SYSTEMS RESEARCH INSTITUTE
POLISH ACADEMY OF SCIENCES

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS

CONTRACTED STUDY AGREEMENT REG / POL / 1

"CONCEPTS AND TOOLS FOR STRATEGIC REGIONAL SOCIO-ECONOMIC CHANGE POLICY"

STUDY REPORT

PART 1

BACKGROUND METHODOLOGIES

COORDINATOR, IIASA: A. KOCHETKOV
COORDINATOR, SRI PAS: A.STRASZAK

ZTS/ZPZC/ZTSW 1-36/85

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Consisting of 3 Parts

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V. ESTIMATION OF INVESTMENT LAGS AND THEIR IMPACT ON PRODUCTIVE CAPITAL FORMATION

by

Krzysztof Cichocki and Waldemar Wojciechowski

V.1 Introduction

Investigations concerning formation of fixed productive assets (capital) and the dynamics of investment process require a thorough look at investment delays. Usually, a substantial amount of time passes before an investment can be considered productive, i.e. the constructions are completed, machines installed and production started. The relations which describe accumulation of fixed assets given in the previous chapter illustrate the contribution of distributed investments to the formation of capital at time t. Given the investments, one has to estimate the investment delay coefficients in order to derive the fixed assets.

The main subject of this paper is to present a new method of derivation of the investment delays (lags) based on past or anticipated investment time series. The major argument is, that the investment lags and the length of an investment realization change irregularly and fast over time and therefore most econometric methods applied to their estimation fail or yield inconsistent results. The method presented yields satisfactory results. We include estimation results for the agriculture sector of economy for the period 1972-1984.

The problem of estimation and forecasting of the investment lags is discussed thoroughly in W. Wojciechowski´s Ph. D. Thesis (1986), where also estimates of investment lags for 14 sectors of Polish economy are given. The ex-post estimation is described in Cichocki and Wojciechowski (1985).

V.2 Estimation of investment delay coefficients

V.2.1 Traditional econometric approaches

In many investigations investment delays are assumed to be constant over time. This assumption allows for application of classical econometric methods, for instance of the method of the mean squares. The above approach implies however, that the distribution of the investment delays is assumed in advance (a priori). In spite of the simplifying assumption, yielding by definition constant values of delays $\psi_\tau(t) = \psi_\tau$, various difficulties can occur. The estimation results obtained, sometimes do not include essential delays, Almon (1965), Koyck (1954). The collinearity of explanatory variables (corresponding time series) entails substantial difficulties in estimating the delay coefficients $\psi_\tau(t)$ or highly depreciate the obtained estimates.

It is also practiced very often to assume that the sum of investment delay coefficients equals unity, $\sum_\tau \psi_\tau(t) = 1$.

The both above assumptions, of $\psi_\tau(t)$ being constant over time or summing up to unity limit the estimation problem of investment delay coefficients to a narrow class of estimation problems.

In addition, analysis of the data concerned with time distribution of investments for particular investment tasks gives the evidence that $\psi_\tau(t)$ varies irregularly and fast over time (see for instance tables V.1,3).

Therefore, the econometric methods, which work best, when applied to stationary processes or to the ones varying slightly and slowly with time fail so often.

In the planning models (as for instance in Cichocki (1985)) the values of delays $\psi_\tau(t)$ have to be prognosed. Theoretically, two approaches to estimate prognosis of $\psi_\tau(t)$ can be applied:

- first, based on historical trends of $\psi_\tau(t)$,
- second, when the values $\psi_\tau(t)$ are computed from equation (V.1) below, based on historical trends of V_t, $I(t)$ and $N^m(t)$.

Since, as discussed, $\psi_\tau(t)$ and hence $N^m(t)$ vary irregularly and fast over time, the econometric methods should not be applied.

