AN ECONOMETRIC ANALYSIS OF
INVESTMENT IN HUNGARY

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April 1983
CP-83-23

PREFACE

Input-output analysis has found widespread empirical appli-
cation, in studies of how certain industrial sectors react to
changes in national and international economic conditions and
in static and dynamic investigations of the interrelationships
between industries. Since 1979 IIASA has been consistently
active in this field, primarily through extensive collaboration
with the Inter-Industry Forecasting Program (INFORUM) coordinated
at the University of Maryland by Clopper Almon and Douglas Nyhus.
IIASA's aims have been to further the development of econometric
input-output models, to assist in the linkage of national models,
and to participate in and extend the international network of
collaborating scientists.

To date, eighteen national models have been installed at
IIASA, the software package SLIMFORP has been distributed widely,
and linked runs of some of the national models have been carried
out. Furthermore, annual task force meetings on input-output
modeling have served to bring together present and prospective
members of the INFORUM-IIASA "family" to review progress and to
exchange ideas for further work.

Gerhard Fink (Vienna Institute for Comparative Economic
Studies) and Andras Simon (Institute for Economic and Market
Research, Budapest) are collaborating in the development of an
INFORUM-type input-output model for Hungary. In this paper
they describe a study of Hungarian investment policy over recent
decades, dealing with both the sectoral allocation of total in-
vestment and the cyclical investment patterns observed. The
results are being used in the construction of an econometric
submodel of investment for the Hungarian INFORUM model.

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Gerhard Fink* and Andras Simon**

1. INTRODUCTION

This paper describes research aimed at setting up an econometric model of investment in Hungary to be used as a submodel in the Hungarian INFORUM input-output model*** (see C. Almon and Nyhus, 1977).

To meet the INFORUM requirement of explaining investment in sectoral detail, we had to move into an area that is relatively unexplored in the Hungarian economic literature. Much has been written about investment, especially in the context of investment cycles in Hungary; following the pioneering observations of Brôdy (1967), the work of Soôs (1978), Tarján and Tényi (1977), and Bauer (1981) has covered almost every aspect of the subject. However, all this work has dealt with total investment and not with the sectoral allocation of investment.

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***The submodel described in this paper has been implemented within the Hungarian input-output model by Gâbor Kornai.

Our aim was twofold. We set out first to select the most important relationships formulated verbally by these earlier authors and to formulate the "economic policy" interpretation of investment cycles into a model-like logical system. Building on former studies of this kind (Lackó, 1980), we quantified the parameters of the model using real data. Our application of Ragnar Frisch's explanation of the persistance of economic cycles to the Hungarian investment case is another extension of the work of the authors mentioned above.

Our second objective was to model the sectoral allocation of investment. In this respect, most authors have stressed the overwhelming role of central decisions (Deák, 1978; Bauer, 1978) but none have tried to identify regularities in the behavior of decision makers that could be a basis for an empirical model. Thus, while the first part of our paper makes no claim to be anything more than an empirical verification of a rather broadly accepted hypothesis, the second part provides and verifies a new hypothesis at the same time.

It is noteworthy that this new hypothesis was developed without recourse to the cyclical hypothesis. Thus the "cycle" approach of the first part of the paper and the "expansion" approach of the second part show marked differences, which cannot be explained purely by the fact that the former deals with total investment while the latter investigates sectoral investment. The range of validity and application of the two approaches will be discussed in Section 4.

2. THE "CYCLE" APPROACH

2.1. The Model

The existence of investment cycles can be deduced from the following three assumptions:

1. Domestic supply is not flexible enough to follow all the fluctuations in investment demand. "Too much" investment leads to tension between supply and demand. This tension can be eased either by reducing consumption or by increasing imports. In Hungary, increasing imports in order to cover the additional

demand for investment is a fairly typical method. Thus, an
immediate relationship is established between investment and
the balance of trade. When the level of investment is low the
balance of trade shows a surplus or a relatively small deficit,
while when the level of investment increases the balance of
trade shows a larger deficit.

2. The long-term development of investment is determined
by the long-term strategy of the planning and economic control
agencies regarding rates of consumption and investment. In the
short run, however, investment policy depends on the actual
tensions between supply and demand in the economy, and primarily
on the balance of trade. The more favorable the trade balance,
the more investment can be "afforded", and vice versa. It seems
a relatively trivial extension to emphasize that investment
depends on present tensions and not on expected or probable
future tensions, but when investigating the emergence of cyclical
behavior this qualification is absolutely fundamental.

3. A certain time elapses between the formulation of
economic policy and the appearance of its results. In contrast
with the first two assumptions, this statement requires some
further explanation.

Let us assume that for some reason the balance of trade is
less favorable than desired in a given year and that economic
policy makers wish to improve the situation by cutting back on
investment. It is often almost impossible to do this within
the year concerned, since decisions on investment have been
taken at an earlier date and projects are either in progress or
otherwise beyond recall. There are also numerous other reasons
why investment cannot be *immediately* reduced. Time is needed
for making decisions on investment restriction, even after
tensions have been observed. First the situation has to be
assessed and discussed, in conjunction with the proposed remedial
measures, their timing, and their form. The measures are usually
of many kinds and they affect the different types of investment
in different ways. Efforts are made to restrict investment
decided by the enterprises by controlling enterprise incomes, by

means of credit policy, and by numerous other measures. Investment projects that are centrally decided can be influenced mainly by rescheduling the starting dates of new projects, although speeding up or slowing down those already in progress is also possible. But all these measures have a common characteristic: a certain amount of time elapses before their effect becomes manifest in terms of reduced investment. And because the resources of individual enterprises for investment projects depend on the income of preceding years, not on that of the current year, time once again elapses between the granting and paying of credit and between the starting and completion of such projects.

In order to show how these three assumptions lead to investment cycles, let us formulate them as simple mathematical functions.

For the development of tensions (assumption 1),

$$B_t = b(I_t) \tag{1}$$

where

B_t = balance of trade in year t, and
I_t = investment in year t.

For the economic policy reaction (assumption 2),

$$I_t = i(B_{t-k}) \tag{2}$$

where B_{t-k} is the balance of trade in year t-k.

