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Investment decision making in Dutch greenhouse horticulture

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Abstract

Panel data from Dutch horticultural firms over the period 1986–1998 were used to analyse the effects of different factors on investment decisions. The factors analysed relate to the firm operator and his family, the firm structure and the economic environment. Results show that firm-operator and firm-family related characteristics play an important role in investment decision making. Moreover, variables that indicate the ability of the firm to attract debt capital and fulfil financial obligations, like firm size, solvency and net firm result, have a positive impact on investment decisions.

Keywords: horticulture, investments, random-effects probit model, panel data.

Introduction

Investments in capital assets are an important determinant of structural change in the agricultural sector of the Netherlands, particularly in its highly capitalized greenhouse industry. The Dutch greenhouse 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 energy used in agriculture. This sector signed an agreement with the government aiming at reducing the use of energy. The agreement entails a reduction of the energy use per unit production (vegetables, pot plants or cut flowers) of 65% over the period 1980–2010 (Anon., 1997). Although growers have considerably reduced the energy use per unit production, monitoring of greenhouse horticulture shows that serious efforts will be needed to achieve this target (Van Der Velden *et al.*, 1999).

An important option for horticultural producers in increasing energy use efficiency is investing in energy-saving technologies. Model calculations indicate that for many horticultural firms, additional investments in energy-saving technologies are profitable (Van Der Velden, 1996). In order to stimulate investments in new technologies, a better insight is needed into factors that explain investment decisions.

The purpose of this article is to provide a better understanding of factors underlying investment decisions of producers in Dutch horticulture. The categories of investment considered are *greenhouses*, *machinery* (mobile equipment like tractors and harvesting tools) and *installations* (immobile equipment like heaters). Factors that are analysed are related to the firm operator and his family, the firm structure and the economic environment. The paper uses econometric estimation and accountancy data from horticultural firms over the period 1986–1998. Using data at firm level means that the variation between firms must be taken into account. Firm operators may have different management experience and skills. Moreover, firms may differ because of factors related to the location of the firm and the quality of the inputs. Such firm-operator and firm-specific factors can usually not be inferred from farm accountancy data. This paper accounts for these factors by applying a random-effects specification.

Investment theories

Two investment theories are discussed to provide a conceptual framework for modelling investment decisions, i.e., the *management theory of capital budgeting* and the *option-value theory*.

Management theory of capital budgeting

Investment decisions are among the most important managerial tasks of an entrepreneur (Boehlje & Eidman, 1984; Lee *et al.,* 1988). As a rule, the actual investment decision is preceded by a procedure for evaluating the effects of a firm-operator's investment choice on firm results. This procedure is called capital budgeting. Capital budgeting is an orderly sequence of steps that produce information relevant to an investment choice. These steps include (i) defining the firm's objectives, (ii) identifying alternative investment opportunities, (iii) determining an appropriate selection method, (iv) collecting relevant data, and (v) taking an investment decision (Barry *et al.*, 1995).

Based on the firm-operator's personal goals, several alternative investment opportunities are identified. These investment opportunities may concern maintenance and replacement of depreciable capital items, adoption of cost-reducing or income-increasing investments, or a combination of the two. The most important step of the decision process is choosing and carrying out a method for ranking, accepting, or rejecting the investment alternatives. In evaluating the investment options, the profitability and the financial feasibility are taken into account. A frequently used method for calculating the profitability of investment alternatives is the Net Present Value (NPV) method. If the NPV of current and future cash flows is positive, the investment is profitable. An investment is financially feasible if the annual net cash flow exceeds principal and interest payments. Firm size, solvency, and labour supply by family members usually have a direct effect on the NPV of investment alternatives and consequently on (the probability of) investments made (Barry *et al.*, 1995).

Management theory stresses the importance of different firm-operator and firm-specific variables in explaining investments. Personal goals of the firm operator may be represented by his own characteristics (e.g. age), but may also be related to the family (e.g. family size, availability of a successor). Age and availability of a successor are factors related to the life cycle of families. A lower age and the presence of a successor means that the firm operator can take a longer time horizon into account. A longer time horizon implies that future costs and benefits of investments are discounted over a longer period, and that the profitability of investments increases. Firm-specific characteristics that determine the profitability of investments are solvency, liquidity and economic performance. The higher these characteristics the more likely a firm operator will invest in new capital assets. Finally, the need for replacement investments depends on the firm's modernity of the capital assets.

