An Empirical Delineation of the European Market for Electric Power Generation

Alain Bousquet — University of La Rochelle and LERNA
Catherine Cazals — University of Toulouse and GREMAQ
Marc Ivaldi — Toulouse School of Economics and IDEI
Norbert Ladoux — University of Toulouse and LERNA

Main concept

- Relevant market
  - Smallest set of products
  - St: No competition from other products
- Relevant market test
  - Measurement of competitive strength of other products
  - Three forms of competitive constraints
    - Demand substitution: change of supplier

    Cross price elasticity's $> 0 \Rightarrow$ substitutable technologies
    - Supply substitution: Economies of scope
    - Potential competition: entry

Relevant market tests

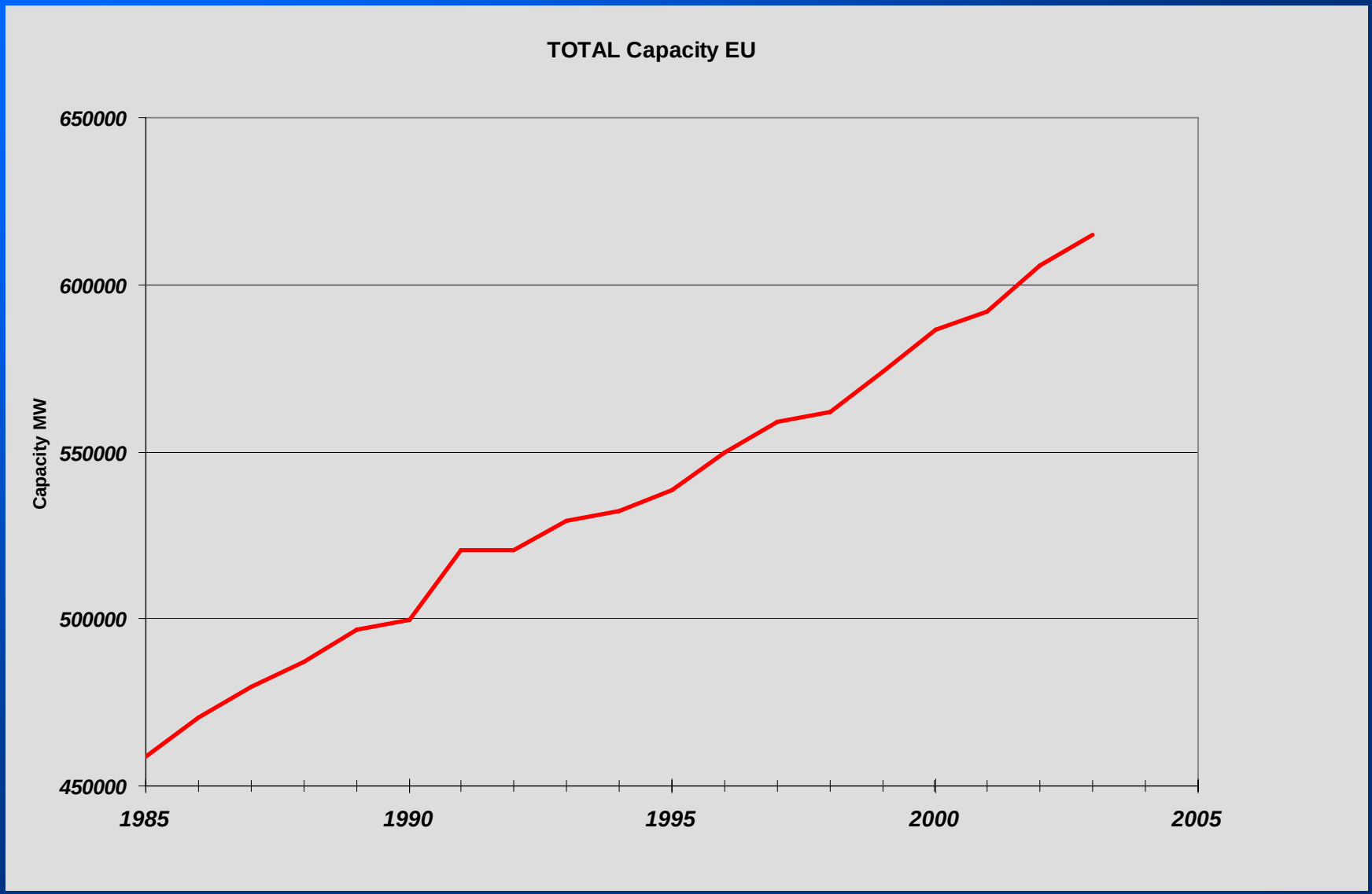
- SSNIP
  - Demand substitution
- Main idea of SSNIP test
  - Hypothetical “monopoly” of all products in subset
  - Consider a SSNIP (e.g. 5%)
    1. Markups increase
    2. Leakage : sales diversion
  - If 2 dominates 1
    - Market too small
    - Profit loss