According to our assumptions, in eqn. (1) B is a decreasing function of I, while in eqn. (2) I is an increasing function of B. This situation is illustrated in Figure 1. The possible combinations of investment and foreign trade balance are located along the curve of the tension function. The point of intersection of the two curves is the equilibrium combination; this is the possible combination which is held to be most desirable by economic policy makers, for example, one which achieves a zero balance of trade.
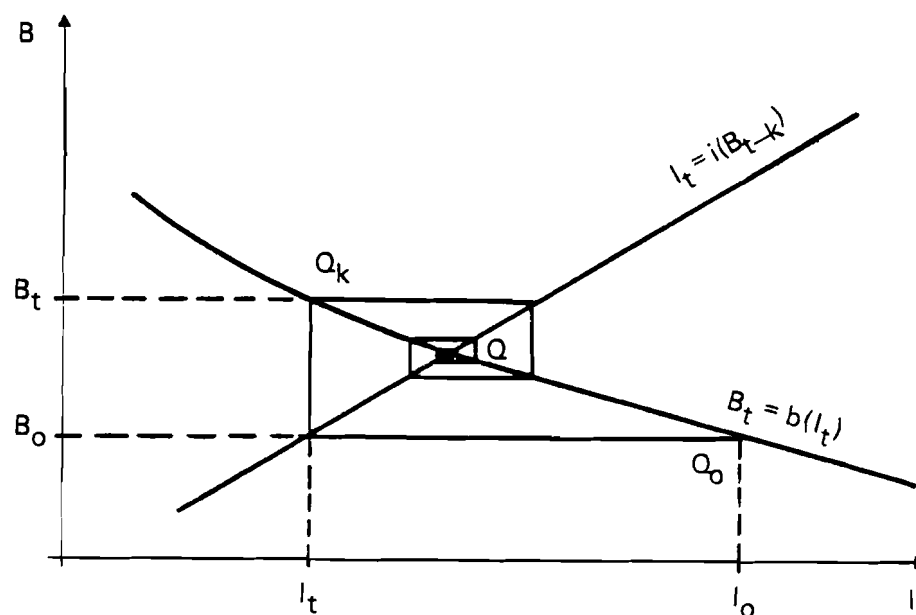
Figure 1. Assumed interrelations between balance of trade and
investment.

Let us assume that the initial numerical value of the
balance of trade is B_0 and that this is unacceptably low. The
policy reaction is to *reduce* investment. According to the
reaction function, investment falls to I_k after k periods have
elapsed. This results in an improvement in the trade balance
to B_k. Thus, after k periods we reach point Q_k, but in so do-
ing the original target, corresponding to point Q, has been
overshot; the policy makers now consider the question of *in-
creasing* investment again, which eventually produces an overshoot
in the opposite direction, and so on ...

With the signs that we have assumed for the slopes of the
functions, investment develops cyclically in the course of time.
Depending on the magnitudes of the slopes, the cycle has a
growing, a constant, or a diminishing amplitude and, accordingly,
investment diverges from or converges toward the equilibrium point
Q.

It is easy to recognize that, formally, the model fully
agrees with the "cobweb model" of Tinbergen (1950), well known
from textbooks. The tension function replaces Tinbergen's
demand function, while the behavior described by the reaction
function is analogous to demand reacting to price with a time
lag.

On the basis of the arguments above, it can be seen that
if our three assumptions are valid then they will necessarily
give rise to investment cycles. But simple logical reasoning
is not sufficient for us to decide whether the cycles have
growing, unchanged, or damped amplitudes: for this we need to
know the parameters of the functions.

2.2. The Empirical Model

We estimated characteristic parameters explaining Hungarian
investment behavior over the last 20 years with the help of
regression equations. The estimated parameters give not only
the amplitude of the cycle but also its length. We realize of
course that the two functions outlined above constitute a very
much simplified model of investment behavior. It is obvious
that investment and balance of trade depend not only on each
other but also on innumerable other factors and events.

In the course of estimating the parameters, a step is made
from abstraction towards reality insofar as the model is ex-
panded by the addition of a few other explanatory variables.

Gross domestic product is included as a factor determining
the long-term development of investment, while the balance of
trade is assumed to be affected somewhat by the terms of trade.
Even so, many other important explanatory variables are missing
from the model. A model that incorporated more details from the
real situation would certainly have yielded better results for
the parameters of the interrelations producing the cyclical
behavior, but for our fairly limited purposes this relatively
simple model should suffice.

Our aims here are restricted to the following. First, to
verify with the tools of mathematical statistics that inter-
relations similar to those represented in the model do play a

role in the development of investment; and second, to establish
whether the parameters of the cycle given by the model (damping
coefficient and length of period) are of the right order of
magnitude to help explain the investment cycles actually observed.
The estimated model is sufficient for these purposes, even if we
reckon on a certain bias in the estimated parameters.

The function describing economic policy reaction was esti-
mated using the following equation:

$$I = -52.7 + 0.018 \text{ BALANCE}_{-2} + 0.46 (\text{GDP}+\text{GDP}_{-1}+\text{GDP}_{-2})/3 \qquad (4)$$
$$\quad (9.1) \quad (2.46) \qquad\qquad (27.9)$$

with R^2 = 0.991, DW = +1.654, and the relative error = 3.51%.
The observation period was 1963-1979, and the following notation
is used:

I	=	total investment in the economy (billion forints) at constant 1976 prices,
GDP	=	gross domestic product (billion forints) at constant 1976 prices, and
BALANCE	=	balance of trade transacted in dollars (million dollars).

The negative subscripts indicate the lag of the variable
concerned in years, while the figures in parentheses below the
coefficients are the ratios of the estimated parameters to the
standard error of parameter estimation. R^2 is the multiple
correlation coefficient adjusted for the number of degrees of
freedom of the equation, DW is the Durbin-Watson statistic, and
the relative error is the standard error of the estimation of
the dependent variable relative to its average value.

The second term of eqn. (4) expresses the lagged effect of
any measures induced by tensions indicated in the balance of
trade; a negative balance reduces, and a positive balance in-
creases investment. Logical reasoning cannot in itself determine
the length of the lag, so that statistical criteria were used.
When we compared regression equations computed with either one-
or two-year lags, the two-year variants consistently gave a better

fit. Of course, two years is an average value, and the precise length of the lag may differ from this average depending on the kind of policy action or the type of investment concerned. The estimation of an integral value of two years was an obvious technical necessity based on the *annual* data available.

The third term of the equation explains the long-term trend of investment. In the long run, investments are obviously determined by the gross domestic product, which affects both sources of investment and the uses to which it is put. We eliminated the effects of short-term fluctuations in GDP by using three-year moving averages.

