INVESTMENTS IN ENERGY-SAVING SYSTEMS IN DUTCH HORTICULTURAL FARMS

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ABSTRACT

In the Netherlands the greenhouse sector is a major user of energy. It accounts for 7% of the total amount of energy used in the Netherlands and for 79% of the total amount of energy used in agriculture. In order to sustain this sector on the long term, it is important that its use of energy is lowered. One way of reducing energy use for horticultural producers is investing in energy–saving systems. The purpose of this paper is to provide a better understanding of the investment behavior of farm operators. A two-stage econometric model has been applied to analyze the factors influencing the decision of farmers to invest and the level of investments.

Key words: investments, two-stage model, management theory, option value, adjustment costs

INTRODUCTION

The adoption of energy-saving technologies is an actual topic in Dutch greenhouse horticulture. This sector is an important user of energy. It accounts for 7% of the total amount of energy used in the Netherlands and for about 79% of the total amount of energy used in agriculture (Oude Lansink et al., 2001). The government and the sector itself put a lot of effort in reducing the use of fossil energy. Although growers have reduced energy use considerably, monitoring of greenhouse horticulture shows that additional efforts will be needed to meet energy agreements (Van der Velden et al., 1999).

An important option for horticultural farmers to reduce energy use is investing in energy–saving systems (Oude Lansink et al., 2001).

The purpose of this paper is to provide a better understanding of the investment behavior of farm operators in relation to the adoption of energy-saving systems. In this regard the following objectives of this research can be stated

- To analyze factors underlying the decision to invest.
- To analyze factors underlying the optimal size of investments.

Three investment theories are discussed in order to construct a theoretical model of investment: management theory of investment, option value theory and neo-classical adjustment cost theory of investment. Management and option value theories are used to explain investment decisions. Neo-classical adjustment cost theory of investment is used to explain the level of investments.

MANAGEMENT THEORY

Management theory of investments emphasizes the importance of different variables related to farm-specific and personal characteristics of farm operators. Personal characteristics include age of farm operators, family size, and availability of a successor. A lower age or the presence of a successor results in a longer time horizon taken into account by a farm operator, which

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in turn, implies that the future costs and benefits of investments are discounted over a longer period. This may increase the expected profitability and consequently the probability of the investment. A farmer with a large family may be more risk averse, resulting in less investment decisions. On the other hand, a large family size may have a positive influence on investments, because when more “own” labor is available, the share of fixed costs is decreasing (Oude Lansink et al., 2001). Farm-specific factors that can motivate farmers to invest are: profitability of investment, solvency, liquidity and net profit of the farm.

The most widely used method for ranking investment alternatives in term of profitability is the Net Present Value (NPV) method (Barry et al., 1995). If the NPV of current and future cash flow is positive, an investment is profitable.

However if a farm is in a bad financial situation an investment will not take place even if it is profitable from the farmer’s point of view. Therefore, liquidity and solvency are assumed to affect investment levels as well (Oude Lansink et. al., 2001). Liquidity refers to cash money available for investments. High solvency motivates farmers to invest and implies that farmers are less dependent on banks (Barry et al, 1995). Consequently, because of lower risk for banks, farms with higher solvency pay a lower interest rate on capital compared to farms with lower solvency.

Net profit of the farm is the sum of net cash operating income, the value of farm products produced on the farm and consumed by the household, total net adjustment for inventory, and total net capital adjustment (Boehlje and Eidman, 1984). The higher the net profit of the farm the higher the probability that a farmer will invest.

