The decision to invest and the investment level: An application to Dutch glasshouse horticulture firms

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Abstract

Investment models typically explain only a small share of the total investment variation within or between firms. A reason for this may be that those models do not explicitly differentiate between the decision to invest and the decision about the level of investment. In this paper, a two-steps theoretical framework and estimation procedure are developed to take into account the different nature of both decisions. 'Nearly zero' investments are considered to be small replacement or maintenance investments and treated as 'zero' investments.

The applied two-step Heckman model shows that the decision to invest is significantly related to available capital (-), wealth (+), debts (-), output prices (+), land price growth (+), capital price growth (-), energy price growth (+), revenues (+) and age of the firm owner (-). The level of investment is also related to available capital, wealth, debts, output price, capital price growth and age of the firm owner, but with opposite signs for debts and capital price growth. Moreover, firm size positively affects the level of investment (but not the decision to invest). The fact that both decisions are affected differently proves the rationale of using a two-step investment model but further research is needed to increase the explanatory power of the models.

Keywords: investments, glasshouse horticulture, Heckman selection model

JEL Classification: D92, Q12

1. Introduction

Investment decisions are complex. They often raise a lot of discussion and investment models typically explain only a small share of the total investment variation within or between firms. A very intuitive approach starts from the observation that a firm invests if the expected discounted long-term value of the firm – including the expected net profits that it generates over time – are higher with an investment than without. This implies a rather straight-forward approach including basic concepts such as adjustment costs, option values, and irreversibilities. Many concepts underlying investment decisions, however, are non-observable or difficult to assess. What can be observed, however, are (1) the decision whether or not to invest (also called the participation decision); (2) the level of investment; and (3) the timing of the investment (Goncharova et al, 2008). In this paper, we limit ourselves to two elements of the decision making process: the participation decision (whether or not to invest) and the level decision (how much to invest).

This paper supplements existing work in three ways. First, we develop a theoretical framework that accommodates a two-step procedure for investments at firm level. Maximizing the value of the firm plays a crucial role in here. Second, we introduce a definition of 'relative zero' investment level. We employ this definition for the estimation of the 'participation' investment decision. Third, we separate the decision to invest from the decision about the level of investment. By applying this to a large set of glasshouse horticultural firms in the Netherlands, we investigate the empirical use of a two-step approach. Most empirical studies do not distinguish the two decisions (see e.g. Thijssen, 1996). In this paper, a Heckman selection model is employed that allows separation of the two decisions.

The following section develops a theoretical model which provides the basic framework for the statistical model described in the third section. The fourth section motivates the development and specification of the data. This is followed the estimation and analysing the results and ends by discussion and conclusions.

2. Theoretical model

The decision to invest is a very important one due to its long lasting effect it may have on the operation of a firm. When e.g. a glasshouse horticulture firm invests, it increases its level of capital in fixed assets such as land area, glasshouses and installations. Whether, and if so, to what extent such an investment decision will be made depends, among other aspects, on two characteristics of the decision itself: presence of adjustment costs and irreversibility. Adjustment costs are the costs that are related to preparing and installing the investment, e.g. planning costs, construction costs, learning costs, and production loss during construction (see e.g. Gardebroek, 2004: 43). Irreversibility means that a firm cannot undo the investment by selling its capital, due to the fixed location of the investment in land, buildings and installations or due to firm-specific characteristics of capital, e.g. glasshouse firms cannot (easily) be converted to another production process.

Although all firms are potential investors in each year, a high frequency of zero investments is typically observed in many years (*Table 1*). This decision 'not to invest' partly can be explained by (a) fixed adjustment costs; (b) irreversibility and (c) variable adjustment costs (e.g. Nilsen and Schiantarelly, 2003). However, their effect on investment decisions will differ. Irreversibility, which reduces the possibility of a firm to disinvest, will be more important when a firm makes the decision to invest or not to invest. Fixed adjustment costs associated with the investment decision include direct costs of search, construction of invested capital, additional administrative costs, as well as indirect costs due to the restructuring of the production process. Variable adjustment costs, which depend on the level of investment, will be more influential on the decision how much to invest.