The tension function used has the following form:

$$\text{BALANCE} = -2342.1 - 32.6\ I + 1188.0\ \text{TERMS} + 251.9\ T \qquad (5)$$
$$(4.4) \qquad (5.1) \quad (4.3) \qquad\qquad (3.9)$$

with $R^2 = 0.844$, DW = 2.538, and the relative error = 60%. Once again the observation period was 1963-1979, and the following additional notation is introduced:

TERMS = terms of trade = ratio of export to import prices in hard currency foreign trade, and

T = time (years) (T = 0,1,2...).

Equation (5) represents the fact that the import requirements generated by investment result in a simultaneous deterioration in the balance of trade. The impact of the terms of trade on trade balance is self-evident. Many other factors affect the balance, but they are represented in this simple model by a trend.

The relative error of the estimate in this case tells us nothing about the fit of the estimated values to the actual data, since the dependent variable is fluctuating around zero and thus its average value--the denominator in the formula for relative error--is very small. However, the R^2 value indicates a relatively good fit.

Substituting the right-hand side of eqn. (5) for the BALANCE variable of eqn. (4), it is easy to see that, because of the

interrelations of the system, a unit change in investment produces a -0.59-times change in investment two years later (-32.6 x 0.018 = -0.59). That is, the change after two years will have the opposite sign to the original unit change and will be damped in amplitude by a factor of 0.59. After another two years, the effect of the same original unit change will be +0.35 (i.e., -0.59 x -0.59); in other words, the change will be back in the original direction but with an amplitude of 0.35-times the original.

This indicates a damping cycle within the model, but this must be reconciled with the empirical observation that the cycles of real investment processes do not seem to diminish at all. One explanation is that investments are continually affected by external shocks that release new cycles, replacing the diminishing waves produced by earlier investment events.* In our model these external shocks are generated partly by the exogenous variables (terms of trade, GDP) and partly by the residual term representing those effects considered as random.

Our simple econometric model of two equations can quantify the parameters of a theoretical model, but it is by no means capable of proving or disproving the theory. The observed data show that investment fluctuations are in general of opposite sign every two years, thus exhibiting cyclical behavior. From the numerical results we have learned that these cyclical fluctuations become damped after four years by a factor of 0.35, corresponding to a 0.8-times change for each year of the four. It has also been verified that there is an interrelation between the balance of trade in a given year and investment two years later.

But the assumption that this lagged reaction is indeed an effect of economic policy has not been proven. Numerous other known or unknown factors might lead to the same numerical results. We might get nearer to verifying the theory if we could formulate an equation in which economic policy appears

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*This is the theory of Frisch (1933) on the survival of economic cycles.

explicitly; in what follows, we report on an attempt to construct such an equation.

2.3. Modeling Economic Policy

On exploring investment mechanisms in greater detail it soon turned out that there was such a great difference between the instruments of economic policy used in Hungary before and after 1968 that there are no relevant statistical time series covering both periods. Thus we were only able to study the period after 1968, and this was further restricted to the period starting in 1970 as regular information on post-economic reform variables was unavailable for earlier years.

Naturally, these restrictions on the length of the period studied impose severe limitations on the conclusions that can be drawn from the mathematical and statistical results. Before the reader develops any exaggerated hopes of getting well-founded information from these econometric methods, we must stress that a firm proof of the theory is unfortunately not possible here. Nevertheless, we still feel it is of some interest to see whether or not the data of the last ten years contradict the theoretical hypothesis.

In order to take economic policy explicitly into account, eqn. (2) of the theoretical model will be replaced by two new equations (6 and 7). The influence of the balance of trade on investment is exerted through economic policy, and the theoretical model is thus expanded as follows:

$$B_t = b(I_t) \tag{1}$$

$$G_t = g(B_{t-i}) \tag{6}$$

$$I_t = i(G_{t-k}) \tag{7}$$

where G_t is some quantitative indicator of economic policy controlling investment in year t. Economic policy reacts to changes in the balance of trade with a time lag of i periods, while investment follows the indicator of economic policy with a lag of k periods.

For the successful quantification of the model it is vital to find a time series that adequately represents "economic policy". From the point of view of the tools transmitting economic policy it was found expedient to distinguish between investment projects that are centrally decided and those decided upon by the individual enterprises. In the former category, economic policy clearly can influence the starting dates and scheduling of the projects, but unfortunately there are no data available to provide information about this area so that we had to exclude centrally decided investment projects from our model.

In contrast, a number of the instruments shaping enterprise investments *are* statistically observable, including enterprise incomes and corporate taxes, investment loans and subsidies, other financial factors influencing the financial position of the firms (such as obligatory deposits), various minimum fund requirements, etc. Thus, in this area it is at least possible that the theoretical model can be quantified. The difficulty here is that the Hungarian financial regulatory system changes almost every year, not only in terms of the quantities (sums collected or allocated), but of the instruments themselves (introduction of deposit systems, abolition of compulsory division of funds, changes in methods of financing inventories, etc.). Fortunately we were able to find one instrument of financial control that existed throughout the ten-year period and which was quantifiable as well: the total of investment loans made available. We assume here that this time series represents many tools of economic policy, including instruments of a financial nature, selective regulations, preference recommendations, "expectations", etc.

As with the more restricted model described earlier, we include a number of exogenous variables that are considered essential in explaining the dependent variable.

Enterprise investment is represented by the following equation:

$$EI = 12.7 + 0.7 \text{ DEPOSIT} + 0.86 \ (\text{CREDIT}_{-1} - \text{CREDIT}_{-2}) \qquad (8)$$
$$(3.97) \ (23.9) (2.8)$$

with $R^2 = 0.993$, DW = 1.902, and the relative error = 2.2%.
The observation period used was 1972-1979, and the notation is
as follows:

EI = enterprise investment (billion forints) at current
    prices,

DEPOSIT = total deposits (billion forints), and

CREDIT = investment loads granted (billion forints).

The variable DEPOSIT represents the sources that firms them-
selves have available for development purposes. The major part
of DEPOSIT is formed during the preceding year from the share of
depreciation allowances left with the enterprises, the share of
profit put into the development fund, and other revenues.

Economic policy measures involve great efforts to use this
variable for influencing investment, but it would be untrue to
state that this variable moves in perfect conformity with the
objectives of economic policy. In fact, there are few areas
where the discrepancies between objectives and realization are
as great as in the planning of enterprise incomes. As an example,
in 1976 the abolition of the compulsory division of profit into
development funds and dividends in predetermined proportions was
expected to reduce development funds, but the effect was pre-
cisely the opposite, namely, an unprecedented increase in
development funds. Similarly, the steep rise in enterprise in-
comes in 1970-1971 was quite contrary to earlier plans.

