A MULTIDIMENSIONAL ANALYSIS OF REGIONAL INFRASTRUCTURE AND ECONOMIC DEVELOPMENT

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ABSTRACT

The paper provides a methodological and operational analysis of the relationship between infrastructure and regional development. After a brief introduction to regional planning and aspects of regional inequality, a survey of theories for the explanation of regional growth differences is given. Next, the concept of infrastructure is dealt with in greater depth, while an analysis of the role of infrastructure for regional development is proposed, based on a multidimensional matrix representation of various infrastructure categories.

In the second part of the paper, it is set out how this framework can be used to study the impacts of infrastructure (policy) on regional development. In this respect, useful multivariate tools are inter alia: multidimensional scaling analysis, principal component analysis and a new technique based on ordinal regression methods. The theoretical foundation of the analysis is formed by a regional development potential theory which uses inter alia a so-called quasi-production function approach. This approach is clarified by means of a case study for the Netherlands as a part of a broader comparative international study for the EEC-countries.

1. Regional Planning

Regional planning is an area characterized by a direct confrontation between abstract, theoretical concepts regarding efficient allocation and equity on the one hand, and the urgent practical problems of regional disequilibrium and underdevelopment on the other hand. Frictions in regional planning emerge among others from (cf. Cumberland, 1971):

- ideological discrepancies between economic planners;
- political differences regarding the desirable range of public policy measures;
- lack of insight into regional economic structures and growth processes;
- rigidy of instruments of economic policy.

In respect to this, Friedmann (1973) makes the distinction between allocative and innovative planning (cf. Lambooy, 1978, and Van der Pluijm, 1978). Allocative planning is oriented to the achievement of an optimal spatial allocation within the social and economic status quo, whereas innovative planning regards also the parameters of the socio-economic system and institutional structure as a variable [1]. Regional planning aims at achieving (direct and indirect) changes in spatial and economic structures so as to guarantee a harmonious adjustment to social, economic and cultural needs in society (cf. Nijkamp, 1980). Especially in case of an imperfect working of the market mechanism (for instance, the emergence of negative externalities), regional policy plays a crucial role for a more balanced spatial development. Berry (1976) makes the following distinction for the style of regional policy:

- ameliorative problem-solving; this approach focuses in particular on avoiding and tackling frictions and problems taking place on the basis of expected developments and trends;
- allocative trend - modifying; in this approach a future structure and reference pattern is required so as to have a reference pattern for current planning possibilities and desirabilities;
- exploitive opportunity-seeking; in this respect, future spatial problems are being identified in order to design future alternatives and to select the most favourable future alternative pattern;

1) Cf. the difference between quantitative policy on the one hand, and qualitative and structural policy on the other hand, made by Tinbergen (1956); cf. also Van Duijn (1979).

- normative and goal-oriented; this approach aims at designing spatial alternatives on the basis a priori specified aims, for instance, by means of systems-theoretic methods.

The above mentioned classification is useful from an action-oriented point of view, but offers not so many perspectives for a practical typology of public policies. In this respect a more practical distinction is:

- direct regional policy: the government controls the regional development in stricto sensu by taking over or directly limitating private economic activities (for instance, investment and location decisions, prohibitions);
- indirect regional policy: the government takes a set of measures which will,to a certain extent, steer the regional economy, without affecting the economic freedom and responsibility of private entrepreneurs (for instance, subsidies and charges).

Consequently, indirect regional policy is a conditional policy: it creates the (necessary) conditions under which regional economic objectives can be realized, without providing however sufficient conditions. The following subdivision of instruments of indirect regional policy can be made (cf. Broersma, 1977) :

- fiscal (special regulations for depreciation and investment reserves, e.g.)
- financial (subsidies and credit guarantees, e.g.)
- non-financial (construction of infrastructure, international trade policy, and mobility policy e.g.).

The latter subdivision shows that infrastructure policy is only a part of a total regional policy; it is only a conditional policy for regional development.

2. Regional Inequality and Underdevelopment

Stilwell (1972) makes a distinction between 3 kinds of problem regions:

- underdeveloped regions: areas with mainly a traditional agricultural structure and low population densities and often located in the periphery of a country; their location profiles are, in general, unfavourable;
- depressed regions: areas which have gone through an industrialization process, but which have not been able to continue the process of economic growth due to lack of innovation or unfavourable locational conditions;
- congested regions: areas in which a further concentration of activities will lead to additional agglomeration disadvantages which exceed the advantages.

The above mentioned distinction shows already that the causes and features of regional inequality and underdevelopment are not unique, so that regional policy should be multidimensional in scope. For instance, Van Duijn (1979) mentions several causes for a stagnation: exogenous disturbances and policy mistakes, over-investments, rise in labour costs, qualitative decline in economic structure, socialization of demand, saturation of demand, lack of technological innovation, uncertainty due to environmental requirements and inflation, exhaustion of raw materials and energy resources, and competition from the Third World.

Regional policy aims at creating conditions for a healthy economic structure by stimulating the economic development, eliminating bottlenecks for growth and modifying less desirable development tendencies. Infrastructure policy is - in the framework of regional policy - one of the means to realize the abovementioned conditions.

It has to be mentioned that concepts such as underdevelopment and inequality are not unambiguous, as they are characterized by multiple attributes. In this respect, it is more adequate to describe the development pattern of a region by means of a so-called multidimensional profile including inter alia income, employment, facilities, population density, environmental quality and energy resources (Nijkamp, 1979). Frequently, an operationalization of the concept of regional development via income and employment indicators is a fairly limited approach, although these concepts are often being employed in regional planning.

It is clear, that also the regionalization problem is an important question. For instance, several peripheral regions show a higher unemployment rate than central regions, so that regional policy is very often oriented to the periphery. On the other hand, however, it turns out that nowadays the unemployment rates in major cities in central regions may even be much higher than those in the peripheral regions. Consequently, the equity problem is also co-determined by the spatial scale of analysis (cf. Molle, 1980).

In addition, it is also important to keep in mind that the equity problem is co-determined by the definition of specific welfare indicators. For instance, absolute unemployment figures lead to an entirely different conclusion about spatial inequality than relative unemployment figures (Klaassen, 1978).

