POLISH ACADEMY OF SCIENCES

GEOGRAPHIA POLONICA

33

PART TWO – ECONOMIC GEOGRAPHY

PWN–POLISH SCIENTIFIC PUBLISHERS

Address of Editorial Board

KRAKOWSKIE PRZEDMIEŚCIE 30
00-927 WARSZAWA
POLAND

Printed in Poland

POLISH ACADEMY OF SCIENCES
INSTITUTE OF GEOGRAPHY

GEOGRAPHIA POLONICA

PART TWO – ECONOMIC GEOGRAPHY 33

PWN — Polish Scientific Publishers • Warszawa 1976

SPECIAL ISSUE

THE 23rd INTERNATIONAL GEOGRAPHICAL CONGRESS

MOSCOW, 1976

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GEOGRAPHIA POLONICA 33, 1976

THE PROTECTION OF MAN'S ENVIRONMENT AND REGIONAL PLANNING

Stanisław Leszczycki

The man-environment interaction had been studied for a long time but it was only after U Thant's well-known report of 1969 that this became a much-discussed and urgent problem attracting the attention not only of scientists but also of public opinion, politicians, governments and international organizations.

(1) *A model of man-environment interaction.* This interaction presents a many-sided and complex problem, one which may be solved from several angles. The scope of the problem can be seen on a three-component model: society — its activity — environment.

The first component, under the heading society, concerns population number and distribution, its natural increase, migrations and occupational structure. Parallel to the growth of population, living standards are rising and so are the requirements that a high-quality environment is expected to fulfill. Health protection, prolongation of human life, assessing man's capacity to adapt to changing environmental conditions, providing him with a good dwelling, work, traffic, and recreation conditions — these are the foremost tasks in this respect.

The second component comprises all social activities of both a productive and non-productive character.

The third component relates to the environment, which, depending on the degree to which man has transformed it, is (a) natural, (b) transformed, and (c) man-made, comprising urban-industrial developments.

These three components are linked with one another by feedback relations. The advance of science and technology stimulates the development of production and services, and this in turn adds to the improvement of living standards and environmental conditions. Production and service activities account for the transformation of environment by drawing on the resources it supplies, and utilizing the various values and amenities it offers. On the other hand, environmental resources and amenities affect the development of production and services. Moreover, man utilizes environmental amenities directly too (as in recreation), and these amenities influence health, mental disposition and living standards.

(2) *The comprehensive nature of environmental research.* Analogously the sciences studying the problems involved in the man-environment interaction are interrelated. It must be stressed that these problems cannot be studied unless by many sciences in close co-operation with one another. In this type of research work some disciplines come to form the leading group of sciences, which is due to the character of that research. When environmental problems are studied from the point of view of the society it is the social, medical and some biological sciences (as ecology), the technical and geographic sciences (spatial planning, town planning, human geography) that come to the fore.

TABLE 1. Models of Man-Environment Interaction

SOCIETY

1. Population
   number, distribution, natural increase, migrations, occupational structure
2. Growth of living standards
   including: quality of the environment
3. Health protection
   social welfare, longevity, acclimatization, adaptation, nutrition
4. Conditions of dwelling, work, traffic and recreation
5. Spatial pattern of settlement, region, town

Effect of scientific and technical advance on the development of production and services →

← Effect of developing production and services on living standards, dwelling, work and recreation

ACTIVITY

1. Productive
   mining, industry, building, transport, agriculture, forestry, water economy, sea economy etc.
2. Non-productive (services)
   education, schooling, science, culture, administration, trade, gastronomy, municipal economy

Impact of society on the quality of the environment.

Influence of the environment on health and living conditions. Population, production and services capacity limits of different types of environment

ENVIRONMENT

1. Natural
   protected areas, natural wasteland, seas and oceans, almost inaccessible areas
2. Transformed (geographical)
   agriculture, forest and recreational areas, some inland surface waters
3. Man-made (urban-industrial)
   built-up areas, agglomerations centres, urbanized zones, urbanizing zones, areas of technical infrastructure, post-production wasteland

Impact of production and services on environment resources and amenities. Rehabilitation of degraded environment

Influence of environmental resources and amenities on the development of production and services

TABLE 2. Scheme od Sciences Concerned with the Man-Environment Problem

SOCIETY

1. Social sciences
   demography, sociology, human geography, economics
2. Medical and biological sciences
   social hygiene, ecology, dietetics
3. Technical sciences
   spatial planning, urban planning, building sciences, engineering (sanitary, municipal) sciences

ACTIVITY

1. Exact sciences and their applications
   mathematics, cybernetics, chemistry, physics
2. Technical sciences
   building and engineering sciences, transport, mining sciences
3. Agricultural sciences
4. Forestry sciences
5. Social sciences
   sociology, economics, economic geography

ENVIRONMENT

1. Earth sciences
   geography, geology, geophysics, oceanography, cartography
2. Biological sciences
   ecology, sozology, nature conservation, agriculture, forestry
3. Technical sciences
   spatial planning, urban planning, architecture
4. Social sciences
   economics, sociology, psychology

With the second component, that of production and services, most important are the exact, technical and also agricultural, forestry and social sciences.

The third component, pertaining to environment, is of greatest interest to the earth sciences, especially geography, the biological sciences, especially sozology, ecology and biogeography, to technical sciences related to spatial planning, and to social sciences, in particular economics and sociology.

(3) *Environmental policy and the level of socio-economic development of the country.* The quality of environment is threatened to the extent that nearly all countries practise their own environmental policies in adjustment to their specific socio-economic needs. However, some connections between environmental policy and living standards can be observed. Depending on the yearly per capita national income, all countries belong to one of four groups (all in US dollars): (1) up to 200, (2) 200 to 1000, (3) 1000 to 2000, and (4) more than 2000 dollars *per capita* income annually.

Countries belonging to the first group up to 200 $ can be said to have practically no environmental policy, their primary concern being the quickest possible improvement of living standards. Environment in these countries is under no serious threat yet.

Countries in the second group (200 to 1000 $ yearly *per capita*) carry on limited environmental policies. When the growth of production comes into con-

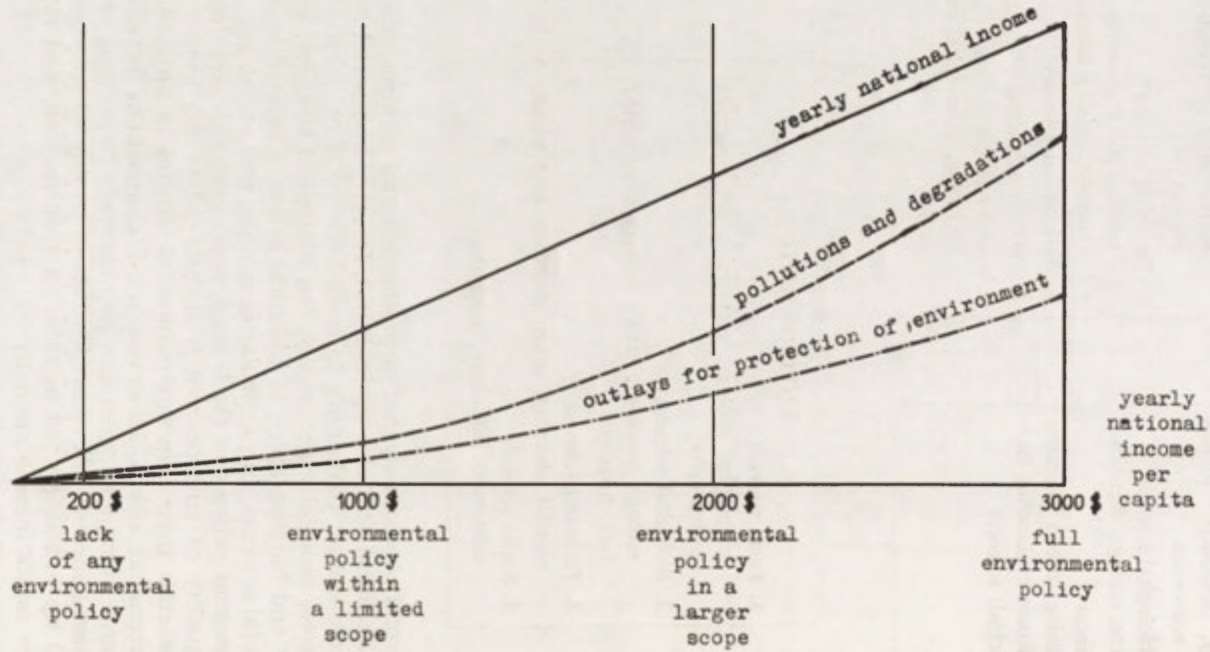

Fig. 1. Types of environmental policy according to the level of living conditions

flict with the quality of the environment, the resulting decisions are nearly always in favour of economic growth relegating the environmental quality to secondary importance.

The third group of countries (1000 to 2000 $ *per capita*) have much more extensive environmental policies, including special expenditures on the protection, transformation and recultivation of the environment. In cases of conflict, though, the preservation of environmental quality may often have to give way to the needs of raising the standard of living.

Thus it is only the countries of group four, whose yearly *per capita* income exceeds 2000 — or, more properly — 3000 dollars, that can really afford full-scale environmental policies. The high level of national income together with the considerable amount of energy at their disposal enable them to safeguard a high-quality environment through sizeable investment outlays. Since environmental qualisty is viewed there as an element of the living standard, in cases of conflict those countries can afford a relaxation of the growth rate of production in order to prevent any excessive deterioration of environmental quality.

(4) *Internationally coordinated environmental policies*. Various types of pollution, such as the danger of ionizing radiation or chemical pollution of the seas and oceans, are often global in character. Some other types of pollution may extend over the territories of several countries (as in the case of river and air pollution) and thus cannot be prevented by the efforts of one country within its own boundaries only. Hence the bilateral and multilateral agreements on the prevention of environmental degradation. Poland, for instance, has signed a tripartite agreement with Czechoslovakia and the German Democratic Republic on the protection of water purity in the Odra river, and seven Baltic countries have worked out a multilateral agreement on the protection of water and organic life in the Baltic Sea. International environmental policies are also worked out by international governmental organizations affiliated to the UN, as UNEP, UNESCO, FAO, WHO, ECE, scientific organizations as ICSU, SCOPE, MAB, as well as non-governmental, social, scientific and such like organizations.

TABLE 3. Types of Environment and Types of Pollution

1. MAN-MADE (URBAN-INDUSTRIAL) ENVIRONMENT Intensive development areas: centres of urban-industrial agglomerations, urbanized zones, urbanizing zones, areas of technical infrastructure facilities, post-industrial wasteland. Pollution of water, air, soil, relief deformation, vegetation and wild life devastation. Noise, vibrations, radiation, garbage and municipal sewage (detergents), obnoxious odours, post--production wastes, durable refuse. Also, substandard dwelling conditions, work, traffic and recreation.
2. TRANSFORMED (GEOGRAPHICAL) ENVIRONMENT Agricultural land, forests, recreation areas, some inland surface waters. Water and air pollution, relief deformation, soil degradation, vegetation and wild life devastation. Noise and bad odours, post-production wastes, durable refuse. Substandard dwelling conditions.
3. NATURAL ENVIRONMENT Areas under protection on account of their natural value. Natural wasteland. Part of the surface waters. Small and sporadic, externally generated pollution.

(5) *Types of environment and types of pollution.* It has been said already that from the standpoint of anthropogenic transformation three types of environment can be distinguished: (1) natural, (2) transformed (geographic), and (3) man-made (urban-industrial) environment.

The man-made environment exhibits the highest degree of pollution and degradation. Some kinds of pollution issue forth from it beyond its boundaries. They include mainly air and water pollution, relief deformation caused by mining, degradation of soils, and vegetation and wild life devastation. The highly concentrated population, production and service activities account for the concentration in urban areas of noise, vibrations, radiation, garbage and municipal sewage threats, troublesome detergents, bad odours and fumes, post-production wastes, and the amassing of discarded non-perishable objects (containers, cars, etc.).

TABLE 4. Environmental Pollution and Degradation

POLLUTION AND DEGRADATION OF THE NATURAL ENVIRONMENT
1. Air pollution
2. Pollution of surface and ground water
3. Relief deformation
4. Soil degradation
5. Devastation of vegetation
6. Devastation in wild life
7. Pollution of seas and oceans
POLLUTION OF THE MAN-MADE (URBAN-INDUSTRIAL) ENVIRONMENT
1. Noise, vibrations, radiation
2. Garbage and municipal sewage (detergents)
3. Obnoxious odours
4. Post-production wastes (post-industrial wasteland)
5. Discarded durable objects (containers)
6. Ionizing radiation (radioactive substances and wastes)
SUBSTANDARD LIVING CONDITIONS
1. Substandard dwelling conditions
2. Substandard work conditions

Pollution is especially high in the central areas of urban-industrial agglomerations, in cities and industrial centres. In urbanized areas pollution is as a rule smaller, and in urbanizing areas still smaller. Pollution in areas of technical infrastructure is of a different character in that it includes noise, vibrations, fumes, air and water pollution. Areas of degraded environment tend to concentrate in traffic nodes and along traffic lines in the form of belts reaching up to a few kilometers on both sides of the lines.

In the areas of a high concentration of investment densely built up, the dwelling, work and traffic conditions as well as recreation conditions are sometimes substandard. Destroyed land (as happens after mining activities) demanding recultivation may also occur in such areas.

The transformed environment is marked by significant (more than 50%) changes in soil conditions, the vegetative cover, the wild life, and in water conditions. The concentration of investment is lower than in the man-made environment and therefore its pollution and degradation are much smaller in that they usually comprise air and water pollution derived from the urban-industrial areas. Typical of this type of pollution is the contamination of soil and water with fertilizers and pesticides. Inefficient agrotechnics may reinforce processes of erosion or denudation. Inefficient land improvement may make formerly fertile land overdry or marshy. Recreation areas are exposed to litter and destruction by excessive numbers of tourists exceeding the environmental capacity. Offshore waters are polluted as a result of overconcentration of the population, production and services, and the shores of water reservoirs are deformed by putting up buildings or other facilities for recreation, water sports or some economic activities.

The natural environment which is transformed by man in less than 10% is as a rule only invaded by pollution from outside but sporadically.

(6) *Functional planning areas.* Depending on the degree of investment concentration, all planning areas can be divided into three categories: (a) areas of high investment concentration, (b) areas of low investment concentration and (c) areas almost devoid of investment, or "investment-free" areas.

TABLE 5. Functional Planning Areas

I. AREAS OF HIGH INVESTMENT CONCENTRATION
1. Urban-industrial agglomerations, regional growth centres, cores of towns and industrial centres
2. Urbanized zone (suburban zone), medium-sized and small towns with specialized functions
3. Urbanizing zone (small towns, individual industrial plants)
4. Rural settlements
5. Transportation areas, nodes and ribbons of technical infrastructure
6. Areas of post-industrial wasteland
II. AREAS OF LOW INVESTMENT CONCENTRATION
1. Agricultural areas
2. Areas of productive and protected forests
3. Recreation areas (weekend, holiday, tourist and health resorts)
4. Some inland surface waters
III. PROTECTED AREAS AND NATURAL WASTELAND
1. Nature conservation areas (national parks, natural reserves)
2. Areas of protected landscape for recreation purposes (landscape parks, scenic areas, rural parks)
3. Natural wasteland (rocky mountains, swampy land, marshes and peat bogs)
4. Some inland waters (rivers, lakes)

Areas of high investment concentration include built up areas, especially settlements and technical infrastructure. Most important among these are urban-industrial agglomerations (existing, developing, and potential) and regional growth centres of national significance. Moreover, this category of areas includes the major towns with specialized functions and industrial centres. Urban-industrial agglomerations and regional growth centres are subdivided into city centres, urbanized zones and urbanizing zones. They are the principal foci of socio-economic life fulfilling definite functions on a national scale and performing specialized production and service activities. This generates specific types of environmental pollution.

Areas invested with technical infrastructure in the form of nodes and lines must also be classed with the group of areas with high investment concentration. These areas exhibit different traffic intensities which generate such types of pollution as noise, fumes or other air pollutants.

Areas of low investment concentration include agricultural land, forests, recreation areas and partly inland surface waters. This type of area accounts for the biggest proportion of the total territory of the advanced countries. Depending on the specific ownership relations, agricultural land constitutes a mosaic of fields, pastures and meadows. The some applies to forest areas. Recreation areas are either "weekend areas" in the vicinity of agglomerations or "holiday areas" situated at some distance from urban-industrial settlements in places of particular recreational values.

Coastal and offshore inland waters serve recreation, sports, fishing and other economic aims. The type and degree of investment should be adjusted to the specific functions which they fulfill.

The "investment-free" areas include land under special protection because of its natural value such as national parks and natural reserves. Some areas of particular landscape or climatic values are recognized as landscape parks or areas of protected scenery with tourism permitted up to a definite capacity level so as to prevent any degradation of environmental values. Some water reservoirs should be included in the protected areas too. Investment-free land includes also natural wasteland which constitutes a reserve of hitherto unexploited and undeveloped space.

In each country the above-distinguished planning areas form a spatial mosaic with a pattern of specific proportions. Definite types of pollution correspond to each area. These problems are illustrated by the model enclosed which shows the proportional pattern of planning areas and the types of pollution pertaining to each of them.

These relations are also illustrated in Fig. 3; its columns are used to mark various types of pollution and the lines shows the types of planning areas.

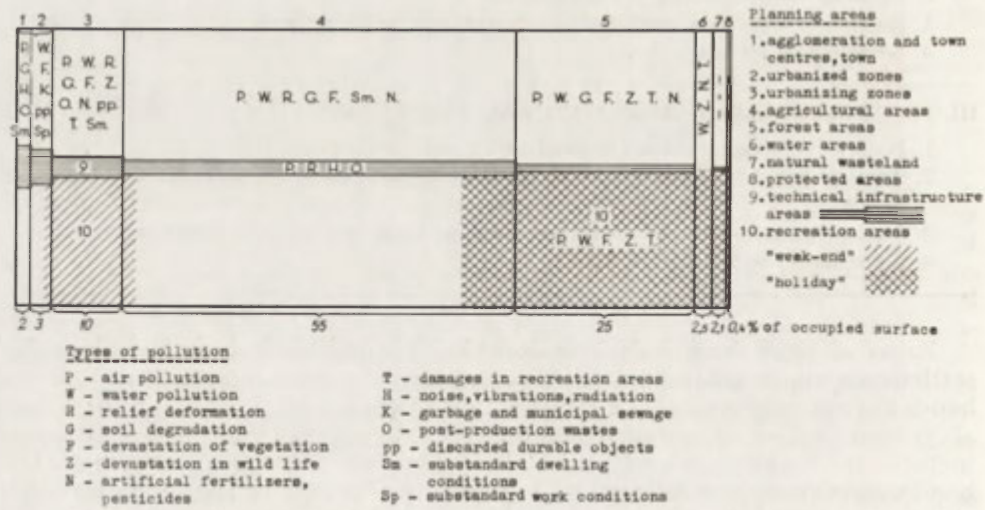

Fig. 2. Interdependence between planning areas and types of pollution. Model for one country

Pollution intensities are marked as strong, medium, and weak. The table envisages the well-known fact that areas of high investment concentration are marked by the highest pollution and that the affliction of protected areas with pollution occurs but sporadically from outside and not too intensively.

(7) *Dangers to the environment.* The growth of the population, production and services results in growing pollution and degradation of the environment. The distribution of pollution and degradation, however, is irregular. They are most intense in areas of high investment concentration where the environment is man-made. Less intensive pollution occurs in areas of low investment concentration corresponding to the transformed environment. Pollution is least intense in the predominantly sporadic cases in protected areas or wasteland which still represent environment in its natural state.

Cases of global pollution, such as the danger of ionizing radiation or chemical contamination of the seas, are extremely grave. Very dangerous are cases of pollution occurring in several countries simultaneously, on an international scale, as pollution of river or lake waters, pollution of air masses along traffic lines and others. In the areas of high investment concentration several

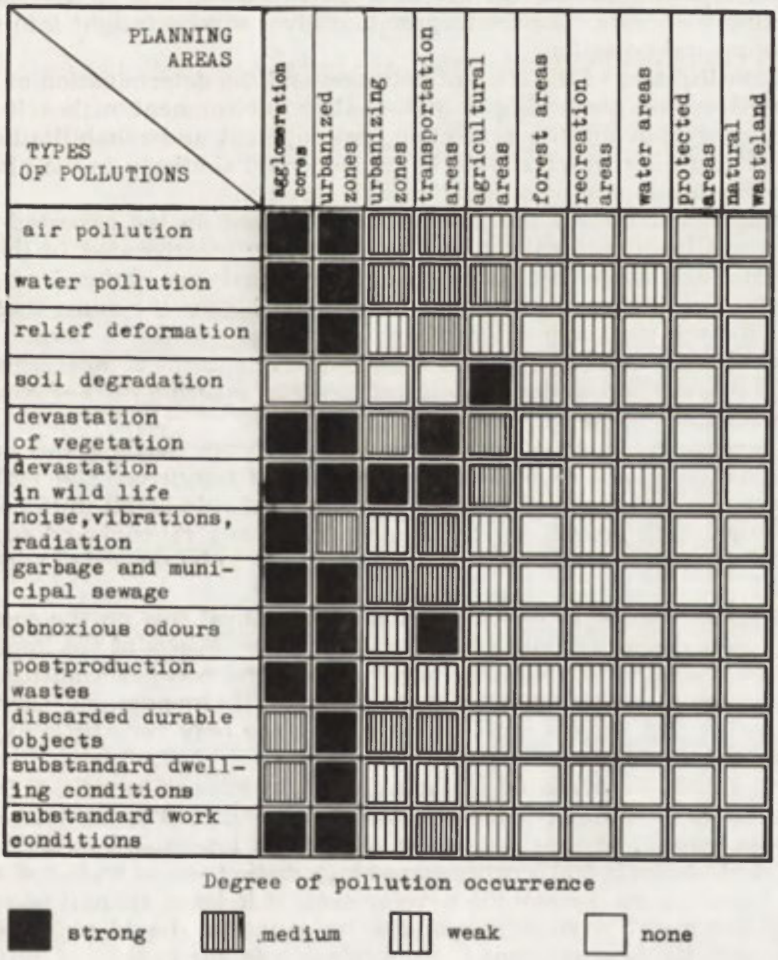

Fig. 3. Planning areas and types of pollutions

types of pollution superimposing one on another in a small area have already become dangerous to human health and to living conditions.

What currently presents the most difficult problem is the satisfaction of the need for usable water. The next most urgent problem is how to secure a growth of power generation without degrading the environment. This is followed by the need to preserve pure air, undeformed relief, undestroyed soil, vegetation and wild life. In addition to these, in the urban environment there is noise, waste utilization, garbage and municipal and industrial sewage discharge.

To evade the degradation of the environment completely or to keep it as low as possible each advanced country carries on environmental policies adjusted to its specific needs.

(8) *Environmental policy.* It has been mentioned already that environmental policy depends on the level of the socio-economic development of each country. Although it may differ from country to country, environmental policy attempts to provide solutions to several basic tasks common to all countries.

These tasks comprise the identification of the state of pollution by means of observation, measurements, data processing, and their statistical and cartographic interpretation. Air and satellite photos furnish one of the basic ways of recording such data. Their interpretation gives a good insight into the state of environmental pollution.

The identification of the state of pollution and the determination of the ultimate objectives of preserving a high-quality environment makes it possible to work out a plan for the protection, development and rehabilitation of the environment, a plan which should be implemented similarly to the plans dealing with the developing of production and services.

The implementation of the plan should be based on the expected expenditures, especially investment outlays, that must be incorporated in the annual and multiannual budget estimates on local, regional and national administration levels. The higher the national income the bigger the sums that can be allocated for the implementation of environmental policies. A certain proportion of these sums should be allocated for the development of measurement and warning networks and to the servicing of facilities securing high environmental quality which are in operation already.

It is necessary to work out legislative provisions settling the principles (among them, the fees) of utilizing environmental resources. The violation of fixed maximum standards of admissible pollution should result in the offenders being charged high penalties. On the other hand, any rational and economical use of environmental resources and qualities ought to be rewarded with special bonuses.

The implementation of environmental policies must rely on the competence of local, regional and national administration. Some aspects of the implementation can be relegated to voluntary organizations and non-governmental bodies.

Environmental policy must be based on scientific foundations. Comprehensive environmental studies must be taken up since only very little experience has so far been gained.

Among others, these should include the construction of models of the socio-economic development of particular countries. In contrast to the known global world-scale models, regional models must contain inputs and outputs such as foreign trade, migrations, the diffusion of information and of technical advance, etc. The model of socio-economic development, if it takes account of resources and amenities of the environment and of its pollution, should comprise: population growth, the improvement of living standards, the growth of agricultural and industrial output, the growth of power output, of transport, of services, recreation possibilities, dwelling comfort, good working conditions, and simultaneously the growth of pollution, the advancing environmental degradation, the growth of areas of high investment concentration, the decline of the natural environment etc.

The implementation of environmental policies can only be entrusted to expert personnel and thus it becomes necessary to start training specialists in environmental problems on elementary, secondary, vocational, and higher levels. What is also necessary is the organization of various supplementary courses for specialists in environmental policy up to the level of post-graduate studies.

Environmental problems must be given publicity to make public opinion realize the dangers of pollution and the degradation of the environment. The mass-communication media (television, radio, press, film, exhibitions, etc.) as well as organized social actions have a special task to fulfill in this respect. Outside the school, special instruction on these problems must be provided, whereas in the school itself young people should be brought up to be fully awareness of the importance of the problems of environment.

The eight points mentioned above merely point out those environmental problems that are the most important and the most urgent, but of course they do not exhaust the list of all tasks facing environmental policy.

(9) *Waste-free production.* Recently the idea was launched to attempt to reduce pollution and environmental degradation directly at their sources by

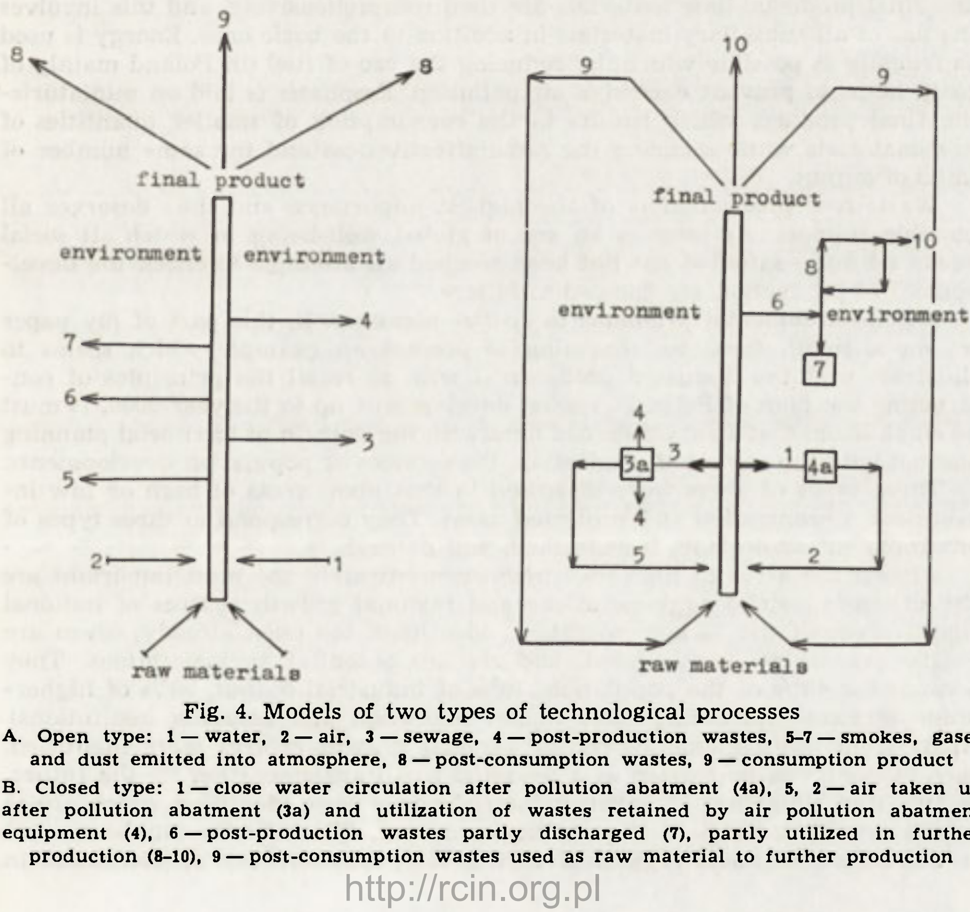

Fig. 4. Models of two types of technological processes

A. Open type: 1 — water, 2 — air, 3 — sewage, 4 — post-production wastes, 5–7 — smokes, gases and dust emitted into atmosphere, 8 — post-consumption wastes, 9 — consumption product

B. Closed type: 1 — close water circulation after pollution abatment (4a), 5, 2 — air taken up after pollution abatment (3a) and utilization of wastes retained by air pollution abatment equipment (4), 6 — post-production wastes partly discharged (7), partly utilized in further production (8–10), 9 — post-consumption wastes used as raw material to further production employing new waste-free technologies. In 1974 and 1975 the Economic Commission for Europe ECE in Geneva made this one of its most fundamental problems. The ultimate aim is to put into practical use such technologies that leave as little unusable wastes as possible. Since power generation and industrial production account for about 80% of all pollution, the primary concern is to find new technologies in power production and industry. For economic reasons such waste-free production must be combined with a frugal use of raw materials, energy, water etc.

The following two models show the possible directions in which industrial plants may develop from the point of view of environmental pollution: (1) the open industrial plant, and (2) the completely closed plant. The first model refers to plants operating on a full scale, using large quantities of raw materials, energy, water, air and producing considerable pollution of both air and water, deforming relief, the soil and vegetation, and practising no waste reclamation.

Model two instead presents a closed plant which uses little water and recirculates it subsequently in closed-circuit systems. The same applies to the use of air. Raw materials are used comprehensively and frugally, waste reclamation permits very little worthless refuse.

Waste-free technologies are also economical technologies. As full rationality is secured in the production of raw materials the concomitant losses are reduced to minimum. The some is true of savings in the transportation of raw materials and final products. Raw materials are used comprehensively, and this involves the use of all subsidiary materials in addition to the basic ones. Energy is used as frugally as possible which, by reducing the use of fuel (in Poland mainly of coal), helps to prevent excessive air pollution. Emphasis is laid on miniaturizing final products which results in the consumption of smaller quantities of raw materials while securing the same effectiveness and the same number of units of output.

Waste-free production is of the highest importance and thus deserves all possible support. As long as an era of global well-being in which all social needs are fully satisfied has not been reached all attempts to check the development of production are doomed to failure.

(10) *Environmental problems in spatial planning.* In this part of my paper let me abandon theoretic reasoning to present an example which seems to illustrate well the discussed problems. I wish to recall the principles of constructing the plan of Poland's spatial development up to the year 2000. It must be emphasized that I am concerned here with the domain of territorial planning and not with the sectors of production, the services or population developments.

Three types of areas were discussed in that plan: areas of high or low investment concentration and protected areas. They correspond to three types of environment: man-made, transformed, and natural.

Among the areas of high investment concentration the most important are the urban-industrial agglomerations and regional growth centres of national significance. Of the 23 agglomerations identified, ten exist already, seven are in the process of development, and six are potential agglomerations. They account for 40% of the population, 70% of industrial output, 90% of higher-order services (including 95% higher education and research institutions). Apart from the agglomerations, 20 regional growth centres were identified, each of them can be treated as a potential small agglomeration for the future. In this way altogether 43 urban-industrial nodes were identified which are to be the principal nodes of the national economy. These nodes can be treated as the centres of nodal regions of various size, functions and specialization in production and services. The pattern of nodal regions can be used as the foundation for a possible territorial division of Poland in the future.

Beside the above-mentioned agglomerations and regional growth centres Poland has about 800 towns. Some of them perform specialized functions. The map shows towns of different size (depending on population) fulfilling industrial, transport, resort-tourist, boundary and seaport functions.

The agglomerations and towns are interconnected by means of infrastructural facilities, the most important role being fulfilled by traffic lines. Depending on significance and technical quality, these lines are classified as national routes (including transit and interregional lines) connecting different agglomerations with each other and with urban-industrial centres beyond the boundaries of Poland, as regional routes, suburban and municipal traffic lines, and — in rural areas — local transport lines. The map illustrates the intensity of railway and bus transports between different agglomerations.

Apart from the towns (345 of which fulfill the role of central places for rural areas) there are about 40,000 villages which represent dense or dispersed rural settlements of various patterns reflecting their historical development and the changing ownership relations. Rural settlements urbanize, agricultural functions are on the decrease and are partly supplemented by recreational functions, a large proportion of the rural population earn their living from non-agricultural sources, a number of people commute daily to work or school etc.

Territorially, the urban-industrial agglomerations are composed of city centres, urbanized zones, and urbanizing zones. These latter account for about one-third of Poland's total territory.

The areas of low investment concentration comprise agricultural land, forests, recreational and partly water areas. Altogether they account for more than 90% of Poland's territory. Developments in agriculture affect the pattern of agricultural land. Ownership relations are of paramount significance. Disintegrated pieces of land are joined together to form larger continuous wholes. Land is submitted to improvement processes. Anti-erosion actions are undertaken. More and more fertilizers and pesticides are used. All this affects the agricultural environment and intensifies chemical pollution. Spatial planning in the rural areas has its foremost task in providing a legislative framework which would help to preserve the best soils (about 30% of land in Poland has soil grades I–III) and arable land with existing production facilities (as glasshouses, hotbeds, plastic tunnels, plantations, orchards, etc.) for agricultural production.

Forest areas can be divided into productive and protected areas. The former yield timber and other subsidiary forest products. Timber production must not exceed the yearly natural growth of wood mass. The index of yearly timber production from one hectare and the yearly wood mass increment from the same area is a good indication for the appraisal of forest economy.

Protected forests are gaining in importance. They fulfill soil-protective, water-preservative, climatic, recreational, curative, tourist and scenic functions. Forest economy in them should be adjusted to the function they fulfill. Forest area improvements and chemical pesticides should be used judiciously and sparingly to prevent the degradation of forests. In view of the many important functions of woods the total afforested areas should be increased. Afforested areas are planned to grow from 27,5% of Poland's territory in 1970 to 30% in the year 2000. The distribution of forest areas is irregular and therefore afforestation should be conducted primarily in the vicinities of urban-industrial agglomerations and in Poland's central regions which have the relatively smallest proportion of forest areas.

As regards recreation areas, they are either "weekend areas" close to the agglomerations or "holiday areas" in places providing high recreational values and amenities. Altogether 47 regions of sojourn tourism have been identified in Poland, mainly in the mountains, in the lake districts and along the coast of the Baltic. Health resorts with predominant curative functions present a separate problem. As now, only a mere one-fourth of the total needs in curative treatment is satisfied, a plan for their development has been worked out according to which by the year 2000 the health resorts will accomodate about two million visitors.

Attention must also be paid to tourist areas, including mountain areas of high landscape qualities, water reservoirs, rivers, lakes and seas. Apart from areas of natural qualities tourist objects include art monuments, architecture, religious cult sites, centres of folk culture, historic places and relics, sport centres, etc. The map shows areas of walking and water tourism and the main centres of hiking tourism.

Protected areas form the last group. In Poland they comprise very little more than the national parks and natural reserves. The map lists 13 national parks and 650 natural reserves. In addition to these, conservation activities embrace about 7000 natural monuments. 384 animal species and 124 plant species are under protection.

Landscape parks and areas of protected scenary as well as rural parks are also under partial protection. Recreation areas will account altogether for 15–20% of Poland's territory.

The enclosed map presents a synthetic picture of the state of development of Poland in 1966. In it agglomerations and regional growth centres are marked in red. Urbanizing areas are grey. Yellow is used to distinguish areas of intensive agriculture and green is for the major forest areas. The principal roads and railways are marked on the map too.

The next map presents the concept of Poland's spatial development till 2000. The area occupied by the agglomerations and regional growth centres is seen to have increased considerably, the transport lines of national and transit significance are also distinctly more developed. The urbanized zone is more extentive, agglomerations begin to grow together into socio-economic macroregions. Among these, the Silesian-Cracow macroregion will reach the highest development.

The concept of the long-term plan is based on moderate concentration, on the nodes and belts pattern, and on the polycentric structure of the principal socio-economic foci. That planning concept is not sensational but, for a number of reasons, it seems to be very realistic. One of its advantages is that the areas of high investment concentration with a man-made environment account for no more than 20% of the total territory, and thus 80% will have a transformed environment in which natural elements are going to predominate. Protected areas will constitute 2% and recreational areas 15–20% of Poland's total territory.

After certain modifications by the Planning Commission at the Council of Ministers this concept was approved by the state's supreme authorities and is going to be implemented by all ministries until the year 1990.

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ENVIRONMENT MAPS

STANISŁAW LESZCZYCKI

In the following we propose a typology of environment maps in terms of their contents and possible applications. We are not concerned here with mapping techniques or with the graphic design of maps. Environment maps are *static* when they represent the environment in its factual aspect at some moment, or *dynamic*, if they are concerned with processes or the changes in them.

Environment maps can also be classified as analytical, composite, or synthetic. *Analytical environment maps*, which may be very narrow in scope, deal with individual environmental features. *Composite maps* represent different environmental components (configuration, waters, flora, etc.) in many aspects and in their multiple interrelationships. *Synthetic maps* represent the environment as a natural-geographic complex in its entirety (e.g. by physical-geographic units, natural lands, geobiotopes etc.).

Environment maps can be divided further into descriptive, evaluative, forecasting, and applied. Descriptive maps represent the actual state of environmental phenomena, forms or processes, possibly with indications as to their origin (e.g. geomorphological maps, geobotanical maps etc.). *Evaluative maps* define phenomena or processes from the angle of their usefulness for socio-economic life (e.g., soil improvement maps). *Forecast maps* take into account casting, and applied. *Descriptive maps* represent the actual state of environment over longer time intervals. *Applied maps* contain both evaluative and forecast elements and they can assist the authorities concerned in decision-making on environmental issues.

Viewed from the point of view of contents, environment maps belong to one of four groups:
(1) Maps describing the environment of an area;
(2) Maps of the degree of transformation of the environment;
(3) Maps of degradation and pollution of the environment;
(4) Maps of natural cataclysms in the environment.

(1) *Maps describing the environment* are either descriptive or evaluative. They represent environment as a natural-geographic complex or in its components, specifically its geological structure together with the occurrence of minerals, its geomorphology (configuration, relief), hydrography (surface waters and subsurface waters, seas and oceans), soils, climate, its geobotanical (phytogeographic) or zoogeographic units. Because maps describing the components of the natural and geographic environment are very numerous — they amount to hundreds of thousands — they are not discussed in this article. Maps covering the whole environment are much less numerous. Such maps represent the specific features of phenomena (facts), their interrelationships, and the processes resulting in further alterations in the environment after definite periods of time. When they indicate the origin of phenomena they become

explanatory maps. These types of environmental maps are also well known (under the name of topical maps in physical geography), as they have been produced by various methods in the customary way for many years now. What does change are the techniques by which such maps are produced and the specific ways of representing phenomena; moreover, due to the continuing progress of specialization the scope of their contents is gradually losing its comprehensiveness.

Maps evaluating the resources or qualities of the environment, or of its components, from some definite point of view are much fewer. As a rule, practical considerations are involved, specifically the evaluation of the environmental quality from the point of view of some aspects of national economy (e.g., soil quality maps for agriculture) or of the satisfaction of the nation's needs as regards services (e.g., forest area quality maps for recreational purposes). Environmental resources and qualities are normally evaluated from the point of view of satisfying socio-economic needs (as in the case of maps for the needs of water economy). Estimates of the possible uses of the environment for satisfying social needs can be utilized in decision-making for investment projects of for the protection of the special qualities of some areas.

(2) *Maps of the degree of transformation of the environment*

In consequence of human activity the natural and geographic environment continually undergoes transformation. This leads to positive or (more frequently) adverse alterations in it. Most conspicuous among these alterations are changes in water balance (draining, irrigation), in soil quality (fertilizing, improvement), as well as the synanthropization of the vegetative cover and relief deformations. To measure the extent to which the environment has been transormed we can use the percentage of anthropogenic forms that have developed in consequence of human activity. Moreover, man implants different durable structures and utilities which satisfy his needs in the natural-geographic environment. Considering the degree of environmental transformation, three types can be distinguished: (1) the natural, (2) the transformed, and (3) the artificial (man-made) environment. *The natural environment* has only been insignificanty transformed by human activity. The alterations of the natural components do not exceed 10%. Natural environment can be found in some parts of the globe only, such as in the polar regions, in the oceans, high mountains or deserts. In densely populated areas, the environment has been preserved in its natural state only in small territories, such as national parks or reserves. *The transformed environment* is largely of a natural character but its individual components are transformed in up to 50% by human activity (e.g., fields, forests, waters etc.). *The artificial environment* has undergone strong transformation, its natural components are changed in more than 50% and include mainly urban and industrial areas, transport nodes and lines, post-industrial wastelands etc.

Maps of the transformation of the environment are few. Their classification coincides with the three listed types of the environment. Such maps are largely arbitrary as any objective criteria are very difficult to employ. Equally rare are evaluative and forecast maps which are helpful in anticipating future environmental alterations and thus in investment decision-making for the further development of each of the three types of environment. Notwithstanding the far-reaching transformation and anthropogenic character of the natural environment, all areas are still subject to the laws of nature.

Man-generated alterations in the environment usually result in the specific socio-economic functions assigned to the individual areas of the country concerned. Hence it is possible to distinguish a number of functional areas for which some environmental transformations are typical.

These functional areas include (1) inhabited areas, (2) areas of technical infrastructure facilities, (3) agricultural areas, (4) forest areas, (5) surface waters, (6) seas and oceans, (7) recreational areas, and (8) wasteland. Groups of environment maps correspond to each of these types of areas.

Inhabited areas have considerable population densities due to different types of settlement. These include *centres of major concentrations* of the population, production and service activities, i.e., centres of urban-industrial agglomerations. The centres, which usually consist of dense and high construction developments, represent the artificial environment in its most typical form, with even the vegetative cover being planted by man, and with water flowing as a rule through canals or pipes. Agglomeration centres are as a rule surrounded by an *urbanized zone*. There, the environment is also typically artificial but the environmental transformations are less drastic and in parts of such areas there are still natural geobiotic complexes. This type of area is also comprised of small and medium-sized towns and urbanized settlements. The third zone surrounding these two is the *urbanizing area* where the rapid socio-economic changes may also affect the environment. The transformation of natural elements is both rapid and intense (more than 50%) but less so than in the two previous types of area.

The artificial environment embrace moreover the *nodes and bands of technical infrastructure* facilities, with varying intensities of the transformation of the environment. The bands creep gradually out of the agglomeration centres thus forming together with the nodes the spatial framework of the economy.

The type of transformed environment is represented primarily by agricultural and forest areas. Environmental transformation has in this case a different meaning in that it mainly affects the soil conditions, the water balance, relief and flora of the area concerned. The transformed environment consists of anthropogenic ecosystems. The degree of the transformation varies from case to case, generally rising together with the development of agricultural and forest economy. Viewed from the angle of productivity of those areas, alterations in the environment may be either desired or adverse.

Areas of surface waters and recreation areas also represent the transformed environment but the degree and specific mode of the transformation are different. Recreational areas belong to either of the following groups: (a) *Intensely frequented areas* with facilities serving definite uses such as health resorts, spas, holidays, tourist or weekend localities etc. They include scenic or rural parks and areas of protected scenery. (b) *Poorly frequented areas* with special natural qualities under protection such as natural reserves, national parks etc. Maps of protected areas are relatively numerous.

The transformation of surface waters is not really very great. The larger the reservoir, the less pervasive man's impact on it. This accounts for the relatively insignificant environmental transformation of seas and oceans in which only water pollution can be observed.

Natural environment occurs in natural wastes, mountains, deserts etc., national parks and natural reserves and, partly, big reservoirs, seas and oceans.

There are but few maps which would classify areas by their functions or indicate areas of transformed environment. Their classification coincides with the one given above for the areas they refer to.

Another group of maps estimate the degree of environmental transformation. The principal way to make such estimates is to determine the population capacity of the area concerned, together with the potential productive or service capacity without inducing a degradation of the area's environment. Typical of this group are maps of the tourist capacity of recreational areas, which are not numerous yet. Maps estimating the capacity of an area's environment as regards population, number and volume of output and services are of primary importance for spatial planning.

(3) *Maps of environmental devastation and degradation*

Maps showing environmental pollution, devastation and degradation have been published for many years now. Best known among them are maps of soil erosion, which are occasionally reinforced by incompetent agrotechnical measures. Environmental pollution and degradation are caused by human activity. They concern the whole environment or its components only. They also effect the human environment. Three groups of maps are most often distinguished:

(1) maps of the pollution and devastation of the natural-geographic environment;

(2) maps of the pollution of the human (artificial) environment;

(3) maps of substandard dwelling and work conditions.

Group one includes maps of:

(1) dust- and gas-generated air pollution;

(2) surface and subsurface water pollution;

(3) pollution of the seas and oceans;

(4) deformation of the earth's surface configuration;

(5) soil devastation;

(6) plant life devastation;

(7) devastation of fauna.

As such maps are frequent and well-known their details are omitted here.

The second group includes maps of the human environment, which is mainly artificial, usually urban. Such maps show the following perturbations:

(1) noise, vibrations, radiation;

(2) municipal sewage and garbage;

(3) annoying odours;

(4) post-production wastes (industrial, agricultural);

(5) discarded durable articles (such as containers);

(6) ionizing radiation.

The third group of maps, representing substandard conditions of dwelling and work include maps of municipal facilities such as the provision of electricity, gas, water, sewage etc. for homes and the provision of work establishments with facilities for securing safe working conditions.

Apart from maps of environmental pollution representing the actual state of things, there are maps which evaluate the situation in terms of living standard as well as forecast maps illustrating possible alterations in the future. Warnings are often implied in this type of maps. Some maps can be used in decision-making for slowing down the progress of devastation and degradation or for the rehabilitation (especially recultivation) of the environment.

(4) *Maps of natural cataclysms*

Cataclysms of nature have for a long time been recorded on maps. There are maps of earthquakes and of points of volcanic activity. Sudden movements of the earth's crust may trigger sea cataclysms, tsunami or high waves of warm or cool water.

But closest attention has been paid to climatic disasters which are represented on numerous maps of cyclones, typhoons, hurricanes, tornados (whirlwind passages), and of various regional winds of excessive power and serious consequences, as for instance mountain winds (foehn), dry, hot and sand- and dust-carrying winds from deserts (samum, khamsin, sirocco), cold storm-type winds (blizzard, bora, mistral) and many others.

Persisting droughts bringing famine upon millions of people have also been represented on maps. The same applies to extreme temperature fluctuations which may result in frost or heat disasters, long-lasting ice cover, glaze, mists etc.

Vehement and abundant rainfall (thunderstorms) may cause dangerous floods. Hail often brings disaster to crops. Abundant snowfall may also be dangerous as it results in excessively thick snow cover, blizzards on roads, and avalanches in the mountains.

Abundant precipitation causes rapid erosion, denudation, suffusion or creeping, which in the mountains may cause slides of stone or earth avalanches.

Massive invasions by insects such as locusts, or by bacteria or viruses, can also be disastrous in their effects on the environment.

Other kind of cataclysm are wandering dunes, icebergs, geysers, mud volcanoes, solfataras, etc.

Environment maps can be classified according to the types of natural cataclysms.

OTHER FEATURES OF ENVIRONMENT MAPS

Depending on the scale to which they are made environment maps can be detailed, survey, or general maps. The scale intervals corresponding to each of these are: 1:10,000 — 1:50,000 for detailed maps, 1:100,000–1:500,000 for survey maps, and 1:1,000,000–1:2,500,000 for general maps. The criteria in this case can be identical with those applied to other maps.

Of special interest are maps made from satellite or air photos. Such maps afford a full and detailed picture of the environment and by updating them periodically we can get a close follow-up of changes as they take place. Satellite and air photos can also help to fix the current state of the environment. This type of photo is of immense use not only to environmental cartography but to all kinds of environmental research. For want of space, however, the problems of satellite and air photos cannot be discussed in this report.

A final classification of environment maps is possible — that by their graphic technique. But since these techniques are, on the whole, similar to those employed in other thematic maps they need not be discussed here.

A GENERAL CLASSIFICATION OF ENVIRONMENT MAPS

(1) Static–dynamic;
(2) Analytical–composite–synthetic;
(3) Descriptive–evaluative–forecasting–applied;
(4) Detailed–survey–general;
(5) Satellite–air–topographic–statistical.

A CLASSIFICATION OF ENVIRONMENT MAPS

(I) *Maps describing the environment of an area*
descriptive, evaluative, maps of phenomena, relationships and processes;
maps of geological structure with the occurrence of mineral resources;
geomorphological (configuration, relief);
hydrogeographic (surface and subsurface waters, seas and oceans);

soil quality maps;
climatic;
geobotanic (phytogeographic);
zoogeographic;
maps of physical-geographic units, natural lands, geobiotopes.

(II) *Maps of the degree of the transformation of the environment*
(1) Natural environment;
(2) Transformed (geographic) environment;
(3) Artificial (urban, industrial) environment;

(III) *Maps of functional planning areas*
(1) Inhabited areas:
(a) centres of urban-industrial agglomerations;
(b) urbanized (suburban) zone;
(c) urbanizing zone;
(2) Areas of technical infrastructure;
(3) Agricultural land;
(4) Forest areas;
(5) Recreational areas;
(6) Surface waters;
(7) Areas of scenic quality under protection;
(8) Natural wasteland (mountains, deserts, polar regions);
(9) Seas and oceans.

(IV) *Maps of environmental perturbations und degradation*
(see The List of Perturbations and Degradation of the Environment)

PERTURBATIONS AND DEGRADATION OF THE ENVIRONMENT

Perturbations and degradation of the natural environment
(1) Air pollution;
(2) Pollution of surface and subsurface waters;
(3) Transformations of the earth's configuration and relief;
(4) Soil devastation;
(5) Devastation of plant life;
(6) Devastation of animal life;
(7) Pollution of seas and oceans.

Perturbation of the urban-industrial environment
(1) Noise, vibrations, radiation;
(2) Municipal garbage and sewage (detergents);
(3) Odours;
(4) Post-production wastes (including post-production wasteland);
(5) Discarded durables (containers);
(6) Ionizing radiation (radioactive substances and wastes).

Substandard living conditions
(1) Substandard dwelling conditions;
(2) Substandard work conditions.

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GEOGRAPHIA POLONICA 33, 1976

A SYSTEM-BASED APPROACH TO RESEARCH CONCERNING THE GEOGRAPHICAL ENVIRONMENT

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The trends towards integrating accumulated knowledge are, in addition to the increasing specialization rate, a typical feature of scientific development in the second half of this century. In other words, we are now passing from that stage of research aimed at the registration, description and classification of the greatest possible number of phenomena to that of global research integrating the substance that has been disintegrated during the process of research.

The fact that the general phenomenon called "mathematization of sciences" — though it has not much to do with mathematics — is taking place now, is by no means incidental. Nor is the fact that the rapid development of cybernetics has been observed since the 1950's incidental, its principles having been, however, formulated as early as in the 18th century. Finally, a more general understanding of the role of synthetising concepts only began recently, despite the fact that they were promulgated earlier by such scholars as, for instance, A. A. Bogdanov — the founder of "tectology" — or M. Petrovich, V. Severtsov or E. Haeckel, who all had most original concepts of the "architectonics" of structures. The development of these tendencies could not, however, have taken place earlier, being, on the one hand, the expression of a certain helplessness in view of the vast and ever more precise information, and on the other hand, a self-defence reaction on the part of what we call *l'esprit social* against unproductivity of accumulated knowledge.

Recently, the general systems theory with all its theoretical and practical implications, has been growing in importance and has found its application in almost all the branches of science. The growth of this theory has been of course accompanied with disputes. The enthusiasts of the theory of systems see in it the future of science, a panacea for the majority of research ailments, a milestone in the development of science, etc., its opponents considering it as a spectacular conception which has been thrown on the market at the appropriate time, a conception which, once the fashion is out, becomes forgotten. From the objective point of view it can be stated that the general systems theory comprises a load of rich possibilities, both theoretical and methodical, being used within a much too narrow scope and in not the most proper place. The further development of this theory and of its application in scientific research as well as in the organization or management of systems of any type is beyond any doubt.

As the basic assumptions of the general systems theory are sufficiently known, especially among geographers, I shall draw attention only to those aspects which seem to be most essential from the geographical research point of view.

(1) The theory is based on three principles: isomorphism of laws at various levels of organization, deduction and entirety.

(2) Any ordered set of elements which mutually interact and which form a uniform structure can be regarded as a system.

(3) The existence of the system is reflected by its action that is expressed by the potential changeability on which the flow of information depends as well as by the transmutation of parameters, i.e. of independent variables.

(4) The system must not and, most often, is not a being that exists in reality. It is a structure of relations within a given set. Which one out of the possible configurations of the object will be considered as a system will depend on the aim, and on the researcher's intuition. It is for this reason that we distinguish the natural, utilitarian, pragmatic and other systems. The total of individuals (for instance of people, plants, forms of terrain) is not a system *per se*, consituating only a collection of elements within the framework of which the systems of different rank and importance can be determined if the definite relations between motives and effects occur in it.

(5) Every system is of a complex character and, according to the theory of levels of organization, it can be decomposed into more simple structures occurring at the lower hierarchical levels or integrated into the structures of higher levels being their integral part. Thus, the principle of decomposition makes it possible to limit substantially the field of research, however, only in the case when the fact that the object under investigation is an integral part of the structure of a higher rank is taken into consideration in the algorithm of a research procedure.

(6) Because of the fact that the system is modelled by mechanisms specific to the organizational level on which it is found no conclusions could be drawn on its functioning neither through the analogies with laws that rule on higher levels nor by summing up the mechanisms on which the lower-order structures depend.

The methodology of system analysis is closely related with modelling. Such research, being obvious for geographers sometimes give raise to the opposition of other specialists. In addition, the opinion that only mathematical language is the language of research finds no ground. It is simply the most convenient language but it is by no means a proof of the researcher's "progressive" or "modern" attitude. Mathematical language is absolutely neutral so far as it concerns the nature of the problem. The fact of using this language says nothing about the researcher's attitude concerning the basic ideas and concepts in his field, or about his ability of creative thinking.

These few remarks concerning the general systems theory aim at correcting some opinions that are also common among geographers. They serve as an introduction to a discussion of the possibilities and usefulness of the application of such an approach to research concerning the geographical environment. In order to avoid any lack of clarity let me put the stress upon the fact that the term "geographical environment" is in my view synonymous with "man-environment" and "man's living environment", both conceived from the spatial point of view, because, as it seems, all the denominations of the latter two terms are comprised in the definition of "geographical environment".

Because of the fact that the problem under consideration is of a broad scope and any description of the advantages and disadvantages, concerning the system approach to the geographical environment would be impossible in a single article, I will limit myself to only certain problems. I have in mind the finding of proper answers to the question whether a geographical environment can be treated as a system. What part of the research field covered by chorological sciences belongs to this problem and to what degree is it internally complicated? Then, I would like to present the reasons which contribute to the fact that the system approach is so slowly gaining ground in geographical sciences. I purposefully disregard the problem of methods, because my conviction is that their selection depends, first of all, on the aim of the research and not on the object of study, i.e. — the environment.