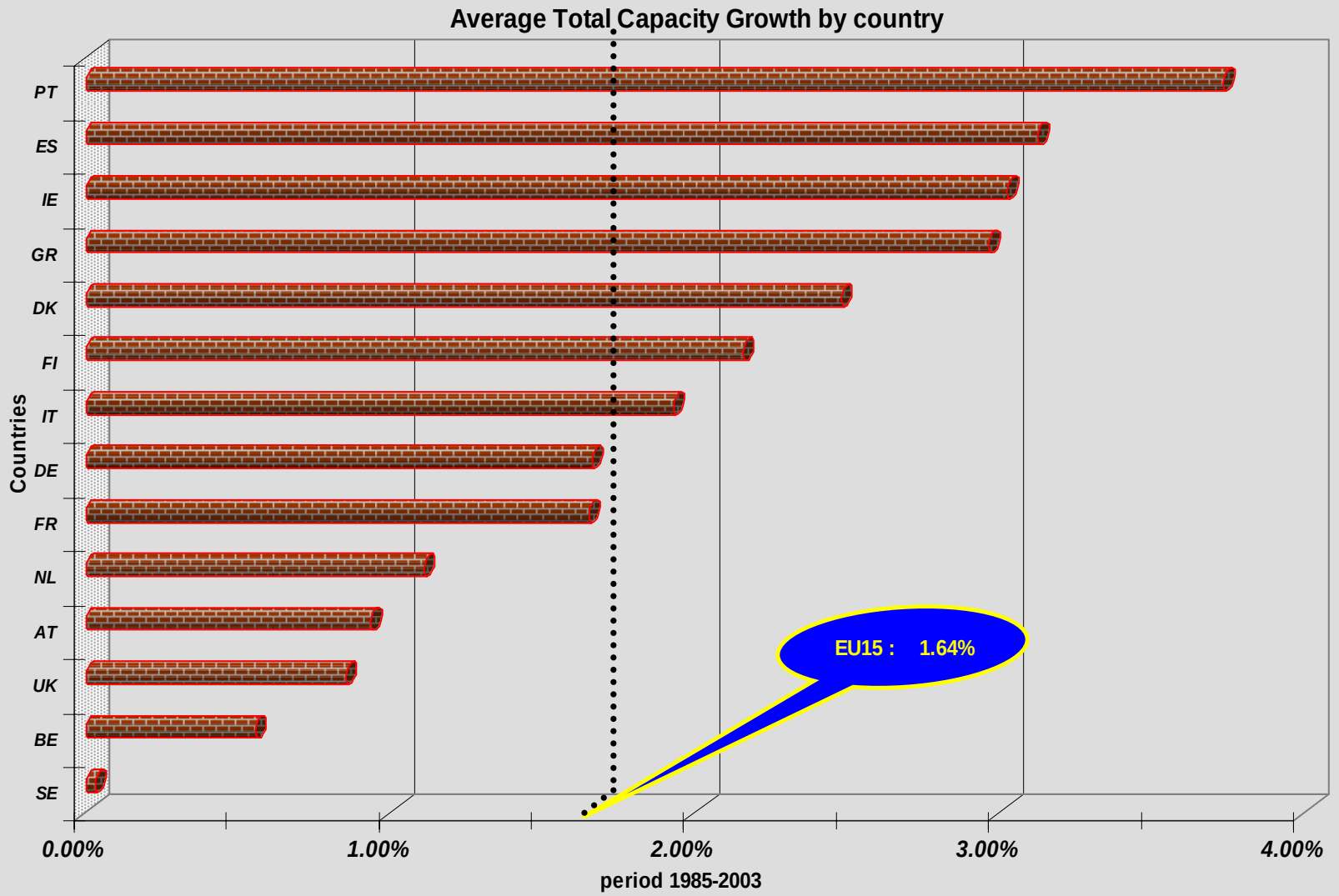
Fuel Substitution :Two approaches

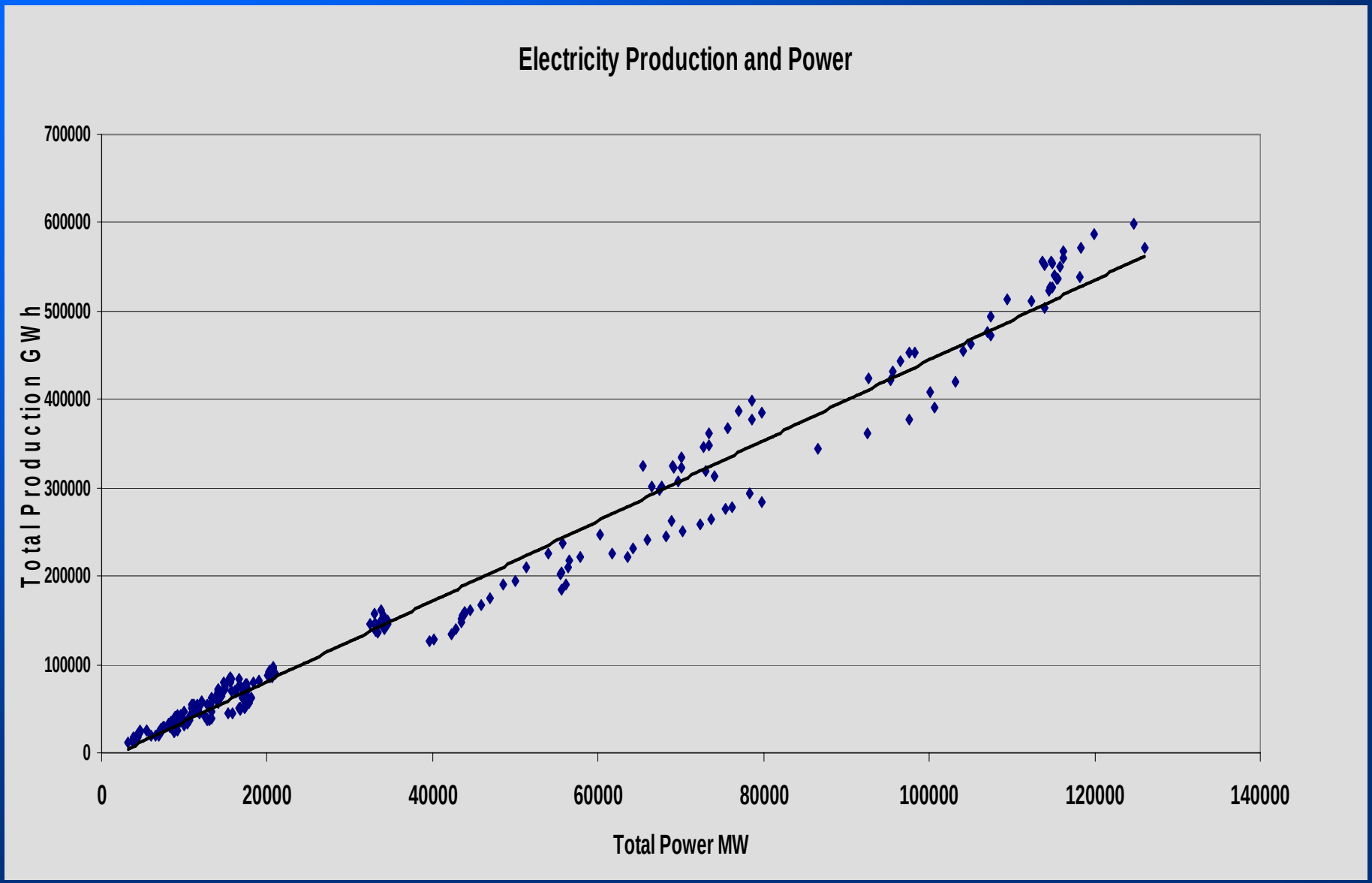
1. Dual
   - Lack of data on prices on the different types of equipment
   - Söderholm (1998) a survey for the electricity sector
2. Primal
   - The estimation of a PF is a key element when analyzing
     - Measurement of the contribution of different factors to productivity growth. But also Economies of scale/scope, learning by doing, returns of R&D…..
     - Complementarity / Substitutability between inputs
     - Estimation of elasticities of substitution (not the cross price elasticities of factor demand)
   - Recent contributions Olley and Pakes (1996), Levinshon and Petrin (2003)

