SERIE RESEARCH MEMORANDA

INVESTMENT PREMIUMS:
EXPENSIVE BUT HARDLY EFFECTIVE

Henk Folmer
Peter Nijkamp

Researchmemorandum 1986-42 November 1986

VRIJE UNIVERSITEIT
FACULTEIT DER ECONOMISCHE WETENSCHAPPEN
AMSTERDAM

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Henk Folmer*
Peter Nijkamp**

* University of Agriculture, Wageningen, The Netherlands.
** Department of Economics, Free University, Amsterdam, The Netherlands.

Abstract

This paper discusses the effects of the investment premiums arrangement, which is one of the main instruments of regional economic policy in most Western countries. On the basis of theoretical considerations and various Dutch case studies it is concluded that a basic revision of this policy instrument might lead to a reduction of the costs and an improvement of the effects. The case study presented in this paper applies a new model framework which allows to handle latent and observable variables simultaneously. In this way effects of policy packages, which are defined as latent variables, can be analysed.

1. Introduction

The investment premiums arrangement (IP) has been the most important instrument of regional economic policy in many Western economies. In the Netherlands, for instance, it has been used since 1953, and since its introduction its use has increased in terms of amounts spent and spatial applicability. This increase has inter alia been caused by the effects expected by national and regional policy-makers. The importance of this instrument of (regional) economic policy also stems from its compatibility with the economic-political tradition in Western societies to prefer incentives to directives in as far as locational decisions of private firms are concerned. In the case of directives the locational behaviour of a private firm is under the command of the government. In the case of incentives the relative attractiveness of one or more options of the set of possible actions of a firm is changed. The firm, however, is basically free in its response to the incentive. The basic feature of the IP is to provide premiums on investments in buildings or equipment in regions with relatively high unemployment rates. By means of these premiums firms are stimulated to locate or to expand in these regions instead of in the regions where they would "naturally" locate. However, location in the latter kind of regions is not prohibited.

The outstanding position of the IP as an instrument of regional economic policy has increasingly been criticized for various reasons since the beginning of the 1980s. First, because of the economic crisis the number of regions with high unemployment rates has strongly increased. Even former solid economic centres, such as the Western metropolitan region in The Netherlands, are now facing unemployment rates which exceed the former rates in the traditional problem regions. Combatting this spatial increase in unemployment by means of the IP would require an almost nationwide application. Secondly, there are no clear indications that the use of the IP has led to a reduction of spatial inequalities. Moreover, there is a revitalization of some variants of the growth pole theory which stress that (stimulation of) economic growth in the economic core regions will automatically and more efficiently lead to economic development, in particular the decrease of unemployment, in problem regions. Thirdly, as argued by, among others, supply side economists, the involvement of the public sector with the private sector in general is an impediment to economic development (see, among others, Hailstones, 1982). Finally, budget and public financial problems have led to a reduction of subsidies in general, including (regional) investment subsidies.

In spite of the above-mentioned criticisms, policy-makers at the regional level experience a growing need for effective regional economic policy, because of the consequences of the economic crisis.

Therefore, reductions of the investment premiums are strongly opposed.

The confusion about its results and the opposing tendencies with regard to its application have led to a growing interest in a systematic evaluation of the IP. Various studies in this field, including the Dutch, however, are limited in their spatial and/or sectoral range.

The purpose of the present paper is to give some more insight into the effects of the IP on the basis of some theoretical considerations and a Dutch case study. This case study refers to the sector of industry during the period 1973-1981 and covers all Dutch provinces. Moreover, it differs from previous (Dutch) studies with regard to its methodology in the sense that it applies a linear structural equations (LISREL) approach which makes it possible to handle policy packages.

The organization of the remainder of this paper is as follows. In section 2 possible effects of the IP are evaluated on the basis of theoretical considerations. In section 3 various previous studies are briefly described. The measurement method applied in the present study is introduced in section 4. In this section attention is also paid to a specific feature of the data, i.e., a time series of cross-sectional observations on provinces (spatial-temporal data), and to the way it is handled in the LISREL framework. The a priori structure of the model describing possible effects of the IP on investments in buildings and equipment is given in section 5, while the estimation results are presented in section 6. The section ends with some recommendations with regard to the role of the IP in the framework of regional economic policy.

2. Goals and Possibilities of the IP

As mentioned above, the main goal of the IP is to improve the economic conditions for investments in problem regions, so as to create employment opportunities. It usually applies to all kinds of sectors and firms although the conditions, such as the size of the investment, may vary. (For the Dutch situation see, among others, Ministerie van Economische Zaken, 1977, 1982, 1985). This implies that the IP applies to those regions which both have relatively high unemployment rates and relatively poor conditions for location or expansions. In this connection two questions can be raised. First, is it possible to improve the location conditions substantially by means of the IP? Secondly, do all kinds of (subsidized) investments lead to an increase of employment conditions?

With regard to the first question it is important to remark that locational conditions are multi-dimensional in nature and differ for different kinds of industries. If we first consider new locations in and relocations to regions where the IP applies, the following cases can be distinguished

(a) One or more conditions which are essential for a given firm are absent in the IP region. In this case a rational decision maker will usually decide not to locate in the region where the IP applies. If location might take place anyway, various goals of the firm, in particular its survival, might be endangered.

(b) The locational conditions in one or more IP regions are at least equal to those in non-IP regions. In this case the IP enlarges the probability of location. It is important to note, however, that the equivalence or superiority of the locational conditions in the IP regions have to be perceived as such. This is because the subjective perception of the locational conditions matter in locational decisions. In the present situation a positive effect of the IP on locations is plausible, although not certain.

(c) One or more IP regions have basic location conditions which are absent in non IP regions. In this case location in the IP regions concerned is quite likely, in particular, if these basic conditions are absent in non-IP regions. However, it is doubtful whether the IP is efficient in this situation because location without the IP would probably also occur.

As the IP mainly applies in regions which both have poor location conditions and high unemployment rates, situation (a) is likely to be dominant. Moreover, in the case of the so called footloose industries which do not require specific location conditions and which could locate anywhere, case (b) may apply. However, the perception condition is basic in this context.

