INVESTMENT BEHAVIOUR OF DUTCH INDUSTRIAL FIRMS: A STUDY BASED ON PANEL DATA

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This paper reports on the early stage of a study of investment behaviour of Dutch industrial firms, viz., an explorative analysis of the relation between investment in fixed assets and other firm characteristics, such as sales and profits. The surveys of the Netherlands Central Bureau of Statistics into investment and production are used. The dataset consists of the individual responses of the firms to these surveys. Some preliminary results for the metal products industry are presented. They are based on the data of 332 firms.

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1. Introduction

The problem of finding the determinants of investment in fixed capital has been studied by many authors. See Jorgenson (1971) and Rowli and Trivedi (1975) for reviews of the literature. Most of these studies are based on time-series of aggregated variables. One notable exception is Eisner. He has published a number of studies based on time-series of individual firm data, i.e. panel data[1]. See also Frijns (1979), who uses Dutch data. Our paper reports on a study of investment in fixed capital, also using panel data.

In the next section we discuss the advantages of panel data. In section 3 we present a theory of investment. We arrive there at a model with four determinants of investment in fixed assets. The dataset is described in section 4. In section 5 we present some preliminary results. Finally, in section 6, we give some conclusions and an indication of further work.

2. Panel data

Panel data consist of time-series of cross-section data. They are a rich source of information. They permit us to estimate a rather general class of models. See INSEE (1978), discussed by Kapteyn and Wansbeek (1978), for the methodology of panel analysis. See also recent econometrics textbooks, such as Kmenta (1971) and Maddala (1977). We restrict ourselves here to single equation fixed effect models, with coefficients that may change over time. In other words, we do not assume that the coefficients are constant over a longer period, as in the case of estimation with macro time-series. When we estimate the model seperately for several time-periods, we arrive at a series of coefficients over time, which gives us an idea of the development over time of the process under study.

With panel data there is obviously no aggregation problem, since micro data are used for the estimation of micro models. Panel data also permit us to estimate models with a lagged dependent variable, without getting involved in the problem of autoregressive disturbances. This can be shown as follows. Suppose we have the following model, with some dependent variable y and independent x,

$$y_t^{(i)} = \sum_{\tau=-\infty}^{t} \beta_{t,\tau}\, x_\tau^{(i)} + e_t^{(i)} \tag{1}$$

with

$$\beta_{t,\tau} = \lambda_t\, \beta_{t-1,\tau}\ , \quad \text{for all } \tau < t\ ,$$

where the subscripts t and τ indicate the time-periods of the dependent and independent variables respectively, the superscript (i) indicates the firm and $e_t^{(i)}$ is the random disturbance of firm i in period t. We assume that the elements of e_t, the vector of all $e_t^{(i)}$ for a certain t, are independently and identically distributed (i.i.d.). We now transform (1), writing β_t for $\beta_{t,t}$, into

$$y_t^{(i)} = \beta_t x_t^{(i)} + \lambda_t y_{t-1}^{(i)} + u_t^{(i)}\ , \tag{2}$$

with

$$u_t^{(i)} = e_t^{(i)} - \lambda_t e_{t-1}^{(i)}$$

The elements of the vector u_t are still i.i.d. over the firms. So when we estimate (2) over the firms, for some fixed t, we have independent disturbances. Notice that this is not the case if we assume that β_t and λ_t are the same for all t and estimate the model with macro time-series. Then we have

$$Y_t = \beta X_t + \lambda Y_{t-1} + U_t\ , \tag{3}$$

with Y_t, X_t and U_t defined as summations over all firms in period t. The time-series of U_t's does not consist of i.i.d. elements and follows a first-order autoregressive scheme.

3. Theory

3.1. The determinants of net investment

We will now briefly discuss the theory of investment in fixed capital. In the literature on the subject, two main determinants of net investment are the change in the level of sales (the accelerator principle) and the level of profits or cash-flows. First, we will discuss these variables.