Thus, the development of enterprise resources cannot be
used as a reliable indicator of short-term economic policy in-
tentions. These resources have followed a somewhat unpredictable
path over the last ten years, as a result of continued experi-
ments with a variety of different systems of enterprise income
formation. From the modeling viewpoint, this is best considered
as an exogeneous factor that causes considerable shocks in in-
vestment but is almost impossible to explain by econometric
methods. (This does not mean that we have *no* explanation for

the long-term development of enterprise resources: economic policy eventually determines an optimal ratio between enterprise and central incomes through repeated trial and error.)

As mentioned earlier, the investment loans variable (CREDIT) represents many other variables not appearing explicitly. We assume that the unobserved policy variables move in parallel with the investment loans variable. The lag of this variable indicates that enterprises invest part of their own resources depending on the amount of credit obtained: in other words, complementary investments are used to finance credit-assisted projects.

Equation (8) shows only the *increment* in credit from one year to the next. This allows us to exclude the effects of long-term strategic credit policy (shifts in the role of credit relative to other factors) from the equation and to concentrate on short-term economic policy reactions.

The tension function used is analogous to the second equation of the reduced model (eqn. 5):

$$\text{BALANCE} = -4178.2 - 36.9 \text{ EI} + 1705.3 \text{ TERMS} + 189.2 \text{ T} \qquad (9)$$
$$\qquad\qquad (2.9) \qquad (2.2) \qquad (4.3) \qquad\qquad (2.23)$$

with $R^2 = 0.894$, DW = 3.151, and the relative error = 37.1%.

The function describing economic policy reaction is now given by:

$$\text{CREDIT} = 37.5 + 12 \text{ GDP} + 0.0084 \text{ BALANCE} + 133.8 \text{ PRICE} \qquad (10)$$
$$\qquad\qquad (5.9) \quad (8.5) \qquad (3.8) \qquad\qquad (3.0)$$

with $R^2 = 0.97$, DW = 2.908, and the relative error = 5.6%. The new variable PRICE is the percentage change in the Hungarian investment price index. The observation period for eqns. (9) and (10) was 1972-1979.

Any developments in the GDP influence investment policy from the source side. Since GDP figures are given in constant prices, whereas credits are made available in current forints,

investment prices had to be included as an explanatory variable.
As our primary interest here is in investment cycles, the
crucial features of the system are that economic policy reacts
to a deterioration in the balance of trade with the dollar area
by restricting credit and to an improvement in this balance by
increasing credits, and that both of these reactions occur with
a time lag of one year.

Calculation of the length and damping factor of the invest-
ment cycle is somewhat more complicated here than for the two-
equation model so we will present only the results: the length
of the cycle is 5.13 years and the damping factor is 0.73 per year.

2.4. An Evaluation of the Cycle Approach

In summary, the experience of the last ten years does not
contradict the hypothesis that the cyclical development of
Hungarian enterprise investment is caused by interaction between
investment policy measures and investment itself. It is inter-
esting to note that the causes of this cyclical movement in
Hungary differ from those of the much-studied cycles charac-
teristic of market economies.

Let us recall the classic example of the pig cycle. The
cycle is based on the fact that the millions of individual
economic decision makers have no foresight whatsoever. Thus,
they make their decisions regarding supply on the basis of
present prices, since they have no way of knowing future prices.
But the effects of these decisions appear only after some time
has elapsed, when prices have already changed. Thus their
present supply never agrees with what they would like to offer
at present prices. Furthermore, the producers never learn from
their mistakes, since they never have any more information at
their disposal than the present price.

But in our system the decision makers are not the millions
of participants in the market; they are the central authorities
that shape economic policy. The present balance of trade (a
notion analogous to the "market price" of the pig cycle) is not
the only information available to the decision makers and they

have numerous ways of assessing the possible effects of their
decisions. Nevertheless, it often appears that those shaping
short-term policy are under pressure from so many simultaneous
events that they give too much weight to present needs at the
expense of future requirements.

Can the cycles be eliminated altogether or can the fluc-
tuations in investment be minimized? There is surely some hope
of the latter. In recent years enterprise investment has ex-
perienced several shocks from sudden changes in enterprise finan-
cial resources. The greatest annual fluctuation in total deposits
was between ten and twelve billion forints, while fluctuations
in credits granted attained at most half of that value. These
fluctuations were not themselves parts of a cyclical process,
but they played a decisive role in reviving the cycle again and
again and causing relatively large amplitude changes. With
accumulating experience regarding the impact of policy tools
it should be possible to minimize these shocks in future.

Of course, in principle it is also possible to change the
behavior of the economic policy makers producing the cycles.
It is open to question to what extent policy makers can free
themselves from short-term pressures when formulating invest-
ment policy, but it is likely that experience, combined with
improved knowledge of just how decisions can generate cyclical
behavior, may prompt them to take greater account of the delayed
effects of their decisions.

3. THE "EXPANSION" APPROACH

Many Hungarian economists are rather dissatisfied with the
economic results of investment in Hungary. They point out that
the actual outcome of investment measures does not come any-
where near meeting either expectations or theoretical possi-
bilities, citing the close involvement of central authorities in
investment decision making as one reason for this low capital
productivity (Bauer, 1978; Deák, 1978). Investment decisions
are not so much guided by "efficiency considerations" as by
so-called "necessities" (Barta, 1981), and the enterprises'
shares of 54.3% in investment financing within the socialized

sector and 61.2% within state and cooperative industry (Table 1) do not convey an accurate picture of the location of real decision-making power.

A special investigation into the process of investment decision making showed that in 1976 the enterprises could only *independently* allocate 10% of the total volume of investment; in all other cases either the banks, the supervising ministry, or the planning authorities participated in the process (Figure 2). This situation raises two questions: Has the role of enterprises in investment decision making remained so small in subsequent years? And is there virtually no way for enterprises to influence the investment decisions of central authorities and banks? On the other hand we cannot accept the proposition that ignorance dominates the central authorities' decision-making process, which has been said to pursue imaginary interests rather than real economic considerations (Barta, 1981).

3.1. The Model

We shall start from the hypothesis that investment decision making basically follows economic considerations, irrespective of whether the decisions are taken by central authorities or by enterprises. This hypothesis makes it possible to describe the process by means of a model that can be tested.