Let us now consider the IP with regard to expansions. By definition, an enlargement takes place in the region where the original facilities are located. Therefore, a change in the spatial location pattern can only be achieved by influencing the timing and/or size of the enlargement. However, these decisions are usually primarily based on a variety of autonomous economic considerations, in particular expected sales. If the prospects are favourable the investments will usually take place, whether or not subsidies can be obtained. Only rarely will the subsidies lead to investments which otherwise would not be realized. Moreover, the same policy goals could be realized by means of more efficient instruments, such as favourable loans. On the other hand, if the subsidies instead of autonomous economic conditions play a dominant role in the expansion decision, too early or too large an investment may be realized. This might endanger the goals of the firm.

So far we have considered investments in buildings. With regard to investments in equipment it is clear that the IP may lead to earlier replacements, especially when important technological changes are occurring. However, also in this case remarks similar to those made with regard to the timing and size of enlargements apply.

The answer to the first question raised above can now be stated as follows. With regard to investments in both buildings and equipment positive effects are to be expected a priori. The former kind of effects, however, are likely to be very slight.

Concerning the second question it is obvious that investments in buildings have a positive impact on employment. The size of the effect depends on the size of the firm and on its labour intensity. With regard to investments in equipment the situation is more complicated. In the short run, a zero or negative effect is likely because of the labour-saving nature of most modern equipment. Moreover, a shift in demand for higher skilled labour is probable. In the long run, however, investments in modern equipment may be essential for the survival of the firm. Therefore, a negative short-run and a positive long-run employment effect is likely.

In the case study, attention will first be paid to the first question. If a clear-cut positive effect of the IP on investments is found the second question will be dealt with.

3. Previous Dutch Case Studies

As an introduction to the case study to be presented below, the most important Dutch studies of effects of the IP are briefly reviewed in this section. Attention will be paid to their methodology and the main results. Before going into detail, the requirements which an adequate impact study should meet are summarized. (For a detailed overview see Folmer, 1986).

(a) An instrument of economic policy may be intended to operate on several goal variables. Furthermore, an instrument may have unintended effects. For example, the IP may not only stimulate investment (intended effect) but may also lead to increased polution (unintended effect). This observation implies that all variables, which may intentionally or unintentionally have been affected by the policy instrument, should be included into the study as endogenous variables.

(b) A goal variable may directly be influenced by a given policy variable or indirectly via a set of intermediate variables. For example, the IP operates directly on investments but indirectly (via investments) on employment. This observation implies that both the ultimate goal variables and the intermediate variables should be incorporated into the impact study as endogenous variables. Furthermore, the causal chain: policy variable → intermediate variables → goal variables should be explicitly taken into account. Each policy variable should be handled as an explanatory variable of each variable it is assumed to affect directly.

(c) Goal variables are usually not only influenced by policy variables, but also by non-policy variables. In order to avoid specification errors (see, among others, Theil, 1971), the goal variables should be specified as function of both the policy variables and the determining non-goal variables.

(d) Economic policy usually comes into being as a reaction to the development of the economic system. In order to obtain an adequate representation of the interactions between the economic system and economic policy, the <u>mutual</u> effects should be estimated. Consequently, the policy variables should be incorporated in to the impact study as endogenous variables.

e? (f) A policy variable may be effective over several periods or its effects may emanate after some periods of time. Similar remarks may apply to the other time dependent endogenous and exogenous variables. Consequently, the appropriate time lags have to be taken into account.

Let us now turn to the various measurement methods applied in Dutch case studies.

- A rather simple method is to equate the effect of the IP to the total amount of subsidized investments. This method is rather popular in applied policy research. It is inadequate, however, because it does not take into account the fact that when investments are solely realized for non-policy reasons in IP regions the subsidies will be collected. In order to get an adequate estimate of the effect the investments for which the IP was decisive have to be separated from investments for which non-policy variables (i.e. autonomous locational conditions) were the main determinants. In other words, requirement (c) has to be taken into account.
- A second kind of measurement method is based on surveys. Surveys may provide detailed information on the various factors influencing decision-making processes and especially on the (perceived) relative weights of the policy instruments. The survey approach as a measurement method of effects of the IP may suffer from the drawbacks that surveys in general may suffer from, i.e. lack of respondent orientation, errors on account of communication barriers and of perception disturbances of the respondent (see among others Cannel and Kahn, 1968). These drawbacks may result in a gap between the actual effects and the effects as reported by the respondent. For example, the respondents might under-estimate the effect of the prevailing investment subsidies so as to promote higher subsidies in the future. Another example is the ex-post rationalization of the proper factors underlying the decisions made. These problems may be mitigated by incorporating questions into the questionnaire which only indirectly relate to the policy variables and by confronting res-

pondents with hypothetical situations (Oppenheim, 1966). Other problems of surveys are that only effects for a short period can be estimated (compare requirement (e)), and that they are costly and time-consuming. Finally, many surveys nowadays suffer from high rates of non-response. All these problems may lead to incorrect estimates of the effects of the IP.
In spite of these shortcomings, surveys are by far the most common in Dutch (and other) studies of location effects of the IP (see among others Bartels et al. (1982) for an overview). The most important conclusion of these studies is that the IP has only a very slight positive effect on locations and relocations.

- The last type of measurement approaches is formed by spatio-temporal econometric models. The data analysed in these models stem from surveys by the Central Bureau of Statistics and do not relate to policy. Therefore, there are less risks of consciously biased answers. As the structure of this kind of models is discussed in detail below attention is only paid here to the main findings.
  Suyker (1979) finds a significant direct effect on employment in the sector of industry. However, as mentioned above, the effect on employment arises via investments and the effect on the latter is not investigated. On the other hand, Bartels and Roosma (1979) do not find significant effects on employment in the service sector.

The upshot of this section is that empirical studies showed only very slight effects of the IP on investments and employment. However, the various studies suffered from methodological drawbacks.

4. The LISREL Approach

In the case study presented below effects of the IP will be estimated by means of the linear structural relations (LISREL) approach. The main feature of this approach is that it allows to handle both latent and observable variables simultaneously within one model framework. The latter type of variables relates to attributes which possess a direct empirical meaning such as age, distance, regional product, etc. Latent variables on the other hand relate to attributes that are supposed to exist but cannot be directly observed. The reason for this is that these attributes do not correspond directly to anything that can be measured, or that observations of these phenomena are contaminated with measurement errors (see, amongst others, McCorguodale and Wheel, 1956, and Hempel, 1958). Examples of latent variables are socio-economic status, economic expectation, location conditions, etc.