Under the assumption that firms strive to maximise the expected value of profit, they will each evaluate the discounted value (with *r* discount rate) of their firm with and without investment (*I*) and then determine whether or not to invest. If a firm is willing and able to invest (decision variable *D=1*) then it also takes adjustment costs *C(I)* into account. If the firm is not willing or not able to invest then *D=0* and no adjustment costs will occur. The Bellman equation (Bellman, 1957) is used to solve the maximisation problem:

$$rV(p_t, w_t, K_t, D_t) = \max_I [\prod (p_t, w_t, K_t) - C(I_t * D)] \qquad (1)$$

The profit $\prod$ is a function of output (*p*) and input (*w*) prices and capital *K*.

Some variables, such as the presence of a successor or a large debt, relate directly to the qualitative distinction between investing and not investing and are independent of the amount invested. In other words, some variables can be significant for the participation decision, but insignificant for the investment-level equation. To model an explicit participation decision, it is plausible that firms compare their value function at zero investment versus the value if they decide to invest. Then a participation decision can be written in the form of:

$$D = 1 \quad if \quad \eta > 0, \qquad D = 0 \quad otherwise \tag{2}$$

$$\eta = V(\bullet) - V^*(\bullet) \tag{3}$$

where η is the change in value of firm due to investment. Firms compare their value function $V(\bullet)$ at positive levels of investment with their value $V^*(\bullet)$ at zero investment. A negative value of η may have several reasons: (a) output prices are low, input prices are high, capital good prices are high, etc. (b) relative high adjustment costs; (c) the irreversibility of investments if future input prices are high or output prices are low[1]; (d) financial constraints.

By summarizing, only firms where η>0 are assumed to be able to invest, which implies that D=1. Otherwise they belong to the group with zero investment (D=0). The crucial item, however, is the set of the variables which determine whether η>0. First we develop the empirical model.

3. Empirical Model

A Heckman model (Heckman, 1979, Greene, 2003) is an appropriate statistical model for implementing the discussed theoretical approach because it takes into account zero observations of investments.

The *Participation Investment equation* will then be represented as (for firm *i*):

$$\eta_i = \alpha' X_i + u_i, \qquad D_i = 1 \quad if \quad \eta_i > 0, \qquad otherwise \quad D_i = 0 \tag{5}$$

where $u_i \sim N(0, \sigma_u{}^2)$

Observed investment:

$$I_i = D_i I_i^{**} \tag{6}$$

Level Investment equation:

$$I_i^{**} = \begin{cases} I_i^* & if \quad InvR_i > \overline{InvR} \\ 0 & if \quad InvR_i \le \overline{InvR} \end{cases} \tag{7}$$

$$I_i^* = \beta' Z_i + v_i \text{ , where } v_i \sim N(0, \sigma_v{}^2) \tag{8}$$

[1] Irreversibility implies uncertainty about future prices and other production conditions.

Investment Ratio is defined as $InvR_i = \dfrac{I_i}{K_i}$, with $\overline{InvR}$ as investment threshold of 'zero' investment; α and β are parameters to be estimated; and X and Z are variables that can be influential on the participation and investment decisions.

The error terms u_i and v_i in the Heckman model are assumed to be correlated and the participation decision dominates the investment decision. This model specification ensures that firms with zero investment observations give no restrictions on the parameters of the investment level decision.