We will assume that the firm has no overcapacity. When a firm expects an increase in sales, it has to invest in fixed capital in order to increase its productive capacity, or rather, to prevent a rise in its output-capital ratio above the optimum. In the appendix we discuss the relation between the accelerator principle and the neoclassical models of investment, mainly of the Jorgenson type.

Cash-flows may influence investment because they restrict the firms capacity to buy investment goods from internal funds. Profits (cash-flows minus depreciation) may also be important as an indicator of future profits.

In addition to these two determinants, last year's investment may be related to this year's investment, for two reasons. Firstly, the effects of the determinants of investment may last for several years, decreasing over time. There are two reasons for this. Firms consider current values of the relevant variables not enough to base their decisions on. They use past values too. Also, investment projects may take more than one year. In that case, current investment is a mixture of projects, started in the current and in earlier years. These effects together may create a lagged relationship between investment and its determinants. Interpreting the dependent variable y in equation (1) as investment, we can apply the transformation from (1) to (2), if the effects of the determinants decrease geometrically with time, all at the same rate. Then, the lagged dependent variable appears on the right hand side with a positive coefficient, assuming $\lambda > 0$. Secondly, consider the following. Investment projects may be of such a large size that they create an initial overcapacity. New investments will then be made only after some time when the overcapacity has disappeared. In this way, a cyclical time pattern arises. This may disturb the relation between investment and its determinants discussed before. But it also causes a (positive) relation between current investment and the investment of one cycle-period ago. These effects together may form a U-shaped lag pattern of the investment variable, just as wide as one cycle-period.

3.2. Replacement investment

So far, we have considered net investment. Since only data of gross investment are available, which include replacement investment, we must add a term to our model that accounts for these replacements. As a crude approximation, we assume that replacement investment is proportional to the existing capital stock. Note that the coefficients of the model are influenced by the fact that we use gross investment as the lagged dependent instead of net investment. This can be shown as follows. Consider the geometric lag model of (1) and (2) and interpret y as net investment. We rewrite (2) as follows

$$I_{NET,t} = \beta X_t + \lambda I_{NET,t-1}, \tag{4}$$

using capitals and omitting the firm indices, just as the disturbance. We define

$$I_{GROSS,t} = I_{NET,t} + R_t, \tag{5}$$

where R indicates replacement investment. The assumption of proportionality between replacement investment and the capital stock is written as

$$R_t = \delta K_t, \tag{6}$$

where K_t is the capital stock at the beginning of period t. Investment and the capital stock are then related by

$$K_{t+1} = K_t + I_{NET,t}. \tag{7}$$

If we substitute (5), (6) and (7) in (4), we arrive at

$$I_{GROSS,t} = \beta X_t + (\lambda+\delta) I_{GROSS,t-1} + (1-\delta-\lambda)\delta K_{t-1}. \tag{8}$$

We find that the coefficient of the lagged dependent has become $\lambda+\delta$, instead of λ, as in (4). Since we have no data of the capital stock, we use one more assumption. We assume that the capital stock is proportional to the labour stock. This can be justified by the discussion in the appendix. The last term on the right hand side of (8) thus becomes a function of the labour stock.

Summarizing, the following model results. Gross investment is a function of sales change, cash-flow, lagged gross investments and the labour stock.

4. Data

4.1. The firms

We use the data, collected by the Netherlands Central Bureau of Statistics (CBS) for its Production statistics (see CBS (c)) and its Statistics on fixed capital formation in industry (CBS (d)). These data refer to individual firm-units (Dutch: bedrijfs-eenheden), being defined as a company producing one, more or less homogeneous product. See Atsma (1978). If a company produces several different products, CBS aims at splitting it up into several firms, such that each firm produces only one product.

For our analysis we need panel data, i.e. time-series of individual firms. It is a difficult task to link the data of individual firms together over several years. Firms may change their legal status, they may merge with each other, they may move into other products. Firms may disappear, while new ones may come into being. Fortunately much of this work has already been done[2]. We use two datasets. One, production data ranging from 1973 to 1975, was extracted from CBS (c). The other, investment data ranging from 1972 to 1976, originates from CBS (d). In both sets, firms with less than 50 employees are excluded. The investment data concern only the investment in machinery. Thus we have no data of investment categories such as means of transport and construction.