Option Value Theories

According to Dixit and Pindyck (1994) “the ability to delay irreversible investment expenditure can profoundly affect the decision to invest”. Investment decisions in energy installations should account for this. A firm with an opportunity to invest is holding an option to wait for new information to arrive that could affect the desirability or timing of the expenditure. When a firm invests, it gives up this option. This lost option value is an opportunity cost that must be included as part of the cost of the investment (Dixit and Pindyck, 1994). Option value is determined by the current price of an underlying asset and by the degree of uncertainty about that price over the term of the option contract (Purvis et al., 1995). Investment expenditures are sunk costs and thus irreversible, when they are firm specific (Dixit and Pindyck, 1994). In case of energy-saving technology, investments are largely irreversible because most capital goods have no alternative application, and the variation in fuel price is an important source of uncertainty. In some cases investments in energy-saving technologies may not be profitable, when the energy price declines after a new technology is adopted (Hasset and Metcalf, 1993).

Neoclassical Adjustment Cost Theory

The theoretical model starts from the optimal value function that assumes to maximize the expected present value of profit. The optimal value function has the following form:

$$V(p_t, Q_t, Z_t) = \max_{I_t} \sum_{t=0}^{\infty} d_t E_t \left[\pi(p_t, Q_t, Z_t) - C(I_t) \right] \qquad \textbf{(1)}$$

Subject to $Q_{t+1} = I_t + (1 - \delta) Q_t$ (transition equation) (2)

In (1) V (.) is the optimal value function, is the discount rate which is defined as $d_t = \frac{1}{(1+r)^t}$, with r as the real interest rate; is the expectation operator.

$\pi(p_t, Q_t, Z_t)$ is the profit function, where , and are vectors of netput prices, fixed inputs and exogenous factors, and quantities of capital inputs, respectively

is the adjustment cost of the capital (I is the gross investments) nonnegative costs that attain their minimum value of zero when I=0 and includes:

1) the purchase or sale costs (costs of buying or selling uninstalled capital),

2) fixed costs per time unit (nonnegative costs that are independent of the level of investment and are incurred at each point in time when investment is nonzero).

is the rate of depreciation.

The Bellman equation is used to solve maximization problem:

$$rV\ (p\ ,Q_t,Z_t) = \max_I \left[\pi(p_t,Q_t,Z_t) - C(I_t) + V_q(I_t - \delta Q_t)\right] \qquad (3)$$

According to Abel and Eberly (1994), investments are positive if the shadow price of capital exceeds the upper critical value and are negative if the shadow price is smaller than the lower critical value. The first order condition for optimal investments and the lower and upper shadow values of capital depend on marginal adjustments.

In order to obtain the first order condition for optimal investments, it is necessary to differentiate the Bellman equation with respect to investment:

$$V_q(p,Q,Z) = C_I(I^*) \qquad (4)$$

Where V_q is the unobserved shadow $I^*(p,Q,Z)$ price and is the optimal investment.

Econometric models of investments in energy saving systems should account for irreversibility of investments. Adjustment cost theory is frequently applied in econometric models of investment. Usually, adjustment cost theory assumes that the adjustment cost function:

1) can be differentiated at any point

2) strictly convex, which means that marginal adjustment costs increase with the size of investment at an increasing rate

3) zero investments do not entail costs and the first derivative at zero investment equals zero

4) symmetric around I=0, that is investments and disinvestments involve the same costs at equal absolute levels of gross investment I (Oude Lansink et al., 2000).

However, when investments are irreversible, the adjustment cost function is not symmetric around the zero. Marginal adjustment cost $C_I(0)$ may not exist at the zero investment level. Taking into account irreversibility of investments, the optimal investments meet:

$$I^*(p,Q,Z) = 0 \qquad \text{if} \qquad V_q(p,Q,Z) \le C_I^+(0) \qquad (5)$$

$$V_q(p,Q,Z) = C_I(I^*) \ \text{ and } \ I^*(p,Q,Z) > 0 \quad \text{if} \quad V_q(p,Q,Z) > C_I^+(0) \qquad (6)$$

Where is the upper limit of the first derivative of C with respect to I when from the right. Consequently, if the shadow price for capital is more than the marginal adjustment cost, than positive investment is observed, otherwise optimal investment is zero (Oude Lansink and Pietola, 2000).

Empirical Model

In this study an empirical model of investment decisions consists of two-stage decisions:

1) whether or not to invest,
2) 2) if the decision is to invest then how much to invest.