As a first step we note that enterprises dispose of a large portion of the finance earmarked for investment, and they are clearly interested in spending the money and not in keeping it in a bank account. From a medium-term perspective, an enterprise gains only advantages when investing: increases in output are more easily achieved, prestige is improved, and today's investment secures future reinvestment via depreciation allowances (Mocsáry, 1981). Central authorities also dispose of a substantial share of investment finance. These finances may be used for establishing new branches in the economy (such as pipeline transport) or for setting up new and modern enterprises, but the central authorities are also free to invest in existing enterprises.

Table 1. Percentage shares of investment in the state/co-
operative sector of the economy decided by central
authorities (state) or by the enterprises.

Year	In the whole economy		In industry	
	State	Enterprises	State	Enterprises
1975	43.9	56.1	31.9	68.1
1976	45.7	54.3	37.9	62.1
1977	43.7	56.2	34.5	65.5
1978	43.0	57.0	33.6	66.4
1979	45.4	54.6	36.3	63.7
1980	45.7	54.3	38.8	61.2

SOURCE: Statisztikai évkönyv 1979, pp. 113 and 117.

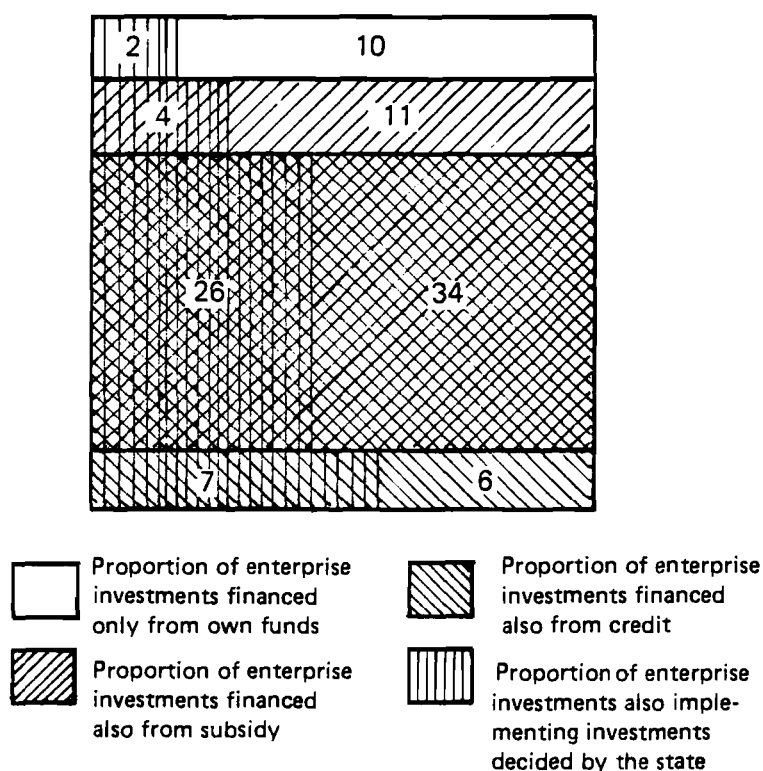| | Proportion of enterprise investments financed only from own funds | | Proportion of enterprise investments financed also from credit |
| | Proportion of enterprise investments financed also from subsidy | | Proportion of enterprise investments also implementing investments decided by the state |

Figure 2. Overlapping decision levels in investment, 1976; the
numbers show percentages of total investment in each
category (Source: Deák, 1978).

Since the enterprises can only gain from investment and from increasing their stock of fixed assets, they try to attract as much finance as possible from the central authorities for their own investment projects. There is strong competition for the central funds. On the basis of our assumption that decision making follows economic considerations, the enterprises must therefore put forward economic arguments to influence the decision makers.

The strongest argument in this respect is a pressing need for more capital equipment, based on fully utilized existing capacities and excess demands that cannot be met because of lack of capital equipment. In most cases an enterprise will try to prevent the situation of substantial excess demand from arising, by forward planning. During periods of increasing capacity utilization, when output is growing fast, the enterprise managers will already be starting to plan further investment in increased capacity. If this hypothesis of enterprise investment decision making is correct, we can formulate a criterion to help distinguish between enterprise induced and centrally originated investment decisions. If investment is positively correlated with the previous development of output, then it has very probably arisen from an enterprise decision, whereas in other cases investment has probably originated from a decision by the central authorities.

Of course, output is not the only factor in investment decision making. We must also mention the capital coefficient (the ratio of capital to output), which helps to formulate the relationship between planned output increase and the investment needed to achieve this increase. In addition, worn out equipment must be replaced and this influences the investment demand of enterprises. Finally, relative prices may have some influence. An enterprise whose value added per unit of output is rather high can attract substantial funds for investment, but on the other hand, if prices for equipment are relatively high, the purchasing power available for investment goods is limited.

These considerations lead us to propose a sectoral investment function of the following general form:

$$I = \Delta K = f(Q,K,d,Pv,Pe) \tag{11}$$

where

I   = net investment,

ΔK = increase of capital stock (fixed assets),

Q   = output,

K   = capital stock (fixed assets),

d   = rate of depreciation,

Pv = value added per unit of output, and

Pe = price of investment goods.

These elements can be easily transformed into an investment function of the type used in Western economic literature, without conflicting with our remarks above on investment behavior.

Starting from a CES production function (C. Almon and Barbera, 1978)

$$Q_t^\beta = A_t (vL_t^\beta + (1-v)K_t^\beta) \tag{12}$$

where

L   = labor,

A   = a function of time, and

v,β = constants,

we differentiate with respect to K, hold L constant, and solve for K, leading to

$$K_t = B_t Q_t \left(\frac{\partial Q}{\partial K}\right)_t^{-\sigma} \tag{13}$$

where $\sigma = 1/(1-\beta)$, and B_t is a function of time only.

We shall further assume that enterprises invest only up to the point where investment costs exceed the discounted returns on investment. Returns in the year of investment amount to $Pv(\partial Q/\partial K)$; in the year t after investment, under the assumption of a constant rate of depreciation d, the returns amount to only $Pv(\partial Q/\partial K)\exp(-dt)$.