A latent variable is given an empirical meaning by means of correspondence statements, which connect it with a set of observational variables (see also Hempel, 1958, 1970, Blalock, 1971). On the other hand, theoretical terms indicate which observable variables are likely to be highly correlated because they are indicators of the same underlying latent variable. More extensive discussions on the meaning, relevance and use of latent variables can be found, among others, in Adelman and Morris (1971), Droth and Fischer (1980), Goldberger (1972, 1973), Kaplan (1964), and Margenau (1956).

The use of latent variables in policy research is very important because it makes it possible to incorporate policy packages into the model. In practice packages of policy instruments are frequently employed in order to reinforce the effects of individual instruments or to counterbalance negative effects of particular instruments. For instance, in The Netherlands the IP was combined into a policy package with the fiscal accelerated depreciation arrangement so as to reinforce the working of the former. In a LISREL model the policy packages are defined as latent variables and the individual instruments as observable variables. (The advantages of the representation of policy packages as latent variables will be described after the formal representation of LISREL models.)

A LISREL model is made up of two types of submodels, viz.

- a latent variables measurement model, which relates the latent variables to their observable indicators. A distinction is made between a measurement model of the exogenous latent variables (denoted by the vector v), and a measurement model of the endogenous latent variables (denoted by the vector u). The latent variables measurement models correspond to the above-mentioned correspondence statements.
- a structural model which links the endogenous and exogenous latent variables.

In formal terms a LISREL model can be represented as follows. Let u and v be of order (M × 1) and (J × 1), respectively. The corresponding observable stochastic variables are y of order (I × 1) and x of order (J × 1). The vectors of latent and observable variables are related to each other as follows:

$$y = \Lambda_y u + \varepsilon \qquad (4.1)$$

and

$$x = \Lambda_x v + \delta \qquad (4.2)$$

with Λ_y (I × M) and Λ_x (J × N) matrices of regression coefficients and ε (I × 1) and δ (J × 1) vectors of random measurement errors with zero expectation. The following remarks are in order:

- First, the observable variables may be continuous and/or discrete. Unless stated otherwise, it is assumed here that we deal with variables measured at least at an interval scale.

- Secondly, usually multiple observable variables for one latent variable are needed in order to avoid identification problems (see Goldberger, 1972, 1973, and Goldberger and Duncan, 1973). Furthermore, a given single observable variable may be an indicator of several latent variables.
- Thirdly, we shall make the assumption that both the observable and the latent variables are centralized. It should be noted that this assumption is not strictly necessary, but in the analysis of single samples, - a usual case for impact studies of (regional) economic policy -, the intercept terms provide hardly any interesting information.
- Fourthly, it is assumed that u and v are uncorrelated with ε and δ, and that ε and δ are mutually uncorrelated.

The structural LISREL model can now be represented as follows:

$$B\,u = \Gamma v + \zeta \qquad (4.3)$$

where $B(M \times M)$ and $\Gamma(M \times N)$ are coefficient matrices, and $\zeta(M \times 1)$ is a random vector of residuals with zero expectation. It is also assumed that B is nonsingular and that ζ is uncorrelated with v, ε and δ.

The following notation is introduced. The covariance matrices of ε and δ (which need not be diagonal) will be denoted as $\theta_\varepsilon(I \times I)$, and $\theta_\delta(J \times J)$, respectively, and the covariance matrices of v and ζ as $\theta_v(N \times N)$ and $\theta_\zeta(M \times M)$ respectively.

The advantages of representing policy packages as latent variables are twofold. First, it is possible to estimate the effects of the policy packages instead of the individual instruments. Secondly, the consequences of multicollinearity (i.e. the increase of the estimated variances of the estimators of the coefficients of the collinear explanatory variables, which may lead one to drop variables incorrectly from an equation) can be mitigated. This can be seen as follows. Collinear explanatory variables, which are indicators of a given latent variable, are dependent variables in one of the latent variables measurement models (4.1) and (4.2) and are therefore not removed from one of these models because of their collinear nature. Moreover, in the structural model the latent variables appear instead of their corresponding observables. So, collinear variables are neither removed from the structural model in spite of the fact that they are collinear.

Model (2.1) - (2.3) can be estimated by the LISREL VI computer programme (Jöreskog and Sörbom, 1984). This programme also provides information about identification problems which may be used in addition to the usual conditions for identification. It should be noted that a model with latent variables is not identified, if the latent variables have not been assigned measurement scales. The reason for this kind of non-identification is that a change in the unit of measurement of a latent variable, combined with a corresponding adjustment of its regression coefficient, will produce the same value of an observed variable. This can easily be seen as follows:

$$x = \lambda v + \delta = \frac{\lambda}{\alpha}(a\ v) + \delta, \qquad (4.4)$$

where α is a rescaling factor. The easiest way of assigning a measurement scale is to put one λ-coefficient equal to 1 for each latent variable. This implies that each latent variable is measured on the scale of the corresponding observable variable with the λ-coefficient equal to 1. Finally it should be mentioned that in the case of non-identified parameters, it is usually possible to find appropriate functions of those parameters in order to render the model identified. Further information on identification issues can be found in, among others, *Fisher* (1966), Jöreskog (1977a) and Aigner and Goldberger (1977).

The LISREL VI program contains five kinds of estimators which are consistent in the case of *fully identified* models. The estimators concerned are:

- instrumental variables
- two-stage least squares
- unweighted least squares
- generalized least squares
- maximum likelihood

The following remarks are in order here.

- First, three kinds of sample matrices of the observables $z^T = (y^T, x^T)^T$ may be analysed for estimation purposes, viz. the matrix of moments around zero, the correlation matrix and the the covariance matrix. The matrix of moments about zero has to be used when intercept terms and means of latent variables are needed. The correlation matrix could be analysed for numerical expediency; then each variable is expressed in units of its standard deviation. In all other situations the covariance matrix should be analysed.
- Secondly, the first two estimators are based on non-iterative procedures, whereas the other three are using iterative procedures.
- Thirdly, the maximum likelihood procedure is based on the assumption that ε, δ, ζ and v are multinormally distributed. The procedure requires that the sample matrix to be analysed is positive definite.