3. Theories Explaining Differences in Regional Growth

The history of regional economics has been marked by a wide variety of contributions to the analysis of interregional welfare discrepancies. There is a whole set of theories for the explanation of differences in regional growth, measured in income, employment or production (Armstrong and Taylor, 1978). The most important theories will briefly be discussed here.

Neoclassical theory

The neoclassical growth theories are more oriented to the supply side than the demand side - in contrast to the Harrod - Domar models (Richardson, 1969). These growth models are usually based on an aggregate production function; the productive capacity of the economy determines its output.

Two important features of neoclassical theory are:

- perfect substitutability between production factors
- flexible prices of production factors.

The consequence of these features is that no long run over-capacity can exist, because this would lead to price and demand adjustments. The growth rate of the economy is determined by three factors:

- accumulation of capital
- increase in labour supply
- technical progress .

Consequently, disparities in labour productivity are the result of either the degree of technical progress or the growth rate in the amount of capital per labourer.

The growth in available capital and labour depends on both intraregional and interregional developments. Given the fact that capital has normally a higher spatial mobility than labour, it follows that capital will flow more rapidly from high-wage regions to low-wage regions than the labourers will move from low-wage regions to high-wage regions (Armstrong and Taylor, 1978).

In spatial variants of neoclassical theory , sometimes the assumption is made that regions do not produce one homogeneous commodity, but a whole set of commodities produced by several sectors. Consequently, in such a case a production increase in the regions can be reached by means of both intersectoral and interregional shifts, so that sectoral and spatial changes can be realized simultaneously.

Finally, it should be repeated that the main emphasis of neoclassical theory on supply factors neglects the fact that economic growth in an open spatial system is also determined by demand factors.

Export-base theory

The export-base theory is essentially based on the comparative cost approach: according to the Heckscher-Ohlin theorem, regions will focus their attention on the production of commodities which can easily be produced by means of the most available production factors. Thus, specialization and export orientation are key factors in the export-base theory (cf. Deane, 1969, and Lloyd and Dicken, 1972), especially when through a multiplier mechanism initial incentives exert a significant impact.

In the long run, a high flexibility of prices of production factors and a high mobility of these factors will lead to a permanent reallocation of production factors and an adjustment to changes in export orientation, so that then a structural economic growth process may be induced.

The emphasis of the export-base theory on demand factors is very important. However, it may be difficult to define precisely which kind of export activities should be stimulated, because many firms will serve both the export market and the local market. Moreover, this theory does not explain the determinants of the demand for export commodities.

Polarization theory

The polarization theory is composed of a set of concepts and views which focus primarily on the study of increases or decreases in regional growth disparities (Hansen, 1972, and Kuklinski, 1972). The polarization theory assumes that economic growth is an integrated and cumulative process. Two types of polarization theory will be discussed here.

A. Growth pole theory

Growth pole theory rests on an integration of spatial and economic interactions. A growth pole is - according to Perroux - a concentration of elements or activities in space. In this respect, the notion of a stimulerende propulsive unit is very important, as this key activity may be the driving force for other activities. Through spatial and economic spillovers this propulsive unit will have (direct and indirect) positive economic impacts on all other economic activities in the region at hand, thus leading to a cumulative growth process. Clearly, a termination of this propulsive unit (for instance, due to lack of innovation) may lead to an economic decay for the region concerned.

B. Cumulative causation

In addition to (positive) centrifugal spread effects, one may also distinguish (negative) centripetal backwash effects. Especially Myrdal has claimed that - among others due to a failing market mechanism - the backwash effects may be more important than the spread effects, so that after a process of cumulative causation even a socio-economic loss for the region at hand may result, leading among others to an increase in spatial disparities. Such backwash effects might undermine the whole development process of lagging regions in a spatial system (cf. also the related heartland-hinterland concepts developed among others by Friedmann, 1973, and Berry, 1976).

Disequilibrium theory

The disequilibrium theory takes for granted the existence of constraints to the economic growth process. By modifying these constraints, it is to a certain extent possible to steer this process (cf. Spiegelglas and Welsh, 1970).

One of the representatives of this approach, Hirschman, assumed that even a chain of imbalanced growth impulses (e.g., indivisibilities) might stimulate economic development by creating stress situations in regional management, thus forcing the authorities to improving the effectiveness of regional policy.

Hirschman has placed much emphasis on public infrastructure investments (social overhead capital). These are basic investments which constitute the necessary conditions for primary, secondary and tertiary activities (for instance, in the field of education, medical care, social-cultural amenities, transportation infrastructure). This social overhead capital is a prerequisite for direct productive capital. Clearly, a fine tuning of social overhead capital and direct productive capital is fraught with difficulties, because due to financial constraints or indivisibilities bottlenecks or overcapacities may emerge (cf. Streeten, 1963).

In this respect, also indirect investment effects (due to input-output linkages) have to be taken into account.

Critical theory

The critical theory assumes that wages and prices are not flexible (Stuart Holland, 1976). This is caused by the fact that a large share of total trade is monopolized by the so-called meso-structure (multi-regional or multi-national firms), so that a traditional micro-economic location and investment analysis is impossible.

Furthermore, wages are not flexible due to the strong position of the unions, so that wages in lagging and peripheral areas are equally high as in the economic centre of the country. Hence, the comparative advantage of lower wages in poor regions does not exist. Moreover, the migration process from peripheral areas to major centres even affects the argument of a sufficiently high labour supply in peripheral regions, so that there is no reason for entrepreneurs to invest in these regions. And - last but not least - entrepreneurs will first implement replacement investments in the central regions before implementing new investments in peripheral areas.

Stuart Holland argues that a higher degree of public intervention in private investment decisions is necessary for a more balanced spatial economic development.

It should be noted that this critical theory focuses its attention more on the causes of the continuation of existing disparities than on the fundamental causes of the emergence of these disparities. As a whole, however, this theory can be regarded as a criticism on the neoclassical interregional equilibrium mechanism.