Can a geographical environment be analyzed in the categories of the system? I would say it can, as it completely suits the definition of the system that has been mentioned above. The geographical environment is undoubtedly an ordered set of mutually interacting elements, constituting a definite uniform structure. The entity of a geographical environment (the system man-environment) is reflected by its activities concerning the potential changeability of the components on which depends the flow of information (matter and energy). The environment, taken as a whole, as well as any of its spatial patterns (geosystem), can be both decomposed into the more simple structures that occur on lower levels of the hierarchical structure and which themselves form the lower-rank systems governed by laws and mechanisms proper exclusively to them.

It is difficult to determine, without detailed research, the degree of the integration of elements or of sub-systems of which the geographical environment is composed. An analysis of interactions that occur within the natural environment throws a certain light upon this problem (see Table 1). The table portrays interrelations between a randomly selected 124 characteristics of an ideal, natural geosystem. The matrix is composed of 26 properties of the sub-system "atmosphere", 28 properties of the sub-system "hydrosphere", 30 properties of the "litosphere" sub-system, 17 properties of the "pedosphere" sub-system and 23 properties of the "biosphere" sub-system. Each of the 126 properties has been analyzed under the angle of both its passive and active links. Moreover, these properties have been examined as to their usefulness as the indicator of the state or of the functioning of the remaining properties. Two matrices have been analyzed: the first one of the so-called non-ranked fulfilled contacts and the second one that includes the ranking of those contacts. The first one points out the amplitude, the scope of the influence that a given property exerts within the geosystem, the second one indicating the potential interrelations between the particular properties.

The presented picture is of a highly generalized character. The inclusion of the complete matrices each comprising some 15 thousand units, would be impossible because of lack of space. Thus it has been necessary to classify the results obtained into a certain number of sections which, of course, has provoked the need for calculating the average data in order that they be adequate to the generalized particular sections. The enclosed table comprises the sets under investigation classified into 15 groups which, in turn, have been divided into 5 sub-systems corresponding to the basic elements of the natural environment.

Insofar as the collection under consideration is concerned, the feature that most strikes the eye is a fairly high integration of properties. This fact has been proven by a low potential value (the relation between the number of emitted influences and that of the absorbed ones by a given property) which can be treated as the independence standard. This index achieves the highest value of 1.8, the maximum possible one as far as this sub-collection is concerned amounting to —13.0 in the case when the exclusively unilateral information passage would occur.

Another moment, which seems to be of interest, is a distinctive separation between the properties that first of all, influence other properties and those

TABLE 1. Interaction and indicative ability of the elements of natural environment

Groups of	properties	Exerts an influence on: (excluding the self-influencing)			Subject to influencing by:			Index of potential (independence)	Indicative efficiency		
		number of collection properties	%	index of intensity rate of influencing	number of collection properties	%	index of intake ability		number of properties indicated by the group	the average efficiency of the indicator	index of the over--information
Sub-system of atmosphere	Physical properties of structure (8 properties)	42	36.3	36.8	32	27.6	29.2	1.3	4	8.3	3.5
	Chemical properties of structure (5 properties)	36	30.5	27.5	30	25.2	20.5	1.6	6	9.1	5.0
	Functional properties of structure (13 properties)	85	76.0	47.3	55	49.6	27.2	1.5	22	8.0	20.8
Sub-system of hydrosphere	Physical properties of structure (10 properties)	77	67.5	59.6	57	50.0	46.3	1.4	16	10.0	14.0
	Chemical properties of structure (5 properties)	72	60.5	64.7	51	42.8	37.7	1.4	15	7.6	12.6
	Functional properties of structure (13 properties)	96	85.7	103.8	53	47.9	58.8	1.8	20	11.7	18.0

Sub-system of litosphere	Physical properties of structure (11 properties)	92	81.5	85.7	58	51.2	50.7	1.6	23	12.4	20.4
	Chemical properties of structure (8 properties)	69	59.5	57.4	54	46.6	43.3	1.3	18	11.0	15.5
	Functional properties of structure (11 properties)	74	65.5	65.5	66	58.4	60.2	1.1	28	9.6	24.8
Sub-system of pedosphere	Physical properties of structure (6 properties)	38	32.2	29.0	83	70.4	75.5	0.5	57	9.4	48.3
	Chemical properties of structure (5 properties)	41	34.4	51.8	83	69.8	90.5	0.5	55	12.0	45.2
	Functional properties of structure (6 properties)	48	40.6	55.0	96	81.5	109.0	0.5	72	12.9	61.0
Sub-system of biosphere	Physical properties of structure (8 properties)	46	39.7	52.8	96	83.0	97.3	0.5	73	11.4	63.0
	Chemical properties of structure (5 properties)	34	28.6	54.7	80	67.2	66.0	0.4	46	9.1	38.7
	Functional properties of structure (10 properties)	50	44.0	57.1	97	85.0	71.5	0.5	51	10.1	44.8

absorbing mainly the influences coming from the outside. Thus, it can be stated, that the structure of the natural environment is shaped by one group of properties, and its functioning depends on another one. This suggests an analogy to human organism, its shape, possible limits of functioning and general efficiency being determined by the dominant structures: the skeleton and muscular structure, without deciding, however, on the use made by the organism. Here the main role falls on the complicated relations between the nervous, hormonal and other systems, which taken as a whole are of weight lower than that of one well developed muscle. It seems that lack of understanding of these essential differences between the structure-creating and functioning-determining properties was at the basis of a number of misunderstandings concerning the synthetic approach to environment, especially from the point of view of practical requirements.

Finally, a distinctive separation between the structure-creating properties and those belonging to indicators is typical. Insofar as the first group is concerned, the index of the ever-information is low, in the second one it achieves the highest values. This fact can be of a high practical importance as it points out that the analysis of all the components of the geosystem is not necessary in order to grasp its character. It is enough to consider a net of well selected indicative properties in order that at least the preponderant part of the elements of the structure, if not all of them, be evaluated.

The conclusion that a geographical environment is something more that the sum of its components would be a truism, similar to the thought that a new general idea organizing all our experiences is needed in our research. Though an adoption of general principles of integration is relatively simple, their application is much more difficult. This fact results, first of all, from the complexity of the examined structure as well as from the lack of precision concerning the determination of the limits of the scope of research.

The system of a geographical environment, of the system "man-environment" can be presented, in a simplified way, as an interaction matrix, that occupies a definite place in a geographical space. The number of elementary features, out of which this matrix is composed, is enormous. Some 500 elementary features can be distinguished in the natural sub-system only (they in turn, can, of course, be divided into even smaller features), their numbers as far as the technical-productive sub-system and the social sub-system being probably of a similar rank. If so, than we obtain an interaction matrix composed of 1,500 elements, i.e., covering 2,250,000 interaction fields. Each of those fields should be evaluated, at least, from the following points of view: (a) — changes in the structure, (b) — changes in functioning, (c) — its usefulness to man, (d) — changes in the production potential (degree of degradation and reclamation possibilities), and (e) its economic value. Taking into consideration only these aspects of evaluation (they are only one part of the possibilities), the number of variants amounts to more than 11 million. These estimative data show to what extent the structure of a geographical environment is complicated and difficult complex analysis. The generalized version of the matrix, presented in Table 2 has only 400 interaction fields. Not all of them directly concern the relation "man-nature", however, all of them concern the system "man-environment" conceived in a broad sense. It is obvious that geographical research does not comprise the whole of the matrix. Its first section (N–N) is subject to many natural disciplines; the last (S–S) is dealt with by medical, social sciences and the like. Thus the scope of research can be limited, in principle, to two sections: N–E and E–N, and, partially, to the structures S–N and N–S. However, in this case, as well, the number of elementary features will

TABLE 2. Field of scientific penetration of research problems concerning "man-environment" against the background of a simplified matrix of influences between the co-operating subsystems

Donor \ Taker		N Natural sub-system Atmosphere Hydrosphere Litosphere Pedosphere Biosphere	E Technical-production sub-system Agriculture Forestry Water management Settlement Industry Transport Recreation Services	S Social sub-system Health state Demographic structure Employment Working conditions Leisure conditions Technical civilization level Level of culture
N Natural sub-system	Atmosphere Hydrosphere Litosphere Pedosphere Biosphere	NATURE	Influences of natural conditions for man's activities	Impact of natural conditions on social life
E Technical-production sub-system	Agriculture Forestry Water management Settlement Industry Transport Recreation Services	Influences of economic management forms for natural conditions	ECONOMY	Impact of technical-production structures on social life
S Social sub-system	Health state Demographic structure Employment Working conditions Leisure conditions Technical civilization Level of culture	Influences of social structures for nature	Social conditions influencing the economic-technical systems of economy	SOCIETY

- (dashed box) Field of indirect interest in the problem "man-environment"
- (thick box) Field of indirect interest in the problem "man-environment"
- (dash-dot box) Motivation-decision making field being also the final aim of the problem "man-environment"

amount to one million. Taking into consideration how greatly complicated the real situation is, it is not strange that despite the fact that we talk so much about geographical systems, the real achievements are rather modest. The difficulty concerning the implementation of a system way of thinking in geographical research results, from other factors, as well. Among them, of major importance are the following:

— lack of knowledge concerning the results attained by other sciences;
— complementarity of structure and functioning of the system;

— complexity of the system;
— the impossibility of creating the unique and universal model of the system because of multilateral possibilities of approach to the phenomena;
— ambiguity of terminology.

Taking into consideration the first of the above-mentioned difficulties, it can be stated, that in recent times the system concepts have been broadly popularized among geographers who have in addition gained experience in making use of system — research carried out in other scientific fields, in technical, economic and natural sciences and the like. Thus, the difficulties that I have mentioned above, mostly concern the past.

The second of the mentioned difficulties — that is the complexity of the system — should be taken into consideration. Theoretically, the enumerated number of the possible combinations is enormous, though not all of them could be implemented in practice because of several reasons:

(a) — the potential coherence of the environment and of the forms of its use. The adaptation capacity of all the three sub-systems bears a character of a continuous changeability. Its is to some extent determined by the degree of technological development shaped owing to the interaction between man's economic activity and nature. This fact limits the number of combinations, theoretically possible concerning interrelations to typical structures that are characterized by a geotechnical metabolism specific exclusively to them. The appearance of this type of "ailing" structures is a warning signal that indicates that the interaction model is inappropriate and harmful.

(b) — the occurrence of environmental types or of interaction types is limited by the albo-topical phenomenon (exclusion exerted mutually in spacer) or by that of allo-chronical character (mutual exclusion in time). Lack of either spatial or time-concerning coherence reduces, moreover, the number of combinations that are theoretically possible. Owing to this only some of the combinations are practically mutually exclusive.

(c) — occurrence of introgression, i.e., of the secondary incorporation of properties of the same type into the complex of properties of the second one. Usually introgression is consciously provoked by man aiming at making uniform either the technics of management (or of the model of living style) or at increasing incomes. It essentially limits the typological variety of the system "man- environment", creating the typical structures with a forced way of functioning which is, in principle, independent of the primary state as well as of the geographical situation (for instance the introgressive systems of urbanized regions).

(d) — occurrence of the phenomenon of resistance of the system, which results from the natural tendency towards restraining the entropic increase. This is a feature typical of biological structures (including that of man). Human society improves its internal organization from the thermodynamic-informative point of view through a continuous disorganization introduced to biosphere. Thus, there exists a definite interdependence between socio-economic progress and the degradation of nature, and it would be similar to a simple one if the resistance of the biotical environment, expressed by the tendency towards reproducing the initial stage or towards the emergence of biocoenotical structures, was not existing. Power of resistance depends on both tension and the pace of the introduced changes as well as on the potential of the vital world of living organisims. Consequently, the existence of biocoenotic resistance results in the emergence of a number of "competing" typical structures, which diminishes, as well, the number of possible combinations.

Because of it, from among many typological structures of a geographical environment that are theoretically possible, only few occur in practice. They should be subjected to system research. The ephemeries that appear sporadically can, at least during the initial period, be emitted.

The problem of the possible complementarity of the structure and the function requires further research. This is a problem of significant importance, especially concerning the methodological aspect. Confirmation of the existence of a correlation between the structure and the function in the structure under consideration would considerably facilitate further research. There are many facts now that speak both for and against the existence of such correlations. Man's activities concerning nature, both the negative and positive ones lead always towards an increased independence of structure from the functioning of geosystems. It is for this reason that in examining the relations "man-environment" from the point of view of pragmatic categories, we should assume the complementarity of the structure and the function. The assumption that the structure and the function constitute the system aspects of equal importance which complement each other excluding themselves mutually in the research procedure, does not restrict re.earch possibilities; in fact it broadens these possibilities.

The fourth difficulty is connected with the impossibility of creating a unique and universal model of geographical environment. Because of it, there is the necessity of multiplying the research till a certain understanding the typological differentiation of the system is achieved from the point of view of the properties that are of interest. Any environmental model is only relatively valid. This fact reflects not so much the existing situation as the state of our knowledge and its goals.

The last of the mentioned difficulties, that is the terminological ambiguity, is a problem not only for geographers. Its impact on research is negligible, however, it makes the exchange of information between researchers difficult or, sometimes, simply impossible. For this reason any comparative synthetic studies based on the results obtained by various authors are impossible to carry out.

There exists one more phenomenon which we do not know how to approach in geographical research, i.e., space. Is space an environmental element, an integral part of the system? or is it one of the parameters, i.e. the independent input variable. Or is it, finally, a system *per se*? Finding the answer to that question is of the utmost importance.

Many descriptions are used in geographical science concerning space, for instance: geographical space, social space, economic, socio-economic, ecological, geodetic or regional space, without mentioning the structural functional definitions such as: open space, built-up space, space equal in the factor of time and the like. All these definitions are characterized by a lack of precision being, in most cases, the terms created *ad hoc* with the aim of facilitating the formulation of thoughts. I think that, as far as system environmental research is concerned, at least two types of space shuld be consequently differentiated: geodetic and informational space.

The geodetic space which is determined by us by means of both length and surface dimensions, is of no value in itself, and it is not an element of the system, contrary to spatial relations between particular objects or properties. These reactions, being the reflection of the variety of styles of filling up space determine the way of the functioning of the structure realizing it in a direct way. The underestimation of the role of space often provokes its degradation and the occurrence of collision between the functions of the system despite the fact that systems do not apparently degrade themselves. It can be assumed that this results from overcoming the thresholds of receptive possibilities. In fact every spatial structure has a definite receptive surface, which is different for different forms filling it. The receptive ability is not a constant feature; it will be different for instance, for housing, for industry, the transport network etc. The receptive surface is not equal to the geodetic one (with the exception of primary geosystem), being usually bigger than the second one.

Contrary to geodetic space — the informational space, which is determined by the structure of the network, efficiency of operation or, sometimes, by the flow of information, is of a completely different character, fulfilling a different role in the system, being its integral part. It is on it that the whole system depends in its existence as well as on its efficiency. That is why special attention should be drawn to it in environmental research. In fact no dependences exist between the geodetic and informational spaces. They concern other complementary aspects of the same reality. Geodetic space can be considered as an attribute of the structure of system, the informational space being the attribute of its function. Both these spatial forms govern themselves according to their own respective laws being subject to other conditions.

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The theory of systems is a relatively young idea. It has emerged by the way, not as a whole, closed entity, being rather a refection on the theory than a theory itself, a loose conception enabling the conceiving of the dispersed phenomena as entire categories.

In a gradual though surprisingly speedy way, the separate elements of this conception have been integrated into a whole that, till now, is by no means a closed one. The introduction of system thinking into the existing scientific disciplines requires both fitting of theory to the study object, to the set of notions and technics that have been applied so far, as well as the finding of a receptive intellectual ground. That is why theoretical studies introducing theory principles for geographical purposes are so important. Unfortunately the amount of such studies is rater small. This fact is somewhat incomprehensible as geography since the very beginning of its history, has been dealing with systems. It seems that this attitude concerning ideas of integration has been decided by the period of intensive specialization and disintegration of geography. In addition to the indubitable advantages, of which we should be aware, this period has provoked an atrophy of geographical thinking and, in many cases, even an incomprehensible complex of inferiority in relation to other more analytical sciences. Ironically, these complexes have been intensified just at the moment when the problem "man and his environment" has become one of the paramount scientific concerns in the world and when the leading role in the research linked to it should be played by geographers, who do not limit themselves to one narrow sphere of problems. It would be unjust to blame exclusively super specialization for the geographers' small share in environmental research. The attempts of summing-up rather than integrating the individual components of the environment are also responsible for this situation. Such studies stem out of the opinion that the more detailed and precise the analytical data, the easier the achievement of the synthesis through a simple addition of elements examined. In other words, according to this point of view "the whole is the sum of its parts", the valour of synthesis that, *ipso facto*, depends exclusively on the rate of precision of detailed data. However, this is an opinion which finds no confirmation in practice, because of the existence of a certain sort of exclusion between the analytical and the global approach to the phenomena that has already been proved many times. Attention has been drawn to this fact by L. v. Bertalanffy who wrote that we can select either the separate features subjecting them to an analysis, in which case the whole would escape our attention, or formulate global laws which makes in necessary to resign from any analytical description. The awareness concerning the essential differences between the analytical and the global approach to the problems of geographical environment would create the premises for development of both research, approaches, which would be complementary rather than competing. This is the condition *sine qua non* which concerns the geographers' role in the attempts aimed at finding a solution for the "man-environment" problems.

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CHANGES IN THE PROCESSES OF INDUSTRIALIZATION AND URBANIZATION

KAZIMIERZ DZIEWOŃSKI

(1) The fact that geography as a science has passed in its development from the descriptive into the explanatory and is passing now into the next, predictive phase is well established and well known. The correct form of the predictive, scientific statements is "if ... then ...", i.e., if certain conditions are fulfilled then certain phenomena will follow. Predictions in geography rarely take this form; specifically it is only rarely that the full statement of the initial assumptions or conditions is explicitly made. In addition, in spite of the existence of multiple, not fully identified conditions and causes, the predictive formulation usually does not include the word "probably".

The easiest and — I think — the most dangerous way of prediction is by and from a simple extrapolation of the past and present conditions and trends. The easiest, because it hardly involves any critical analysis, the most dangerous because in all probability the conditions will change. However there is almost no alternative in the construction of a prediction which would not involve in one way or another some extrapolation from our present knowledge. In such a situation the correct procedure is to make such extrapolations the complex ones, i.e., by the critical estimation of the existing conditions, their interrelations (mutual interactions) as well as of their evolution and probable changes (naturally with their implications for the future course of events). New phenomena, foreseen or expected have to be additionally taken into account.

In making predictions as to the course which processes of industrialization and urbanization shall take in the future we have to follow this path. It is not sufficient to extend present trends, it is necessary to analyze their stability, the changes which are already taking place and the new situations and phenomena which may be expected to take place in the future.

The process of industrialization has recently been described (Szczepański 1974) as the growth of technical civilization. On the other side, urbanization has been identified by sociologists (Wirth 1938, Rybicki 1972) as the spread of the urban way of life. In this paper I shall adopt these definitions, although they differ from those generally used. They are very wide but in this lies their value. In fact they define the processes in which we are interested well enough in all phases through which they were and are passing. Various nations or societies undergo these processes in different ways and forms, depending on the geographical environment (which forms the framework and the basis of their existence, functions and economics) as well as on the historical vicissitudes (whether economic and social, cultural and political, or technical and scientific) through which they passed.

With the acceptance of the basic view that these processes do change in time with various stages through which nations develop, we have to agree that the various phenomena by which we measure progress in industrialization and urbanization will have to differ too, depending on the stage or phase in their evolution.

As the definitions of these processes differ it is easy to infer that they are not identical although they may be and in fact they are closely connected and interdependent. In describing and forecasting the course which both industrialization and urbanization in Poland have taken recently, are taking at present and may take in the future, we shall discuss each of these seperately and then we shall try to define their interrelations.

(2) In the course of the first seventy-five years of the 20th century but mostly in the last thirty years Poland has followed the road from an agricultural still partly feudal but largely capitalistic society to an industrial, socialist nation and state (Table 1). The highest industrial production during the first of those diametrically different periods and stages of development was reached in 1913, i.e., just before the beginning of the First World War. The inter-war years (although without the change of the socio-economic structure and relations) brought the recovery of national independence and the reconstitution of the Polish state. However, as a result of war destruction and of the great world economic crisis which followed, the former level of industrial production had again been reached just immediately before the Second World War began. Poland therefore still remained essentially an agricultural country with about 40% of the total population living from non-agricultural occupations and about 12% of all the gain-fully employed, employed in industry. In addition, the location of the highly concentrated industries was very impropitious, being extremely eccentric with the main, almost the only strongly industrialized

TABLE 1. Growth of the urban population and processes of urbanization in the 19th and the 20th centuries within the present territory of Poland*

Years	Total population		Urban population		Population in cities of over 100 thous. inhab.		Non agricultural population		Living from work in industry	
	million	%	million	%	million	%	million	%	million	%
1810	9.0	100.0	2.0	22.2	—	—	.	.	.	.
1850	14.0	100.0	3.1	22.2	0.3	2.0	.	.	.	.
1868/1871	17.5	100.0	4.1	23.2	0.5	2.8	.	.	.	.
1897/1900	23.7	100.0	6.3	26.6	1.8	7.6	.	.	.	.
1921/1925	26.6	100.0	8.7	32.8	2.9	10.8	.	.	.	.
1931/1933	29.8	100.0	10.6	35.5	4.3	14.4	.	.	.	.
1939/1940	32.5	100.0	12.0	36.9	4.9	15.1	.	.	.	.
1946	23.9	100.0	7.5	31.8	2.4	10.0	.	.	.	.
1950	25.0	100.0	9.6	39.0	4.0	16.0	13.0	52.9	5.1	20.9
1955	27.6	100.0	12.1	43.8	5.1	18.5	.	.	.	.
1960	29.7	100.0	14.2	48.3	6.1	20.6	18.1	61.6	7.3	25.0
1965	31.6	100.0	15.7	49.7	6.8	21.6	.	.	.	.
1970	32.6	100.0	17.0	52.3	7.4	22.6	23.0	70.5	8.9	27.3
1971	32.9	100.0	17.3	52.7	7.5	22.8	23.3	71.1	.	.
1972	32.2	100.0	17.7	53.4	7.7	23.1	23.9	71.9	.	.
1973	33.5	100.0	18.1	54.2	7.9	23.7	24.4	72.8	.	.
1974	33.8	100.0	18.5	54.6	8.1	24.0	24.5	72.9	.	.

* Estimated by the author on the basis of various statistical data.

region (Upper Silesia) situated on the south-western frontier and split into two separate parts, Polish and German. Although in the late thirties some efforts to obtain a less disbalanced location through the creation of a centrally sited industrial district were made, the effect in the few remaining years before the beginning of the Second World War was not, at least on a national level, of great importance. Till the end, very large tracts of the central part of the country and the whole of the eastern part were outside the direct or even indirect reach of industrialization both in industrial employment and in the spread of technical civilization. The distance friction played an important or even the decisive role in the complete standstill of industrialization there.

The post-war social and economic revolution together with the shift in the national territory changed the situation radically and quick increase in the rate of industrialization followed immediately. In spite of war damage the locational situation was from the beginning more propitious. The unified and integrated mining and industrial district of Upper Silesia was now in an almost central position. The technical infrastructure was more evenly distributed although the denser transport network and better developed communal services in the former Prussian (German) part of Poland made and, even now thirty years later, makes an evident difference in the regional development. However, the destruction of dispersed industrial plants was — generally speaking — greater than of the industrial centres with one, very big, exception that of the Warsaw agglomeration. This phenomenon together with some centralization of small industrial plants after their nationalization brought in at least temporarily a very heavy concentration of industrial production. In 1946 the industries of Upper Silesia accounted for 32.1% of total industrial employment, for 54.6% of energy consumption, for 31.1% of the processed mineral resources when measured by weight and for 15.7% of the same resources when measured in money value. The index of the industrial concentration of Poland measured on the basis of the Lorenc curve of concentration by voivodships amounted then to 0.458 (it was in 1970 at the level of 0.300). Effort went on the reconstruction of those damaged or destroyed plants which promised the quickest resumption of production. However, by the end of 1949 the possibilities of quick reconstruction were practically exhausted and the time had come for the realization of very ambitious plans for rapid industrialization. The six-year plan containing this programme was extended later by several consecutive five-year plans and today twenty-five years later the progress achieved is very large indeed. The industrial employment has grown (on the basis of the statistical data for 1974 in relation to 1950) by 341% and industrial production, ten times. Poland has passed from an agricultural economy first into an agricultural and industrial, then into an industrial and agricultural and now is entering a fully industrial phase of development. The industrial part in the national income has risen from 31.8% to 51.3% and the agricultural part (in spite of the fact that it is now over twice as big as it was in 1950) has fallen from 47.9% to 11.8%.

Originally the plan of industrialization provided for a more even regional and local distribution of industrial plants. This aim was modified several times and only partly implemented. There were several reasons. First from the beginning the priorities given to the heavy industries (specifically machine industries producing the tools of production) increased locational advantages of the largest industrial and urban agglomerations with their reserves of qualified labour. Secondly with increasing deficiencies and indeed lack of technical infrastructure the advantages of common location became very evident, bringing in tendencies toward some concentration, at least on a regional level. Finally, the progress achieved in industrial production has increased the demand for raw materials, in particular for minerals. This, together with a growing consumption of building materials for ever growing productive and non-productive investments, has created inavoidably the increased exploitation of the existing and prospective seams and deposits. The location of mines and quarries, determined by geological formation, is predominantly in the southern region of the country. From this point of view only the great seaports of the Baltic coast, which represent the location of the import of raw materials, could compete with the southern regions (and this only recently) so far as location advantages were concerned.

The net result was that although the industrial concentration — as already mentioned — has diminished, this was obtained more by the extension of the existing industrialized areas than by the even distribution of new industrial development. However, several new industrial centres in the northern and eastern regions (which may be compared to or even designated as the regional growth poles) were created, especially along the lower Vistula or in connection with the main regional capitals, the seats or regional administrations.

At present the impact of industrial plants, centres and districts on the human and natural environment is beginning to play an ever growing role in locational policies and decisions. In the first years of forced industrialization only scant attention was paid to environmental questions. One of the main reasons was that without any greater experience with larger industrial plants and with large-scale production, practically nobody was able to foresee their full environmental consequences. By now it is generally recognized that on one side it is difficult to develop properly environmental preservation measures in conditions of the complete dispersal of industries but on the other side, too large a concentration creates specific pollution problems by breaking the barriers of the natural capacity to absorb (or to dilute) which could lead to catastrophic consequences. As a result the formula at present generally accepted is a moderate concentration of industry with specific large tracts of land exempted completely or partly from industrial development in the form of national (complete exemption) or landscape (partial exempted) parks.

But with large industrial production dominating the whole national economy the problem of industrialization changes its character. The spread of technical civilization does not depend solely on the increase in industrial employment and production but more and more on the assimilation of that civilization by the whole population. In such a situation the problem of distance, the distance friction so far as the location of industrial plants is concerned, loses its importance in the industrialization of the country. At the same time technical education and culture come to the fore as decisive factors. They become the real criteria of further progress. In addition the few data available which may serve as measures of their spread present quite different patterns from these characteristic to the present distribution of industrial enterprises.

Obviously there is a marked difference between numbers of people technically educated, to whom the technical achievements are easily accessible, in the urban and rural areas. However, those differences are diminishing with the diffusion of urban ways of life throughout the countryside. But there exists also a very strong regional differentiation, one perhaps stronger than the contrast between urban and rural areas. It reflects past situations and historical traditions in education as well as in the development and the state of the technical (economic) infrastructure. The dividing, curved line runs more or less from the Tatra Mountains in the South to the north-eastern tip of the state. To the east of that line there is the large island of the Warsaw agglomeration, nearer in its characteristics to the western, larger part, more advanced in

TABLE 2. Changes in the number of towns and cities by size classes from the middle of the 19th century till 1973 within the present territory of Poland

Number of inhabitants	Number of towns and cities										
	half of 19th century	1867/1871	1897/1900	1910	1921/1925	1931/1933	1950	1960	1965	1970	1973
under 1000	238	156	96	70	19	13	15	5	5	43	1
1001– 2,000	368	321	277	217	124	99	115	93	82	68	60
2001– 5,000	369	446	431	441	298	283	263	315	289	287	247
5001– 10,000	80	125	178	225	185	201	159	238	247	220	199
under 10,000	1055	1048	982	953	626	596	552	651	623	579	507
over 10,000	23	55	124	165	167	193	144	242	268	310	329
10,001– 20,000	15	39	75	98	100	106	76	135	145	162	169
20,001– 50,000	5	11	34	48	48	59	50	65	76	97	107
50,001– 100,000	1	3	9	12	12	14	12	20	25	27	29
under 100,000	1076	1101	1100	1111	786	775	690	811	869	865	812
over 100,000	2	2	6	7	7	14	16	22	22	24	24
100,001– 200,000	2	×	2	3	3	7	10	13	13	14	13
200,001– 500,000	×	2	3	2	2	4	4	7	6	6	7
500,001–1,000,000	×	×	1	2	2	2	2	1	2	3	3
under 1,000,000	1078	1103	1106	1118	793	788	706	892	890	888	835
over 1,000,000	×	×	×	×	×	1	×	1	1	1	1
Total	1078	1103	1106	1118	793	789	706	893	891	889	936

Sources: A. Jelonek, *Ludność miast i osiedli typu miejskiego na ziemiach Polski od 1810 do 1960 r.* (Populations of towns and urban settlements on Polish territory, 1810–1960), *Dok. Geogr.* 1967, 3/4. Central Statistical Office, Statistical Yearbooks 1964, 1971, 1974.

industrialization than the eastern areas. The elimination of these differences depends more on the creation of a denser network of technical and communal infrastructure as well as on easier access for all inhabitants to technical education and knowledge than on the construction of new large industrial plants.

(3) The new wave of urbanization which began in Western Europe in the 17th century and was strongly established by the 18th century reached Eastern Europe during the 19th century. In Poland the new urban growth (Table 2) was superimposed on the feudal urban network formed mainly in the Middle Ages. This network was very dense, being composed of a large number of small towns only slightly differentiated in size. Only the national capital and some provincial cities possessed a larger number of inhabitants. The average density reached about 35 towns per 10 thousand of sq.km raising in the more economically developed (on the basis of the mining and the artisan industrial production) regions to 50 or even 60 towns and falling in the largely afforested lakelands to 15 or even 10 towns per 10 thousand sq.km. The growth in the 19th century of new urban population took place either by the increase of inhabitants in the existing towns, mainly in the largest cities or by the growth of new industrial villages and other settlements. In the later stages of the evolution out of and around the existing larger cities grew the monocentric urban agglomerations (usually called metropolitan districts or areas), while from the denser, industrial settlements arose the polycentric agglomerations (industrial conurbations). The process of the growth of the industrial settlement has involved also another phenomenon — that of the thinning out of the dense network of very small market places and towns. The extent of this may be easily understood when we observe that after the Socond World War the density of towns and cities outside the areas of the urban agglomerations had fallen to about 20 per 10 thousand sq.km. In addition, all these changes were taking place in three different evolutionary chains, depending on the road followed by each of the three occupying powers in the development of a capitalistic economy and society. In Prussia (Germany) this was based on the close alliance between the large feudal land-owners and the industrial capital. In consequence the changes although very intensive, were evolutionary, tending to preserve the historical patterns of settlement. In Austria the feudal system survived by compromise with some of the numerous national communities (Hungarians and Poles, but not the Czechs, Slovaks, Slovenes or Croats) and the urbanization was based mainly on the civil (state and local bureaucracy) and cultural services, highly concentrated in the provincial or regional capitals. The urbanization processes were also partly expressed by the emigration overseas. In Tsarist Russia the same processes were slowed down even more. Migration abroad was much higher as it was almost two times larger than the influx into the towns and cities. The urban growth was seriously hampered by an almost total lack of communal infrastructure and the strong underdevelopment of almost all material and cultural services. The only positive factor in the growth of urban centres were privately developed industrial enterprises, producing goods for essentially distant, eastern markets.

The net result may be seen in the great regional differences and disparities persisting in spite of the changed conditions throughout the present century up to our times (Table 3).

The consequences of the First World War together with the restitution of national independence and the Polish state brought in new incentives to the urban growth by the establishment of the Polish civil service and of the national system of education. At the same time — there arose an additional necessity on a national and regional level for the readjustment of urban central

TABLE 3. Changes in the number of towns and cities by voivodships from the middle of the 19th century till 1973 within the present territory of Poland

Voivodships	Number of towns and cities									
	half of 19th century	1867 1871	1897 1900	1910	1921 1925	1931 1933	1950	1960	1970	1973
Białystok	58	58	60	61	40	40	33	34	36	35
Bydgoszcz	50	50	51	53	47	47	56	58	56	56
Gdańsk	18	18	20	22	22	24	24	31.	32	29
Katowice	36	60	67	69	52	43	45	94	91	75
Kielce	92	92	95	97	27	27	27	37	37	36
Koszalin	34	34	34	34	34	34	33	35	35	34
Cracow with the City of Cracow	67	67	60	60	50	51	42	56	52	51
Lublin	80	80	83	84	27	27	24	32	32	32
Łódź with the City of Łódź	58	58	59	59	32	32	36	40	40	38
Olsztyn	50	50	50	50	48	48	34	39	39	39
Opole	28	28	28	28	28	28	28	38	36	36
Poznań with the City of Poznań	157	157	143	143	126	127	97	102	102	100
Rzeszów	85	85	82	83	40	40	39	46	46	44
Szczecin	39	39	39	39	40	40	38	41	40	36
Warsaw with the City od Warsaw	93	93	103	103	50	51	50	70	70	69
Wroclaw with the City of Wroclaw	89	89	89	89	88	88	65	98	99	85
Zielona Góra	45	45	43	43	42	42	35	42	42	41
Poland	1078	1103	1106	1118	793	789	706	893	889	836

Sources: Table 2.

functions. This was due to the creation of an integrated hierarchical structure of the central and the territorial administration.

But the real upsurge in the urbanization processes came only after the Second World War (Table 4, Figs. 1 and 2). It is rather paradoxical, as the losses in the urban population were much greater than in the rural one. Perhaps the necessity to fill up the decimated ranks of urban inhabitants in the central and eastern parts of the country together with the depopulated cities and towns in the northern and western parts released pent up trends of migration which by sheer inertia continued although the original causes had ceased to function. In addition it is necessary to remember that in the inter-war period emigration abroad (because of the restrictions placed on the number of immigrants allowed to enter the receiving countries) was cut down to an insignificant size and the intensity of the urbanization processes was insufficient to consume the growing surplus of the rural population. This resulted in the overpopulation of the rural areas and the so-called "hidden" unemployment in agriculture reached a very high level (it was estimated by 1939 by various sources as between 4.5 and 8 million people).

TABLE 4. The urban population: rates of growth (within the present territory of Poland)

	Inter-war years					Post-war period				
	1921		1939	1946		1950		1970		1973
		1921–1939			1946–1950		1951–1970		1971–1975	
Total population in millions	26.6		32.5	23.9		25.0		32.7		34.2
Index of growth		1.221			1.046		1.304		1.146	
Average annual index of growth		1.011			1.009		1.013		1.009	
Urban population — in millions	8.7		12.0	7.5		9.8		17.1		18.9
Index of growth		1.379			1.307		1.742		1.104	
Average annual index of growth		1.018			1.064		1.038		1.020	
Population in millions of cities with over 100,000	2.9		4.9	2.4		4.0		7.4		8.2
Index of growth		1.689			1.666		1.850		1.115	
Average annual index of growth		1.030			1.136		1.031		1.022	

Sources: K. Dziewoński and L. Kosiński, *Rozwój i rozmieszczenie Ludności Polski w XX wieku*; *Ludność Polski Ludowej* (The growth and distribution of population in Poland during the 20th century. Population of the Peoples Poland), vol. 1, Warszawa 1967. Główny Urząd Statystyczny, *Rocznik Statystyczny 1974*, Warszawa 1974 Authors'. estimates.

The Second World War brought in a radical change in the numbers and structure of the urban population. The final result was a sum of heavy population losses and material destruction, the annihilation of the Jewish population (very numerous among urban inhabitants of the eastern and central regions) and finally the post-war resettlement of the German and Polish populations in connection with the change of the state territory. The size of the urban population (within the present territory) has diminished from the estimated 12.0 million in 1939 to 7.5 million in 1946, and 9.6 million in 1950 or from 36.9% of the total population to 31.8% in 1946. But by 1950 this index was higher than at

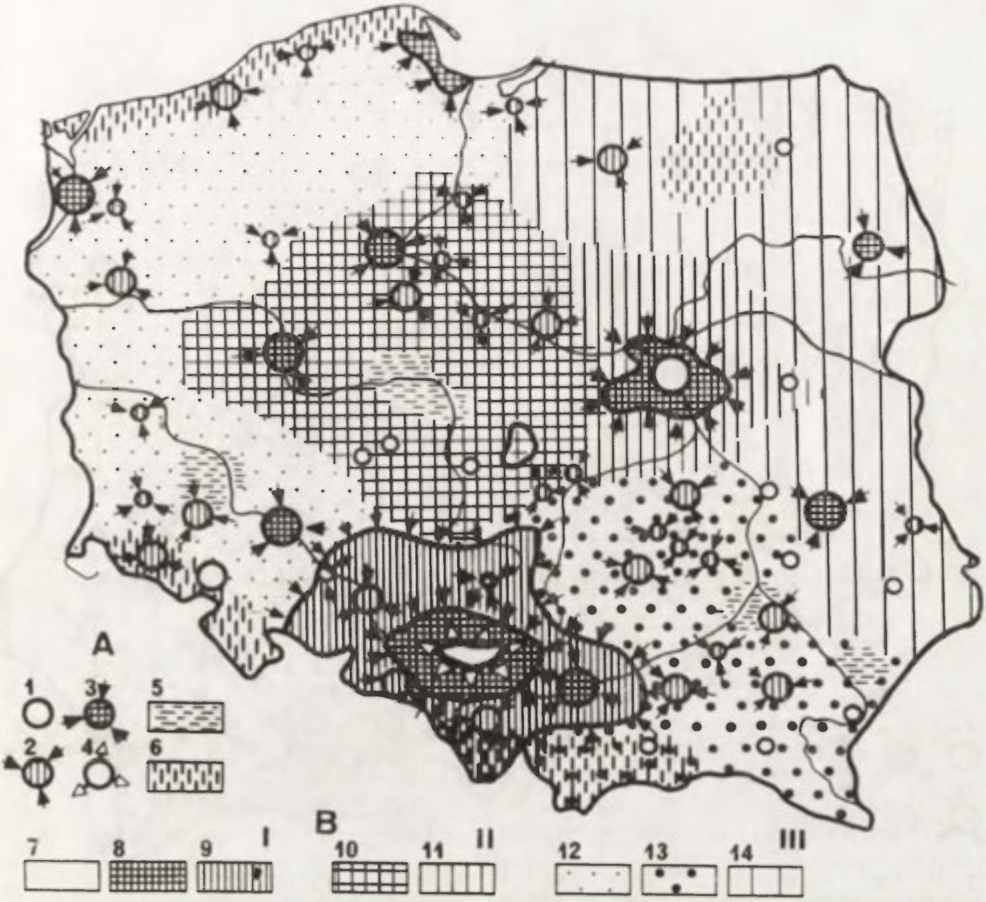

Fig. 1. Processes of urbanization in Poland in the years 1950–1970

A. Main urban centres and areas: 1 — limited growth, 2 — strong growth, 3 — very strong growth, 4 — signs of decentralization, 5 — new mining areas, 6 — areas of mass tourism; *B. Zones of urban growth*: I. Areas strongly urbanized: 7 — conurbations, metropolitan areas, 8 — areas of direct deglomeration, 9 — areas of indirect deglomeration, II. Areas of decreasing growth of urbanization: 10 — areas of balanced structure, 11 — areas of deformed structure, III. Areas of strong urbanization: 12 — areas of balanced structure, 13 — areas of growth of middle-sized towns, 14 — areas of concentration in the largest cities

any time before (39.0%) and by 1955 the urban population increased to 12.1 million. Such a quick recovery indicates the strength of the whole trend toward urbanization in the post-war period. The persistent growth brought the total number of the urban population by 1974 to 18.5 million and the corresponding index to 54.6%. To compare the post-war period with one of the inter-war years it is sufficient to state that between 1921 and 1939 the urban population had grown by 37% and between 1950 and 1974 by over 100% (between 1946, a year of stil unstable conditions and 1974 even by 147%) i.e., in the first case the average mean annual rate of growth amounted to 1.018 and in the second to 1.027. However, in reality the growth of the urban population was not even, the indices were not constant (Table 5).

If we omit the first years, immediately after the war with their large but irregular waves of re-emigration and resettlement, the first decade (1951–1960)

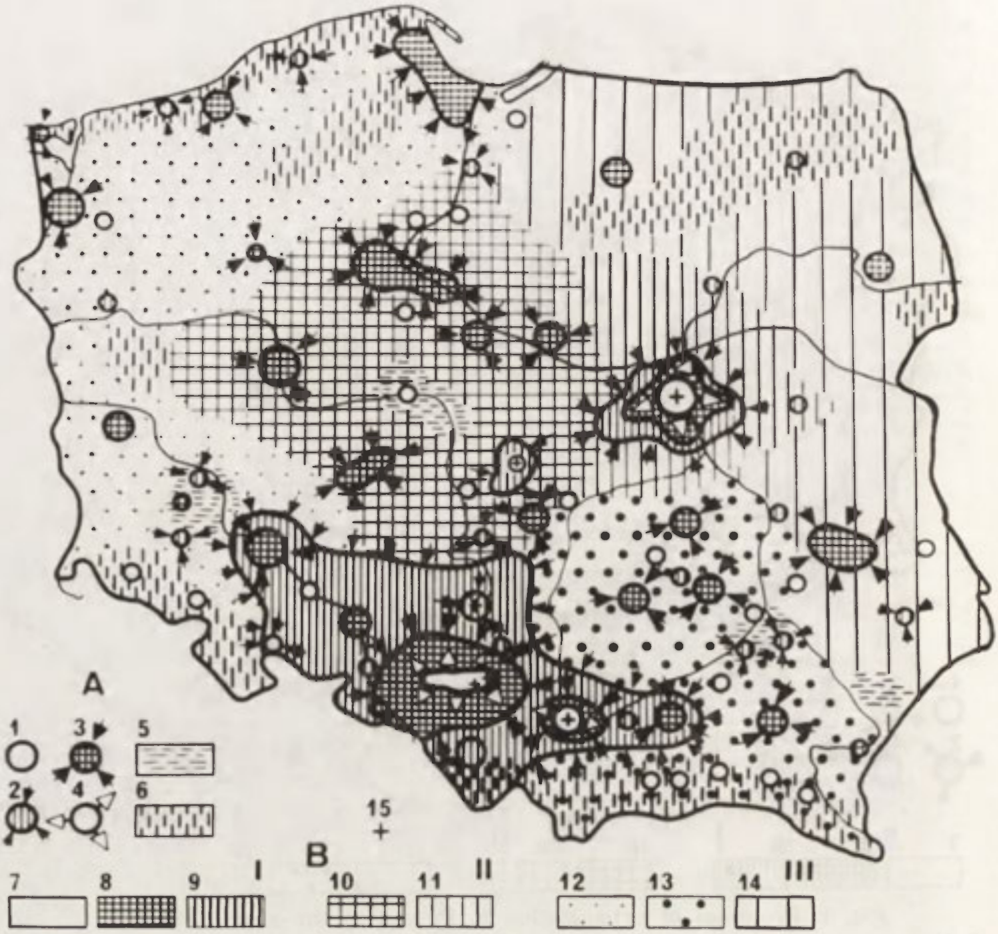

Fig. 2. Processes of urbanization in Poland in the years 1970–1980

A. Main urban centres and areas: 1 — limited growth, 2 — strong growth, 3 — very strong growth, 4 — signs of decentralization, 5 — new mining areas, 6 — areas of mass tourism; *B. Zones of urban growth:* I. Areas strongly urbanized: 7 — conurbations, metropolitan areas, 8 — areas of direct deglomeration, 9 — areas of indirect deglomeration, II. Areas of decreasing growth of urbanization: 10 — areas of balanced structure, 11 — areas of deformed structure, III. Areas of strong urbanization: 12 — areas of balanced structure, 13 — areas of growth of middle-sized towns, 14 — areas of concentration in the larges cities, 15 — reconstruction of the central districts

witnessed a very steep rise of 48% (average annual indices of growth for the years 1951–1955: 1.042 and for the years 1956–1960: 1.036) and a much slower growth (by 20% and the average annual index of 1.017) in the following decade (1961–1970). After 1970 a new rise in the growth of the urban population becomes evident (average annual index at 1.020).

The best way of representing the regional differences in the progress of urbanization is by the variances from the national average (Figs. 3 and 4). To understand them fully they should be related on the one hand to the increase of the total population within each region and on the other to the initial size of the urban population there.

TABLE 5. Indices of growth of total and urban population

Voivodships	Total population							Urban population						
	1950–1955	1956–1960	1961–1965	1966–1970	1971–1975	1951–1975 total	1951–1975 annual average	1951–1955	1956–1960	1961–1965	1966–1970	1971–1975	1951–1975 total	1951–1975 annual average
Białystok	1.072	1.059	1.054	1.014	1.024	1.241	1.009	1.237	1.229	1.144	1.150	1.132	2.265	1.033
Bydgoszcz	1.083	1.087	1.058	1.042	1.046	1.360	1.012	1.161	1.180	1.070	1.078	1.101	1.708	1.022
Gdańsk	1.140	1.153	1.084	1.086	1.078	1.668	1.021	1.245	1.203	1.106	1.122	1.116	2.075	1.041
Katowice	1.114	1.090	1.063	1.050	1.068	1.449	1.015	1.808	1.162	1.074	1.060	1.095	1.786	1.023
Kielce	1.075	1.039	1.037	0.995	1.016	1.157	1.006	1.355	1.216	1.102	1.116	1.136	2.303	1.029
Koszalin	1.197	1.106	1.080	1.054	1.062	1.600	1.019	1.406	1.237	1.125	1.122	1.114	2.444	1.036
Cracow with the City of Cracow	1.078	1.058	1.061	1.047	1.049	1.327	1.011	1.288	1.222	1.086	1.105	1.144	2.163	1.031
Lublin	1.049	1.060	1.043	1.013	1.024	1.176	1.007	1.168	1.340	1.103	1.183	1.139	2.325	1.034
Łódź with the City of Łódź	1.051	1.055	1.033	1.010	1.020	1.180	1.007	1.097	1.091	1.066	1.045	1.054	1.404	1.014
Olsztyn	1.155	1.105	1.068	1.024	1.047	1.462	1.015	1.272	1.240	1.086	1.142	1.119	2.189	1.032
Opole	1.074	1.069	1.064	1.050	1.047	1.346	1.012	1.253	1.291	1.102	1.125	1.124	2.259	1.033
Poznań with the City of Poznań	1.080	1.066	1.059	1.046	1.023	1.303	1.011	1.162	1.150	1.084	1.099	1.049	1.671	1.021
Rzeszów	1.102	1.048	1.056	1.038	1.044	1.322	1.011	1.332	1.224	1.098	1.138	1.173	2.391	1.035
Szczecin	1.220	1.168	1.098	1.060	1.078	1.784	1.023	1.280	1.234	1.131	1.103	1.104	2.174	1.032
Warsaw with the City of Warsaw	1.122	1.081	1.056	1.035	1.046	1.386	1.012	1.267	1.199	1.083	1.078	1.095	1.943	1.027
Wrocław with the City of Wroclaw	1.363	1.142	1.075	1.025	1.046	1.915	1.026	1.240	1.235	1.101	1.063	1.083	1.943	1.027
Zielona Góra	1.185	1.170	1.068	1.045	1.062	1.643	1.020	1.349	1.336	1.126	1.116	1.110	2.514	1.038
Poland	1.101	1.081	1.059	1.035	1.046	1.364	1.012	1.230	1.193	1.089	1.090	1.104	1.924	1.027

For 1971–1975 estimates.
Calculated by the author on the basis of the official statistical data.

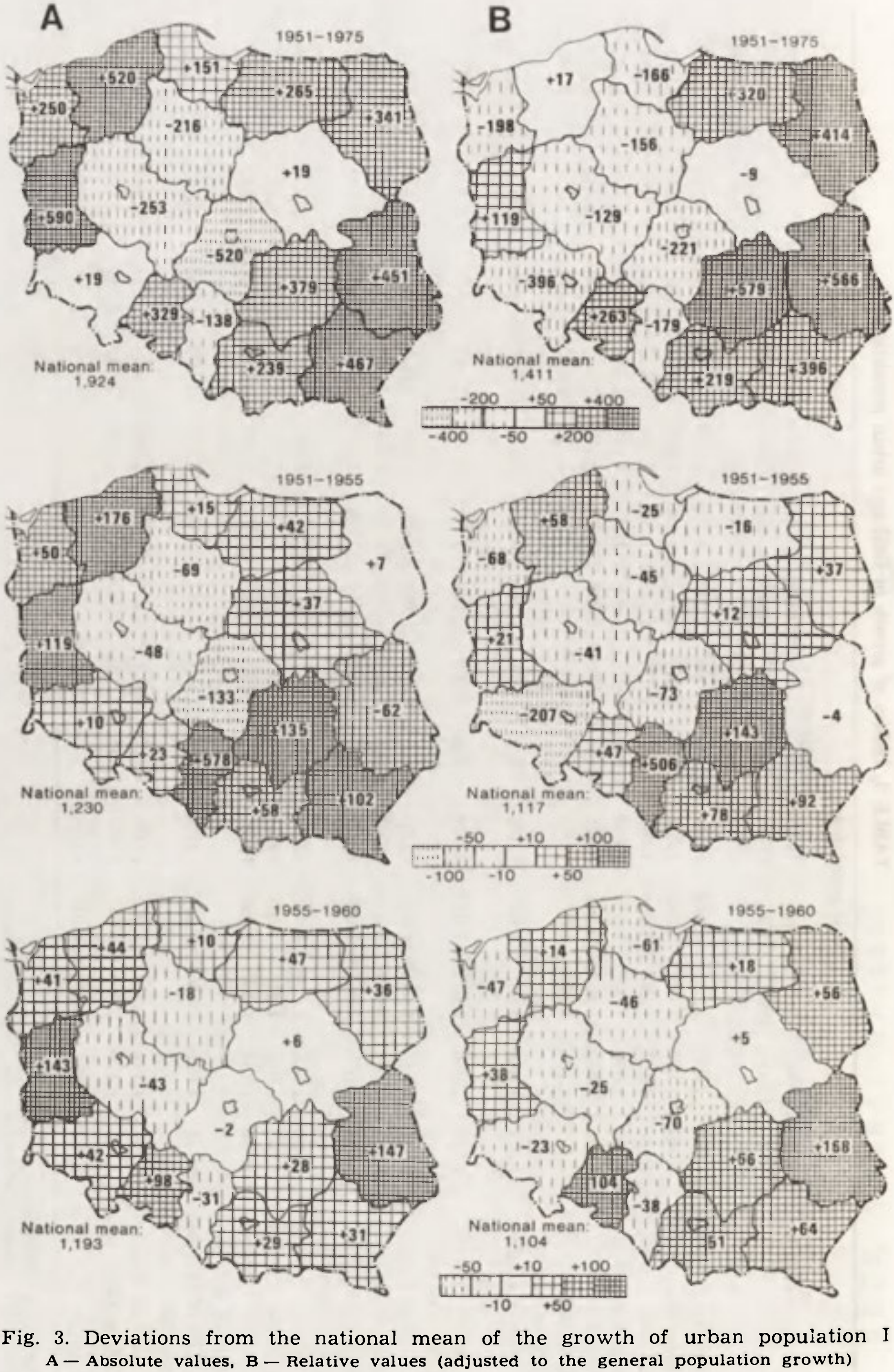

Fig. 3. Deviations from the national mean of the growth of urban population I
A — Absolute values, B — Relative values (adjusted to the general population growth)

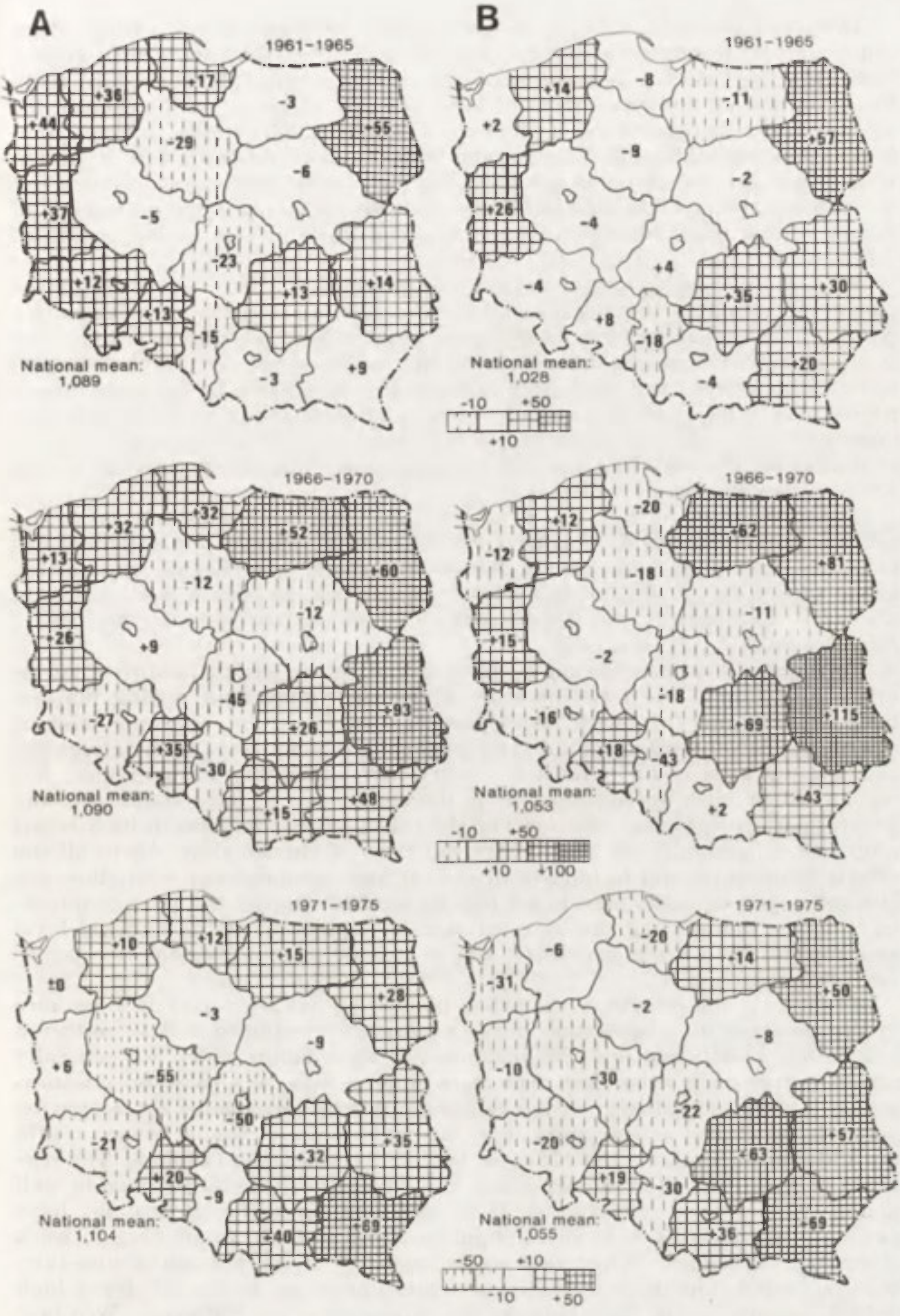

Fig. 4. Deviations from the national mean of the growth of urban population II
A — Absolute values, B — Relative values (adjusted to the general population growth)

Generally speaking three types of regions (voivodships) or rather, three zones may be identified in the last twenty-five years: the first with a growth well over the national average composed of the peripheral voivodships (with the exception of the voivodships of Wrocław and Katowice in the South); the second with a growth at the level corresponding to the national average comprising the voivodships of Warsaw and Wrocław and the third with a growth well below the national average, covering the central part of the country (i.e. the voivodships of Łódź, Bydgoszcz and Poznań). In addition the voivodship of Katowice had an intermediate index between those of the second and third zones.