There is no need to consider further components in our investment function. The tax on fixed assets previously in force had a rather limited allocative effect because of the extensive subsidization policy which accompanied the tax in all years after its introduction in 1968; it was only logical that this tax was finally abolished in 1980. Interest rates in Hungary are extremely low and expectations of price increases were also low during the period under investigation. We can therefore assume that a rational investment policy will lead to continued investment up to the point where either

$$Pe = \int_{t=0}^{\infty} Pv \left(\frac{\partial Q}{\partial K} \right) e^{-dt} \tag{14}$$

or

$$Pe = Pv \left(\frac{\partial Q}{\partial K} \right) \frac{1}{d} \tag{15}$$

and

$$\left(\frac{\partial Q}{\partial K} \right) = \frac{Pe \cdot d}{Pv} \tag{16}$$

Substituting from eqn. (16) into eqn. (13) leads to

$$K_t = B_t Q_t \left(\frac{Pe \cdot d}{Pv} \right)_t^{-\sigma} \tag{17}$$

Equation (17) implies that capital stock changes immediately when either output or capital cost changes. However, such behavior cannot realistically be expected. It will take some time before the enterprise managers convince the civil servants in the central authorities that investment is urgently needed. The enterprise itself will not be able to step up investment *immediately* when its income (value added per unit of output) increases; neither will it be in a position to reduce planned

investment immediately when prices for investment goods go up.
In view of these factors it is more realistic to introduce lags
into our equation. After defining*

$$r_t = \left(\frac{Pe \cdot d}{Pv}\right)_t \tag{14}$$

we can replace eqn. (17) by

$$K_t' = B_t \prod_{i=0}^{m} Q_{t-i}^{w_i} \prod_{i=0}^{n} r_{t-i}^{-\sigma_j} \tag{15}$$

where

$$\sum_{i=0}^{m} w_i = 1, \quad \sum_{i=0} \sigma_i = \sigma.$$

Under the assumption that $B_t = B_0 e^{at}$, where a is a small number
(on the order of 0.01), we take logarithms and then first
differences of both sides of eqn. (15), and obtain

$$\underline{\Delta}K_t = a + \sum_{i=0}^{m} w_i \, \underline{\Delta}Q_{t-i} - \sum_{i=0}^{n} \sigma_i \, \underline{\Delta} r_{t-i} \tag{16}$$

where the symbol $\underline{\Delta}$ denotes first difference of logarithm, which
we shall approximate by the fractional changes:

$$\underline{\Delta}Q_t = \frac{Q_t - Q_{t-1}}{Q_{t-1}} \quad \text{and} \quad \underline{\Delta}r_t = \frac{r_t - r_{t-1}}{r_{t-1}} \tag{17}$$

After multiplication of eqn. (16) by K_{t-1} we get

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*Definition (14) is introduced by analogy with the procedure
followed by C. Almon and Barbera (1978), so that the invest-
ment function that follows (and transformations thereof) are
identical to Almon and Barbera's. In this way we are able to
use for our eqn. (18) the estimation program developed by Almon
et al.; the provision of this program is gratefully acknowledged.

$$I = \Delta K_t = aK_{t-1} + K_{t-1} \sum_{i=0}^{m} w_i \frac{Q_{t-i} - Q_{t-1-i}}{Q_{t-1-i}}$$

(18)

$$- K_{t-1} \sum_{i=0}^{n} \sigma_i \frac{r_{t-i} - r_{t-1-i}}{r_{t-1-i}}$$

3.2. The Data

It is beyond the cope of this paper to describe in detail all sources of data used and all the adaptations that were necessary. The period under investigation is 1961-1980. In Statisztikai évkönyv* (1980, p. 110 ff.) we find data on *investment* for 1970-1980 at current and constant prices for nine industrial branches and for five broader sectors of the economy, which are further disaggregated into a number of subsectors. Since it was impossible to find all the data needed classified in the same way, we finally used a 23-sector classification in our investigation; details are given later in Tables 2-5. Data for the years before 1970 can be found in older yearbooks (SY 1976, pp. 75-83; SE 1971, p. 86 for agriculture; SY 1970, pp. 83-103 for all other sectors). The time series were linked to each other and preference was given to data published in more recent yearbooks. In most cases, therefore, time series were linked twice: those for 1966-1969 were linked to later series on the basis of 1970 data, and 1961-1965 series were linked to those for 1966-1969 on the basis of 1966 information. Data for 1961-1965 on the subsectors of the construction industry were estimated under the assumption that investment in all four subsectors developed at the same rate as in construction as a whole.

Data on *output* for 21 branches of industry at constant prices in the period 1970-1980 are found in SE 1980 (pp. 166, 167); these data were aggregated and linked to time series given

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*Yearbook of Hungarian economic statistics; elsewhere in the text we shall use the abbreviations SE (Statisztikai évkönyv) for the Hungarian edition and SY (Statistical Yearbook) for the English edition.

in older yearbooks. The same procedure, in the main, was
applied to the data on other sectors of the economy. Sometimes
data from older yearbooks were used for interpolating between
data for the years 1960, 1965, or 1970, which are published in
more recent yearbooks.

Particular problems were encountered when putting together
time series on output in the transport sectors. Here, only
data expressed in current prices are published; moreover, the
data are disaggregated into subsectors for a few years only.
We therefore derived an index of output in real terms from
quantity data published elsewhere. For rail transport, freight-
ton-kilometers and passenger-kilometers were aggregated with
the respective weights 1.5 and 1. These weights were derived from
data for the FRG (Statistisches Jahrbuch der BRD 1977, pp. 258-260)
and are similar to data for Italy (1.6:1) (Annuario Statistico
Italiano 1973, p. 273). Similarly, an output index for road
and urban transport was created; missing data on freight-ton-
kilometers for 1961-1963 had to be estimated (based on the same
rate of growth as in 1964-1968) and data on passenger-kilometers
had to be interpolated for the periods 1961-1964 and 1966-1969.
We assumed the same weights as in rail transport.

For the output of "other transport" we assumed the following
weights for freight-ton-kilometers,

Water transport:	150
Air transport:	1500
Pipelines:	75,

and for passenger-kilometers,

Water transport:	1000
Air transport:	1000.

The same problem arose for "communications" where we assumed the
following weights,

Letters:	100
Telegrams:	1000
Parcels:	500
Telephone (local calls):	100
Telephone (long distance calls):	500
Newspapers	30.

Missing data on telephone calls for 1961-1964 were interpolated; for the years after 1976, the published numbers of impulses were converted to unit calls (one local call = 1000 impulses, and one long distance call = 5000 impulses).

