Carbon tax and substitution effects in the French industrial sector: an econometric assessment

Nicolas Blanc
Gaël Callonnec

ADEME, France

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The Climate-Energy Contribution

- **Possible « French carbon tax »?**
- **Every fossil energy source**
- **With exonerations:**
  - **Industrial sector: installations submitted to the EU ETS and double usage**
  - **Residential sector: up to the mean energy demand of households, and for welfare recipients**
  - **Tertiary sector: mean energy demand of new buildings**

Evaluation of the Substitution Effects

- **How to evaluate the response to a carbon tax?**
  - **Own-price elasticity of demand**
  - **Substitution effects -> cross-price elasticity**

- **> the aim of this study: evaluate the substitution effects in the French industrial sector**

  - **Differenciation between energy sources (coal, heavy fuel oil, heating oil, natural gas, electricity)**

  - **Demand for one energy source as a function of all energy prices**

Existing Models

- **Key parameter: the elasticity of substitution:**

$$\sigma_{ij} = \frac{\partial \ln(X_i / X_j)}{\partial \ln(P_j / P_i)}$$

- **Review of existing models (demand functions):**
  - **The most used: CES production functions (Cobb-Douglas, Leontieff)**
    - **-> equal elasticity of substitution among all energy sources**
  - **Flexible functional forms**
    - **-> our model was inspired from the Translog function**

Source Data

- **Demand and price for coal, natural gas, heavy fuel oil, heating oil, electricity**
- **Annual data 1986-2004 (CEREN, Enerdata)**
  - **> 19 observations**
- **In the French manufacturing sector**
- **Sectors with double usage or non-energy use of fuels were removed**
  - **Exoneration from carbon tax**
  - **For these sectors, the fuel they use is not substitutable**

Our Model

Lowercase = logarithmic variables:

$$e_{iT} - e_{totT} = A_i + B_i T + C_i T^2 + \sum_{j=1}^{n} \alpha_{ij} p_{jT} + \beta_i \left(e_{i(T-1)} - e_{tot(T-1)} \right) + \varepsilon_{iT}$$

- $e_{iT} - e_{totT}$: Share of energy source i in the total
- $A_i + B_i T + C_i T^2$: Quadratic time trend
- $\sum_{j=1}^{n} \alpha_{ij} p_{jT}$: Influence of the prices of all energy sources
- $\beta_i \left(e_{i(T-1)} - e_{tot(T-1)} \right)$: Lagged term

with $\sum_{j=1}^{n} \alpha_{ij} = 0$

- **Easy to evaluate and interpret**
- **Inspired from the Translog production function and CES demand function**
- **9 parameters for 19 observations: all the non-significant terms were removed**

The Results: Short-Term and Long-Term Cross-Price Elasticities

$$e_{iT} - e_{totT} = A_i + B_i T + C_i T^2 + \sum_{j=1}^{n} \alpha_{ij} p_{jT} + \beta_i \left(e_{i(T-1)} - e_{tot(T-1)} \right) + \varepsilon_{iT}$$

	Coal share	Heavy fuel oil share	Heating oil share	Natural gas share	Electricity share
Coal price	**-0.674** ***-1.04***				
Heavy fuel oil price		**-0.102** ***-0,109***			
Heating oil price	**0.441** ***0.678***		**-0.0827** ***-0.0938***		
Natural gas price	**-0.521** ***-0.801***			**-0.0520** ***-0.333***	**0.0510** ***0.103***
Electricity price	**0.754** ***1.16***	**0.102** ***0.109***	**0.0827** ***0.0938***	**0.0520** ***0.333***	**-0.0510** ***-0.103***

The Results: Comments

- **The most significant substitution effect occurs with electricity**
- **Own-price elasticity is by far the greatest for coal**
- **Adjustment speed very fast for oil products, slow for electricity and natural gas**
- **Possible improvements**
  - **Introduce energy demand in level?**
  - **Other functional form?**
  - **Only 19 observations -> Panel data**
  - **How to take the trend into account?**

Conclusion

- **Substitution effects remain low and difficult to highlight**
- **However, elasticities are bigger than in Urga and Walters, 2003: USA from 1960 to 1992 (but different handling of non energy use)**
- **Only valid for variations in prices of the order of magnitude that occurred between 1986 and 2004**
- **Has been used to make a sectorial evaluation of the impact of a carbon tax**

Thank you for your attention!