With the disaggregation of data on the quinquennial basis the overall clear pattern turns out to be more complex. The general progress of urbanization parallel in regional patterns to the natural growth of population is disturbed in successive years by the inter-regional migrations caused first by the resettlement of the western and northern territories and afterwards by the large investments both in new industry and the modernization of industry. In the long run these variances and deviations become absorbed both by the general trends of evolution on the one side and by the immanent immobility (inertia) of the whole urban system on the other.

The differences in the rates of growth are very marked in relation to the patterns established and supported by the overall growth, but still they are too low to introduce more serious changes in the inter-regional structure of the urban settlement. It will probably take another half or even a full century to transform significantly the general pattern of the urban system inherited by Socialist Poland from the past.

To explain this phenomenon we have to look at the basic structure of rural-urban migrations. The large majority of all such migrations during the last twenty-five years (i.e., with short post-war period of re-emigration and of resettlement excluded) are of an intra-regional character and the inter-regional ones did not account for more than about 30.0% of all migrations (regions being identified with voivodships). It is therefore easy to understand why the general pattern (physical structure) of the urban system remains in its national proportions immobile and static, with the rates of change slow. Again all the efforts to urbanize and to industrialize or at least economically strengthen the less developed or under developed regions tend to support the present migratory trends, diminishing the concentration of population at the national level and limiting it to a regional level, where at least in some regions it becomes very strong indeed.

So far only the growth of the urban population has been used as a measure in the progress of urbanization but — as already mentioned — it is neither a unique nor a sufficient one. For instance two voivodships which are generally considered as more urbanized than many others, those of Opole and Rzeszów, occupy a very low position in the ranking order of voivodships considered by percentages of the urban population, the voivodship of Opole being in 1970 the 12th and of Rzeszów the 17th (the last) in the whole set (Table 6). The reason is easy to find. Both do not posses any large cities (the largest having well under 100 thousand inhabitants), both, although for different reasons, have unusually high densities of rural population and in both, commuting to work is strongly developed. When ranking is based on the percentage of non-agricultural population the voivodship of Opole moves up to the 5th (very high indeed because it is just behind the voivodships of Katowice, Wrocław, Gdańsk and Szczecin) but that of Rzeszów does not shift more than to the 15th position. Their position is farther improved when ranking is based on the em-

TABLE 6. Regional structure od urbanization on a comparative basis

Voivodships	Urban population									Non-agricultural population									Employment in Socialist industries					
	1950			1960			1970			1950			1960			1970			1960			1970		
	in thous.	%	rank	in thous.	%	rank	in thous.	%	rank	in thous.	%	rank	in thous.	%	rank	in thous.	%	rank	in thous.	%	rank	in thous.	%	rank
Białystok	219	22.4	14	333	30.2	14	438	37.2	15	260	27.2	16	409	37.5	16	558	47.3	16	41	4.0	17	68	6.6	17
Bydgoszcz	626	42.5	7	836	48.2	7	971	50.7	8	794	55.1	9	1042	61.0	10	1290	66.7	11	141	8.9	8	201	11.9	9
Gdańsk	550	58.0	2	824	66.4	2	1022	69.6	2	667	71.7	2	937	76.6	2	1192	80.8	2	112	10.0	6	173	13.6	6
Katowice	1741	63.2	1	2495	75.3	1	2941	76.8	1	2378	86.7	1	2947	90.0	1	3451	93.1	1	716	22.9	1	845	25.3	1
Kielce	304	18.3	15	501	27.3	15	616	32.6	14	515	31.6	14	779	49.9	14	1091	57.8	13	128	7.4	12	195	11.6	11
Koszalin	180	34.1	10	313	44.8	10	395	49.6	10	218	41.7	12	378	55.0	12	518	64.8	12	32	4.9	14	57	8.7	14
Cracow with the City of Cracow	663	31.0	11	1044	41.8	11	1254	45.2	11	1001	47.6	11	1490	60.3	11	1988	71.0	9	245	10.5	5	339	13.6	5
Lublin	292	17.2	16	457	25.1	16	596	31.0	16	387	24.1	17	598	33.2	17	872	45.5	17	70	4.3	16	117	7.1	16
Łódź with the City of Łódź	1020	48.5	5	1221	52.7	6	1359	55.9	6	1182	56.9	6	1467	63.4	8	1730	71.0	8	320	14.6	2	397	17.6	3
Olsztyn	206	29.3	12	325	36.3	13	403	41.1	13	290	41.7	13	443	50.2	13	563	57.3	14	38	4.5	15	60	7.6	15
Opole	225	27.3	13	364	38.4	12	451	42.6	12	475	58.5	5	603	64.9	5	785	73.9	5	108	12.2	4	148	15.7	4
Poznań with the City of Poznań	876	42.0	8	1171	47.2	9	1395	50.3	9	1161	55.3	8	1562	62.6	9	1844	69.0	10	192	8.6	9	278	12.9	8
Rzeszów	238	17.1	17	388	24.2	17	485	27.6	17	376	27.5	15	655	41.3	15	1003	57.0	15	95	6.3	13	176	11.3	13
Szczecin	304	55.9	3	480	62.2	3	599	66.6	4	312	59.3	4	512	67.6	4	668	74.2	4	55	8.0	11	89	11.7	10
Warsaw with the City of Warsaw	1247	43.0	6	1895	54.0	5	2213	57.7	5	1577	55.3	7	2206	63.9	7	2758	71.4	7	257	8.1	10	382	11.4	12
Wrocław with the City of Wrocław	906	49.6	4	1388	62.1	4	1625	64.9	3	1134	66.8	3	1655	74.0	3	2024	80.6	3	305	14.4	3	415	18.4	2
Zielona Góra	212	37.1	9	382	48.2	8	480	54.3	7	292	52.3	10	501	64.0	6	65	72.9	6	73	9.9	7	104	13.4	7
Poland	9811	36.9	—	14401	48.2	—	17088	52.3	—	13016	52.9	—	18125	61.6	—	22996	70.2	—	2949	10.4	—	4072	13.9	—

ployment in industry. Opole becomes the 4th and Rzeszów the 13th. It seems that the dispersed industrialization, typical for these two regions serves as a substitute for the urbanization in the form of larger cities.

Moreover, a completely different physical pattern is obtained when accessibility is taken into account (Table 7). Assuming as a rough measure (omitting the influence of the actual transport network and services) the regional density of all cities and towns (by voivodships) the three voivodships of Silesia take first place as the most urbanized and the two eastern voivodships of Lublin and Białystok as the least urbanized areas of the whole country.

TABLE 7. Average size of urban fields in 1975

Voivodships	Number of towns			Average size of urban field					
				all towns		over 20,000		over 100,000	
	total	over 20,000	over 100,000	sq.km	rank	sq.km	rank	sq.km	rank
Białystok	35	5	1	663	16	4641	16	23207	14
Bydgoszcz	56	6	2	372	8	3475	12	15425	8
Gdańsk	29	11	2	380	9	1003	2	5518	2
Katowice	75	33	9	127	1	289	1	1061	1
Kielce	36	5	2	542	15	3902	13	9755	5
Koszalin	34	5	(1)	532	13	3420	11	(18102)	11
Cracow with the City of Cracow	51	12	1	306	5	1292	4	15584	9
Lublin	32	6	1	777	17	4146	14	24878	15
Łódź with the City of Łódź	38	11	1	455	12	1573	5	17302	10
Olsztyn	39	3	(1)	537	14	6982	17	(20954)	13
Opole	36	6	1	265	3	1592	6	(9554)	3
Poznań with the City of Poznań	100	8	1	271	4	3389	10	27111	16
Rzeszów	44	10	(1)	424	10	1863	7	(18637)	12
Szczecin	36	3	1	354	6	4251	15	12754	6
Warsaw with the City of Warsaw	69	16	1	434	11	1871	8	29933	17
Wrocław with the City of Wrocław	85	17	2	225	2	1126	3	9574	4
Zielona Góra	41	6	(1)	356	7	2429	9	(14576)	7
Poland	836	163	25 (29)	374	—	1918	—	12507 (10782)	—

Data in brackets pertain to the main urban centres (capitals) of voivodships with population below 100,000 inhabitants. Computed by the Author from various sources.

Accessibility to the largest cities (urban agglomerations) representing the full set and the best organization of services cannot be measured on the basis of the average regional densities, it has to be considered on the basis of the cartographic presentation (Fig. 5). Roughly speaking towns and rural areas of ten voivodships are within an easy reach of the already developed urban agglomerations. It seems significant that in the remaining areas, those voivodships which in near perspective are within the reach of quickly growing new agglomerations are characterized at present by the distinct and specific underdevelopment of regional urban systems. Evidently the lack of proper urban services at the lower level favours the urbanization in the form of heavy concentration at the highest levels.

(4) Let us turn now to the comparison of patterns of industrialization and of urbanization. We shall try to analyze the extent of their spatial correspondence — their similarities and differences — and to identify causes.

As the starting point for this discussion we shall take the relation between the urban population and the industrial employment by voivodships. The picture obtained in this way seems to be very clear. In the southern regions the

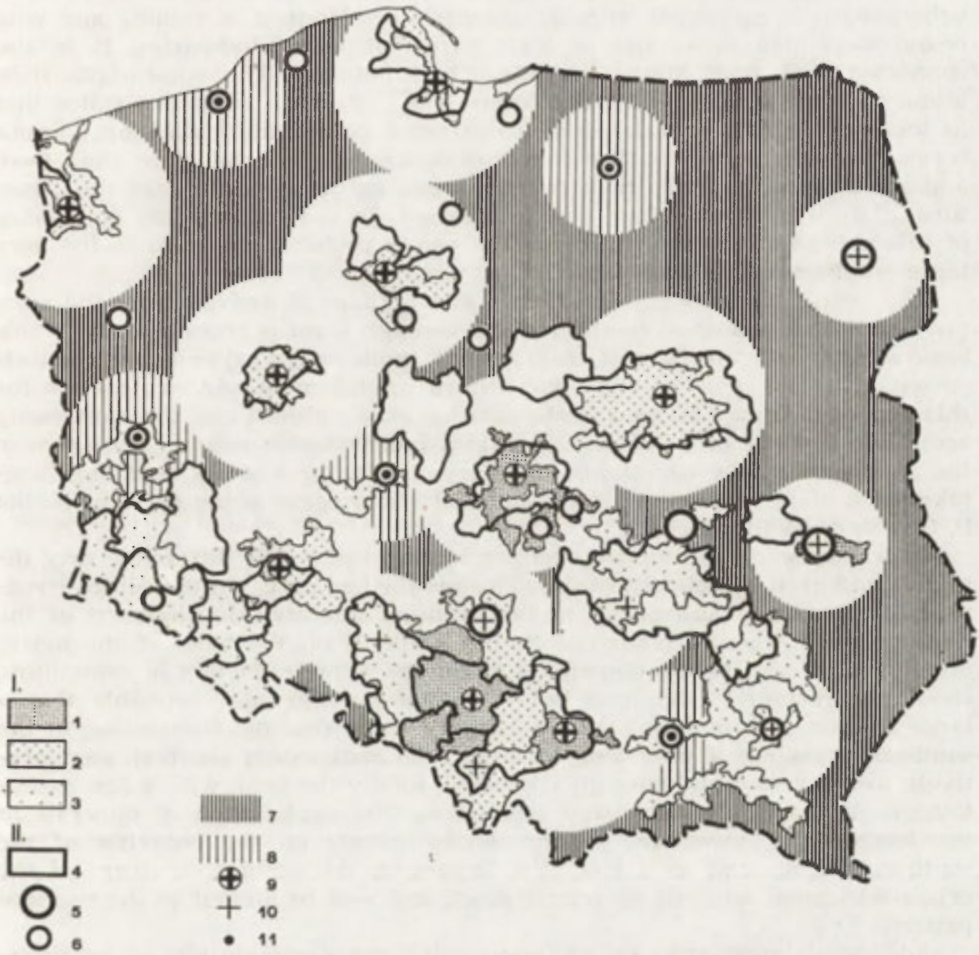

Fig. 5. Urban agglomerations, industrial districts and the spread of technical civilization

I. Industrial districts after S. Misztal: 1 — with over 1000 employed in industry per 10 sq.km, 2 — with between 500 and 1000 employed in industry per 10 sq.km, 3 — with between 200 and 500 employed in industry per 10 sq.km; *II. Industrial districts and centres after the Central Statistical Office*: 4 — industrial districts, 5 — larger industrial centres, 6 — smaller industrial centres, 7 — areas outside spheres of influence of any urban agglomerations, 8 — areas within spheres of influence of potential urban agglomerations, 9 — centres of developed urban agglomerations, 10 — centres of developing urban agglomerations, 11 — centres of potential urban agglomerations industrialization is more advanced than the urbanization; the central belt is an intermediary zone, where these two phenomena are parallel in their intensity (near to the national average); and in the North the urbanization is clearly stronger than the industrialization. This zonal pattern of latitudinal belts is rather unusual because in the economic and social phenomena all regional differences have usually a different structure, most often with quasi-longitudinal belts. This last pattern was often treated as a sign of the transitory character of Poland, a country between "East and West".

In a more detailed analysis (by *poviats*) the latitudinal pattern although less integrated, being more fragmentated and intertwined is still observable.

The interpretation is fairly easy: the dominance of industrialization over urbanization is connected with the stronger development of mining and with resource-oriented areas and at least partly dispersed industries. It is also connected with mass commuting to work in industry. The same explanation although formulated in different terms, those of urban functions states that in the areas with a prevalence of urbanization over industrialization, various service and other central urban functions dominate over productive (industrial) and/or other specialized urban functions and in the opposite case the structure of the same urban functions is reversed. In the seaports the dominance of urban population over the industrial one is probably due also to the very large employment in transport.

The latitudinal pattern conforms to and perhaps is derived from the morphological and geological conditions and through them is related to the whole basic structure of the natural environment, while other patterns are connected with — to use a new term — the historic environment. An explanation for this dependence may be seen in the location of the richest and the most easily accessible deposits of valuable and indeed indispensable mineral resources in the piedmonts of the mountains (the Carpathians, the Sudetes, and the Świętokrzyskie Mts.) where the older geological strata come to the surface (cf. the P. Geddes'es "Valley Section").

It is interesting to wonder whether in the future this difference may diminish and even completely vanish. The answer lies partly in the future structure of commuting and partly in the eventual intensive development of the mining and processing industries in the lowlands on the basis of the newly discovered, deeper laying deposits of resources. Some reduction in commuting should be certainly envisaged but it still seems the most probable that a large amount of commuting will persist for three reasons: commuting in the southern areas has a very long tradition, the settlements are both comparatively well invested and strongly dispersed, finally the land, with a few exceptions is now agriculturally very productive. The exploitation of minerals in the lowlands is developing rather slowly, mostly on the outskirts of the southern regions and as a result its impact on the general structure of the urban settlement will not be very distinct, and will be limited to the regional pattern.

Additional information on the similarities and dissimilarities of urbanization and industrialization patterns was obtained by the correlation and the multiple regression analysis of the urban population, industrial empolyment and the agricultural population. The last two were treated as idependent variables and the urban population as the dependent one. The most interesting conclusions came from the comparison of deviations of the actual, from the estimated urban populations in regions. The voivodships in the industrial South where larger groups of industrial workers live in the rural areas (either working there or commuting to work in towns and cities) were characterized by large negative deviations and the voivodships with industrial workers concentrated heavily in the larger cities had large positive deviations. The changes between the years 1960 and 1970 supported this conclusion because in areas in which commuting to work had increased the deviations have increased and the same was true where the concentration of industrial workers in the largest cities had grown as a result of new housing developments within their perimeters.

With the widening of the concepts of industrialization and of urbanization, new additional problems however do arise. These may be identified as the regional differentiation of the degree to which the urban system serves as the intermediary in the spread of technical civilization and of the impact of technical civilization on the diffusion of the urban way of life. The answer in the first case lies on one side in the accessibility (density) of the largest urban centres — urban agglomerations and on the other in the intensity of interactions between cities or towns and their spheres of influence. In the second case there are three factors arising from the technical civilization which play a major role in the spread of urbanization: increasing mobility of modern man due to privately owned cars, the so-called "mass media" (in particular television) and the technical progress in agriculture, which transforms culture and ways of rural life.

When the spheres of influence in the already developed urban agglomerations are assumed to be defined by the radii of 75 km from their centres and for the developing ones of 50 km and then confronted with the distribution of industrial regions and centres, it is easy to observe that: (1) urban agglomerations play a much more important role in the spread of technical civilization than the industrial regions, indeed a very large majority of these regions lie within their spheres of influence; (2) all areas outside these spheres of influence are in the eastern, north-eastern and north-western parts of the country, with four developing agglomerations (those of Lublin, Białystok, Rzeszów and Kielce with Radom) and three so-called potential agglomerations (those of Zielona Góra, Koszalin and Olsztyn) forming an important planned diminuation of their extent. In addition in the western and northern regions the development of modern socialized agriculture compensates partly for the deficiencies in the access to urban agglomerations — the disseminators of technical civilization.

The spread of technical civilization in turn radically changes the channels through which urban culture and ways of living are diffused. Mass media of information and the technical revolution in agriculture (specially the mechanization of agricultural production) practically destroy the impact of distance on the diffusion of urban culture. And the increased mobility of men, in particular of the city inhabitants due to the privately owned cars when associated with tourism brings urbanization to those areas (such as the Mazurian Lake District) which on the distance basis are outside the spheres of influence of any major urban centre.

(5) Let us sum up the result of the whole descriptive analysis. At present Poland is entering already the stage of a post-industrial highly urbanized society. As a result further progress in industrialization and urbanization which so far were leading, dominant factors in the transformation of the physical — spatial structure of the nation, the state and the country are becoming common phenomena in all the regions, throughout the national territory. On their basis the integration of all urban, indeed of all settlements into one national system is quickly developing.

At present there exists a well developed polycentric network of urban agglomerations. With few exceptions it begins to coalesce into one core, urban or at least very strongly urbanized in character, forming roughly a triangle with the southern mountain chains at its most industrialized base and with its vortex in the North at the cities and ports of the Bay of Gdańsk which are partly connected with the delta of the Vistula. There, urban services (in particular material services) still predominate over the industrial functions. Outside the core area remain the northwestern and the north-eastern regions (as well as some mountainous areas in the South) with their developing and potential urban agglomerations and large tracts of land outside the direct spheres of urban and industrial influence. However, with the development of tourism, of modern socialized agriculture with the available (through the mass media) access to the technical industrial civilization and urban culture, these also belong to this strongly integrated system. Indeed, they seem to have a special role to play and a specific function to fulfill in the preservation of the natural environment for the whole nation.

The functionalization of regional economies seems at present to be slowly superseding the so-far dominating industrialization and urbanization as a leading factor in the transformation of the physical structure and spatial patterns of the country.

All these changes introduce an additional problem — that of the new territorial organization of the country. The recently established new system and network of communes (*gminas*) together with the newly introduced changes in the set-up and patterns of higher administrative organization and division seem to be the correct move towards the closer correlation between the settlement system and the territorial organization of the state.

Note: This paper was written on the basis of the available statistics pertaining to the seventeen voivodships, basic regional administrative units existing in the years 1950 to 1975. The administrative reform which increassed their number to about fifty and which grouped them into several macro-regions is at present being carried out. When the statistics are adjusted to the new division, specially in the time series — the whole analysis will have to be repeated. It is the belief of the author that the result, although more precise, will not present a different picture from that described above.

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GEOGRAPHIA POLONICA 33, 1976

REGIONAL AND SUBREGIONAL CENTRES IN POLAND. A GENERAL CHARACTERIZATION

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INTRODUCTION

Empirical research plays an important role in the studies on the settlement network of Poland, providing the analysis of the current state of the settlement network, and at the same time suggesting certain concepts with respect to its future model. Investigations of this kind can be divided into at least two groups, depending on the approach to the subject.

To the first group belong investigations which can be said to be on the border of the formal approach and which, contain certain information on the functions of elements, or the functioning of the network of the given area. These are the studies on the size and rank of settlements (the Zipf diagram), analyses of the spatial structure of the network (distribution of the settlements, understood as points, lines and surfaces, studies on the distances between the settlements and settlement centres, etc.). In this group can be included also the analysis of the morphology of settlements (morphogenesis), investigations into the concentration and diffusion (compactness) of the network.

The other group includes investigations characterized by the functional approach, whose aim is to explain the structure of the network. The network consists of elements and systems of different degrees and hierarchy, which are, however, integrated by certain relations. Investigations of this kind are concerned with more complicated problems, i.e., with the theory of the network as a particular system.

However, in both these cases the research worker should not confine himself to a mere description of certain phenomenon (by adequate notation), but should also try to determine certain trends of transformations, so as to be able to formulate hypotheses for accurate forecasts.

During the last few years the number of publications concerned with these problems has notably increased, as has also the research work in this field. An extremely important role has been played by the national plan of research work,[1] which ensures the right form of organization of research, as well as its financial support and other resources.

THE LINKS (ELEMENTS) OF THE POLISH SETTLEMENT SYSTEM

In the settlement system of our country the following links (i.e. elements) can be observed:

(1) Agglomerations, or other similar large units, based on the mono- or polycentric structure. Three kinds of agglomerations are usually distinguished

[1] These are the so-called governmental and key programmes — of great importance for the national economy.

in respect of the advancement of their formation or development: the already-existing agglomerations, i.e. those at the mature stage of development, the emerging agglomerations, and the potentially-existing ones (S. Leszczycki et al. 1975).

(2) Specialized centres, being the elements of larger wholes, such as settlement systems, production complexes, etc. These elements occur in industrial (or industrialized) regions in which the settlement system is based on specialization (often very narrow specialization) of its elements. The consequence (and at the same time the cause) of this is a system of internal relations between the specialized elements. When a given settlement unit suffers from the lack or shortage of a certain function, then owing to this system it can be supplemented through contacts with other settlement units which may have a surplus of this particular function.

(3) The centres of clear central (normalized) functions which concentrate a certain number and kind of institution which ensures proper service of the region on an appropriate level of hierarchy of needs. The characteristic feature of this group of settlements (towns) is the formation of a special hierarchical system. If in the given centre there are many institutions that ensure a high hierarchy of needs, then we speak of a regional or subregional centre.

Apart from these three main links of the network (differentiated both with respect to the type and the region), there exists a so-called "settlement tissue" — "dispersed more or less evenly on the area of the whole country, which consists of village settlements and small towns", functionally connected with agriculture, rest, and tourism (B. Malisz 1976).

When investigating the spatial distribution of the links of settlement network in Poland, it must be noticed that almost all the agglomerations are based on regional capital cities, i.e. the voivodship centres. The only exception to this rule is the so-called Sudetes agglomeration.

In the settlement system of Poland an essential role is also played by the urban centres of considerable population (over 50,000 inhabitants). Until 1975 these centres played a special role in the categories of administrative division, as the so-called provincial capitals. That is why, perhaps, they were more frequently and more thoroughly dealt with than the remaining centres. Obviously, they were somewhat artificially separated out of the system of Polish towns, however, they represent richer statistics and this made research procedure easier. The studies that aimed at the description of the functions (functional classification), their characterization in view of a greater number of characteristics, etc. were concerned with this group of towns (M. Jerczyński 1972). The analysis of their distribution on the map and of their situation in relation to the official capital of the region, allowed the deduction that at least some of them perform the functions of regional or subregional centres. The other aspect of the matter is their development in time: from relatively large stabilization to dynamic development.

All these considerations allowed the formulation of a number of research theses and hypotheses, all of which aimed at further investigation into this group of towns. However, if we ask the main question: do these towns play the role of a centre of appropriate hierarchical rank (and if so, to what extent) then it is clear that this artificial system of elements should be considerably extended. There are many centres which did not reach that particular level and which yet played the role of centres of quite a high rank.

I think that the above considerations fully justify our decision of presenting here the results of preliminary and yet incompleted investigations[2] into the regional and subregional centres of Poland.

AN ATTEMPT AT THE DEFINITION OF REGIONAL CENTRES AND GROWTH CENTRES

The chief notions and terms used in urban research, such as the regional and local centres, development and growth centres, urbanized areas, or agglomerations, are all connected with certain theories and can be defined only in the language of a given theory (S. Golachowski).[3]

The term "regional centre" is understood within the theory of the network structure and based on the hierarchy of central functions. According to this theory, which was initiated by W. Christaller, by the system of regional centres we should understand not only the spatial distribution, but also certain proportions of rank of individual centres, their interrelations and the area of influence. A considerable defect of terminological expressions is the statical approach to the definition of the regional centre.

The term "growth centre" or "growth pole" is integrally connected with the polarization theory (F. Perroux), and the term "innovation centre" related to it — with the theory of diffusion, interaction, of the spread of information, etc.

Agglomerations and agglomerating processes are defined by means of appropriate dynamic models, such as the trends surface wave model (P. Korcelli 1974).

As a result of contemporary industrialization and urbanization processes many terms, notions and theories are depreciated in favour of the new ones. Besides the system of centres with the central functions new settlement forms appear, such as the regional or local settlement complexes, or the specialized centres — being the elements of larger, integrated settlement forms. The development and functioning of the "specialized centres" can be explained in the language of the systems theory.

However, each of these notions needs different research techniques, mathematical models and information. That is why the problem of the bank of data, i.e., of information in the broad meading of the word, seems to be of paramount importance.

This task on the one hand exceeds the possibilities of particular scientific centres and research units, and on the other it would be pointless from the economic point of view to double this kind of activity.

The definitions suggested can be grouped into certain categories, such as:

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[2] The investigations are being carried out at the Research Centre of Social and Political Geography, Institute of Geography, University of Wrocław, within the key programme (commissioned by the Institute of Geography of the Polish Academy of Sciences) under the guidance of Professor S. Golachowski. The author of the present paper was studying the centres in industrial regions and continued the investigations into statistical analysis of the set, initiated by Professor Golachowski.

[3] Certain terminological obscurities and, resulting from them difficulties with the determination of the area of research work on the set of towns, were revealed during the seminar on regional and growth centres, organized in 1973 in Warsaw, for the coordination of studies, by the Institute of Geography of the Polish Academy of Sciences and the Research Centre of Social and Political Geography, Institute of Geography, University of Wrocław.

— definitions concerning both kinds of centres (i.e., the regional and growth centres) jointly, treating them either as equal or, on the contrary, as opposed groups of towns,

— statistical and dynamic definitions. The former treat the network of regional centres as a formed, or stabilized system (the stabilized size of centres, definite scope of ranks). The latter are concerned with the towns in terms of growth, i.e., they treat them as growth centres (or poles),

— with respect to the aim they serve one can also distinguish the research (analytical) and plannistic definitions. The former reflect a concrete situation that has emerged as a result of research studies, the latter are concerned with the need for programming or controlling the development of the settlement network. It can be assumed that the *regional centre* is a town of remarkably great central functions at a relatively high hierarchical level, in which the functions of the centre of control, decision, information, and cencentration of industry, should also occur (K. Dziewoński 1975).

The network of regional centres of today in many ways supplements the urban agglomerations; as a matter of fact, it often happens that due to the development of industry a centre changes into the urban (urban-industrial) agglomeration. From the above it follows that the regional centre performs in the first place the function of supra-elementary service of the given area (region or subregion). Certainly, this is also connected with the size of towns, effectiveness of functioning of the service institutions, structure of the settlement network, and the like. From the point of view of development it is a statical system, corresponding to a fairly homogeneous space, on which both the management and the number of population remain on more or less the same level (B. F. Winiarski 1964).

A *growth centre* has also its dynamic content. These are the towns characterized by the accelerated process of growth of certain values characteristic of economic activity, in comparison with the dynamics of this process on the national or regional scale, depending on the assumed plane of reference (B. F. Winiarski).

In view of the changes in economic activity, which are usually accompanied by structural and social transformations as well, the author would prefer to use the term of "development centres".

In some cases it may be necessary to use sets of "development centres", hence we can also speak of "development axis" or "development zones" which take into account the possibility of more "area-oriented" arrangement of expansion processes (B. F. Winiarski).

S. M. Zawadzki uses the term "Centre of Regional Development" (CRD) and says that it does not necessarily have to concentrate the functions of control (administration) and of decision. In this definition the regional centre is identified with the growth centre, thus independent of current administrative divisions, although at the same time emphasizing their stimulating influence (economic and social) on the adjoining areas. In such a case the regional centre will be simultaneously the growth (or development) centre. In order to fulfil these tasks with respect to the environment, the CRD must have well-developed producer and service functions. It should be the industrial centre on a national scale, and it should also concentrate the central institutions on a high level. It seems that such an approach may be useful, especially for plannistic purposes. However, it should not eliminate the previous approach, because we have to deal with at least two kinds of centres which play a certain role, depending on the part of the region and socio-economic structure.

GENERAL CHARACTERISTICS OF REGIONAL CENTRES IN POLAND

In the preliminary characteristics of regional centres we shall eliminate out of a set of towns the centres with clearly formed service (central) functions whose influence reaches far beyond the poviat (unit) boundaries.

The towns selected for the investigations all had more than 15,000 inhabitants, the upper limit being established as 500,000 inhabitants. This set was delineated by 30 characteristics which can generally be divided into the following groups:

(1) characteristics of the population (number of population, dynamics of changes, level of education, and others),

(2) characteristics of housing,

(3) characteristics relating to the equipment of the centres with certain fittings which can be indicative of the central functions (hotels, schools, commerce, socialized economy),

(4) characteristics of employment,

(5) characteristics of the transport functions (transport-nodes).

We shall discuss now two most important fragments of the general research procedure.

The first one consists in the elimination of more significant groups by the chief component Hotelling method. The second one is concerned with the classification of the elements of the set in three-dimensional space, with special reference to the plane of the F_1, F_2 components. The results can be summarized as follows.

— All information contained in the 30 initial characteristics was accumulated in the first 13 main components, accounting for 98.1% of common variation.

— The share of the first three components was dominant; it accounts for 85.6% of common variation, out of which the first component accounts for 77.24%, the second — for 4.68%, and the third — for 3.88%.

— Each of the following factors occounts for less than 2%, and, beginning with the ninth one, for less than 1% of common variation.

— In the further procedure only the first three factors were taken into account, losing 14.4% of initial information.

The first factor, F_1, is loaded high by 19 characteristics (Annex 1) which concern employment (according to the sectors of national economy), number of the population and its structure, and education. The degree of correlation of these characteristics with the F_1 factor is about 0.9. Each of them was included in the first factor, and accounted for over 84% of the variation. Thus this factor can be defined as the social-professional factor and it can be assumed to show the central functions of the towns.

The second functions, F_2, can be identified with the dynamics of development because such characteristics as: the growth rate (increase of the number of population), investment outlays, domestic migrations, housing (number of new flats) and the bus service (Annex 2) are the most loaded.

The third factor, F_3, is mostly influenced by the following characteristics: number of trains at the transport-node, employment in industry, and domestic migrations.

FACTOR VALUES

For a proper arrangement of the set of towns, the 30-dimensional space was reduced to three dimensions, the factor values being calculated for the first three main components. The final interpretation was made in the plane of the F_1, F_2 components. In addition to that, linear classification for both components was performed. The arrangement of towns according to the factor values is presented in Tables 1 and 2. The central character of the town is defined by the F_1 component. Together with the decrease of the factor value, decreases the area of influence of the centre. This is in agreement with the assumption of interrelation between the size and rank of the centre and the scope of its influence. The values according to the F_1 component are characterized by great disparity (from 171 — Poznań to 17.4 — Augustów), with the largest differences in the higher values (4.6). Thus the direct sequence of occurrence of two centres does not mean that they are of similar centrality (i.e., that they have similar F_1 value). On the contrary, they are often characterized by a large disproportion in rank. In the group of towns of the high-

TABLE 1. One-factor classification according to the F_1 component

No.	Town	F_1 value
1	Poznań	171.582
2	Szczecin	100.782
3	Lublin	84.424
4	Bydgoszcz	77.669
5	Kielce (+Skarżysko)	46.964
6	Białystok	46.373
7	Częstochowa	43.067
8	Bielsko-Biała	35.149
9	Rzeszów	32.876
10	Toruń	28.952
11	Opole	28.832
12	Rybnik	27.024
13	Radom	26.280
14	Olsztyn	24.683
15	Wałbrzych	21.735
16	Piotrków Tryb. (+ Tomaszów)	17.841
17	Jaworzno	17.505
18	Jelenia Góra	16.503
19	Tychy	15.738
20	Pruszków	15.721
21	Zielona Góra	14.864
22	Zakopane (+N. Targ)	14.108
23	Tarnów	12.851
24	Płock	12.395
25	Nowy Sącz	12.170
26	Tarnowskie Góry	12.181
27	Koszalin	11.655
28	Wodzisław	10.079
29	Gorzów Wlkp.	9.741
30	Kalisz	9.019
31	Włocławek	8.648
32	Słupsk	7.162
33	Cieszyn	6.807
34	Świdnica	6.282
35	Legnica	4.617
36	Pabianice (+Łask)	2.451
37	Zduńska Wola (+ Sieradz)	2.069
38	Inowrocław	2.027
39	Elbląg	1.728
40	Ostrowiec Świętokrzyski	1.001
41	Żyrardów (+Grodzisk)	0.955
42	Koźle (+Kędzierzyn)	0.756
43	Grudziądz	0.718
44	Przemyśl	0.598
45	Otwock	0.428
46	Zgierz	0.160
47	Ostrów Wlkp.	0.058
48	Oświęcim	−0.204
49	Nysa	−0.614
50	Puławy	−1.150
51	Konin	−1.467
52	Dzierżoniów	−1.661
53	Krosno	−1.986
54	Wołomin	−1.937
55	Zamość	−1.943
56	Kłodzko	−2.418
57	Gniezno	−2.848

cont.

No.	Town	F_1 value	No.	Town	F_1 value
58	Chełm	−3.467	105	Krotoszyn	−11.544
59	Zawiercie	−3.816	106	Skierniewice	−11.565
60	Mielec	−4.191	107	Starogard Gdański	−11.617
61	Lublin	−4.191	108	Lubań	−11.711
62	Piła	−4.335	109	Sandomierz	−11.767
63	Jarosław	−4.638	110	Żary	−11.909
64	Olkusz	−4.851	111	Świnoujście	−12.507
65	Siedlce	−4.965	112	Pszczyna	−12.074
66	Stalowa Wola	−5.027	113	Strzelce Opolskie	−12.135
67	Racibórz	−5.283	114	Ełk	−12.201
68	Stargard Szczeciński	−5.411	115	Ostrołęka	−12.269
69	Starachowice	−5.579	116	Hrubieszów	−12.301
70	Kutno	−5.608	117	Malbork	−12.331
71	Żywiec	−5.644	118	Kętrzyn	−12.814
72	Zgorzelec	−6.043	119	Kościan	−12.839
73	Leszno	−6.520	120	Sochaczew	−12.890
74	Radomsko	−6.657	121	Ostróda	−13.019
75	Tczew	−6.750	122	Nowa Ruda	−13.015
76	Sanok	−6.060	123	Suwałki	−13.032
77	Biała Podlaska	−7.636	124	Jarocin	−13.142
78	Tarnobrzeg	−7.657	125	Turek	−13.471
79	Szczecinek	−7.682	126	Kamienna Góra	−13.647
80	Jasło	−7.741	127	Mława	−13.686
81	Nowy Dwór Maz.	−8.035	128	Lębork	−13.808
82	Kraśnik (+Kraśnik Fabr.)	−8.231	129	Iława	−13.883
			130	Myszków	−13.971
83	Nowa Sól	−8.239	131	Września	−14.095
84	Piaseczno	−8.271	132	Giżycko	−14.272
85	Bochnia	−8.585	133	Śrem	−14.316
86	Głogów	−8.653	134	Kwidzyn	−14.368
87	Łowicz	−9.138	135	Wałcz	−14.375
88	Lubliniec	−9.216	136	Jawor	−14.624
89	Brzeg	−9.494	137	Szczytno	−14.561
90	Bolesławiec	−9.751	138	Żagań	−14.705
91	Wieluń	−10.015	139	Świebodzin	−14.777
92	Mińsk Maz.	−10.026	140	Oława	−14.794
93	Kołobrzeg	−10.138	141	Międzyrzecz	−14.828
94	Chojnice	−10.467	142	Bielsk Podlaski	−14.852
95	Kluczbork	−10.814	143	Ostrów Maz.	−15.853
96	Ciechanów	−10.823	144	Białogard	−15.126
97	Wejherowo	−10.867	145	Wągrowiec	−15.281
98	Łomża	−10.880	146	Bartoszyce	−15.471
99	Gorlice	−10.951	147	Chełmno	−15.652
100	Oleśnica	−11.037	148	Brodnica	−15.751
101	Dębica	−11.363	149	Kościerzyna	−16.497
102	Prudnik	−11.402	150	Środa Wlkp.	−16.532
103	Świecie	−11.504	151	Goleniów	−16.808
104	Łuków	−11.538	152	Augustów	−17.351

TABLE 2. One-factor classification according to the F_2 component

No.	Town	F_2 value
1	Lublin	7.965
2	Wodzisław	6.053
3	Tarnobrzeg	4.326
4	Głogów	4.087
5	Puławy	3.767
6	Konin	3.735
7	Rybnik	2.940
8	Płock	2.603
9	Lublin	2.223
10	Sanok	1.566
11	Kielce	1.498
12	Śrem	1.289
13	Bielsko-Biała	1.061
14	Białystok	1.004
15	Olsztyn	0.915
16	Oława	0.903
17	Świdnica	0.903
18	Włocławek	0.837
19	Jasło	0.805
20	Świnoujście	0.820
21	Zielona Góra	0.663
22	Rzeszów	0.661
23	Wieluń	0.656
24	Ostrołęka	0.619
25	Stalowa Wola	0.617
26	Gorzów Wlkp.	0.578
27	Kołobrzeg	0.575
28	Toruń	0.540
29	Koszalin	0.522
30	Świecie	0.496
31	Ostrowiec Święto-krzyski	0.390
32	Chełm	0.350
33	Olkusz	0.344
34	Łuków	0.340
35	Nysa	0.327
36	Międzyrzec	0.257
37	Zamość	0.252
38	Bydgoszcz	0.223
39	Krosno	0.220
40	Gorlice	0.184
41	Oleśnica	0.184
42	Dębica	0.184
43	Zgorzelec	0.182
44	Nowy Sącz	0.174
45	Częstochowa	0.172
46	Turek	0.163
47	Koźle	0.162
48	Sandomierz	0.158
49	Zduńska Wola	0.156
50	Tychy	0.148
51	Dzierżoniów	0.147
52	Łomża	0.126
53	Suwałki	0.121
54	Słupsk	0.118
55	Piaseczno	0.104
56	Nowy Dwór Maz.	0.080
57	Jelenia Góra	0.055
58	Bartoszyce	0.035
59	Hrubieszów	0.027
60	Szczytno	0.024
61	Opole	0.004
62	Kraśnik	−0.001
63	Cieszyn	−0.016
64	Tarnów	−0.017
65	Mława	−0.034
66	Radom	−0.052
67	Elbląg	−0.091
68	Biała Podlaska	−0.092
69	Piotrków Tryb.	−0.125
70	Zawiercie	−0.140
71	Nowa Sól	−0.156
72	Bolesławiec	−0.162
73	Świebodzin	−0.186
74	Żywiec	−0.215
75	Żary	−0.216
76	Myszków	−0.224
77	Szczecin	−0.238
78	Bielsk Podlaski	−0.239
79	Kościerzyna	−0.224
80	Starogard Gdański	−0.244
81	Kalisz	−0.260
82	Łowicz	−0.263
83	Augustów	−0.284
84	Kłodzko	−0.288
85	Oświęcim	−0.296
86	Kętrzyn	−0.325
87	Giżycko	−0.325
88	Wągrowiec	−0.337
89	Lubań	−0.344
90	Mińsk Maz.	−0.345
91	Siedlce	−0.347
92	Zakopane	−0.353
93	Jawor	−0.354

No.	Town	F_2 value	No.	Town	F_2 value
94	Chojnice	−0.360	123	Szczecinek	−0.694
95	Legnica	−0.370	124	Brzeg	−0.716
96	Racibórz	−0.382	125	Ciechanów	−0.722
97	Gniezno	−0.394	126	Chełmno	−0.728
98	Ostróda	−0.398	127	Nowa Ruda	−0.733
99	Ostrów Maz.	−0.417	128	Środa Wlkp.	−0.741
100	Wałbrzych	−0.432	129	Przemyśl	−0.760
101	Sochaczew	−0.436	130	Mława	−0.765
102	Kluczbork	−0.437	131	Wejherowo	−0.771
103	Września	−0.388	132	Wałcz	−0.804
104	Piła	−0.456	133	Pszczyna	−0.826
			134	Kwidzyn	−0.881
105	Kamienna Góra	−0.508	135	Kutno	−0.866
106	Jarosław	−0.512	136	Kościan	−0.889
107	Stargard Szczeciński	−0.523	137	Tarnowskie Góry	−0.912
108	Goleniów	−0.526	138	Ostrów Wlkp.	−0.917
109	Grudziądz	−0.552	139	Żagań	−0.922
110	Radomsko	−0.558	140	Krotoszyn	−0.924
111	Ełk	−0.582	141	Lębork	−0.950
112	Pabianice	−0.583	142	Lubliniec	−0.974
113	Jaworzno	−0.585	143	Białogard	−1.048
114	Strzelce Opolskie	−0.586	144	Jarocin	−1.137
115	Prudnik	−0.603	145	Malbork	−1.397
116	Inowrocław	−0.623	146	Skierniewice	−1.494
117	Tczew	−0.631	147	Wołomin	−1.753
118	Brodnica	−0.639	148	Otwock	−1.961
119	Bochnia	−0.673	149	Żyrardów	−2.241
120	Starachowice	−0.684	150	Mielec	−2.521
121	Zgierz	−0.684	151	Pruszków	−3.004
122	Leszno	−0.694	152	Poznań	−4.092

est F_1 values, performing the function of the centres whose influence reaches beyond the boundaries of the region, were included almost all the voivodship centres and several larger industrial centres (Table 1). Some other towns included in this group were either those of almost the same rank, or else highly urbanized *poviats*.

The regional centres that are highest in rank are not equally distributed over the area of the country (Fig. 1). Most of them are grouped in southern Poland, and very few are found in the northern regions.

A group of centres of lower rank (subregional centres) can be eliminated out of the set of towns by means of appropriate "cutoff" according to the limit of the index. It was assumed that this set is isolated by the following values of components: $4.6 < F_1 < 17.8$. This group includes 20 centres in which, in comparison with the previous ones, the central functions are not fully developed.

Next are the centres which show some characteristics typical of subregional centres ($-7.0 < F_1 < +2.5$) and the "remaining cities" which do not show any characteristics typical of supra-*poviat* centres.

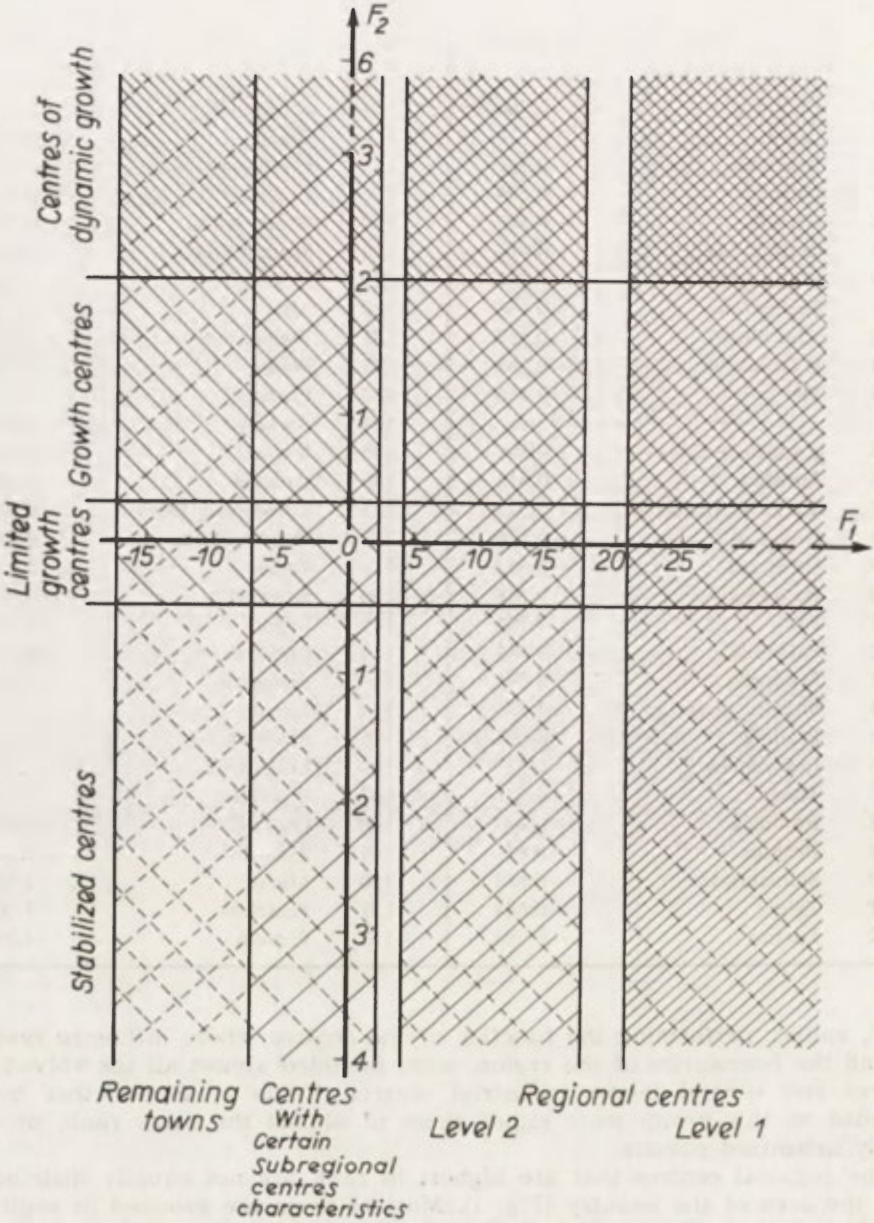

Fig. 1. Classification of towns according to F_1 F_2 components

According to the F_2 component the towns were divided into two groups: the *growth centres* and the *stabilized centres*. However, it seems more useful to divide the towns into four groups:

— stabilized centres ($F_2 \leqslant -0.5$),
— centres of limited growth ($-0.5 < F_2 \leqslant 0.3$),
— growth (development) centres ($0.3 < F_2 \leqslant 2.0$),
— centres of dynamic growth ($F_2 > 2.0$).

TABLE 3. Classification of towns according to the F_1, F_2 components

Dynamics of development according to the F_2 component	Degree of central character — F_1 component				
	Remaining towns $F_1 \leq -7.0$	Centres with certain subregional centres characteristics $-7.0 < F_1 \leq 2.5$	Regional centres Level 2 $4.6 < F_1 \leq 17.8$	Regional centres Level 1 $F_1 > 21.0$	Total
1	2	3	4	5	6
Centres of dynamic growth $F_2 > 2.0$	Tarnobrzeg Głogów	Lublin Puławy Konin	Wodzisław Płock	Lublin Rybnik	9
Growth centres $0.3 < F_2 \leq 2.0$	Śrem Oława Jasło Świnoujście Wieluń Ostrołęka Kołobrzeg Świecie Łuków	Sanok Stalowa Wola Ostrowiec Chełm Olkusz Nysa	Włocławek Zielona Góra Gorzów Wlkp. Świdnica Koszalin	Kielce (+ Skarżysko) Białystok Bielsko-Biała Rzeszów Toruń Olsztyn	26
Limited growth centres $-0.5 < F_2 \leq 0.3$	Gorlice Międzyrzecz Oleśnica Turek Sandomierz Łomża Suwałki Piaseczno Nowy Dwór Maz. Bartoszyce Hrubieszów Szczytno Kraśnik Dębica Mława Biała Podlaska Zawiercie Nowa Sól Bolesławiec Świebodzin Żary Myszków Bielsk Podlaski	Zamość Krosno Zgorzelec Koźle (+ Kędzierzyn) Zduńska Wola Dzierżoniów Elbląg Żywiec Starogard Gdański Kłodzko Oświęcim Siedlce Racibórz Gniezno Piła	Nowy Sącz Tychy Słupsk Jelenia Góra Cieszyn Piotrków Tryb. Kalisz Tarnów Zakopane Legnica	Bydgoszcz Częstochowa Opole Radom Wałbrzych Szczecin	69

cont.

1	2	3	4	5	6
	Kościerzyna				
	Łowicz				
	Augustów				
	Kętrzyn				
	Giżycko				
	Wągrowiec				
	Lubań				
	Mińsk Maz.				
	Jawor				
	Chojnice				
	Ostróda				
	Ostrów Maz.				
	Sochaczew				
	Kluczbork				
	Września				
Stabilized centres	Kamienna Góra	Jarosław	Jaworzno	Poznań	
$F_1 \leqslant -0.5$	Stargard	Grudziądz	Tarnowskie Góry		
	Szczeciński	Radomsko	Pruszków		
	Goleniów	Pabianice			
	Ełk	Inowrocław			
	Strzelce Opolskie	Tczew			
	Prudnik	Starachowice			
	Brodnica	Zgierz			
	Bochnia	Leszno			
	Szczecinek	Przemyśl			
	Brzeg	Kutno			
	Ciechanów	Ostrów Wlkp.			
	Chełmno	Wołomin			
	Nowa Ruda	Otwock			
	Środa Wlkp.	Żyrardów			
	Iława	Mielec			
	Wejherowo				
	Wałcz				
	Pszczyna				
	Kwidzyń				
	Kościan				
	Żagań				
	Krotoszyn				
	Lębork				
	Lubliniec				
	Białogard				
	Jarocin				
	Malbork				
	Skierniewice				
Total	77	40	20	13+2	152

The last group is characterized by the dynamics of changes of the socio-professional structure and by great concentration of investments.[4] In this group were included all the centres of the industrialized regions, as well as some regional centres exhibiting the characteristics of development. It can be supposed that the development of towns in this group is accompanied by large shifts in the character of performed functions. However, additional investigations are necessary to answer the question whether at the same time these centres grow in rank within the settlement network structure.

A typical group (26 towns) is the third one, i.e., that of the development centres whose dynamics of development is not so large as in the preceding

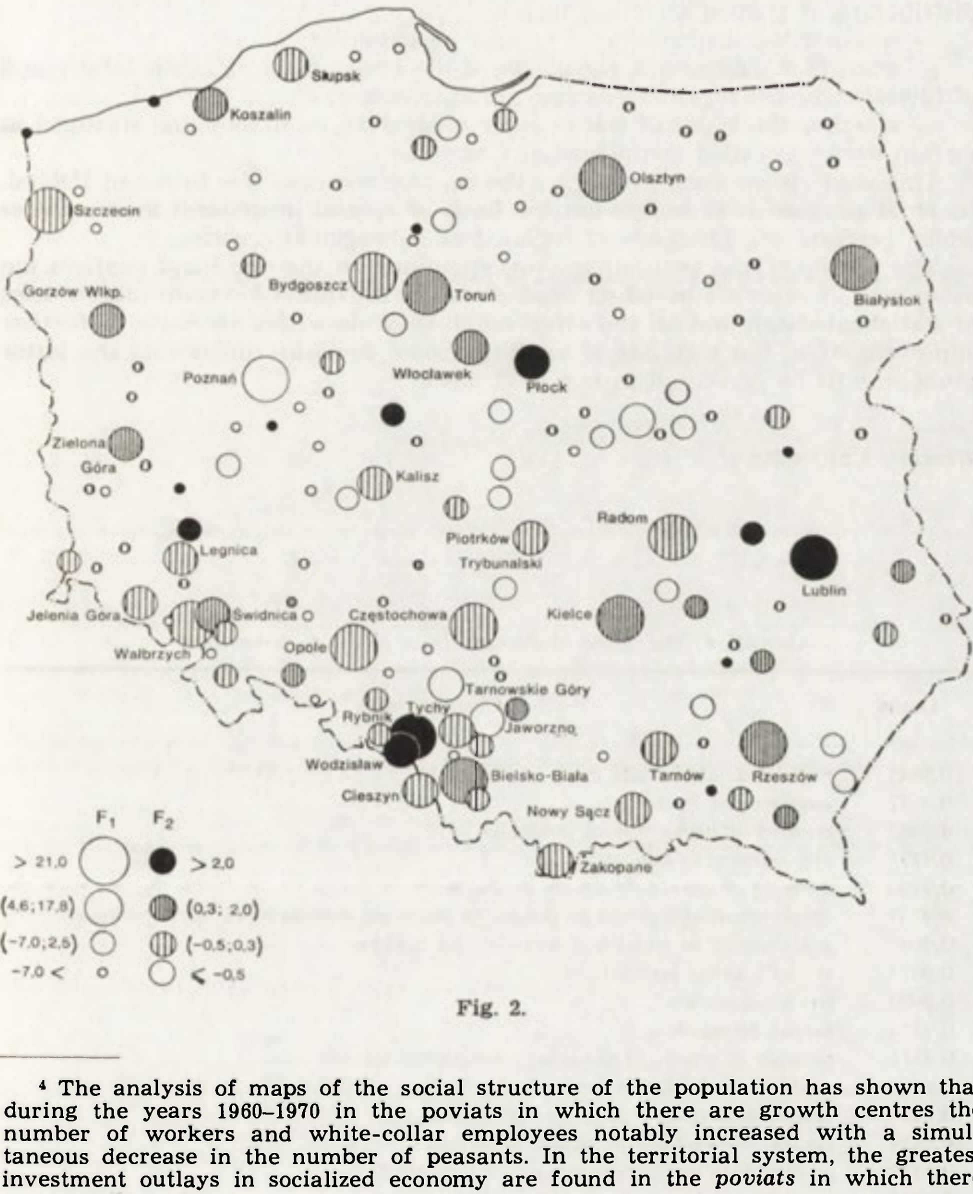

Fig. 2.

[4] The analysis of maps of the social structure of the population has shown that during the years 1960–1970 in the poviats in which there are growth centres the number of workers and white-collar employees notably increased with a simultaneous decrease in the number of peasants. In the territorial system, the greatest investment outlays in socialized economy are found in the *poviats* in which there are growth centres.

group, but still worth noting. Most numerous is the group of the "centres of limited growth" — 69 towns.

Looking at the analyzed set of towns from the point of view of both components at the same time, one can make an attempt at their classification. For this purpose Table 3 can be used, in which the set of 152 towns was divided into 16 classes, depending on the values of both components (cf. Fig. 2). Both Table 3 and Fig. 2 were based on the same principles: analogical direction of the F_1, F_2 axis and the choice of classes.