The final aspects to be discussed here are model evaluation and model modification.

Concerning model evaluation two extreme forms can be distinguished, viz., assessment of model fit and genuine hypothesis testing. The first form of model evaluation presents itself in studies the purpose of which is to find a model that fits the data available as well as possible. For that purpose the same data are explored several times. By genuine hypothesis testing we mean the evaluation of a given hypothesis on the sample data by means of the rules of statistical decision theory (see, for example, Ferguson, 1967). It should be noted that in exploratory studies, where the same data are analysed over and over in order to find an acceptable model fit, genuine hypothesis testing is not appropriate, because the accuracy of the estimator of the resulting data-instigated model will be over-estimated to an unknown extent (see, among others, Leamer, 1978, Lovell, 1983). The LISREL programme provides several statistics which can be used for both types of model evaluation. An overview can be found in Jöreskog and Sörbom (1984).

With respect to model fit and model modification we only mention here that the LISREL VI programme produces modification indices with respect to all fixed and constrained parameters. (A fixed parameter is a priori given a value whereas a constrained parameter is unknown but assumed to be equal to one or more other model paramters). The fixed or constrained parameter corresponding to the largest modification index is the one which, when relaxed, improves the model fit to a maximum extent. It is obvious that the modification index may be helpful when one is in search for an appropriate model. However, a parameter should only be relaxed when it makes sense from a theoretical point of view. (For further details and criticisms see Dijkstra, 1981, 1983).

Finally, we want to make some remarks here on genuine hypothesis testing. When the observable variables are normally distributed and when a covariance matrix has been analysed, the standard theory applies (cf. Joreskög and Sörbom, 1984). In particular, the estimated coefficients are normally distributed and the overall fit of the model can be tested by means of the χ^2-distribution. When these conditions are not met, as in the case study presented below where the observables are not normally distributed, alternative procedures are available, such as the jackknife procedure. This procedure has been described extensively among others by Gray and Schucany (1972), Efron (1982) and Mosteller and Turkey (1977). Below a brief summary is given.

Assume the availability of G groups and observations each containing L elements. Let $\hat{\tau}$ be the LISREL estimate of the unknown parameter τ

based on all G groups of observations and $\hat{\tau}_{(j)}$, j=1,...,G, the estimate based on G-1 groups, with the jth group deleted. Then a pseudo-value of $\hat{\tau}_j$ is defined as:

$$\hat{\tau}_j = G\,\hat{\tau} - (G-1)\,\hat{\tau}_{(j)} \tag{4.5}$$

The jackknifed estimate $\hat{\tau}^*$ is

$$\hat{\tau}^* = \frac{\sum_{j=1}^{G} \hat{\tau}_j}{G} \tag{4.6}$$

The sample variance of the pseudo-values, $\hat{s}^2$, is

$$\hat{s}^2 = \frac{1}{G-1} \sum_{1}^{G} (\hat{\tau}_j - \hat{\tau}^*)^2 \tag{4.7}$$

In a wide variety of situations the pseudo-values may be treated as independent, identically distrbuted, random variables. Furthermore, if $\hat{\tau}_{(j)}$ is a consistent estimator, then $\hat{\tau}^*$ is consistent as well (Thorburn, 1976, Gray and Schucany, 1972).

Miller (1974) has shown that the jackknife estimator of a function of the regression paramters in a general linear model is asymptotically normally distributed under fairly mild conditions. In particular, the residuals are not required to be normal. Furthermore, he has shown that the sample variance of the pseudo-values (4.7) is a consistent estimator for G times the variance of the jackknife estimator under similar conditions. It should be noted that the estimates $\hat{\tau}$ and $\hat{\tau}_{(j)}$ underlying the pseudo-values may be obtained by any of the estimators in the LISREL VI programme, including the maximum likelihood procedure.

As mentioned above the data analysed in the case study is spatio-temporal data, i.e. a time series of cross-sectional observations on the 11 Dutch provinces. When spatio-temporal data is analysed the possible presence of spatio-temporal correlation has to be taken into account. This kind of correlation is made up of three components: temporal autocorrelation, spatial autocorrelation, and spatial cross-correlation (the latter two will jointly be referred to as "spatial correlation"). Temporal auto-correlation has been extensively described in the literature (see, for instance Judge et al., 1980) and will not be discussed here any further. In the case of spatial autocorrelation, a variable in a given region, say region r, is influenced by the same variable in other regions from multiple and different directions in current or previous periods. Furthermore, there may be a reverse influence: the variable in any other region may be influenced by the variable in region r in current or previous periods. When two <u>different</u> variables are influencing each other, one speaks of <u>spatial cross-correlation</u>.

A well-known measure for spatial cross-correlation is the generalized Moran coefficient for two variables y and x. This measure is based on the order of contiguity of adjacent regions. Following Hordijk (1974) this concept can be described as follows. Assume a country, say A, partitioned into regions A_r, r=1, 2, ... R such that:

$$\bigcup_{1}^{R} A_r = A \tag{4.8}$$

and:

$$A_r \cap A_{r'} = \phi, \ \forall\, r, r', r \neq r' \tag{4.9}$$

Now any two regions of A are first-order contiguous if they have a common boundary of non-zero length. A region r of A is contiguous of k-th order (k>1) to a region r' of A (r' ≠ r), if region r is first-order contiguous to one of the regions of A, which is contiguous of order k-1 to r' and is not already contiguous of an order less than k. Finally, a region is defined to be non-contiguous with itself.