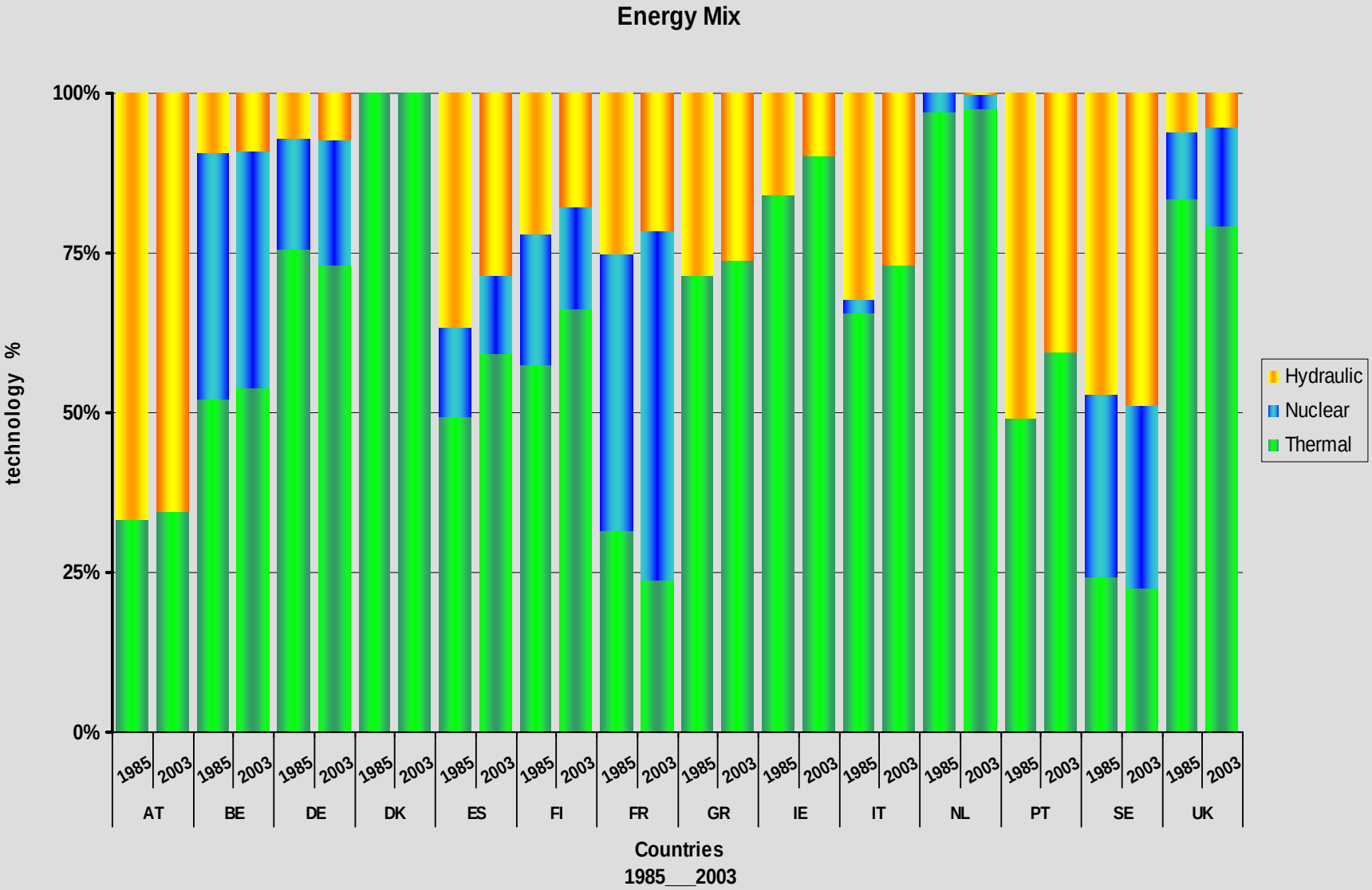
Eurostat data

- Period 1985-2003
- Countries EU 15
- Power capacity for Thermal Hydraulic and Nuclear
- Total electricity production


TOTAL Capacity EU
Capacity MW
650000
600000
550000
500000
450000
1985
1990
1995
2000
2005


Average Total Capacity Growth by country
Countries
PT
ES
IE
GR
DK
FI
IT
DE
FR
NL
AT
UK
BE
SE
EU15 : 1.64%
0.00%
1.00%
2.00%
3.00%
4.00%
period 1985-2003


Electricity Production and Power
Total Production GWh
700000
600000
500000
400000
300000
200000
100000
0
0
20000
40000
60000
80000
100000
120000
140000
Total Power MW


Energy Mix
100%
75%
50%
25%
0%
technology %
1985
2003
AT
BE
DE
DK
ES
FI
FR
GR
IE
IT
NL
PT
SE
UK
Countries
1985___2003
Hydraulic
Nuclear
Thermal