Regional development potential theory

The basic idea of this theory is that regional disparities are the result of long-run developments and not of short-term cyclical fluctuations. Consequently, much emphasis is placed on the supply side and hence on the capacity side. The reason is that a region is too small - in comparison with the total world economy - for exerting a significant influence. Thus, the world demand is considered as given. Consequently, the problem of regional disparities is essentially a comparative allocation problem, viz. which share of total world demand will be attracted by the successive regions in an open spatial system? This also explains the degree to which regions succeed in utilizing their production capacity, so that the question as to which factors determine the regional development potential becomes crucial (cf. Biehl, 1980).

The regional development potential depends on:

- regional potentiality factors (such as availability of natural resources, locational conditions, sectoral compositions, international linkages and existing capital stock)
- mobile production factors (such as various kinds of labour and new investments).

Potentiality factors for capital can be subdivided into:

- material and immaterial capital
- private and public capital.

Infrastructure capital is essentially public capital which may be either material or immaterial. These potentiality factors determine the regional development potential, although the impacts of these factors may differ, depending on their mobility, indivisibility, non-substitutability, polyvalence and non-exclusiveness. By means of these 5 characteristics the regional potentiality factors may be distinguished from other (directly or indirectly) productive resources.

The emphasis of the regional development potential theory on public capital is extremely important for regional infrastructure policy, since in this case such a policy may be an effective tool in coping with the problem of spatial disparities.

Evaluation

The abovementioned theories will be briefly reviewed in light of the relationship regional development - infrastructure policy.

Neoclassical theory: has limited relevance, because it provides only a description of the mechanism of regional development, but it gives no fundamental explanation for the emergence of different growth rates nor does it provide a contribution to an effective regional management; only certain aspects - such as labour productivity and technical progress - are relevant in relation to infrastructure.

Export-base theory : has limited relevance, as the relationship between regional development and infrastructure is not quite clear: it only assumes that transportation infrastructure is a prerequisite for export, but this is only a part of total infrastructure; moreover, the impact of infrastructure on the regional multiplier mechanism is not clear; only certain aspects - such as a comparative cost approach - are relevant.

Polarization theory : has more relevance because of the emphasis on driving forces of the regional economy and on the spatial and economic interactions; the multiplier effects of infrastructure investments and the complementarity between regional development and infrastructure is an essential aspect; a precise description of the relationship between infrastructure and regional development is, however, missing.

Disequilibrium theory : has also more relevance, as it pays much attention to the close complementary relationship between infrastructure as a condition and as a bottleneck for regional development; the unbalanced growth approach is a fairly realistic explanation for the occurrence of regional disparities.

Critical theory : has some relevance, as it pays explicitly attention to bottleneck factors in regional development (such as price and wage rigidities and the power of multiregionals and multinationals), but it has no specific answer to the intricate question of infrastructure policy in relation to regional development.

Regional development potential theory: has much relevance, since infrastructure is here an integral component of a set of regional potentiality factors ; infrastructure determines here the growth perspectives of a region, while it also has impacts on the spatial disparities.

In view of the abovementioned remarks, a study group initiated by the EEC in order to analyse the relationship between infrastructure and regional development, has adopted the regional development potential approach as a framework for a further investigation into the impacts of infrastructure policy on regional disparities in the EEC-countries [1].

4. Infrastructure and Regional Development

In this section, more attention will be paid to the question as to how infrastructure policy may contribute to realizing the objectives of regional development.

Infrastructure will be regarded here as (material and immaterial) public capital which constitutes the foundation of all other socio-economic activities in a country. Although regional development is - as set out before - essentially a multidimensional concept, it is very often limited to employment, production or income indicators. Regional disparities can be regarded as discrepancies between

1) See for a more extensive report: D. Biehl et al., Intermediate Report on the Contribution of Infrastructure to Regional Development, EEC, Brussels, 1980.

regional profiles composed of relevant indicators. A major aim of many regional policies is to reduce disparities, so that the overall picture of the economy is more in agreement with socio-economic objectives regarding equity (cf. Richardson, 1969).

There is usually a wide variety of different regional objectives. Furthermore, these objectives are not the same for all regions and at least do not have the same weights, while they also have to be placed in the context of a national - or even supra-national - policy (Klaassen and Vanhove, 1980).

Objectives of regional socio-economic policy may be among others:

- decline in unemployment
- increase of average income
- improvement of regional amenities.

Consequently, regional policy may focus on both an improvement of the elements of this regional welfare profile and a reduction in the interregional discrepancies among these profiles (cf. Folmer and Oosterhaven, 1980).

The fulfilment of these objectives requires many policy instruments. These instruments can be subdivided into macro-economic instruments (oriented to changes in average income and in expenditures) and micro-economic instruments (oriented to individual households or entrepreneurs in order to modify the allocation of production factors) (see Armstrong and Taylor, 1978). This once more illustrates that infrastructure is only one of the instruments to improve the development of a certain region.

There are two main lines to realize regional development objectives with the help of infrastructure instruments, viz. an expenditure policy and a price policy. An expenditure policy is a Keynesian approach based on the idea that a too low volume of demand has to be increased by means of public expenditure stimuli. A price policy includes measures which affect the relative factor prices.

In the short-run infrastructure policy is often an expenditure policy, where public investments stimulate the local and regional demand via a multiplier /accellerator mechanism. At the same time, the creation of social overhead capital will stimulate the economic development potential of the region at hand. The creation of such public capital is extremely important in order to fulfil the needs of lagging regions, especially in the case of a low accessibility and poor locational conditions of these regions.

Thus infrastructure policy may have both a direct effect (via the impacts on the demand sector) and an indirect effect (via the change in development conditions).

5. Analytical Framework for the Contribution of Infrastructure to Regional Development

As mentioned before, infrastructure can be seen as one of the regional potentiality factors, which determine the regional development perspectives. It is clear that these potentiality factors may contribute in different ways to the regional development potential. Therefore, it may be worthwhile to identify the relative contribution of infrastructure categories to the regional development potential.