Time series on *value added* (at current prices) per unit of output were derived via the data on net production, which is calculated (at current prices) as the difference between output and production costs. The time series of indexes of net production were divided by the time series of indexes of output at constant prices. In cases where data are available for a broad sector only (e.g., construction) but not for subsectors, we assumed the same development in all subgroups. Missing data for the years before 1968 were estimated with the help of information derived from the input-output tables for 1958, 1965, and 1968 and appropriately interpolated.

Price indexes for investment were calculated by dividing the investment time series at current prices by those at constant prices. For the years 1961-1967 the published price indexes for broad sectors (industry, agriculture and forestry, etc.) are assumed to hold for all the respective subsectors.

The *rate of depreciation* is calculated as the ratio of depreciation allowances to fixed assets (both at current prices). Missing single data (mostly for subsectors in transport and construction) are estimated or interpolated.

3.3. The Method of Estimation

Assuming that the theory behind the investment model of eqn. (18) holds, a number of results should follow:

If investment is determined solely by economic considerations, the development of output and capital costs should be sufficient to explain the development of net investment. Thus we would expect the constant term in eqn. (18) to be relatively small.

In the case of a constant capital coefficient, and an explanation of investment solely in terms of output, we can expect the sum of the weights in the lag structure to be equal

to unity. Thus, even without formulating any detailed hypothesis on the development of the capital coefficient, we think that the sum of weights can be expected to be not too far from unity.

As regards the time distribution of the lags, we expect a regular pattern; for example, it seems implausible that the years two and four should have higher weights than years one and three. We would expect that years farther back would have a smaller weight than more recent years. As the lags become shorter, the weight increases; but the weight may decrease again for the most recent year (e.g., because only incomplete or preliminary information is available for the previous year).

The estimation technique applied was developed by Clopper Almon and co-workers (Reimbold and C. Almon, 1970; C. Almon et al., 1974) based on Dantzig's "quadratic programming" (Dantzig, 1963). This technique allows us to use a priori expectations as to the results of the estimation procedure for interpretation. Almon and his colleagues were interested in achieving results well suited for projections; for this purpose, the most appropriate features are a constant term close to zero, the sum of the weights close to unity, and a distribution of lags of the type developed by Shirley Almon (S. Almon, 1965).

To achieve such results without losing too much of the explanatory value of the estimated coefficients, an objective function was introduced to minimize

$$Z = G1(1-R^2) + G2(1-\sum_i w_i)^2 + G3(\frac{a}{v})^2 \tag{19}$$

where G1, G2, and G3 are the chosen weights in the objective function, and

R = coefficient of determination,
w_i = weights of the Almon-distributed lags,
a = constant term, and
v = variance of observed investment.

In other words, we are willing to give up some explanatory value (as measured by the coefficient of determination) if the sum

of the weights comes closer to unity or the constant term closer to zero.

We shall use these features of the estimation procedure in the following way. If it is possible to keep the constant term small and the coefficient of determination remains significant, we can assume that investment decisions have not been made independently by the central authorities. In such cases the enterprises do have an influence on the investment decision. If, in addition, we can identify a significant sigma value (larger than 0.1), then the investment decision was also influenced by efficiency (productivity) considerations, such as enterprise income, prices of investment goods, or depreciation costs.

3.4 The Results

We estimated the investment equations with four different sets of weights in objective function (18): first, with G1 = G2 = G3 = 1; second, with G1 = 10 and G2 = G3 = 1; third, to suppress the constant term, with G1 = G2 = 0.1 and G3 = 10; and fourth, so that $\Sigma_i w_i \simeq 1$, with G1 = 1, G2 = 10, G3 = 1. For each of the equations we estimated four Almon-distributed lags. The results of these estimations are given in Tables 2-5.

The previous findings of Hungarian economists (Bauer, 1978; Soós, 1978) that capital costs have little influence on investment decision making* are confirmed by our results. For only four branches (mining, chemical industry, non-building construction, and telecommunications) did we obtain, in all four variants of the estimations, a sigma value greater than 0.1. The possibility of coincidence cannot be completely excluded, because of the substitution effect between the constant term and sigma. When the constant term is suppressed (Table 4) we get sigma values higher than 0.1 in eight cases.

The results of the estimated equations show that the development of output in the four preceding years has a high explanatory value for investment. Suppressing the constant term

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*Similar results were obtained for the FRG (Uhlmann, 1981, p. 31)

Table 2. Estimated investment equations using G1 = 1, G2 = 1,
          G3 = 1 in objective function (19).

Sector	Coefficient of determination (R)	Constant term (a)	Sum of weights ($\Sigma_i w_i$)	Sigma (σ)
Mining	0.858	612.9	0.842	0.500
Electricity	0.938	-608.8	1.153	0.062
Metallurgy	-0.362	779.7	0.858	0.001
Machine building	0.767	0.0	0.946	0.0
Construction material	0.433	934.4	0.963	0.033
Chemical industry	0.872	-502.8	0.875	0.113
Light industry	0.586	1084.9	0.987	0.0
Other industry	0.881	42.1	1.099	0.0
Food processing	0.707	1112.0	1.125	0.0
Building	0.868	534.6	1.196	0.002
Nonbuilding construction	0.837	267.6	1.188	0.071
Fitting and mounting	0.681	64.0	1.119	0.0
Designing	0.396	100.3	0.941	0.0
Agriculture	0.704	6384.1	1.153	0.063
Forestry	0.648	193.1	1.006	0.104
Water management	-0.094	1907.1	0.377	0.0
Rail transport	0.528	2131.5	0.236	0.089
Road and urban transport	0.770	0.0	0.546	0.0
Other transport	0.348	256.1	0.694	0.093
Telecommunications	0.397	807.4	0.052	0.720
Home trade	0.796	1354.0	1.152	0.116
Foreign trade	0.846	123.5	1.145	0.0
Services	0.901	1807.3	0.980	0.008

Table 3. Estimated investment equations using G1 = 10, G2 = 1,
G3 = 1 in objective function (19).