The likelihood function corresponding to this model is (Greene, 2003, Gourieroux, 2000):

$$\ln L = \sum_0 \ln(1-\Phi(\alpha' X_i)) + \sum_+ \ln\left(\frac{1}{\sqrt{2\pi\sigma_v^2}}\right) + \sum_+ \frac{1}{2\sigma_v^2}(I_i^* - \beta' Z_i)^2 + \sum_+ \ln\Phi\left(\frac{\alpha' X_i + \rho\left(\frac{I_i^* - \beta' Z_i}{\sigma_v}\right)}{\sqrt{(1-\rho)^2}}\right) \quad (9)$$

$$(u,v) \sim BVN(0,\Gamma), \qquad \Gamma = \begin{bmatrix} 1 & \sigma\rho \\ \sigma\rho & \sigma_v^2 \end{bmatrix}$$

where *BVN* is bivariate normal distribution and ρ is a correlation coefficient.

If the correlation between error terms is equal to zero, then the investment decision and the decision about the level of investment are independent and can be estimated separately. This model is named the Complete Dominance Model.

4. Data

Data is obtained from the stratified sample of the Dutch Farm Accountancy Data Network (FADN) of LEI Wageningen UR (Vrolijk et al., 2009). Records of glasshouse horticultural holdings from 1975 till 1999 formed an unbalanced panel data set consisting of 6912 observations for 1505 firms.

The second and third column in *Table 1* present the frequencies of zero and negative investments in this panel data set. A remarkable finding is the high frequency of negative investments, particularly in buildings (15.3%). It is possible to assume that buildings will be sold when a firm exits, but then the land area should also be sold, which is not the case. Further examination of the data showed that positive investments are mostly close to zero; this can be due to small replacement and maintenance of buildings and installations, while small negative investments may result from administrative corrections and depreciation.

Therefore we constructed an indicator for 'nearly zero' investments, an investment ratio which is equal to the investment level divided by accumulated capital. An investment is then treated as a 'zero' investment when the investment ratio is higher than -0.05 but lower than 0.05. This implies an investment threshold ($\overline{InvR}$) of 0.05.

Table 1: Percentages of observations with zero and negative investments without and with an investment threshold

	Without investment threshold		*With* investment threshold[1]	
	Zero Investment	Negative Investment	'Zero' Investment	Negative Investment
- Land	91.7	1.9	93.9	1.2
- Buildings	35.7	15.3	77.6	0.6
- Installations	16.2	8.0	48.6	0.6
- Machinery	20.4	9.9	43.1	1.4
Total	3.2	6.7	54.0	0.7

[1] An investment is considered a 'zero' investment if $-0.05 \leq InvR \leq 0.05$ where InvR is equal to the investment level divided by accumulated capital

By using this threshold, the frequencies of negative and 'zero' investments (last two columns of *Table 1*) are substantially changed and represent a more plausible result: a high frequency of 'zero' investments and a low frequency of substantial negative ones. This result is consistent with the assumption concerning the irreversibility of investments, because under irreversibility the sunk cost of investments induces firms to postpone investment decisions (Dixit and Pindyck, 2001). Even the total investment, which due to aggregation usually shows a low level of zero investments (3.2%), now reveals 54% of 'zero' investments. Most frequently, 'zero' investment appears in the case of investments in land (93.9%), which can be explained by the location aspects of land and the restricted availability of land.

The selection of the variables to include in the Heckman Selection Model was based on a principal component analysis (PCA) (Goncharova, 2007: 33-37). Following the theoretical discussion (*Section 2*), two sub samples can be distinguished: one which represents 'zero' investments, and another which represents positive investments. Thus, the dependent variable for the *Participation Equation* is a binary variable with zero or one values. The total level of investments is used as a dependent variable for the *Investment Level Equation*, which contains zero values for those observations below the investment threshold[1]. Rationalizing the selection, why one variable will affect participation and not the investment level or vice versa, is difficult. Elhorst (1993) used financial variables to determine the participation decision, but the empirical results were disappointing. Therefore, we started with a specification where both equations were postulated to be a function of the same variables, as given in *Table 2*. Compared to the PCA (Goncharova, 2007), one additional variable, which indicates firm entry, is also included. The reason is that the first year of operation is usually accompanied by investments. The decision about participation due to entry can have a different structure than the decision to invest of an existing firm.