For a systematic treatment of this problem, it is meaningful to distinguish the following steps:

(1) the construction of discriminating criteria in order to distinguish infrastructure from other potentiality factors.
(2) the description of various kinds of infrastructure categories by means of their characteristics or attributes.
(3) the assessment of all infrastructure attributes across all regions.
(4) the evaluation and ranking of various infrastructure categories with regard to their contribution to regional development.

(1) identification of infrastructure

As mentioned before, infrastructure capital can be separated from other types of public capital by means of the following criteria: mobility, indivisibility, non-substitutability, polyvalence and non-exclusiveness. Thus those types of public capital which lead to relatively high values of these criteria will be selected in the infrastructure list (see table 1). This means that infrastructure is regarded here as a broad potentiality factor.

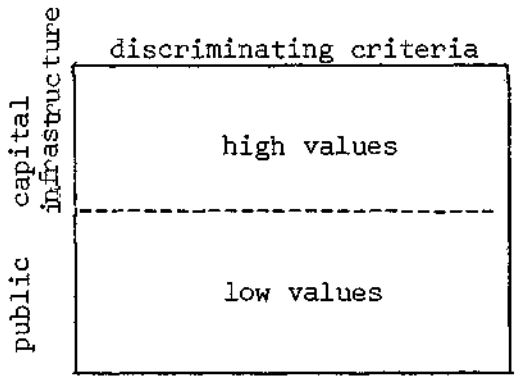


Table 1. Discriminating criteria for infrastructure capital

(2) list of infrastructure categories

The following main infrastructure categories have been selected for a further analysis of the relationship between regional development:

1. Transport infrastructure
2. Communication infrastructure
3. Energy supply infrastructure
4. Water infrastructure
5. Environmental infrastructure
6. Education infrastructure
7. Health infrastructure
8. Special urban (local) infrastructure
9. Sportive and touristic facilities
10. Social infrastructure
11. Cultural facilities.
12. Natural endowment.

The abovementioned main infrastructure categories can be subdivided into various sub-components and attributes.
For instance, transport infrastructure can be subdivided into a road network system, a railway network system, a waterway network system etc., while each of these components can be further subdivided into characteristic attributes such as roads, highways, tunnels, parking places etc. Consequently, a long list of infrastructure attributes is obtained.

(3) regional infrastructure endowment.

For all regions of the spatial system concerned, the values of the infrastructure attributes can be assessed. This leads to a big matrix of regional infrastructure endowments (see table 2).

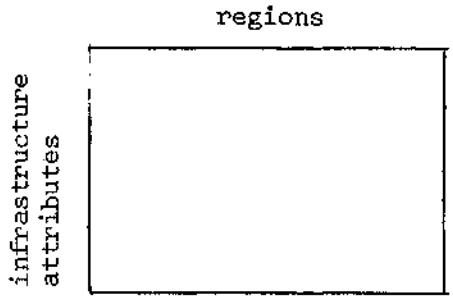


Table 2. Matrix of attributes of regional infrastructure.

Table 2 represents essentially a set of capacity indicators (supply). In principle, one might also construct a matrix of utilization indicators (demand), but this is in practice extremely difficult.

(4) regional development indicators

The development of each region can be characterized by a set of indicators such as average income, employment, urbanisation rate, etc. This information can be included in the regional development matrix (see table 3).

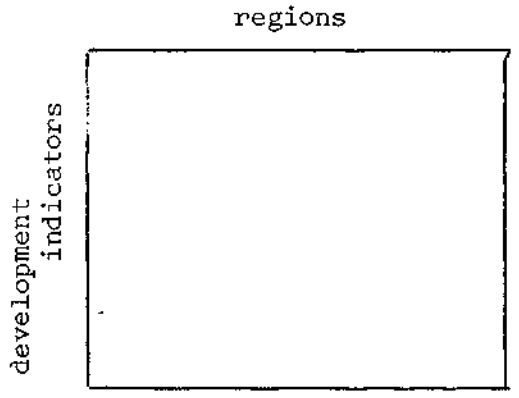


Table 3. Matrix of regional development indicators.

Cleerly, the operationalisation of the above-mentioned matrices is a complicated and time-consuming matter. Besides, there is a serious lack of information, so that sometimes soft data (ordinal numbers, e.g.) may be used.
The next stage is, of course, to analyze the relationships between tables 1 and 2 in order to identify the impact of infrastructure on regional development. The following multivariate techniques will successively be employed (see Nijkamp, 1979, 1981):

- principal components analysis (section 7)
- multidimensional scaling analysis (section 8)
- ordinal regression analysis (section 9)

In addition to these multivariate techniques, an operational application of the above mentioned potentiality approach based on a so-called quasi - production function will be presented (see also Biehl, 1980).

In these production functions, (the growth of) average regional income (or product) is explained from the availability of labour and/or productive capital, as well as from specific location and infrastructure indicators. This approach presupposes, of course, sufficient observations on a time series or cross section basis (see section 10).

6. Infrastructure and Regional Development Policy:A Case Study.

The European regional development policy is based on 2 grounds: 1) contribution to the national socio-economic objectives, and 2) decline of undesirable socio-economic disparities. Especially the latter (convergence) objective is major importance in the regional policy of the EEC. In this respect, the European Fund for Regional Development plays a dominant role in order to reduce spatial disparities.
The necessary policy measures in the EEC are related to both institutional and financial aspects. As far as these financial aspects is concerned, especially the European Fund for Regional Development plays a dominant role in financing infrastructure investments.
It is clear that a prerequisite for a balanced regional policy is more insight into the effectiveness of infrastructure policy on regional development. In respect to this, the above mentioned matrix profile approach may be an important and operational approach.

In the context of an EEC-study regarding the impacts of infrastructure endowments on regional development, a case study has been performed for the Netherlands. In regard to this study, the above mentioned tables 1, 2 and 3 have been employed and assessed. The detailed data for these tables can be found in de Graaff (1981). In the concise framework of the present paper, only the aggregate infrastructure matrix and regional development matrix for the eleven Dutch provinces will be presented. These data are included in the Annex in tables A.1 and A.2, respectively, for two periods (1970-1975 and 1976-1980). These data are normalized (by dividing each by its maximum value (x100)) and standardized (by relating point infrastructure indicators and regional development indicators to regional population size, and by relating network (space-opening) indicators to regional surface), and will be named functional data. The data have been collected at the so-called level II of the EEC; this means for the Netherlands a provincial subdivision.