Sector	Coefficient of determination (R)	Constant term (a)	Sum of weights ($\Sigma_i w_i$)	Sigma (σ)
Mining	0.838	1470.9	0.315	0.500
Electricity	0.952	-3170.9	1.705	0.085
Metallurgy	0.087	2387.9	0.016	0.005
Machine building	0.767	-2539.3	1.374	0.0
Construction material	0.441	1260.7	0.739	0.028
Chemical industry	0.873	-97.4	0.809	0.112
Light industry	0.589	1499.8	0.820	0.0
Other industry	0.881	17.8	1.189	0.0
Food processing	0.715	-252.4	1.724	0.0
Building	0.869	247.7	1.581	0.014
Nonbuilding construction	0.843	116.3	1.734	0.133
Fitting and mounting	0.682	39.4	1.691	0.0
Designing	0.391	140.4	0.665	0.0
Agriculture	0.720	7667.7	1.067	0.089
Forestry	0.649	241.4	0.882	0.085
Water management	-0.094	5171.1	0.009	0.009
Rail transport	0.752	2794.9	0.008	0.067
Road and urban transport	0.771	-4157.1	0.996	0.007
Other transport	0.369	745.9	0.383	0.057
Telecommunications	0.475	1062.3	0.0	0.514
Home trade	0.803	947.7	1.411	0.002
Foreign trade	0.847	82.0	1.366	0.0
Services	0.901	3133.1	0.939	0.009

Table 4. Estimated investment equations using G1 = 0.1,
G2 = 0.1, G3 = 10 in objective function (19).

Sector	Coefficient of determination (R)	Constant term (a)	Sum of weights ($\sum_i w_i$)	Sigma (σ)
Mining	0.864	26.9	1.132	0.500
Electricity	0.929	-25.8	1.060	0.073
Metallurgy	-0.356	47.5	1.111	0.012
Machine building	0.767	-29.3	0.950	0.0
Construction material	0.403	69.9	1.348	0.037
Chemical industry	0.873	-14.3	0.811	0.112
Light industry	0.570	62.2	1.307	0.0
Other industry	0.881	2.1	1.196	0.0
Food processing	0.718	86.5	1.337	0.0
Building	0.868	42.8	1.505	0.0
Nonbuilding construction	0.842	25.6	1.507	0.109
Fitting and mounting	0.681	7.7	1.359	0.0
Designing	0.353	6.0	1.407	0.0
Agriculture	0.601	304.1	1.738	0.0
Forestry	0.647	13.4	1.328	0.117
Water management	-0.094	77.9	0.546	0.0
Rail transport	0.068	100.2	0.848	0.146
Road and urban transport	0.770	-74.3	0.554	0.0
Other transport	0.342	16.5	0.792	0.100
Telecommunications	0.218	45.8	0.181	1.239
Home trade	0.782	105.2	1.438	0.311
Foreign trade	0.843	10.7	1.371	0.0
Services	0.901	75.6	1.026	0.009

Table 5. Estimated investment equations using G1 = 1, G2 = 10,
          G3 = 1 in objective function (19).

Sector	Coefficient of determination (R)	Constant term (a)	Sum of weights ($\Sigma_i w_i$)	Sigma (σ)
Mining	0.843	719.7	1.000	0.132
Electricity	0.935	-27.0	1.021	0.060
Metallurgy	-0.348	559.3	0.983	0.000
Machine building	0.767	-512.0	1.010	0.000
Construction material	0.431	897.4	0.995	0.035
Chemical industry	0.868	-1110.5	0.973	0.113
Light industry	0.585	1062.4	0.998	0.000
Other industry	0.880	65.2	1.016	0.000
Food processing	0.704	1361.7	1.014	0.000
Building	0.868	668.5	1.025	0.000
Nonbuilding construction	0.831	315.5	1.022	0.051
Fitting and mounting	0.681	68.9	1.013	0.000
Designing	0.394	94.1	0.991	0.000
Agriculture	0.700	6923.6	1.022	0.048
Forestry	0.648	194.3	1.001	0.103
Water management	-0.101	-1769.6	0.832	0.000
Rail transport	0.138	1105.0	0.683	0.123
Road and urban transport	0.771	-3730.4	0.969	0.004
Other transport	0.334	-104.3	0.943	0.124
Telecommunications	-0.116	-411.9	0.426	1.500
Home trade	0.732	1461.5	1.016	0.500
Foreign trade	0.845	149.7	1.020	0.000
Services	0.901	1367.4	0.996	0.007

has very little effect on the coefficient of determination, which remains larger than 0.5 for 16 out of 23 branches of the economy.

Output, however, was of little or no help in explaining investment in metallurgy, the construction material industry, designing, water management, the transport sectors, or tele-communications. In transport and telecommunications this may be connected with poor data, but infrastructures that were neglected for decades and relatively new developments in trans-port (pipelines) probably also play a role. Similar considera-tions may apply to water management. In the construction material industry we observe major fluctuations in investment since 1971, which can hardly be explained in terms of sector-specific arguments. It is difficult to avoid the conclusion that the investment process has suffered over the years due to frequent abrupt changes in the priorities of the central decision-making authorities.

Having achieved these results, we agree with most Hungarian economists that prices and capital costs play only a very limited role in Hungarian investment decision making. The tendency to base investment decisions on the development of output in preceding years seems to be dominant. In other words, an expansion-oriented rather than an efficiency-oriented investment policy has been pursued during the last 15 years. There seems to be little conflict between enterprises and cen-tral authorities in using past output as the main argument for future investment. In the infrastructure sectors, however, in-vestment decisions follow a different set of arguments, which cannot be identified using the type of statistical analysis applied in this paper.

4. RECONCILING THE APPROACHES

We now have a model for total investment and a model for sectoral investment. In the first model investment depends on output, among other factors, but economic policy cycles lie at the center of the analysis. In the second model, policy cycles are completely ignored and output is the main explanatory variable for investment. How can we reconcile these different approaches when trying to set up a model explaining both total investment *and* its sectoral distribution? Several possibilities suggest themselves:

1. First, we could extend the sectoral model by introducing policy variables into each sectoral equation. If the policy-cycle model is correct, this should lead to better estimation results. However, we would soon run into practical problems caused by either the lack of sufficient degrees of freedom in the estimation or the difficulty of finding a sufficiently long time series to represent "economic policy".

2. Another way of retaining the best features of both models would be to model total investment using the policy cycle approach and then to distribute investment using the expansion approach model, replacing sectoral output and investment in the expansion model with *shares* of sectoral output and investment. This procedure seems theoretically feasible and it may be experimented with in the future.

3. But the simplest way to handle the problem is to consider our input-output model as a medium-term model and to ignore investment cycles as short-run phenomena. At present the model is set up along these lines. Further work, in which the simulated values of sectoral investments will be summed and compared to actual total investments, will show whether the errors arising from this omission are substantial or not. The results of this comparison are difficult to foresee. Cyclical behavior is already simulated adequately for some sectors by the expansion approach model without any explicit policy variables. However, if the aggregate results are not satisfactory in this respect, we may try to improve the short-term behavior of the model as outlined in point (2) above.

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