Table 2: **Sample means**

Variable	**Mean**		
	Full Sample N=5341	**Zero investment n1=2927**	**Positive investment n2=2414**
Investment, level*	50.4	6.8	103.2
Investment, observation	0.457	0	1
Capital*	391	388	394
Wealth*	420	380	469
Debts*	331	338	323
Firm Size, 1000 SFU	0.584	0.554	0.621
Output Price Index	0.887	0.870	0.907
Land Price Change	0.059	0.054	0.064
Capital Price Change	0.005	0.005	0.005
Energy Price Change	0.015	0.011	0.020
Revenue*	377	338	424
Labour Cost*	111	104	120
WIR (investment subsidy)*	0.43	0.32	0.58
Age	44.8	45.7	43.8
Entry (=1 if first year of operation, =0 otherwise)	0.005	0.003	0.007

* *All monetary values are calculated in 1985-year prices and transformed to thousands of euros*

Table 2 contains variable means for the entire sample and for the two sub samples. To make our estimation consistent, all observations with missing values were excluded, resulting in 5341 observations on 1390 firms in the full sample. An examination of *Table 2* reveals a

[1] A very small number of large negative investments have been dropped from the analysis. They require separate investigation, but the number of observations is too small.

substantial difference between variables. This difference can lead to different estimation results conditional on what sample is used. Comparing sub samples with ‘zero’ and positive investments, one can see that investing firms have a bigger scale, which exposes a higher level of revenue, wealth and capital; and are managed by younger firm owners. A higher level of debts at the beginning of a year is typical for firms choosing not to participate. The combination of lower debts with larger family wealth allows firms to overcome the financial constraints in acquiring investment, and it is typical for the second sub sample. The difference in output price index between the sub samples is obvious: presumably for reasons of business expectations and tax deduction, firms prefer to invest in years of high output prices.

5. Results

Following earlier discussion on the Heckman Selection Model the first decision is made about participation (invest or not invest) and this decision dominates the second decision about the level of investment. Therefore the model is also called the Dominance Model, which analyses the two equations in one framework.

The results of estimation[1] (with taking into account a firm-specific effect) are represented in *Table 3*. The Wald test ($\chi^2(13)=398.2$) confirms that coefficients of Level Investment equation are significantly different from zero. To accomplish the validity of choice of the Heckman selection model, we should test the hypothesis that equations are independent (ρ=0). The Wald test does not reject this ($\chi^2(1)=2.04$) at a 5% level; this means that standard regression techniques applied to the Investment Level equation could have yielded biased results. The selectivity effect is represented by λ, for which $\sigma\rho$ is the coefficient. This coefficient is -14.9, because it is the product of the correlation coefficient (-0.1023) and the standard error of the residuals of the level equation (145.8). The Heckman model is only identified through the non-linearity of the Inverse Mill’s Ratio (IMR), as there are no exclusion restrictions on other variables. Including a number of exclusion restrictions on variables, however, led to the conclusion that the identification via IMR does not depend very much on those restrictions.

Most variables in the *participation equation* are significantly different from zero (*Table 3*). A firm is more likely to invest if it has less capital, more wealth, relatively low debts, a younger firm owner, higher revenue and if it observes higher output prices and

[1] For Estimation STATA 9 software is used

growing energy and land prices. Growing capital prices work in opposite direction. All of them are plausible results. The positive sign of changes in energy price can be explained by the fact that an increase of energy costs (particularly during oil-crises) forced many firms to invest in energy-saving glasshouses and installations (Diederen et al., 2003). Higher land prices run parallel to investment participation. Revenue, as expected, has a significant positive effect on the decision to invest: higher revenues give a more positive evaluation of the future.

