Killing two birds with one stone: the US and the EU biofuel programs

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Why are biofuels being produced?

The biofuel programs have a dual objective:

- environmental (CO_2 mitigation, fuel oxygenation)
- agricultural income

⟹**How can both objectives be lead simultaneously?**

Fiscal incentives needed to develop biofuels

Even at the ongoing oil prices, biofuel production is still unprofitable in the EU and in the US.
⟹ Fiscal incentives have been established in order to bridge the gap between the market price of biofuels and their costs.

The agricultural policies could be profoundly altered:

To summarize, the production of energy crops could cause the following scenario:
The competition between food and energy uses ⇒ ↗ crop prices ⇒ ↗ Agricultural income ⇒ ↘ "traditional" agricultural payments.

Architecture of the model

The model involves two sectors (each modeled through a representative firm)

- An incumbent food sector "F"
- A newcomer: the energy sector "E"

Each sector buys the same homogeneous good from a competitive agricultural supply modeled by the inverse supply function $w(X)$, with $w'(.) > 0$.

Modelling the food sector

We postulate an increasing and concave production function for the food sector: $f_F' > 0$ and $f_F'' < 0$

The program of the representative firm of the food sector can be written as:

$$\max_{x_F} p_F f_F(x_F) - w(X) x_F$$

Modelling the biofuel sector

$$f_E(x_E) = \gamma_E x_E,$$

where γ_E is a positive parameter.

Assume that the energy firm cannot operate without subsidy since:

$$p_E \gamma_E < w(X_0),$$

where X_0 is the total quantity of crops bought by the food firm when no biofuel is produced.

$\Longrightarrow$ The energy sector receives a subsidy:

$$\sigma = w(X) - p_E \gamma_E$$

in order to attain the level Q/γ_E.

Quantity of food crops vs energy crops

As x_E increases, the aggregate quantity X increases and x_F decreases, i.e.

$$\frac{dx_F}{dx_E} \in [-1,0]$$

Hence:

$$\frac{dX}{dx_E} = 1 + \frac{dx_F}{dx_E} > 0$$

Who gains, who loses?

As x_E increases

- The agricultural surplus increases
- The consumers' surplus decreases
- The agro-food industry may gain ($|\epsilon_F| < 1$) or lose ($|\epsilon_F| > 1$)
- The biofuel sector makes no profit (perfectly adjusted subsidy)

The social welfare function

The regulator maximizes the following SWF:

$$\max_{x_E} \overline{\Pi}_A + \Pi_C(x_E) + \Pi_F(x_E) - (1+\lambda)\{T(x_E) + [\overline{\Pi}_A - \Pi_A(x_E)]\} + q x_E$$

$$s.t. x_E \geq Q/\gamma_E$$

The optimal production of energy crops

The first-order condition of the SWF leads to the following equation:

$$\lambda x_F w'(X) \frac{dX}{dx_E} + q - (1+\lambda)\{w(X) - p_E \gamma_E\} \leq 0 (x_E^* \geq 0)$$

This equation determines the optimal quantity of energy crops x_E^*.

Comparison with the Pigovian level

If $\lambda = 0$, we would have the following first-order condition:

$$q - [w(X) - p_E\gamma_E] \le 0 (x_E^* \ge 0)$$

which is the Pigovian rule: the optimal subsidy should equalize the marginal benefit of GHG mitigation.

The real cost of the biofuel program

Hence, if $\lambda > \lambda_s$, x_E^* is strictly positive and we have:

- if $Q/\gamma_E < x_E^*$, the biofuel constraint is slack and it is optimal to produce energy crops up to x_E^*.
- If $Q/\gamma_E > x_E^*$, the biofuel constraint is binding. However, the real cost of the environmental program should be calculated only on the residual quantity $Q/\gamma_E - x_E^*$.

The social welfare function with imports

The program has now the following form:

$$\max_{x_E, x_I} \overline{\Pi}_A - (1+\lambda)\{T(x_E+x_I) + (\overline{\Pi}_A - \Pi_A(x_E))\} + \Pi_F(x_E) + q(x_E+x_I)$$

$$s.t. x_E + x_I \ge Q/\gamma_E$$

Imports

First-order conditions of the program:

$$\lambda x_F w'(X)\frac{dX}{dx_E} - (1+\lambda)\{w(X) - p_E\gamma_E\} + q \le 0 (x_E^* \ge 0),$$

$$-(1+\lambda)(\overline{w} - p_E\gamma_E) + q \le 0 (x_I^* \ge 0)$$

Imports

if $\lambda > \lambda_N$, x_E^* is strictly positive and we have:

- if $Q/\gamma_E < x_E^*$, the biofuel constraint is slack and it is optimal to produce energy crops up to x_E^*.
- If $Q/\gamma_E > x_E^*$, the biofuel constraint is binding and it is optimal to produce energy crops domestically at level $\hat{x}_E > x_E^*$. Importations of raw material are given by $x_I^* = Q/\gamma_E - \hat{x}_E$.
- The internal price of agricultural feedstock verifies $w(X) > \overline{w}$ leading to subsidies $\sigma_E > \sigma_I$

Biofuels and the environment

Environmental policies and biofuel production

- Positive externalities of biofuels concerning GHG emissions.
- But: negative externalities in agricultural production (fertiliser and phytosanitary products), due to a more important feedstock production.

Let $C(X,e)$ denote the cost function of the representative farmer $(C_X = w.)$

Biofuels and the environment

The regulator chooses the optimal quantity of energy crops and the optimal level of environmental standard $\bar{e}$. Neglecting the constraint on the biofuel production, the agency program can thus be written as:

$$\max_{x_E, x_F, \bar{e}} \overline{\Pi}_A + CS + \Pi_F - (1+\lambda)[(C_X - p_E\gamma_E)x_E + \overline{\Pi}_A - \Pi_A] + B(x_E) - D(\bar{e})$$

$$s.t. EQFood$$

Biofuels and the environment

If $\lambda > \lambda_s$, and $Q = 0$, the optimal policy $\bar{e}^*, x_E^*$ and x_F^* is implicitly defined by

$$(1+\lambda)[C_X - p_E\gamma_E] - q = \lambda x_F C_{XX} dX/dx_E =$$

$$-\frac{C_{XX}}{C_{Xe}}\{-(1+\lambda)C_e - D'(\bar{e})\}$$

$\Rightarrow$ The optimal standard $\bar{e}^*$ is more stringent than the Pigovian level.

Conclusion

Biofuel policies might deeply alter agricultural and environmental policies.

- The support to the agricultural sector could be lowered (as the subsidies for biofuels partly substitute for them).
- Environmental issue will be crucial, with an intensive production of energy crops.