The Moran coefficient of contiguity order s and of time lag ℓ, $M_\ell(x,y)$ is defined as:

$$M_\ell^s(y, x) = \frac{\sum_{r=1}^{R} (y_{r,t} - \bar{y}_t)\ (L^s x_{r,\ t-\ell} - \bar{x}_{t-\ell})}{\{\sum_{r=1}^{R} (y_{r,t} - \bar{y}_t)^2\}^{\frac{1}{2}}\ \{\sum_{r=1}^{R} (x_{r,\ t-\ell} - \bar{x}_{t-\ell})^2\}^{\frac{1}{2}}} \tag{4.10}$$

$$s = 1, 2, \ldots, S$$
$$\ell = 0, 1, 2, \ldots, T$$

where $y_{r,t}$ and $x_{r,t}$ are the variables under consideration in region r at time t. L^s is the spatial lag operator which satisfies the condition that:

$$\sum_{i \in Z_{s,r}} w_{r,i}^{s} = 1, \ \forall r, s \tag{4.12}$$

Furthermore:

$$\bar{y}_t = \frac{1}{R} \sum_{r=1}^{R} y_{r,\ t} \tag{4.13}$$

and:

$$\bar{x}_t = \frac{1}{R} \sum_{r=1}^{R} X_{r,t} \tag{4.14}$$

The Moran coefficient of spatial <u>auto</u>-correlation (for <u>one</u> variable y) can easily be determined by adjusting (4.10) accordingly. Furthermore, the Moran coefficient can also be applied in a similar way to disturbance terms.

More details on spatial correlation measures can be found in Cliff and Ord (1973), Martin and Oeppen (1975) and Hordijk and Nijkamp (1977). It is clear that for each variable, a Moran coefficient can be calculated for each time lag and for each contiguity order, both for spatial auto-correlation and for spatial cross-correlation. Thus, a matrix of spatial auto- and cross-correlation coefficients can be constructed (see Martin and Oeppen, 1975, and Hordijk and Nijkamp, 1977). This matrix will be denoted here by C.

Cliff and Ord (1973) and Haggett et al. (1973) derived the first two moments of $M_\ell^s(y, y)$. They showed that it is asymptotically normally distributed under the hypothesis of no spatial auto-correlation. So, the hypothesis of the presence of spatial auto-correlation can be tested in a straightforward way.

The development of a similar test procedure for spatial cross-correlation is far from easy and therefore an alternative procedure is proposed here which is less time consuming. In the present paper, this procedure is applied to spatial auto-correlation as well. Before describing this procedure we remark that spatial correlation can be caused by variables explicitly <u>included</u> in the model and/or by variables represented by the <u>disturbance</u> term. The procedure only relates to the former type, and can be described by means of the following steps:

- Estimating the LISREL model without any specification for spatial auto- and crosscorrelation.
- Calculate the vector of reciduals ℓ with elements $e_{r,t}$, defined as:

$$e_{r,t} = y'_{r,t} - \hat{y}_{r,t} \qquad (4.15)$$

where

$y'_{r,t}$ is the vector of observed values for the observable endogenous variables,

$\hat{y}_{r,t}$ is the vector of LISREL estimates of the observable endogenous variables, based on the postulated model.

The latter vector is not given by the LISREL computer programme, but can be obtained as follows

$$\hat{y}_{r,t} = \hat{\Lambda}_y \hat{B}^{-1} \hat{\Gamma} \hat{\Theta}_v \hat{\Lambda}_x^T (\hat{\Lambda}_x \hat{\Theta}_v \hat{\Lambda}_x^T + \hat{\Theta}_\delta)^{-1} \qquad (4.16)$$

where ^ indicates LISREL estimates.

- Test the residuals for spatial auto-correlation by means of $M_\ell^s(e,e)$. If the hypothesis of spatially correlated residuals is rejected for all time lags and all orders of contiguity, spatial correlation need not be considered any further. Otherwise, the matrix of Moran coefficients C is calculated.
- Variable i indicated by the element of largest absolute value in the

matrix C, denoted as $\max|M_{\ell}^{s}(e, e)|$ is provisionally incorporated into the model as a spatially lagged variable of order s.

- The extended model is re-estimated. If the coefficient of the spatially lagged variable is significantly different from zero this variable is definitely included into the model. Otherwise the variable indicated by the element with the next largest absolute value in C is considered.
- This search process stops when a coefficient of a spatially lagged variable which is significantly different from zero is found or when the number of relevant variables is exhausted.
- The model extended with the spatially lagged variable is re-estimated, its residuals are estimated, checked for spatial autocorrelation, and so on.

If the procedure stops when the number of relevant variables is exhausted and if then the residuals are still spatially auto-correlated, there is necessarily spatial auto- or cross-correlation in the variables represented by the disturbance term. The latter phenomenon can be taken into account by procedures described by Hordijk (1974), and Folmer and Nijkamp (1984) which imply transformations of the data. These transformed observations may then be used to re-estimate the LISREL model. Three remarks are still in order here: First, the Moran coefficients in the matrix C should only be calculated for variables for which spatial correlation may hold from a theoretical point of view in order to avoid a mechanical analysis and implausible spatial correlations. Secondly, handling of spatially lagged variables by means of LISREL models has certain advantages, which can be seen as follows. Suppose the jth exogenous observable variable x_j is spatially correlated with y_i for several temporal and spatial lags. This kind of correlation can be dealt with by defining a new exogenous latent variable, say $v_{n',r,t}$, of which $\{L^p, x_{j,r,t-\ell}\}$ are indicators for the various combinations of p and ℓ concerned. Thus, instead of using a bunch of variables, one latent variable, representing the effects of the variable under consideration in spatial units of several orders of contiguity in several periods, is used. It is obvious that this may lead to a considerable reduction in multicollinearity. When - on the basis of prior information or data analysis - the sequence $\{L^p x_{r,t-1}, p=1,2,\ldots,P;\ 1=0,1,\ldots,L\}$ is assumed to exhibit spatial or temporal transient features in its structure, more than one latent exogenous variable may be used (see Folmer and Van der Knaap, 1981, for the case of temporal transients). If x_j and x_h are indicators of the same latent variable and if both of them are spatially correlated with y_i, both sequences $\{L^p x_{h,r,t-\ell}\}$ and $\{L^{p'} x_{j,r,t-\ell}\}$ can be used as indicators of $v_{n',r,t}$.

An analogous approach can be used, if there is evidence of spatial auto- or cross-correlation among endogenous observable variables. In this case, a new endogenous latent variable, say $u_{m',r,t}$, is defined. As the aim is not to explain $u_{m',r,t}$ in terms of the other variables in the model, it is a quasi-endogenous variable, so that it may be put equal to its disturbance in the structural model. The procedure just described can be applied to all observable variables characterized by spatial correlation.

