Outline

- Price Elasticities
- Partial Equilibrium
- A Partial Equilibrium Model of the Global Coal Market

Equilibrium Modeling

Price Elasticities

Own price elasticity: the percentage decrease in the demand of a fuel as its price increases by 1% holding other prices constant

But:

- energy price increases motivate interfuel substitution

- the interfuel substitution leads not only to decreases in the demand for the fuel whose price increases, but also to increases in the demand for competing fuels

- as a result aggregate energy demand is reduced by less than the demand for a single fuel

Equilibrium Modeling

Price Elasticities

Example:

Let E_1, E_2 be demands for two types of energy, and let P_1, P_2 be the corresponding prices. Let the prices and demands be related by

$E_1 = 1.2 - P_1 + 0.8\ P_2$

$E_2 = 1.2 + 0.8\ P_1 - P_2$

What are the own- and cross-price elasticities, and the aggregate elasticity of demand ?

Suppose $p_1 = p_2 = 1$ ➔ $E_1 = 1, E_2 = 1$

Let $p_1 = 1.1$ ➔ $E_1 = 0.9, E_2 = 1.08$

$E_T = E_1 + E_2 = 2.4 - 0.2\ p_1 - 0.2\ p_2$; $p_T = (p_1 + p_2)/2$

$p_1 = 1, p_2 = 1$ ➔ $E_T = 2$; $p_T = 1$ Let $p_1 = 1.1, p_2 = 1$ ➔ $E_T = 1.98$; $p_T = 1.05$

Equilibrium Modeling

Price Elasticities

Price elasticity for household gas and electricity consumption for different energy price cases

Total price changes	1995		2000	
	Gas	Electricity	Gas	Electricity
1. Minor increase (+20%)	−0.07	−0.07	−0.13	−0.11
2. Major increase (+100%)	−0.04	−0.05	−0.08	−0.07
3. Major decrease (−50%)	−0.05	−0.06	−0.10	−0.09
4. Gas only (+20%)	−0.08	(+0.02)	−0.15	(+0.03)
5. Electricity only (+20%)	(+0.01)	−0.09	(+0.02)	−0.13

Price elasticity* for household gas and electricity consumption in the presence of policy measures (year 2000)

Policy variants	Gas	Electricity
No policy case	−0.138	−0.124
Standards only	−0.113	−0.124
Subsidies only	−0.142	−0.119
Taxes only	−0.125	−0.100
Taxes/subsidies/standards	−0.103	−0.091

* For a change of +20% in the price without regulatory tax.

Ref.: Boonekamp, P.G.M., 2007. Price elasticities, policy measures and actual developments in household energy consumption – A bottom up analysis for the Netherlands, *Energy Economics*, Vol.29 (2),pp.133-157.

Equilibrium Modeling

Price Elasticities

Average energy price elasticities in the empirical literature

	Short term	Long term
Electricity	−0.126*	−0.365*
Natural Gas	−0.180***	−0.684*
Gasoline	−0.293***	−0.773***
Diesel	−0.153**	−0.443***
Heating oil	−0.017	−0.185

*** Significant at the 1% level.
** Significant at the 5% level.
* Significant at the 10% level

Xavier Labandeiraa, b, José M. Labeagac, Xiral López-Otero, A meta-analysis on the price elasticity of energy demand, Energy Policy Volume 102, March 2017, Pages 549–568

Equilibrium Modeling

Elasticity of Supply

- The price elasticity of supply shows the responsiveness of the quantity supplied to a change in its price.
- η_s = % change in quantity / % change in price
- The elasticity is a dimensionless representation of the slope of the supply curve
- For policy analysis models, the elasticity of supply is an input; in econometric exercises, the elasticity of supply is often a model output
- In equilibrium models the elasticity of supply can be used with a reference price and a reference quantity to define a linear ***supply function***

$$q_s(p) = \overline{q_s}\,(1+ \eta_s\,(p_s / \overline{p_s} - 1)$$

where
$\overline{q_s}$ is the reference supply quantity
$\overline{p_s}$ is the reference supply price

Equilibrium Modeling

Elasticity of Demand

- Similarly, a ***demand function*** can be calibrated to match a reference price-quantity pair

$$q_d(p) = \overline{q}_d \, (1 + \eta_d \, (p_d / \overline{p}_d - 1)$$

where

$\overline{q}_d$ is the reference demand quantity

p_d is the reference demand price

Equilibrium Modeling

A Simple Model of the Global Coal Market

- The basic structure of the model is summarized as

$$\sum_r S_r(p) = \sum_r D_r(p, t_r)$$

where

p is the world market price of coal

$S_r(p)$ is the coal supply in region r

t_r is the specific tax on coal in region r

$D_r(p, t_r)$ is coal demand in region r

- The supply and demand functions are linear, hence

$$S_r(p) = a_r + b_r\, p$$

$$D_r(p, t_r) = \alpha_r - \beta_r \{p \times (1 + t_r)\}$$

Equilibrium Modeling

A Simple Model of the Global Coal Market

- *Benchmark inputs* include base year supply and demand
- *Econometric inputs* include elasticities of supply and demand in each of the regions
- *Policy* inputs include tax rates
- *Equilibrium* is defined by a single variable: the international coal price
- The equilibrium determines
  - ✓ supply and demand for each of the regions
  - ✓ leakage rate
- Minimize the squared deviation between agregate supply and aggregate demand

$$\Delta = \left\{ \sum_r (S_r - D_r) \right\}^2$$

Equilibrium Modeling

A Simple Model of the Global Coal Market: Policy Analysis

- Finding an *equilibrium price*
- Applying a *carbon tax* in Annex B countries
- Evaluating the *leakage rate*

$$\text{Leakage} = \frac{\text{increase in coal use in non-Annex B countries}}{\text{decrease in coal use in Annex B countries}}$$