Model and Estimation

- Separable production function

$$Y = ag(K_T, K_H, K_N)$$

- CES form

$$y = A\left[\alpha_T K_T^{-\rho} + \alpha_H K_H^{-\rho} + \left(1-\alpha_T-\alpha_H\right)K_N^{-\rho}\right]^{-1/\rho}$$

$$\sigma_{ij} = \frac{1}{1+\rho} \quad \forall i, j \quad i, j = T, H, N$$

Estimation of the CES production function

- Results

Parameters	Estimated Values	Standard Errors	Student Statistics
A	12.1700	0.1285	94.739
α_T	0.4010	0.0065	62.174
α_H	0.1848	0.0095	19.403
ρ	-0.8055	0.0340	-23.707

- Elasticity of substitution

$$\sigma_{TH} = \sigma_{TN} = \sigma_{HN} = \frac{1}{1+\rho} = \frac{1}{1-0.8055} = 5.14$$

Nested CES production function

- Separating Hydraulic from Thermal and Nuclear

$$y = A\left\{\beta K_H^{-\mu} + (1-\beta)\left[\alpha K_T^{-\rho} + (1-\alpha)K_N^{-\rho}\right]^{\mu/\rho}\right\}^{-1/\mu}$$

- AES

$$\sigma_{TH} = \sigma_{NH} = \frac{1}{1+\mu}$$

$$\sigma_{NT} = \frac{K_N f_N + K_H f_H + K_T f_T}{K_N K_T} \frac{|F_{NT}|}{|F|},$$

Results

Parameters	Estimated Values	Standard Errors	Student Statistics
A	11.9948	0.1415	84.776
β	0.2221	0.0120	18.535
α	0.4735	0.0089	53.160
ρ	-0.8332	0.0362	-22.989
μ	-1.4990	0.1668	-8.988

$$\sigma_{Nunclear-Hydraulic} = \sigma_{Thermal-Hydraulic} = \frac{1}{1+\mu} = \frac{1}{1-1.4990} = -2.00$$

$\sigma_{Nuclear-Thermal}$:

Belgium	6.22 *(0.01)*
Germany	6.16 *(0.02)*
Spain	8.87 *(0.37)*
Finland	6.85 *(0.12)*
France	7.07 *(0.11)*
Italy	8.76 *(0.11)*
Netherlands	6.00 *(0.00)*
Sweden	11.78 *(0.31)*
UK	6.11 *(0.01)*

The Generalized Leontief Production Function

- Functional form

$$Y=\alpha_N K_N+\alpha_T K_T+\alpha_H K_H+2\alpha_{NT}\sqrt{K_N K_T}+2\alpha_{NH}\sqrt{K_N K_H}+2\alpha_{TH}\sqrt{K_T K_H}$$