As mentioned above, spatial auto- and cross-correlation in the variables represented by the disturbances can be taken into account by transforming the data. These methods can also be used to deal with spatial auto-correlation in the measurement errors of the exogenous variables.

Thirdly, depending on primarily identification problems various methods can be applied to take temporal autocorrelation into account (see Folmer, 1986). In the case study presented below covariance analysis is employed which is a method for correcting statistically for the effects of uncontrolled variables (for time-specific features in the present case). The uncontrolled variables are generally represented by dummy variables. In case of model (2.2), this means that dummy variables are included in the vector of observables such that

$$x_{j,r,t} = \left| \begin{array}{l} 1 \text{ for period } t \\ 0 \text{ period } s,\ s \neq t \end{array} \right. \qquad r=1,\ 2,\ldots,\ R;\ t=1,2,\ldots,\ T \qquad (2.17)$$

The use of dummy variables has certain drawbacks (see Maddala, 1971), but these can be overcome by using 'real' information instead of dummy variables. In this case, a latent variable representing relevant information with respect to the various periods under consideration, has to be used (see Section 5). After these corrections, the usual LISREL assumptions may be assumed to be fulfilled. It should be noted that when the covariance analysis approach is used, the x variables should be treated as <u>fixed</u> variables. This means that the conditional distribution of the endogenous variables y is analysed for given values of the x variables. In that case $v = x$, Λ is an identity matrix, and Θ_v is the sample covariance matrix of the x variables. When the fixed variables option is used, no latent v are possible. When such latent variables are needed, they have to be specified as quasi-endogenous latent variables (i.e., as endogenous variables which in the structural model are equal to their corresponding residuals).

After this treatment of LISREL models and its spatio-temporal features, the formal measurement model of effects of economic policy will be given in the next section.

5. Dutch Case Study: a priori Model Structure

We will start this section with a discussion of the endogenous variables. As mentioned above, the purpose of Dutch regional industrialization policy was to stimulate investments, both in buildings and in equipments. Therefore, a distinction will be made in the model between investments in buildings (IB) and investments in equipment (IM). It should be observed that it would be desirable to distinguish new investments, enlargements and replacements in the case of buildings, and new investments and replacements in the case of machinery. The main reason for this is that the reactions of each kind to the various policy and non-policy variables may differ. The data, however, does not allow disaggregation along these lines.

As pointed out above, an adequate representation of the interaction between the regional economic system and regional policy requires the policy instruments to be endogenous. Therefore, the model contains a third endogenous variable: regional industrialization policy (RI). This policy package is made up of the observable instruments investment premiums arrangement (IP) and fiscal accelerated depreciation (FA).

Let us now turn to the explanatory variables of both investment equations. As was pointed out above, one of the main requirements of measuring effects of policy is to establish to what extent the impact variables have been affected by policy and to what extent by autonomous developments. In order to meet this requirement, both the relevant policy variables and the relevant non-policy variables have to be included in the set of explanatory variables of each investment equation.

Concerning the first category, both current and lagged policy variables are included in each investment equation. This is because the investments consist of aggregates of both 'short-term' realizations, affected by current policy, and 'long-term' realizations, affected by lagged policy. At first instance, only one time lag will be considered. It is obvious that the effect of regional industrialization policy must be either positive or zero.

The following explanatory variables of the non-policy kind are included into the investment equations:

- In each equation the dependent variable lagged for one period is included. This variable is incorporated because investments started up in a given period may be terminated in a following period, i.e. there may be some continuity of investments through time. The sign of the effect of the lagged variable is uncertain. Because of the simple follow-up nature one would expect a positive sign. However, in situations where large investments in one period lead to relatively modest investments in the next period, or vice versa, a negative sign may occur.

- In each equation changes in current and lagged regional products (RP) are included. These variables provide information on the basis of which expectations about the development of the regional economy can be formed. It is well-known that these expectations play an important role in investment decisions. Both current and lagged variables are considered in order to take the various degrees of inertia into account. The sign of the effect of this variable is expected to be positive. It should be noted that it would have been more appropriate to use current and lagged sales instead of current and lagged regional products. Unfortunately, data on this variable was not available. However, the variables sales and regional product are usually highly correlated.
- According to location theory the socio-cultural and the physical environment are important explanatory variables with regard to investments in buildings. The latent variable socio-cultural environment (SE) will be operationalized by population density (PD) and degree of urbanization (DU). The sign of the socio-cultural environment is expected to be positive.

The only observable indicators available for the physical environment are distance by road from the economic ecntre of The Netherlands (the Randstad) (DR), and avaible sites for industrial activities in hectares (SH). Because each of these two variables represents a quite different aspect of the physical environment, they will not be combined into a single latent variable but will be separately treated as observables. On the basis of location theory the distance variable is expected to have a negative effect. The availability of sites for industrial locations is likely to have a positive impact.

It should be observed that the four last-mentioned variables will be treated as time-invariant background variables. For the variable DR this is obvious. For the other variables it is a consequence of the availability of one observation only. However, these variables usually change slightly, so that they may well be considered as time-invariant here.

- Changes in labour volume (LV) is included in the investments in machinery equation. The reason to include this variable is that production costs can usually be depressed by exchanging labour for capital. For the same reason this variable is expected to have a positive impact on investments in machines.
- Investments in buildings is incorporated into the investments in machinery equation. The sign of this effect is uncertain. On the one hand, one would expect a positive sign because the new buildings have to be equipped as soon as possible after their construction has been terminated. On the other hand, during the process of construction there is no need for investments in machinery for the new buildings.

Furthermore, investments in buildings may lead to a shortage of funds for investments in machines. This may in particular be the case in periods of slow or negative growth of the regional economy. In the latter two cases the sign of the effect is negative.

- Variables representing spatial auto- and cross-correlation effects will be included in each equation. The variables for which spatial correlation has to be taken in to account and the orders of contiguity and time lags will be identified by means of the procedure described in the preceding section.
- A time specific variable is included in each investment equation. As mentioned above, dummy variables, which are applied in covariance analysis, have certain drawbacks. Hence, an alternative will be used here. It consists of including the variable "total national investments" (NI) in the investments equations. This procedure can be rationalized in the following way. Maddala (1971) states that dummy variables represent some ignorance, just like the residuals. In the present regional case, however, this ignorance can be partially circumvented by using existing knowledge of the national trend, because the national trend is the aggregate of the regional trend. Because it is the aggregate the regional variables, the sign of the national investment variable is expected to be positive or zero. The latter will be the case when the explanatory power of the other explanatory variables is high and temporal correlation is not relevant.