To begin with, we select the metalproducts industry (excl. machinery and means of transport), Standard Industrial Classification (SBI) no. 34. For both datasets, this group consists of about 375 firms. We exclude some firms with missing or very unreliable data. Some other firms have experienced an in- or decrease of more than 50% in their labour stock (and at least 30 persons). We suspect them of a merger with another firm or the closing of a factory. We purge them too. Finally, we exclude some extreme outliers, i.e. the firms with an annual investment in machinery of more than 15,000 guilders per employee. As a result, we arrive at a set of 332 firms.

4.2. The variables

Table 1 shows the totals and the coefficients of variation for these 332 firms of the four variables in the model: investment in machinery, sales, cash-flows and the number of employees. All amounts are in current prices.

Cash-flows are approximated by the "census value added" minus labourcosts. The census value added (Dutch: waardeverschil) equals the value of the production minus the value of the consumption according to the results of the Production statistics. In the Production statistics, some miscellaneous costs are not included in the firm consumption, such as the fee of an external accountant. Therefore, the census value added slightly overestimates the value added.

The lower part of table 1 shows the total amounts of investment in machinery and sales for the metal products industry (excl. machinery and means of transport). This intends to show the coverage of our dataset. The figures indicate that we miss nearly one half of the total amounts of these variables. This is due to the absence of firms with less than 50 employees in our dataset and to our purging of firms with unacceptable or missing data.

4.3. <u>Deflation</u>

In order to arrive at a meaningful indicator of the change in sales volume, we have to deflate the amounts of sales. We use one price-index for the whole group of firms, derived from the indices of producer's prices. These are published by the CBS, for domestic sales and exports seperately. See CBS (a). We weigh these indices with the shares of domestic sales and exports in the total amount of sales. We arrive at price changes relative to the previous years of 13 and 8% in 1974 and 1975 respectively. We used 1973 as the base year of the deflated sales.

Since we do not use changes over time of the cash-flow or the investment variable, their price change can be accounted for by deflating the regression coefficients directly from the estimates, discussed in the next section. We have not done so, considering the fact that it would have a very small effect on the estimates, relative to their standard errors.

Table 1. A summary of the data[a]

	1972	1973	1974	1975	1976
Total amounts of the 332 firms, studied in this paper (firms with 50 employees or more)					
investment in machinery	.086	.092	.100	.090	.100
	(2.6)	(2.2)	(1.7)	(1.7)	(2.0)
sales	--	3.33	3.85	3.67	--
		(1.2)	(1.2)	(1.1)	
census value added[b] minus labour costs	--	.63	.78	.54	--
		(1.5)	(1.8)	(1.5)	
number of employees	--	56,000	56,000	52,000	--
		(1.0)	(1.0)	(1.0)	
Total amounts of the metal products industry (excl. machinery and means of transport), SBI 34 (firms with 10 employees or more)					
investment in machinery[c]	.15	.18	.19	.19	.18
sales[d]	--	6.2	7.3	7.3	--

a) all amounts in guilders x 10^9 (current prices); standard deviations divided by means (coefficients of variation) are in brackets.

b) value of production minus value of consumption according to the results of the Production statistics (= value added plus some costs).

c) source: CBS (d)

d) source: CBS (c)

5. Regressions

5.1. The choice of the variables

In this section, we present some preliminary regression results. Using least squares regression, we estimate linear models to explain investment in machinery. The explanatory variables are, according to section 3, sales change, cash-flow, lagged investment and the labour stock. To avoid heteroscedasticity, we divide all variables by the average number of employees over the period 1973-1975. We use a constant for the last explanatory variable, the labour stock.

Both for 1975 and 1976 we have used three different combinations of the explanatory variables. Table 2 shows the results of these 6 regressions in lines (2) to (7). We ignore the first line of table 2 for the moment. In the choice of the explanatory variables, we applied not only the theoretical discussion of section 3, but we also considered the explorative nature of the analysis. Therefore, we start with all the available explanatory variables in the equations. These are presented in lines (2) and (5) of table 2.

