



**Cátedra**  
ECONOMÍA DE LA ENERGÍA Y DEL MEDIO AMBIENTE



**15<sup>th</sup> IAEE European Conference 2017**

**'HEADING TOWARDS SUSTAINABLE ENERGY  
SYSTEMS: EVOLUTION OR REVOLUTION?'**

**INDUSTRY LEVEL PRODUCTION FUNCTIONS AND ENERGY  
USE**

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**There is no widely accepted theory which shows the relationship between energy and economic growth.**

**Studies show results:**

- without causality;
- with a causal direction running from energy to production;
- with a causal direction running from production to energy consumption;
- and that double causality exists.

**Although many of these studies suggest the existence of at least a causal relationship running from energy to economic growth, the inclusion of the energy factor in the production function has been scarce**

**The industrial sector uses more delivered energy than any other end-use sector, consuming about 54% of the world's total delivered energy.**

**Additionally, industrial sector energy consumption is projected to increase by an average of 1.2%/year worldwide.**

**Despite the importance of energy use by industry, there are few studies examining the effect of energy consumption on industrial output by sectors.**



## OBJETIVE

**The aim of this study is to analyse the role of energy in the industry sector economic growth**

**With that purpose**

**Industry-level translog production functions are estimated including an energy variable as independent variable**

**Panel Data techniques are used to estimate it**

## DATA SAMPLE

### 9 EU countries- depending on available data (EU-KLEMS)

Austria, Finland, France, Germany, Greece, Netherlands, Spain, Sweden and the United Kingdom

Period analyzed **2000 to 2014**

The translog production functions are estimated for for total manufacturing, construction and mining sectors and **7 manufacturing branches:** Food and beverages, Textiles, Wood, paper and printing, Chemicals, Machinery and metals production, Transport equipment and Other manufacturing.

**Productive energy use, physical capital and total employee hours are considered as production factors**



## Variables Used

- **Gross Value Added**  
data came from the Economic Data by Enerdata
- **Physical capital**  
data came from the *EU-KLEMS*
- **Employment**  
Data came from the WIOD Socio-Economic Accounts sub-base.
- **Energy**  
Data came from the Global Energy Statistical by Enerdata *Odysee database*



## Modelling

### Starting point

$$Y_{it} = A_{it} + \beta_1 L_{it} + \beta_2 K_{it} + \beta_3 E_{it} + \beta_4 K_{it} L_{it} + \beta_5 K_{it} E_{it} + \beta_6 E_{it} L_{it} + \beta_7 L_{it}^2 + \beta_8 K_{it}^2 + \beta_9 E_{it}^2$$

**Y is the sum of the logarithm of the TFP (A<sub>it</sub>) and total input**

**Total input is determined by a translog production function with 3 arguments (K, E and L),**

**All variables are in natural logs.**

## Modelling

**We assume**: constant returns to scale. Variables are expressed in per employee

Data were converted to **deviations from the geometric mean** of the sample. In order to avoid multicollinearity between variables

Data were converted to **first differences, so we can include: the evolution of the technological progress as**

$$\delta_t + \lambda_1 (y_{it} - y_{mt}) + \lambda_2 (Y_{it} - Y_{ind_{it}})$$

equal to the sum of a common temporal effect for all the countries ( $\delta t$ ) and a technological catch-up term



## Modelling

$$Y_{it} = \delta_t + \lambda_1 (y_{it} - y_{mt}) + \lambda_2 (Y_{it} - Y_{ind_{it}}) + \beta_k \Delta k_{it} + \beta_e \Delta E_{it} + \beta_{ke} \Delta k_{it} e_{it} + \beta_{kk} \Delta k_{it}^2 + \beta_{ee} \Delta e_{it}^2$$

### Coefficients of terms with cross-products

Positive values indicate complementarity  
Negative values indicate substitutability

### Coefficients of the quadratic terms

Negative values indicate decreasing returns to scale



## SOME RESULTS

	Total Industry		Construction		Mining	
	GLS	GMM	GLS	GMM	GLS	GMM
K	0.68***	0.42***	0.50***	0.73***	0.52***	0.52***
E	0.05	0.019	0.06***	0.015	0.12***	0.11***
KE	0.014	0.24	-0.006	0.005	0.016	0.007
E2	0.007	-0.003	0.02	-0.005	0.10**	-0.01
K2	0.16	-0.023	-0.02	-0.012	0.04**	0.13*
$\lambda_1$	0.04***	0.04***	0.15	-0.008	-0.02***	-0.018*



## SOME RESULTS

	CHEMIC.		FOOD		MACHIN.		TRANSPORT	
	GLS	GMM	GLS	GMM	GLS	GMM	GLS	GMM
K	0.31***	0.30***	0.56***	0.42***	0.44***	0.23**	0.43***	0.20**
E	0.15***	0.11***	0.08*	0.05*	0.16***	0.24**	0.08**	0.24***
KE	0.08**	0.16***	-0.48***	-0.17***	0.60***	0.11***	-0.032	0.20*
E2	-0.007**	-0.02	0.11*	-0.01***	-0.24***	-0.006*	-0.030	-0.03
K2	0.10**	0.02	0.50***	0.32***	-0.29***	-0.008*	0.062	-0.05
$\lambda_1$	0.003	0.009	0.013***	0.025***	-0.0001	0.014	0.020	0.03*
$\lambda_2$	0.77***	0.77***	0.735***	0.58***	1.25***	1.50***	0.93***	0.84***



## SOME RESULTS

	WOOD&PAPER		TEXTIL		OTHERS	
	GLS	GMM	GLS	GMM	GLS	GMM
K	0.43***	0.35***	0.57***	0.61***	0.47***	0.34***
E	0.06**	0.003	0.03	0.03	-0.009	-0.09
KE	0.05	-0.031	-0.09	-0.12	0.29***	0.37**
E2	0.18**	-0.009	-0.03	-0.007	0.002	-0.02
K2	0.02	-0.051	0.064	-0.05	0.0009	0.04
$\lambda 1$	0.044***	0.07***	0.029***	0.019***	0.02***	0.03***
$\lambda 2$	0.63***	0.61***	0.59***	0.52***	0.31***	0.35***



## Conclusions

Mostly, energy is a factor that influence industry production growth in all sector except for *others* and *textil*

Energy and Stock of capital are substitutes factors in *Food and beverages*

Energy and Stock of capital are complementary factors in *Chemicals, Machinery and metals production, Transport equipment and Other manufacturing*

Decreasing returns to scale for Energy are observed in *Chemicals, Machinery, Food and beverages and metals production*

Increasing returns to scale for Energy are observed in *Wood and paper and Mining.*



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***Thank you for your  
attention***