- Estimation

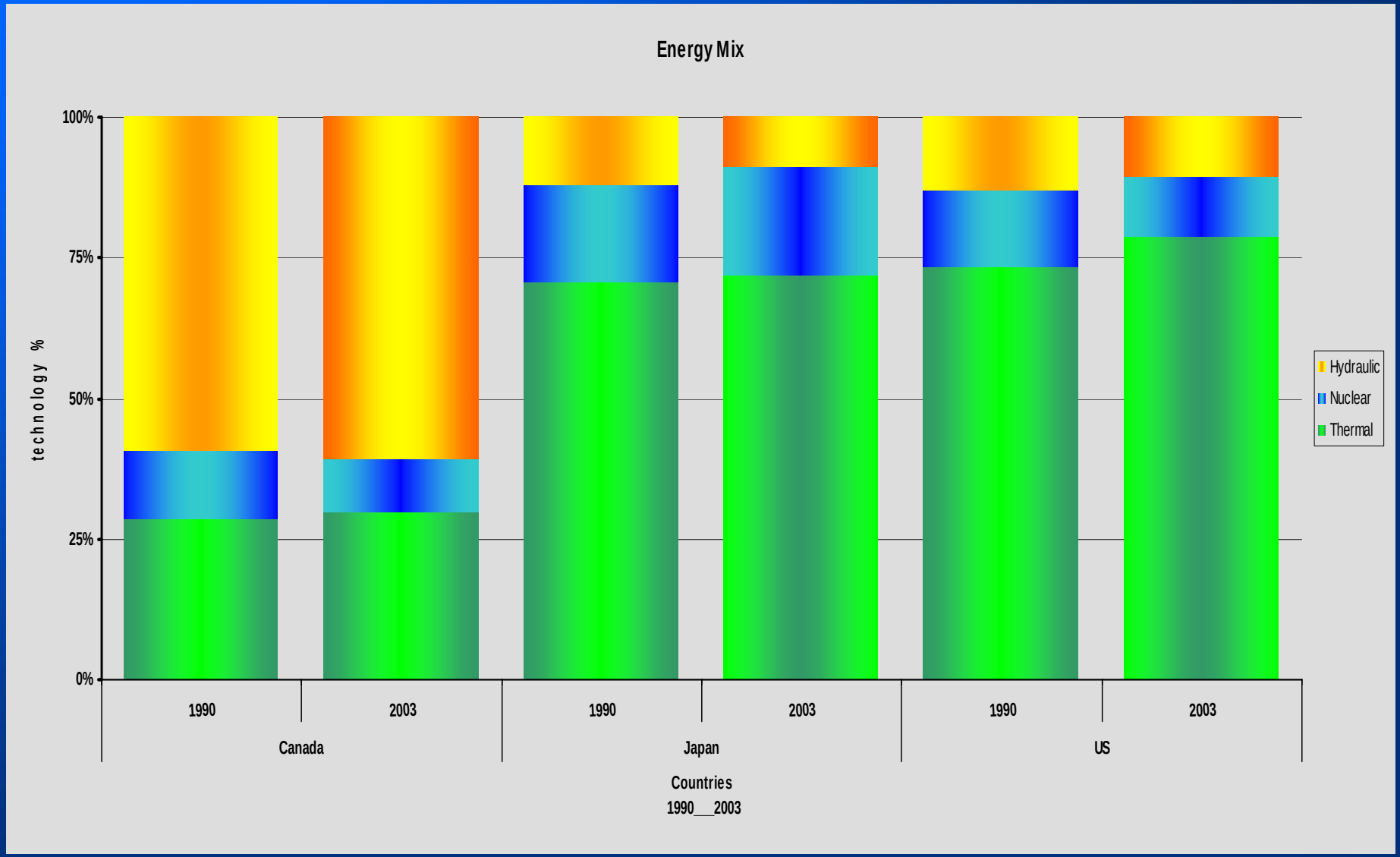
Parameters	Estimated Values	Standard Errors	Student Statistics
α_N	4.6106	0.3313	13.92
α_T	4.0875	0.1854	22.05
α_H	4.0189	0.5562	7.23
α_{NT}	0.9911	0.1922	5.16
α_{NH}	-0.6768	0.3837	-1.76
α_{TH}	-0.6579	0.2620	-2.51

AES Elasticity of substitution for GL

	Nuclear-Thermal	Nuclear-Hydraulic	Thermal-Hydraulic
Belgium	6.138 *(0.038)*	-0.854 *(0.030)*	-0.661 *(0.092)*
Germany	5.561 *(0.065)*	-2.004 *(0.179)*	0.001 *(0.077)*
Spain	10.719 *(0.710)*	-5.127 *(0.218)*	-2.637 *(0.121)*
Finland	6.972 *(0.323)*	-3.817 *(0.124)*	-1.513 *(0.155)*
France	7.587 *(0.252)*	-1.666 *(0.131)*	-4.046 *(0.248)*
Italy	9.423 *(0.105)*	-11.563 *(1.625)*	-3.453 *(0.352)*
Netherlands	3.286 *(0.075)*	-2.852 *(0.119)*	1.827 *(0.017)*
Sweden	15.961 *(0.532)*	-3.158 *(0.057)*	-4.661 *(0.172)*
UK	5.143 *(0.177)*	-2.319 *(0.448)*	0.277 *(0.088)*

