The welfare cost of energy insecurity

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INTRODUCTION

- The 1973-1974 oil crisis revealed the vulnerability of developed economies to oil price shocks.
- Increasing uncertainty in energy markets makes energy security an important objective of energy policy.
- Together with efficiency and sustainability, the EU includes energy security as one of the three pillars of its energy policy (European Commission (EC) 2008).
- Despite its importance, there is no much information on the (macro)economic impact of energy insecurity.

LITERATURE

- Definition:
  - IEA: the uninterrupted physical availability at a price which is affordable.
  - EU: physical (disruptions), economic (price volatility), social and environmental risks.
  - Bohi and Toman (1996): the loss of welfare resulting from a change in the price or physical availability of energy.
- Measurement:
  - Scheepers et al (2007), Supply/Demand Index.
  - IEA Model of Short Term Energy Security (MOSES).
  - Variables: relative level of imports, diversification of supply sources…

GOAL and FRAMEWORK

- The goal of the paper is to quantify the welfare cost of energy insecurity in a macroeconomic model.
- We relate energy insecurity with energy price volatility:
  - In a perfect market, prices reflect all possible events and risks (Kilian, 2009).
  - Energy insecurity is not caused by high prices, but volatility and uncertainty.
- The paper is related to two strands of the literature:
  - Energy price shocks: Kim and Loungani (1992), Rotemberg and Woodford (1996), Finn (2000).
  - The welfare cost of business cycles: Lucas (1987).

THE MODEL

- We use a Dynamic Stochastic General Equilibrium model.
- The model consists of a representative household and a firm.
- Energy is a consumption good for households and a production input for firms.
- Energy is imported from abroad at an exogenous price.
- There is perfect competition in the model.

1. Households

$$Max \quad E_0 \sum_{t=0}^{\infty} U\left(c_t, n_t, e_t^h\right)$$

$$s.t.: c_t + k_{t+1} - (1-\delta)k_t + p_t e_t^h = w_t n_t + r_t k_t$$

F.O.C:

$$\frac{U_{e_t^h}}{U_{c_t}} = p_t$$

$$\frac{-U_{n_t}}{U_{c_t}} = w_t$$

$$U_{c_t} = \beta E_t U_{c_{t+1}} \left\{1 - \delta + r_{t+1}\right\}$$

$$c_t + k_{t+1} - (1-\delta)k_t + p_t e_t^h = w_t n_t + r_t k_t$$

2. The firm maximizes profits:

$$Max \quad F(n_t, k_t, e_t^f) - w_t n_t - r_t k_t - p_t e_t^f$$

F.O.C:

$$w_t = F_{n_t}; \quad r_t = F_{k_t}; \quad p_t = F_{e_t^f}$$

3. The relative energy price is exogenous:

$$\ln p_t = (1-\rho)\ln p_{ss} + \rho \ln p_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim N(0, \sigma_p^2)$$

4. Markets clear:

$$c_t + k_{t+1} - (1-\delta)k_t + p_t\left(e_t^h + e_t^h\right) = F(n_t, k_t, e_t^f)$$

We focus on the competitive equilibrium of the economy

CALIBRATION

- We employ numerical methods to obtain a solution.
- The parameters are chosen to reproduce the main variables of the Spanish economy.
- We use standard values for key parameters of the model: the relative risk aversion, the elasticity of substitution between energy and non-energy consumption, the elasticity of substitution between energy and capital.
- We use oil prices rather than energy prices because (1) explain most of volatility and (2) oil and gas account for more than 75% of Spanish energy consumption.

$$\mathrm{U}\left(A_t, n_t\right) = \frac{\left[A_t^{1-\mu}\left(1-n_t\right)^{\mu}\right]^{\sigma}}{\sigma}$$

$$A_t\left(c_t, n_t, e_t^h\right) = \left[(1-\gamma)c_t^{\alpha} + \gamma e_t^{h\ \alpha}\right]^{1/\alpha}$$

1/(1-α): elasticity of substitution between energy and non-energy consumption

$$F(n_t, k_t, e_t^f) = n_t^{\theta}\left[(1-a)k_t^{-\nu} + a e_t^{f\ -\nu}\right]^{-\frac{1-\theta}{\nu}}$$