V.2.2 Formulation of the investment delay estimation problem

The investments V_t committed in the years t, t-1,..., $t-N^m(t) + 1$, where $N^m(t)$ is the maximum length of an investment delay (cycle), measured at time t, contribute to the formation of the new fixed assets at time t, with portions of their value. The new fixed assets I(t) can be written as

$$I(t) = \sum_{\tau=0}^{N^m(t)-1} \psi_\tau(t)\, V_{t-\tau} = \overline{\psi}(t)\ \overline{V}(t) \qquad (V.1)$$

where $\overline{V}(t)$ denotes a vector of investments and $\overline{\psi}(t)$ is a vector of investment delay coefficients, $\overline{\psi}(t) = \left[\psi_o(t), \psi_1(t), \ldots \psi_{N^m(t-1)}(t)\right]$.

The vector $\overline{\psi}(t)$ and the length of an investment cycle $N^m(t)$ characterize the effectiveness of an investment process.

Relation (V.1) is graphically illustrated in Figure V.1. The maximum length of the investment cycle $N^m(t) = 3$ is assumed. The investments completed at time t consist of one-year, two-year and three year investment tasks. The letters A,B,C,D,E,F denote investments committed at consecutive years t-2, t-1, and t, which are considered in the example. A denotes the investment at time t-2 with the three year realization time, D is the investment made at time t-1 with the realization time of two years, and so on.

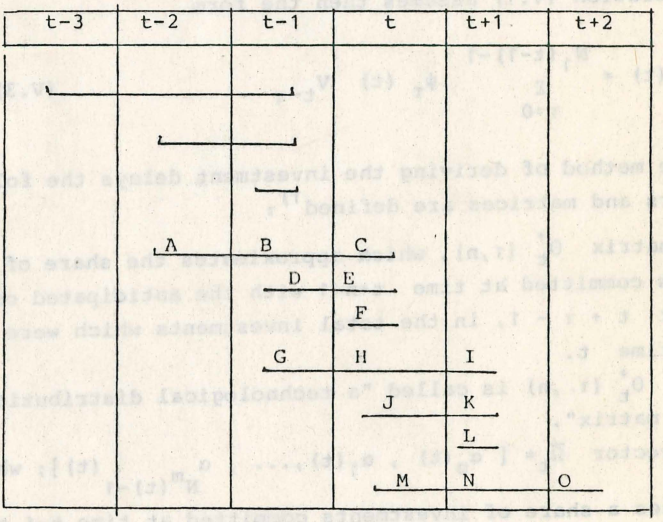

Figure V.1.

The following identities derived from (1) can be written

$$I(t) = A + B + C + D + E + F \qquad (V.2.a)$$

$$\psi_o(t) = \frac{C + E + F}{V_t} \; ; \quad \psi_1(t) = \frac{B + D}{V_{t-1}}$$

$$\psi_2(t) = \frac{A}{V_{t-2}} \; , \qquad (V.1.b)$$

where V_t is the total investment expenditure at time t.

In this chapter we estimate the coefficients ψ_τ (t), based on the relation (V.1) when estimation ex post is applied.

For <u>making prognoses</u> of investment delays we reformulate the relation (V.1). A vector of expected length of an investment cycle $\bar{N}_\tau(t)$ is introduced

$$\bar{N}_\tau(t) = [N_1(t), \ldots, N_{T(t)}(t)] \qquad (V.2)$$

where $N_i(t)$, $i=1,\ldots,T(t)$ denotes an expected realization length of the longest investment task which is committed prior to and at time t and whose completion is anticipated for the year t + i; T(t) is the maximum realization period, from time t until its completion, of the investments made at and prior to time t.

The relation (V.1) assumes then the form

$$I(t) = \sum_{\tau=0}^{N_1(t-1)-1} \psi_\tau(t) \; V_{t-\tau} \qquad (V.3)$$

In the method of deriving the investment delays the following vectors and matrices are defined[1]:

A matrix $\Theta_t^+(\tau, n)$, which approximates the share of investments committed at time t+n-1 with the anticipated completion time at t + τ - 1, in the total investments which were initiated at time t.
The matrix $\Theta_t^+(\tau, n)$ is called "a technological distribution investment matrix".