The adjustment cost theory (Eisner & Strotz, 1963; Lucas, 1967; Gould, 1968) can be seen as an extension of the management theory of capital budgeting. It takes into account the costs associated with the purchase, productive implementation or sale of capital goods (Nickell, 1978). These costs of reorganization, retraining or the teething troubles involved in the adoption of new equipment are assumed to increase with the size of the investments. Costs of adjustment can explain why firms tend to conduct investments in smaller proportions, spread over time, rather than to adjust to new conditions instantaneously. Because the purpose of the present study is to better understand factors underlying investment decisions, rather than the size of the investments, the adjustment theory has not been further elaborated in the empirical section of this paper. Moreover, adjustment cost theory is not an appropriate framework for explaining investments that are lumpy by nature, as this theory imposes the restriction that investments are a continuous variable.

Option value theory

The foregoing shows that the NPV rule plays an important role in management theory, i.e., it explains investments. The NPV decision criterion generally predicts investments correctly when anticipated expenses and receipts of investment alternatives are relatively certain and when the investments are reversible, or sunk costs are insignificant (Purvis *et al.*, 1995).

The NPV rule implies that investments are reversible and that the option of delaying investments is overlooked. If the option value of delaying investments – in order to wait for new information – is not accounted for, the NPV rule could give misleading predictions and could recommend investment at too low returns. Nevertheless, the NPV rule can be modified and applied such that it capitalizes on favourable future opportunities and reacts so as to mitigate losses (Trigeorgis, 1997). These modifications of the NPV rule are most often referred to as *the real options approach to investment.*

A firm with an opportunity to invest is holding an option to buy an asset. A firm that makes an irreversible investment outlay exercises its option to invest. Besides, it gives up the possibility of waiting for new information that could affect the desirability or timing of the expenditure. This lost option value is an opportunity cost that must be accounted for as part of the cost of the investment.

The option value theory helps to explain why the actual investment behaviour of firms frequently differs from that predicted by the orthodox NPV rule. Previous studies show that firms that account for the option value do not invest in projects that are expected to yield a return in excess of a required hurdle rate equal to three or four times the capital cost (Summers, 1987). This option value is highly sensitive to uncertainty over the future cash flows of an investment. Therefore, changing economic conditions that affect the perceived risk of expected cash flows have a large impact on investment spending.

The option value theory shows the need for incorporating uncertainty in the analysis of investment decisions. Moreover, the option value theory provides a theoretically consistent explanation for the observation – from firm data – that in certain periods firms often do not invest despite a positive NPV of investment alternatives (Dixit & Pindyck, 1994).

Empirical model

Research that aims at explaining investments using firm-level data is frequently founded on a statistical method that does not correspond with the complexity of the actual investment decision (Elhorst, 1989). Inspection of firm data shows that investments take place in a limited number of years, frequently followed by a period without investments. The usual assumption of independent and identically distributed errors is not valid when applying ordinary least squares (OLS) for estimating the model (Amemiya, 1984; Elhorst, 1987).

A solution could be the elimination of the zero observations. However, this is not correct, since excluding observations with zero investment expenditures from the sample creates a sample selection bias. Furthermore, it should be noted that firms that do not invest might display economically rational behaviour. So eliminating zero observations also implies a loss of information (Elhorst, 1993).

Another possibility is to set up a model in which the investment decision is specified in binary form (i.e., 1 if there is investment, and 0 otherwise). In this case the dependent variable is non-continuous, so the usual OLS method cannot be applied. A disadvantage of binary-choice estimation models is the limited use of information contained in the data, i.e., information about the size of the investment is ignored. Observations are grouped into observations with zero and observations with non-zero investments, irrespective of the size of the investment. However, this is not problematic in studies – like the present one – that focus on explaining investment decisions, i.e., whether firm operators will or will not invest.

Binary choice models assume that individuals are faced with a choice between two alternatives and that their choice depends on various underlying factors (Pindyck & Rubinfeld, 1991). In case of investment decisions in Dutch greenhouse horticulture, the objective is to predict the likelihood that a firm operator decides to invest in a capital asset dependent on a number of explanatory factors.