1/(1-ν): elasticity of substitution between energy and capital

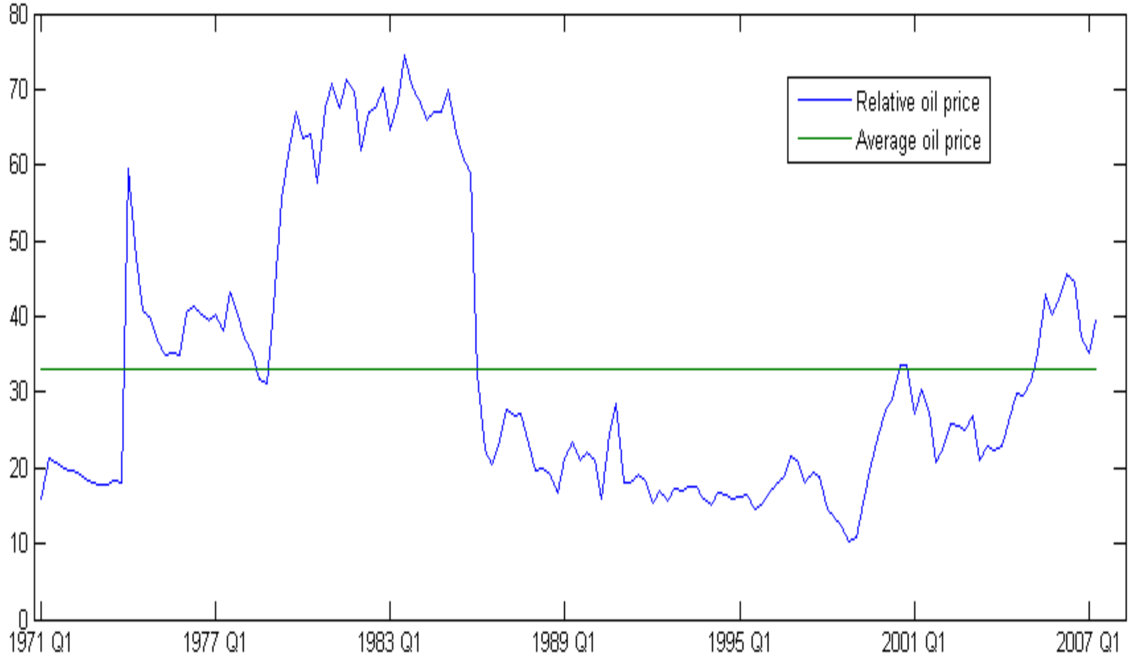
CALIBRATION

Table 1: Parameter values

Preferences		
Subjective discount factor	β	0.99
Energy consumption share	γ	0.036
Elasticity of substitution between energy and non-energy consumption	$1/(1-\alpha)$	0.85
Preference for leisure	μ	2/3
Risk aversion	σ	-1
Technology		
Labor share	θ	0.64
Rate of depreciation	δ	0.025
Elasticity of substitution between energy and capital	$1/(1+\nu)$	0.76
Prices		
Persistence	ρ	0.95
Standard deviation	σ_p	0.18

Computing the Welfare cost of Energy Insecurity

Relative oil price (€2000)



$$\mathrm{U}\left(c_{SS}(1-x), n_{SS}, e_{SS}^{h}\right) = E\left[\mathrm{U}\left(c_t, n_t, e_t^{h}\right)\right]$$

$$WC = x\frac{c_{SS}}{y_{SS}}$$

where:

$$E[U(c_t, eh_t, n_t)]$$

$$= U(c_{ss}, eh_{ss}, n_{ss}) + \left(\frac{\partial U}{\partial c_t}\bigg| c_{ss} \;\; \frac{\partial U}{\partial eh_t}\bigg| eh_{ss} \;\; \frac{\partial U}{\partial n_t}\bigg| n_{ss}\right) E\begin{pmatrix} c_t - c_{ss} \\ eh_t - eh_{ss} \\ n_t - n_{ss} \end{pmatrix}$$

$$+ \frac{1}{2}\left(\frac{\partial^2 U}{\partial^2 c_t^2}\bigg| c_{ss} \;\; \frac{\partial^2 U}{\partial^2 eh_t^2}\bigg| eh_{ss} \;\; \frac{\partial^2 U}{\partial^2 n_t^2}\bigg| n_{ss}\right) E\begin{pmatrix} (c_t - c_{ss})^2 \\ (eh_t - eh_{ss})^2 \\ (n_t - n_{ss})^2 \end{pmatrix}$$

RESULTS

	Benchmark model	γ=0
σ=-1	0.84%	0.026%
σ=0	0.83%	0.023%
σ=-5	0.91%	0.042%
1/(1-α)=0.5	1.59%	-
1/(1-α)=1	0.65%	-
1/(1+ν)=0.5	1.47%	0.50%
1/(1+ν)=1	0.77%	0.001%

- The welfare cost is large even in a competitive framework (0.84% of GDP in terms of consumption.
- Risk aversion has only slight effects on the estimation of the welfare cost.
- The elasticity of substitution of energy in the preferences and technology affects the welfare cost. The larger the elasticity of substitution the smaller the welfare cost.
- Most of the welfare cost comes from the household consumption of energy.

CONCLUSIONS and FUTURE RESEARCH

- We find that energy price fluctuations lead to significant welfare losses.
- Notice that our model represents an economy without distortions or rigidities. Welfare losses may be even higher.
- Most of the cost comes from households' energy consumption.
- The ability of the economy to encourage energy substitution for both households and firms is crucial to reduce the cost of energy insecurity.