A first glance at these data teaches already that there are substantial differences among regional infrastructure endowments as well as among regional development indicators. A certain dichotomy among the western (industrialized) areas and the peripheral areas can be observed. Furthermore, this picture has not shown remarkable changes during the last decade.
The following sections will be devoted to a closer analysis of the relationships from tables A.1 and A.2.

7. Results of a Principal Components Analysis of Main Infrastructure Indicators

The correlation among the 12 main infrastructure indicators is, in general, high for several items, except for item 12 (related to all other items). This indicates that a principal component analysis (PCA) may be a useful tool for reducing this mutual correlation. PCA is a transformation from a set of originally mutually correlated variables to a new set of independent variables, based on an orthogonal data transformation in which the original variables are replaced by independent components. These components are calculated in such a way that the first component accounts for the largest part of the common variance, etc.

For the Dutch infrastructure data, the following results have been obtained. For both periods, a reduction of the 12 variables to 3 components appears to be possible. The characteristics of these components are [1]:

component	eigen value	pct of variation
1	4.95 (4.50)	51.8 (52.4)
2	2.51 (2.27)	26.3 (26.5)
3	2.09 (1.81)	21.9 (21.1)

Component 1 includes mainly the following infrastructure categories: transport (1), communication (2), energy (3) and water (4). Hence, this component can be regarded as a network indicator.

Component 2 includes mainly education (6), sport and tourism (9), social infrastructure (10), and cultural facilities (11), so that this component may be interpreted as an social welfare indicator.

Component 3 is mainly composed of environmental infrastructure (5) and urban infrastructure (8), so that this component refers to man's quality of life.

It turns out that the natural endowment indicator (no. 12) has a completely different picture compared to the abovementioned 11 indicators.

1) Figures in brackets refer to the first period.

8. Results of a Multidimensional Scaling Analysis of Main Infrastructure Indicators

Despite the meaningful results achieved in the previous sections, it may be useful to examine in greater detail the mutual relationships among the respective infrastructure indicators (see Annex).
In respect to this, multidimensional scaling (MDS) techniques are an extremely useful tool.

MDS analysis is a multivariate technique which aims at reducing an original data set to a smaller subset. The original rationale behind the use of MDS techniques was to transform ordinal data into cardinal units. Suppose that the matrices in the annex (aanhangsel) are measured in ordinal units. Then a transformation to a metric system can be made by assuming that each region r (r = 1, ..., R) can be represented as a point in an N-dimensional Euclidean space. Since there are R such points, a whole pattern of regions emerges such that the Euclidean distances among each pair of these R points may be regarded as a measure for the discrepancy between each pair of regions. The co-ordinates of these R points can be gauged by means of a similarity rule stating that the R points have to be located in the Euclidean space in such a way that their positions correspond to a maximum extent with the ordinal information in the original data matrix (see Nijkamp, 1979).

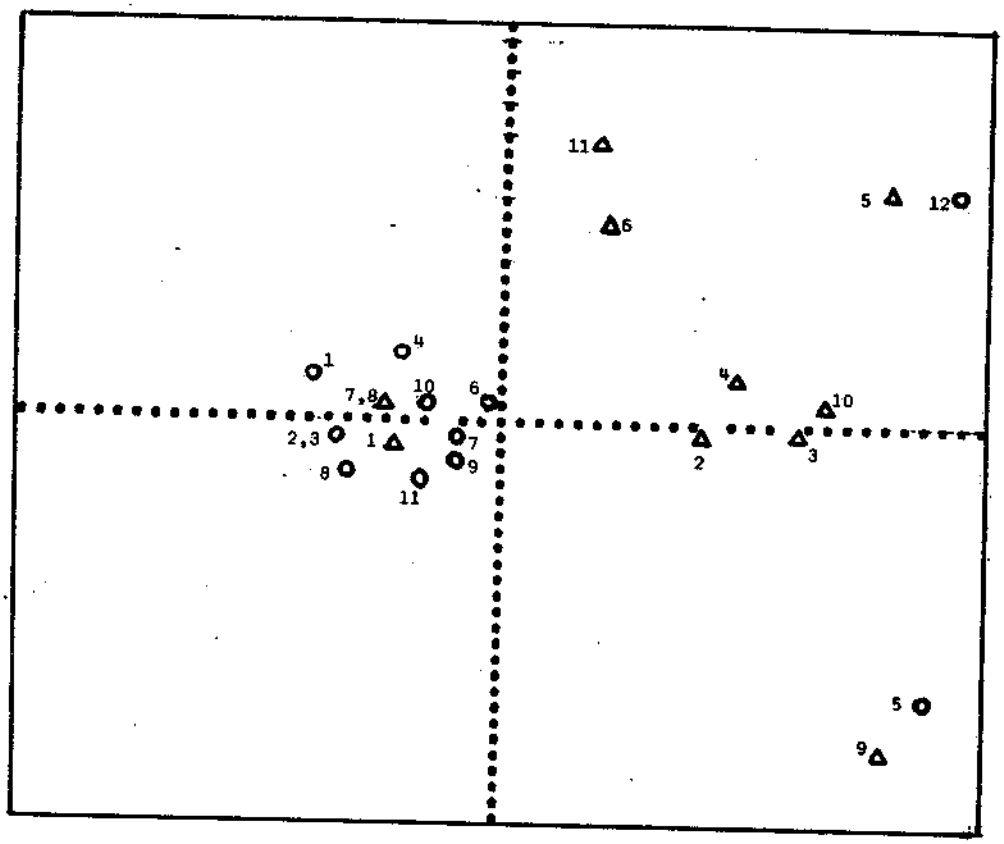
In a similar way, the values of the infrastructure categories can be depicted in a Euclidean space, while also a joint representation of both regions and infrastructure categories may be given. The latter picture which will be used in our case allows one to identify correspondences between regions and their endowment of certain infrastructure categories.