The probit model is a binary choice model that is associated with the cumulative normal probability function. This model assumes a continuous variable Z_i^* as the dependent variable. With N individuals and T different time periods, the relation between Z_{it}^* and the explanatory variables is given by the following equation:

$$Z_{it}^* = \beta' \cdot X_{it} + \varepsilon_{it} \qquad i = 1,..,N,\ t = 1,..,T \tag{1}$$

where
Z_{it}^* = variable reflecting the preference of individual i for investing in period t,
β = parameter vector,
X_{it} = matrix of explanatory variables for individual i in period t,
ε_{it} = composite error term.

In the case of investment decisions, Z_i^* is an unobserved latent variable indicating the willingness of a firm operator to invest. If Z_i^* exceeds a critical value (0), the incentive to invest is sufficient to undertake the actual investment. Defining a dummy variable Z_i, the decision rule translates into:

$$\text{invest if } Z_i^* > 0,\ Z_i = 1 \tag{2}$$

$$\text{do not invest if } Z_i^* \leq 0,\ Z_i = 0$$

The role of various farm-specific factors in explaining the investment decision of an individual farmer can be determined by formulating a random-effects probit model. The random-effects model uses the fact that the data are from a panel of firms, i.e., each firm is observed over a number of years. The random-effects probit model is incorporated in Equation 1 by specifying the composite error term (ε_{it}) as follows:

$$\varepsilon_{it} = u_i + v_{it} \tag{3}$$

where
u_i = time-invariant firm-specific component, and
v_{it} = independent and identically distributed random error with 0 mean.

The parameter u_i is time-invariant and accounts for firm-specific variables not accounted for by the explanatory variables represented by X_i, like managerial skills of the firm operator or factors related to firm location. Importantly, the firm-specific component (u_i) picks up factors that are not observed in the data. The probit specification assumes that the random error (v_{it}) follows a normal distribution. The variance (var) of the composite error term and the correlation (cor) between two composite errors of the same firm are given by the following two equations:

$$\text{var}\,[u_i + v_{it}] = \text{var}\,[\varepsilon_{it}] = \sigma_u^2 + \sigma_v^2, \qquad \text{cor}\,[\varepsilon_{it}, \varepsilon_{is}] = \rho = \sigma_u^2 \big/ (\sigma_u^2 + \sigma_v^2) \tag{4}$$

Within the random-effects probit model the parameter vector β (= β_*/σ_v) and the correlation term of the unobservable farm-specific term (ρ) are estimated.

Data

The data used in this study were derived from a sample of Dutch horticultural firms included in the Farm Accountancy Data Network of the Agricultural Economics Research Institute (LEI). Annual data from greenhouse firms for the period 1986–1998 were used for the estimation of three random-effects probit models, one for each category of investments. The firms usually remain in the panel for about five years; the data set forms an unbalanced panel. The sample used in the analysis consists of 3006 observations on 768 firms.

Table 1 gives a description of the variables that are used in this study. Decisions to invest or to not invest are represented by dummy variables for investments in greenhouses, installations and machinery. The dummy variable of an investment in a capital asset takes the value 1 if the real annual investment in the concerning capital good exceeds Dfl. 5000 (€ 2269). Expenditures smaller than Dfl. 5000 are considered as insignificant investments and the dummy takes the value 0. For calculating the real expenditures, price indexes were used of the particular assets with base year 1980.

The following variables derived from the management theory of capital budgeting were included in the model: firm size, solvency, economic performance, liquidity,

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

Name of variable	Description	Mean	SD
Invglass	= 1 if investment in greenhouse > Dfl. 5000 [1]	0.13	0.34
Invinst	= 1 if investment in installations > Dfl. 5000 [1]	0.54	0.50
Invmac	= 1 if investment in machinery > Dfl. 5000 [1]	0.36	0.48
Size	Standard Farming Units	693.33	535.21
Famfirm	= 1 if family runs the firm; = 0 otherwise	0.85	0.35
Fammem	Number of family members	2.46	1.11
Age	Age of firm operator	45.63	9.88
Succ	= 1 if successor available or age <40	0.66	0.47
Liquidity	Availability of liquidity	225.19	379.44
Solvency	Solvency (ratio of equity to total assets)	0.55	0.33
Modgl	Book value/replacement value of greenhouse	0.34	0.21
Modin	Book value/replacement value of installations	0.31	0.16
Modma	Book value/replacement value of machinery	0.48	0.31
Realres	Real net firm result	−7.80	127.23
Prvar	Price variance	7.95	16.23
Trend	1986=1, 1987=2, etc	6.94	3.78
Flower	Specialized flower firm = 1; = 0 otherwise	0.40	0.49
Potplant	Specialized potplant firm = 1; = 0 otherwise	0.22	0.41