Table 3: **Parameters estimates of Dominance (Heckman) Model**

Variable	**Participation Investment Equation**		**Level Investment Equation**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Capital	-0.0011****	0.0002	-0.050*	0.033
Wealth	0.0002***	0.0001	0.085****	0.021
Debts	-0.0004****	0.0001	0.194****	0.037
Firm Size	-0.103	0.120	46.2**	26.2
Output Price	0.848****	0.097	46.8****	14.0
Land Price Growth	0.205**	0.111	-17.8	20.5
Capital Price Growth	-2.100***	1.067	737.8****	157.0
Energy Price Growth	0.424****	0.174	-15.0	21.8
Revenue	0.0017****	0.0002	-0.018	0.04
Labour Cost	0.0004	0.0008	-0.04	0.12
WIR	0.0084*	0.0056	0.75	0.79
Age	-0.0232****	0.0020	-0.64**	0.36
Entry	0.4075*	0.2659	-16.1	20.7
Sigma	145.8	7.84		
Rho	-0.1023	0.071		
Lambda	-14.92	10.40		
Wald[1)] chi2(1): rho=0	2.04			
Prob>chi2	0.15			
Wald[2)] chi2(13)			398.2	
Prob>chi2			0.00	
– Log Pseudolikelihood	18875.45			

*****; *** ; **, * 1%, 5%, 10%, 15% -level of significance*

[1)]The test is the comparison of the joint likelihood of an independent probit model for the participation equation and a regression model on the observed level of investment against the Heckman model likelihood.

[2)] Test of all regression coefficients in the Investment level equation being equal to 0.

The estimation of the *level equation* reveals both significant and insignificant variables (see *Table 3*). This can be an indication of the dominance of the participation decision that is in compliance with the Heckman Selection model framework. The variables that influence the investment level positively are wealth, debts, firm size and output price and growth of capital price. The negative (but not significant) coefficient of revenue can be a direct effect of the investment on the revenues due to depreciation but can also indicate a concern of firms about adjustment costs, particularly internal ones, which imply a reduction in production. Because the output price is already in the model yields are incorporated in the revenue variable. Adjustment costs might appear via the revenue variable, if adjustment requires a temporary reduction of production. Some variables are important for both decisions and have the similar effect. A higher level of wealth as a source of internal financing and also as collateral is positively influencing both decisions. The output price has a positive impact, because it implies a positive expectation about future revenue. When more capital in fixed assets is in the operation, a firm is less probable to invest and the firm is investing less. Growth of capital prices has a direct effect on increase of the investment level, simply because the firm owner has to pay this higher price (under the condition that he or she already has decided to invest). The effect may even become stronger because of the business cycle effect: if many firms want to invest, prices of capital goods increase. Age has the same negative effect in both equations, which can be explained by the fact that a younger firm owner has a longer time-planning horizon and may be less risk-averse.

Although the equations are slightly correlated, the correlation is not very strong and this can explain that the effect of explanatory variables is varying in sign and significance level. The difference in signs for significant coefficients highlights the importance of using a selection model, rather than for example a Tobit model (Amemiya, 1974), which could disguise the differentiated effects of conditioning variables on the probability and level of investment. For this reason, previously assumed double effect of debts at the beginning of the year on investments is clearly revealed here. Debts have a negative effect on the (participation) decision to invest, because they make it difficult for a firm to get a loan or because it is an indication that recently investments were made. However, debts have a positive effect on the level of investment. If a firm decides to invest in spite of the presence of debts, it may indicate an innovative or growing firm with a good financial reputation. Firm size only has a significant effect on the level of investment. It looks as if larger firms do not have other investment patterns but do make bigger investments than smaller firms.

As expected some variables that influence the participation equation, have no significant impact on the level of investment, e.g. the entry decision leads to participation in investing but do not predetermine a level of investment. The opportunity to get WIR investment subsidy has a slightly significant positive coefficient for the participation equation, but not for the level equation. The WIR subsidy was introduced in 1978 and repealed in 1988. Moreover the specified rules of the WIR-subsidy changed during that period. According to Schlagheeke (1988) the measure did not stimulate large investments. This might explain the non-significant coefficient in the level equation.