The two-dimensional results of the MDS analysis applied to the matrix of infrastructuralvalues for both time periods are included in fig. 1. a. and 1. b., respectively.

The results show a pattern which is analogous to the cluster patterns observed in paragraph 7. Thus the same remarks can be made here in relation to the sectoral structure of the provinces concerned.

It also turns that the respective infrastructure categories are closely located together, except category 12 (natural environment). It is easily seen that the province with the highest natural endowment (Gelderland, no. 5) is located close to this natural environment co-ordinate.
The industrialized and urbanized regions have a position close to network type of infrastructure categories.

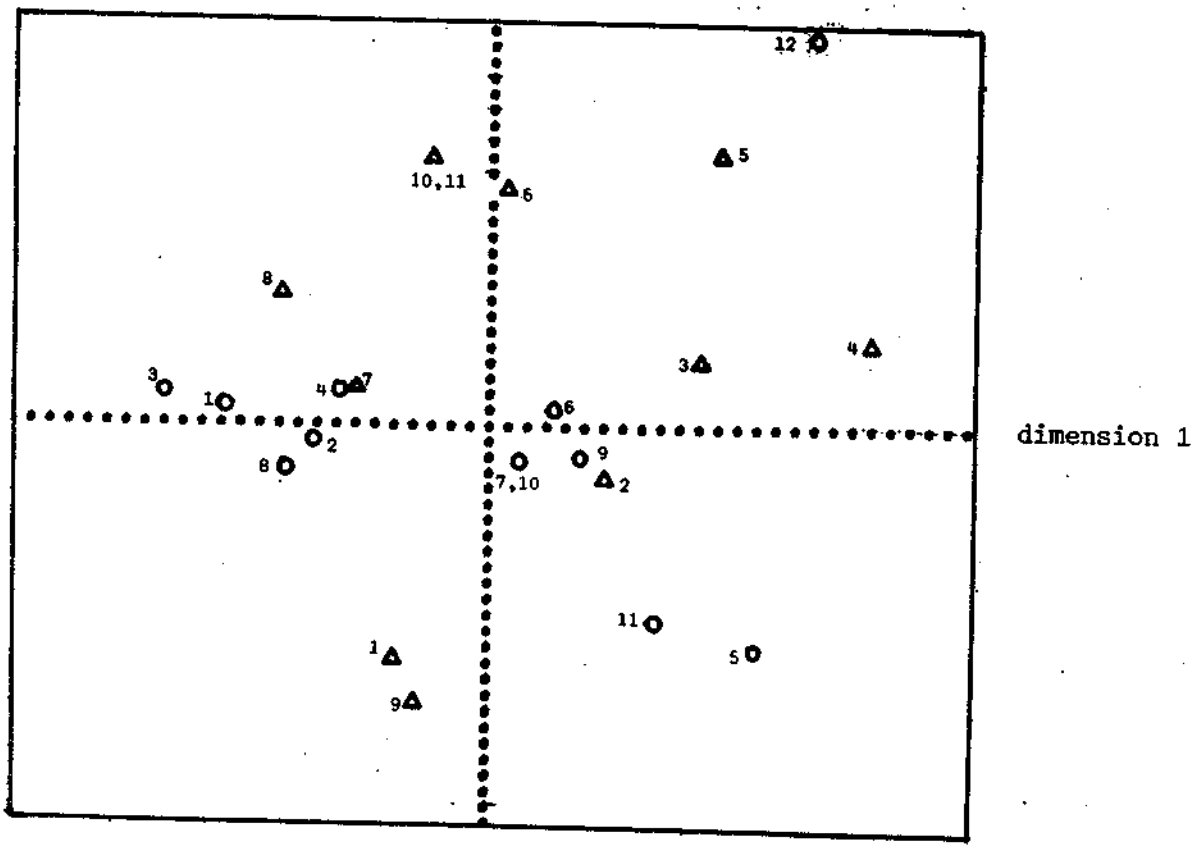
Fig. 1.a. Results of MDS-analysis (1970-1975)



△ Provinces

○ Infrastructure categories

Fig. 1.b. Results of MDS-analysis (1976- 1980)



9. Results of an Ordinal Regression Analysis[1)]

The present section is mainly based on a statistical method recently developed by McCullagh(1980), who has designed a general class of regression models for ordinal data in particular. One of these 'soft' econometric models called the proportional odds model, will be employed here.

This proportional odds model is based on a logit model which employs the provincial shares in the infrastructural facilities. After the calculation of the provincial logit, one may assess a parameter which reflects the inter-provincial distances based on differences in provincial infrastructure endowment. These results can be included in an interprovincial distance matrix (see Table 4). Since the data did not show much variation among the two successive periods, only the results of the first period (1970-1975) will be presented here. These results give a fairly good description of the actual infrastructural endowments. The central provinces appear to have a good infrastructure equipment, whereas several peripheral areas have a poor infrastructure performance.

+0.0000	-0.0262	+0.1868	-0.5112	-1.1434	-0.2227	-1.2438	-1.3890	+0.3757	-1.1920	-0.3994
+0.0262	+0.0000	+0.2130	-0.4851	-1.1172	-0.1965	-1.2176	-1.3628	+0.4019	-1.1658	-0.3733
-0.1868	-0.2130	+0.0000	-0.6980	-1.3302	-0.4095	-1.4306	-1.5758	+0.1889	-1.3788	-0.5862
+0.5112	+0.4851	+0.6980	+0.0000	-0.6322	+0.2885	-0.7326	-0.8778	+0.8870	-0.6807	+0.1118
+1.1434	+1.1172	+1.3302	+0.6322	+0.0000	+0.9207	-0.1004	-0.2456	+1.5192	-0.0485	+0.7440
+0.2227	+0.1965	+0.4095	-0.2885	-0.9207	+0.0000	-1.0211	-1.1663	+0.5984	-0.9693	-0.1767
+1.2438	+1.2176	+1.4306	+0.7326	+0.1004	+1.0211	+0.0000	-0.1452	+1.6195	+0.0519	+0.8444
+1.3890	+1.3628	+1.5758	+0.8778	+0.2456	+1.1663	+0.1452	+0.0000	+1.7647	+0.1970	+0.9896
-0.3757	-0.4019	-0.1889	-0.8870	-1.5192	-0.5984	-1.6195	-1.7647	+0.0000	-1.5677	-0.7752
+1.1920	+1.1658	+1.3788	+0.6807	+0.0485	+0.9693	-0.0519	-0.1970	+1.5677	+0.0000	+0.7925
+0.3994	+0.3733	+0.5862	-0.1118	-0.7440	+0.1767	-0.8444	-0.9896	+0.7752	-0.7925	+0.0000

Table 4. Interprovincial differences in infrastructure endowment

1) The author is indebted to Floor Brouwer for his computational assistance.