[1] In 1000 Dfl. of 1980. (Dfl. 1000 = € 454)

modernity of the firm, family size, age of the operator, and availability of a successor. Firm size (*size*) is measured in standard farming units, and is a measure of the income-generating capacity of the firm.

Famfirm and *fammem* represent characteristics related to the family of the firm operator. Family members may have a positive effect on investments by increasing the labour force on the firm and decrease the share of fixed costs. Moreover, family members may contribute to the family income by working off the firm. However, firm operators with large families may also be more risk averse. So the number of family members can have a negative impact on investments. A number of variables – the *age* of the entrepreneur, the age squared and the presence of a *successor* – are included as a measure of the firm-operator's planning horizon. They indicate the time period in which the farmer can expect future cash flows of the investment.

Liquidity and *solvency* are expected to increase investments in capital assets. *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.

The real-options theory hypothesizes that uncertainty has a negative impact on investment decisions. Variance of oil prices can be used as an indicator for this and was therefore included in the model. Oil prices are selected because energy costs comprise a large part of variable costs on Dutch greenhouse firms and because oil prices are subject to large fluctuations. Annual variance of oil prices is measured as the variance of the mean expected oil prices in year t. It is assumed that future oil prices are unknown at the time the producer decides on investments in different capital goods. So expected rather than actual prices are relevant to producers. Expected annual oil prices are determined by applying an AR(1) filter to the actual oil prices (Judge *et al.*, 1988). Next, following Coyle (1992) and Oude Lansink (1999), the variance of the price of i in year t (*Prvar*) is calculated using the differences between actual prices at time t (p_t) and expected oil prices at time t–1 ($E_{t-1}p_t$) according to the following equation:

$$\mathrm{var}_t(p^i) = 0.50\,(p^i_{t-1} - E_{t-2}\,p^i_{t-1})^2 + 0.33\,(p^i_{t-2} - E_{t-3}\,p^i_{t-2})^2 + 0.17(p^i_{t-3} - E_{t-4}\,p^i_{t-3})^2 \qquad (5)$$

The *Trend* variable was included in the model to represent e.g. technological changes that affect the investment decision. Finally, two variables were included in the model to distinguish between three different firm types: (i) firms producing mainly vegetables, (ii) firms producing mainly cut flowers, and (iii) firms producing mainly pot plants. Two dummy variables represent these firm types, where vegetables firms act as the reference type, i.e., parameters associated with *Flower* and *Potplant* indicate deviations from the investments at vegetables firms. Investment decisions are expected to differ between firm types since different firm types have different capital requirements and use different production technologies.

Results

The equations for investments in different capital assets are estimated using the random-effects probit model. Table 2 lists the estimated parameters and corresponding t-values. Fifty-three, 47 and 60% of the parameters are significantly different ($P < 0.05$) from zero in the equations for investments in greenhouses, installations and machinery, respectively.

The trend is negative and statistically significant ($P < 0.05$) in the equations for investments in greenhouses, installations and machinery (Table 2). This implies that in the period under consideration (1986–1998) the probability of annual investments decreased over time. Additional calculations have shown that in spite of the decreasing probability of investments, total annual *expenditures* did not change importantly during the period.

The number of family members has a positive effect on the likelihood of making investments. This implies that the presence of family members probably reduces business risks by the reduction of the share of fixed costs and the contribution of family members to the income generation on the firm (off-firm labour).

Age of the firm operator has a negative effect on investments, whereas availability of a successor has a positive effect. These results are consistent with the observation that a lower age and availability of a successor increase the time horizon that firm operators use in evaluating the profitability of investments. Elhorst (1993) found a similar effect of successor on investments. The negative influence of the firm operator's age on the investment decision appears to be a non-linear relationship. This is because the positive parameter associated with Age^2 indicates that the marginal effect of age on the probability of investments increases, i.e., the effect becomes less negative with increasing age.