Next, attention is paid to the explanatory variables in the policy equation. The variables included are the following:

- Lagged regional industrialization policy. This variable is included because regional industrialization in a given period is usually continued in subsequent periods, inter alia, for political reasons, such as the promotion of regional interests at the national level by regional governments. For the same reason the sign of this variable is expected to be positive.
- Changes in the official total unemployment percentage because the major ultimate goal of Dutch regional industrialization policy was to stimulate employment. As data on this variable can easily and frequently be obtained (in contrast to information about investments at the regional level), policy-makers usually base their decisions (partly) on the development of the unemployment percentage. For reasons of inertia of regional policy a time lag of one period will be assumed. It is obvious that the sign of the effect is expected to be negative.
- A time-specific variable, which is decided to be the change in total national investments. It should be noted that the variable national investments and not national unemployment has been chosen because policy-makers usually base their decisions with respect to regional investment policy also on this variable rather than on the development of unemployment solely. From the discussion above it follows that the

sign of this variable is likely to be negative.

- From a theoretical point of view there is no reason to take spatial correlation into account in the policy equation. Regional policy or unemployment in a given region is usually no reason to intensify regional policy in another region.

The model described above will be estimated in the next section.

6. Dutch Case Study: Empirical Results

The model presented below has been estimated on the basis of observations on the eleven Dutch provinces (the spatial units) over an eight-years period (1973-1981). Because of the presence of one-year lagged variables the ultimate number of observations for the time series is equal to 7 and the total number of observations to 77.

The observable variables have been measured as percent changes. As the endogenous observable variables are not normally distributed the jackknife procedure has been used. Mosteller and Tukey (1977) and Gray and Schucany (1972) show that the standardized jackknife estimator follows the t-distribution.

Because a variant of the covariance analysis approach is applied, the fixed variables option will be used. Another reason for the use of this option is to keep the number of parameters to be estimated to a minimum because of the relatively small number of observations. As mentioned above, when in the case of the fixed-x option latent exogenous variables are wanted, such as the social location environment variable, they have to be specified as quasi-endogenous latent variables.

As mentioned in the preceding sections, spatio-temporal correlation has to be considered in connection with the present data set. Let us first pay attention to spatial correlation. The detection of spatial correlation is carried out by means of the procedure described in section 3. First the model is estimated without specifications for spatial correlation. Next the residuals are calculated and tested for spatial auto-correlation by means of (4.10). The weights $w^{s}_{r,i}$ in (3.4) are choosen as:

$$w^{s}_{r,i} = \frac{1}{\sum\limits_{i \varepsilon A_{sr}} \delta_i} \qquad \forall\ r,\ s,\ \ell \qquad (6.1)$$

where $\delta_i=1$ if $i\ \varepsilon\ A_{sr}$, and $\delta_i=0$ if $i\ \varepsilon\ A_{sr}$, with A_{sr} as defined in (4.11).

The detection procedure resulted in the rejection of the hyptohesis of spatially uncorrelated disturbances. Therefore, the matrix of Moran coefficients of spatial auto- and cross-correlation was calculated. For the sake of brevity of the paper this matrix is omitted here. The largest Moran coefficients in absolute value turned out to be third-order auto-corrrelation for IB (t), being equal to -.64 and the next largest the third-order auto-correlation for IM (t), viz. -.56. It should be noted that in The Netherlands the peripheral problem regions in the North and in the South and the Western core regions are third-order contiguous. Substantial differences in growth rates of various economic variables, including investments, are known to exist between these regions.

Two new spatial auto-correlation variables C(IB(t)) and C(IM(t)) corresponding to IB(t) and IM(t), respectively, were added to the list of variables. The new model, extended with C(IB(t)) and C(IM(t)), was estimated. As will be shown in (6.2) and (6.3), the coefficients of these variables were significantly different from zero. Therefore, these variables were included into the model. The residuals of the enlarged model were found to be spatially uncorrelated. So, the search for spatial correlation was terminated.

Temporal auto-correlation was also found to be present. It was taken into account by means of the variable total national investments (NI).

The directly observable variables in the model are (the sources of the variables are given in the Appendix):

IB : investments in buildings;
IM : investments in machines;
NI : total national investments;
IP : the prevailing percentage of investment premiums;
FA : the prevailing percentage of accelerated fiscal depreciation;
RP : regional product;
PD : population density;
DU : degree of urbanization;
DR : relative distance from the Randstad;
SH : relative availability of sites for industrial activities;
LV : labour volume;
UE : official total unemployment percentage;
C( ) : variable representing third-order spatial correlation.

The latent variables are:

RI : regional industrialization policy, measured in the scale of investment procedures;
SE : the socio-cultural environment, measured in the scale of population density.

The most important estimation results are given in the equations (6.2)-(6.9)

The latent variables measurement models

$$\mathrm{IP}(t) = \mathrm{RI}(t) + E_1(t) \qquad (6.2)$$

$$R^2 = .81$$

$$\mathrm{FA}(t) = \underset{(6.5)}{1.5}\ \mathrm{RI}(t) + E_2(t) \qquad (6.3)$$

$$R^2 = .69$$

$$\mathrm{PD} = \mathrm{SE} + E_3 \qquad (6.4)$$

$$R^2 = .93$$

$$\mathrm{DU} = \underset{(30.3)}{0.90}\ \mathrm{SE} + E_4 \qquad (6.5)$$

$$R^2 = .90$$

The structural model

$$\begin{aligned}\mathrm{IB}(T) = {} & \underset{(.04)}{.01}\ \mathrm{RI}(t) + \underset{(.34)}{.11}\ \mathrm{SE} + \underset{(4.53)}{.28}\ \mathrm{RP}(t-1) + \underset{(3.27)}{.85}\ \mathrm{IB}(t-1) + \qquad (6.6) \\ & \underset{(-2.58)}{-.12}\ \mathrm{CIB}(t) + \underset{(.12)}{.03}\ \mathrm{DS} - \underset{(-.51)}{.08}\ \mathrm{NI}(t) + I_1(t)\end{aligned}$$