Line (3) contains a set of regressors that is, as a whole, lagged one year behind the set of line (6). We selected these sets, because, with the data at hand, they are the largest ones that have this possibility. Finally, we deleted from lines (3) and (6) the multiple occurrence of explanatory variables over several years. E.g., from line (3) we deleted the cash-flow in 1973 and the investment in 1973 and 1972. This results in lines (4) and (7).

Before we discuss the contents of table 2, we mention that none of the regressions suffer from multicollinearity. All correlations between regressors are less than .6 in absolute value, as are the correlations between the estimated coefficients.

5.2. The results

We will now discuss the contents of table 2, lines (2) to (7). Line (1) will be discussed later in this subsection. First, we consider the sales change variable. All of its estimated coefficients have the expected sign. Some of them have relatively large standard errors, while others are nearly three times their standard error. The 1975 regression of line (2) suggest that sales change has a very quick effect on investment, operating within one year. Unfortunately we can not compare this with the 1976 regressions, since the sales data of 1976 are not yet available.

The cash-flow shows a slightly different picture, with two negative coefficients. The negative coefficient of the cash-flow in the current year, in line (1), agrees with the findings of Eisner. He explains this i.a. by "start-up" costs or "other reductions of accounting (net) income, associated with higher capital ex-

Table 2. Regressions of investment in machinery per employee[a)]

year of dependent variable	independent variables (per employee)										constant	R^2
	sales change		cash-flow			investment in machinery					(x 1 000 guilders per employee)	
	1974/75	1973/74	1975	1974	1973	1975	1974	1973	1972	1971		
(1) 1975	.027 (.009)	.026 (.009)	-.017 (.014)	.031 (.014)	.029 (.017)	--	.23 (.07)	.06 (.07)	-.03 (.08)	.13 (.07)	.39 (.19)	.19
(2) 1975	.026 (.009)	.026 (.009)	-.018 (.014)	.028 (.014)	.036 (.017)	--	.26 (.07)	.07 (.07)	.02 (.08)	--	.44 (.19)	.19
(3) 1975	--	.019 (.008)	--	.019 (.013)	.023 (.016)	--	.27 (.06)	.06 (.07)	.01 (.08)	--	.40 (.19)	.17
(4) 1975	--	.013 (.007)	--	.033 (.011)	--	--	.31 (.06)	--	--	--	.52 (.18)	.16
(5) 1976	.016 (.008)	.004 (.008)	.022 (.013)	-.025 (.013)	.026 (.015)	.37 (.05)	.00 (.06)	.11 (.06)	.23 (.07)	--	.51 (.17)	.32
(6) 1976	.012 (.008)	--	.029 (.012)	-.015 (.012)	--	.38 (.05)	.05 (.06)	.20 (.06)	--	--	.64 (.17)	.28
(7) 1976	.011 (.007)	--	.029 (.009)	--	--	.41 (.05)	--	--	--	--	.77 (.16)	.25

a) Estimated standard errors in brackets.

penditure" (Eisner (1978), p. 110). All cash-flow coefficients are rather small, less than .04. One might interpret this as an indication that less than 4 cents of every extra guilder of cash-flow is invested in machinery. Here again, the ratio between the coefficients and their estimated standard errors is rather variable.

The lagged dependent variables have a significant influence, declining quickly after one year. The 1976 regression of line (5) shows a U-shaped lag-pattern, rising after four years. This confirms the cyclical-pattern-hypothesis of section 3. The estimates indicate that the cycle-period is at least four years. This can not be compared with the 1975 regressions of lines (2) and (3), because that requires an estimate of the 1971-coefficient: four years back from 1975. Until now, we have not mentioned 1971 investment data, although they are in fact available. At first, we did not intend to use them because the procedure of the enquiry into fixed capital formation has been changed in 1972. For the first time in 1972, the enquiry has used the Business Registers of the CBS (Dutch: Algemeen Bedrijfsregister, see Atsma (1978)). Therefore, it has been difficult to link the individual firm data of 1971 to those of 1972 and later years and we must handle the result of this operation with great care. But we can not resist the temptation to extend the regression of line (2) with a coefficient for investment in 1971, in order to see if the U-shaped pattern would also occur in that case. Line (1) shows the result. Indeed, we have the U-shaped pattern again and the coefficient of 1971 is nearly twice its estimated standard error.