Firm size is an important aspect in explaining investment behaviour. Larger firms

Table 2. Parameter estimates and t-values of the three random-effects probit models.

Variable	Investment in greenhouses		Investment in installations		Investment in machinery	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Intercept	0.040	0.062	–0.107	–0.159	0.192	0.364
Trend	–0.058	–4.536	–0.029	–2.714	–0.050	–5.066
Famfirm	0.050	0.531	–0.034	–0.351	0.056	0.751
Fammem	0.136	4.316	0.111	3.466	0.077	2.788
Age	–0.071	–2.572	–0.027	–0.986	–0.054	–2.472
Age^2	0.001	2.197	0.000	0.598	0.001	2.333
Succ	0.168	1.721	0.236	3.088	0.159	2.121
Size	0.000	4.333	0.001	10.892	0.001	13.289
Flower	–0.051	–0.625	0.129	1.721	0.032	0.479
Pot-plant	0.290	3.184	0.003	0.032	0.209	2.584
Liquidity	0.000	0.543	0.000	0.196	–0.000	–1.363
Solvency	0.532	3.497	0.414	3.995	0.446	3.928
Modgl	–0.379	–1.912	–	–	–	–
Modin	–	–	0.596	2.760	–	–
Modma	–	–	–	–	–0.172	–1.655
Prvar	0.001	0.279	–0.001	–0.368	–0.004	–1.935
Realres	–0.000	–0.133	0.001	4.502	0.002	7.736
ρ	0.096	2.062	0.219	7.202	0.081	2.936

have higher probabilities of investments in greenhouses, installations and machinery. Because of economies of scale, investments are more profitable on large than on small firms. This holds in particular for capital assets requiring investments that are independent of firm size, like computers. Consequently, larger firms can generate higher net returns to such capital goods and therefore will invest more frequently.

The probability of investments in greenhouses and machinery is significantly higher on pot-plant firms than on firms producing vegetables. The favourable economic prospects of this sub-sector may explain the frequent investments on pot-plant firms. Results also show that specialized cut-flower firms do not have a probability of investments that is significantly different ($P < 0.05$) from vegetables firms.

Solvency has a large positive impact on the number of investments made, implying that firms with a high equity : total assets ratio have the possibility to pursue their own (investment) policy. In their investment activities they are less dependent on banks or other providers of capital. Moreover, firms with good solvency pay a lower interest rate for debt capital than firms with poor solvency. Beside this, firms with a high equity : total assets ratio are expected to be less risk averse since they have a larger capacity to cope with business risks. Results in Table 2 also show that liquidity has no significant effects on investments in the capital assets that are considered here. The availability of liquidity is no precondition for, nor does it provide an incentive to investment activities.

Real net firm result has a positive effect on the probability of investments in installations and machinery. Investments in greenhouses are not significantly influenced by the firm result. This implies that investments in greenhouses more likely depend on factors with little annual variation, like the firm's solvency. In a period with favourable firm results, and consequently high tax claims, relatively small investments in installations and machines appear to more frequent.

The parameter estimates of *Prvar*, indicating the effect of variation of oil prices on investments, are not significant for investments in greenhouses and investments in installations. However, a larger variation of oil prices has a significant ($P < 0.10$) impact on investments in machinery. So the results provide weak support for the hypothesis from real-options theory, i.e., that uncertainty has a negative impact on investment decisions.

Results also show that firms with modern greenhouses and machinery (high modernity) have a lower probability of investing than firms with less up-to-date assets. This indicates that replacement investments play an important role in investments in greenhouses and machinery. The positive impact of modernity on investments in *installations* indicates that firms with modern installations are also investing more frequently to keep their installations up to date.

The parameter ρ, representing the ratio of the variance of the firm-specific effects and the total variance, has statistically significant ($P < 0.05$) values for each of the three models. This implies that factors like entrepreneurial skills and firm location significantly contribute to the explanation of investments in greenhouses, installations and machinery.