A vector $\bar{\Omega}_t = [\alpha_o(t), \alpha_1(t), \ldots, \alpha_{N^m(t)-1}(t)]$; where $\alpha_i(t)$ denotes a share of investments committed at time t-i and completed at t, in the total investment completed at time t.

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1) The definitions of $\Theta_t^+(\tau, n)$, $\bar{\Omega}_t$ as well as of $N_\tau(t)$, are new in the literature

$\overline{\Omega}_t$ is called the relative share of investments in the total completed investments.

A matrix $ZAA_t(k,l)$ evaluates the amount of investments at time $t+1$, which are necessary for continuation of an investment task initiated at time t whose completion is anticipated for the time $t+k$.

A matrix $ZAM_t(n)$ approximates the amount of continued investments, which have been continued until time t, and whose completion is anticipated for the moment $t+n$.

The above definitions will become more explicit and clear when Figure V.2 and expressions below the figure are considered. In Figure V.2, the one-year, two-year and three-year investment tasks are graphically illustrated. The capital letters, as in Figure V.1, denote investments committed at a given time t. For instance, investments I,K,X committed in the year $t+1$, complete the investment tasks and the investment M, committed in the year $t+2$ is a continuation investment which will be completed at time $t+2$ and was initiated at time t.
Thus, $\dim(\overline{N}_\tau(t)) = 3$ and $t \in (t+T)$, $T=2$

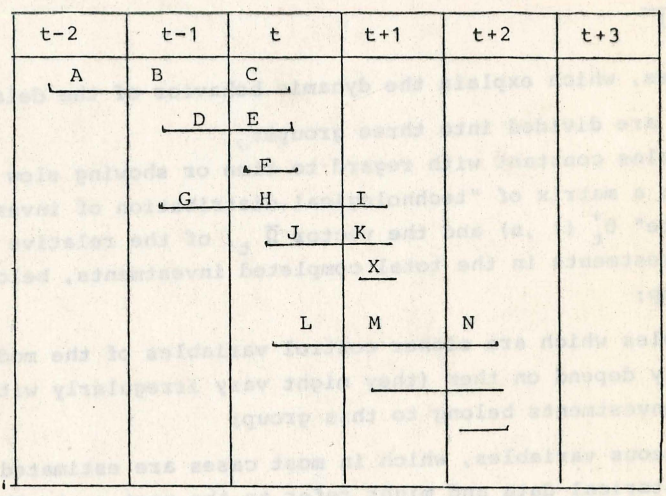

Figure V.2

The below exemplary expressions, derived from the Figure V.2 explain the definitions of $ZAA_t(k,l)$, $ZAM_t(n)$, $O_t^+(\tau, n)$ and $\overline{\Omega}_t$:

$ZAA_t\ (1,1) = I + K$

$ZAA_t\ (2,1) = M$

$ZAA_t\ (2,2) = N$

$ZAM_t\ (1) = G + H + J$

$ZAM_t\ (2) = L$

$$\Theta_t^+\ (1,1) = \frac{F}{F+J+K+L+M+N}$$

$$\Theta_t^+\ (2,1) = \frac{J}{F+J+K+L+M+N}$$

$$\Theta_t^+\ (2,2) = \frac{K}{F+J+K+L+M+N}$$

$$\Theta_t^+\ (3,1) = \frac{L}{F+J+K+L+M+N}$$

$$\Theta_t^+\ (3,2) = \frac{M}{F+J+K+L+M+N}$$

$$\Theta_t^+\ (3,3) = \frac{N}{F+J+K+L+M+N}$$

$$\alpha_o(t) = \frac{C+E+F}{I(t)}$$

$$\alpha_1(t) = \frac{B+D}{I(t)}$$

$$\alpha_2(t) = \frac{A}{I(t)}$$

The variables, which explain the dynamic behavior of the delay vector $\overline{\psi}(t)$ are divided into three groups:

- the variables constant with regard to time or showing slow variability; a matrix of "technological distribution of investments ex ante" $\Theta_t^+\ (\tau\ ,n)$ and the vector $\overline{\Omega}\ _t$, of the relative share of investments in the total completed investments, belong to this group;

- the variables which are either control variables of the model or explicitly depend on them (they might vary irregularly with time); the investments belong to this group;

- the exogeneous variables, which in most cases are estimated based on historical data and might refer to the past or to the future values of these variables; the vector $N_\tau(t)$ (see (V.2) and (V.3)) and the matrices $ZAA_t\ (k,l)$ and $ZAM_t(n)$ belong to this group.

The matrices and vectors defined above are not explicitly available in the official statistics. Based on available data these values are estimated in Wojciechowski (1986).

The investment decisions made until time t, which concern the amount of investments to be committed at time t+1 are described by the matrix $ZAA_t(l,1)$, $l=1,\ldots,T(t)$.

The investment expenditures V_{t+1}, at time t+1 can be greater than, equal to, or smaller than the investments anticipated, at time t, to be committed at time t+1.

1. Assume first, that the investments V_{t+1} are greater then the investments anticipated to be committed at time t+1

$$V_{t+1} > \sum_{l=1}^{T(t)} ZAA_t(l,1) \tag{V.4}$$

Thus, it is possible to undertake new investments at time t+1. They will be denoted by NV^N_{t+1}

$$NV^N_{t+1} = V_{t+1} - \sum_{l=1}^{T(t)} ZAA_t(l,1), \tag{V.5}$$

The total expenditures (calculation value) of investments started at time t+1 are denoted by NI_{t+1}. The value NI_{t+1}, based on estimation experiments of Wojciechowski (1986) can assume the form, $NI_{t+1} = aNV^N_{t+1} + b$. Using the definitions of the matrices $ZAA_t(l,1)$, $\Theta^+_t(\tau,n)$ and Figure V.2 we can define the elements of the investment delay vector $\bar{\psi}(t)$ as

$$\psi_o(t+1) = \frac{I+K+X}{V_{t+1}} = \frac{ZAA_t(1,1) + \Theta^+_{t+1}(1,1)\cdot NI_{t+1}}{V_{t+1}}$$

$$\psi_1(t+1) = \frac{H+J}{V_t} = \frac{ZAA_{t-1}(2,1) + \Theta^+_t(2,1)\cdot NI_{t+1}}{V_t} \tag{V.6}$$

$$\psi_2(t+1) = \frac{G}{V_{t-1}} = \frac{ZAA_{t-2}(3,1) + \Theta^+_{t-1}(3,1)\cdot NI_{t+1}}{V_{t-1}}$$

It has been assumed that

$$\Theta^+_{t+1}(1,1) = \Theta^+_t(1,1) \tag{V.7}$$

The relation (V.6) results from a technical assumption which expresses the fact that the technological data of the time period t (on December 31) are used for planning investments expenditure at the beginning of the period t+1 (on January 1).

2. The second case describes a situation when no new investments are anticipated, $NV_{t+1}^{N} = 0$, and the investment expenditures V_{t+1} are determined as

$$V_{t+1} = \sum_{l=1}^{T(t)} ZAA_t(l,1) \qquad (V.8)$$

The investment delay vector (in our example $\psi_\tau(t+1)$ $\tau = 0,1,2$) is determined analogously as in the case 1 by expressions (V.6).

3. The third case considers the situation when the investment expenditures V_{t+1} are smaller than the investments anticipated for the year t+1:

$$V_{t+1} < \sum_{l=1}^{T(t)} ZAA_t(1,1) \qquad (V.9)$$

In this case some investment tasks have to be suspended or verified. No new investments will be undertaken. Various verification possibilities are discussed in Wojciechowski (1986). The major principles applied in these verifications are summarized below.