An important consideration in quantifying investment decisions is the existence of a large number of zero observations in the data set. Excluding farms with zero investments from the sample leads to a sample selection bias and biased regression parameters. Sometimes farmers do not invest because of insufficient financial capital (Elhorst, 1993) and sometimes they do not invest because they have invested a lot in previous years. Therefore, it is important to include zero as well as non-zero observations in the estimation procedure.

The Cragg's model, also known as the Double Hurdle model, was selected for this purpose. It allows one set of parameters to determine the probability of a limit observation, and a second set of parameters to determine the density of the non-limit observation (Cragg, 1971; Blundel and Meghir, 1987).

Cragg's Model

The Cragg's model implies that farmers have to overcome two hurdles:

1) they have to develop a willingness to make investments
2) they have to decide the optimal level of investments.

Taking into account the Cragg's model the following can be written:

$$I_i = \begin{matrix} I_i^*\text{, if } I_i^* > 0 \text{ and } D_i = 1 \\ 0\text{, if } I_i^* \leq 0 \text{ and } D_i = 0 \end{matrix} \qquad (7)$$

Where

I_i is the observed investment expenditure

I_i^* is the corresponding latent value that includes the level of investment

D_i is a latent variable and describes the decision to invest

$$I^*{}_i = \beta' X_i + e_i \qquad (8)$$

$$D_i = \gamma Z_i + w_i \quad (9)$$

X_i is the vector of explanatory variables in the linear regression model

β' and γ' are the row vectors of parameters

Z_i is the vector of variables that affect the decision to invest.

e_i and w_i are error terms

$$e_i \sim N(0,\sigma_e^2) \quad \text{and} \quad w_i \sim N(0,1) \text{ so that } P_i = \Phi(Z_i \cdot \gamma')$$

DATA DESCRIPTION

The data used in this study were taken from a sample of Dutch horticultural farms included in the Farm Accountancy Data Network of the Agricultural Economics Research Institute

Table 1. Description, mean and standard deviation of the variables used

Name of variables	Description	Mean	SD
Decision to Invest			
FIRMSIZE	Standard Farming Units	745.2	566.8
FAMSIZE	Number of family members	2.5	1.2
AGE	Age of firm operator	45.9	10.1
AGE^2	Age square	2106.8	938.5
SUCCESS	=1 if successor is available	0.7	0.5
LIQUID	Availability of liquidity	250.9	419.0
SOLVEN	Ratio of equity to total assets	0.5	0.3
MODGL	Book value/replacement value of glassh.	0.3	0.2
MODIN	Book value/replacement value of install.	0.3	0.2
MODMACH	Book value/replacement value of mach	0.5	0.3
REALRES	Real net firm result*	8.7	57.9
PRVAR	Price variance in energy	0.1	0.2
FLOWER	Specialized Flower firm=1,=0 otherwise	0.4	0.5
POTPLANT	Specialized Potplant firm=1,=0 otherwise	0.4	0.5
Level of Investment			
CAPGLASS	Capital in greenhouse*	431.1	377.7
CAPINST	Capital in installations*	159.4	191.1
LAB	Man years	1.1	0.1
ENERGP	Prices for gas ,oil, electricity	1.1	0.1
MATERP	Prices for materials	0.9	0.1
SERVP	Prices for services	7.1	4.9
Dependent variable			
INVINST	Investments in energy installations	26.2	58.6

* In1000 Euros

(LEI). Observations for the period 1990-1998 are taken into account. The data set is an unbalanced panel. The sample used in the analysis consists of 1879 observations on 397 farms. The data set contains observations of three different farm types: farms specialized in cut-flower production, pot-plant production and vegetables production.