Results of a Provincial Quasi-Production Function Approach

As mentioned above, the functional values of the infrastructure indicators appear to give a fairly representative and reasonable picture of the regional infrastructure endowment. Hence these figures will also be employed in the statistical methods of the quasi-production function approach.

A useful step in this statistical analysis will be a test on the relationship between regional infrastructure and regional development (i.e., average regional product). In regard to this, a so-called quasi-production function will be used. The quasi-production function takes for granted that regional product is determined by traditional (substitutable) production factors (such as capital and labour) as well as by specific regional determinants (such as agglomeration and infrastructure). Since in our study agglomeration factors are already incorporated in the infrastructure endowment, it is reasonable to select only aggregate infrastructure indicators as explanatory region-specific variables (in addition to production factors). Due to lack of information regarding regional direct productive capital, only labour (measured as the activity rate (= share of active labourers in total population)) will be included as a production factor. Hence, the following quasi-production function, based on a Cobb-Douglas specification, will be used:

$$Y = \alpha L^{\beta} I^{\gamma} \quad ,$$

with : Y = average regional product
L = activity rate of labour
I = infrastructure index .

This function has been estimated for the two time periods concerned and over all provinces. The results of this cross-section time-series regression analysis were:

$$\begin{aligned} \ln \alpha &= -0.973 \quad (0.750) \\ \beta &= 1.017 \quad (0.578) \qquad R^2 = 0.515 \\ \gamma &= 0.620 \quad (0.240) \end{aligned}$$

where figures in brackets represented the standard deviation. It turnes out that the infrastructure index gives a (statistically) significant explanation for regional development (measured as average regional product). The activity rate gives a slightly less significant explanation, which may be due to the fact that regional policy aims at reducing regional unemployment differences, so that the activity rate is a less discriminating regional indicator. The values of β and γ ($\beta + \gamma \geq 1$) indicate that increasing economies of scale do exist in regard to the regional activity rate and regional infrastructure.

The residuals show a fairly diffuse pattern around the regression line, so that no unambiguous conclusion can be drawn concerning the relative position of developed or less developed provinces.

For the moment, the conclusion may be that regional infrastructure endowment gives a meaningful explanation for regional development, based on the quasi-prodution function approach.

The correlation matrix among Y, L and I is :

	Y	L	I
Y	1		
L	0.59	1.	
I	0.67	0.55	1.

12. Conclusion

After the extensive analysis of the relationship between infrastructure and regional development, the following final remarks can be made:

- the question whether or not infrastructure determines regional development depends very strongly on the spatial level of analysis; a refined spatial subdivision may reveal more interesting relationships than the global scale of level II of the EEC-countries.
- the time periods for studying the impacts of infrastructure (1970-1975 and 1976-1980) were essentially very short and may conceal the real long-terms effects, as especially social overhead capital needs in general a long gestation period.
- the conclusions drawn from the analysis are also co-determined by the definitions of variables, the aggregation procedures, the normalization and the standardization.
- the conclusions are mainly based on capacity-oriented indicators, so that user-oriented indicators were - due to lack of reliable information - left out of consideration., altough serious botllenecks are not likely to exist.
- the provincial variety in infrastructure endowment in the Netherlands is not extremely high, while its dynamics are relatively low; the latter observation is also a result of regional and infrastructure policy carried out in the past. A case study would be a useful complement.
- the statistical results (e.g., from multidimensional scaling and principal component analysis) demonstrate a high degree of correlation among the successive infrastructure categories, except for environmental indicators; this once more justifies the aggregate level of analysis.
- the statistical and econometric results show a certain relationship between infrastructure and regional development; especially the use of a quasi-production function demonstrates that infrastructure endowment provides a statistically significant explanation for regional development.
- the results demonstrate that densely populated, industrialized and more developed areas tend to have a higher infrastructure endowment than peripheral, agricultural and less populated areas.
- for the Netherlands, the discrepancies among provincial infrastructure endowments as well as among provincial development levels are not very high due to the regional, infrastructure and general economic policy realized in the past, so that clear discriminating impacts of infrastructure on specific regional development levels could hardly be identified.
- Regional infrastructure endowments appear to be represented in some clusters such as a network cluster, a social welfare cluster and a quality-of-life cluster.

References:

Armstrong, H. en J. Taylor, Regional Economic Policy and its Analysis, Philip Allen, Londen, 1978.

Berry, B.J.L., The Geography of Economic Systems, Prentice-Hall, Englewood Cliffs, 1976.

Berry, B.J.L., Urbanisation and Counterurbanisation, Sage Publ., Beverly Hills, 1976.

Biehl, D., Determinants of Regional Disparities and the Role of Public Finance, Public Finance, vol. 35, no. 1, 1980, pp. 44-71.

Broersma, J., Doelstellingen, Instrumenten en Effectiviteit van Sectorpolitiek in de Lid-Staten van de E.E.G., Master's Thesis, Economic Faculty, Free University, Amsterdam, 1977.

Cumberland, J.H., Regional Development, Mouton, Den Haag, 1971.

Deane, Ph., The First Industrial Revolution, Cambridge University Press, Cambridge, 1969.

Duijn, J.J. van, De Betekenis van een Innovatie-georiënteerd Regionaal Beleid voor Nederland, Beleid en Maatschappij, 6e jaargang, nr. 6, 1979, pp. 162-171.