According to the random-effects probit models, several factors significantly ($P < 0.05$) influence the firm-operator's investment decision. Overall assessment of the

Table 3. Number of predicted and actual investment decisions. 0 = no investments; 1 = positive investments. Total = total number of observations.

Actual	Predicted								
	Greenhouses			Installations			Machinery		
	0	1	Total	0	1	Total	0	1	Total
0	2596	15	2611	835	532	1367	1732	182	1914
1	388	7	395	455	1184	1639	708	384	1092
Total	2984	22	3006	1290	1716	3006	2440	566	3006

three models reveals that the probabilities of investing in each of the different investment categories are affected by more or less the same factors. *Famfirm*, *cut flower* and *liquidity* have no significant influence on the investment decision in each of the three investment categories. Possibly, their role is already explained by other factors included in the models.

The predictive power of the models is investigated by comparing the observed and predicted investment decisions (Table 3). The percentages of correct predictions (0 prediction if actual decision is 0; 1 prediction if actual decision is 1) for annual investments in greenhouses, installations and machinery are 87, 67 and 70, respectively. These values are satisfactory. However, when considering only the actual and predicted positive investments (value 1), these percentages decrease to 1.8, 61 and 35, respectively. This implies that the random-effects probit model does not predict positive investments in greenhouses accurately. This finding is quite common for probit models with very small shares of one category. In this case, the share of positive investments in greenhouses in the total number of observations is only 13%. Investments in installations and machinery are predicted much more accurately by the random-effects models.

Conclusions

This paper presents an analysis of the role of different factors in investment decision making on Dutch horticultural firms over the period 1986–1998. Decisions on investing in greenhouses, machinery and installations were analysed separately. Unobserved characteristics related to the firm, the firm operator and his family are accounted for by employing a random-effects probit model.

Most of the findings in this study are consistent with the management theory of capital budgeting. Factors that are expected to increase the time horizon like lower age and availability of a successor, or lower business risk (family members) have a positive effect on the probability of investing. Furthermore, factors that are expected to increase the ability of the firm to attract debt capital and fulfil financial obligations (real result, solvency, firm size, economic prospects), have a positive effect on decisions on investing in greenhouses, installations and machinery. Parameters associated with modernity show that replacement investments are important in investments in greenhouses and machinery. Investments in installations have a different character, i.e., firms with modern installations invest more frequently. This can be a result of characteristics of the firm operator – such as 'a drive to stay ahead of other firms' – that were not accounted for in the model.

Direct availability of cash as represented by liquidity has a negligible effect on investment decisions in all categories, but as the effects are not significant they do not contradict management theory,

Consistent with real-options theory, fluctuations in oil prices have a significant ($P < 0.10$) negative effect on investments in machinery. This effect was not found for investments in greenhouses and installations. It should be noted, however, that real-options theory hypothesizes that uncertainty *in general* has a negative impact on investments, irrespective of the source of uncertainty. Also, uncertainty of government policy and uncertainty of technical change are likely to affect investment decisions in Dutch greenhouse horticulture. These uncertainties were not accounted for in this study.

The wider implications of the results in this paper can be summarized along four lines. First, the negative effect of age and the positive effect of the availability of a successor suggest that policies that enhance the succession of firms by a younger generation could be successful in stimulating investments in all categories. Such policies could take the form of e.g. tax benefits for successors of older farmers as they could enhance firm succession (lower the age of the firm operator) and improve the prospects for potential successors (increase the likelihood of availability of a successor). Second, programmes aiming at stimulating investments in greenhouses and machinery are probably less efficient for firms that already have a high modernity of these capital assets, whereas programmes stimulating investments in installations are likely to be more effective on firms with a high modernity of machinery. This implies, for instance, that information on new technologies and programmes aiming at enhancing investments in greenhouses or machinery and in installations should be focused more directly on firms with a low or high modernity of greenhouses or machinery or a high modernity of installations. Third – following a similar reasoning – pot-plant firms and large-scale firms have a larger probability of investing in greenhouses and machinery, implying that these firms need information on new technologies and programmes more frequently than other firms. Fourth, the results suggest that fluctuations of oil prices have a significant negative impact on investments in machinery. So reducing uncertainty on energy prices through e.g. a futures market for energy, or an insurance against high energy prices could increase investments in machinery.

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