$$R^2 = .89$$

$$\begin{aligned}\mathrm{IM}(t) = {} & \underset{(.23)}{.04}\ \mathrm{IB}(t) + \underset{(2.22)}{.18}\ \mathrm{RP}(t) + \underset{(1.02)}{.24}\ \mathrm{RI}(t-1) - \underset{(-1.76)}{.34}\ \mathrm{IB}\ (t-1) + \qquad (6.7) \\ & \underset{(5.31)}{.81}\ \mathrm{IM}(t-1) - \underset{(-.68)}{.10}\ \mathrm{LV}(t) - \underset{(-2.02)}{.14}\ \mathrm{C}(\mathrm{IM}(t)) - \underset{(-.93)}{.07}\ \mathrm{NI}(t) + I_2(t)\end{aligned}$$

$$R^2 = .84$$

$$\begin{aligned}\mathrm{RI}(t) = {} & \underset{(3.68)}{.77}\ \mathrm{FA}(t-1) + \underset{(3.01)}{.51}\ \mathrm{IP}(t-1) + \underset{(.29)}{.01}\ \mathrm{UE}(t-1) + \\ & - \underset{(2.53)}{.11}\ \mathrm{NI}(t) + I_3(t) \qquad (6.8)\end{aligned}$$

$$R^2 = .92$$

Before paying attention to the judgement of model (6.2)-(6.8) it is worth noting that the model has a data-instigated nature, because several specifications (i.e., the spatial correlation variables C(IB(t)) and C(IM(t)), various elements of the matrices θ_ζ and θ_ε), were found by trial and error. Therefore, the accuracy of the estimators may be over-estimated to an unknown extent. So, judgement statistics (especially t-values), which slightly exceed their critical values, should be interpreted cautiously.

From the following two facts it may be concluded that the *operationalization* of the latent variables is quite satisfactory. First, from the t-values one can derive that the observable variables are highly significant indicators of the underlying latent variables. Secondly, in the estimated variance-covariance matrix of the measurement errors, $\hat{\theta}_\varepsilon$ (which is not given here because of the length of the paper) the only substantial element is the variance of accelerated fiscal depreciation: .40.

Concerning the investment equations we want to point out the high R^2 values. Furthermore, we remark that the estimated coefficients are in conformity with prior expectations. The only point to be stressed here is that in both investment equations the effects of regional industrialization policy are not significantly different from zero (at, e.g., the 5% level). This applies especially to equation (6.6). So, we may conclude that for the sector of industry as a *whole* no effects of regional industrialization policy significantly different from zero can be discerned for the period under investigation. This means that the usefulness of regional industrialization policy as *global* instrument to improve the relative attractiveness of the benefitting regions can be doubted. However, the aggregate nature of the investments under consideration should be taken into account. For instance, if only investments in new establishments had been considered, significant effects might have been discovered. Similar results might have been found for specific *sub-sectors* of industry.

Finally, we will pay attention to the explanation of regional industrialization policy. From equation (5.8) it follows that regional industrialization policy is primarily influenced by accelerated fiscal depreciation and investment premiums in the previous period. Furthermore, the time-specific variable, national change in investments, had a significant effect. The change in the official unemployment percentage is insignificant. So, we may conclude, that during the period under investigation regional industrialization policy had a very strong autonomous tendency and was rather insensitive to changes in the unemployment percentage.

As mentioned in section 2 the investigation of effects of the IP on employment follows a two-step procedure: if the IP has a significant effect on investments the employment effects will be considered. The results of this section show that the second step is superfluous.

7. Conclusions

The main conclusion of this paper is that the IP has only slight positive effects on investments in buildings and in equipment. This conclusion is based on theoretical considerations and on the empirical results of various Dutch case studies. As the IP is the most important instrument of regional economic policy in many Western countries this finding has far-reaching consequences for this kind of policy. In this connection we make the following suggestions for reconsideration.

First, it may be worthwhile to reconsider the application of the IP in its present form. In particular, its use in terms of applicability to expansions and new locations as well as to all kinds of sectors might be revised. As argued above, the spatial distribution of investments is most likely and most effectively to be affected by new locations. Therefore, the IP should be aimed at the location of sectors for which the location conditions are favourable in the IP regions but which do not necessarily have to locate there. The application of the IP to expansions should be replaced by e.g. favourable loans.

Secondly, it is a well-known fact that many firms do not base their location decisions on extensive (own) examinations of the location conditions but merely follow so-called "leading firms". Therefore, the IP should in particular be oriented towards leading firms. In this regard it might be vital to develop a more flexible kind of IP than the present version. In particular, it might be important to revise the maximum of the subsidies and various other conditions for special cases. For "followers" a reduction or even the abolition of the IP might be considered.

Thirdly, as the IP is aimed at compensating negative location conditions it may also be important to improve the location conditions directly, e.g. by means of infrastructural projects. Moreover, such projects often have substantial employment effects (Folmer, 1986).

Revision along these lines might not only reduce the costs of the IP but also improve its effectivity.

Appendix

- The data on labour volume and regional product comes from Regionale Economische Jaarcijfers, 1971 and 1973-1981, Centraal Bureau voor de Statistiek; Den Haag.

  Industry is defined as the total of the sectors 4 (food industry) to 20 (remaining industry). It does not include mining and quarrying (sectors 2-3) and public utility.

  The data for 1972, which is not available, is calculated as the unweighted average for 1971 and 1973. Because data for 1972 was not available and had to be calculated as indicated, only effects of policy for the period 1973-1976 have been estimated.
- The data on investments in buildings and in machinery comes from Statistiek van de Investeringen in Vaste Activa in de Nijverheid, 1973-1978, Centraal Bureau voor de Statistiek, Den Haag.
- The data on investment premiums and fiscal accelerated depreciations is derived from Folmer and Oosterhaven (1983).
- The data on unemployment comes from Sociale Maandstatistiek, 1972-1981, Centraal Bureau voor de Statistiek, Den Haag.
- The data on distance by road, sites available for industrial activities, population density and degree of urbanization comes from Centraal Economisch Plan 1978, Centraal Planbureau, Den Haag.

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