Preferences are given to investments:

- With the shortest completion time, relative to t. (Investments with a long realization time can be suspended).
- With high values of elements of the matrix $ZAM_t(n)$. If the investment expenditures committed until time t are large, then the probability of continuation of this investment task is high.
- With low values of elements of the matrix $ZAA_t(k,l)$. If the completion time is short and the amount of investments to be committed until the completion of the investment task is low, then this investment will be continued.

V.3 Numerical example

The sector of agriculture is considered in the way of an example. Based on the methodology presented, the prognoses of investment delays over the years 1985-1990 are presented in Table V.1. Table V.2 includes the values of investments V_t in constant prices of 1985.

The values of the entries to matrix ZAA_t (k,l) and of the vector 0_t^+ (τ,n) are taken from Wojciechowski (1986).

In Table V.3 the estimates of investment delays over the years 1972-1984 are presented for the agriculture sector. The value of the matrix ZAM_t(n) and of V_t is taken from Cichocki, Wojciechowski (1985).

Table V.1

year / $\psi(t)$	1985	1986	1987	1988	1989	1990
ψ_o (t)	0,178	0,449	0,637	0,527	0,3919	0,563
ψ_1 (t)	0,311	0,389	0,335	0,258	0,2736	0,2657
ψ_2 (t)	0,026	0,155	0,090	0,0625	0,1940	0,2171
ψ_3 (t)	0,011	0,026	0,0002	0,0328	0,0468	0,00023

Table V.2

year	1985	1986	1987	1988	1989	1990
Investm. V_t, 10^9 zl	146.3	150.4	154.6	158.9	163.0	168.0

Table V.3

rok $\psi_j^t(l)$		72	73	74	75	76	77	78	79	80	81	82	83	84
$\psi_j^t(0)$		0.84	0.84	0.84	0.83	0.92	0.96	0.98	0.9627	1.096	1.061	0.96	0.12	0.03
$\psi_j^t(1)$		0.069	0.07	0.05	0.09	0.05	0.07	0.0996	0.1028	0.08	0.10	0.1353	0.07	0.12
$\psi_j^t(2)$		0.02	0.02	0.03	0.02	0.0278	0.047	0.0622	0.0556	0.039	0.065	0.032	0.01	0.071
$\psi_j^t(3)$		0.005	0.006	0.007	0.0064	0.0068	0.0235	0.0103	0.0088	0,02	0.03	0.019	0.01	0.03
$\psi_j^t(4)$		0	0.004	0.002	0	0	0.0027	0.0078	0.0144	0.0027	0.009	0.025	0.007	0.01
$\psi_j^t(5)$		0	0.0017	0.0019	0	0	0	0	0.0022	0.0004	0.0042	0.015	0.007	0.01
$\psi_j^t(6)$		0	0.0007	0.0014	0	0	0	0	0.0014	0	0.0074	0.017	0.0004	0.00002
$\psi_j^t(7)$		0	0	0.0011	0	0	0	0	0.001	0	0	0	0.0005	0
$\psi_j^t(8)$		0	0	0.0004	0	0	0	0	0	0	0	0	0.0003	0

V.4 Conclusions

The accuracy of econometric methods applied to estimation of distributed investment lags $\overline{\psi}$ (t) is limited due to their irregular and fast changes over time.

The fast and irregular changes of $\overline{\psi}(t)$ include the changes of the length of a realization of an investment and the change of the distribution of the investment lags.

The investment delay vector $\overline{\psi}$ (t) depends on the investment expenditures V_t, on the cost calculation value of newly started investments NI_{t+1}, on the value of the matrix ZAA_t (k,l) and on the technological distribution investment matrix Θ_t^+ (τ,n).

In our investigations we do not assume neither the maximum length of realization time of an investment, nor the distribution of the investment delays.

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STUDY REPORT

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