The spatial distribution of the types of towns is presented on the map (Fig. 1) which helps to answer several questions concerning the regularity of distribution of particular types, such as:

— whether the distribution is regular or irregular,

— what is the degree of regularity of the towns network, both totally and of idividual types: regional centres, growth centres, etc.,

— whether the types of towns occur separately, or if they are arranged in certain systems, called complexes and the like.

This study is an attempt to give the characteristics of the towns of Poland. Its chief purpose is to isolate (on the basis of special procedure) those centres which perform the functions of regional or subregional centres.

The results of the preliminary investigations on the one hand confirm the usefulness of research based on mass statistics (in spite of certain inaccuracies of statistical data), and on the other hand, they show the necessity of further improvement in the methods of analysis. Some remarks concerning the latter problem will be presented in our next work.

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ANNEX 1. The share of characteristics in the F_1 component

Loads	Characteristics
0.9885	socialized retail trade sales
0.9857	employment in trade
0.9782	number of higher-school graduates
0.9771	employment in education
0.9766	number of secondary-school graduates
0.9707	employment in services pertaining to the living conditions of the population
0.9695	employment in municipal services and housing
0.9673	poviat's urban population
0.9609	town population
0.9544	poviat population
0.9513	number of pupils in secondary vocational schools
0.9495	usable area in towns
0.9449	general-education secondary school pupils
0.9424	electric power used by urban households
0.9372	employment in finance and social insurance
0.9282	employment in transport and communications

0.9254	employment in culture and art
0.9229	employment in administration
0.9168	employment in the health service, social welfare and physical culture
0.8861	number of occupied beds in hotels
0.8543	employment in industry
0.8386	floor area of flats commissioned in socialized economy
0.8385	number of pupils in primary and secondary art schools
0.8363	number of permanent beds in hotels
0.8173	investment outlays in the socialized economy
0.7456	domestic migrations
0.6670	employment in science
0.5267	number of bus arrivals and departures
0.0500	urban population growth rate

ANNEX 2. The share of characteristics in the F_2 component

Loads	Characteristics
0.8293	urban population growth rate
0.3909	number of bus arrivals and departures
0.3097	investment outlays in socialized economy
0.3065	domestic migrations
0.2617	floor area of flats commissioned un the socialized economy
0.0831	employment in industry
0.0054	number of permanent beds in hotels
0.0276	number of occupied beds in hotels
0.0121	poviat population
0.0771	employment in transport and communications
0.0599	employment in finance and social insurance
—0.0041	employment in administration
—0.0118	socialized retail trade sales
—0.0156	general-education secondary school pupils
—0.0168	employment in trade
—0.0171	employment in education
—0.0311	poviat's urban population
—0.0435	floor area of flats in towns
—0.0479	number of secondary school graduates
—0.0448	employment in municipal services and housing
—0.0479	employment in services pertaining to the living conditions of the population
—0.0501	employment in the health service, social welfare and culture
—0.0602	town population
—0.0701	electric power used by urban households
—0.0733	number of higher schools graduates
—0.0863	employment in culture and art
—0.1303	number of pupils in primary and secondary art schools
—0.1969	employment in science
—0.3794	number of train arrivals and departures

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GEOGRAPHIA POLONICA 33, 1976

URBANIZATION PROCESSES AND THE RURAL AREAS IN POLAND: A TREND SURFACE ANALYSIS

JAN ŁOBODA

INTRODUCTION

Urbanization processes are among the most characteristic and significant contemporary phenomena. In spite of, or perhaps because of their importance, no universal and comprehensive indices of urbanization have so far been developed. The processes cover complex economic, social, cultural, demographic and technological transformations and therefore they cannot be treated within narrow limits. In addition, the character of the transformations vary over time and space: they may refer to different phenomena under different historical and socio-cultural conditions. Generally, however, the percentage of the population living in cities increases and the living conditions of the population remaining in the rural areas become increasingly similar to the conditions prevailing in the urban areas.

J. Ziółkowski (1965) has identified four principal dimensions of urbanization: the demographic urbanization (or, the statistical urbanization, see S. Golachowski 1973, B. Jałowiecki 1972) which is reflected in the growing number of cities and in the rural-urban migrations; the social urbanization — when individuals and groups of population adopt "the urban way of life" (see L. Wirth, 1967 edition); the spatial urbanization — as expressed in the change of landscape which becomes dominated by "urban" forms and patterns; and finally, the economic urbanization which consists of the growth of the percentage of non-agricultural employment.

The present analysis is confined to the last dimension, i.e., the economic urbanization. Changes occurring in the rural areas of Poland over the 1950–1970 period are traced. Their essence is related to the fact that complete urbanization is usually preceded by a partial urbanization (or semi-urbanization, according to S. Golachowski, 1967), particularly affecting rural-urban zones and the areas either already industrialized or undergoing industrialization.

First of all, general trends in the spatial pattern of urbanization phenomena occurring within rural areas will be discussed. The index adopted is the percentage of non-agricultural population within administratively rural territory. In more detail, the distribution and some other characteristics of the economically active population, earning their living from sectors other than agriculture, will be analyzed on the *poviat* basis over the last decade. A hypothesis to be tested portrays the urbanization in the rural areas as a function of industrialization. From this point of view the spatial relations between the patterns of industrialization and that of rural areas are particularly important. Thus, spatial trends of urbanization in the rural areas and of the post-war industrial development will be mutually compared.

It may also be assumed that the spread of urbanization phenomena over a still rural territory is closely related to the patterns of innovation diffusion. Television is undubitably one of these innovations that have been disseminated recently at a faster rate than others. Therefore, in a later section of the paper a hypothesis will be tested according to which the spatial trends of urbanization and innovation diffusion (as examplified by the spread of television) in Poland are basically similar.

NON-AGRICULTURAL POPULATION WITHIN RURAL AREAS

We have assumed the percentage of the non-agricultural population to be an index of the economic urbanization occurring within rural areas. This index also reflects the general change in the occupational structure of the rural population. Its values for the whole Poland have been growing rapidly: from 23% in 1950 to 31% in 1960 and over 43% in 1970. It should be mentioned that the rate of growth of the urban population has been slower over the same period. At the same time, disproportions in the distribution of the non-agricultural rural population have not changed radically: they amounted to 47 percentage points in 1950, 53 in 1960 and 52 in 1970.

Over the decade, 1950–1960 the highest rate of urbanization within the rural areas occurred in the southern voivodships of Rzeszów and Cracow (12 percentage points), followed by Katowice, Wrocław and Zielona Góra voivodships (11). Also the next decade, i.e., 1960–1970, witnessed the highest rate of change in the rural areas of the Rzeszów voivodship (17 percentage points) followed by Cracow and Kielce (16) voivodships. Over the whole 20-year period the

TABLE 1. Non-agricultural population in the rural territory of Poland, 1950–1970

Voivodships	Percentage of non-agricultural population			Increase in percentage points		
	1950	1960	1970	1950–1960	1960–1970	1950–1970
Poland total	23	31	43	8	12	20
Białystok	10	15	22	5	7	12
Bydgoszcz	26	30	38	4	8	12
Gdańsk	33	38	45	5	7	12
Katowice	57	68	78	11	10	21
Kielce	16	24	40	8	16	24
Koszalin	18	27	38	9	11	20
Kraków	25	37	53	12	16	28
Lublin	10	15	26	5	11	16
Łódź	18	27	38	9	11	20
Olsztyn	21	27	34	6	7	13
Opole	43	48	59	5	11	16
Poznań	28	35	43	7	8	15
Rzeszów	15	27	44	12	17	29
Szczecin	18	25	35	7	10	17
Warszawa	19	26	38	7	12	19
Wrocław	30	41	52	11	11	22
Zielona Góra	27	38	49	11	11	22

Sources: Ludność, zasoby mieszkaniowe, indywidualne gospodarstwa (Population, housing stock, individual households) Central Statistical Office, Warszawa 1971; Roczniki statystyczne (Statistical yearbooks of Poland), Central Statistical Office, 1950–1974.

non-agricultural rural population increased by more than 20 percentage points in the voivodships of Rzeszów, Cracow, Kielce, as well as in the Wrocław and Zielona Góra voivodships. The values of the index when plotted on a map, interpolated and transformed into a linear form, display major spatial trends in the "urbanization level" of the rural areas in Poland. The data show that the level of economic urbanization of the rural population is also the highest in southern and south-western Poland (over 50% in the voivodships of Katowice, Opole, Cracow and Wrocław), while it is the lowest in the eastern voivodships of Białystok and Lublin (below 30%).

Fig. 1. Generalized spatial trend of the "economic urbanization" of the rural population in Poland, 1950–1970

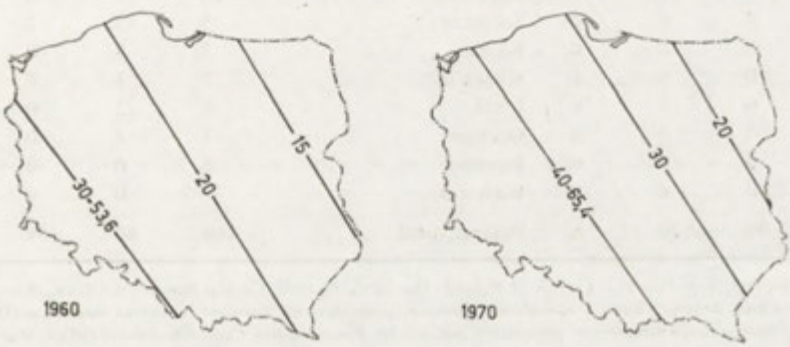

Fig. 2. Generalized spatial trend of the "occupational urbanization" of the rural population in Poland, 1960–1970

A zone of intensive economic urbanization in the rural areas covers the region of Silesia, the vicinities of large cities, as well as the voivodships of Zielona Góra and Gdańsk. Central Poland has been characterized by a moderate level of urbanization, while the eastern part has been traditionally the least urbanized. By 1970 the intensive urbanization zone had moved towards the centre and only in the north-eastern regions had low values of the index been retained. The general trend in the economic urbanization of the rural territory shifted over the 1950–1970 period from SW-E to SW-NE. Interregional disproportions have decreased slightly.

ECONOMICALLY ACTIVE — NON-AGRICULTURAL RURAL POPULATION

The percentage of the non-agricultural population by voivodships shows general, macro-scale features of the economic urbanization in the rural territory. A much more detailed picture is provided by the index of the economically active non-agricultural population as a percentage of the total labour force in the rural areas. The analysis based on data for individual *poviats* pertains to the decade of 1960-1970.

It is assumed that the index value of 30% or more reflects a relatively high level of the "occupational urbanization" within the administratively rural territory, and this percentage is used as a threshold value in Table 2.

TABLE 2. Economically active, non-agricultural rural population by *poviats*, 1960 and 1970

1960				Voivodships	1970			
Number of *poviats* with the percentage value above					Number of *poviats* with the percentage value above			
30%	40%	50%	60%		30%	40%	50%	60%
15	9	4	2	Wrocław	24	15	9	5
13	12	9	4	Katowice	14	13	13	10
6	4	1	0	Kraków	13	6	5	2
5	1	0	0	Zielona Góra	14	9	1	1
8	5	4	0	Opole	12	7	5	i
5	1	0	0	Poznań	19	3	1	1
6	3	2	0	Warszawa	10	6	3	3
3	0	0	0	Rzeszów	12	5	0	0
6	1	0	0	Gdańsk	10	4	0	0
3	0	0	0	Bydgoszcz	10	2	0	0
2	0	0	0	Szczecin	5	3	2	0
2	0	0	0	Kielce	7	3	0	0
0	0	0	0	Koszalin	7	1	0	0
1	0	0	0	Łódź	6	2	0	0
1	0	0	0	Olsztyn	3	1	0	0
0	0	0	0	Lublin	2	0	0	0
0	0	0	0	Białystok	1	0	0	0
76	36	20	6	Poland total	169	80	39	23

Sources: Compiled from National Census of Poland, December 6, 1960, Central Statistical Office, Warszawa 1965; Struktura demograficzna i zawodowa ludności, gospodarstwa domowe — wyniki ostateczne (Demography and occupational structure of population, households. Final results), Central Statistical Office, Warszawa 1972.

It follows from the Table that in 1960 only one out of four *poviats* was above the threshold, and only one out of nine reached the index value of 40%. Over the decade the situation has changed quite radically — more than half of all *poviats* are above the 30% value, and in one out of four the index value is more than 40%. The share of the non-agricultural, economically active population in the rural territory amounts to 50% or more in 39 *poviats* and to over 60% in 23 *poviats.*

The distribution of the index values reveal a pronounced spatial pattern. In 1960 the highest values were concentrated in the south-western parts of Poland, with some *poviats* having 50-60% of the rural labour force employed in non-agricultural activities. Examples are the *poviats* of Tychy — 73.2%, Tarnowskie Góry — 70.9% and Jelenia Góra — 60.8%. The lowest values occurred in the voivodships of Lublin and Białystok, where the majority of *poviats* had only about 6% of their rural labour force in non-agricultural activities. Generally, interregional differences are roughly proportional to the disparities in the overall urbanization level.

The rate of change during the 1960s was very high. While in 1960 the "occupational urbanization" index for Poland as a whole was 22.9%, by 1970 it already equalled 33.5% — the level typical of urbanized areas. The biggest increase took place in those regions where the "occupational urbanization" level in the rural areas had not been very high (the voivodships of Cracow, Rzeszów, Zielona Góra, and Kielce). The traditional concentration in south-western Poland expanded in a belt-like fashion, across the voivodships of Poznań, Bydgoszcz, Gdańsk, and (partly) Olsztyn Secondary concentrations developed around the urban agglomerations of Warsaw and Łódź. This pattern is in fact very similar to the pattern of overall urbanization as identified by K. Dziewoński (1964) who considered mainly the structure of the settlement networks, their dynamics, as well as migrations. The general spatial trend, i.e., the SW-NE direction in the occupational urbanization pattern, has been retained.

INDUSTRIALIZATION AND URBANIZATION IN THE RURAL AREAS

The main phase of industrialization in Poland (the "big push" period, according to A. Kukliński, 1964) started in the 1950s. The share of industry in the total capital outay increased from 38% in 1950 to 47% in 1951–1953, and became stabilized at the 43–40% level during 1954–1960. Total industrial employment grew from 1,984,000 in 1950 to 2,674,000 in 1955 and 2,975,000 in 1960.

The majority of new or expanded industrial establishments were located in the southern part of Poland. They formed the foci of the "occupational urbanization" in the rural territory — which was subsequently diffused into other regions. The basic spatial trend of urbanization is shown in Fig. 3.

After 1960 the industrial development grew in momentum again with large investments going to primary industrial branches and with an expansion of subsidiary establishments. The total industrial employment increased to 3,480,000 by 1965 and to 4,100,000 in 1970 with the resulting growth of its share in the national labour force from 20.4% in 1950 to 24.9% in 1960 and 26.8% in 1970 (or 124 employed per 1000 population). Over the whole period interregional dispartities in the industrialization level were substantially diminished.

In 1949 about one fifth of all *poviats* had less than 15 industrial employees per 1000 population. This category of *poviats* had nearly disappeared by 1972. At the same time, the percentage of *poviats* with 15–50 industrial workers per 1000 population dropped from 60 to 22. The biggest advance of industrial-

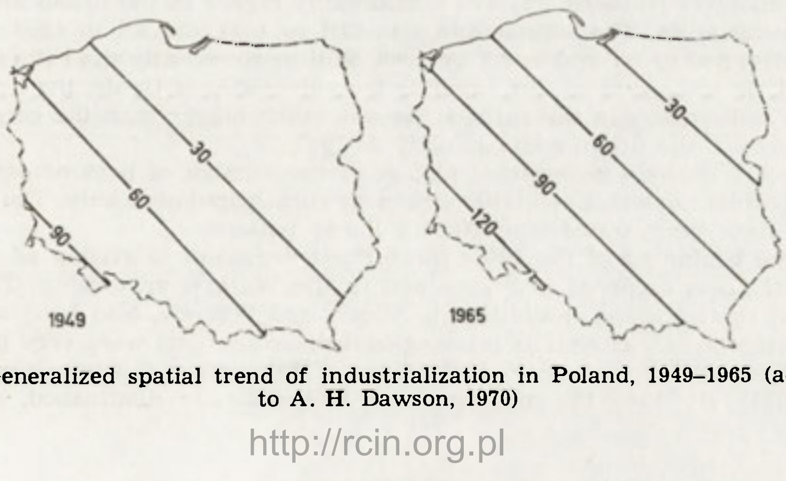

Fig. 3. Generalized spatial trend of industrialization in Poland, 1949–1965 (according to A. H. Dawson, 1970)

ization occurred in the voivodships of Kielce, Rzeszów, Olsztyn, Koszalin and Łódź — those which during the 1960s witnessed the greatest change towards the "occupational urbanization" of the rural population. This is related to the emergence and formation of new industrial districts, including the districts of Tarnobrzeg, Płock, Puławy, Legnica-Głogów, Turoszów, Rybnik and Konin.

The congruence of the basic spatial trends of industrialization and of the "occupational urbanization" within the rural areas supports the initial hypothesis, according to which urbanization phenomena in the rural areas are a function of industrialization. To prove the hypothesis to the full extend we would have to discuss the effects of the location of industrial plants over the rural territory. This problem, however, would call for separate treatment and some additional research.

TABLE 3. The level of industrialization by *poviats*

Year	Total number of *poviats*	Industrial employees per 1000 population (number of *poviats*)				*Poviats* with less than 50 industrial employees per 1000 population (%)
		below 15	15–50	51–150	over 150	
1949	391	77	156	99	59	59.6
1972	390	5	81	197	107	22.1

Sources: Data of the Industrial Census of 1966, Warszawa; Rocznik statystyczny powiatów (Poviats Statistical Yearbook), Central Statistical Office, Warszawa 1973.

INNOVATION DIFFUSION AND THE URBANIZATION PHENOMENA

The question of the interrelations between the innovation diffusion and the urbanization processes within the rural areas is limited here to the case of television diffusion over the period of 1961–1970.

On the basis of earlier research (J. Łoboda 1973) it is possible to put forth a hypothesis, according to which the spatial diffusion of television receivers in the rural areas of Poland has followed the pattern of urbanization. Television diffusion centres were initially formed in areas characterized by a high level of urbanization, and from those centres the innovation has subsequently spread into the surrounding territory.

During the early period of television development in Poland the number of new adopters (subscribers) was considerably higher in the urban areas than in the rural areas. The actual ratio was 19:1 in 1957 and 6:1 in 1960 while in 1965 it dropped to 3:1 and to 2:1 by 1968. Still more recently the ratio has been nearly 1. In some regions, for example the voivodship of Opole, the number of new TV subscribers in the rural areas was much bigger than the corresponding figure for the urban areas as early as 1967.

Figure 4 shows a generalized picture of the number of persons per TV set for individual *poviats*. Calculations refer to rural population only. The original isolines have been transformed into a linear pattern.

At the beginning of the 1960s the highest degree of television adoption in the rural areas occurred in Silesia and in the Warsaw voivodship. The main diffusion centres were in addition to Silesia and Warsaw, also Łódź and Poznań. Interregional, as well as intraregional disproportions were very pronounced — a feature typical of an early stage of innovation diffusion (see J. Łoboda 1974). By 1965 the disproportions had radically diminished, although some of the differences had been preserved. The line of 50 persons per TV set was separating (1) the western part with a high level of television adoption in the regions of Silesia and in the north-western voivodships from (2) the eastern part, with a much lower level of television adoption in the rural areas except for the diffusion centres around Warsaw, Łódź, Lublin, as well as the *poviats* of Ostrołęka and Przasnysz.

Fig. 4. Generalized spatial trend of television diffusion in the rural territory of Poland: 1961, 1965, 1970. Values represent the number of persons per TV set

By 1970 the initial interregional disparities in the level of television adoption had decreased manifoldly. However, in the south-western and central regions the adoption level was still much above the national average, while in some rural areas in the north-east and the south-east the diffusion process was greatly retarded. Generally it was found that the television diffusion pattern corresponded to the spread of the urbanization phenomena in the rural areas. Although this finding is based upon one kind of innovation only and therefore is subject to limitations, one should not rule out the possibility that other innovations diffuse over the rural areas in a broadly similar fashion.

CONCLUSIONS

The comparison of linear trends depicting the level of economic (and occupational) urbanization within the rural areas, the level of industrialization and the pattern of innovation diffusion, show that all these processes have run parallel under the socio-economic conditions prevailing in Poland. This finding supports the initial hypothesis, according to which:

— urbanization phenomena in the rural areas of Poland have been a function of industrialization;

— the spatial diffusion of television (as one of the contemporary innovations) over the rural areas has corresponded to the level of economic (or occupational) urbanization of the rural territory.

The role of urban centres in the spread of the phenomena in question has been pronounced.

It is suggested that the findings presented above should be further tested as they may also be of practical importance, particularly from the point of view of national settlement policies and the planning of rural areas.

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THE GROWTH POLE CONCEPT AND THE SOCIO-ECONOMIC DEVELOPMENT OF REGIONS UNDERGOING INDUSTRIALIZATION

MARIA DOBROWOLSKA

REGIONAL DEVELOPMENT AND ECONOMIC GROWTH: GENERAL REMARKS

Problems of regional development related to the rapid industrialization, urbanization and production concentration processes attract the research interest of the representatives of many socio-economic disciplines. These problems are considered within the growth pole approach as well as from the point of view of the factors of social and economic development. In the Western literature the concepts of F. Perroux (1955), a founder of the Institue of Applied Economics, are mainly developed, which emphasize the role of growth centres in economic development. Preliminary discussions on this theory within the framework of the contemporary social and scientific-technological transformations extending over the large areas of the world, lead to the conclusion that the growth pole theory should not be treated separately from regional dynamics as experienced within the two different socio-economic systems, i.e., the capitalist and the socialist system. Under the existing conditions as marked by the revolutionary socialist change the growth pole theory needs to be reevaluated from the philosophical perspective and the divergent value systems — the capitalist — economically dominated system and the socialist system which apprises the economic effects from the standpoint of social criteria.

In the discussions on the growth pole theory the original form as conceived by F. Perroux, detachment from real-world geographical conditions and a need of its empirical testing, are often emphasized. There are a number of interrelated problems and structural linkages which should not be separated from the linkages to the differentiated natural conditions, in particular to mineral and energy resources. The role of geographical environment, which is being formed and transformed by the interplay of two kinds of forces: the labour and organization of society, and the forces of nature, as released by industrial activity, can not be disregarded. This activity is no doubt the motive factor of socio-economic and cultural development, but it may be also sometimes a pole of the destruction of nature, endangering the biological life, and heritage of society.[1]

[1] We are especially concerned with those adverse effects of economic activity which follow from the rural of direct economic benefits, disregarding disfunctional effects. These problems are within the scope of interest of sociology, socio-economic geography and economics, and in a more narrow sense, of national sciences (the Man and Biosphere complex) which investigate degradations of the environment together with the factors responsible for degradations. See S. Leszczycki and Z. Tokarski (1970), S. Leszczycki (1972), A. S. Kostrowicki (1972), Z. Chojnicki (1972), W. Michajłow (1975), and *Problemy środowiska człowieka* (1971).

From the point of view of regional planning and the role of scientific research, a number of basic tasks emerge pertaining to the guiding of the socio-economic development at the national as well as at the regional level. These tasks have received consideration in the work of what is generally known as the Polish school of regional planning, in which geography plays a major port.

The place of industrialization in the process of growth centres formation is examplified by the expansion of urban agglomerations which now constitute the skeleton (see S. Leszczycki, P. Eberhardt, S. Herman 1971) of the spatial structure of the national economy. In addition, a number of industrial districts at the stage of formation and of urban-industrial centres, including Płock, Konin, Puławy, and Tarnobrzeg, are important components of the overall structure.

A number of scientific questions emerge (see J. Turowski 1974) concerning the tendency in the planned economy towards a balanced regional development and the levelling-out of the disproportions in living conditions and the opportunities for young people between industrialized and relatively undeveloped regions, as well as between the city and the rural areas. Among the controversial problems there are questions on the role of individual industrial centres and industrial branches in the processes of socio-economic and cultural development. There are substantial differences in this respect, both on the interregional scale and within the regions undergoing industrialization (see M. Dobrowolska 1970).

EMPIRICAL STUDIES ON REGIONAL SOCIO-ECONOMIC DEVELOPMENT

(1) *Theoretical assumptions.* The problems of socio-economic and cultural development are here approached from the point of view of the role of urban-industrial centres in the transformation of regional structures and the role of industrialization and urbanization processes. We refer to the regional, geographical interpretation of the growth pole as related to the concept of the development of nodal regions (see J. Grzeszczak 1971).

The analysis has been built around the function of industry and of industrial centres in the formation of growth foci and in the trasformation of rural hinterlands. The region is interpreted as a production complex — the highest form of concentration and the development of urban-industrial nucleations. Industrial centres perform both the functions of labour markets and transportation nodes on the interregional scale, and the role of gravitation centres in the exchange of goods, persons, and information with the surrounding rural areas. Their social and cultural functions as seats of numerous institutions of varied hierarchical levels, have also to be taken into account.

(2) *The study area.* Individual and team work on regional development, carried on under the direction of the author, has extended gradually into five regions in southern Poland: the Upper Silesian Industrial District together with its surrounding zone, the Cracow region, the Carpathian oil basin, the Tarnobrzeg sulphur region, and the so-called Old Poland industrial district (Kielce–Radom–Skarżysko-Kamienna). The methods used in the studies were described in an earlier article on: The structure of a region and of regional linkages (M. Dobrowolska 1967). Generally, the following methods have been used: (a) genetic analysis; (b) field work based on interviews with representatives of industrial and service enterprises and local institutions, as well as with individual farmers; (c) statistical and cartographic analysis. The purpose of the study was a comparative analysis of change as encountered in regions

differing in physiography, and historical development, as well as in the development of the technical-economic, and social infrastructure.

(3) *Functions of industry and regional growth centres: their structural and spatial differentiation.* In earlier studies (M. Dobrowolska 1960; M. Dobrowolska and J. Rajman 1965) the leading role of industry in the formation of regional centres and structures has been ascertained. These findings were based upon the study of several dozen industrial centres — both the old ones — formed during the capitalist period, and the newly developed centres. Interdependencies between industrial growth and the resource basis, and transportation

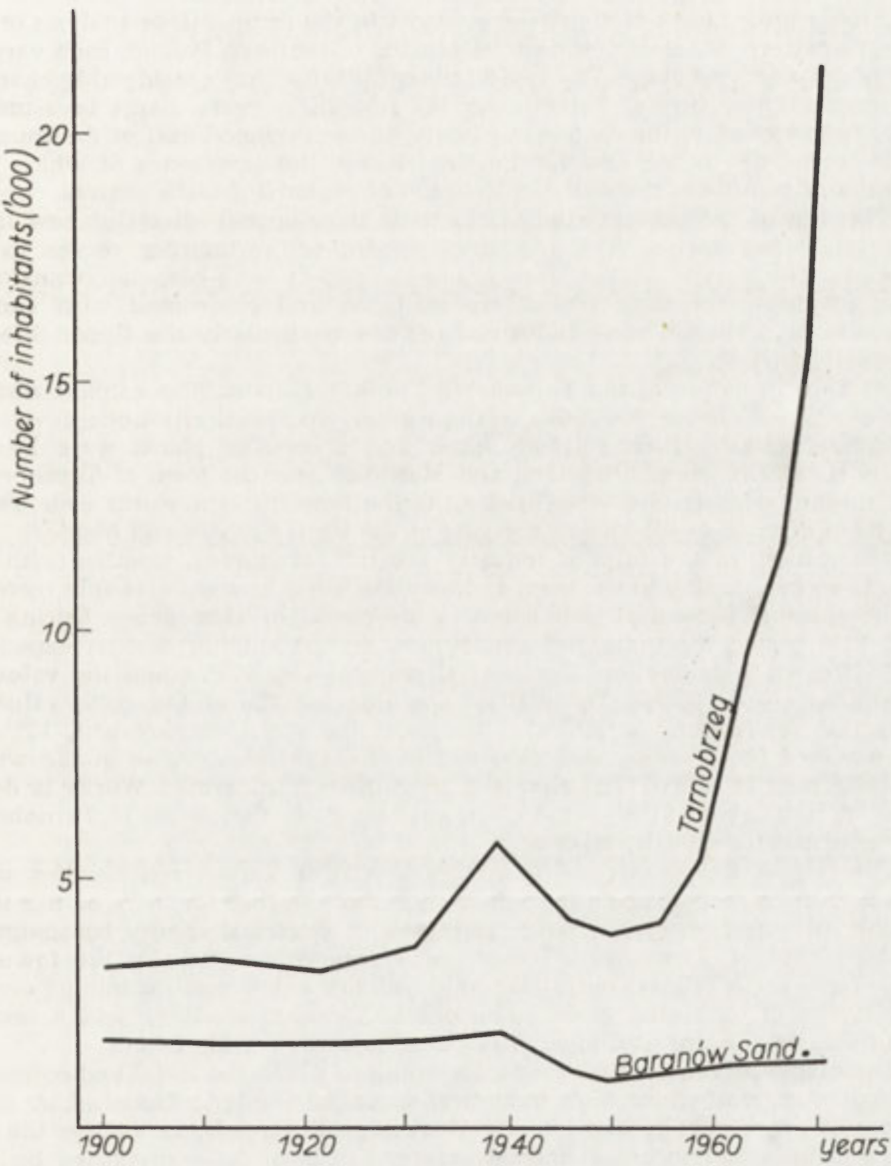

Fig. 1. Population increase of the towns in Tarnobrzeg Industrialized District, 1900–1972

networks, relations between the occupational structure and immigration, as well as the diverse consequences of those factors in regional development were traced. Considerable disproportions in the spatial distribution of industrial centres were found with resulting economic disparities in the interregional level.

It is possible to pose the questions: to what extent have those disparities been levelled-out during the planned economy period and what are the current tendencies? To what degree does the potential of newly developed industrial centres induce the development of regions, and alter the social structure of urban centres. What is its influence on the rural hinterland?

Answers to those questions were sought in the comparative analysis of the growth pattern of selected industrial centres in southern Poland, each varying in the development stage. The rapid industrialization has considerably changed the regional structure of Poland over the last thirty years. Large investments have been moved to the eastern, formerly underdeveloped part of the country; most recently — to the new Lublin Coal Basin, the emergence of which will eventually transform the existing patterns of regional growth centres.

The aim of the present study is to trace the regional effects of new large industrial investments. The industrial centre of Tarnobrzeg serves as an example. The growth of Tarnobrzeg and the recent socio-economic transformation of its surrounding region are analyzed and confronted with similar processes occurring in older industrial regions, particularly the Upper Silesian Industrial District.

(4) *The formation of the Tarnobrzeg Sulphur District.* The sulphur district was developed during the 1960's in the formerly economically underdeveloped Sandomierz Basin. First sulphur mines and processing plants were located in the rural villages of Piaseczno and Machów, near the town of Tarnobrzeg. The sulphur deposits discovered belong to the largest in the world scale, ranking third after the well-known deposits in the United States and Mexico.

The growth of the sulphur industry around Tarnobrzeg, together with the expansion of industry in the town of Nowa Dęba has brought a 14-fold increase in the value of industrial production in the *poviat* of Tarnobrzeg. During the 1965–1970 period the industrial employment in the sulphur district expanded by 152%, the consumption of electrical energy — by 273%, and the value of fixed assets — by 328%. The district accounts for 8% of the gross value of industrial production, for 10% of the total industrial employment, 13% of the value of fixed assets, and 20% of the electrical energy use in the whole voivodship of Rzeszów. The share of the Sulphur Integrated Works is dominant. In 1970 about 91% of the electrical energy in the *poviat* of Tarnobrzeg was used for industrial purposes.

The largest industrial centre in the district is Tarnobrzeg–Machów with its sulphur extraction and processing works, accounting for 38% of the total number of employees in industry and 74% of electrical energy consumption in the *poviat* of Tarnobrzeg. Other important centres include: the town of Nowa Dęba (24% of total industrial employment), a new sulphur mining centre at Jeziorko (27% of the gross value of industrial production), and a textile manufacturing centre at Skopanie oriented towards female labour.

The earlier advanced hypothesis, according to which the social and economic change in regions undergoing industrialization is heavily influenced by such factors as physiography and historical development trends, as well as the social, economic and technical infrastructure, has been fully supported by the studies carried out in the Tarnobrzeg district. The intensity of the urbanization processes in the district varies depending on the original development level.

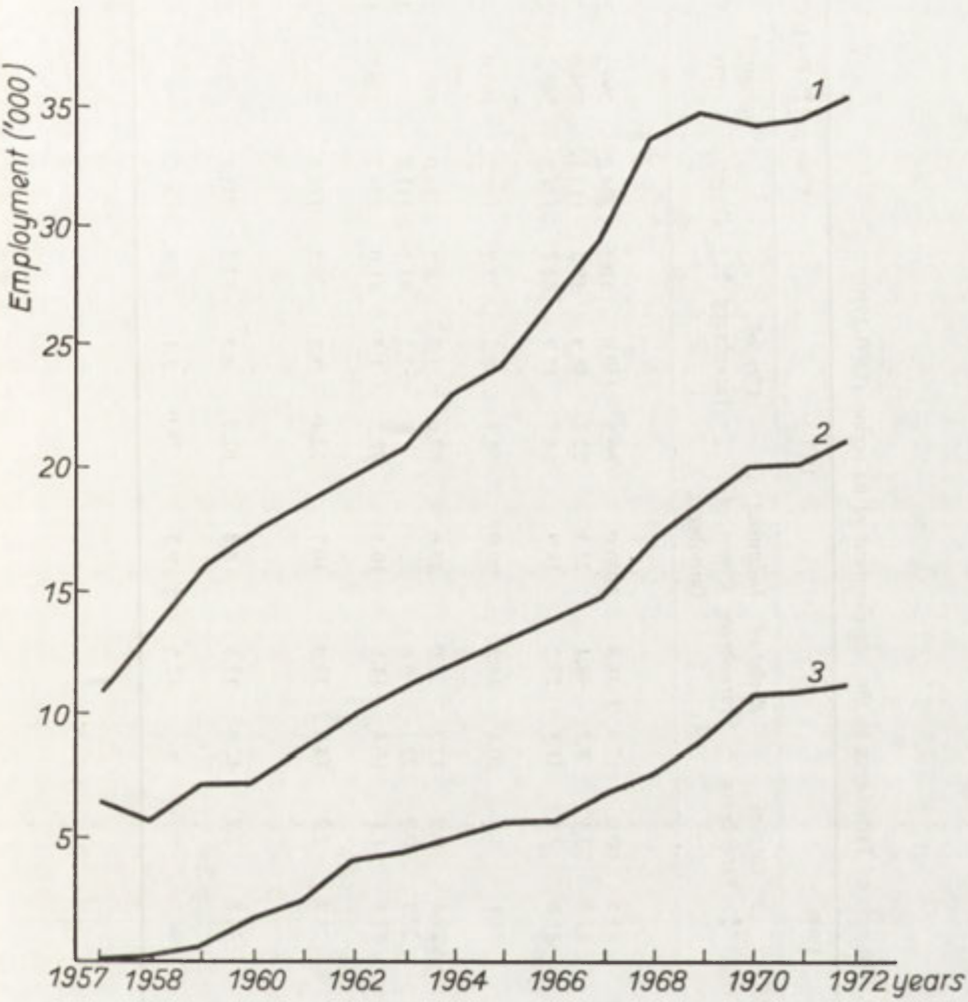

Fig. 2. The role of the Sulphur Plant employees in the non-agricultural employment increase of the Tarnobrzeg Industrialized District, 1957–1972

1 — non-agricultural employment, 2 — industrial employment, 3 — Sulphur Plant employment

Thus, the Sandomierz-Opatów Highland, situated on the left bank of the Vistula river, had been dominated by agriculture, while the local economy on the right bank of the Vistula had been of a mixed type, with agriculture, livestock production, forest economy and industry represented. In the fertile alluvial valleys of the Vistula, San and Wisłoka along the major transportation lines, a number of urban places had developed. In the growth process of the Tarnobrzeg district the leading role of industry in establishing basic transportation and energy transmission lines can be clearly demonstrated. The region, formerly disintegrated (in the 19th century it was divided by partition lines), has been covered by a network of bus and railway lines, connecting Tarnobrzeg with Warsaw, Cracow and Rzeszów. A dense local bus network has been developed, drawing a number of isolated rural settlement into the sphere of contemporary social and economic transformations, facilitating the commut-

TABLE 1. The role of Tarnobrzeg in the development of its region (1960–1970)*

Indices	1960					1970					Change (1960=100)		
	Poviat of Tarnobrzeg	Industrial Centre of Tarnobrzeg	%	City of Tarnobrzeg	%	*Poviat* of Tarnobrzeg	Industrial Centre of Tarnobrzeg	%	City of Tarnobrzeg	%	*Poviat*	Industrial Centre	City
Capital outlays in the public sector (million zl)	463.5	387.0	83.5	60.0	12.9	1548.3	1030.0	66.5	150.0	10.3	334.0	266.2	250.1
Population total (000)	87.0	10.9	12.5	7.1	8.2	98.4	22.3	22.7	18.9	19.2	113.1	204.6	266.2
Urban population (000)	17.0	7.1	41.8	7.1	41.8	29.2	18.9	64.7	18.9	64.7	171.8	266.2	266.2
Employment in the public sector (000)	17.3	6.6	38.1	3.6	20.8	34.3	20.0	58.3	8.2	23.9	198.3	303.0	227.8
Employment in industry (000)	7.1	2.8	29.4	0.9	12.7	21.0	13.6	67.6	1.7	8.5	283.0	495.7	188.9
In-migration (0000)	3.2	0.9	27.1	0.9	27.1	3.6	.	.	2.2	61.1	111.6	.	251.4
Commuters (000)	6.7	3.8	57.4	1.1	16.4	14.5	10.5	72.2	1.3	11.0	204.2	276.8	120.0
Labour force in non-agricultural activities	18.9	4.7	24.9	2.7	14.3	33.0	10.7	32.4	8.8	26.7	174.6	227.7	325.9
Labour force in non-agricultural activities (urban places)	6.3	2.7	42.8	2.7	42.8	13.3	8.8	62.2	8.8	62.2	211.1	325.9	325.9
Total capital outlays, 1960–1970 (billion zl)	×	×	×	×	×	12.5	9.5	76.0	1.1	6.6	×	×	×

* According to Z. Ziolo.

ation to work by the inhabitants of areas a high percentage of very small farms, and a high role of out-migration to France, Germany and the United States before the war. The peasant population of the region came into a direct contact with modern industry due to the latter's massive labour demand. Peasant farms have became rapidly electrified. The development of the power transmission network has rapidly accelerated the modernization processes within rural areas, including the mechanization of agriculture and the equipment of households with modern appliances. The expansion of radio and television ownership and their effect upon social and cultural patterns has also to be emphasized. A detailed analysis by B. Gorz of a sample of 360 rural households, has revealed sizeable differences in the use of electrical energy between the industrialized regions of Tarnobrzeg and Stalowa Wola on one hand and the predominantly rural *poviats* of Staszów and Kolbuszowa on the other.

TABLE 2. Population migrations. The *poviat* of Tarnobrzeg

Year	In-migration			Out-migration			Balance		
	Total	To urban places	To rural areas	Total	To urban places	To rural areas	Total	Urban places	Rural areas
1960	2,148	934	1,214	1,927	717	1,210	+221	+217	+4
1961	1,977	876	1,101	1,722	669	1,053	+255	+207	+28
1962	1,998	997	1,001	2,007	724	1,283	−9	+273	−282
1963	1,666	906	760	1,180	593	647	+486	+373	+113
1964	2,345	1,354	991	1,979	940	1,039	+366	+414	−48
1965	2,739	966	1,773	2,072	675	1,397	+667	+293	+376
1966	2,395	1,217	1,178	1,966	570	1,396	+429	+647	−218
1967	2,599	1,442	1,157	2,092	668	1,424	+507	+774	−267
1968	3,044	1,547	1,497	2,301	741	1,560	+743	+806	−63
1969	2,269	1,762	1,507	2,373	741	1,632	+896	+1021	−125
1970	3,605	2,527	1,078	2,879	937	1,942	+726	+1590	−864
		14,528	13,257		7,975	14,583			

Compiled by Z. Bobek from primary population registers.

(5) *The labour market functions of regional centres.* The analysis of the individual factors of regional growth in the Tarnobrzeg district — the sulphur industry, the power and transportation network, and the change in social and occupational structure of the local population — shows the existence of a chain of linkages and feedback effects between the advance of industrialization and that of urbanization. Parcelled to the expansion of new industry and infrastructure, new labour linkages are formed within the polycentric pattern of industrial centres, including Tarnobrzeg-Machów, Stalowa Wola–Rozwadów, Nowa Dęba, and the Sandomierz–Nadbrzezie–Gorzyce centres. All these are important local labour markets, although they are relatively small on the national scale. The rapidly growing demand for labour by new mining, manufacturing and construction establishments generated large-scale streams of commuters from rural areas and small stagnant service towns. The range of commuting increased between 1960–1970 from about fifty to about one hundred kilometres, drawing into the sphere of daily contact the inhabitants of the adjacent parts of Rzeszów, Kielce, and Lublin voivodships. The streams of

permanent migration to Tarnobrzeg and Stalowa Wola originating in a number of places throughout the country. During the first stage of construction of the industrial plants these streams consisted mainly of highly-skilled workers and technicians from the chemical industries of Upper Silesia, Cracow and Lower Silesia. In relative figures the majority of commuters and migrants came from the poviat of Tarnobrzeg itself (over 50%) and from other *poviats* of Rzeszów voivodship. During the second stage, i.e. 1965–1970 the percentage of dependents in the total number of migrants markedly, increased as a consequence of major housing development in the city of Tarnobrzeg which assumed the role of the main residential area for the Sulphur Integrated Works, in addition to its functions as an administrative, managerial and commercial centre.

TABLE 3. The immigrating population in towns of Tarnobrzeg region, 1950–1960

Towns	Number of immigrants		Share of family members in the total number of immigrants	Percentage of males among immigrants	Children and persons over 60 years old per 100 persons in productive age
	total	per 100 inhabitants (as of 1950)			
Baranów Sandomierski	185	14.1	40	48.5	28.4
Kolbuszowa	413	16.7	70	45.0	31.5
Mielec	5919	26.9	79	47.2	24.7
Nisko	1024	12.3	67	46.8	30.6
Nowa Dęba	2500	52.0	88	46.8	30.8
Radomyśl Wielki	87	8.6	69	48.2	24.2
Rozwadów	453	15.8	59	47.8	30.6
Rudnik	341	6.1	68	55.3	40.8
Sandomierz	1800	13.9	32	43.2	47.5
Sokołów Małopolski	100	4.2	60	46.0	42.8
Stalowa Wola	6900	30.0	78	45.3	36.6
Staszów	674	11.5	61	46.1	26.2
Tarnobrzeg	1702	26.6	76	45.8	38.2
Ulanów	103	7.0	66	47.5	39.1

In the case of Tarnobrzeg region our earlier findings, based upon an analysis of other industrial centres together with their zones of influence, have been sustained. It was found that the labour market and migration linkages are of a critical importance in: (a) the demographic growth of urban-industrial centres (also reflected in stagnation and degradation of small towns which become centres of outmigrations), (b) the change in the demographic structure (a growing percentage of young people) and in the occupational structure (growing percentage of the working population), (c) the growth of the population density in suburban zones and the "occupational urbanization" (or "semi-urbanization") of rural areas.

Statistical data and the relevant cartographic material show that the population increase in the Tarnobrzeg district due to migrations is similar to that of other regions undergoing industrialization, including the Puławy, Konin and Płock districts although it is only one half of the respective figure for the newly developed coal mining district of Rybnik. Transitory migrations to the Sulphur district are also sizeable: during 1960–70 the gross immigration equalled 28,800 persons, while the gross outmigration was 24,000 persons. The positive migration balance of the Tarnobrzeg *poviat* contrasts with a negative balance of the surrounding rural *poviats*.

J. Herma (1968) and others analyzed the structure of the in-migration population (both family heads and their dependents) during the periods of 1960–1964 and 1965–1970. It was possible to estimate the percentage of the population living in the area since they were born, and the percentage of in-migrations with a breakdown into categories of age, formal education and also occupational skills. Generally speaking, changes which occurred in the social and occupational structure of the population throughout the decade of the 1960's

TABLE 4. Migrations to towns of Tarnobrzeg region, 1960–1970

Towns	Total in-migration	From the same *poviat*			From other *poviats* within Rzeszów voivodship			From other voivodships		
		Total	Urban places	Rural areas	Total	Urban places	Rural places	Total	Urban places	Rural places
Tarnobrzeg	10,416	3,046	411	2,635	2,715	1,343	1,372	4,612	2,340	2,272
Baranów Sandomierski	735	270	40	230	197	68	129	254	106	148
Nowa Dęba	2,491	412	70	342	1,035	360	725	958	636	322
Rozwadów	1,414	423	37	386	537	349	138	448	210	238
Stalowa Wola	11,683	—	—	—	7,383	2,594	4,989	4,250	1,887	2,363
Nisko	3,056	1,177	153	1,024	960	681	279	890	734	156
Rudnik	1,472	589	112	477	379	220	159	491	349	142
Ulanów	387	183	56	127	94	63	26	102	81	21

were quite radical. A new city was virtually formed, dominated by the working population, with a high percentage of young families, and a majority of jobs in industry and construction. The development of vocational schools, including those run by industrial enterprises, facilitated a rapid progress in the educational level and skills (A. Krakowska 1969, 1974). Interviews and questionnaires have shown a tendency towards the stabilization of crews, despite rather difficult working conditions (high air pollution) in the sulphur industry. At the same time sizeable transitory migrations from the rural areas to small towns and then to the major industrial centres have been recorded. Similar phenomena accompanying the processes of industrialization have been described in a number of sociological studies, by authors such as Pohoski, Nowakowski, Malanowski and Kołodziejski.

In those changes the leading part was performed by the employees of the Sulphur Integrated Works, as was shown by the study of I. Turczyn-Zioło, who analyzed the social structure of the crew before 1962 and during the 1963–1970 period. She found that at a later date about 65% of the Works employees were residing in the city of Tarnobrzeg, and that labour, organizational and cultural linkages between the city and the mining and processing centres of Machów, Piaseczno and Jeziorko, situated in the 7–10 kilometre radius, have become substantially stronger.

All this suggests a growing integration of settlement and economic pattern and the development of Tarnobrzeg as a regional multifunctional centre combining the administrative, service, production, transportation and residential functions. Thus, Tarnobrzeg may be treated as a "growth pole" on a supra-local scale. An important planning task is the rational division of functions between Tarnobrzeg and the older centres of Stalowa Wola and Sandomierz which together form a backbone for the developing, polycentric industrial district at the junction of the Vistula and San rivers. The studies also show a tendency towards an administrative integration of the historical district (*poviat*) of Sandomierz, which was disjointed by the late 18th century partitions of Poland. The formerly integrating factor which was the water navigation system of the Vistula and San has now been substituted by the network of railway and bus transportation. Of course, the economic structure has changed completely, with mining and manufacturing assuming the formerly dominant role of agricultural and forest economy.

(6) *Regional functions of the Sulphur Integrated Works.* These functions are not limited to the area of the growth centre itself. A large labour demand by the plant resulted in the formation of a broad zone of its influence, as

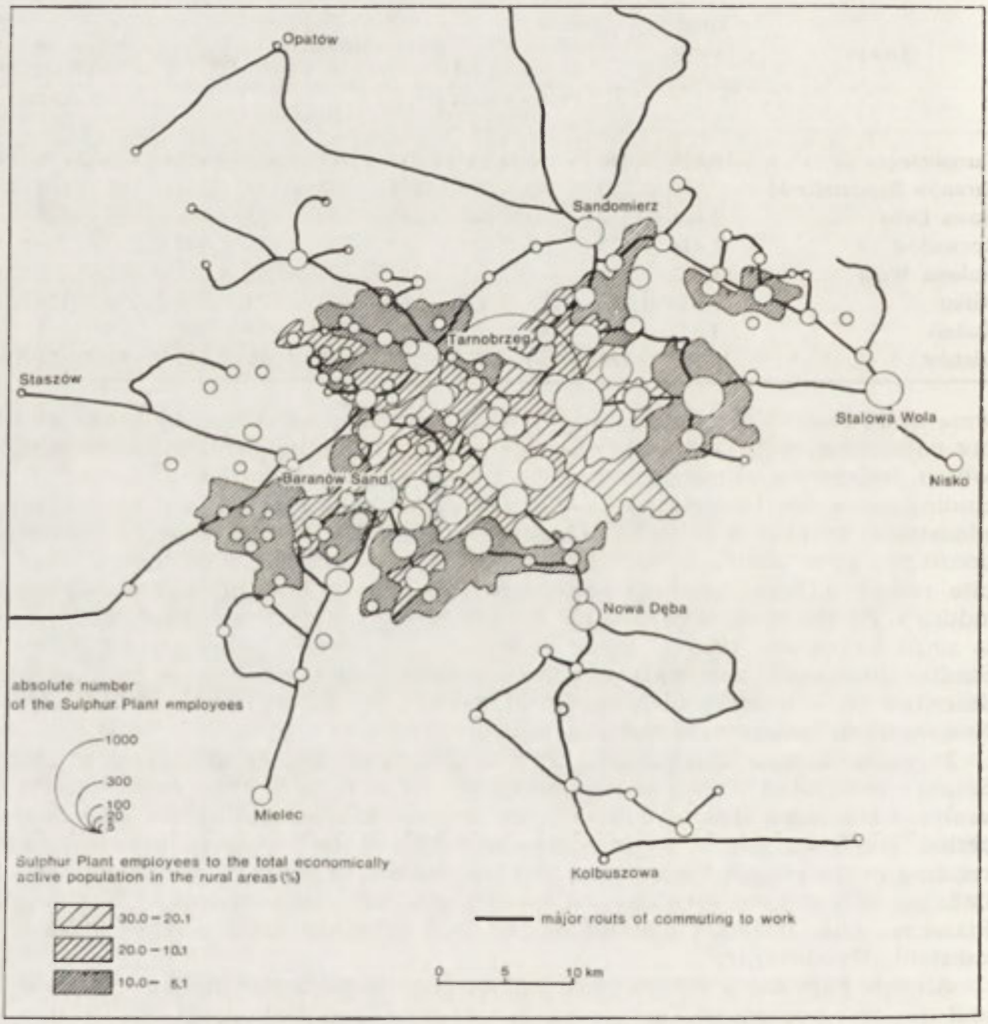

Fig. 3. Production-settlement complex of the Sulphur Integrated Works

illustrated by the map showing the distribution of the places of residence of the plant's employees. This zone, together with the central area, constitute a production-settlement complex at the stage of formation, and a basic component of the spatial structure of the region. In its changing scale, its spatial patterns and in the growing education level and skills, the role, and interdependences between the processes of industrialization and urbanization are reflected. One of the characteristic features of the spatial pattern is a negative correlation between the level of skills and the distance travelled to work. A high percentage of skilled labour lives within the 30 minutes isochrone from their place of work, while the majority of non-skilled workers, particularly construction workers, commute to work from a belt of rural villages over distances of up to one hundred kilometres. One of the results is a territorial differentiation of the "occupational urbanization" or "semi-urbanization" phenomena related to the processes of industrialization.

THE FORMATION OF PRODUCTION-SETTLEMENT COMPLEXES AND THEIR SOCIO-OCCUPATIONAL STRUCTURE

The concept of production-settlement complexes, which develop on the basis of labour linkages has been empirically substantiated by a number of studies on the regions of Cracow, Tarnobrzeg (T. Jarowiecka 1962, 1967), the outer zone of the Upper Silesian Industrial District (J. Rajman 1969), and the Kielce-Radom-Skarżysko-Kamienna district (Cz. Szewczyk 1963). Those studies portray the emergence and spread of the peasant-worker category and the development

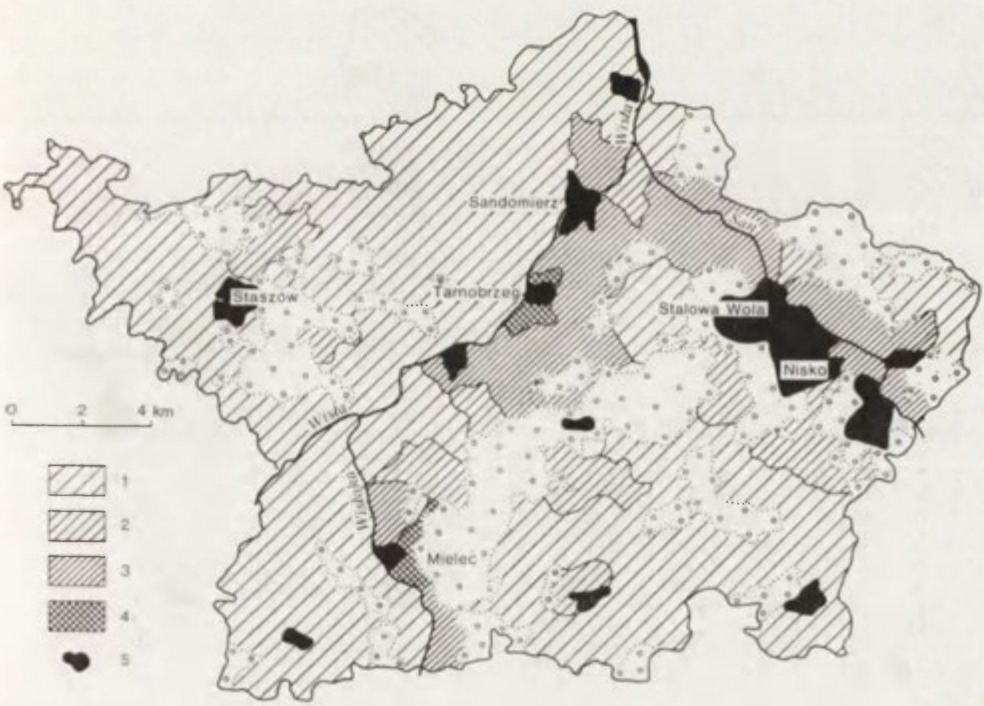

Fig. 4. Population employed in non-agricultural sectors, 1960. The percentage of rural population with income coming from non-agricultural jobs
1 — below 30, 2 — 30.1–40, 3 — 40.1–60, 4 — over 60, 5 — towns

of workers' settlements along transportation lines, and their growing density around the urban-industrial centres.

In the Sulphur district these processes are of a major magnitude. They were triggered-off by both the labour demand on the part of industry and the pre-existing rural overpopulation, in the surrounding region. A complex cross-commuting pattern acts as a factor integrating the concentrations of the peasant-worker population and accelerates the urbanization processes in the tributary areas. Their spatial patterns closely correspond to the networks of bus and railway transportation and their changes (M. Dobrowolska 1959; J. Herma 1965).

An important element in the chain of urbanization phenomena is the growing income from sources other than agriculture. Its share may serve as an index showing the intensity of ties of a particular rural area with urban and industrial centres. The percentage of income coming from non-agricultural sectors shows also the prevailing type of relations of the rural population to the land — traditionally the basis of sustenance. The farms, subdivided into garden and building lots reflect the peasants' changing attitudes, values and life styles. Income derived from jobs in industry, construction, transportation, and more recently also in other tertiary activities is most clearly seen in the rapid growth in the number of new houses in the rural areas. The changing value systems affect particularly the young, who more and more frequently link their future and standards of living requirements with industry and new employment opportunities. Even those remaining on the land connect their future living with additional income from non-agricultural sources.