Estimation based on DOE data

- Eu countries + Canada, Japan and US states
- Period 1990 to 2003


Energy Mix
100%
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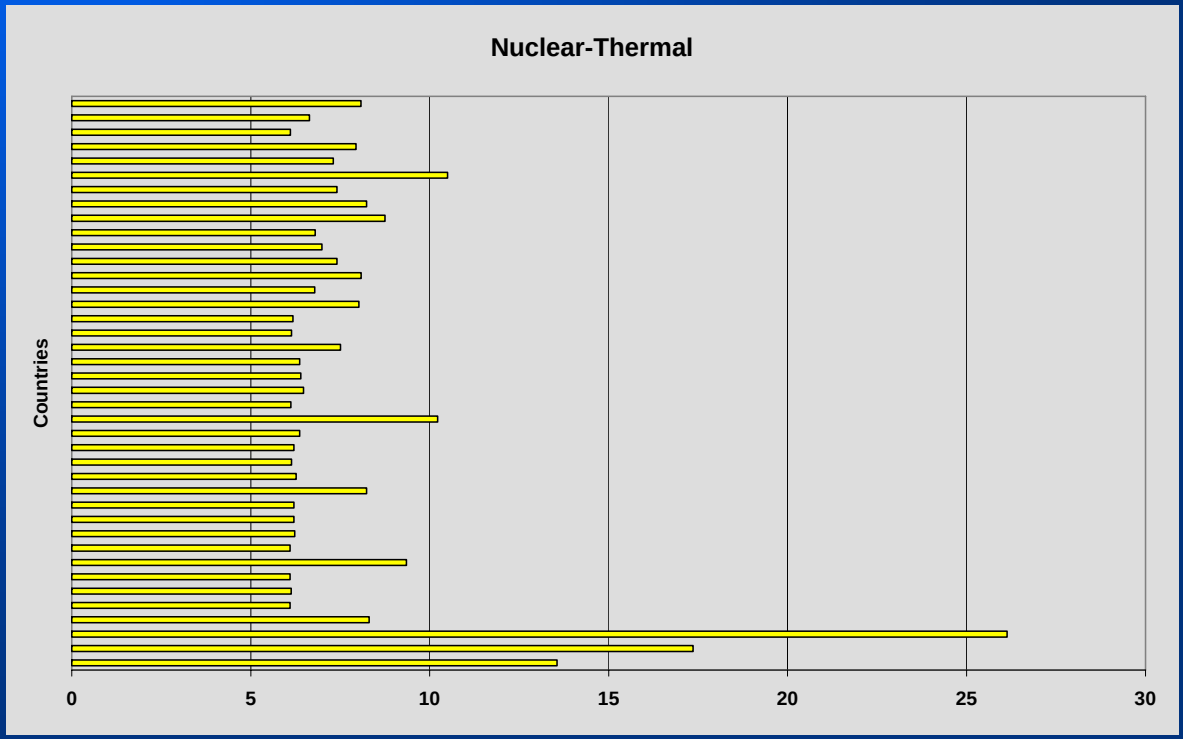
50%
25%
0%
technology %
1990
2003
1990
2003
1990
2003
Canada
Japan
US
Countries
1990__2003
Hydraulic
Nuclear
Thermal