Folmer, H. en J. Oosterhaven, Dutch Regional Economic Policy : A Review of Contents and Evaluation of Effects, Research Memorandum nr. 67, Economic Faculty, State University, Groningen, 1980.

Friedmann, J., Retracking America, Anchor Press, Garden City, 1973.

Graaff, H. de, Regional Policy Analysis, Dept. of Economics, Free University, Amsterdam, 1981. (mimeographed).

Hansen, N.M. (ed.), Growth Centers in Regional Economic Development, Free Press, New York, 1972.

Hirschman, A.O., The Strategy of Economic Development, Yale University Press, New Haven, 1958.

Holland, S., Capital versus the Region, MacMillan. Londen, 1976.

Klaassen, L.H., De Nota inzake het Regionale Sociaal-Economische Beleid 1977 t/m 1980 : Enkele Notities, Regionaal Beleid (P. Nijkamp en C. Verhage, ed.), Stenfert Kroese, Leiden, 1978, pp. 43-52.

Klaassen, L.H. en N. Vanhove, Regional Policy in the E.E.C., Saxon House, Farnborough, 1980.

Kuklinski, A.R. (ed.), Growth Poles and Growth Centers in Regional Planning, Mouton, Den Haag, 1972.

Lambooy, J.G., Regionaal-Economische Theorie en Beleid : Een Stand van Zaken, Regionaal Beleid (P. Nijkamp en C. Verhage, ed.), Stenfert Kroese, Leiden, 1978, pp. 7-16.

Lloyd, P.E. and P. Dicken, Location in Space, Harper & Row, New York, 1972.

McCullagh, P., Regression Models for Ordinal Data, Journal of the Royal Statistical Society, vol.42, no.2, 1980, pp. 109-142.

Molle, W., Regional Disparity and Economic Development in the European Community, Saxon House, Farnborough, 1980.

Nijkamp, P., Multidimensional Spatial Data and Decision Analysis, Wiley, Londen, 1979.

Nijkamp, P., Waarden en Waarheid in de Ruimtelijke Wetenschappen, Radix, 6e jaargang, nr. 1, 1980 , pp. 2-19.

Nijkamp, P., New Developments in Multidimensional Geographical Data and Policy Analysis, Quantitative and Theoretical Geography (R.J.Bennett, ed.), Pion,London, 1981.(forthc.).

Pluijm, Th.W.H.A. van der, Regionale Ongelijkheid en Regionaal Beleid, Van Kolonialisme tot Zelfontwikkeling (W. van Sprengen, ed.), Romen, Bussum, 1978, pp. 215-238.

Richardson, H.W., Regional Economics, Weidenfeld & Nicholson, Londen, 1969.

Spiegelglas, S. en C.J. Welsh (ed.), Economic Development - Challenge and Promise, Prentice-Hall, Englewood Cliffs, 1970.

Stilwell, F.J.B., Regional Economic Policy, MacMillan, Londen, 1972.

Streeten, P., The Crisis of Indian Planning, Oxford University Press, Oxford, 1968.

Tinbergen, J., Economic Policy : Principles and Design, North-Holland Publ. Co., Amsterdam, 1956.

infrastructure categories	provinces										
	61.	37.	25.	44.	60.	73.	100.	96.	20.	47.	73.
	66.	41.	43.	48.	46.	62.	92.	100.	57.	46.	46.
	63.	26.	41.	38.	46.	65.	69.	100.	19.	58.	54.
	47.	39.	35.	67.	62.	86.	100.	94.	40.	64.	78.
	41.	24.	52.	45.	56.	40.	51.	62.	100.	78.	51.
	96.	100.	91.	92.	85.	90.	79.	84.	88.	87.	81.
	73.	66.	92.	64.	76.	100.	83.	74.	68.	72.	70.
	71.	42.	41.	39.	40.	52.	59.	79.	100.	63.	60.
	86.	100.	91.	64.	74.	73.	79.	65.	90.	64.	61.
	92.	87.	76.	68.	90.	96.	98.	66.	100.	72.	64.
	78.	100.	72.	70.	60.	45.	84.	64.	61.	60.	58.
	10.	39.	81.	67.	100.	78.	48.	21.	15.	81.	80.
Σ	81	73	77	73	83	89	100	94	77	82	79
Regional Product	82	72	64	76	71	76	99	100	73	78	78
Activity Rate	88	88	94	94	95	98	96	97	94	100	93

Table A.1. Infrastructure and development indicators(1970-1975)

infrastructure categories	provinces										
	65.	41.	27.	40.	60.	71.	100.	99.	22.	51.	78.
	81.	46.	48.	53.	50.	72.	97.	100.	42.	57.	57.
	50.	32.	32.	46.	43.	66.	79.	100.	21.	57.	64.
	46.	40.	36.	70.	65.	91.	100.	98.	42.	71.	86.
	58.	44.	48.	57.	65.	36.	43.	61.	100.	46.	33.
	98.	100.	88.	93.	87.	87.	79.	85.	88.	64.	77.
	71.	64.	93.	61.	83.	100.	83.	72.	61.	67.	69.
	76.	45.	46.	43.	46.	55.	83.	84.	100.	71.	68.
	73.	100.	63.	68.	69.	66.	75.	61.	75.	63.	68.
	90.	93.	79.	68.	84.	88.	92.	67.	100.	68.	68.
	75.	100.	74.	70.	54.	50.	93.	55.	51.	45.	55.
	12.	40.	65.	55.	100.	67.	45.	28.	16.	70.	67.
Σ	82	77	74	75	83	88	100	94	74	79	82
Regional Product	86	69	73	78	75	88	99	100	96	83	76
Activity Rate	87	89	94	91	93	95	100	98	95	94	88

Table A.2. Infrastructure and development indicators(1976-1980)

Legenda: The 12 infrastructure categories are defined in par. 5. The ranking of the 11 provinces is as follows: 1 Groningen, 2 Friesland, 3 Drente, 4 Overijssel, 5 Gelderland, 6 Utrecht, 7 Noord-Holland, 8 Zuid-Holland, 9 Zeeland, 10 Noord-Brabant, 11 Limburg.

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