The constant in the regressions ranges from about 400 guilders per employee in 1975 to nearly 800 in the next year. From table 1 in section 4 we learn that in our dataset the total investment per employee is approximately 1700 guilders. Thus the constant term is on the average roughly one quarter to one half of total investment. However, this figure is difficult to interpret. According to equation (8), it underestimates the replacement investment with a fraction of $\lambda + \delta$, which is equal to the coefficient of one year lagged investment. This coefficient ranges from .3 to .4. Notice however, that we have divided by the average labour stock, which is assumed to be proportional to the capital stock. But this does not take into account the variations in the capital stock, due to the investment process. Finally,, as we have shown in the appendix, part of this constant term may be induced by a change in prices.

Since we do not know the distributions of the disturbances, we are unable to compare likelihoods of hypotheses. The normality assumption is untenable here: the estimated residuals are skewly distributed, with a negative median and a long upper tail.

6. Summary, conclusion and suggestions for further work

In this paper we have reported on the first, explorative phase of a study of investment behaviour of Dutch industrial firms in the metal products industry, based on individual firm data. We have discussed the theoretical framework and estimated some linear specifications. Most of the coefficients have the correct sign. It seems that only a small fraction of profits is invested in machinery. The lumpiness of investment projects seems to generate cycles in the investment process with a cycle-period of four years or more.

We intend to continue this work in three directions. First, we will examine these data in more depth. E.g., we want to know if firms with increasing sales behave according to another model than firms with decreasing sales. Also, small firms might behave different from large firms. Other explanatory variables might also be explored, such as the change in the level of stocks and the fraction of exports in the total sales. We will also take up the remark at the end of the appendix, concerning the effect of a change in prices. The estimation method can be improved by making a better use of the panel character of the data.

Second, we intend to include other branches of industry in the analysis. Third, with these data we can examine firm behaviour more generally, e.g., by including the level of employment as an endogenous variable in the model.

Appendix. The neoclassical theory of investment

In the neoclassical investment model of the Jorgenson type[3], the firm maximizes the discounted flow of revenues, minus the labourcosts and the investment outlays, under two restrictions: the production function on the one hand and the increase of the capital stock being equal to net investments on the other. Net investment is equal to gross investment minus replacement investment, which is assumed to be proportional to the capital stock. The well-known first-order conditions for the maximum are,

$$\frac{\partial Q}{\partial L} = \frac{w}{p}$$

and (9)

$$\frac{\partial Q}{\partial K} = \frac{c}{p},$$

where Q, L, K, w, and p are the volumes of output, labour and capital, and wage rate and output price, respectively. c can be interpreted as the cost of capital and is a function of the price of capital goods (and its time derivative), the discount rate and the ratio of replacement investment to the capital stock. We assume that the services of both factors of production are proportional to their respective stocks. K and L indicate stocks everywhere in this appendix. All quantities are time-dependent. We assume perfect competion in all markets. The production function and (9) define the time-path of the three endogenous variables Q, K and L, although only the solution for the present moment is used. Notice that in the case of time-invariant ratios w/p and c/p and a constant production function, any unique solution for Q, K and L is constant over time too. In the case of a cross-section of firms, all operating on the same markets and with the same w/p and c/p ratios, the solutions for Q, K and L are the same for all firms, except when the production function exhibits constant returns to scale, in which case no unique solution exists.

Jorgenson circumvents the problem of identical firms as follows. He uses (9), combined with the production function, to express K as a function of Q. In the case of a Cobb-Douglas production function, he arrives at

$$K = \alpha \frac{p}{c} Q, \tag{10}$$

with

$$Q = \gamma K^{\alpha} L^{\beta}. \tag{11}$$

The optimal capital stock is now a function of the volume of output and the ratio p/c. Even if this ratio is the same for all firms in a cross-section, different values of K for different firms are possible, depending on the values of Q. As we noticed, this is not possible with (9), combined with the production function (11), unless we have constant returns to scale. See also Gould (1969), discussed by De Jong and Kiviet (1979), who suggests the use of the reduced form of (9) and (11), instead of (10).

