy policies confirms that taking action to improve energy efficiency can lead to significant improvements, and helps identifying policies with the best potential.

- in the residential sector EE is particularly affected by heating regulation, by subsidies and tax reductions. Measures which apply to the production side, such as financing at low interest rate, proved to be effective;
- in the transport sector, tax reductions, incentives to eliminate old and polluting cars, car sharing, commuter plan and traffic management are effective;
- in the industrial sector, mandatory technology standards, financing at low interest rate, information activities, education and outreach are effective.

Further research directions:

- more countries (too few data for NMCs panel analysis; convergence analysis with BRICs),
- continuous, instead of binary, policy variables and the role of the intensity of energy policy,
- different dimensions of energy policy (such as climate change mitigation, energy security).

Thanks for your attention!

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