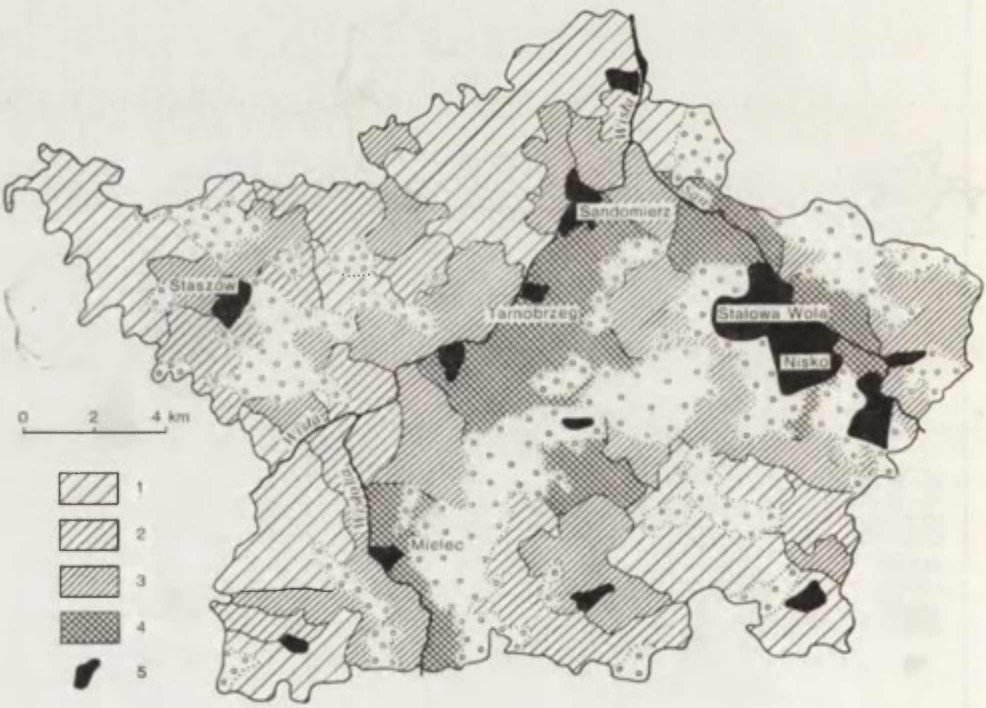

Fig. 5. Population employed in non-agricultural sectors, 1970. The percentage of rural population with income coming from non-agricultural jobs
1–5 cf. Fig. 4

In the rural areas of the Tarnobrzeg region these changes have been rather recent, nevertheless during the 1960–1970 decade their rate was already very high. A detailed analysis of family structure, the occupational characteristics and those related to land ownership was conducted by T. Jarowiecka who studied a sample of households in 357 rural villages. Statistical and cartographic analysis allowed the drawing of the following conclusions:

(a) The spatial patterns of the developing socio-occupational structure are organized around the urban-industrial centres of Tarnobrzeg, Stalowa Wola, Nowa Dęba, Sandomierz and Mielec.

(b) The spatial patterns are superimposed on and related to, the old transportation routes of the Vistula and San valleys, and to the network of medieval urban places, including Mielec, Tarnobrzeg-Dzików, Sandomierz and Opatów.

(c) There are marked spatial differences in the intensity of urbanization phenomena. The areas situated on the left banks of the Vistula remain predominantly rural, while on its right bank the percentage of the non-agricultural rural population is generally over 50% and exceeds 70% in a number of rural villages. In the vicinities of Tarnobrzeg and Stalowa Wola the respective index is about 80–90%. Further to the south large areas are covered by the Sandomierz Forest. Only in the vicinity of the town of Kolbuszowa which goes back to the 16th century, is a cluster of peasant-worker villages found. The influence of Tarnobrzeg reaches deep into the forest, along the Kolbuszowa transportation line.

THE DEVELOPMENT OF AN URBANIZED ZONE WITHIN THE REGION OF TARNOBRZEG

We have emphasized in the preceding sections some of the territorial differences in the advancement of urbanization which occur in the region under investigation. Their specific forms are related to a low level of economic development and a high degree of rural overpopulation, as inherited from pre-World War II periods. (Still in 1960 there were over 80 persons per 100 hectars of agricultural land in some parts of the region, despite a sizeable outmigration to the Northern and Western regions during the 1940's and rapid rural-urban migration during the 1950's). The emergence of modern, large industrial plants and an expansion of local towns brought new employment opportunities to the rural population the majority of which was living on small and very small farms.

During the first stage, i.e., the 1960–1970 decade, the spread of the urbanization phenomena could be observed mostly around the industrial centres, and, generally, east of the Vistula. In more distant areas transformations were occurring mostly along the transportation lines. More recently the "Occupational urbanization" zone has expanded considerably (with a parallel rapid expansion of bus networks) although west of the Vistula it does not extend beyond a relatively narrow strip along the river.

We have based our analysis of the urbanization zone formation on the following criteria:

(a) The percentage of family heads and other family members employed in non-agricultural activities;

(b) The development of clusters of workers' and peasant-worker settlements, differentiated in terms of socio-occupational structure;

(c) The level of education and skills;

(d) The size of income derived from employment in industry in each rural household;

(e) The percentage of farms with electricity;

(f) Changes in housing stock: the level of investments in housing and the percentage of dwelling units with more than two rooms.

Values of those indices give a tentative evaluation of the degree to which the peasants' community has been transformed into the workers' community. A more detailed picture gives the analysis of the nature of ties which the inhabitants of the rural areas maintain with their farms on the one hand and with their employment places on the other. A job in industry means a gradual change in the lifestyle of a peasant a relaxation and even a desintegration of the traditional local communities (see M. Dobrowolska, 1968). Changes in the socio-occupational and demographic structure are also accompanied by changes in the sphere of material culture, building forms and equipment. The land ownership structure as well as the production profile of agriculture is gradually altered with the subdivision of farms into building lots and a shift to less labour-intensive crops.

A zone undergoing urbanization maintains a double kind of socio-economic linkages — with local communities and with urban-industrial centres. It is characterized by a multitude of forms, of intermediate stages and by an irregular rhythm of change. Differences in the social and occupational structure can be traced within individual rural villages and frequently even within individual households. The family head may be employed in a different sector and location than the other household members, their educational level, skills, working conditions and earnings may also differ substantially. Variations in farms' product profile and productivity level further complicate the general picture.

In the Tarnobrzeg Sulphur District we have found a number of rural villages and even individual households whose members travel to employment places at Tarnobrzeg, Machów, Stalowa Wola, Nowa Dęba or Gorzyce, hold jobs in industry, construction, transportation or services. These involved linkage patterns attest to a development of a complex socio-economic and settlement structure within the zone undergoing urbanization. This complexity can be only partially reflected by statistical indices.

The identification and understanding of those variations and complexities is an important task from the perspective of a planned economy. Equally important is their spatial manifestation. In our studies on a number of urban-industrial centres and their influence zones in southern Poland we have found marked variations and iregularities in the size, extent and forms of the spatial patterns of the urbanization phenomena. One general rule that we have been able to ascertain is the tendency towards a grouping of individual components of socio-economic and cultural change in the industrial centres and their accretion proportional to the time-distance function. As a result, the inter-related components of socio-demographic, economic, settlement and cultural change cluster along the transportation lines. Thus, a sectoral rather than a concentric growth pattern is typical of all the investigated regions of southern Poland.

In the region of Tarnobrzeg this multi-linear, sectoral pattern reflects the old historical network of transportation routes, and the subsequent development pattern of towns, population densities and the spatial trend in the socio-economic and cultural change. In the region of Opole and Racibórz (a part of Silesia) the spatial pattern of urbanization is determined by the contrasting loess and sandy soils on the two banks of the Odra river. Also the region of Cracow, a zone undergoing urbanization, shows few concentric forms, with most of the new development appearing south and south-east of Cracow (near the historical centres of Wieliczka and Skawina), as well as along the

Cracow–Tarnów transportation line. Areas situated to the north and west of Cracow have much lower values of the indices of socio-economic and technological development, despite their rich soils and a productive agriculture.

A synthetic picture of the range of urbanization phenomena in the region of Tarnobrzeg can be presented as follows:

(A) The technical urbanization zone, which is directly formed by the sulphur industry. It comprises two sub-zones:

(a) the developed areas, including the open-pit sulphur mines at Piaseczno, Machów, and Jeziorko, the sulphur processing plants, areas covered by waste-heaps and waste-dump water reservoirs,

(b) the areas for the future expansion of mining and industry. Their extent will be determined by the occurrence of sulphur deposits.

(B) The social-demographic and occupational urbanization zone, the structure of which has been described earlier.

The extraction and processing of sulphur brings serious environmental problems. Therefore, the situation and size of the protective zone is of critical importance. The present expansion of the technical urbanization zone may suggest that it may eventually absorb the whole area originally allocated for protective purposes. Therefore, the latter has to grow outwards. The settlement pattern is also affected by the expansion of mining and processing operations.

CONCLUSIONS

(1) We have discussed the growth of industry as a motive factor in the development and change occurring on the regional scale. Its linkages with individual components of the regional structure have been shown. We have attempt to identify the complex chain of interdependencies and feedback effects between the production capacity, the structure of the labour market, the intensity of migrations, the expansion of growth centres and the formation of zones undergoing urbanization.[2]

Studies on a number of individual centres in southern Poland have shown that the intensity and spatial patterns of socio-economic transformations are heavily influenced by the geographical environment, the historical milieu and the development stage of the technical, economic and social infrastructure.

Particular attention has been devoted to the study of linkages between industrial centres and the rural areas surrounding them. It is possible to conclude that the intensity of those linkages and their stability level is dependent on: (a) external factors (i.e., governmental policies, general socio-economic and political system, (b) natural factors, including physiography, and mineral resources, (c) historical factors and the technical infrastructure.

(2) The system of structural and functional interdependencies is extremely complex both in its substance and in spatial patterns. As a matter of fact, a number of individual spatial patterns may be identified. The growth centres of Tarnobrzeg, Stalowa Wola, Sandomierz and Nowa Dęba have developed their linkage patterns on a local scale, but also on the regional and national scale. In a comparison of their development with the respective processes in other industrialized regions we have found that the rate and directions of the growth of production and service functions closely correspond to the level of the technical and economic infrastructure of regions.

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[2] The role of migrations in the economic progress and urbanization processes was discussed by V. I. Lenin in his *The development of capitalism in Russia* (Moscow, 1960 edition).

(3) The analysis of the initial stage of industrialization processes within the Sulphur District (the 1960–1970 decade) indicates that:

(a) Large investments in industry, power, transportation and housing, related to the development of the Sulphur Integrated Works have initiated a phase of dynamic socio-economic and cultural growth within the region.

(b) Highest growth rates characterize the central area, i.e., the industrial centre of Tarnobrzeg with its four-fold increase in industrial employment. This in turn has generated large scale in-migrations and a general expansion of the town which is now the main residential area for the employees of the Sulphur Integrated Works.

(c) One of the consequence is a development of institutions of regional and supra-regional range. Their employment has expanded in Tarnobrzeg much faster than in other administrative centres of a comparable level.

(d) Economic growth is followed by social change. It is reflected, among other things, in the growth of highly skilled staffs and of various forms of supplementary education. The expansion of cultural functions of Tarnobrzeg should also be noted.

It has been found that the newly formed labour markets have generated (a) large-scale commuting to work, (b) a large-scale development of housing construction in the rural areas and the growth of new settlement forms, (c) the formation of production — settlement complexes and zones undergoing urbanization, closely connected with the employment and urban centres. These developments are interrelated with the expansion of transportation and power transmission networks.

The new and the older developing industrial centres perform the role of regional growth poles which function on the basis of feedbacks between industrialization and urbanization processes. Some of the results are: (a) the shift of the rural population from agricultural to non-agricultural activities, (b) the development of territorial concentrations of the peasant-worker and working population, (c) the rapid development of housing and its growing standards, (d) the growth of aspirations and the spread of urban lifestyles.

Both the role of development and the transportation level are functions of technological development. Thus, scientific-technological progress together with large investments in mining and industry have brought basic structural transformations and an increase in living standards to a formerly underdeveloped, primarily agricultural region.

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GEOGRAPHIA POLONICA 33, 1976

AN APPLICATION OF FACTOR ANALYSIS TO DEMOGRAPHIC REGIONALIZATION

ADAM JELONEK

Factor analysis is a technique which is helpful in dealing with large statistical aggregates, described by a number of variables. It allows the isolation of multi-variable groupings of units and the reduction of the original set of variables into a smaller number of factors; therefore it may help to identify certain links or dependencies, which might otherwise go unnoticed. The technique, of course, has some important shortcomings. Thus, the results obtained reflect all the weaknesses of the initial arbitrarily selected sets of information. Identification of common factors and a conversion from typology to regionalization also presents problems which might be difficult to solve.

The present analysis was based on the Jacobi-Hotelling principal components method, the *R* technique and orthogonal Varimax rotation. Computations were performed on the Polish ODRA 1204, in ALGOL 1204. The aim of the study was demographic regionalization in the case of Poland. Such a regionalization is of a complex (or multi-dimensional) type as regards demographic phenomena whilst it may be treated as single-dimensional in relation to general economic regionalization.

A region is interpreted here as a continuous area, uniform with respect to demographic features which are mutually interconnected. Regionalization procedure consists in identifying areal classes obtained *via* grouping of "individuals" or basic areal units. In the present study units were represented by 396 *poviats*. One of the basic requirements is territorial continuity of regions — a specific feature of regionalization — when confronted with other classification or typological procedures. Regionalization, therefore, consists of two stages of analysis:

(a) areal typology and interpretation of areal patterns,

(b) delimitation of regions, or continuous areal types using broader similarity intervals.

The regionalization procedure applied in the present study covered the aggregation of similar and territorial contiguous areal units. In those cases when this approach proved unfeasible, units of a higher order, built of a certain number of basic units, were identified. In the spatial pattern obtained certain types occur repetitively. To overcome this problem a two-level division was used in which regions are treated as unique, while individual subregions may have similar features, whilst differing in location.

Statistical information included all the data collected by state statistical offices which pertained to population characteristics by territorial divisions. The basic data were those from the National Census of 1970. 26 characteristics included in the observation matrix pertained to: population distribution (density per sq.km, percentage of the urban population), vital statistics (marriages, births, and deaths per 1000 inhabitants, the infant mortality rate), migrations (net migrations as a per cent of the average population figure for 1961–1970), sex composition (percentage of males), age structure (percentage of the population in age groups of: 0–18, 19–59, 60 and over), family size (average number of persons per household), occupational structure (seven characteristics referring to employment in agriculture and in other economic sectors in relation to the total population and total labour force; for characteristics referring to the population living on private farms and the population earning their living from industry, construction, and transportation as a percentage of the total population), education (the percentage of persons with college and secondary school education), housing conditions (average number of persons per room).

On the basis of the analysis it was possible to identify six factors explaining 82.30% of common variance. The first three factors were considered important in further typology and regionalization, although in the following analysis all the computational results obtained were taken into account.

TABLE 1. Factor structure

Factor	Eigenvalue	Common variance explained by factor	
		% explained	cumulation % explained
F_1	11.331	43.58	43.58
F_2	4.827	18.56	62.14
F_3	1.591	6.13	68.27
F_4	1.410	5.42	73.69
F_5	1.128	4.34	78.03
F_6	1.109	4.27	82.30

Factor F_1, which explains 43.58 per cent of the total variance, is the major factor, and, at the same time, one very difficult to interprete because it comprises a large number of highly intercorrelated variables. Among the features correlated positively with the factor those pertaining to socio-economic structure, high percentage of young persons, and high birth rate, are dominant. Negative factor loadings and the number of negatively correlated variables is higher; these variable relate to industrialization and urbanization and include such features as: occupational structure, population distribution, educational level, the percentage of persons in productive age, and migrations. Generally, the factor describes the *social and occupational structure of the population* and reflects the impact of industrial development and urbanization on population characteristics.

Factor F_2 explains 18.56% of the total variance and is positively correlated with variables referring to the percentage of persons in post-productive age and the death rate. Negatively correlated variables include those describing the percentage of males and of the 0–18 age group. We can therefore label this factor as the factor of *age structure and death rate*.

Factor F_3 accounts for only 6.13% of the common variance and is positively correlated with the percentage of the economically active population. It can be denominated the *labour force participation factor*.

Factor F_4 had no loading values of over 0.500. When taking into account the variable with the highest loading we can identify this factor with the *size of farm households*, or the number of non-working household members per family head earning their living from agriculture. Finally, Factor F_5 refers to *marriages*, and Factor F_6 to *infant mortality*.

In order to obtain demographic typology, factor scores were grouped into classes of maximum homogeneity. A general rule followed was the division of scores into three classes with negative values. Class intervals were set differently for each factor as frequency distributions of factor scores differed. It was assummed that individual classes represent distinct types. In searching for spatial regularities it was decided to group first the areas with positive or negative scores, and then to consider class intervals, particularly with respect to the highest and lowest scores.

Maps showing spatial distribution of factor scores indicate that although the basic areal units (*poviats*) of a given type tend to form clusters, they are usually intermixed with units representing other types. The distribution of F_1 scores is most essential both for typology and demographic regionalization (Fig. 1). The positive scores of this factor represent mostly social and economic characteristics typical of an agricultural population, while its negative scores express industrialization and urbanization phenomena. The spatial pattern of F_1 has brought to light one of the basic contemporary socio-economic processes which finds its expression also in demographic structure. Region-

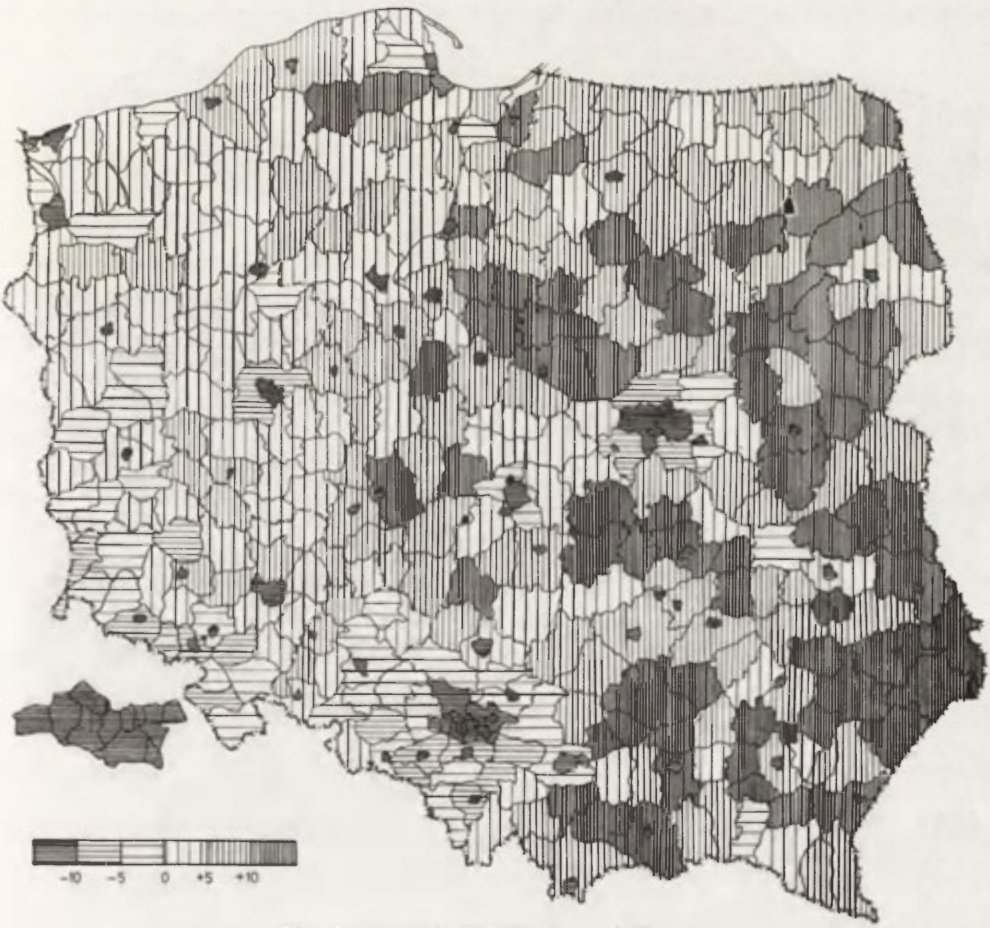

Fig. 1. Spatial distribution of F_1 scores

alization based solely on F_1 would be, however, partial. The patterns of F_2 and F_3 scores (Figs. 2 and 3), and, to a lesser extent of F_4 and F_5 scores, suggest the existence of a dividing line running in a NE-SW direction. In those pattern the phenomena and processes have mainly been expressed which were related to post-war migrations and the settling of northern and western voivodships. The patterns discussed also take account regional variations in agricultural characteristics such as a high percentage of large, state- and co-operative farms in the north-west and a predominance of small, owner-occupied farms in the south-east.

It follows from the above that none of the factors identified can serve as an exclusive basis for demographic regionalization fulfilling the assumptions of the present study.

Two-factor typology is based on the distribution of individual areal units in two-dimensional orthogonal space. Six factors identified could produce fifteen combinations, when paired. However, the patterns of F_1 and F_2 were selected, since they explain the highest percentage of the common variance. We find that after rotation the majority of points cluster near to the F_1 axis,

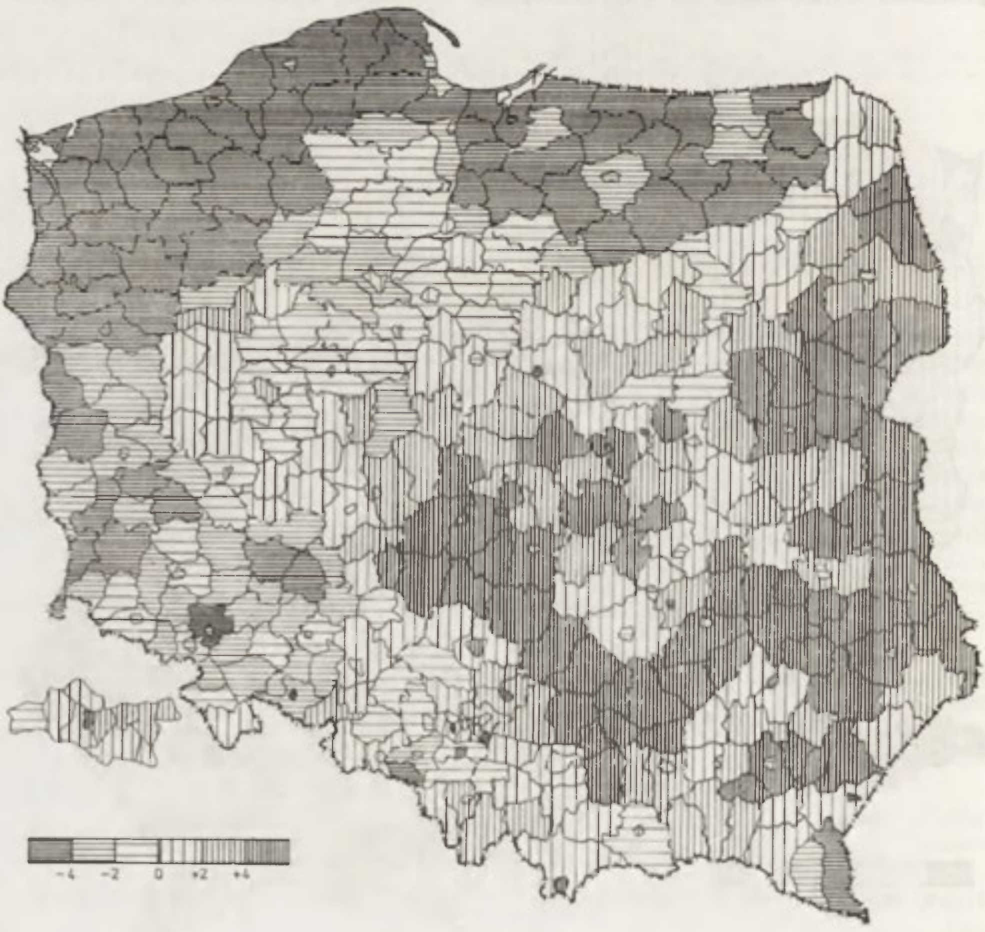

Fig. 2. Spatial distribution of F_2 scores

and a smaller number close to the F_2 axis. Only four variables are situated away from any of the two axes. Assuming this orthogonal pattern as a basis for classification we can divide the set of points into quarters. Thus, types of areal units are determined with respect to signs of factor scores. In a case like this, when a large number of units are involved, their classification into four types only brings a high generalization, or aggregation level. Types are uniform only relatively (with respect to the arrangement of signs), while taxonomic distance separating individual units within the types remains substantial. Such a classification, however, is able to ensure their spatial continuity and this condition is fulfilled by the actual pattern of F_1F_2 types (Fig. 4).

The spatial pattern of F_1F_2 types represents a synthesis of basic social and occupational characteristics of the population on the one hand and of the features referring to age composition and death rates on the other. It covers the majority of diagnostic variables and can serve as a basis for demographic regionalization.

The following two-factor typologies using F_1 as one of the factors, give patterns similar to the F_1F_2 distribution (Fig. 5). In some of the combinations

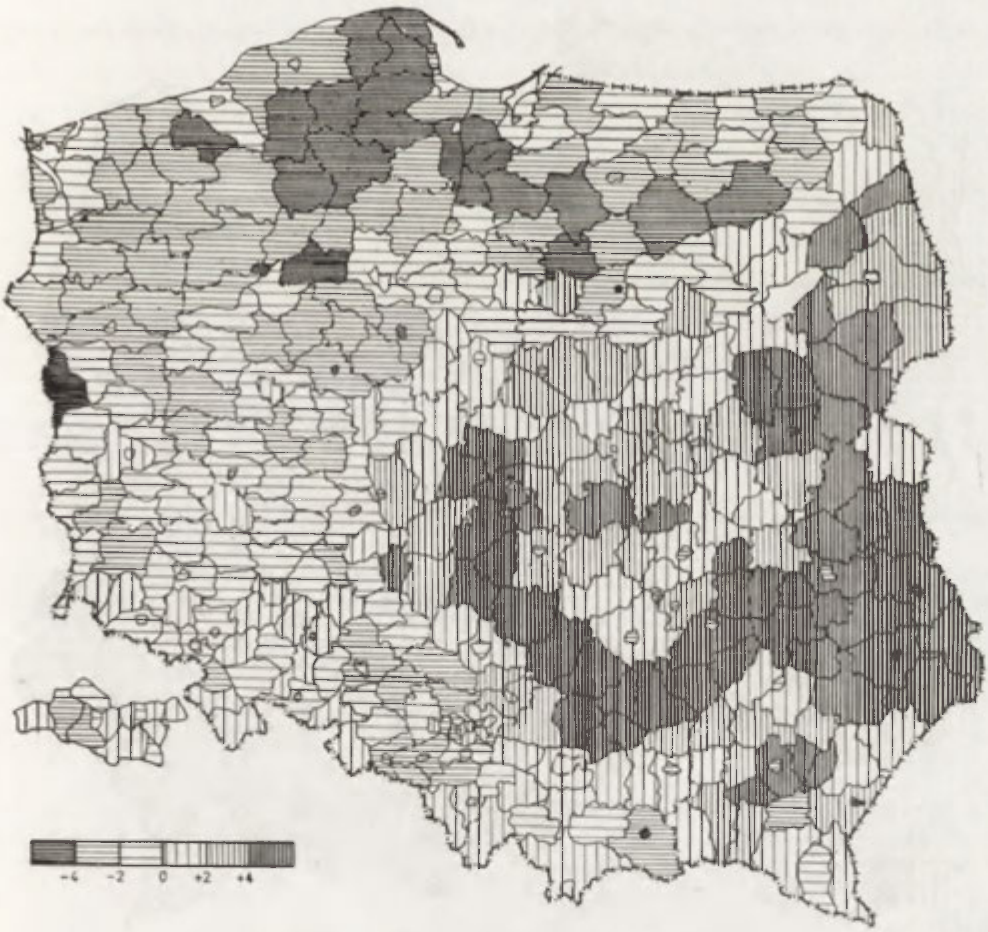

Fig. 3. Spatial distribution of F_1 scores

certain characteristics stand out very clearly forming distinct spatial patterns, but, generally, the interspersion of areal units is greater than in the former case.

A conclusion to be drawn from single-factor and two-factor typologies performed is that they allow a tentative division of Poland into demographic regions (Fig. 6). The starting point was an analysis of the distribution of areal units in two-dimensional space denoted by F_1 and F_2 factors. This combination accounted for 62.14% of the common variance — the highest of all possible combinations. In addition, it ensured to a high degree the spatial continuity of individual types. In the next step, on the basis of the occurrence of homogeneous areal groupings within single-factor patterns, certain units of an enclave character were included in adjoining areas, and certain additional subregions were identified. The lines separating regions and subregions represent ranges of individual types. In the two-level division obtained there are three major regions, the formation of which can be attributed to various historical factors, including the massive shifts of population after World War II, as well as seventeen uniform subregions, representing the main building blocks of the contemporary (1970) demographic structure of Poland. They include:

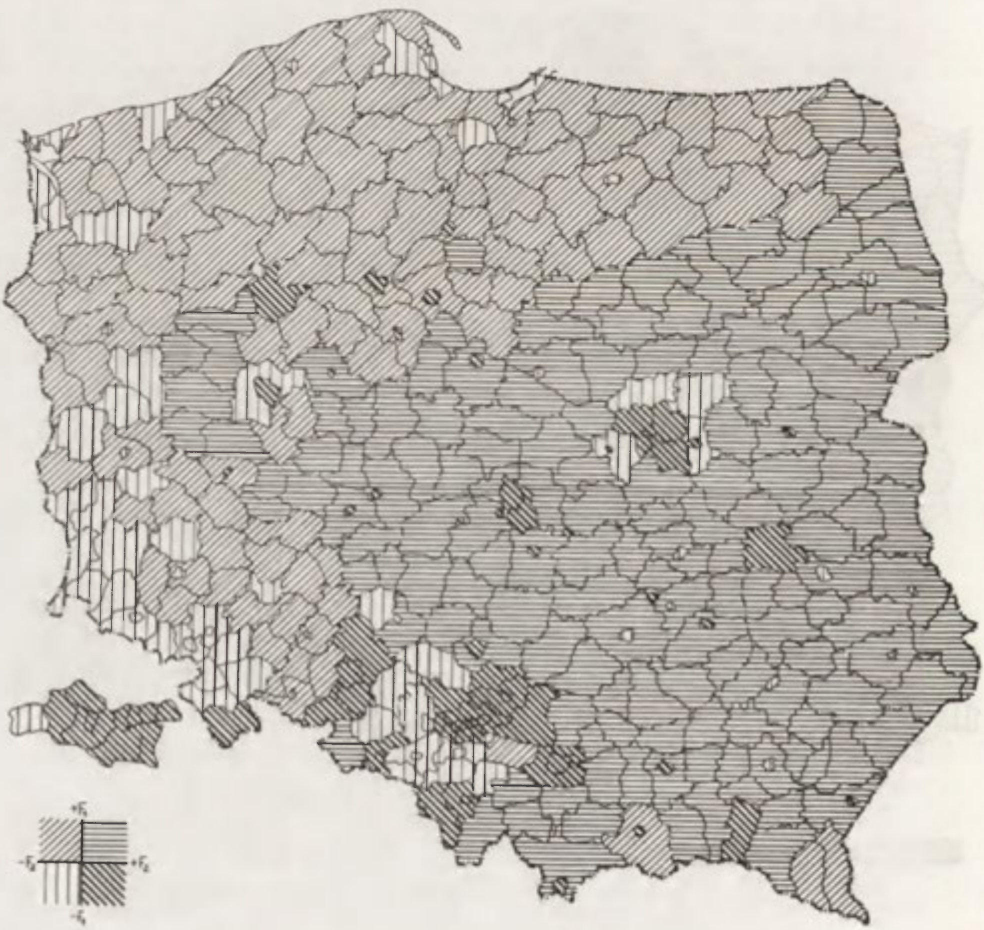

Fig. 4. Spatial distribution of two-factor (F_1, F_2) types

1. *The North-Western region*
   1 a Northern and Western subregion
   1 b Sudetes-Lubush subregion
   1 c Szczecin subregion
   1 d Gdańsk subregion
   1 e Poznań subregion
2. *The Silesian-Cracow region*
   2 a Opole-Rybnik subregion
   2 b Upper Silesia-Cracow subregion
   2 c Bielsko-Biała subregion
3. *The Central-Eastern region*
   3 a Warsaw subregion
   3 b Łódź subregion
   3 c Kielce subregion
   3 d Nowy Sącz-Sucha subregion
   3 e Bieszczady Mts. subregion
   3 f Chełm-Zamość subregion

Fig. 5. Spatial distribution of two-factor (F_1, F_3) types

3 g Lipsko-Zwoleń subregion
3 h Podlasie subregion
3 i East-central subregion

In the delimitation procedure the principle of internal homogeneity of regions, according to the results of two-factor and single-factor typology, was generally adhered to. Individual regions and subregions were based on those types which displayed a distinct character of given territorial aggregates in relation to the surrounding areas. The two-level form of the regionalization pattern is closely related to fundamental demographic changes caused by World War II. The war losses that amounted to over six million people, and the massive migrations associated with the shift of the national boundaries and the settling of western and northern territories caused substantial inter-regional differences in the population structure and population dynamics. The scale of external and internal migrations decreased rapidly by the end of the 1940s (and since then natural increase became the principal factor of population growth and change), nevertheless the industrialization and urbanization

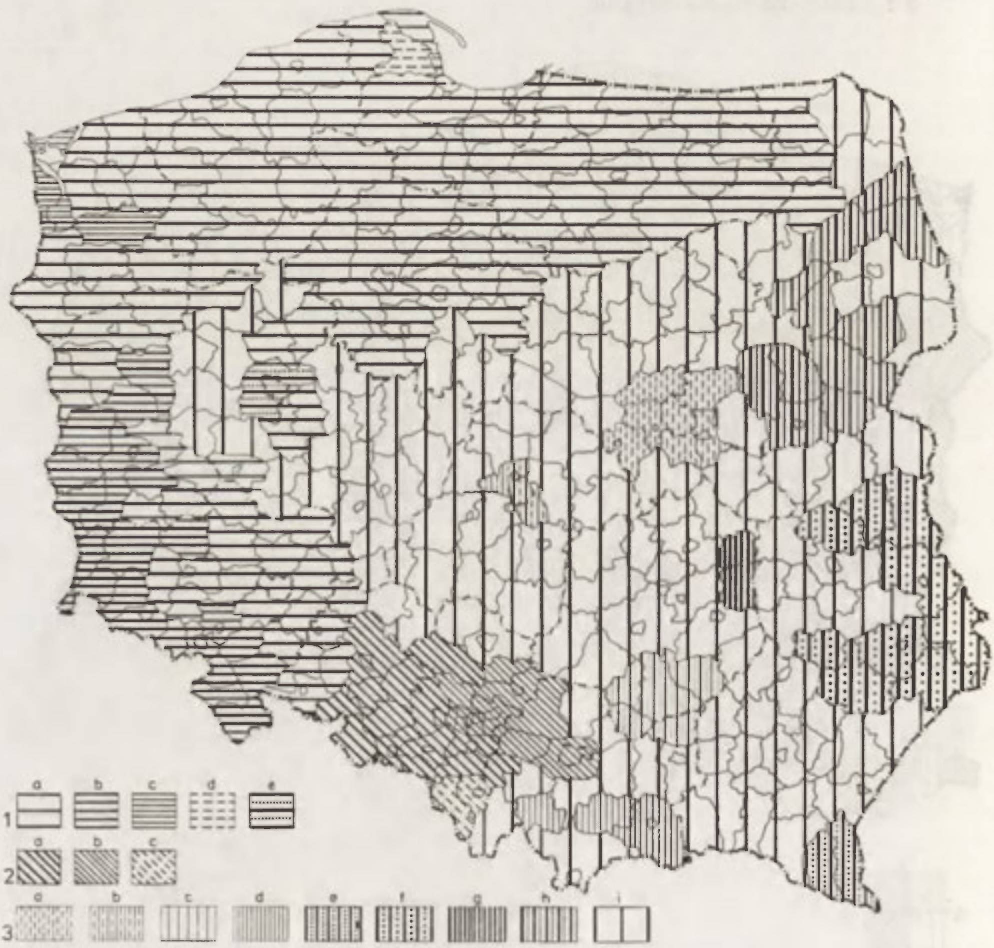

Fig. 6. Demographic regions of Poland, 1970
Note: Description of symbols in the text

processes of the 1950s brought a new surge of internal population shifts. The general trends have been the concentration of population in major urban centres and industrial districts and the gradual elimination of inter-regional contrasts in the population structure and population dynamics, however, the initial differentiation was of such a magnitude that it can still be discerned; a few more decades are needed to erase it completely.

The above attempt at a demographic regionalization of Poland was based on factor analysis, a technique well suited to structural decomposition, but which is still only a typological method. A single-factor typology, if accounting for a high percentage of the common variance, may constitute a starting point for regionalization, i.e. the interpretation of types as homogeneous areas, or regions. In later stages, however, supplementary methods facilitating the territorial aggregation of individual types, as well as some arbitrary decisions, are unavoidable. Nevertheless, factorial analysis makes it possible to identify some basic structural components and certain basic links. In the present study it proved to be useful in the identification of the multi-variable spatial pattern.

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A MODEL OF THE SOCIOETHNIC STRUCTURE OF AUSTRALIA'S METROPOLITAN CITIES

STANISŁAW OTOK

The trend toward population concentration in urban centres is now a specific feature of migrations throughout the world, especially in industrial countries. In Australia this trend is of a relatively recent vintage, as it commenced just before the Second World War and became a fully-fledged tendency after the war.

In the specific conditions of Australia — the low population density (1.2 persons per sq.km), the excessive concentration of population in the cities situated chiefly along the coast (more than 85% of Australia's total population), and the occurrence of almost totally uninhabited areas in the central zone — the cities in that country exert an obviously powerful migrational pull.

Migration to cities, especially to the metropolitan cities, is observed not only among native Australians but also among immigrants who arrived in this continent on a massive scale after the war. Immigrants did not always have the chance to settle in a metropolitan city directly on arrival. Bound by contract with economic organizations financing their immigration, they had to work some time in different locations, often in the desert-dominated central zone of Australia. On the termination of their obligations they migrated to the cities, to the metropolitan cities. Life in a metropolitan city is regarded as a specific social advance, which provides a better start in new surroundings and, consequently, good prospects for a more convenient and easier life. These better possibilities are commonly associated with a job in manufacturing.

In the studied territorial units, the various ethnic groups have different shares in the socioethnic structure. The relative role of the minority ethnic groups with respect to native Australians and to the total population of a city quarter varies both with the number of such groups and with their size. The problem of the significance of the ethnic groups for a given country and of how it can be determined has been discussed in a number of studies. The case of Australia was studied by Rose (1958), Zubrzycki (1960), Scott (1965), Stimson (1970), Burnley (1972), Otok (1974); in its broader aspect, by Duncan and Lieberson (1959), Lieberson (1961), Piasecki (1964), and Timms (1965).

The present study takes as the point of departure the view of E. Piasecki that "the significance of a group is proportional to the number of possible intragroup links, and thus intranational links". This implies that direct links need not actually exist but that such links are possible, that there are possibilities of influencing the group, and its sense of identity, also through the mass media.

Hence, the significance of the ethnic group can be expressed statistically as the index of socioethnic differentiation of the studied country or of some part of it. That index is the number of possible links between members of an ethnic group, that is $e_1 (e_1-1)$, as related to the total possible number of international links of the total population of the studied area, that is $E(E-1)$.

Since in practice it is of no avail to deduct 1 in the case of very large sets, the studied magnitudes must first be squared. The formula reads then

$$S = \frac{e_1^2+e_2^2+e_3^2+ \dots +e_n^2}{E^2} \cdot 100$$

where $e_1, e_2 \dots e_n$ are the sizes of the ethnic groups, and E denotes the total population of the area.

This index can be computed both from absolute and relative figures. Its value decreases with the growing number of the groups and with the decreasing number of their members; when there are no ethnic minorities at all it reaches 100 (per cent).

The results obtained by means of the above procedure show that the degree of socioethnic differentiation of Australia is not uniform: Sydney 57.5, Melbourne 53.8, Adelaide 54.2, Brisbane 80.4, and Perth 50.1. In four cases, in which the socioethnic differentiation index ranges from 57.5 to 50.1, the cities are shown to be multinational in character; in one case we have a nearly single-national city (index 80.4) with a significant minority group.

These general remarks on the ethnic structure of Australian metropolitan cities introduce our proper subject. This comprises the presentation of the ethnic differentiation in the individual metropolitan cities and a tentative explanation of its causes by using the Spearman coefficient to correlate that differentiation with the industrialization index.[1]

The statistics used in this study are taken from the Australian census of 1972.[2] The census lists a total of 18 countries of origin of the majority of Australia's present population. Less numerous ethnic groups are given jointly.

The ethnic structures of each of the five metropolitan cities are presented for territorial units of a lower order (city districts) to a total number of 224. The appendix gives the socioethnic differentation indexes for individual districts for each of the five cities studied. For Sydney the index values range from 36.6 to 74.0, for Melbourne 19.4–97.7, for Adelaide 40.5–78.3, for Perth 38.1–63.9, and for Brisbane 47.2–83.2. In virtue of these data the following groups were distinguished for each city (except for Perth):

(1) maximum ethnic differentiation — the multinational group,
(2) medium ethnic differentiation — the intermediate group,
(3) the group of single-national population with a minority.

The upper index value for each of these groups were 50, 70, and 100, respectively. In each city these groups form three distinct zones of ethnic differentiation. The zones in turn correlate strongly and negatively with the industrialization index. The correlation coefficient ranges from -0.4 to -0.7.

In Sydney, the maximum ethnic differentiation zone extends over 10 reference units (city districts) situated along the bays of Port Jackson and Botany Bay. These form the oldest part of the city which exhibits high industrial concentration. This is also the area of one of Austrlia's biggest harbours. Industrial employment reaches 212 persons per 1,000 population. The third zone, of single-national groups with a minority, is composed of 5 city quarters in the northern and south-eastern parts of the city. They include mainly residential

[1] The industrialization index shows the number of persons employed in industry per 1,000 population.
[2] Census of Population and Housing, 1971, Australia.

and agricultural and recreation districts. In between these two zones there is the second zone — that of medium ethnic differentiation — composed of 26 reference units of medium industrial concentration. Industries are just beginning to localize in those areas, either through the construction of new plants or through the relocation of plants from the congested old city core.

In Melbourne, the maximum differentiation zone comprises the central, south-eastern, and north-western districts; altogether it consists of 20 reference units concentrating mainly along Port Phillip or in its closest vicinity. As in the case of Sydney, this is connected with high industrial concentration in those areas which extend to the vicinity of the harbour. Industrial employment is also very high, reaching 218 per 1,000 population. The second zone, of 29 reference units embraces the first zone in a semi-circle. The third zone, that of single-national population with a minority, consists of 6 reference units and comprises chiefly the north-eastern part of the city. It is there that the highest index of ethnic differentiation of all studied cities was found — 97.7 in the Coburg district. This indicates an exceptionally high national homogeneity, which is very infrequent in Australia. It is remarkable considering that the Coburg district is not situated on the city's peripheries but in close vicinity to the city core.

Each of the remaining cities has no more than two distinct zones of ethnic differentiation.

In Adelaide, the metropolis of Southern Australia, the maximum differentiation zone comprises the central districts around the city core and those in the northern part of the city — altogether 7 reference units. This pattern coincides with the distribution of industry. What is specific for Adelaide is that the single-national zone with a minority consists of only one peripheral district (Gawler). The other districts form the second zone, altogether 19 reference units.

In the case of Perth, the metropolis of Western Australia, only two zones have been distinguished in a specific distribution pattern: the maximum ethnic differentiation zone extends almost all over the whole metropolis and, within it, insulated districts crop up with areas conforming to the criteria of the intermediate zone. The third, single-national zone with a minority has not been found to occur in Perth. The rapid development of the city and of its industries has in recent years been largely based on immigrant labour.

In Brisbane, the metropolis of Queensland, one district only conforms to the criteria of maximum ethnic differentiation; it is situated in the western periphery of the city, in the vicinity of the Ipswich coalfields. The intermediate zone of medium differentiation is composed of 18 reference units concentrating chiefly around the city core; three units of that zone lie in the southern part of the city. The third zone of single-national population with a minority is well developed and comprises 33 reference units. Many districts of that area have a high index of socioethnic differentiation which attests to its principally single-national character. The zone extends over the northern, southern, and eastern parts of the city. This specific socioethnic structure of Brisbane is due to historical reasons and is connected with the rank of the city on the national scale.

As has been presented here, the picture of ethnic differentiation in the Australian metropolitan cities suggests a spatial pattern common to all cities. We have an incomplete and adverse relationship: the higher the industrialization index the lower the index of socioethnic differentiation. Ethnic differentiation attains its maximum in the industrial districts. The pattern of distribution of these districts in the case of the Australian metropolitan cities suggest more general conclusions. As a rule, the highest concentration of ethnic minorities is observed in the central city districts, and at the same time it is in those districts that the industrial coefficient reaches its maximum in each of the studied cities. With growing distance from the city core the socioethnic differentiation index grows and the industrialization index decreases. This accounts for the fact that the second intermediate zone surrounds the first zone almost in a circle. The third zone is composed of peripheral districts in which immigrants have but a small share of the population and hence the socioethnic differentiation is small. They are districts of lower industrialization or even of agricultural and residential character. Immigrants are not strongly attracted to those districts.

The similarity of the zone pattern in all the cities studied can also be confirmed mathematically, by means of function plots. Since the operation entails an incomplete relationship it is necessary to use a function which permits the determining of that relationship and the disclosure of certain regularities. Thus, whenever two magnitudes (the socioethnic differentiation index and the industrialization index) appear to be inversely proportional to each other we can expect them to be related by a homographic function. Graphically this function exists as an equi-axial hyperbola shifted with respect to the coordinates. The homographic function is used further on as a gauge of likelihood and solved by using Sydney and Melbourne as examples. The homographic function:

$$y = a + \frac{b}{x-c}$$

has three parameters, a, b, c. To determine them we class the city district into three groups (e.g., for Sydney, 14 in the first group, 13 in the middle group, 14 in the last group — see Appendix) and for each of them we find the mean values of both indexes. The three points obtained in this way yield three equations by means of which we can calculate parameters a, b, c for each city.

The mean values of both indexes for Sydney and Melbourne are as follows:

(*a*) for Sydney: $\bar{A}(72.95)$, $\bar{B}(56.118)$, $\bar{C}(44.140)$,

(*b*) for Melbourne: $\bar{A}(77.100)$, $\bar{B}(61.128)$, $\bar{C}(41.171)$.

Accordingly, the equations to calculate parameters a, b, c are the following:

for Sydney:

$$72.95 - 72c = 95a - ac + b$$
$$55.6\ \ 118.4 - 55.6c = 118.4a - ac + b$$
$$43.7\ \ 139.6 - 43.7c = 139.6a - ac + b$$

for Melbourne:

$$77.100 - 77c = 100a - ac + b$$
$$61.128 - 61c = 128a - ac + b$$
$$41.171 - 41c = 171a - ac + b$$

The following values were obtained from these equations:

for Sydney: $a = -69.1$ $b = 25084$ $c = -82.8$

for Melbourne: $a = -116.5$ $b = 70646$ $c = -210.6$

Substituting the values obtained from the equations into the equation of homographic functions we obtain:

for Sydney:

$$y = -69.1 - \frac{25084}{x+82.8}$$

for Melbourne:

$$y = -116.5 + \frac{70646}{x+210.6}$$

The plots of these functions show that the hyperbola is very similar in shape in both cases and this suggests a similarity of the patterns of zones in the two cities.

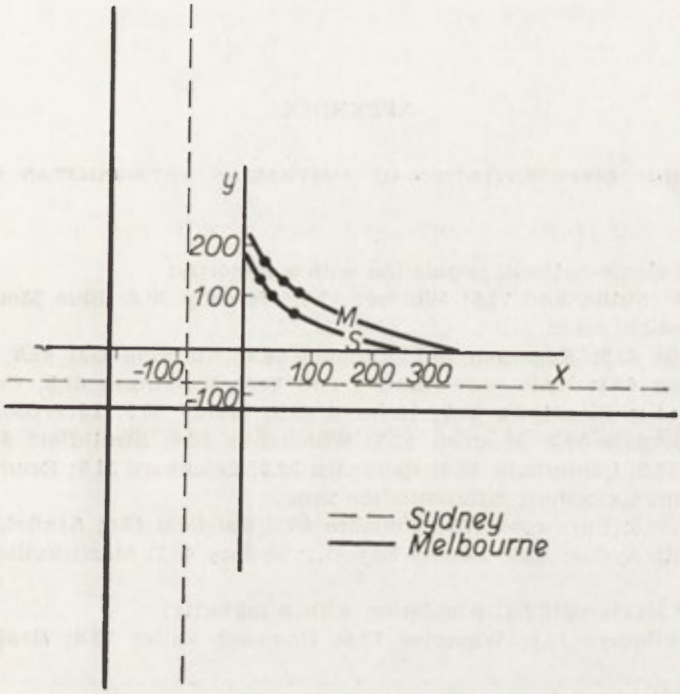

Fig. 1.

APPENDIX

THE SOCIOETHNIC DIFFERENTIATION OF AUSTRALIAN METROPOLITAN CITES

Sydney:

(a) Zone of single-national population with a minority:
Hurtsville 74.0; Sutherland 72.9; Windsor 72.2; Hornsby 70.6; Blue Mountains 70.1;

(b) Intermediate zone:
Baulkham Hills 69.5; Kogarach 69.1; Camden 68.9; Ku Ring Gai 65.6; Parramatta 65.6; Bankstown 65.1; Ryde 64.9; Hunters Hill 64.3; Warringah 62.8; Campbelltown 61.6; Penrith 61.1; Blacktown 60.7; Holroyd 60.5; Manly 60.5; Liverpool 59.7; Lane Cove 59.2; Rockdale 58.2; Mosman 57.5; Willoughby 56.6; Strathfield 56.0; Auburn 55.5; Concord 55.2; Canterbury 53.9; Randwick 52.0; Leichhard 51.7; Drummoyne 51.0;

(c) Maximum socioethnic differentiation zone:
North Sydney 50.0; Burnwood 47.5; Wollahra 46.1; Fairfield 46.0; Ashfield 43.5; Waverley 43.3; South Sydney 42.5; Botany Bay 41.1; Sydney 40.1; Marrickville 36.6.

Melbourne:

(a) Zone of single-national population with a minority:
Coburg 97.7; Flinders 73.6; Waverley 73.6; Diamond Valley 72.8; Healesville 71.8; Eltham 71.0;

(b) Intermediate zone:
Heidelberg 69.7; Hasting 69.5; Sandringham 68.8; Doncaster 68.3 Chelsea 68.2; Camberwell 67.7; Box H. 66.4; Mordialloc 65.3; Ringwood 65.2; Nunawading 65.0; Moorabbin 64.5; Brighton 64.2; Mornington 64.1; Cranbourne 63.5; Sherbrooke 60.5; Frankston 59.1; Malvern 59.0; Bulla 58.7; Croydon 58.3; Preston 58.0; Kew 57.4; Knox 56.0; Lillydale 55.2; Werribee 55.1; Hawthorn 54.6; Broadmeadows 53.1; Berwick 52.9; Essendon 52.8; Caul-field 50.6;

(c) Maximum socioethnic differentiation zone:
Dandenong 49.4; Oakleigh 49.1; Williastown 48.2; Springvale 48.0; South Melbourne 47.6; Whittlesea 46.1; Northcote 45.0; Prahran 44.8; Melbourne 44.4; Keilor 43.7; Footsray 41.6; Sunshine 40.6; Melton 38.0; Richmond 37.7; Brunswick 37.0; Altona 36.6; Collingwood 35.5; Kilda 34.8; Fitzroy 28.9; Port Melbourne 19.4;

Adelaide:

(a) Zone of single-national population with a minority:
Gawler 78.3;

(b) Intermediate zone:
Mitcham 68.5; 3 Burnside 68.5; Stirling 67.2; Walkerville 67.2; Brighton 66.9; Marion 66.6; Henley 62.0; Glenelg 61.8; Torrens 61.4; Enfield 58.0; Unley 57.9; Port Adelaide 57.2; Prospect 56.7; Woodville 53.6; Teatree 52.9; Payneham 52.8; Kensington 52.2; Adelaide 52.1; Campbel-town 51.1;

(c) Maximum socioethnic differentiation zone:
Peters 48.2; Noarlung 47.0; Hindmarsh 46.1; Elizabeth 43.1; Salisbury 42.0; Thebarton 41.0; Munno Parra 40.5;

Perth:

(a) No single-national population zone has been found.

(b) Intermediate zone:

Merville 63.9; Claremont 59.7; South Perth 59.4; Nedlands 58.4; Cottesloe 57.4; Stirling 54.6; Mundaring 54.5; Bassendean 51.5;

(c) Maximum socioethnic differentiation zone:

Subiaco 49.7; Bayswater 49.5; Kalamunda 49.5; Swan 49.3; Belmont 48.3; Canning 48.3; Cockburn 45.7; Wanneroo 45.5; Fremantle 44.5; Perth 43.6; Gosnells 43.5; Armadale 43.4; Rockingham 40.6; Kwinana 38.1;

Brisbane:

(a) Zone of single-national population with a minority:

Banyo 83.3; Chermside 82.9; Stafford 82.2; Nundah 81.5; Geebung 81.2; Kedron 80.3; Enoggera 80.1; Chatsworth 80.1; Farragindi 79.6; Mitchelton 79.3; Carina 78.7; Morningside 78.5; Holland 78.0, Ashgrove 77.3; Camp H. 77.2; Bald H. 76.8; Graceville 75.8; Mt. Gravatt 74.7; Sandgate 74.7; Newmarket 74.6; Kalinga 74.6; Wynnum 74.4; Handra 74.2; Meeandah 73.6; Moorooka 73.3; The Gap 73.2; Ascot 72.6; Balmoral 71.8; Yeronga 71.6; Corinda 71.4; Greenslopes 71.2; Aspley 70.3; Western 70.1;

(b) Intermediate zone:

Ithaca 69.9; Toowong 69.6; Indooroopilly 69.3; Windsor 68.6; Eastern 68.6; South Eastern 68.4; Kenmore 67.9; Lucia 67.7; Ekibin 67.5; Fernberg 66.9; Coopers P. 65.6; Normanby 61.9; North City 59.1; City 56.2; Inala 55.3; Brisbane E. 52.9; South City 52.1; S. Western 50.7;

(c) Maximum socioethnic differentiation zone:

Darra 47.2;

Warsaw University

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GEOGRAPHIA POLONICA 33, 1976

ACCESSIBILITY OF URBAN TRANSPORT SYSTEMS. THE CASE OF POZNAŃ CITY

Zbigniew Taylor

1. INTRODUCTION

1.1. THE PURPOSE AND SCOPE OF THE STUDY

The problems of systems structure and transportation networks have been attracting more and more interest over recent years. In the literature of the subject there are at least three different approaches to network structure: (1) the linear-algebraic approach, or, more strictly, the application of eigenfunctions and eigenvectors, (2) the comparison of real world networks against hypothetical ideal structures,[1] including radial structures,[2] and (3) the utilization of topological properties of networks. The present study is in keeping with the third approach.