Table 1 gives a description of the explanatory variables used in this study. Tornquist indices are calculated for output and inputs with prices obtained from LEI/Statistics. The price indices vary over the years but not over the farms, implying differences in the composition of netput or quality differences are reflected in the quantity (Cox and Wohlgenant, 1986). Implicit netput quantity indexes were generated as the ratio of value to the price index. For calculating the real expenditure, price indexes were used of the particular assets with base year 1990. The price of energy includes prices of gas, oil, electricity and also delivery of thermal energy by electricity plants. The price of materials covers prices of seeds and planting materials, fertilizers, pesticides and other materials. The price index of services includes services by contract workers and services from storage and delivery of output. The price of output consists of prices of flowers and pot-plants.

Variance of oil prices is used in this research as an indicator of uncertainty. The variance of the price i in year t is calculated using the difference between actual prices at time t and expected oil prices at time t-1(Oude Lansink et al., 2001).

Capital invested in structures (buildings, greenhouses and land) and installations is measured at constant 1990 prices and is valued at replacement cost. Modernity of different capital goods is determined as the ratio of book value and replacement value of the machinery and reflects the need for replacement investments. Solvency is measured as a ratio of equity to total assets. Liquidity of the farm is related to the level of cash, marketable securities, and other current assets it holds. Net farm result is defined as the difference between gross revenues and total costs. Farm size is measured in standard farming units. Labor is measured in man-years and includes family as well as hired labor. Other farm characteristics that may affect investments in

Table2. Parameter estimates of RE Probit Model

Variable	Coefficient	T-value	P-value
CONSTANT	-0.748	-0.961	0.336
FLOWER	0.213	1.665**	0.096
POTPLANT	0.294	2.310*	0.020
FIRMSIZE	0.001	7.260*	0.000
FAMSIZE	0.085	2.095*	0.036
AGE	-0.004	-0.101	0.919
AGE^2	0.000	0.079	0.937
SUCCESS	0.376	3.768*	0.000
LIQUID	0.000	0.489	0.625
MODGL	-0.004	-0.014	0.988
MODIN	0.648	1.826**	0.067
MODMACH	0.346	2.595*	0.009
SOLVEN	0.277	2.169*	0.030
PRVAR	0.106	0.539	0.589
REALRES	0.001	1.648**	0.099
ρ	0.252	6.173*	0.000

Log likelihood	-1077.389
Restr. Log likelihood	- 1182.898

count R^2 =0.70; χ^2 =55.205

* Significant at 5% level

**Significant at 10% level

energy installations are age of farmer, availability of a successor and family size. The importance of these variables has been discussed in the theoretical model of this study.

Estimation Method

The Cragg's model is a combination of a Probit model and a Truncated regression model. The model is estimated in two steps: by using the Probit model for the indication whether or not investments are positive and the Truncated regression model for determining the level of investment at non-zero observations. The Cragg's model consists of estimated coefficients for equations (8) and (9). In the first stage the dependent variable is a dummy variable (DINVEST), which takes value one if investments in energy installations are positive and zero otherwise. Independent variables are farm size, family size, age of farmer, age square of farmer, availability of successor, liquidity, solvency, real net result of the farm, modernity of greenhouses, machinery and energy installations (seeTable1). In the second stage the dependent variable is investment in energy installations (INVINST); the dependent variables consist of the capital in greenhouses, capital in installations, energy price, material price, service price and labor (see Table 1).

Empirical Results

Results of the Probit Model

The Probit model includes the estimated coefficient for equation (9). The model is estimated using the Random Effect (RE) Maximum Likelihood estimation method.

Results of the Maximum Likelihood estimation (see Table 2) reveal that 6 coefficients are significant at χ^2 χ^2 the critical 5% level and 3 coefficients are significant at a level of 10%. χ^2 χ^2

The -value indicates that all parameters are jointly significant at the critical 5% level (=55.205; critical at 5% =3.8).

The probability to invest in energy-saving installations is significantly higher in pot- plant farms ($P<0.05$) and farms specialized in cut flower ($P<0.1$) than in farms specialized in vegetables production. A possible explanation for this is that pot-plant and cut flower farms have better economic prospects.