Results for the nested CES production function

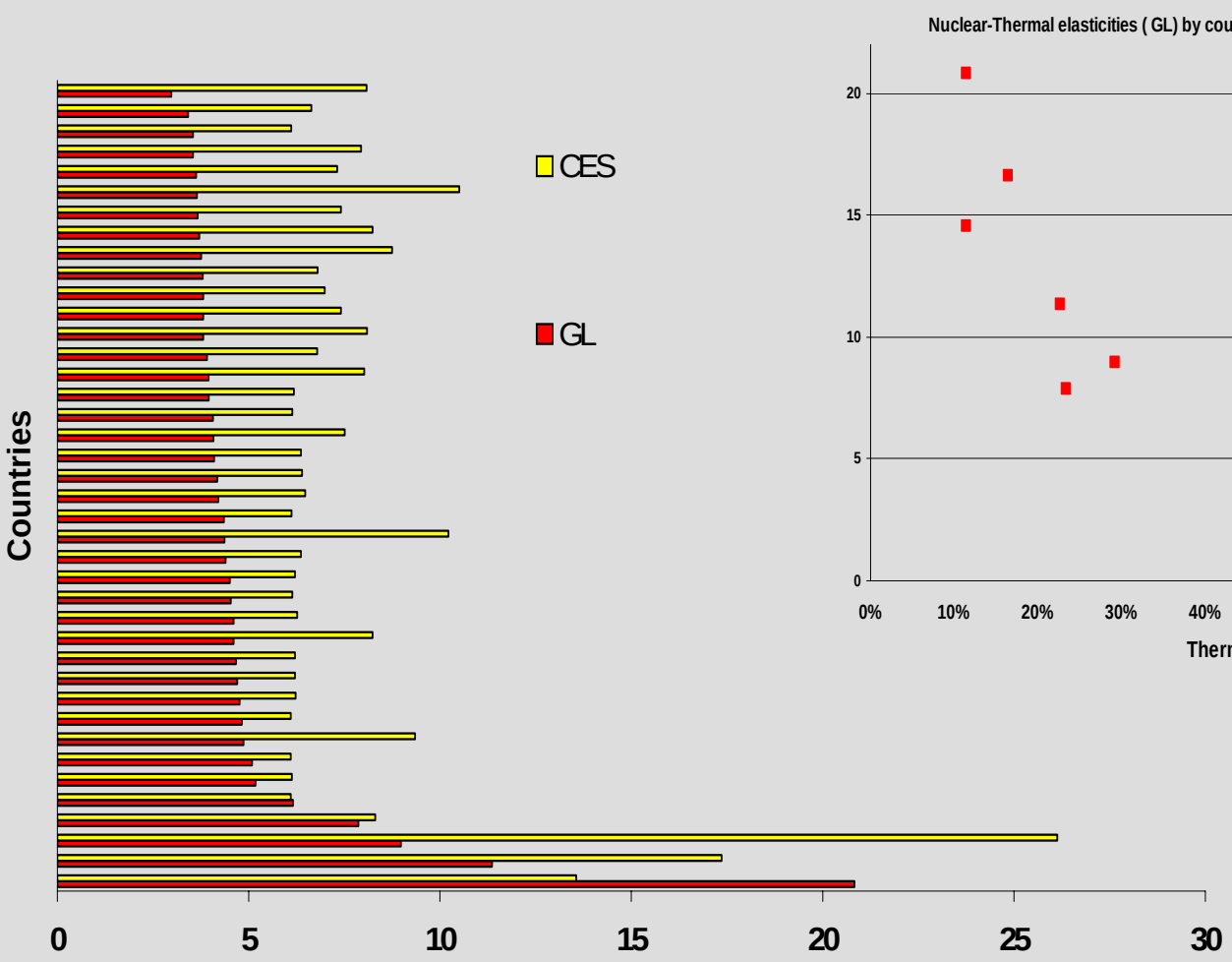
- AES

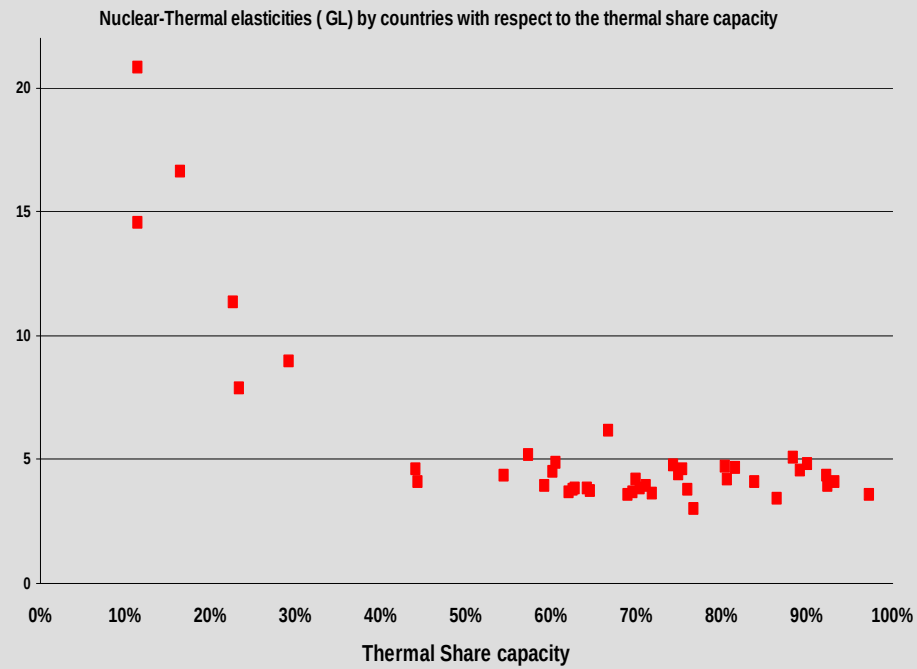
$$\sigma_{Nuclear-Hydraulic} = \sigma_{Thermal-Hydraulic} = -4.09$$

$\sigma_{Nuclear-Thermal}$:



Nuclear-Thermal Elasticities
Comparison between CES and GL





Conclusion

- Real and Substantial substitution between Nuclear and Thermal technologies
- Hydraulic and Nuclear are always complements
- Mitigated results for Hydraulic and Thermal that appears complements or substitute depending on the PF specification

⇒ **We cannot reject substitution between equipments, so markets must be considered not as separated but as one market including different types of equipment for electricity generation.**

Improvements and future research:

- Distinguishing coal and natural gas within thermal technologies
- Discrete choice among equipments and Microeconomic data at plant level