The structure of transport systems is certainly among the foremost problems of economic geography. One property of the system structure is its accessibility. The definition of urban function itself points to the importance of accessibility. Functions within the town are interrelated and interact with functions in other parts of a metropolitan city. Accessibility implies easy interaction of each subarea, and of its population, with various urban functions, whatever their location. Many concepts, and hence many measures, of accessibility are used. This study presents four of them — the topological, the temporal, the physical, and the *S-I* index measures. It is to be remembered that accessibility cannot be submitted to direct observation but it must be made up by virtue of other data.

The aim of this study is: (1) to determine the actual accessibility of the urban transport system of Poznań city, (2) to explain the similarities and differences between variants of accessibility, and (3) to give a preliminary appraisal of the methods employed, especially of graph techniques.

Specifically, the research procedure includes the following: first, bus line segments are assumed to substitute the tramway network; the former are ranked in the order of importance and compared against the actual segments hierarchy; secondly, the above-mentioned variants of accessibility are characterized from two angles: as overall accessibility, and as accessibility from the

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[1] In this manner, for instance, R. K. Semple and L. H. Wang (1971) compared the entropy of ideal networks with that of real-world networks obtaining the statistical index of redundancy, which shows how accurately real networks approximate ideal networks.

[2] K. J. Tinkler (1972B), whose prime concern is to describe structural network characteristics in terms of radial structures, thinks that this procedure may furnish the link between K. J. Kansky's (1963) topological indexes and matrix network analysis, with a simultaneous emphasis on flows and hierarchies in networks.

central point. The underlying intention is that this approach secures the understanding and explanation of the similarities and differences between the individual variants of accessibility.

1.2. THE METHOD

Description, inference and determination of spatial interrelationships and dependencies are carried out primarily by means of graph methods. By graph methods I mean techniques based on graph theory. Graph methods usually make it possible to avoid meticulous mathematical formalization, which is a precondition of the mathematical graph theory interpreted as a branch of algebraic topology which deals with set relations, algebraic systems and structures (Pulczyn 1968, p. 5). Graph theory, and thus graph methods, permit the study of structures composed of few elements.

Inference, establishing spatial relations and dependencies as well as generalization are all performed in accordance with the overall principles of political economy, among them economic efficiency, complementarity and substitution.

All spatial studies are typically carried out by means of the cartographic method. This term is used with at least two meanings (J. Pasławski 1970, p. 713): (1) as the graphic presentation of phenomena and processes, and (2) as a self-dependent approach to phenomena and processes of spatial character. This study uses the cartographic method chiefly in the former meaning; in its second sense it is useful in inference and interpretation of results.

The Spearman's rank correlation coefficient and variate normalization are two statistical methods used, to a limited extent, for purposes of verification.

2. THEORETICAL CONCEPT

2.1. BASIC NOTIONS AND POSTULATES

The interdependence of many phenomena and processes that we face gave birth to the notions of system and structure. System can be defined (D. Harvey 1969, p. 451): (1) as a set of relations between variable features of things, and (2) as a set of relations between features of things (objects of study) and environment. The third — and Harvey's first — definition of system as "a set of elements identified with some variable attribute of objects" is unacceptable because it neglects the element of interrelations.

The system under study must be treated as a closed system, one which does not involve interaction with its environment (this seems to be acceptable in the case of analysing accessibility). Any boundary line between a system and its environment is to some extent arbitrary. It is also assumed that the relations between the elements of the studied system do not change in the course of analysis. The system is in the form of a network which is a set of links (or edges) and nodes (or vertices) situated within the administrative boundaries of the city. Each system has its specific structure, that is an arrangement of its components. In our case the structure elements include the links and nodes.

This definition of system and system structure implies a model approach. The notion of model is also vague and unequivocal in science. Some research workers identify models with the mathematical sense of the term, others with an approximate picture of the future. As far as I know, the most adequate definition of model was furnished by P. Haggett and R. J. Chorley (1967, p. 22). They define it as a simplified structure of the real world which represents allegedly significant features or relations in a generalized form. Remarkably,

C. Ponsard (1972) writes that the contribution of graph theory, and thus of graph methods, consists in overcoming the discrepancies between theoretical models and their counterparts in the real world.

As it has been said, the transport system is in the form of a network. In reality, though, no network in general exists but several different networks which are complementary and substitutive to one another. This is a result mainly — though not exclusively — of the functional requirements of transport itself. To develop this idea, which is due to R. Domański (1963, p. 40), a little further it can be assumed that alongside the tramway network there is a bus line network in Poznań and that this latter is of course both complementary and substitutive to the tramway network.

2.2. TOPOLOGICAL MEASURES

The tramway network of a city can, as any other network, be represented as a finite planar undirected graph.[3] Graph G is an ordered pair $\langle X, \Gamma \rangle$ such that X is a nonempty set, and Γ is a mapping of X in X. An ordered pair $\langle X, \Gamma \rangle$, composed of elements X, Γ, is a pair in which the order of elements is significant. The first element of the pair, X, is called the predecessor, the second, Γ, is the successor. The principle according to which the set elements are ordered against each other is called mapping.

Each element of set X is called a point or vertex of the graph, and the ordered pair of elements $\langle x, y \rangle$, such that $y \in \Gamma x$, is called an arc. Any unordered pair of vertices $\{x, y\}$, such that $\langle x, y \rangle \in U$ or $\langle y, x \rangle \in U$, is called an edge. Thus an edge differs from an arc because the former has no orientation (is not directed) whereas the latter has.

In an undirected graph each arc has been substituted by an edge. Graph $G = \langle X, \Gamma \rangle$ is finite if the set of its vertices X is finite. A planar graph is one in which arcs or edges have no common points except the vertices.

In the present study, transport nodes correspond to the points or vertices of a graph, and links between two neighbouring nodes correspond to graph edges. Transport nodes include: (1) departure (terminal) stops of the particular tramway lines, irrespective of their technical pattern (loops, turnouts), (2) stops at tramway line crossings, (3) stops at crossings of tramway lines with the 13 bus line segments which are regarded as substitutive. Thus defined, the nodes include about 50% of all tramway stops in Poznań city up to the end of 1971. Only those nodes have been chosen which appear to be fairly stable in their situation. The links, or graph edges, are segments of tramway lines connecting the nodes. Links that are bus line segments have a special role to fulfill.

Although our network is defined as an undirected graph (we do not study the direction of the traffic flow or capacity), we need the notions of arc and path to calculate topological measures. Each sequence of ordered pairs of vertices $\langle x_1, x_2 \rangle$, $\langle x_2, x_3 \rangle$, ..., $\langle x_{n-1}, x_n \rangle$ is called a path. A path is elementary if each of the vertices belonging to it occurs once only. One case of path is a circuit defined as a path in which the initial vertex of the first arc is the terminal vertex of the last arc. In turn, a special but frequent case in this connection is the Hamiltonian circuit, which is a path running through all vertices of the graph. By length $1(\mu)$ of path $\mu = (\mu_1, \mu_2, ..., \mu_k)$ is meant the number of arcs in the sequence μ. A circuit of length equal to unity and defined by an arc

[3] The definitions are borrowed from C. Berge (1963), O. Ore (1966), W. Pulczyn (1968), H. Sachs (1970–1972), W. K. Chen (1971), L. Szamkołowicz (1971), and J. Sedláček (1972).

of form $\langle x, x \rangle$ is called a loop. By distance d_{xy} of vertices x to y is meant the shortest path from x to y.

The simplest measure of graph connectivity, which will be dealt with later, is the associated number of a vertex. It denotes the largest distance of a vertex to all the remaining vertices:

$$e(x) = \max_{y \in X} d_{xy} \tag{1}$$

Vertex x_0 for which the associated number is finite and smallest with respect to all the other vertices is called the central point of graph G. A graph may have no central point at all or it may have many of them. The maximum associated number of a vertex denotes the graph diameter:

$$\delta(G) = \max_{x, y \in X} d_{xy} \tag{2}$$

whereas the initial and terminal vertices are then called its peripheral points.

With a view to measuring certain graph properties by means of graph methods several other topological measures were furnished. Specifically, graph connectivity is measured by the number of arcs (edges) between vertices. The highest possible number of links L^* in a graph (network) of v nodes can be computed from the formula:

$$L^* = \frac{v(v-1)}{2} \tag{3}$$

Z. Prihar (1956) devised degrees of network connectivity:

$$\text{maximum connectivity} = L^* / \left(\frac{v(v-1)}{2}\right) = 1 \tag{4}$$

$$\text{minimum connectivity} = L^*/(v-1) \tag{5}$$

$$\text{degree of connectivity} = L^*/q \tag{6}$$

where q stands for the number of links observed in the network.
To make them comparable it is necessary to express the connectivity degrees as percentages.

A. Shimbel (1953) proposed two further topological measures:
— network (graph) dispersion:

$$DG = \sum_{x=1}^{n} \sum_{y=1}^{n} d_{xy} \qquad x, y \in G \tag{7}$$

where D is the dispersion of network G, d is the distance of vertices x to y, and
— accessibility of network (graph) from a given vertex:

$$A_g = \sum_{x=1}^{n} d_{xy} \qquad x = 1, \ldots, n \qquad x, y \in G \tag{8}$$

Accordingly, by topological accessibility is meant the sum of distances of a given vertex to all other vertices in the network. Network dispersion is simply the sum of accessibility indices. The lowest value of measure A_g indicates the most accessible node.

The relations between vertices in a graph or nodes in a network can be written in the form of a symmetric matrix of links. A square matrix $[a^i]$ with n column and n rows is called the matrix associated with graph G. In the zero-one notation, 1 is written whenever there is a link between two nodes, and 0 whenever there is none. The values of the main diagonal are 0, which excludes the existence of a loop.[4]

It is useful to consider the purpose for which the above measures are introduced. The results of introducing new additional links into the existing network can be inferred from changes in the associated number. Of course, the smaller the associated number the more desirable it is to establish an additional link. At the same time, the number of central points will grow. The establishment of new links between existing nodes will contribute to the growth of network connectivity. The present study is concerned not so much with the introduction of new additional links (the connectivity of the tramway network is assumed to be insufficient) as with ordering the existing segments of bus lines connecting the particular transport nodes. Ordering, that is establishing the hierarchy of the bus line segments, consists in putting them in the order of their effect on the reduction of dispersion D (G). Hence the significance of the index of dispersion: it indicates the most desirable order of linking the transport nodes with each other.

2.3. TEMPORAL AND PHYSICAL ACCESSIBILITY

Temporal accessibility has so far been studied as a feature of the transport relations of an area with respect to a predetermined point (e.g., Z. Baja 1948, A. Gawryszewski and S. Pietkiewicz 1966, W. Ostrowski 1970). For this purpose maps of isochrones, most often centrifugal, have been (and still are) used. Without reducing its significance it must be said that this is a one-sided approach. All it does is to give information about the accessibility of an area with respect to a particular point, and conversely, it says nothing about the mutual accessibility of all transport nodes. A map of isochrones exclusively for the tramway lines may be of little use in the case of Poznań considering the highly varying density of that network which prevents any adequate interpolation.

The definition of topological accessibility has induced me to adopt another approach, which is especially suitable for the description of a city transport system. As in the case of topological accessibility, temporal accessibility is to be understood as the sum of distances in minutes of a given node to all the others as calculated along the shortest traffic routes. One variant of general temporal accessibility A_t is temporal accessibility from a central point (a point predetermined by means of graph methods) which is defined by distances in minutes of the central node to all other nodes.

Physical accessibility A_f can be determined in an analogous manner: it is the sum of distances in metres of a given node to all the other nodes of the network along the shortest traffic route. Here, too, we have a variant of A_f from a central point by which is meant the sum of distances in metres from a central point to all the other points.

The sum of distances should of course be minimal in each case, though they need not be measured along the same path. It must be added that by distance of two vertices x to y is meant the total length of the shortest path of x to y measured in minutes or in metres. This is not always identical with the previous definition of distance.

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[4] The application of matrices to network problems is treated more comprehensively by N. Alao (1970).

3. THE CASE OF POZNAŃ CITY

3.1. TOPOLOGICAL ACCESSIBILITY

As viewed in terms of graph methods, the tramway network of Poznań as it was in December 1971 consisted of 40 nodes numbered 1, 2, 3, ..., 40 connected by 43 edges. A comparison of Figs. 1 and 2 will show to what extent the graph simplifies the real world network. The main difference consists in substituting the real course of the links by straight lines. The mutual situation of the nodes has not been changed though.

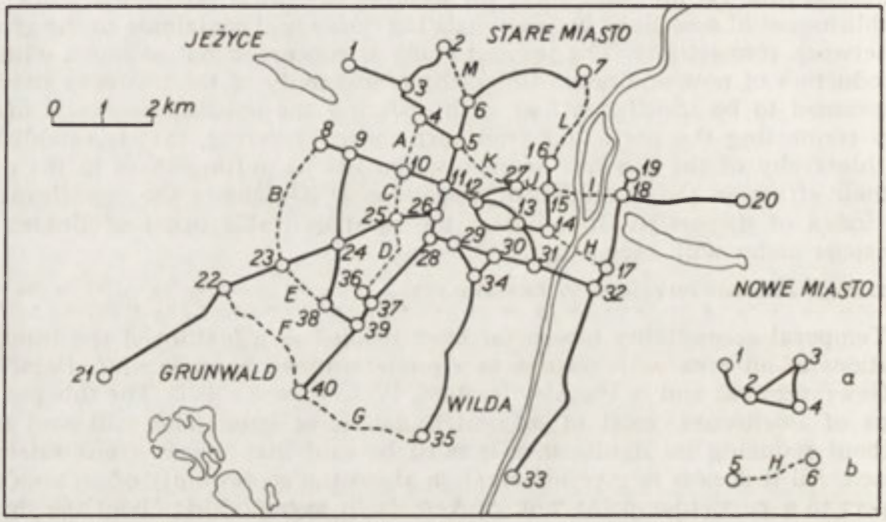

Fig. 1. The tramway network (a) with the studied bus line segments (b)

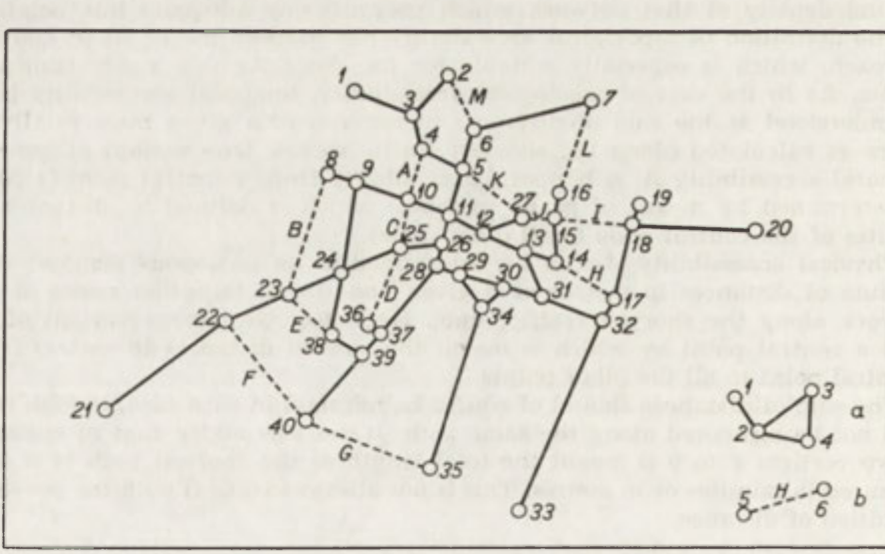

Fig. 2. The tramway network (a) with the studied bus line segments (b) as a planar undirected graph

Since we are mainly concerned with the degree of connectivity and accessibility within the system, and not with the volume of traffic flow, we include in the analysis the existence or lack of links between nodes rather than the number of seats in the modes of transportation or the number of passengers. Using the zero-one notation we can represent the relations between nodes in the tramway network as a symmetric matrix of links in a graph (the notation is of necessity abridged):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	...	40
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	...	0
2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	...	0
3	1	1	0	1	0	0	0	0	0	0	0	0	0	0	...	0
4	0	0	1	0	1	0	0	0	0	0	0	0	0	0	...	0
5	0	0	0	1	0	1	0	0	0	0	1	0	0	0	...	0
6	0	0	0	0	1	0	1	0	0	0	0	0	0	0	...	0
7	0	0	0	0	0	1	0	0	0	0	0	0	0	0	...	0
8	0	0	0	0	0	0	0	0	1	0	0	0	0	0	...	0
9	0	0	0	0	0	0	0	1	0	1	0	0	0	0	...	0
10	0	0	0	0	0	0	0	0	1	0	1	0	0	0	...	0
11	0	0	0	0	1	0	0	0	0	1	0	1	0	0	...	0
12	0	0	0	0	0	0	0	0	0	0	1	0	1	0	...	0
13	0	0	0	0	0	0	0	0	0	0	0	1	0	1	...	0
14	0	0	0	0	0	0	0	0	0	0	0	0	1	0	...	0
..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	...	.
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...	0

= M

In this matrix, distances are obtained if the zeroes — except those lying on the main diagonal — are replaced by the number of edges counted along the shortest path between each pair of vertices.[5] The distances are shown in matrix N.

In accordance with formula (1), the biggest distances sought along the rows or column of matrix X (of necessity given in abbreviation) determine the associated numbers of nodes. The maximum associated number denotes the graph (network) diameter, which amounts to 13, between the most peripheral nodes of the network, in both the model and the real world.

The smallest associated number, in turn, indicates the central points. There are four central points whose associated numbers are equal to seven: 11, 12, 28, and 29 (cf. Table 1). The identified central points are situated in the central part of Poznań city or in its vicinity. But the circumstance of there being four

[5] M. E. Harvey (1972) followed another procedure. He transforms the matrix associated with graph A into matrix C so that for

$$a_{ij} = 1 \text{ or } 0$$

$$c_{ij} = \lambda \log_e f_i (1 + \log_e f_i)^{-1}, \quad 0 \leqslant c_{ij} \leqslant 1$$

where f_i is the number of functions of the central place in node i ($i = 1, 2, ..., n$), and $\lambda = a_{ij}$. Matrix C takes account both of the functional characteristics of nodes and determines the direct connectivity with respect to other nodes. Thus Harvey obtains a more aggregate connectivity index. As this procedure is much easier to apply to the study of the transport network of a region than to a city it has not been used in this study.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	...	40
1	0	2	1	2	3	4	5	7	6	5	4	5	6	7	...	9
2	2	0	1	2	3	4	5	7	6	5	4	5	6	7	...	9
3	1	1	0	1	2	3	4	6	5	4	3	4	5	6	...	8
4	2	2	1	0	1	2	3	5	4	3	2	3	4	5	...	7
5	3	3	2	1	0	1	2	3	4	2	1	2	3	4	...	6
6	4	4	3	2	1	0	1	5	4	3	2	3	4	5	...	7
7	5	5	4	3	2	1	0	6	5	4	3	4	5	6	...	8
8	7	7	6	5	4	5	6	0	1	2	3	4	5	6	...	5
9	6	6	5	4	3	4	5	1	0	1	2	3	4	5	...	4
10	5	5	4	3	2	3	4	2	1	0	1	2	3	4	...	5
11	4	4	3	2	1	2	3	3	2	1	0	1	2	3	...	5
12	5	5	4	3	2	3	4	4	3	2	1	0	1	2	...	6
13	6	6	5	4	3	4	5	5	4	3	2	1	0	1	...	7
14	7	7	6	5	4	5	6	6	5	4	3	2	1	0	...	8
..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	...	.
40	9	9	8	7	6	7	8	5	4	5	5	6	7	8	...	0

= N

TABLE 1. Associated numbers of nodes $e(x)$ of the tramway network

No.	Name	$e(x)$	No.	Name	$e(x)$
1	Sołacz	11	21	Junikowo	13
2	Winiary	11	22	Jugosłowiańska	12
3	Wołyńska	10	23	Grochowska	11
4	Nad Wierzbakiem	9	24	Reymonta	10
5	Wielkopolska	8	25	Matejki	9
6	Obornicka	9	26	Bałtyk	8
7	Winogrady	10	27	Plac Wielkopolski	8
8	Ogrody	10	28	Most Dworcowy	7
9	Przybyszewskiego	9	29	Dworzec PKS-u	7
10	Rynek Jeżycki	8	30	Dzierżyńskiego	8
11	Most Teatralny	7	31	Bema	9
12	Lampego	7	32	Rataje	10
13	Strzelecka	8	33	Starołęka Dworzec	11
14	Plac Bernardyński	9	34	Rynek Wildecki	8
15	Wielka	10	35	Dębiec	9
16	Garbary	11	36	Bogusławskiego	9
17	Kórnicka	11	37	Rynek Łazarski	8
18	Śródka	12	38	Chociszewskiego	10
19	Zawady	13	39	Hetmańska	9
20	Os. Warszawskie	13	40	Górczyn	10

central points is inconvenient as we do not know which of them should be taken as the reference point for further comparisons.

F. P. Stutz' (1973) index of relative topological accessibility of nodes Ω_g was used to identify one of them as the central point:

$$\Omega_g = \frac{A_g - A_*}{A^* - A_*} \cdot 100. \tag{9}$$

$$0 \leqslant \Omega_g \leqslant 100$$

where A_g is the topological accessibility of the studied node (Eq. (8)), A^* is maximum value of accessibility (that is, the most inaccessible node), A_* the minimum value of accessibility (the most accessible node of the whole network). If $A^* = A_g$, then $\Omega_g = 100$; if $A_* = A_g$, then $\Omega_g = 0$. The node whose relative topological accessibility is closest to zero can be recognized as the central point. In our case, the relative topological accessibility for the four central point is: $\Omega_{11} = 0$, $\Omega_{12} = 12.58$, $\Omega_{28} = 9.43$, and $\Omega_{29} = 15.72$. On account of its most central situation in the network node 11 will henceforward be referred to as the central point.

The same result was obtained using the weighted Shimbel-Katz index (in W. L. Garrison's terminology, 1960) which is based on the idea that the significance of inter-node links is inversely proportional to topological distance between the nodes.

How about network connectivity? The largest possible number of edges in a network of 40 nodes is, according to Eq. (3), 780. Minimum connectivity is 20, and the degree of connectivity 18.14. In relative terms, this means that network connectivity amounts to 9,8% only.[6]

For example, if a single edge is added to the existing nodes the degree of connectivity rises to 17.14, or 12.4%, and for the thirteen bus line segments comprised in this study connectivity amounts to 13.93, or 31.9%.

For our purposes it is topological accessibility that is most interesting. Topological accessibility is interpreted as the sum of distance from a given node to all the other nodes of the network (cf. Table 2). The principal advantage of this measures is its composite character. The topological accessibilities of each node are graphically presented in Fig. 3. What is typical is that the most accessible nodes concentrate in the centre of the network and that accessibility declines gradually with the distance from the centre. The lowest accessibility was found for what have been called peripheral nodes, i.e., those with associated numbers equal to the graph diameter.[7]

By analogy to time accessibility from a predetermined point, Fig. 4 presents topological accessibility from the central point. This accessibility is determined by distances of node 11 to the other nodes. Here, too, we obtain a similar picture as in Fig. 3: the nodes that are most accessible concentrate around the central point, those less accessible occupy the "intermediate zone", whereas peripheral nodes exibit small accessibility.

Assuming insufficient connectivity of the tramway network which found its confirmation in the connectivity indexes, it was decided to establish the hierarchy of the thirteen existing bus line segments (cf. Figs. 1 and 2). The segments marked *A, B*, ..., *M* fulfill a substitutive role with respect to the tramway network.

In order to define the order of significance, that is the hierarchy of *A, B*, ..., *M*, the distances of nodes in the tramway network were calculated and, after considering the bus links, the distance of each of them individually and of all of them together. This was done in the form of a symmetric connectivity matrix analogous to N. Adding up the distances yielded the indexes of topological accessibilities A_g for each node (Table 2). Another addition, this time of values in the columns of Table 2, gave the measure of dispersion $D(G)$. Of co-

[6] The percentage was calculated as follows: minimum connectivity — maximum connnectivity $= 20-1 = 19$, minimum connectivity — degree of connectivity observed $=$ $= 20-18.4 = 1.86$. As $19:1.86 = 100:x$, the value of x is 9.8%.

[7] The same results follow when the average graph distance, i.e. the ratio of topological accessibility to the number of vertices in the graph, is used instead of topological accessibility. This index was used by W. E. Reed (1970).

TABLE 2. Indexes of topological accessibility and dispersion of the tramway network and of studied segments of the bus network

Node no.	Tramway network	Studied bus network segments and gains (k) in accessibility and dispersion from a given segment													
		A	k_A	B	k_B	C	k_C	D	k_D	E	k_E	F	k_F	G	k_G
1	268	250	18	268	0	268	0	267	1	268	0	268	0	268	0
2	268	250	18	268	0	268	0	267	1	268	0	268	0	268	0
3	230	212	18	230	0	230	0	229	1	230	0	230	0	230	0
4	196	178	18	196	0	196	0	195	1	196	0	196	0	196	0
5	174	174	0	174	0	173	1	174	0	174	0	174	0	174	0
6	200	200	0	200	0	200	0	199	1	200	0	200	0	200	0
7	238	238	0	238	0	238	0	237	1	238	0	238	0	238	0
8	216	208	8	210	6	216	0	214	2	216	0	216	0	214	2
9	178	170	8	178	0	178	0	176	2	178	0	178	0	176	2
10	160	152	8	160	0	158	2	159	1	160	0	160	0	160	0
11	138	138	0	138	0	138	0	137	1	138	0	138	0	138	0
12	158	158	0	158	0	158	0	157	1	158	0	158	0	158	0
13	158	158	0	158	0	158	0	157	1	158	0	158	0	156	2
14	192	192	0	192	0	192	0	191	1	192	0	192	0	190	2
15	228	228	0	228	0	228	0	227	1	228	0	228	0	226	2
16	266	266	0	266	0	266	0	265	1	266	0	266	0	264	2
17	225	225	0	225	0	225	0	225	0	225	0	223	2	223	2
18	259	259	0	259	0	259	0	259	0	259	0	257	2	257	2
19	297	297	0	297	0	297	0	297	0	297	0	295	2	295	2
20	297	297	0	297	0	297	0	297	0	297	0	295	2	295	2
21	294	286	8	292	2	294	0	292	2	289	5	272	22	292	2
22	256	248	8	254	2	256	0	254	2	251	5	234	22	254	2
23	220	212	8	218	2	220	0	218	2	215	5	218	2	218	2
24	186	178	8	186	0	186	0	184	2	186	0	186	0	184	2
25	178	178	0	178	0	176	2	174	4	178	0	178	0	178	0
26	146	146	0	146	0	146	0	145	1	146	0	146	0	146	0
27	187	187	0	187	0	187	0	186	1	187	0	187	0	187	0
28	153	153	0	153	0	153	0	153	0	153	0	151	2	153	0
29	163	163	0	163	0	163	0	163	0	163	0	161	2	162	1
30	173	173	0	173	0	173	0	173	0	173	0	171	2	171	2
31	165	165	0	165	0	165	0	165	0	165	0	163	2	163	2
32	193	193	0	193	0	193	0	193	0	193	0	191	2	191	2
33	231	231	0	231	0	231	0	231	0	231	0	229	2	229	2
34	185	185	0	185	0	185	0	185	0	185	0	183	2	181	4
35	223	223	0	223	0	223	0	223	0	223	0	221	2	198	25
36	215	215	0	215	0	215	0	184	31	212	3	211	4	214	1
37	177	177	0	177	0	177	0	176	1	174	3	173	4	176	1
38	204	196	8	204	0	204	0	204	0	201	3	204	0	201	3
39	197	193	4	197	0	197	0	197	0	194	3	193	4	193	4
40	255	251	4	255	0	255	0	255	0	252	3	245	10	222	33
$D(G)$	8347	8203	144	8335	12	8343	4	8283	64	8317	30	8255	92	8239	108

TABLE 2 ctd.

Node no.	Tram-way net-work	Studied bus network segments and gains (k) in accessibility and dispersion from a given segment													
		H	k_H	I	k_I	J	k_J	K	k_K	L	k_L	M	k_M	$A,..,M$	$k_A,..,k_M$
1	268	264	4	265	3	266	2	266	2	264	4	266	2	173	95
2	268	264	4	265	3	266	2	266	2	264	4	228	40	183	85
3	230	226	4	227	3	228	2	228	2	226	4	228	2	171	59
4	196	192	4	193	3	194	2	194	2	192	4	196	0	154	42
5	174	170	4	171	3	172	2	172	2	170	4	173	1	139	35
6	200	196	4	197	3	198	2	198	2	191	9	195	5	168	32
7	238	234	4	235	3	236	2	236	2	214	24	233	5	179	59
8	216	212	4	213	3	214	2	216	0	215	1	215	1	175	41
9	178	174	4	175	3	176	2	178	0	177	1	177	1	152	26
10	160	156	4	157	3	158	2	160	0	159	1	159	1	136	24
11	138	134	4	135	3	136	2	138	0	137	1	137	1	126	12
12	158	154	4	155	3	156	2	158	0	158	0	157	1	136	22
13	158	154	4	155	3	158	0	158	0	157	1	157	1	147	11
14	192	178	14	182	10	191	1	192	0	188	4	191	1	173	19
15	228	214	14	208	20	201	27	228	0	215	13	227	1	162	66
16	266	252	14	246	20	239	27	266	0	223	43	265	1	192	74
17	225	196	29	218	7	225	0	225	0	224	1	224	1	182	43
18	259	230	29	226	33	259	0	259	0	258	1	258	1	182	77
19	297	268	29	264	33	297	0	297	0	296	1	296	1	220	77
20	297	268	29	264	33	297	0	297	0	296	1	296	1	220	77
21	294	290	4	291	3	292	2	294	0	293	1	293	1	227	67
22	256	252	4	253	3	254	2	256	0	255	1	255	1	189	67
23	220	216	4	217	3	218	2	220	0	219	1	219	1	179	41
24	186	182	4	183	3	184	2	186	0	185	1	185	1	161	25
25	178	174	4	175	3	176	2	178	0	177	1	177	1	145	33
26	146	142	4	143	3	144	2	146	0	145	1	145	1	130	16
27	187	183	4	184	3	180	7	173	14	187	0	186	1	150	37
28	153	153	0	153	0	151	2	153	0	152	1	152	1	147	6
29	163	163	0	163	0	163	0	163	0	163	0	162	1	156	7
30	173	173	0	173	0	173	0	173	0	172	1	172	1	161	12
31	165	165	0	165	0	165	0	165	0	164	1	164	1	153	12
32	193	190	3	191	2	193	0	193	0	192	1	192	1	178	15
33	231	228	3	229	2	231	0	231	0	230	1	230	1	216	15
34	185	185	0	185	0	185	0	185	0	185	0	184	1	166	19
35	223	223	0	223	0	223	0	223	0	223	0	222	1	182	41
36	215	215	0	215	0	213	2	215	0	214	1	214	1	177	38
37	177	177	0	177	0	175	2	177	0	176	1	176	1	161	16
38	204	204	0	204	0	202	2	204	0	203	1	203	1	178	26
39	197	197	0	197	0	195	2	197	0	196	1	196	1	176	21
40	255	255	0	255	0	253	2	255	0	254	1	254	1	179	76
$D(G)$	8347	8103	244	8127	220	8237	110	8319	28	8209	138	8259	88	6781	1566

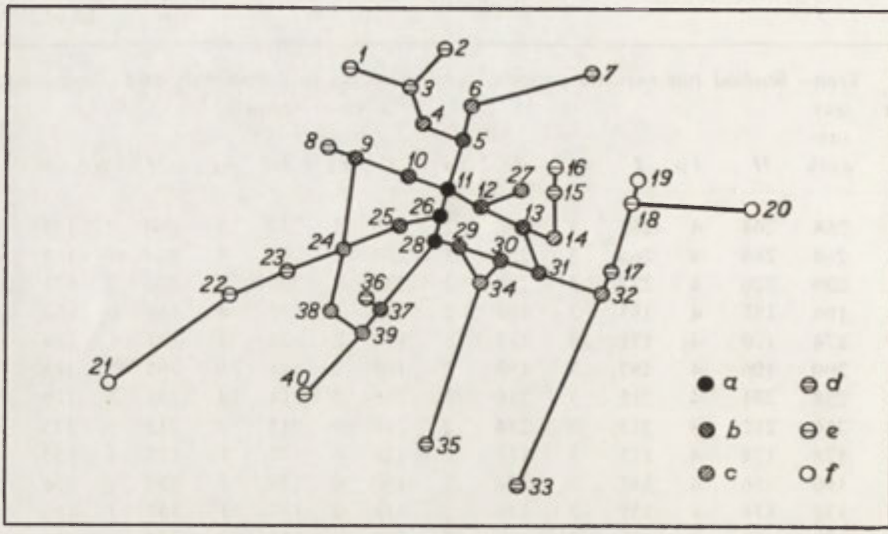

Fig. 3. Topological accessibility of tramway nodes equal to: (a) 135–155, (b) 156–180, (c) 181–210, (d) 211–240, (e) 241–270, (f) 271–300

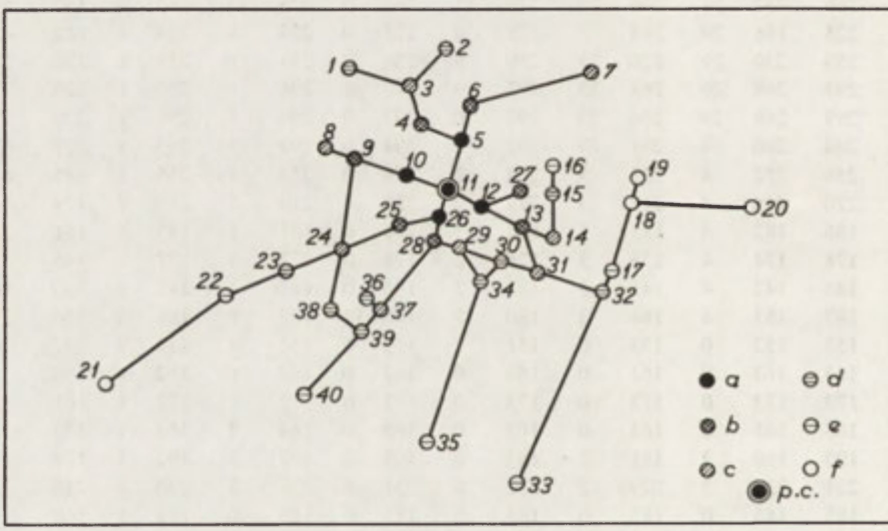

Fig. 4. Topological accessibility of nodes from the central point (p.c.) equal to: (a) 1, (b) 2, (c) 3, (d) 4, (e) 5, (f) 6 and 7

urse, each of the segments *A*, *B*, ..., *M* contributes differently to the reduction of both A_g and of $D(G)$. Since each segment reduces dispersion by a different margin, this information can be used to establish a certain hierarchy (Table 3).

From the point of view of dispersion, links *H* and *I* yield the greatest benefits. The high rank each of them occupies is evidence of the insufficient connectivity of the tramway network of the two parts of Poznań city situated on either bank of the Warta. Indeed, only a single tramway link across the river is in operation. Some other city districts have no direct tramway link either,

TABLE 3. The hierarchy of bus line segments by the index of dispersion

Segments	Reduction in dispersion $D(G)$	Hierarchy	Reduction in $D(G)$ to a single segment	Hierarchy
A	144	4	144	3
B	12	13	12	13
C	4	14	4	14
D	64	10	64	10
E	30	11	30	11
F	92	8	92	8
G	108	7	108	7
H	244	2	244	1
I	220	3	220	2
J	110	6	110	6
K	28	12	28	12
L	138	5	138	4
M	88	9	88	9
A, B, ..., M	1440	1	110,8	5

hence the high rank of segments *A* and *L*. In dispersion $D(G)$ least beneficial are the segments that run parallel to the tramway network, specifically *C*, *B*, and *K*. Peripheral or central situation is less significant for dispersion than a course parallel to some other segment.[8]

3.2. ACCESSIBILITY IN TERMS OF THE *S-I* INDEX

As it was pointed out by G. A. James, A. D. Cliff, P. Haggett, and J. K. Ord (1970, p. 21), "the *S-I* index can be used to examine the distribution of path lengths from any given node, *i*, in a graph to all nodes $j \neq i$ in the graph. If an *S-I* value was computed for each *i*, itmight be possible to distinguish different kinds of nodes within a graph". I use this suggestion in the present study to determine tentatively the accessibility of the nodes of the tramway network by the *S-I* index.[9]

Since the value of the index (Table 4) is determined by two variates, *S* and *I*, the following interpretation was adopted. The index values were plotted on a diagram (Fig. 5) and, subsequently, the "resultant" *S* and *I*, or the radius *r* as measured from the origin of the coordinate system, are read from the diagram. The *r* values are henceforward taken into account in all comparisons of accessibility variants.

This interpretation, which is certainly only one of several possible interpretations, relies on the assumption that the value of the *S-I* index depends on the frequency distribution of distances d_{xy} of the studied graph (network). Accordingly, of several nodes that is the most accessible which has the largest number of small distances to all the other nodes and for which, consequently, there is a low *r* value. And conversely, that node is less accessible for which high-value distances are more numerous and whose *r* value is high too.

[8] J. B. Riddell (1973) proposed another way of hierarchizing links. The algorithm he constructed consists in aplitting up a more complex network of circuits so as to obtain a simpler dendrite structure for which Horton had worked out a special algorithm.

[9] For the procedure of constructing the index see J. K. Ord (1967) and G. A. James and others (1970).

TABLE 4. Accessibility of the tramway nodes in the light of the *S-I* index

Node no.	*S*	*I*	*r* value
1	−1,801	1.001	2.07
2	−1.801	1.001	2.07
3	−1.317	1.067	1.68
4	−0.518	0.998	1.12
5	−0.034	0.856	0.86
6	−0.600	0.900	1.09
7	−1.150	0.840	1.42
8	−0.530	0.952	1.09
9	−0.351	1.056	1.11
10	0.250	0.750	0.74
11	0.229	0.782	0.78
12	−0.244	0.678	0.74
13	0.003	0.860	0.87
14	−0.924	0.880	1.28
15	−1.132	1.027	1.48
16	−1.951	0.825	2.09
17	−0.661	1.251	1.37
18	−1.457	1.312	1.92
19	−1.752	1.232	2.10
20	−1.752	1.232	2.10
21	−0.953	1.276	1.57
22	−1.220	1.321	1.77
23	0.116	1.409	1.40
24	0.450	1.436	1.47
25	0.923	1.038	1.39
26	−0.061	0.898	0.91
27	−1.030	0.619	1.20
28	0.030	0.835	0.82
29	−0.607	0.778	0.97
30	0.022	0.976	0.97
31	−0.290	1.033	1.05
32	0.391	1.233	1.28
33	−0.534	1.064	1.18
34	−0.613	0.862	1.07
35	−0.644	0.797	1.03
36	−0.528	0.881	1.00
37	−0.285	0.970	1.00
38	0.132	1.068	1.08
39	−0.197	1.192	1.19
40	−0.673	0.984	1.20

The structure of the *S-I* measure indicates that accessibility from the central point is of course possible to compute but the resulting aggregate value cannot be used for comparisons.

The spatial distribution of accessibility of nodes by the *S-I* index is similar to the pattern of topological accessibility. As in the former case, we find a concentration of most accessible nodes in the central parts of the network, that

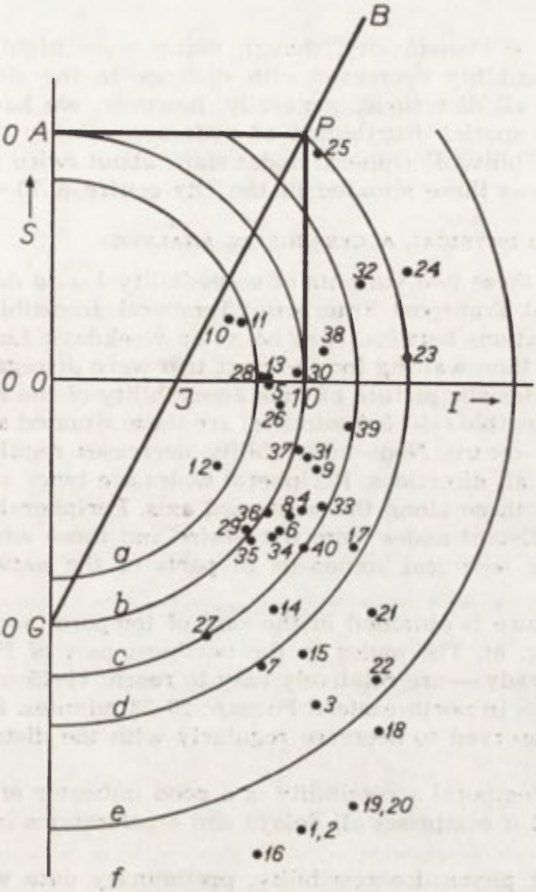

Fig. 5. Tramway nodes in terms of the *S-I* index

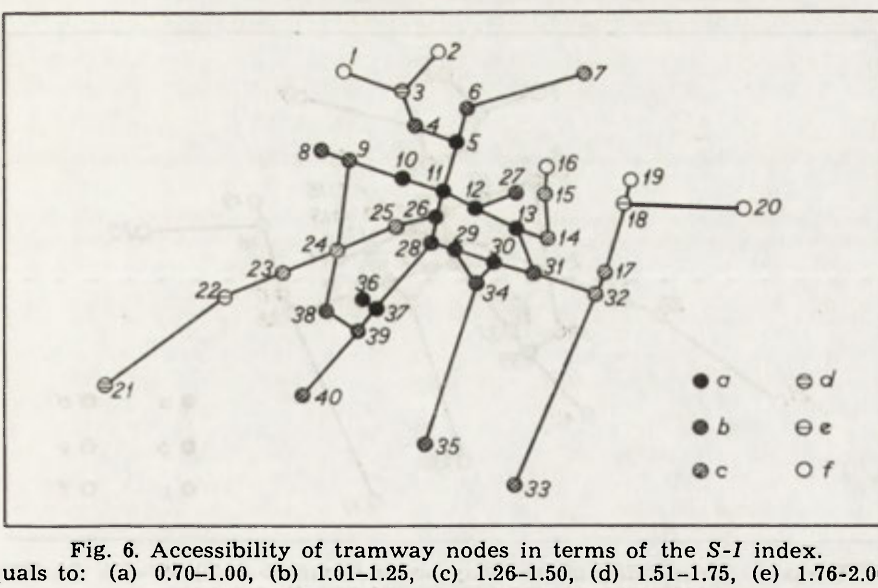

Fig. 6. Accessibility of tramway nodes in terms of the *S-I* index.
r equals to: (a) 0.70–1.00, (b) 1.01–1.25, (c) 1.26–1.50, (d) 1.51–1.75, (e) 1.76-2.00, (f) 2.01–2.10

is in the centre of Poznań city, though many more highly accessible nodes exist. Node accessibility decreases with distance to the city centre, more or less regularly in all directions; generally, however, we have to do with less regularity in the spatial distribution of node accessibility than in the case of topological accessibility. Peripheral nodes show about twice as low accessibility values ($r > 2.00$) as those situated in the city centre ($0.70 < r < 1.00$).

3.3. TEMPORAL AND PHYSICAL ACCESSIBILITY ANALYSES

To determine these two variants of accessibility I used data supplied by the Poznań Municipal Transport Enterprise. Temporal accessibility was expressed as mean trip durations between rush hours on weekdays. Losses of time due to changeovers and time waiting for the next trip were disregarded.

A very characteristic picture of time accessibility of the nodes was obtained (Fig. 7). Most accessible (450–500 minutes) are those situated along the westward axis off the city centre. Node accessibility decreases regularly with distance from that axis in all directions. Peripheral nodes are twice as inaccessible (901–1,100 minutes) as those along the westward axis. Peripheral nodes include the most physically distant nodes from the centre and those which are less accessible due to poor technical standards in parts of the network or to terrain conditions.

A similar picture is obtained in the case of temporal accessibility from the central point (Fig. 8). The nodes in the northern part of Poznań–Sołacz, Winiary and Winogrady — are relatively easy to reach: 11–15 minutes. Less accessible are the nodes in north-eastern Poznań: 20–28 minutes. Here of course, too, accessibility is observed to decrease regularly with the distance from the central point.

On the whole temporal accessibility is a good indicator of the accesibility of each node in that it comprises all delays and accelerations irrespective of their causes.

In the case of physical accessibility, preliminary data were used together with arithmetic means of distances from two directions between each pair of

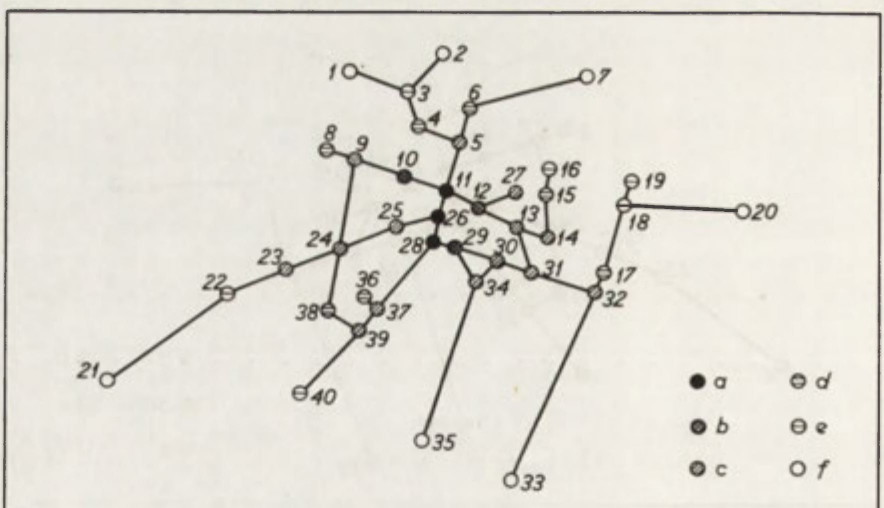

Fig. 7. Temporal accessibility of tramway nodes in minutes: (a) 450–500, (b) 501–550, (c) 551–650, (d) 651–750, (e) 751–900, (f) 901–1,100

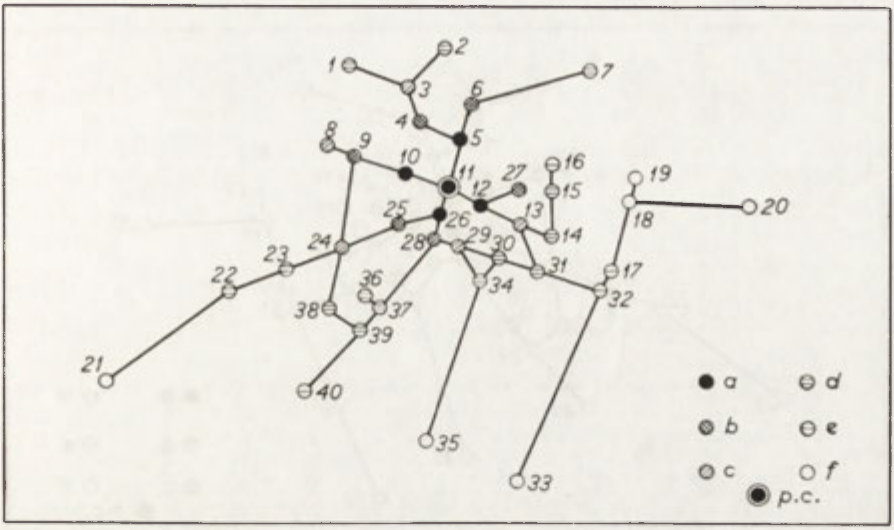

Fig. 8. Temporal accessibility of nodes from the central point (p.c.) in minutes: (a) less than 4, (b 4–7, (c) 8–10, (d) 11–15, (e) 16–20, (f) 20-28

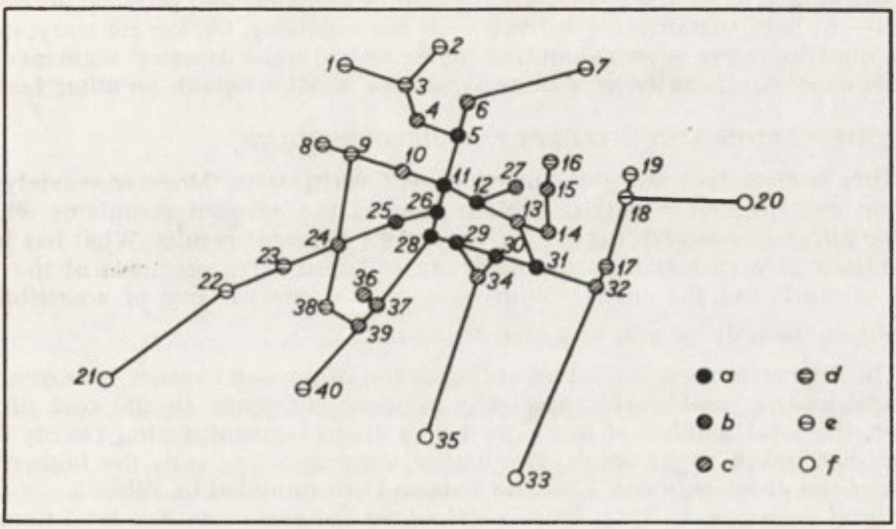

Fig. 9. Physical accessibility of tramway nodes in kilometres: (a) 100–115, (b) 116–130, (c) 131–160, (d) 161–190, (e) 191–240, (f) 241–310

nodes. The spatial distribution of physical accessibility of nodes (Fig. 9) is in its pattern almost identical with that of Fig. 7. In contrast to this latter, the peripheral nodes in the north of the city have better physical accessibility than temporal accesibility characteristics. The nodes along the centrifugal southward route are also situated better than temporal accessibility might suggest.

A_f from the central point (Fig. 10) is analogous to A_t. Some nodes in the south and east of Poznań have better physical accessibility than temporal accessibility.

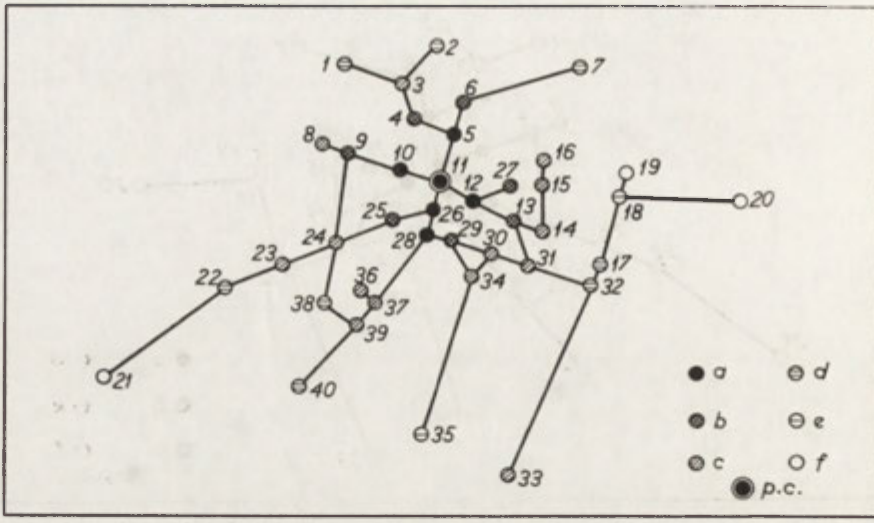

Fig. 10. Physical accessibility of nodes from the central point (p.c.) in metres: (a) less than 1,000, (b) 1,000–2,000, (c) 2,001–3,000, (d) 3,001–4,000, (e) 4,001–5,500, (f) more than 5,500

The similarity of the spatial distribution of temporal and physical accessibilities — in both variants, respectively — is not suprising. On the contrary, mean trip duration over several-hundred-meter or several-kilometer segments depends most significantly on distance and, to a smaller extent, on other factors.

4. VERIFICATION AND INTERPRETATION OF RESULTS

This section does not give an exhaustive verification. More adequately we should speak about a partial confirmation of the adopted postulates which, under different research conditions, may yield different results. What has been submitted to verification is the hierarchy of substitutive segments of the bus line network and the spatial comparison of the four variants of accessibility.

4.1. THE HIERARCHY OF THE BUS LINE SEGMENTS

This hierarchy, established according to the dispersion indexes, was compared against the "real-world" hierarchy of those segments. In the case of the latter, the total number of bus runs over a given segment during twenty-four hours was taken as its index. The higher the number of runs the higher the rank of the given segment. The data obtained are compiled in Table 5.

Since segments *A*, *B*, ..., *E* are serviced by the same line, the total number of bus runs is identical. In establishing the hierarchy in this case use was made of S. Gregory's (1968, p. 205) statement that "when two or more items occupy the same rank, the normal procedure is to allocate to each of them the average of the rank values that would have been assigned if no ties occurred". Thus segments *A*, *B*, ..., *E* occupy *ex aequo* the eleventh rank in the hierarchy by the number of bus runs.

The ranks of both series were compared with each other by means of the Spearman's rank correlation coefficient:

$$r_s = 1 - \frac{6 \sum_{i=1}^{n} (x_{ij} - x_{ik})^2}{n(n^2-1)} \qquad (10)$$

TABLE 5. The hierarchy of substitutive bus line segments according to the number of bus runs and dispersion index values

Segments	Total numbers of bus runs in 24 hrs	The hierarchy by bus runs	The hierarchy by dispersion index values
A	224	11	3
B	224	11	13
C	224	11	14
D	224	11	10
E	224	11	11
F	306	4	8
G	225	8	7
H	246	6	1
I	488	2	2
J	565	1	6
K	196	14	12
L	239	7	4
M	395	3	9
A, B, ..., M	291*	5*	5*

* per segment.

where x_{ij}, x_{ik} are ranks and n is the number of pairs of values considered. The obtained value of r_s (0.573) was verified on a diagram of significance values for the correlation coefficient. It turns out that this value is statistically significant somewhat below the 1-per cent level. Thus it is rather unlikely that the obtained correlation coefficient could be accidental in its value. The value is therefore assumed to be sufficient.

Graph methods are well suited for the study of the hierarchy of new or previously existing network segments of substitutive character. It can be though that if proper "weights" could be attributed to the individual transport nodes, still better results could be obtained. Attributing such weights, as has already been mentioned, is no doubt easier in the cases of regional or national networks than in the case of a single city network.

4.2. THE SPATIAL COMPARISON OF VARIANTS OF ACCESSIBILITY

The comparison of accessibilities was preceded by normalizing the relevant variates according to the formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}, \tag{11}$$

where x_{ij} is the value of variate j for node i, $\bar{x}_j$ is the averaged value of j, and s_j is the standard deviation of variate j. Normalization of variates permits a comparison of features which, measured in various units (minutes, metres), after normalization occur as indenominate numbers. For the normalized elements absolute differences were computed and subsequently these were grouped into classes.

A comparison of the topological and *S-I* index accessibilities with the temporal and physical accessibilities in terms of space helps to establish the usefulness of graph methods, and that of the temporal and physical accessibilities to disclose similarities and differences in the tramway network of Poznań.