Table 3.Number of Predicted and Actual Investments

	Predicted		
Actual	0	1	Total
0*	135	473	608
1**	76	1195	1271
Total	211	1668	1879

*No investment
** Positive investment

Farm size is an important factor in explaining the decision to investment in energy-saving installations. Large farms, ceteris paribus, have higher probabilities of investments in energy installations than small-scale farms, because they use more energy than small farms and therefore experience economies of scale. Family size has a significant and positive impact on investment decisions. A supposed relation between family size and risk aversion seems to play a less important role than expected.

In line with prior expectations, availability of a successor has a significant and positive impact on the investment decision.

Results show that modernity of machinery and energy installations has a positive significant impact on the investment decision. This relationship is explained by the fact that farmers with modern equipment and installations are willing to make frequent investments in order to keep their installations up-to-date.

In line with prior expectations, solvency has a significant positive impact on the decision to invest. This result suggests that high solvency motivates farmers to make investments because they are less dependent on banks. Consequently, farms with higher solvency pay a lower interest rate for capital compared to farms with a lower solvency because of low risk on repayments.

Table 4. Parameter estimates of RE Truncated Model

Variable	Coefficient	T-value	P-value
CONSTANT	6.434	0.114	1.003
CAPGLASS	-0.003	-0.530	0.596
CAPINST	0.030	5.681*	0.001
LAB	1.461	4.312*	0.000
ENERGP	49.659	0.794	0.427
MATERP	-106.493	-1.461	0.144
SERVP	57.134	1.003	0.315

Log likelihood -6637.073
* Significant at 5% level

As expected, real net farm result has a positive significant ($P<0.1$) influence on investment decisions.

The parameter has a significant impact on investment decisions. This parameter is the ratio of the farm-specific effects and the total variance. This implies that other factors such as location of the farms and other unobserved factors that are not captured in data set significantly contribute to the explanation of investment decisions.

Other factors such as age of farmer, age square of farmer, liquidity, modernity of greenhouse and energy-price variance appear to be not significant (at 5 or 10 % critical level).

The predictive power of the model (count R2) is calculated by comparing the actual and predicted investments (seeTable 3). Seventy percent of the predictions for investments in energy installations are correct (0 prediction if actual decision is 0 and 1 prediction if actual decision is 1). Moreover looking at positive investments only (value 1), 94% is predicted correctly, indicating that the RE Probit model predicts positive investments with precision.

Results of the Truncated Regression Model

The Random Effect (RE) Truncated model is applied in order to be consistent with the RE Probit Model. The number of observations is limited to 1271 due to the specification of the Truncated Regression model. Results show that only two parameters are significant at the critical 5% level (seeTable 4).

Capital in energy installations has a positive significant influence on the level of investments, which means the more capital in (existing) energy installations the higher the level of investments. One explanation may be that investments in energy-saving systems require more investments next years to keep installations up-to-date. Another explanation may be that a high level of installations also requires a high level of replacement investments.

Labor has a positive significant impact on the level of investment. Labor can be viewed as a complement of capital in energy installations, which means that the number of workers increases the opportunity of good returns on investments in energy installations.

CONCLUSIONS

The Dutch greenhouse sector is an important user of energy. In order to sustain this sector on the long term, it is important that its use of energy is lowered. Three investment theories are discussed in order to construct a theoretical model of investment. Management and option value theories are used to explain investment decision. Neo-classical adjustment cost theory of investment is used to explain the level of investments. The Cragg's model is used to reveal the factors that determine the decision of farmers to invest and the level of investments.

The results are highly consistent with management theory and reveal that capital in energy saving systems and labor are major determinants of the level of investment. Variation of energy prices is used as an indicator of uncertainty in order to test the option value theory However, the parameter estimates indicate that the impact of energy-price variation on investment decision is not significant. For future research, it might be interesting to include other sources of uncertainty in the model (e.g. technological change, governmental regulations, etc.). Another possibility for future research is to analyze factors that determine investment (level)s in specific energy-saving technologies.

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