The goodness of fit for the participation model could be judged on the basis of the number of correct predictions. Of course, without using any model the number of 'correct predictions' can be substantial e.g. 2927 (=54.8%) if all predictions are classified as zero investments. The model results should be judged on the basis of the correct observations.

Table 4: Goodness of fit for participation model

		Predicted values*		
		Zero investment	Positive investment	Total
Actual observations	Zero investment	2189	738	2927
	Positive investment	1217	1197	2414
Total		3406	1935	5341

** Predicted values defined by (0.5 , 0.5) criterion*
*** 3386 correct observations, Count R^2= 63.4 %; a naive model would result in Count R^2= 54.8 %;*

The goodness of fit of the participation model is represented in *Table 4.* Zero investments were predicted better (2189 out of 2927) than positive ones (1197 out of 2414), but in general the prediction power of selection (63.4%) gives a modest improvement compared to "naive" prediction. But another goal of the model is to predict the level of positive investment taking into account the participation equation estimation.

As a type of goodness of fit for the level equation, the investigation of the expected conditional mean and the actual mean of total investments was conducted. The conditional mean is calculated by Rosinski and Yen (2004):

$$\mathrm{E}(I_i^* \mid I_i^* > 0) = \exp(\beta' Z_i + \sigma_i^2 / 2) * \Phi(X_i\alpha + \rho_{ii}^{vu}\sigma_i) / \Phi(X_i\alpha) \qquad (10)$$

and equals 46.7. Using the t-test, the null hypothesis that the conditional mean is equal to the actual mean of total investments (50.4, see *Table 2*) is rejected (*t=2.14, df=534)*.

6. Conclusions and Discussion

Conventional models are often based on the assumption that all firms are potential investors and that investment participation and investment levels are influenced by the same variables and in the same way (see e.g. Thijssen, 1996). However, if two decisions are involved, a double-hurdle approach is desirable.

A Heckman selection model, as an appropriate statistical model for implementing the proposed theoretical approach, was chosen due to the censoring (zero observations) in the dependent variable, which is the yearly total investment of a firm. The model distinguishes two decisions: the participation decision whether or not to invest and the (level) decision how much to invest.

For testing our approach the investment decisions of Dutch glasshouse horticulture firms over the period 1975-1999 were investigated. The empirical analysis of the data reveals a high frequency of zero investments and even incidences of negative investments. It was shown that including relatively small ('maintenance') investments in the definition of zero investments better reflects the occurrence of 'zero' and negative investments. The high frequency of the former and low frequency of the latter is consistent with irreversibility of investment (Nilsen and Schiantarelli, 2003).

The results of the Heckman selection model confirm that increasing profitability of firms, together with limited financial constraints and younger firm owners, increase the probability that firms will invest. Also with increasing land prices and energy prices, a firm is more willing to invest. This can be explained by the fact that increasing land prices include the business cycle effect, which builds up the expectation of higher profitability in farming and attracts investments. Energy-price shocks encourage investments in energy-saving technologies.

A smaller set of significant variables predetermines the level of investments. Some of these variables exhibit an opposite sign compared to the participation decision. So, the high level of debt is negative with respect to participation decision, but positive for the investment level decision, presumably separating different types of firms.

The two equations were (slightly) correlated. Still the estimation results provide two arguments for using a two-step model to explain investment decisions. First, for some variables as debts, revenue, labour cost, prices of land and indication of firm-entry, opposite signs are observed for the participation equation and the investment level equation. Second, some variables are significant for the participation equation (e.g. energy- and land-prices, revenue) but not for the investment level equation.

The results of the Heckman selection model demonstrate the rationale of using a two-step approach of investment decisions and show the impact of each variable for both steps. But even with this further developed modelling approach only a small share of the total investment variation within or between firms could be explained and the number of correct predictions of zero investments only gives a modest improvement compared to a naive model. Further research is needed to increase the explanatory power of the two-step models.

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