If applied to the description of the system, topological accessibility results in considerable deviations from the real world. Therefore taking account of the temporal or physical accessibilities (using the graph method approach) is recommended, as both of them can suggest optimal locations for economic activities and cultural facilities which require different degrees of accessibility. The index of topological accessibility instead can only be used in test researches, since "would appear to have more intuitive appeal than real world usefulness" (J. B. Riddell 1973).

Accessibility as determined by the *S-I* index is a more adequate measure than topological accessibility. By virtue of its structure itself the *S-I* index makes this measure more accurate and hence more commendable for further application.

As for the description of accessibility of a transport system, the principal advantage lies in the specific approach permitting the study of the accessibility of each node with respect to all others. This approach can be employed in instruction organized for planners of transport network structures. One advantage of it is that it draws attention to the transport network as a whole not only to the links of peripheral areas (fulfilling residential or production functions) but also to the city centre. Let it be emphasized that it is by establishing direct links of urban transport network between the peripheral areas that the decongestion of city cores can be efficiently achieved. This would eliminate the necessity of going through the city centre each time it is necessary to travel from one periphery to another.

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THE DISTRIBUTION OF SERVICE CENTRES WITHIN LARGE URBAN AREAS. A MARKET ACCESSIBILITY MODEL

Kazimierz Polarczyk

The service sector, or the tertiary activity is treated below as an array of the following socio-economic activities (K. Polarczyk 1971):

(1) Renovation — services pertaining to the products already in use (repair, conservation etc.),

(2) Distribution — services pertaining to new products (mainly retail trade, also the catering trade),

(3) Recreation — services oriented towards individuals — their biological characteristics (mainly medical and tourist services),

(4) Education and culture — services for individuals, oriented towards their spiritual characteristics,

(5) Organizational services — oriented towards groups and their social structure (mainly administration).

The term "large urban area", as used throughout this paper, could as well be substituted by "urbanized area", "metropolitan area", "urban agglomeration" and the like. Within such an area a system relatively closed in terms of service linkages, should be identified for the sake of the study.

I. MODELS EXPLAINING THE DISTRIBUTION OF SERVICES WITHIN LARGE URBAN AREAS

One can find in the literature at least eight models, differing in character and generalization level, which explain the actual distribution of service establishments and service centres within cities. These include:

(1) The consumer behaviour model which defines one of the basic premises of the distribution of services (see R. U. Ratcliff 1939; D. L. Huff 1964). The description of consumer behaviour does not form, however, a complex model which could be quantified and transformed into a spatial pattern.

(2) The consumer travel model which takes into consideration only the factor of consumers' locational preferences. Its operational and explanatory potential is limited, as in case (1) (see L. Curry 1962).

(3) The transportation accessibility model which points to one of the essential factors in the service location but disregards the size of consumer flows and can not be transformed into a model of service distribution over space (see D. Foley 1956; B. J. Garner 1968).

(4) The urban land values model which considers implicitly all the three factors listed so far. The correlation between the distribution of the peaks of land value and the location of service centres is very pronounced (see R. Murphy and J. Vance 1954; B. J. Garner 1968). It is not clear, however, whether land

values are the explanitory or the explained variable. Moreover, the model is irrelevant under the planned economy prevailing in Poland, as land values are not calculated.

(5) The concentric zones model by E. Burgess which gives a certain picture of the service distribution within the city as shown against the distribution of other activities and the distribution of population, without going far into the explanation of the pattern (see R. Dickinson 1960; R. U. Ratcliff 1965). At present this theory finds littel support as being in conflict with the actual spatial patterns of service distribution.

(6) The multiple nuclei model by Ch. D. Harris and E. L. Ullman (1945) which does not specify what kinds of nuclei are in question. The model initiated a number of investigations but it has not been developed into a complex picture of the distribution of service centres.

(7) The central place theory which, according to its advocates explains the multicentricity and hierarchy of service centres within cities (see B. J. L. Berry 1959; H. Carol 1960). Nevertheless, empirical studies by numerous authors have proved that the theory is less effective in the modelling of intra-urban service patterns than in the case of urban-rural systems. Some authors (including B. J. L. Berry and A. Pred 1961) see the necessity of reformulating the theory while others (see L. Curry 1962) consider it completely useless as a model of the distribution of services within cities.

(8) Sets of statements of varied generalization level which more or less closely approximate a theory of service distribution within large urban areas (see for example K. Toeplitz 1965). However, they do not constitute an integrated model.

The models listed above are not satisfactory from the point of view of the information they supply about the real distribution of services within cities. It is suggested that a spatial organization model of a given socio-economic phenomenon should be constructed so as to meet the following conditions:

(1) It should take into account the systematic factors, i.e., the factors that affect the distribution of a given phenomenon in the same manner over time and space providing that certain basic assumptions are met and random factors are disregarded.

(2) It should take into account the transformation function of the systematic factors on the state which is the result of their action.

(3) It should consider the geographical distance relations, i.e. it should be able to indicate the spatial pattern of the given phenomenon.

(4) It should be of an operational character, i.e., reproducible with respect to different areas and time points.

(5) It should yield to empirical tests, i.e. describe real-world situations, i.e., real spatial patterns.

(6) It should possess optimization characteristics.

(7) It should facilitate predictions concerning the distributions with the assumption that the pattern of the influencing factors is known.

II. THE MARKET ACCESSIBILITY MODEL

This attempt to build a model of intra-urban service patterns is based upon the hypothetico-deductive procedure. Therefore, it is necessary first to formulate the initial assumptions taken as axioms. One should add that the assumptions, statements and the hypothesis may concern any type of area, while the model in its mathematical form applies to large cities in particular.

Assumption 1: Service establishments are locationally footloose, i.e., they are under no constraints of the natural environment.

Assumption 2: Customers representing the demand side behave rationally, i.e., they tend to minimize their effort while overcoming the friction of distance separating the places of residence from the places of service supply.

In an extreme case, from the coustomers' point of view all the services should be located at their place of residence; for example the residents of each apartment least effort assumption lay also at the bases of the agricultural lacation (von building would be able to find in the building all the services required. The least effort assumption lay also at the bases of the agricultural location (von Thünen), industrial location (Weber), as well as the settlement location (central place) models.

Assumption 3: Enterpreneurs representing the service sector behave in a rational way, i.e., they seek to maximize the economic returns of their units by attracting as much of the consumers' demand as possible above their threshold value.

According to B. J. L. Berry and W. L. Garrison (1958) the threshold value of a given branch may be calculated as the minimum population size which is required to ensure the profitability of a typical unit of the branch service function in question. It is a simplification to use the population size rather than the size of demand, but it allows the clear illustration of the role of the threshold in the formation of the spatial organization of services. In the case of non-economic services the social advantages are substituted for economic efficiency.

Assumption 4: Units of different service branches differ in terms of their threshold size.

Such establishments as grocery stores, elementary schools, or tailors' shops have low thresholds, i.e., they serve small numbers of people and have a small range; therefore, within a given settlement system they are relatively numerous. On the other hand, art shops, specialized artisans' shops or universities have respectively high thresholds, i.e., they serve large numbers of people, and have a greater range. At the same time, they are found in small numbers within a city.

The first three assumptions may be violated in single cases with the resulting deviations in the location of certain service establishments from the pattern established by the market accessibility model. The second assumption remains valid also when transactions take place at the customers' place of residence. In that case enterpreneurs rather than customers behave so as to minimize transportation costs.

The assumptions listed make it possible to derive three statements which answer some of the questions on service distribution patterns.

Statement 1 constitutes a compromise between the interests of the enterpreneurs and the customers as expressed in Assumption 2 and 3. The former are not able to reduce radically the number of units of a given branch within the city and thus to reach profits much above the threshold value via increasing the demand per unit. Such tendencies are curtailed due to one or a combination of the following factors: (a) the competition in every area where the demand is above the threshold value of two units; (b) the possibility of enforcing the customers' rights via administrative measures; (c) the declining rate of the effective demand increase for a given kind of service due to the fact that some consumers may drop out if the distance to be travelled increases. At the same time the enterpreneur is not able to add to the number of units in such a way as to reduce their patronage below the threshold (Fig. 1).

Statement 1: A unit of a given branch attracts the demand which is not smaller than its threshold value and not bigger than thrice the threshold value (twice is not enough to ensure the profitability of two units).

Statement 2: determines the location of the units of a given branch on the basis of the Assumptions 1 and 2, as well as Statement 1. It follows from Statement 1 that the number of units within the city is not bigger than P/P_j (aggregate service demand within an urban area to the threshold size of the unit of *j* branch) and not smaller than one third of that ratio. If, for example, the threshold for shoe stores equals 10,000 persons, then for an area of 1 million people the number of shoe stores should fall within the (34,100) interval. With the absence of locational constraints each store may be located at the point of highest accessibility within the market area, i.e. at the local central point of demand.

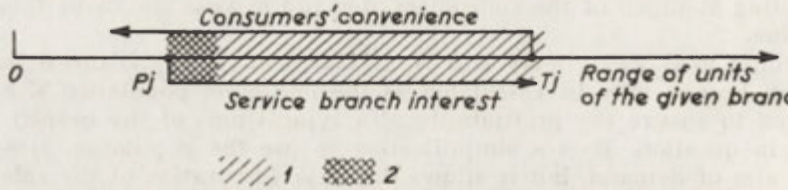

Fig. 1. The actual range for the establishments of *j* branch

1 — marginal value; 2 — typical values; P_j = threshold for *j* branch establishments; T_j = optimum range for *j* branch establishments

Statement 2: A unit of a given service branch is located at the central point of demand sufficient to ensure its profitability. The number of the central points of demand for a service branch is determined indirectly by the threshold value of its units.

Statement 3 defines the locational linkages between the establishments representing service branches of similar threshold values. Assumption 4 and Statement 2 could imply that a separate set of central places could be identified for each service branch. However, the least effort principle on the part of customers leads to their joint trips to varied services, and the rational behaviour of enterpreneurs also suggests the costs savings *via* the concentration of establishments. In addition, it follows from Statement 1 that the number of possible central places for each service branch falls into a rather broad interval. The result is that units representing varied branches fall within a certain threshold interval, cluster in service centres, providing that the number and location of the central places is suited to those branches with the highest threshold values within the interval. The factors identified are responsible for the hierarchical arrangement of service branches according to their range (Fig. 2).

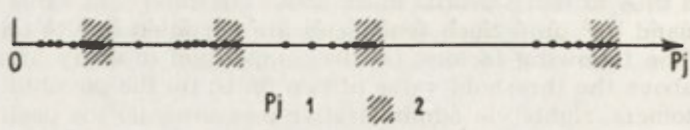

Fig. 2. A tendency towards a hierarchical arrangement of individual service branches according to their range

1 — Threshold value; 2 — Upper part of the population threshold interval for group of service branches

Statement 3: Establishments representing service branches with similar threshold values are located in the same central places which are determined by those branches with the highest values falling within the given interval. The subsets of service branches, thus determined, constitute separate hierarchical levels in terms of the spatial range.

From the assumptions and statements listed it is possible to derive a hypothetical idealized verbal model of the spatial organization of the service sector within large urban areas.

It follows from the premises standing behind Statement 3 that the establishments representing higher hierarchical levels are located at the central places determined by the lower branches, but only in those places which are simultaneously the central places of demand with respect to the higher branches. This leads to superimposing the central places of the higher levels onto the lower level places and to the emergence of several hierarchical levels of central places and of service centres located at those places, as well as of the respective hierarchical levels of market areas. It should be mentioned that the range of locational freedom of a service branch, as determined by its threshold value on the one hand and the value three times greater on the other hand, is analogous to the market principle in the Christaller theory, according to which a market area of the higher level comprises three market areas of the lower level.

The hypothesis: the distribution of service establishments belonging to each range level corresponds to the spatial pattern of the central places of demand as determined by the upper threshold value of the service branches of the given level. The central places and the respective service centres are hierarchically arranged, the higher level centres performing also the functions of the lower level centres.

To test the hypothesis it is necessary to identify the central places of demand for each level and to find whether they coincide in space with the service centres of the respective levels. The method to be used should allow a transformation at the dispersed spatial demand pattern into the central points of demand. The way to proceed is to move from a verbal to a mathematical model. It follows from the hypothesis that for each hierarchical level of a given service branch one should identify the central places of demand as the highest accessibility points within the market area. The market accessibility value for each place within an urban area (settlement system) is calculated using the potential model (see Z. Chojnicki 1966) which will be interpreted here as a mathematical model of market accessibility.

$$D_k = \sum_{i=1}^{n} \frac{P_i}{r_{ki}}, \qquad \begin{matrix} (k = 1, 2, \ldots, n) \\ (i = 1, 2, \ldots k, \ldots, n) \end{matrix} \tag{1}$$

where:
D_k = the market accessibility of k territorial unit
P_i = the size of demand in i territorial unit
r_{ki} = the friction of distance between i and k (?)

On the basis of formula (1) the market accessibility values for centres of all basic territorial units were calculated. These values were then plotted on a map, and isolines drawn. The area within the highest value isoline was considered the central place of the demand generated by the settlement system as a whole. According to the hypothesis, within this area the service centre of the highest level (on an urban scale) should also be found. The potential values received are considered as the total accessiblity.

The total accessibility is the market accessibility of individual territorial units with regard to the system as a whole. On the other hand, the partial accessibility (K. Polarczyk 1969) is calculated in relation to a part of its territorial units. The latter allows the identification of the central places of demand of the levels lower than the all-urban area level.

The starting point in the calculation of partial accessibility for service branches of the hierarchical level is the determination of the size of demand on the basis of the threshold value for the level in question. The ${}_hD_k$ values for each territorial unit are found from the P_i and r_{ki} values for the contiquous group of nearest territorial unit, which generate the demand equal to the threshold value (Equation 2). The accessibility of k unit itself is also considered, as in the former case

$$ {}_hD_k = \sum_{i=1}^{m} \frac{P_i}{r_{ki}}. \tag{2}$$

where: m = the number of basic territorial units situated nearest to k unit and generating the demand equal to the threshold value.
The Equations (1) and (2) form together a hierarchical market accessibility model.

III. TESTING THE MARKET ACCESSIBILITY MODEL IN THE CASE OF POZNAŃ

To test the model and the initial hypothesis it was derived from, an empirical analysis was carried out using the 1967 data for the city of Poznań. The central places of demand on the city, district and community scale were identified and confronted with the actual distribution of services (K. Polarczyk 1974).

Market accessibility values were calculated for 138 basic functional territorial units (as determined by the author, each unit having approximately 3 200 inhabitants). For practical considerations population size was assumed to be the measure of demand within the units in question. Therefore, the variation of demand due to income variation as well as the workplace-to-service place relations were disregarded. Such a simplification was necessary because of data limitations, but the resulting distortions are not believed to be great.

The friction of distance was estimated using the time-distance values between individual territorial units (travel time by public transportation plus walking time). In every case $a = 10$ minutes were added to the estimated time-distance values. It was found, while running provisional tests of the model on the data aggregated for 16 territorial units that the highest correspondence between the distribution of services and market accessibility values occurred when such an addition was made. Tests with varied exponents of L and t parameters (also for 16 units) proved that the best fit was received when the exponents were equal to 1. As a result, the equation for calculating both the total and partial market accessibility took the following form:

$$ D_k = \frac{L_k}{10+t_k} + \sum_{\substack{i=1 \\ i \neq k}} \frac{L_i}{10+t_{ki}}. \tag{3}$$

where: L = population size of i territorial unit as a measure of demand
t = travelling time (in minutes) between:
— the k territorial unit and other units (t_{ki})
— the places of residence within the k unit and its centre (t_k).

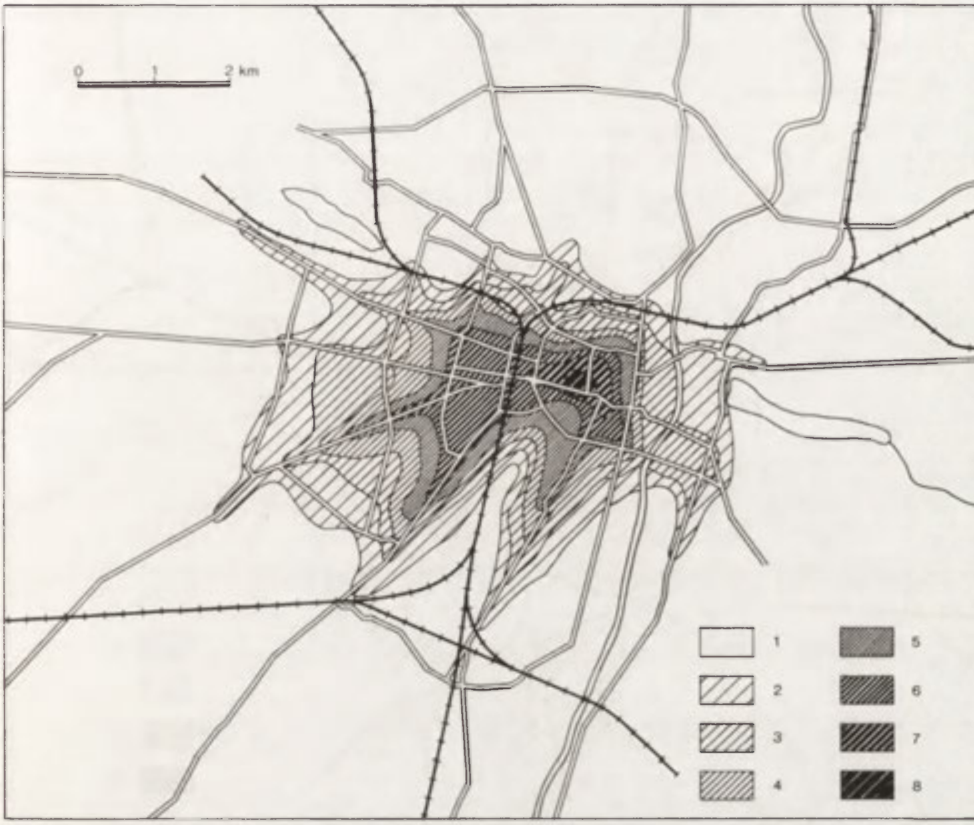

Fig. 3. Total accessibility, Poznań 1967 $a = 10$ minutes;
1 — below 13,500 persons/minute; 2 — 13,500–14,000; 3 — 14,000–14,500; 4 — 14,500–15,000, 5 — 15,000–15,500; 6 — 15,500–16,000; 7 — 16,000–16,500; 8 — above 16,500 persons/minute

To identify central places of the district level the partial accessibility values for each territorial unit in relation to its nearest units, comprising the total population of 85,000, were calculated. This figure was established empirically; it was found that it fits the range of a relatively large number of service branches. In the case of central places of the community level (an approximate range = 30,000 inhabitants) the isoline pattern came close to the pattern of population density as the territiorial units turned out to be too large for the purpose.

The procedure described is a sequence from a geometric model (more precisely — from the picture of population distribution and transportation linkages) through a mathematical model (the transformation of the two patterns into the central place of demand pattern) back to a geometric model, i.e., a map of the spatial distribution of the market accessibility.

A detailed empirical analysis, using the number of service employees as the basic index, was conducted with respect to the "distributory" services (retail trade, catering trade, finance and insurance) accounting for over 20% of the total service sector employment in the city of Poznań. For each of the basic territorial units the service intensity (the ratio of service employment to the population totals) was calculated, while the detailed location of 2500 service establishments served to delimit the service centres.

Fig. 4. Partial accessibility, Poznań 1967
1 — below 1,000 persons/minute; 2 — 1,000–2,500; 3 — 2,500–4,500; 4 — 4,500–7,000; 5 — 7,000–9,500; 6 — above 9,500 persons/minute

In addition to the "distributory" services, the centres identified comprise also the organizational and cultural service institutions, while the services representing "renovation" activities extend partly beyond their outskirts. Institutions of recreation and education show the least tendencies to form distinct centres and to be spatially associated with other service branches. On the other hand, over 50% of polyclinics, hospitals and schools are found within the delimited service centres.

Once the hierarchical arrangement of the service centres was revealed, it was possible to test the main hypothesis, i.e. the interrelations between the spatial distributions of market accessibility values and the distribution of services. Tests were based upon map inspection, graphic methods, as well as regression and correlation analysis. They showed a high degree of correspondence between the service and the market accessibility patterns. It may be of interest to list some of the more detailed results:

(1) Service centres of a given level are in nearly all cases located precisely at the central places of demand of the respective level.

(2) The intensity of the service activity within the individual territorial units increases with an increase in the market accessibility.

(3) The higher the level of the central places of demand (market accessibility) the greater the centrality of the service centres.

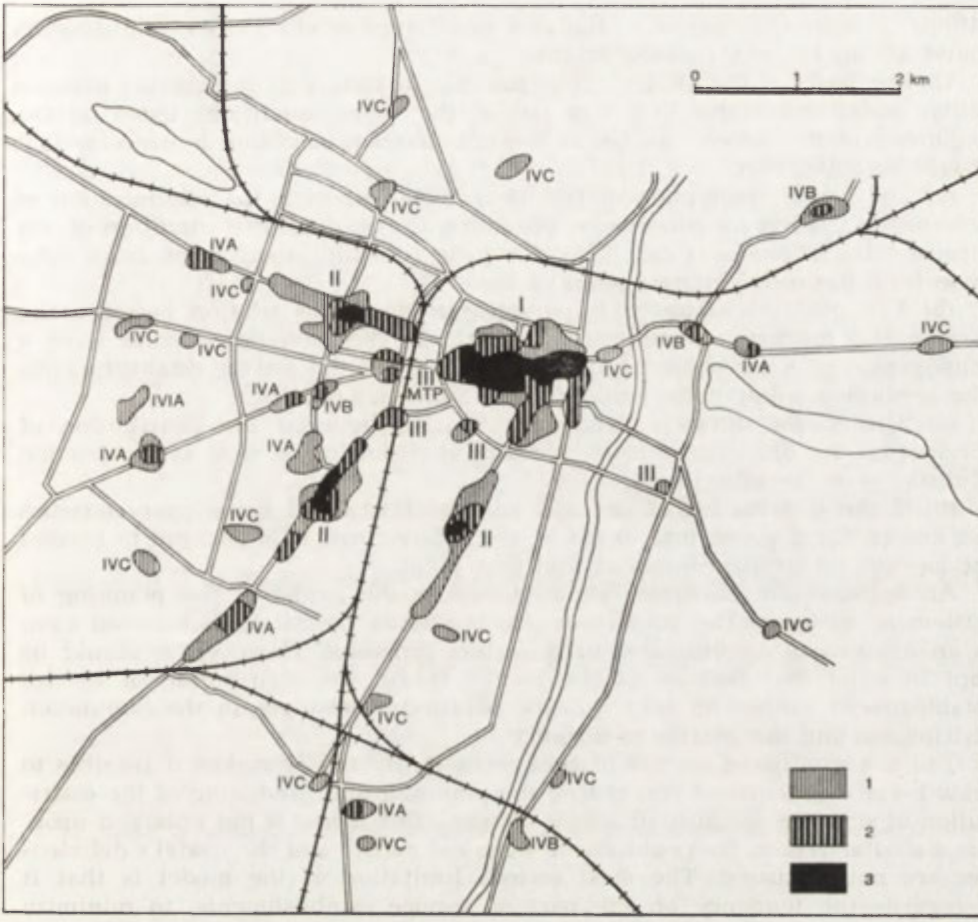

Fig. 5. Service centres, Poznań 1967
1 — Low density of service employment, 2 — Medium density of service employment, 3 — High density of service employment,
I — The Central Service District; II — District Service Centres; III — Service Centres at transportation nodes; IV — Community Service Centres
A — Larger, with services of the district range; *B* — Larger, without services of the district range; C — Small, with a small number of service branches

(4) The service branches of city range are mainly located in the principal central place of demand, while the branches of a district range are usually found in the central places established for individual city districts.

(5) The higher the centrality of the place the more diversified the functions of the service centre located at that place.

(6) The shape of the large service centres corresponds to the pattern of the isolines showing the market accessibility values.

(7) The greater the range for a given service branch, the more likely their units are to be found at the highest accessibility points within the service centres.

Of course, the interrelations between the service distribution and the market accessibility patterns are of a stochastic rather than a deterministic character. However, the actual deviations from the model are clearly explained by non-rational locations, mainly — a relatively small number of service establishments found within the new housing estates.

On the basis of the analysis it is possible to state that the market accessibility model meets the first five out of the seven conditions listed at the beginning of the article. As far as the optimization condition is concerned, it should be noted that:

(a) The major assumption of the hierarchical model is the minimization of time-distance costs by consumers, providing the profitability condition of the service establishments is met. Therefore, the resulting distribution is an optimum from the social interest point of view.

(b) The model was tested by showing a stochastic relation between the service and market accessibility distributions. The deviations found were a consequence of a non-rational location of a part of the service establishments. The predictive value of the model follows from two premises:

(a) The model shows a functional relation between the distribution of services on the one hand and the demand distribution as well as the friction of distance on the other hand.

(b) If the distribution of demand and the friction of space characteristics are known for a given time point in the future, then it is possible to predict the location of service centres at that time point.

An optimization character allows to apply the model in the planning of settlement systems. The predictive characteristics permit it to be used even in an analysis of uncontrolled urbanization processes. However, it should be kept in mind that because of the inertia factor, the distribution of service establishment cannot be very quickly adjusted to changes in the population distribution and the friction of distance.

The analysis based on the market accessibility model makes it possible to draw certain conclusions concerning the planning and predicting of the distribution of services. Because of a lack of space this theme is not enlarged upon. For a similar reason the problems of technical nature and the model's deficiencies are not discussed. The most serious limitation of the model is that it disregards the tendency on the part of service establishments, to minimize distance between the individual units within a service centre. This tendency is responsible for a growth of service density towards the centre, much greater than the increase in the market accessibility would suggest.

It should be added that the model is oriented towards large urban areas rather than towards settlement systems in general, because: (a) the market accessibility is represented on a map in a continuous form; also continuous are the demand and supply in highly urbanized areas. On the other hand, demand and supply in the rural areas are definitely of a discrete character; (b) no tests for rural areas were attempted.

IV. MODELS OF THE SPATIAL STRUCTURE OF SERVICES WITHIN LARGE URBAN AREAS: A COMPARISON

In the introductory section to this article a number of models of service patterns within cities were discussed. Two of these models, namely, the central place theory and the land value model will now be compared with the market accessibility model. The central place theory is shown in its three versions, as presented by Christaller (1966 edition), Lösch (1961 edition) and Isard (1956). It is necessary to stress that the comparison does not aim at emphasizing the differences between the market accessibility model and the central place models. If the central place theory is treated broadly, then it could encompass also the market accessibility model which determines the location of the central places of demand within the socio-economic space and assumes the development of service centres at those central points.

Both the central place theory and the market accessibility model are deductive in character and based upon the rational service distribution assumptions — the minimization of the travel time and the profitability of service establishments. On the other hand, land values are a consequence of site rents, which in turn are a product of the real size of consumers flows. The basic difference between the central place models and the market accessibility model is the latter's departure from such unrealistic assumptions as the uniform population distribution.

Table 1 depicts some of the characteristics of the five models, including their usability in planning. Those elements which are explained by all the models or by none, as well as those which were not adequately tested in the present

TABLE 1. Selected characteristics of the five models of the spatial structure of services within large urban areas

Number	Elements subject to explanation, prediction, or planning	Central place theory			Market accessibility model	Land value mode
		Christaller	Lösch	Isard		
1	Ordering of centres: from ideal hierarchical arrangements to perfect rank-size patterns	—	o	o	+	+
2	Centres of higher order perform also the function of lower order centres	+	o	o	+	o
3	The shift towards higher order centres in relation to the population centre of a settlement unit	—	—	+	+	o
4	Geometric pattern of service centres (differentiated metric distances)	—	—	o	+	+
5	Centres oriented towards linear concentration of demand (mainly arterial street forms)	—	—	—	+	+
6	The shape of service centres	—	—	—	+	+
7	The spatial ordering and changing service density within centres	—	—	—	+	+
8	Planning the optimum location of centres	—	—	—	+	—
9	Planning the optimum shape of the centre	—	—	—	+	o

Symbols: + applicable
o possibly applicable
— non-applicable

study (such as the shape of market areas) are disregarded. It follows from Table 1 that the market accessibility model is the most useful in the explanation, prediction and planning of the spatial structure of services within large urban areas. The model originates from the market location principle — the notion treated by the location theory of economic activity. Therefore, it is proved by the model that the service location theory forms a part of the general location theory rather than a part of the settlement structure theory, as might be suggested by its interpretations within the framework of the central place theory.

One should nevertheless admit that out of all the economic sectors, the spatial structure of the service sector is the one most closely related to the spatial structure of settlement.

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GEOGRAPHIA POLONICA 33, 1976

TENDENCIES IN THE LOCATION OF NEW INDUSTRIAL PLANTS IN POLAND IN THE YEARS 1945–1970

Teofil Lijewski

After the Second World War there began in Poland a period of intensive industrialization; the most rapid in the history of this country and, comparatively, one of the fastest in the world. This process has placed Poland, hitherto a rather underdeveloped agricultural country, among industrial-agricultural states, and has resulted in Poland's total industrial production (including mining production) amounting today to the tenth position in the world.

To a certain extent this has been caused by the change of her borders in 1945; it was not, however, the most important factor in the process since the industry in the territories regained from Germany had suffered extremely heavy devastation in wartime, and had, moreover, been greatly out of date. Thus the industrialization mainly relied on the post-war investment and construction. This comprised the building of new industrial plants, the reconstruction of the devastated ones and the development and modernization of the ones which had suffered the least.

This paper discusses the most significant tendencies in the location of new industrial plants built in the years 1945–1970. The choice of the considered period of time has been motivated by the availability of adequate statistical data. Only the larger new plants have been taken into account; the ones in which the fixed asset value exceeds 20 million zloty (c. 1 million dollar US). Such plants have consumed most of the investment expenditure assigned for industrial construction, for the socialist system of economy favours the construction of large plants which yield the best economical effects and can substitute often for the great number of small factories which, in their time, would have been built by private owners.

Altogether the data had been collected for 1270 plants constructed, reconstructed or developed so that they can be treated as new. Branch structure of the plants is given in Table 1. It shows that heavy industry, which produces capital goods and supplies energy, dominates the investment structure. This is caused both by the demand for heavy industrial products in the process of industrialization, and by the favourable raw-material situation in this country for the development of heavy industry branches (Poland is one of the largest contractors of energetic raw materials on the world scale).

Heavy industry is the most capital intensive. Thus its share in investment expenditures and in fixed asset value is the highest, but it decreases when the number of employed is considered, and in the number of plants it is preceded even by the consumer goods industry, if smaller objects absent from Table 1 are taken into account.

The location of new industrial plants is governed by a few genetal tendencies, partially contradictory to each other. It is according to the kind of the

TABLE 1. Branch structure of new industrial plants built during the years 1945–1970 (of a fixed asset value higher than 20 million zloty)

Industry	Number of plants	Employment		Fixed asset value	
		1000's	%	milliard zloty	%
Fuel and power	107	114	10.1	111.0	28.9
within it coal	20	77	6.8	34.0	8.8
electroenergetic	49	22	2.0	56.3	14.7
Metallurgy	46	92	8.2	54.8	14.3
Engineering	348	486	43.2	78.2	20.4
within it machine	127	128	11.3	20.9	5.5
transport[a]	64	177	15.7	30.5	7.9
Chemical	88	97	8.6	56.2	14.6
Mineral[b]	177	72	6.4	30.4	7.9
Timber	65	34	3.0	5.6	1.5
Paper	8	11	1.0	7.0	1.8
Textile	56	71	6.4	10.3	2.7
Clothing	27	27	2.4	0.9	0.2
Leather	20	23	2.0	1.9	0.5
Food	283	80	7.2	24.6	6.4
Printing	16	10	0.9	2.0	0.5
Others	29	7	0.6	1.3	0.3
Total	1270	1124	100	384.2	100

[a] Construction of vehicles and ships
[b] Manufacturing of building materials, glass, china and pottery

plant and to its purpose that one of these tendencies prevails in the end. Often the choice of the location must be a compromise between a number of these tendencies.

Among the most important location tendencies the following should be noted:

(1) Referring to the existing network of industry, which is manifested in the development of existing plants, the reconstruction of destroyed ones, and the construction of new ones within traditionally industrial areas or centres.

(2) Bringing industry closer to its supply sources in raw materials, intermediate products, fuel, energy, and water (material orientation).

(3) Coming nearer to prospective consumers (market orientation).

(4) Utilizing manpower reserves (activization of non-industrialized, economically stagnant towns and regions).

(5) Looking for possible advantages of joint location in larger centres and in the urban-industrial agglomerations.

THE EXISTING NETWORK OF INDUSTRY

The existing network of industry is most important for the development of engineering, chemical and textile industries. It is in these branches that production has been traditionally most strongly continued in certain centres or regions. Thus among 348 new plants representing metal engineering, as many as 140 of them have not been located otherwise than with the consideration of the existing old factories or of what had remained of them (though they may not necessarily have been of the same branch). Such plants are usually larger than those which have been newly allocated; they comprise as much as 60% of the total fixed assets invested in the new plants representing these branches of industry.

The ways of development of such plants have been various; most typical, however, are the following:

(1) The gradual change of the old plant into a new one through the construction of new buildings and installation of new machines within the old premises.

(2) Construction of the new plant next to the old one; in this case the old factory is still used for a time for production purposes or complementary functions.

(3) Construction of a new plant in a different part of the town (usually in the new industrial district which can yield more free space for future development) and the complete or partial transfer of the production from the old plant.

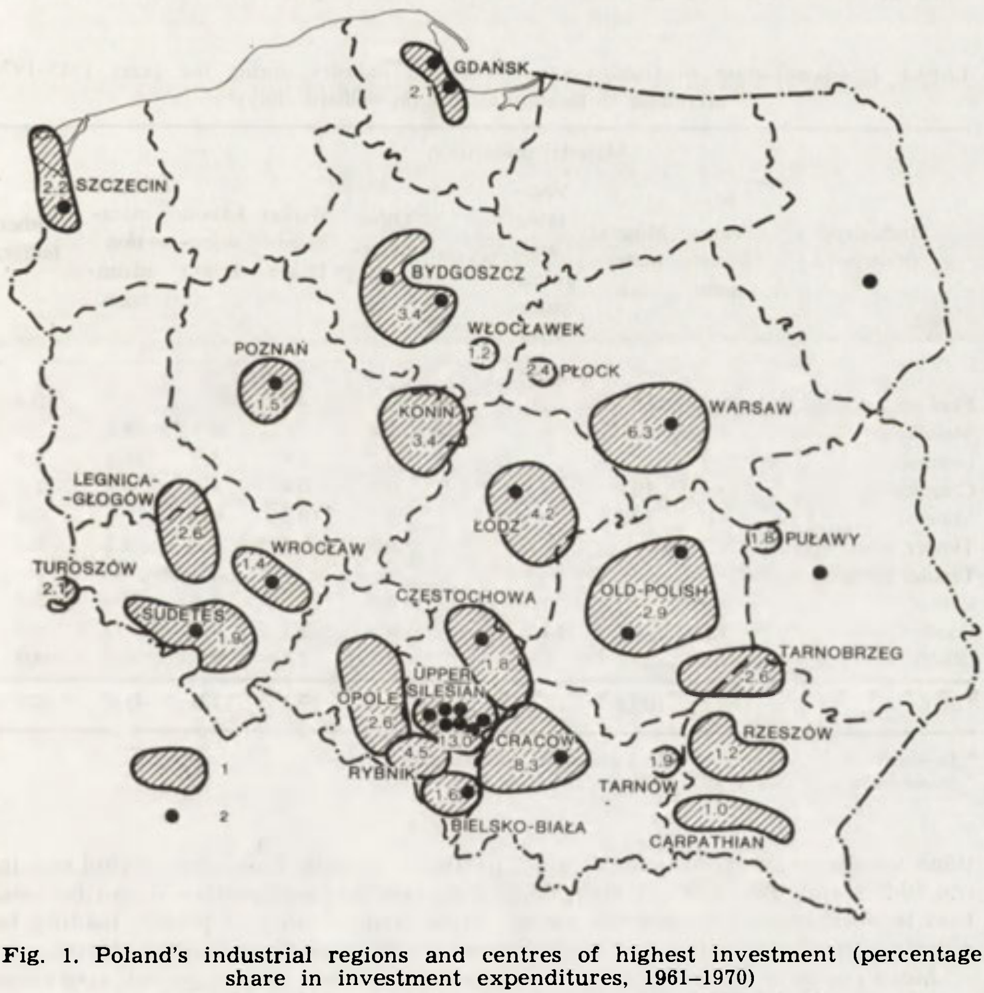

Fig. 1. Poland's industrial regions and centres of highest investment (percentage share in investment expenditures, 1961–1970)

1 — industrial regions and centres, 2 — towns of over 100,000 inhabitants

Such a new plant employs the staff and partially utilizes the machines of the old one. Often one new plant would here substitute for a number of smaller ones, hitherto scattered in various parts of the town (this is the scheme, for instance, of the reconstruction of the textile industry in Łódź). This type of industrial development is connected with the urbanistic reconstruction of old towns.

(4) Rebuilding of the plant destroyed in the time of war; in the course of reconstruction the plant often changed its production range.

(5) Adaptation of a partially destroyed industrial, store, military or other installation for the purpose of industrial production; in such cases the new range of production had nothing to do with the previous purposes for which the plant had been used.

The two last forms of industrial development are specific to post-war Poland where a great number of industrial installations had been ruined and devastated; especially the ones in Warsaw and in the larger towns of western Poland (Wrocław, Gdańsk, Szczecin, etc.). The lack of building materials and installations and of skilled labour made it essential then to put into use of all installations which could have been at least partially rebuilt. This was carried out in the 1940's and the 1950's. Today, from the historical perspective it can be said that this sometimes caused the rather haphazard location of plants, leading to a certain malfunctioning and outdatedness of some of the rebuilt factories.

TABLE 2. Classification of fixed assets invested in industry during the years 1945–1970 according to location factors (in milliard zloty)[a]

Industry branches	Previous investment	Material orientation: Mineral materials	Vegetable and animal materials:	Water	Other materials and power	Market orientation	Labour orientation	Agglomeration advantages	Other factors
Fuel and power	16.0	66.3		3.9	0.3	14.1			10.4
Metallurgy	4.5	19.3			2.4		0.5	28.1	
Engineering	45.4				0.2	5.6	5.6	16.1	5.3
Chemical	30.4	10.6	0.1	7.2	0.5	0.4	4.4	0.8	1.8
Mineral[b]	4.0	12.8			2.5	10.2	0.3		0.6
Timber and paper	3.8		1.2	5.3	0.5	0.5	0.8	0.2	0.3
Textile, clothing and leather	6.9		0.5		0.3		5.2	0.0	0.2
Food	3.1		14.7		0.6	5.9	0.2		0.1
Others	0.2				0.5	2.4	0.0	0.2	0.0
Total	114.3	109.0	16.5	16.4	7.8	39.1	17.0	45.4	18.7

[a] In new plants of a fixed asset value higher than 20 million zloty

[b] Manufacturing of building materials, glass, china and pottery

More recently no war devastated objects have been reconstructed; sporadically, however, it happens that a plant representing a branch of industry going into liquidation (as iron ore mining, for instance) is adapted for some other purpose.

The tendency to develop and reconstruct old industrial plants perpetuates the hitherto existing network of industry with all its setbacks. This is a large scale process; even larger, indeed, when one realizes that it is precisely there, in engineering, that most new employees have started work (in the years 1946–1970 this branch of industry comprised 40% of the total new jobs in industry). The machine industry, electrical engineering and transport industry belong to the most dynamic branches of heavy industry in Poland, but at the same time they are characterized by great immobility as far as space and location are concerned, notwithstanding the theoretical freedom of location. Such factors as staff qualification, strongly-developed inter-factory co-operation and necessary connections with scientific and research staff and appliances play a great role in this situation.

The chemical industry has had to face other problems in different conditions. Here the great share of investment expenditure spent on reconstruction and development of the previously located plants has resulted mainly from the concentration of investment in a few combined chemical plants; among these are the works built by Nazi Germany on Polish territories for military purposes (Kędzierzyn, Blachownia Śląska, Brzeg Dolny, Oświęcim). These plants have been rebuilt from wartime wreck and ruin and are used in Poland nowadays for different purposes.

Great investment have also been granted to the development of the combine in Tarnów and to the rebuilding of the devastated artificial fibre factories in Gorzów Wielkopolski and in Jelenia Góra. Totally, these seven big chemical plants have consumed almost 40% of the investment expenditure involved in the development of the chemical industry.

In the textile industry many old installations have been either rebuilt or adapted for new production purposes. In the old textile industrial centres (i.e., first and foremost in Łódź — both in the town itself and its districts) a number of big new factories were built to which production was transferred from the old small, scattered and outdated workshops.

MATERIAL ORIENTATION

Material orientation of new plants prevails in all location tendencies, at least as far as investment expenditures are concerned. This is the result of the fact that Polish industry is material intensive and it processes great masses of heavy raw materials. Therefore, the location of plants near material sources is quite justified. However, the materials fall into certain groups according to the particular conditions under which they are found. These would comprise mineral materials, vegetable- and animal-originated materials, materials which have been generated by other branches of industry (intermediate and waste products) and finally, power and water (the latter used both as a cooling medium and as a source of power).

Mineral materials. Mineral materials must be recognized as the most important group of all. The fixed asset value of plants which have been located after the Second World War in the immediate vicinity of mineral deposits amounts to c. 29% of the total value of all new factories. This figure does not include either the developed and rebuilt plants which have previously been discussed within the first tendency, or the works which indirectly depend on mineral materials, for instance through the power generated from these materials.

The most important groups of plants located according to mineral deposits are the following (in milliard zloty):[1]

steam power plants	28.8
coal mines	24.7
lignite mines	8.9
copper mines and mills	8.2
sulphur mines and processing plants	8.1
iron mines and mills	6.6
cement plants	5.9
zinc and lead mines and mills	3.7
oil and natural gas mines	2.2

Moreover, this location orientation includes lime and gypsum plants, a number of concrete-mixing and building prefabricated plants, brickyards, sand and gravel pits, salt mines, natron processing plants, clay mines and roasting plants.

Mineral materials used by industry can be divided into two groups according to how common they are:

(1) materials which are found in one district or in small number of regions in Poland, e.g., coal and lignite, metal ores, oil and natural gas, sulphur, building stone;

(2) materials which are common or comparatively common, such as sand, gravel, various kinds of clay and silt.

Although the plants which use ubiquitous materials are more numerous, the works located by more valuable and unique materials are incomparably bigger and more costly. Therefore, in the regions where such materials appear, the concentration of investment is exceptionally high. Thus the value of new plants allocated after the war by coal deposits in Upper Silesian Basin amounts to 10% of the value of all new industrial works in Poland. The respective figure for new plants in the lignite fields of Konin and Turoszów is 7%; for new plants in the metal ore fields it is 5% (out of which most has been invested in the copper district between Lubin and Głogów), and for new plants in the sulphur field near Tarnobrzeg it comes to 2.2%. The above total figures naturally refer only to the plants mining and processing mineral materials.

It ought to be noted that out of the 20 regions and the five industrial centres where the concentration of investment has been the highest (Table 3), in as many as 11 regions and one centre, mineral materials have become the most decisive factor of their development, at least in the initial phase of their growth.

Vegetable and animal materials. If mineral materials usually help towards concentrating industry within a limited, and comparatively small area of the mineral fields, the materials which originate from agriculture and animal rearing tend to diffuse production, since they appear in small quantities over the whole country. Particular materials of this group are not, however, spread evenly; on the contrary, it is precisely the cultivation of such important industrial plants as sugar beet, flax, tobacco or hops which tends to be most consistently confined within certain regions. Apart from these, however, the industry processes other agricultural products as well, the ones which are more commonly grown in Poland, such as various kinds of corn, potatoes, numerous vegetables and fruits, milk, livestock and various wood products, with timber first and foremost.

Altogether, vegetable and animal materials have decided the location of 168 industrial installations (out of the 1270 which have been considered), mainly

[1] The fixed asset value in new plants (of the value higher than 20 million zloty).

TABLE 3. Poland's industrial regions and centres of highest investment

Regions	More important new industrial plants[a]			Total investment expenditure on industry 1961–1970 in milliard zloty	Employment in industry and crafts in 1970 in'000
	Number	Fixed assets in milliard zloty	Employment in '000		
Upper Silesian	48	25.8	58	78.7	602
Cracow	76	57.7	92	50.1	284
Warsaw	137	30.4	150	38.0	378
Rybnik	11	13.4	32	27.0	115
Łódź	49	9.0	44	25.1	342
Bydgoszcz	42	10.2	39	20.5	148
Konin	17	18.6	17	20.5	27
Old-Polish	44	12.5	57	17.6	171
Opole	31	16.8	25	15.8	101
Tarnobrzeg	26	13.5	20	15.8	55
Legnica-Głogów	6	8.7	11	15.8	34
Gdańsk	23	7.1	36	13.4	131
Szczecin	18	12.3	29	13.1	73
Sudetes	21	3.2	14	11.5	177
Częstochowa	29	8.6	30	11.4	120
Wrocław	18	6.0	26	10.7	130
Bielsko-Biała	7	1.8	3	9.8	112
Poznań	35	3.8	22	8.8	127
Rzeszów	24	6.6	40	7.1	65
Carpathians	19	4.3	22	6.3	50
Centres					
Płock	10	11.4	11	14.6	17
Turoszów	3	9.8	5	13.0	7
Tarnów	9	5.5	9	11.6	36
Puławy	5	8.1	5	10.6	10
Włocławek	7	1.8	3	7.3	20
Regions and centres totally	715	306.9	800	474.1	3332
Poland	1270	384.2	1124	604.8	4784

[a] Plants built during the years 1945–1970 of a fixed asset value higher than 20 million zloty

representing the food industry and, to a lesser extent, the timber and textile (linen) industry.

The average factory of this kind is not, however, large; thus, this location tendency has only amounted to a c. 4.4% shere of the total investment expenditure.

The most important groups of factories built for vegetable and animal materials are the following (in milliard zloty).[2]

fish processing factories and sea fisheries	6.2
dairies	2.2
fruit and vegetable processing factories	1.8

[2] Cf. footnote 1.

timber processing plants	1.2
meat processing factories	1.0
corn mills and elevators	1.0
egg and poultry processing factories	0.9

The paper and leather industries which also exploit mainly the home resource base have not become material oriented in their post-war development; neither has the wool industry which relies mostly on imported materials.

The majority of vegetable and animal material factories are located in the eastern half of the country which has been the most industrially underinvested so far, and which can at the same time boast of a rapid rise in agricultural production. In the western voivodeships, with their prevailing tradition of great landowners estates (now state-owned), many factories processing vegetable and animal products were established by the 19th century, in order to utilize the surplus production.

Industry-produced materials. The supply of materials and intermediate products generated by other industrial works has become the most decisive location factor for a number of factories belonging to various branches of industry. Such factories would often utilize what had been considered as waste products during the earlier production phases (thus, e.g., chips from sawmills and furniture factories become material for a chip board factory; flax shoves from a rettery are utilized in flax board production; coal dust from steam power plants makes a material for concrete-mixing plants; corn milling wastes can be used in the production of fodder).

It is usually the plants which are mainly based on one product supplied by one purveyor that are located because of the supplies of such materials and intermediate products, especially if the product they use is heavy in weight, such as metal casting, sheet metal, cement, or some chemical substances. This location tendency can be also called co-operation orientation, on the condition that in this case the term would include both passive (receiving of goods) and active (the supply of products) co-operation.

Power. Energetic orientation is comparatively rare in Polish industry if mineral power-supplying materials (discussed above) are excluded. Power-oriented industry had either been developed earlier around the coal fields and now is developing further in these same centres, or is supplied by own power stations now being built more or less independently of the distribution of power resources. Nevertheless, a few of the more important plants where power orientation had decided the location can be mentioned. These are aluminium works (Skawina, Maliniec near Konin), a silicon carbide plant in Koło and some glassworks built in the regions supplied by natural gas.

Water. In the present article water is treated as a raw material, which may seen controversial because in the process of industrial production water can have a number of functions. Nowadays, industrial plants are located near rivers and other big water reservoirs mainly because of the possibility of using it as a coolant, and also because of the need to drain industrial wastes therein.

The most important types of plants built in the years 1945–1970 the location of which has been decided by the water reservoirs nearby are the following (in milliard zloty):[3]

nitrogen plants	7.2
water-power plants	3.9
pulp and paper mills	3.9
hardboard factories	1.3

[3] Cf. footnote 1.

Recently, after 1970, water orientation has received more attention and consideration; this new trend, however, cannot be yet presented in Table 2. Since then a number of big steam power plants located by big rivers have been or are being built. These are Kozienice, Połaniec and Opalenie on the river Vistula, Dolna Odra and Opole on the river Odra, Ostrołęka B on the river Narew.

MARKET ORIENTATION

The term "market orientation" has been adopted here because of its international application, though in a socialist country many articles are not subject to free marketing at all, but they are produced within the scope of the planned economy specifically to supply the given consignees or given regions. It is implicit in the term that according to this tendency factories are located as near the consumer as possible; naturally, this may involve individual consumers, other factories or industrial plants, or indeed even different branches of the economy such as agriculture, forestry, transport, building industry, etc.

Factories producing for individual customers are generally located in large population centres, i.e., in big towns and urban agglomerations. The more important groups of plants located according to this orientation are the following (in milliard zloty):[4]

power plants and urban thermal-electric power stations	5.2
building-prefabricate factories	2.9
cold stories	2.4
dairies (located in big towns)	0.9
bakeries	0.9
meat factories (located in big towns)	0.6

Among other numerous branches located in consideration of this tendency one can find gas-works, brickyards, building joineries, corn mills and elevators (connected with big towns), breweries, soft drinks factories, etc.

Less numerous but more capital intensive are plants producing for mass consumers, such as — above all — other factories or complete branches of an industry; they would also be located in view of the network of their consignees. Thus this orientation is convergent to the first location tendency, referring to the hitherto existing network of industry. The most important groups of plants governed by this tendency are the follows (in milliard zloty):[5]

power plants and industrial thermal-electric power stations	5.6
sand mines excavating sand for coal-mine floor making	4.6
coke plants located by ironworks	2.9
machine factories and service stations	2.3
print-works	1.9
factories of fireproof materials for the iron and steel industry	0.8

Summing up, the market tendency generally signifies the concentration of factories in urban agglomerations and in existing industrial centres.

[4] Cf. footnote 1.
[5] Cf. footnote 1.

LABOUR ORIENTATION

According to this tendency the future employment in the factory decides its location. The employees will be recruited from one — sometimes both — of the main groups of manpower reserves.

(1) Reserves of unskilled labour which ought to be utilized for social reasons. These vould mainly occur in small non-industrialized towns and in overpopulated agricultural regions. Women constitute a large part, often a majority, of these reserves.

(2) Reserves — usually small — of skilled labour which appear when certain branches of industry do not develop dynamically, when some factories go into liquidation, or when vocational schools train more specialists than are required in a given area. This group of reserves also includes some centres where certain production traditions are kept and where therefore, new factories are located, because similar types of products used to be manufactured in the area in the past, or are perhaps still produced in the vicinity.

Thus this tendency is partially convergent with the first location orientation which refers to the hitherto existing network of industry. However, the first aspect of the tendency under discussion, the employment of unskilled labour and the activization of economically stagnant towns signifies, as a rule, the diffusion of industry onto the so far non-industrialized areas and, consequently, the deglomeration of industry.

The most important labour-oriented branches of industry are the following (in the order of the highest fixed asset value, in milliard zloty):[6]

textile industry	4.2
metal industry	4.0
chemical industry	3.9
machine industry	2.7
timber industry	0.8
electrical engineering	0.7
shoe-making industry	0.5
clothing industry	0.5

If, however, it is the number of the employed which is considered as the main criterion, the proportions would change radically:[7]

textile industry	30.4
metal industry	16.6
machine industry	15.1
clothing industry	13.5
chemical industry	10.8
shoe-making industry	10.3
electrical engineering	7.5
timber industry	6.4

This happens because factories complying with this location tendency are characterized by high employment figures in comparison with relatively smaller capital consumption. Within this orientation even as highly capital intensive as the chemical industry is represented mainly by more labour intensive branches, such as chemical fibres manufacturing, plastic materials processing and rubber generating factories. Therefore, the share of labour orientation in investment expenditure amounts to 4.4%, whereas in the number of jobs it

[6] Cf. footnote 1.

[7] The number of employed in thousand in industrial plants of a fixed asset value higher than 20 million zloty.

reaches 10.8% (when only the plants of a fixed asset value higher than 20 million zloty are considered). However, this tendency has decided the creation of a great many smaller factories of respectively lower investment expenditures; if they had been taken into account at all in the present discussion, the share of this orientation in national investment would finally have appeared much higher.

AGGLOMERATION ADVANTAGES

The above discussion of other location orientations has already pointed out, at least partially, the tendency to concentrate industrial plants in certain centres and regions in consideration of financial incentives which apply most strongly there. If the location of a factory has not been exclusively caused by the existence of an old industrial plant in the same place, nor has resulted from either the material base, market opportunities or manpower reserves nearby, but has been decided by the advantages of joint location together with other industrial objects, its location may be treated as conditioned by the advantages of agglomeration.

This concerns, above all, the location of factories in big towns where, apart from all other advantages, there exists a sufficient technical and social infrastructure; which offer ample opportunities for many professions and vocations for their inhabitants; where it is possible to co-operate with a number of other industrial plants, and to rely on specialized research-organizing bodies such as universities, institutes, design and planning offices, etc.

Therefore, big towns enjoy the most popularity among industrial investors. This popularity would have been even more considerable had the trend not been curbed by the bodies responsible for economic planning, which guard general social interests.

This location tendency applies mainly to factories of a more complicated or of unique production which, for the sake of such production, demand high and varied qualifications of their staff. Here, for instance, belong factories of electrical engineering and electronics, of precision goods and instruments, and of some machines and vehicles. Some other branches of industry would also be represented here, e.g. factories producing pharmaceutical and orthopaedical goods and equipment would be located according to this tendency; so would the factories manufacturing the so-called "cultural goods" (e.g., music, phonographic, film, teaching aids industries, etc.).

Thus out of 88 more important factories which can be included in this location tendency not less than 68 represent engineering; most of them electrical engineering, electronics, and precision goods and instruments production. Two big iron and steel mills built in Warsaw and in Cracow have also been counted in this orientation although this may appear controversial since their location was caused by a combination of various reasons. The desire to change the social structure of the towns in question was pointed out as one of the official arguments for the location of steelworks in big towns.

Most of the factories which have been located in consideration of the advantages of agglomeration are situated in Warsaw where these advantages appear in the highest degree.

OTHER FACTORS

One more consideration, transport orientation, ought to be mentioned among other factors deciding the location of a factory. This tendency concerns but a small number of industrial installations in Poland as, for instance, the mineral oil refinery in Płock, the location of which results from the location of the oil pipeline; also, natural gas pumping stations and seaport factories which process materials imported by sea can serve as examples of plants located in consideration of transport means and costs. Yet, since Poland receives most of her imported raw materials by land (and at transfer stations on the Polish-Soviet Union border where no processing plants have been located), transport oriented factories are not numerous in this country. The only other example of this tendency, the shipyards which could necessarily show port orientation have not been located in Poland since 1945 but have been rebuilt according to the network of the destroyed pre-war ones.

