Dynamic and Static behaviour with respect to energy use and investment of Dutch greenhouse firms

Daphne M.I Verreth[1)], G. Emvalomatis[1)], F.Bunte[2)], A. Oude Lansink[1)]

1) Business Economics Group, Wageningen University, The Netherlands

Corresponding author: daphne.verreth@wur.nl.

2) Fontys Venlo, Food and Flower Management, the Netherlands

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Background

Dutch greenhouse horticultural firms:

- Energy-intensive and major emitters of greenhouse gases
- Forced by Dutch government to reduce their energy-use, decrease the quantity of CO2 emissions and invest in energy technologies
- Use combined heat and power equipment to exploit economies of scope in producing electricity, heating and CO_2 at the same time

To reduce energy use:

- Factor substitution and abatement activities
- New energy-saving technologies, but increase use of capital

Objectives

- To describe greenhouse firms` behaviour regarding energy use and investments in energy technology
- To determine the optimal quantities of energy inputs, both in short-run and long-run
- To derive the optimal quantity of energy and energy capital

Methods

- The behaviour of the firm with respect to the optimal use of energy is modelled in two stages
- A combination of dynamic cost minimization and a profit maximization framework
- Two-stage approach enables to stress the dynamic relations between energy capital accumulation and electricity production
- Dynamic model of adjustment of energy capita stock is used to determine optimal energy input quantities
- Short-run marginal cost of dynamic cost function is linked with the shadow price of static profit function. This linkage is used to derive the optimal quantity of energy

Results

- The own-price elasticity of electricity is divided into two parts:
  - an own-price elasticity with respect to firms which only use electricity as an input
  - an own-price elasticity with respect to firms which use electricity as an input as well as an output
- The energy elasticities show that less electricity will be produced (and sold to the grid) if the total quantity of energy increases.
- If the quantity of energy capital increases, a representative greenhouse firm will use more gas and produce more electricity as a netput
- The adjustment rate of capital toward the long-run equilibrium is 33.01%
- An increase in the price of capital induces firms to use more electricity as an input or to produce less electricity as an output

	Price vegetables	Price ornamentals	Price materials	Price electricity	Price gas	Price other energy	Price capital
Short-run elasticities							
Q. vegetables	0.174**	-0.032	-0.141**				
Q. ornamentals	-0.032	0.150	-0.118				
Q. materials	0.467**	0.396	-0.862				
Q. electricity[1]				0.511	-0.809	0.298	0.292
Q. electricity[2]				-2.335**	3.699**	-1.364	-1.339
Q. gas				0.589	-0.974*	0.386**	0.299
Q. other energy				-0.072	1.589	-1.517	2.475
Optimal Q. energy	1.671**	2.270**	-3.942**	-7.062**	-2.58**	9.638**	0.073**
Long-run elasticities							
Q. electricity[1]				6.739**	1.514	-8.253**	0.213
Q. electricity[2]				-30.82**	-6.92**	37.75**	-0.974
Q. gas				-1.104*	-1.60**	2.705**	0.315*
Q. other energy				-4.86	-0.239	5.098	2.302
Optimal stock capital				-1.672	3.433*	-1.76	-2.372
Optimal quantity of energy	2.566***	3.487**	-6.052**	-10.854**	-3.94**	14.797**	0.104

Note: Asterisk (*) and double asterisk (**) denote variables significant at 10% and 5% respectively
Note: Superscript (1) and superscript (2) denote firms which use electricity as netput and firms which use electricity as input only, respectively

Change (%) in quantity of CO_2 emissions		
Change of 1% in:	**Short run**	**Long run**
Price vegetables	0.394	0.404
Price ornamentals	0.536	0.549
Price electricity[1]	-1.078	-1.085
Price gas[1]	-1.582	-1.57
Price other energy[1]	2.659	2.652
Price capital[1]	0.317	0.307

[1] A direct price effect and an indirect price effect via the optimal quantity of energy contribute to the elasticities.

- Effects of a one percent increase in the input and output prices on the quantity of CO_2 emissions varies.
- Ad valorem taxes on the price of gas, electricity or capital result in a decrease of CO_2 emissions.
- If the price of capital increase, firms are less willing to invest in a CHP installation (which uses gas an input).

Conclusions

- Dutch greenhouse firms have a moderate rate of adjustment of energy capital towards its long-run equilibrium for the Dutch greenhouse sector.
- Investing in energy capital will reduce energy cost and will increase CO2 emissions.
- If firms invest in energy capital, they will use a larger volume of gas and other energy, and lower volumes of electricity as an input.
- An increase in energy capital results in an increase in the volume of gas and electricity as a netput (produced electricity)
- Incentives to invest enhance the use of energy technologies by greenhouse firms.
- Dutch greenhouse firms shift from being net electricity users to net electricity producers in the long run.

WAGENINGEN UNIVERSITY
WAGENINGEN UR

Business Economics Group
Wageningen University
E-mail: Daphne.Verreth@wur.nl