We propose the following alternative. We consider output as exogenous. In that case, revenue is also exogenous and profit maximizing reduces to cost minimizing. It can easily be shown that the first order condition for this minimum is

$$\frac{\partial Q}{\partial K} \Big/ \frac{\partial Q}{\partial L} = \frac{c}{w}. \tag{12}$$

Together with the production function, (12) defines the two endogenous variables K and L. If we apply the Cobb-Douglas production function (11), we have

$$K = aQ^{b}, \tag{13}$$

with

$$a = \left[\frac{w\beta}{c\alpha} \gamma^{\frac{1}{\alpha}} \right]^{\frac{\alpha}{\alpha+\beta}},$$

and

$$b = \frac{1}{\alpha+\beta}.$$

The expression for L can be found by exchanging α and β, as well as c and w. Here, the optimal capital stock is not influenced by the ratio c/p, as in (10), but by c/w. This is intuitively clear. With a given output level Q, the capital stock K increases only when capital is substituted for labour. This substitution is ruled by the ratio of the costs of capital and labour, c/w.

If we have constant returns to scale ($\alpha + \beta = 1$), (13) reduces to

$$K = aQ. \tag{14}$$

In the model of (9) and (11), the scale of operation is undefined in the case of constant returns to scale. Then the model permits any pair of K and Q values that satisfy Jorgenson's (10). The two models become quite similar and we can write (10) in the form of (14), with $a = \alpha p/c$. The remainder of this appendix applies to both interpretations of (14). (Notice, however, that Jorgenson did not assume constant returns to scale.)

Before we derive an investment relation from (14), we notice that the K/Q ratio is the same for all firms, operating at the same markets, with the same c, w and p values. This is also the case with the L/Q ratio, if we extend (10) with the corresponding equation for labour, $L = \beta(p/w)Q$. Therefore, the K/L ratio is the same for all firms. We use this result in the discussion of replacement investment in section 3.

Now we will derive an investment equation from (14). We define net investment equal to the time derivative of the capital stock,

$$I_{NET} = \frac{dK}{dt}, \tag{15}$$

which we can write with (14) as

$$I_{NET} = a\frac{dQ}{dt} + \tilde{a}K, \tag{16}$$

where the tilde indicates the relative change over time. We combine this with the definition of gross investment (5), and with the assumption concerning replacement investment (6). We arrive at

$$I_{GROSS} = a\frac{dQ}{dt} + (\tilde{a} + \delta)K. \tag{17}$$

The first term on the right hand side of (17) corresponds to the simple accelerator model, which we adopted in section 3. But the second term tells us that if one of the two interpretations of (14) is true, our estimate of the replacement investment contains some part which is due to the change in some price ratio, either p/c or w/c respectively. This part may be positive or negative, depending on the direction of the change. In this paper, we will not pursue this matter any further. The computation of the "price" of capital c is a complicated matter[4] and we leave this for the future.

Footnotes

1) See, among others, the reference list in Jorgenson (1971) and in Rowley and Trivedi (1975). See also Eisner (1978). Oudiz(1978) has tested Eisner's models on French panel data.

2) These data have been prepared at the CBS for the so-called "fourth-part analyses industry 1973-1975" (Dutch: Kwartenonderzoek industrie 1973-1975), as described in CBS (1978).

3) This model has been described by many authors. See e.g. the first two references mentioned in footnote 1 and textbooks on applied econometrics, such as Wallis (1973).

4) The price of capital, in the sense of the models of the appendix, depends among others on the discount rate and the rate of replacements. Also tax parameters may be included. Magnus (1978) and Magnus and Vastenou (1978) have constructed a series for the Netherlands, for several values of the discount rate. Their series show considerable fluctuations over time, both upward and downward.

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