Most transport in Poland is by rail; however, the existing railway network influences the location of industry only on a local (topographic) scale. The more important industrial investments which had been located beyond the existing range of the railway network have always resulted in consequent railway-building investments.

Other factors of industrial plant location include the considerations of state defence, of political issues and of international agreements but they concern only a small fraction of the existing factories. For about 60 of the considered plants it has proved impossible to indubitably decide what the main location factor was; they, however, contain less than a 2% share of the fixed asset value of the plants under discussion.

SPATIAL CONCENTRATION OF INVESTMENT

The majority of the location orientations mentioned above tend to act in a concentrated fashion, i.e. to group industrial plants in certain centres and regions of especially advantageous conditions for the development of industry. This proposition has been proved by the research undertaken by the author of the present article. Thus out of 1270 plants built during the years 1945–1970 as many as 715 are concentrated in the area of the 20 regions and the five centres shown on Map 1 and indicated in Table 3. This amounts to 56% of the total number of new plants; but then they comprise as much as 80% of the total sum of fixed assets and 71% of the jobs in all newly-created plants. This means that on average it is the larger and more capital intensive plants which are concentrated within the areas of the centres and regions in question, in comparison with the comparatively smaller factories which are scattered over the whole territory of Poland.

The above-mentioned areas on which industry is being developed embrace but c. 18% of the territory of the country. Their number and delineations have been established through research upon statistics of general investment expenditure on industry in Poland. The data are available for *poviats* for the years 1961–1970; unfortunately, statistics for the earlier period were not so precisely divided to indicate the development in particular small districts. For the present discussion only such *poviats* or groups of *poviats* have been considered to which credit there falls more than 1% of the total national investment expenditure. If, however, this figure falls to a particular centre situated in an otherwise poorly industralized area, it has been called an industrial centre, not an industrial region (this applies to the five last positions in Table 3).

Totally, the indicated centres and regions comprise 78% of the investment expenditure granted to industry in the years 1961–1970 and 70% of the total number of jobs in industry in 1970. Thus they represent the most essential links of the spatial network of Polish industry. The regionalization presented in this paper does not completely comply the hitherto classifications of Poland's industrial regions as discussed in many previous works, since they were almost always based on the number of jobs, thus considering labour orientation as the most decisive factor for the choice and delineation of industrialized areas. In this way regions of old, labour intensive industry (especially the textile industry) were favoured at the cost of regions of modern, capital intensive production which was often omitted altogether from the discussion if it had not employed a sufficient number of staff.

The borderlines of the regions on map 1 are simplified; they do not embrace the *poviats* in their administrative boundaries but show only their industrialized parts. Among industrial regions two groups can be noticed:

— raw material regions which had been created and at least partially developed thanks to mineral materials; they are concentrate mainly in the southern part of the country.

— urban regions which have developed around big towns.

The regions of Cracow and of Bydgoszcz can be included into both groups. Only two regions developed away from the mineral fields and from the big towns. One of them (Rzeszów) owns its foundation to the between-the-wars investments located there because of the reasons of national defence. The other (Bielsko) region developed within the areas of the old traditions of weaving and cloth-making.

The strong correlation between industrialization and urbanization is best proved by the fact that almost all towns which in 1970 had over 100,000 inhabitants, with the exception of two (Białystok, Lublin), are found within the areas of the industrial regions distinguished in the course of the research. As a matter of fact, Białystok and Lublin are also local points of somewhat smaller (and therefore ommited in the present discussion) industrial regions.

At present two new industrial regions based on mineral materials are being developed. These are the region in the area of the coal deposits east to Lublin, and the Bełchatów region situated on the lignite fields south from Łódź. Their existence will furthermore contribute to the strengthening of the material orientation of industry in Poland.

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THE DEVELOPMENT OF OPTIMUM TERRITORIAL FORMS OF INDUSTRIAL CONCENTRATION

Zbigniew Zioło

An important question in a planned economy is the formation of optimum industrial structures in microscale (Probst 1965, 1968). In building optimization models for such industrial aggregates a major difficulty encountered is related to the high degree of their openness. In addition, a debatable problem is the linearity assumption with respect to economic processes (Dziewoński 1967; Domański 1972; Gruchman 1972).[1]

The aim of the present analysis is to determine the functional structure of territorial industrial concentrations (such as industrial centres and industrial districts) and the processes of their transformation. The aim of the model is the minimization of production costs in territiorial microscale. The underlying idea is related to one of the contemporary theoretical trends in economic geography which is to proceed from the investigation of simple interactions to complex structural wholes, or systems (see Chojnicki 1970, p. 201).

Territorial industrial concentration forms are interpreted as microscale components of the spatial structure of industry. According to the socio-economic space theory (Dziewoński 1961, 1967; Domański 1965, 1967, 1972) the spatial structure of industry constitutes one of partial sub-spaces in the overall socio-economic space (Zioło 1970, 1971).

Basic elements of the spatial structure of industry and of its territorial concentration forms, are individual establishments. It is the industrial plant where what may be called passive links (X) are focused which, due to transformations in the production process generate active links (Y).

	system	sub-system
space	overall socio-economic space	region
sub-space	spatial structure of industry	territorial form of industrial concentration

[1] The importance of this problem has been indicated by Probst (1965a, 1965, 1970); according to him territorial organization of production under socialist conditions is determined by given objective laws, constituting a part of the general system of economic laws of socialism. Gajda (1970) also emphasized the need to develop research on the distribution and internal structure of industrial centres and industrial complexes. The problem is extensively treated in the literature on territorial-production complexes (see Bandman 1973).

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} - \boxed{\text{industrial plant}} - \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = Y$$

The links are to other elements of the spatial structure of industry (x_1 and y_1), to other sub-spaces of the socio-economic space (x_2, y_2) and to the physical-geographical situation (x_3, y_3), which together form the plant's environment.

The feedback relations represented above result in certain functions the plant performs in the structure of the system. In the planned economy the development of the plant is conditioned by socio-economic benefits (k):

$$k_i = \frac{y_i}{x_i}, \text{ where } i = 1, 2, 3 \quad k > 1$$

Territorial industrial concentrations are formed by agglomeration processes (Secomski 1956; Isard 1960; Probst 1965a; Gruchman 1967; Misztal 1970; Pakuła 1973). In the growth process these forms are differentiated in terms: (a) production potential and capacity, (b) the effects of their production activity within the socio-economic space (industrial, national supraregional, regional, supralocal, or local range), (c) production links, technical and economic infrastructure, labour force, and the characteristics of their natural environment (Chardonnet 1955; Ziołο 1973).[2] The functional structure of territiorial concentrations is built of individual industrial establishments which via their linkage systems perform a given role in the structure.

Following the criterion of grouping industrial establishments according to the importance of production activity within the structure of an industrial centre and within the socio-economic space (Probst 1965a; Chardonnet 1955; Kolosovsky 1965) it is possible to distinguish:

(a) Basic establishments (Z_p), representing the core of the centre. They are characterized by large production capacities, and their production activity is of an international or national range. They may belong to one, or more industrial branches, and may be organized in the form of integrated works with vertical or horizontal links dominating (Dziewoński 1949; Stepanov 1955; Secomski 1956). These establishments determine to a high degree the specialization of the centre.

(b) Service establishments (Z_u), performing service functions for basic plants, i.e., repair shops, construction establishments, power plants. These establishments are frequently integrated within large industrial works formed by basic plants.

(c) Subsidiary establishments (Z_t) producing for basic and service establishments, and covering their demands for raw materials, spare parts, equipment, etc.

(d) Establishments producing for economic sectors other than industry (Z_b), i.e., construction, agriculture of the given region.

(e) Establishments oriented towards the local consumer market (Z_l).

The location of basic establishments is determined by "primary" factors, which may be local in character (i.e., the resource basis) or connected with regional growth policies and the demand for given products generated on the

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[2] In the broad literature devoted to delimitation and analysis of territorial forms of industrial concentration various criteria of identification and hierarchy are proposed. The concept of the industrial centre is particularly equivocal (Ziołο 1971). In the present paper the notions of the industrial centre and industrial district are used and differences between their internal complexity underlined.

national or international markets. Examples are: the location of a sulphur-processing plant, of a copper-smelting works, or of a nitrite plant. The remaining establishments in the industrial centre develop, as a rule, due to "secondary" factors — as a result of the activity of basic plants and of overall trends towards the modernization of the industrial structure of the region.[3]

Each category of the establishments listed perform different functions in the structure of an industrial centre. The realization of these functions is facilitated by the formation of spatial-and-production linkages. They are represented in a diagram showing the functional pattern of an industrial centre and serving as a starting point for the model construction (Fig. 1).[4] On the diagram both internal and external linkages have been marked. The internal linkages are those between individual establishments, while the external linkages are to the environment — of regional and supraregional scale.[5]

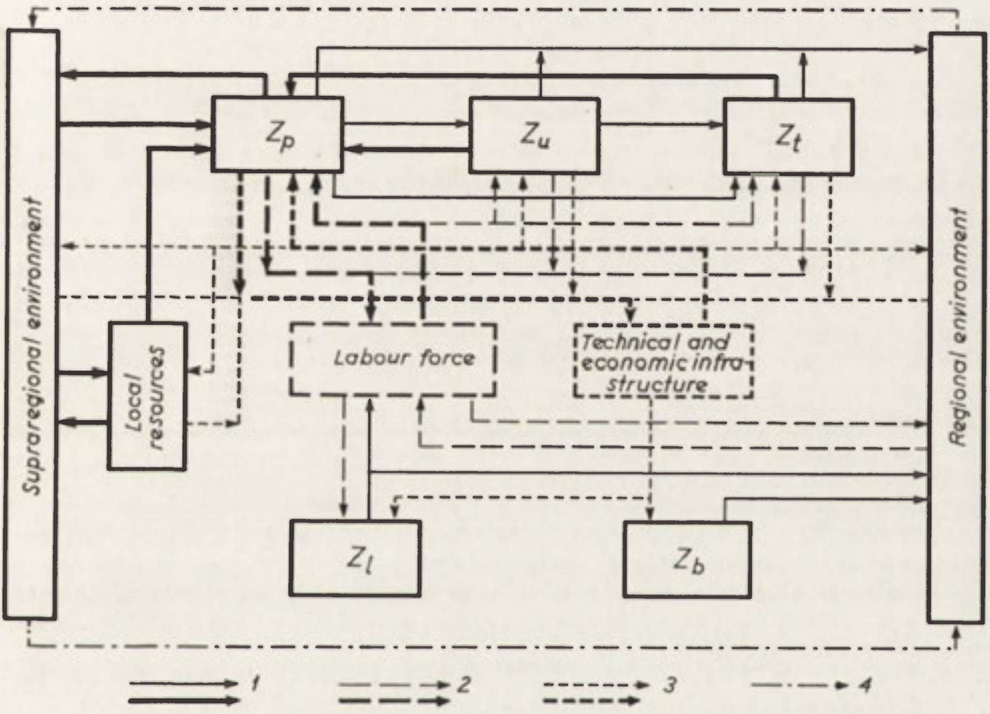

Fig. 1. A functional model of the industrial centre
1 — production links, 2 — labour force links, 3 — technical and economic infrastructure links, 4 — other links

[3] The model of the functional structure of the industrial centre proposed shows the possibilities of improving the territorial allocation of industrial establishments and the co-operation between organizational networks (Byrski 1970). In the case of a newly-developing centre it may point to spheres of activity of individual organizational units.

[4] The interaction between individual establishments as represented in the model is based on the principle of internal (Fajferek 1966), direct production linkages (Z_p, Z_u, Z_t) and an the principle of indirect linkages in the domain of labour force, and the technical-economic and social infrastructure. It should be added that a large number of establishments are characterized by mixed functions.

[5] The industrial centre and its immediate environment (region) are mutually closely tied and form a regional structure (Dobrowolska 1961, 1968, 1970, 1974; Klasik 1974; Probst 1965a; Zhirmuncky 1964).

A proper functioning of an industrial centre is dependent on the ability on the part of the functional types of establishments identified, to supply due quantities of goods. The quantities are determined by the internal demand of the industrial centre and the demand from the national economy. The interdependences are represented below:[6]

(a) matrix of internal flows — A

$$A = \begin{bmatrix} x^z_{11} & x^z_{12} \dots & x^z_{1n} \\ x^z_{21} & x^z_{22} \dots & x^z_{2n} \\ \cdot & \cdot & \cdot \\ x^z_{n1} & x^z_{n2} \dots & x^z_{nn} \end{bmatrix} \quad i = 1, 2, \dots, n$$

(b) matrix of flows between functional types of establishments and the regional environment — B

$$B = \begin{bmatrix} x^r_{11} & x^r_{12} \dots & x^r_{1k} \\ x^r_{21} & x^r_{22} \dots & x^r_{2k} \\ \cdot & \cdot & \cdot \\ x^r_{k1} & x^r_{k2} \dots & x^r_{kk} \end{bmatrix} \quad i = 1, 2, \dots, k$$

(c) matrix of flows between the types of establishments and the supraregional environment — C

$$C = \begin{bmatrix} x^p_{11} & x^p_{12} \dots & x^p_{1l} \\ x^p_{11} & x^p_{22} \dots & x^p_{2l} \\ x & \cdot \dots & \cdot \\ x^p_{l1} & x^p_{l2} \dots & x^p_{ll} \end{bmatrix} \quad i = 1, 2, \dots, l$$

(d) matrix of utilization of local resources — D[6]

$$D = \begin{bmatrix} x^m_{11} & x^m_{12} \dots & x^m_{1h} \\ x^m_{34} & x^m_{22} \dots & x^m_{2h} \\ \cdot & \cdot \dots & \cdot \\ x^m_{h1} & x^m_{h2} \dots & x^m_{hh} \end{bmatrix} \quad i = 1, 2, \dots, h$$

In a similar way it is possible to build matrices of passive linkages — of regional and supraregional supply systems.

The above patterns of flows between the functional types of establishments are greatly simplified.[7] More detailed matrices would show, for example, flows between individual plants.

As was mentioned earlier, basic functions in the centre's structure can be performed by establishments which have no mutual production linkages:

$$Z_p = x_{11} = \begin{bmatrix} a_{11} & 0 & \dots 0 \\ 0 & a_{22} & \dots 0 \\ \cdot & \cdot & \dots 0 \\ 0 & 0 & \dots a_{nn} \end{bmatrix}$$

or by integrated works with well-developed internal linkages (Fig. 2):

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[6] Nemchynov (1963, p. 136) emphasises the importance of resource matrices, since the specialization and development of a region depend first of all on the supply of, and the demand for local resources.

[7] According to Harvey (1967), because of the intricacy of realworld phenomena it is seldom proper to attach a high explanatory value to a model. However, if a large number of elements in the pattern (n) are considered, then it is possible to account for a multitude of linkages : $p = n\ (n-1)$.

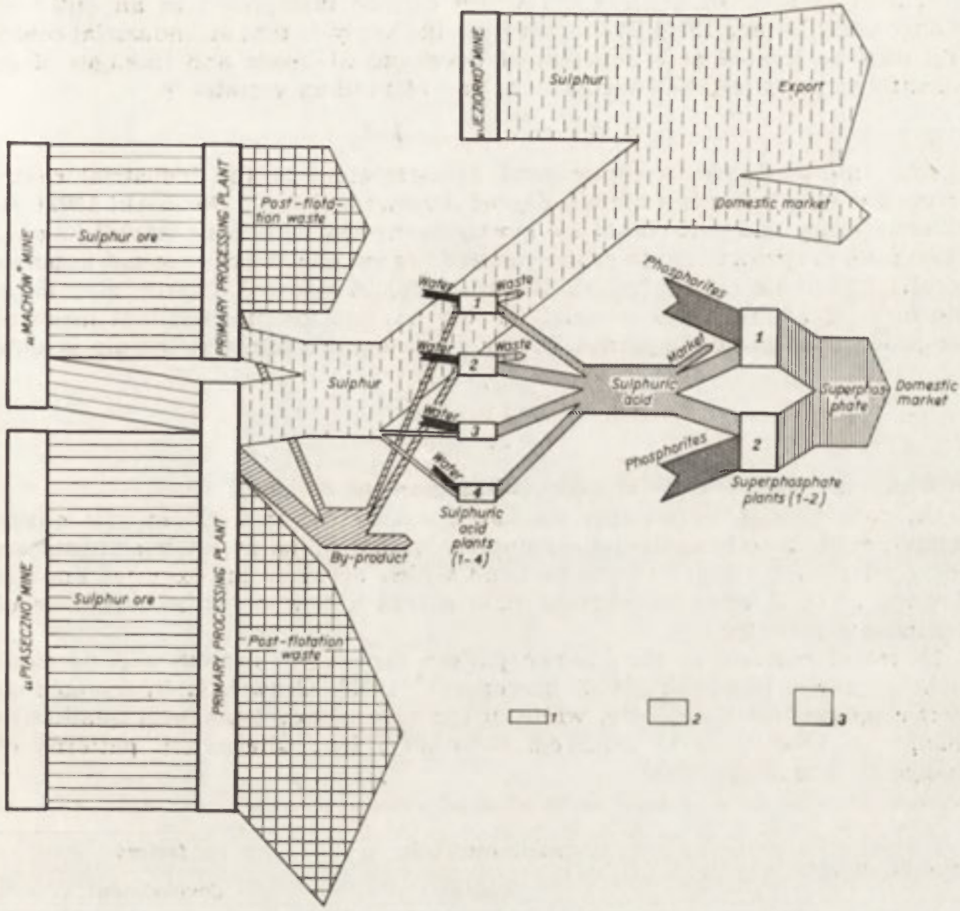

Fig. 2. Internal production linkages between the basic establishment. The case of the Tarnobrzeg Sulphur-processing District

Width of bands proportional to the size of flows; 1 — 100,000 metric ton, 2 — 200,000 metric ton, 3 — 300,000 metric ton

$$Z_p = x_{11} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1k} \\ a_{21} & a_{22} & \cdots & a_{2k} \\ \cdot & \cdot & \cdots & \cdot \\ a_{k1} & a_{k2} & \cdots & a_{kk} \end{bmatrix}$$

The volume of production by the basic establishments is related to external factors which, in turn, exert an influence on the production of the remaining establishments. An insufficient production in one plant or a group of plants brings adverse effects to the total pattern. The optimum is reached when exchange matrices are equal to demand matrices: A', B', C', and when all the resources (D') are utilized:

$$A - A' = 0,$$
$$B - B' = 0,$$
$$C - C' = 0.$$

This is a state of equilibrium which can be interpreted as an optimum (Lange 1962; Lerner 1971). It follows from the analysis that an industrial centre (T_o) may be treated as a function of development levels and linkages of its constituent parts (establishments) — x_i and of random variable ξ.

$$T_o = f(x_1, x_2, \ldots, x_n) + \xi$$

The interdependences represented demonstrate that the industrial centre forms a system open to a certain degree (Dziewoński 1967; Domański 1972). Its external entry and exit points are mostly connected with basic establishments. Therefore, the growth of the centre proceeds as an outcome of external impulses received by these establishments (Moran 1966). A positive impulse may be in the form of an increased demand (on the national or international markets) for products of the basic plants. This is a non-equilibrium state of the system:

$$A - A' > 0$$
$$B - B' > 0$$
$$C - C' > 0$$

in which the volume of production is less than the demand.

In consequence, adjustment mechanisms are triggered off by the centre behaving like a self-regulating system. Individual units, or establishments are being adapted to the increased demand which acted as an external impulse (Lerner 1971). A new equilibrium state marks a new optimum structure of the industrial centre.

A transformation of the linkage pattern occurs via growth and development processes (Secomski 1970; Szczepański 1973). Growth is interpreted as increasing production volume, while in the case of development a qualitative change in production is involved. Generally, four alternative patterns of change (a_i) are in question:

Type of change	socio economic	factors
	stable	development
growth	a_1	a_2
development	a_3	a_4

When socio-economic factors remain stable and growth occurs, basic components of the centre evolve via additions to the production volume (a_1). This type of change is characteristic of short time intervals. Over a longer period the development of production forces and of the territorial labour division result in changing socio-economic factors, and the functional structure of the centre is subject to transformations. The result of change is a modernization or an alteration of production profiles with a partial or complete exchange of equipment (a_4). It is reflected in changing technical labour outfit, labour efficiency, and, consequently, in a changing relation between production, fixed assets and employment (Lissowski 1962).

Similar changes affect service establishments (Z_u), as well as subsidiary units (Z_t) which are adjusting to the new demands originating from the basic establishments. New plants, specializing in new production lines, frequently emerge, while some old ones are eliminated. The expansion of those establishments which sell their products to non-industrial enterprises is related to modernization processes on the regional scale. The last category of the establishments, those oriented towards local consumer markets, are the least sensitive to changing linkage patterns of the industrial centre. Population concentration generally results in an increasing production volume, an expansion of the existing, or the location of new plants to meet the growing social demand.

The stability of development factors allows the application of growth models in predicting future growth (Czerwiński 1973). Changing socio-economic factors, on the other hand, may bring perturbations (sometimes of a critical character) in the existing growth trends, which become particularly visible in the spatial pattern of an industrial centre (Dobrowolska 1961, 1968, 1970, 1974; Dobrowolski 1973). In a situation like this, predictions pertaining to the development of basic establishments have to be based on analyses of their abilities to develop new lines of production, according to the external demands.

The volume of production influence other parameters of industrial plants such as: employment, volume of fixed assets etc. (Zioło 1970, 1971). Selected indices, like capital outlays per unit product (k_i), labour outlays per unit of product (p_i), total production volume (x_i) allow the determination in a synthetic way, of the size and character of an industrial centre.[8] Thus the employment figure (S) is given by the formula:

$$S = \sum_{i=1}^{n} x_i p_i$$

while the volume of fixed assets (ST) may be calculated as:

$$ST = \sum_{i=1}^{n} x_i k_i$$

A model of the industrial centre may serve:

(a) As a standard against which to compare and evaluate the effects of economic decisions in spatial microscale;

(b) As a planning model to produce desired structural change in the system (Mazur 1966);

(c) As a criterion for optimum decisions with respect to the development of the system in microscale.

It follows from the analysis that the industrial centre may be interpreted as a functional-structural pattern (system) developing over time. The spatial and temporal transformation of the system is the result of external impulses affecting its basic units, which, in turn, are transmitted to its remaining components.

Several industrial centres, closely interconnected, form a more complex system which can be labelled an industrial district. Depending on the nature of the interconnections, production linkages of lateral, parallel, or of a mixed type may occur (Fig. 3). In the functional structure of an industrial district those linkages interconnect the basic establishments of individual centres and to a much smaller degree — the service and subsidiary units. A high level of concentration of industrial plants within a district's structure creates possibilities of an advantageous location of new establishments which generate new

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[8] Empirical studies in Rzeszów voivodship (Zioło 1970, 1973) have shown that different indices were producing different spatial patterns of industry. Thus, for employment and fixed assets the coefficient of determination was 70.7, and for employment and electrical energy consumption — 50.4.

linkages. These are mostly co-operating units, supplying the basic establishments with semi-finished products or assembling parts produced in other plants.

These interdependences are illustrated by the matrices of flows of goods between centres

$$P = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \cdot & \cdot & \cdots & \cdot \\ y_{n1} & y_{n2} & \cdots & y_{nn} \end{bmatrix}$$

The industrial district (system) described constitutes a set of interdependent centres (patterns) which together form a more complex whole interacting with its environment (Chojnicki 1973), in other words — operating within the environment.

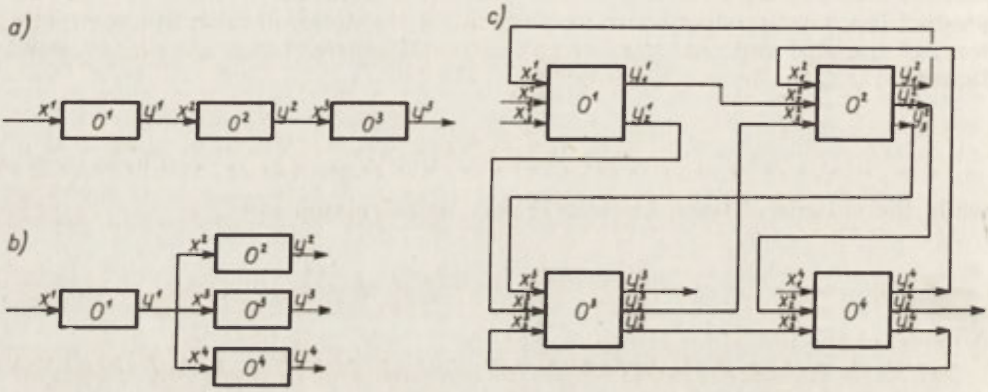

Fig. 3. Models of production linkages in the structure of an industrial district
a — vertical production links, b — horizontal links, c — mixed links

Individual centres perform different functions in the system, and, therefore, their behaviour is not necessarily identical with that of the system. The rules govering the system's behaviour do not pertain to individual centres. Industrial districts, representing systems at a higher organizational level, are able to develop into new functional wholes (Lange 1962; Chojnicki 1970, 1973) which tend towards an equilibrium, or an optimal structural and functional composition.

The equilibrium of the system is dependent on its internal and external linkages. It follows from the discussion that the state of an industrial district (similarly to that of an industrial centre) can be regarded as a function of its development level, of linkage patterns between its components (individual centres) — p_i, and of a random factor — ξ.

$$T = f(p_1, p_2, \ldots, p_n) + \xi$$

The growing intensity of external impulses is a precondition for the development of the district and the evolution of its internal functional structure. The developing industrial district (a system), via its external linkages generates further changes in the structure of its surrounding region.

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CHANGES IN INDUSTRIAL STRUCTURE: A CASE OF THE UPPER SILESIAN INDUSTRIAL DISTRICT

BRONISŁAW KORTUS

1. INTRODUCTORY NOTES

Important features of the present-day economic development are the transformation processes — both spatial and structural. This study contains an analysis and evaluation of structural changes in the industry of the Upper Silesian Industrial District — the biggest industrial agglomeration in Poland, heavily oriented towards primary industrial branches. The analysis covers the period of 1946–1970.

The branch structure of industry within a given area is formed, on the one hand by what may be called objective factors — the given resource base, and on the other, by various subjective factors, such as investment and locational policies, which, in time, are determined by the structure of demand on home or foreign markets. The branch structure of industry is evolving, the main factor of change being technological progress. To a given level of technological development there corresponds a certain type of branch structure, which facilitates the full use of available technologies and also creates conditions for further technological improvements. The so-called leading or propelling industries are formed, characterized by faster growth than is true in the case of the remaining industrial branches. In the former industries technological advance is the fastest; therefore, they become the carriers of the scientific-technological revolution. Contemporarily, such branches are generally identified with electro-power, engineering (first of all — electronics), and with some modern chemical industries, i.e., petrochemical, synthetic fibres and the related industries.

For the last 20 years structural transformations of a particularly broad extent have been affecting old industrial regions based on coal mining, as in the case of the Upper Silesian Industrial District. In Western countries those transformations have been mostly produced by the so-called coal crisis, which in turn may be ascribed to technological change — the utilization of more economical fuels, such as oil and natural gas.[1] The decline of the coal industry has affected all coal-mining areas in Western Europe, bringing economic and social problems, including economic depression and population decrease. The recovery measures which have been applied, include the introduction of new industries

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[1] This may not be true in the future in the face of the worldwide resource and energy crisis which has pointed out to the importance of more traditional fuels, including coal.

(re-conversion of industry), which results in a nearly-total or partial change of the former branch structure of industry.[2]

As follows from Table 1, the Upper Silesian Industrial District has experienced no coal crisis, nor economic crisis; on the other hand, since 1965 employment in coal mining has been stabilized there, or even declining, which in itself is a positive phenomenon. However, over the last few years specific structural problems have emerged which can not be related to the coal crisis but to a gap between technological change, growing in momentum, and the existing structure of industry.

TABLE 1. Basic data on the development of the Upper Silesian Industrial District over the 1946–1970 period

Year	Population ('000)	Employment in industry ('000)	Value of industrial production (billion zlotys)	Coal extraction (million tons)
1946	1482.0	311.4	.	36.3
1949	1702.8	404.0	.	61.2
1960	2027.8	519.1	82.0	79.7
1965	2160.5	567.0	107.8	88.4
1970	2219.2	601.6	133.9	98.0
Poland = 100 (1970)	6.8	12.6	12.1	70.0

Note: The area of the District is 2721 sq.km.

2. EVALUATION OF THE BRANCH STRUCTURE OF INDUSTRY IN THE UPPER SILESIAN INDUSTRIAL DISTRICT OVER THE 1946–1970 PERIOD

The changes in the structure of Upper Silesian industry over the 25-year period complied, generally, with the overall contemporary trends in the branch structure of industry. They are expressed by a decline in the share of the fuel industry from 49.7% in 1946 to 40.6% in 1970, and of the iron and steel industry from 18.7% to 14% respectively. On the other hand, the share of the engineering industries increased substantially (from 11.4% to 20.8%), and the percentage of the chemical industry also increased, although much less markedly (from 3.6% to 4.2%). These positive trends, however, were much slower than the average shifts for the whole country. According to location quotients (Table 2) the share of the region under examination in the national totals has remained nearly constant (increase in Q_{loc} from 0.6 to 0.7 in 1970) in the engineering industries, while in the chemical industry it even decreases (from 0.9 to 0.6, respectively). This implies that Upper Silesian industry has been lagging behind other regions in the rate of structural transformations. Rodger's index of industrial diversification calculated for Upper Silesian industry as compared to the national totals shows some decrease (from 0.53 to 0.40) over the 25-years period, i.e., a growing diversification, which, however, remains inadequate (Table 3). In other words, since World War II the industrial structure of the Upper Silesian District has been characterized by a relatively high stability, this fact is illustrated in Fig. 1. This inertia in the industrial structure can be

[2] W. Dege, *Das Ruhrgebiet*, Braunschweig 1972; P. Riquet, Conversion industrielle et reutilisation de l'espace dans la Ruhr, *Ann. Geogr.*, Sept.–Oct. 1972; M. Gresillon, Nordfrankreich — eine Region im Krisenzustand, *Geogr. Ber.*, 67 (1973), 2.

TABLE 2. Evolution of the branch structure of industry in the Upper Silesian District

Industries	Per cent of total employment 1946	1956	1970	Change in proportion 1946–1970	Location quotient* 1946	1970
Power	2.4	1.8	2.2	−0.2	0.9	0.9
Fuels	49.7	48.5	40.6	−9.1	2.6	4.1
Primary iron and steel	18.7	13.7	14.0	−4.7	3.1	3.3
Primary non-ferrous metals	3.8	4.1	3.5	−0.3	3.4	2.7
Engineering	11.4	15.8	20.8	+9.4	0.6	0.7
Chemicals	3.6	3.4	4.2	+0.6	0.9	0.6
Building materials	3.0	3.3	3.2	+0.2	0.6	0.6
Glass and pottery	0.8	1.2	1.0	+0.2	0.4	0.5
Lumber and wood	0.8	1.0	0.8	—	0.1	0.2
Paper	0.7	0.5	0.4	−0.3	0.3	0.3
Textile	1.3	1.0	1.2	−0.1	0.1	0.1
Apparel	0.5	0.9	2.1	+1.6	0.2	0.5
Leather and shoe	0.2	0.4	0.6	+0.4	0.1	0.2
Food	1.9	3.5	4.4	+2.5	0.2	0.4
Printing	0.9	0.5	0.6	−0.3	0.5	0.5
Other	0.3	0.4	0.5	+0.2	0.3	0.4

* Location quotient calculated according to the formula:
$\frac{Gx/G}{Px/P}$, where: Gx/G = the proportion of the x industrial branch in the total industry of the region: Px/P = respective index for the country.

Source: *Rozmieszczenie przemysłu wg województw i powiatów w latach 1946 i 1956* (Distribution of industry by voivodships and poviats, 1946 and 1956), GUS, Warszawa 1960 and materials of the Regional Planning Office, Voivodship of Katowice (1970).

TABLE 3. Change in industrial diversification, 1946–1970*

Year	Rodger's crude index of industrial diversification: Upper Silesian District	Rodger's crude index of industrial diversification: Poland	Rodger's refined index of industrial diversification Upper Silesian District: Poland total
1946	1,334.3	1,149.4	0.53
1956	1,319.7	1,155.9	0.48
1965	1,302.9	1,153.8	0.43
1970	1,297.2	1,160.0	0.40

* See W. Isard, *Methods of regional analysis*, The M.I.T. Press, 1960, pp. 273–74.

attributed to the high proportion of primary industries, which are traditional to the region, i.e., coal, and the iron and steel industries. Despite the drop these industries experienced over the period under investigation, their share remains very substantial (Table 4). Thus, the coal and coke industry accounted for over 40% of the total industrial employment in the Upper Silesian District in 1970. On the other hand, the proportion of "leading", modern industries is still relatively low, and their expansion is somewhat slower than in the country as a whole (Table 5).

Since models of optimal industrial structure are not available, it is possible to base evaluations of the existing structures on inter-regional comparisons. It may be of interest, therefore, to compare the industrial structure of the

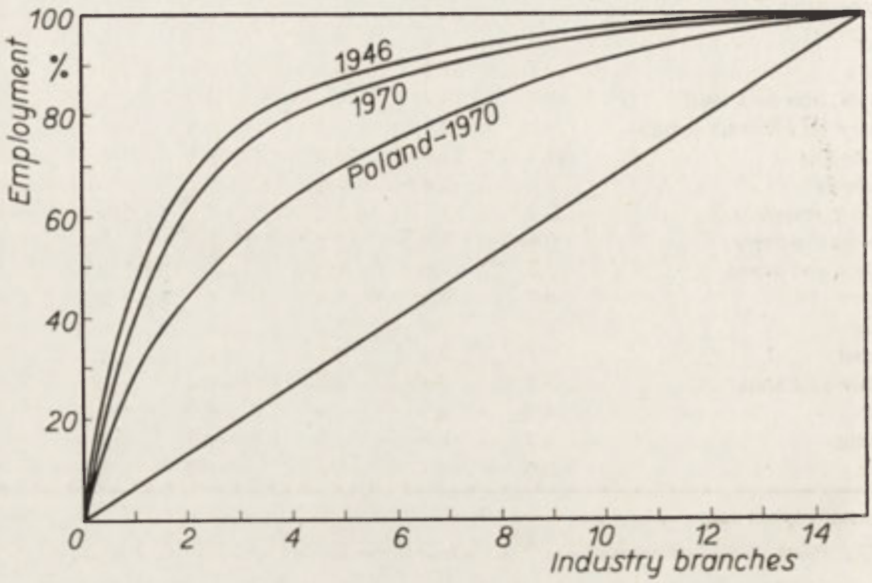

Fig. 1. Industrial diversification patterns for the Upper Silesian Industrial District and for Poland

Upper Silesian District with that of the Ruhr area (Table 6). Both areas are heavily specialized, although in the case of the Ruhr the diversification process is more advanced. Primary industries in that region account for over 45% of total industrial employment and about 40% in value terms, while in the case of Upper Silesia the respective figures are 58% and 57%. The existing structure of industry in the Upper Silesian Industrial District is an outcome of diversified

TABLE 4. The percentage of fuel and primary metals industries in total industrial employmen

	1964	1956	1965	1970
Upper Silesian District	72.2	66.3	60.3	58.1
Poland	26.0	21.4	15.6	15.5

TABLE 5. The percentage of engineering and chemical industries in total industrial employment

	1946	1956	1965	1970	$\frac{1970}{1946}$
Upper Silesian District	15.4	19.2	23.0	25.1	1.63
Poland	21.9	29.0	35.3	37.9	1.73

development dynamics in particular industrial branches in the country and in the region in question, as illustrated by Table 7. It follows from the Table that in chemical and engineering industries the difference was the biggest (index values of 0.4 and 0.6, respectively), if we disregard the non-ferrous metals industry as being primarily mineral deposit — oriented.

TABLE 6. Industrial structure of the Upper Silesian and the Ruhr districts

Industries	Per cent of total industrial employment		Per cent of total value of industrial production	
	Ruhr area (1971)	Upper Silesian District (1970)	Ruhr area (1971)	Upper Silesian District (1970)
Coal mining	22.0	40.6[a]	11.1	26.3[a]
Iron and steel	23.5	17.5[b]	28.3	30.9[b]
"Traditional" industries totals	45.5	58.1	39.4	57.2
Engineering industry	32.2	20.8	29.9	20.3
Chemical industry	7.7[c]	4.2	16.2[c]	6.2
Light industry	4.0	3.9	2.5	3.1
Food industry	4.1	4.4	6.3	5.7
Other branches	6.5	8.6	5.7	7.5
Totals	100.0	100.0	100.0	100.0

[a] Fuel industry.
[b] Including primary non-ferrous metals.
[c] Including oil processing.
Source: *Statistische Rundschau fur das Ruhrgebiet 1972* and data obtained from the Regional Planning Office for the Voivodship of Katowice.

TABLE 7. Trends in individual industral branches: the Upper Silesian District vs. national totals

Industries	Growth of employment (%) 1946:1970		Index of retardation Upper Silesian District: Poland's totals
	Upper Silesian District	Poland's totals	
Power	162.4	261.8	0.6
Fuels	151.5	173.1	0.9
Primary iron and steel	138.0	226.4	0.6
Primary non-ferrous metals	172.1	395.7	0.4
Engineering	338.9	563.2	0.6
Chemical	220.4	546.2	0.4
Building materials, glass, pottery	205.4	312.8	0.7
Wood and paper	158.1	236.9	0.7
Textile, apparel	343.6	256.2	1.3
Leather and shoe	567.5	642.3	0.9
Food processing	398.8	308.7	1.3
Other	168.7	313.0	0.5
Totals	185.2	323.9	0.6

Source: Author's calculations using data quoted in Table 2.

The existing industrial structure of the Upper Silesian District is accompanied by a specific occupational structure of its population. With a very high level of urbanization (92% of the urban population in 1970), the secondary sector (industry and construction) accounted for 68.7% of the total employment in the public sector, while the tertiary sector accounted for a mere 30%. It follows from these proportions that the Upper Silesian Industrial District is facing the need to alter its occupational structure (i.e. to expand the service sector) parallel to the need to transform the structure of its industry.

3. FACTORS IN THE DEVELOPMENT OF THE EXISTING INDUSTRIAL STRUCTURE AND PROSPECTS FOR ITS MODERNIZATION

The present branch structure of industry in the Upper Silesian Industrial District can be attributed to several factors, which are discussed below.

(1) The character of the area, based originally on the extraction of mineral resources, gave rise to the development of coal and coke, as well as the primary metal (both iron and non-ferrous) industries. The local coal supplies — which form the central part of the Upper Silesian Coal Basin, are among the largest in Europe. In 1970 about 72% of the coal mined in Upper Silesia, and about 70% of all Polish coal production came from the District. In lead and zinc mining and smelting Upper Silesia ranked among the biggest in the world in the 19th century. At present, the share of the District in lead and zinc are extraction in Poland is about 50%, while in zinc refining — about 75%, and in lead refining nearly 100%. Thus, the mineral resource base, and particularly the importance of coal as a major source of energy for domestic use, and as a major export item, has acted as a barrier, preventing radical structural transformations in Upper Silesian industry, or at least limiting the possibilities of such transformations.

(2) During the 19th century, the main phase in the formation and growth of the District, the prevailing political and economic conditions hindered the development of a rational industrial structure. The territory of the present District was divided among the invading powers — Prussia and Russia whose policies favoured resource extraction and their primary working, while impeding the growth of the processing industries. In the inter-war period Upper Silesia remained politically divided, and in its Polish sector foreign capital was still dominant. The overall conditions were still disadvantageous and the economy of the area continued to be of a monoculture-type.

(3) In People's Poland, particularly during the first post-war period, Upper Silesia supplied the main material base for the reconstruction of the national economy; and, later on, for the industrialization of Poland, as a major producer of fuels, energy and heavy manufacturing goods. Investments in Upper Silesian industry generally corresponded to the existing structure of fixed assets. About 70–80% of the outlay went to coal-mining, power generation, and the metallurgical industries. Because of limited resources, it was not possible to develop other industrial branches rapidly.

(4) The "degglomeration", or deconcentration policies of the 1960's did not contribute to a modernization of the branch structure of industry in the Upper Silesian Industrial District. Expansion of local coal-mining and related industries, rather than of other industries, was supported. As a result, the percentage of new industrial plants (i.e. those built after 1945) is much lower in the District than in Poland as a whole (cf. Table 8).

New economic policies after 1970 have effectively promoted industrial modernization processes. The development of modern branches (such as electrical, machinery, transportation equipment, and chemical industries), representing advanced manufacturing stages, are supported; at the same time, the redevelopment of old industries, whose role remains vital in the case of the Upper Silesia, has been started.

TABLE 8. The percentage of new industrial plants, 1965

	Employment	Value of production	Value of fixed assets
Upper Silesian District	14.6	13.9	12.6
Poland	33.2	35.9	38.3

Source: Industrial Census, Central Statistical Office, Warsaw 1966.

A gradual modernization of the industrial structure of the Upper Silesian District, quite evident over recent years, has proceeded in two parallel directions: (a) The number of branches in which the District achieved a degree of specialization is increasing. In addition to fuel and primary metal industries (amounting to 72.2% of the total industrial employment in 1946 and to 58.1% in 1970) they now include the engineering industries (14% in 1946 and 20.8% in 1970, respectively), as well as some branches of the chemical and consumer goods industry. In this way the basis for further industrial growth of the Upper Silesian District is becoming substantially broader than in the past. (b) Traditional industries, mainly coal mining and metallurgy are undergoing a process of modernization which will facilitate their further expansion and growth of efficiency. Owing to continued modernization of mines the labour effectiveness in Upper Silesian coal mining increased two-fold over the period 1946–1970. It is anticipated that by 2000 the coal production of the District will reach over 150 million tons (a 50% increase) with only a small percentage of increase in employment. Also the iron and steel industry is undergoing fundamental technical reconstruction, owing mainly to the new "Katowice" steel plant which will take over the production of crude iron and steel now located in numerous old mills. The latter will either be gradually liquidated or adapted to steel processing and the manufacturing of steel products. A similar change will take place in lead and zinc smelting: a new plant in Miasteczko Śląskie is taking over the production of old and obnoxious establishments in Katowice and Świętochłowice. The chemical industry will also move to a more advanced stage of processing; the still dominating coal-based chemical plants are supplemented by petrochemical plants. Finally, the engineering industry's share is expanding and is undergoing technical modernization — through the reconstruction of the existing and the introduction of new establishments, including factories making electrical mining equipment, and a large automobile plant in Tychy, making motor vehicles on FIAT license.

The modernization of the industrial structure in the Upper Silesian District is accompanied by a substantial expansion of its higher education facilities. Post-war additions include a technological institute, a number of colleges and the Silesian University, founded in Katowice in 1969. In addition, a large number of industrial research institutes and laboratories have been established; now the Upper Silesian District ranks second only after Warsaw as a research and development centre. These facilities attract, and are attracted by modern industries.[8]

[8] In fact, the expansion of higher education and research institutes is a trait common to the evolution of old industrial regions all over Europe, including the north of England, the Ruhr area, the Donbas region and others.

Protection of the human environment is another crucial component of modern economy. The Upper Silesian District faces the task of eliminating adverse environmental effects that have accumulated over the past periods of its industrial activity, to prevent future environmental disfunctions, and to provide conditions for a rational recreation of its 2 million inhabitants. Evident results have been achieved in this respect but much remains to be done. Thus a conceived and comprehensively implemented modernization programme of the industrial, or, more generally, the economic structure of the Upper Silesian Industrial District is entering a new stage of its development. Present structural transformations should add substantially to its quality and variability.

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GEOGRAPHIA POLONICA 33, 1976

DIVISION OF THE SHORTEST DENDRITE ACCORDING TO MAXIMUM INTRA-GROUP LIKELIHOOD

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The Wrocław taxonomy method, also referred to as the dendrite method, is often used in the hierarchical grouping of territiorial units. The method permits the subdivision of a set of nonlinearly ordered territiorial units[1] described in a multidimensional space into homogeneous subsets. Such subsets are called typologically homogeneous clusters. A subset is considered to be homogeneous if, for each possible variant of division into two disjoint subsets the difference between the similarity variation indexes for the two parts is statistically insignificant.

The concept of similarity of territorial units in the dendrite does not postulate the existence of a point of reference; closeness is measured to the closest neighbour in a multidimensional space.

Geographers use taxometric techniques for the regionalization of natural characteristics to gather areas of similar structure into groups. The techniques of dividing, dendrites used so far — among them the Wrocław division (Florek *et al.* 1951), the critical edge length method (Hellwig 1968), the dividing radius method (Lewiński 1970), and the elementary linkage method — have failed to come up to the expectations attached to them.[2] Each of these techniques usually cut off many single peripheral elements which were to form separate one-element groups. This made it difficult, if not impossible, to delimit homogeneous regions within the mosaic obtained on cartograms. Further subdivision of the dendrite with the intention of obtaining regions that would be homogeneous (i.e., would belong to the same group in the divided dendrite) resulted merely in increasing the number of regions. It was decided to change the criteria of dendrite division so as to ensure that the groups resulting from the classification be more useful for regionalization purposes. The present study is intended to develop a new method of dividing the Wrocław dendrite based on intra-group stability of similarity.

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[1] Nonlinear ordering is presented in the form of the shortest dendrite. By the shortest dendrite is meant a compact graph without cycles in which the sum of edge lengths attains minimum; the edges are proportional to the measure of similarity of the vertices connected by the edges.

[2] The present study is part of a research project completed within a scheme of key problems coordinated by the Institute of Geography of the Polish Academy of Sciences.

DESCRIPTION OF THE METHOD

The dendrite is cut up so as to ensure division into two components D_{I} and D_{II} containing N_{I} and N_{II} elements; the components must be such that one of them has minimum intra-group variance. Let D be the initial dendrite containing N vertices and hence $n = N-1$ edges (links) d_{ij}; $i, j = 1, 2, \ldots, N$, $i \neq j$.

By excluding an edge d_{ij} we divide the dendrite into two components:
D_{ij}^{i} — the component subdendrite containing the i vertex,
D_{ij}^{j} — the component subdendrite containing the j vertex.

We define the two-argument composite function

$$S_{ij}^{k} = f(g(k, d_{ij})), \text{ where } k = i \text{ or } k = j$$

determined on the Cartesian product

$$d_{ik} \times k, \ (i \neq k \quad \text{i} \quad k = 1, \ldots, N)$$

where $g(k, d_{ij}) = D_{ij}^{k}$, ($k = i$ or j).
Let $E_{N \times N}$ be a matrix associated with graph D whose elements are:

$$e_{ij} = \begin{cases} 0 & \text{if } d_{ij} \notin D \\ 1 & \text{if } d_{ij} \in D \end{cases}$$

We define the function

$$f(D_{ij}^{k}) = \begin{cases} \infty & \text{if } l < 2 \text{ or } l \geqslant N-2 \\ S_{ij}^{k} & \text{if } 2 \leqslant l < N-2, \end{cases}$$

where l is the power of component D_{ij}^{k} defined as

$$l = \sum_{d_{ij} \in D_{ij}^{k}} e_{ij}$$

The constraints in the formula result from the definition of S_{ij}^{h} as intra-group variance

$$S_{ij}^{k} = \frac{1}{l} \sum_{d_{ij} \in D_{ij}^{k}} \left(d_{ij} - \frac{\sum\limits_{d_{ij} \in D_{ij}^{k}} d_{ij}}{l} \right)$$

Function S_{ij}^{k} takes values from the left-side semiclosed interval $[0, \infty]$; it has zero value when all edges of D_{ij}^{k} are of equal length.

To obtain components of needed power let us introduce an epsilon tolerance for variance, $\varepsilon = F(D)$. If for some d_{ij}, $S_{ij}^{k} < \varepsilon$ ($k = i$ or j), the division is disregarded because the group identified is recognized to be homogeneous.

Let us consider all the possible divisions of dendrite D into two components D_{I} and D_{II} and the resulting values of S_{ij}^{k}.
Let:

$$S_{pq}^{r} = \min \{S_{ij}^{k}\}, \ r = p \text{ or } r = q.$$

Component D_{pq}^{r}, which has attained minimum value, and the other component of the pair, D_{pq}^{s}, are the initial dendrites for the next iteration. After k iterations we obtain at the most 2^{k} separate almost homogeneous groups (subdendrites):

step	subdendrites
0	D
1	D_{11}, D_{12}
2	$D_{21}, D_{22}, D_{23}, D_{24}$
.	.
.	.
.	.
k	$D_{k1}, D_{k2}, \ldots, D_{kl}$

The total of objects submitted to classification in the process of grouping does not change (the division is, with respect to the elements involved, disjoint and exhaustive) but the total of edges is smaller by k and amounts to $n-k$.

THE ADVANTAGES OF THE METHOD

(1) The variable k (the number of divisions) is kept under stricter control than in the other techniques.

(2) The number of elements of the smallest group can be determined beforehand.

(3) The division is unarbitrary; it is performed by a computer according to an algorithm.[3]

(4) We are in a position to wath the formation of regions as the products of successive phases of subdivision or, conversely, as the procedure of integrating elements that belong to neighbouring (in the sense of similarity) groups in the dendrite.

(5) The peripheral elements are certain not to be cut off in the first steps of the procedure.

The algorithm of division was tested on a dendrite spread over a set 364 territorial units (*poviats*); these had been selected according to the criteria suggested by S. Golachowski (1969) and characterized in terms of 11 socio-economic features. Because of its considerable size, the dendrite has not been included in this paper. The results of the division procedure, which was composed of seven steps, are given in Table 1.

TABLE 1. Description of the identified groups of homogeneous territorial units

Group No.	Number of units in a group	Exhaustion of elements of the set in percentages	Intra-group similarity variance
I	15	4	0.0050
II	30	12	0.0128
III	61	29	0.0016
IV	29	37	0.0057
V	35	47	0.8923
VI	89	71	0.0046
VII	53	86	0.0036
VIII	24	92	0.0014
IX	28	100	1.4901
Total	364	100	

[3] Calculations were made on an ODRA-1204 computer in the Institute of Informatics at Wrocław University.

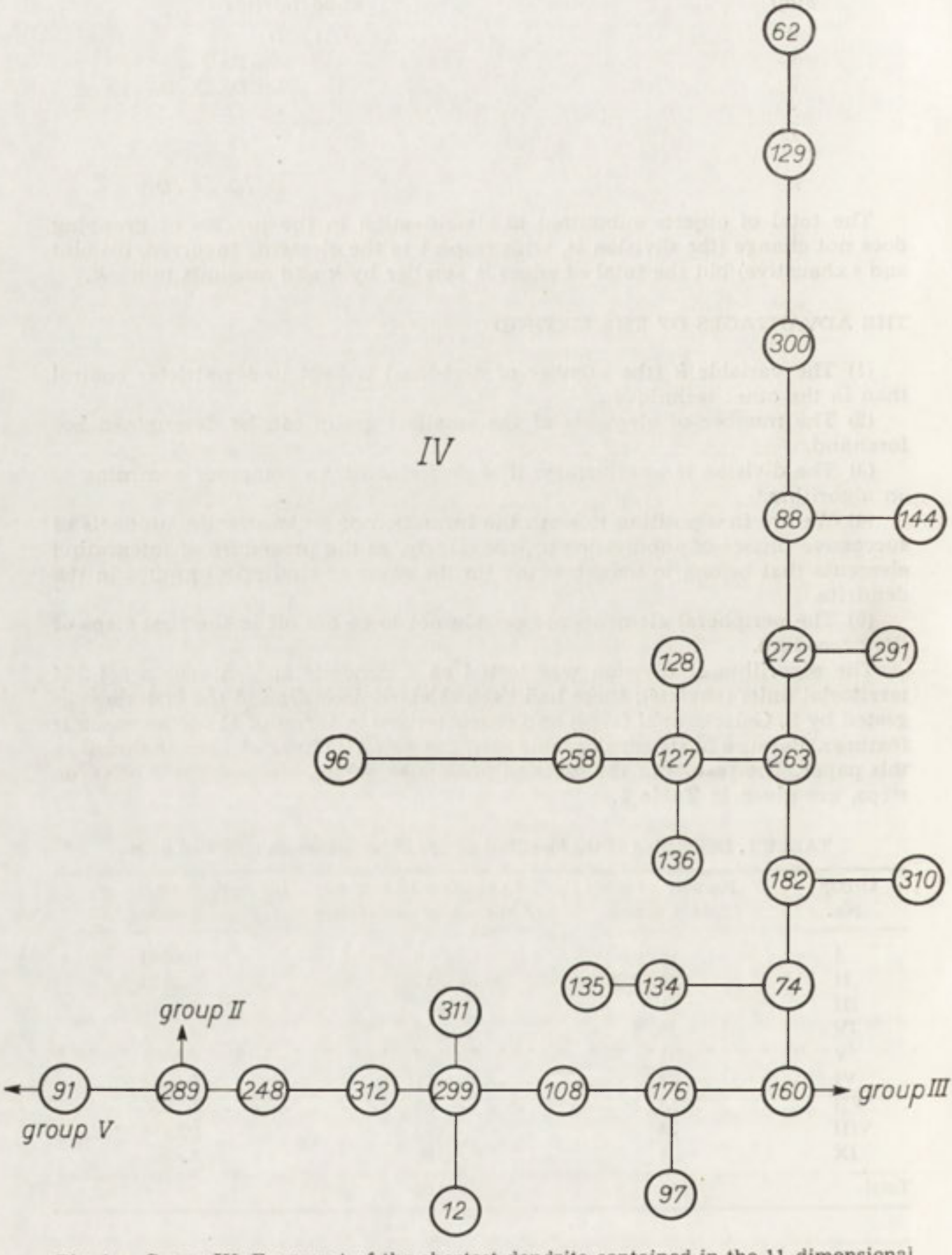
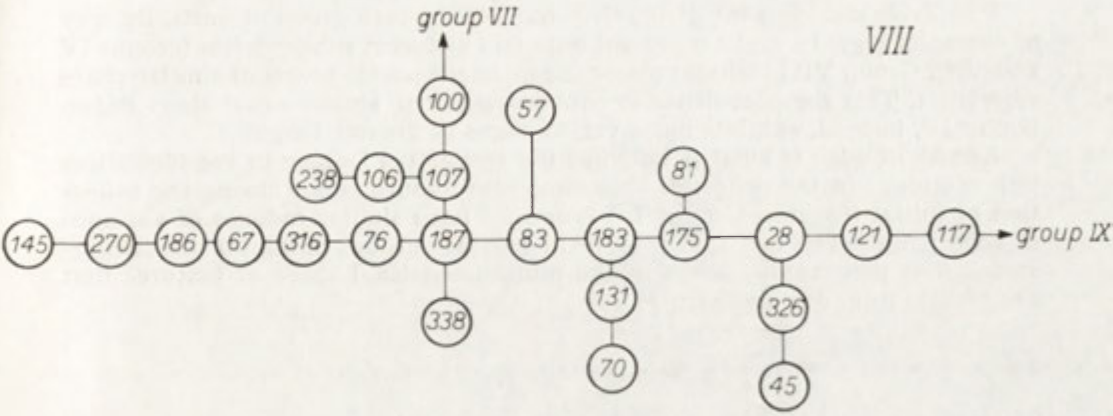


Fig. 1 a. Group IV. Fragment of the shortest dendrite contained in the 11-dimensional space of features



1 b. Group VIII. Fragment of the shortest dendrite contained in the 11-dimensional space of features

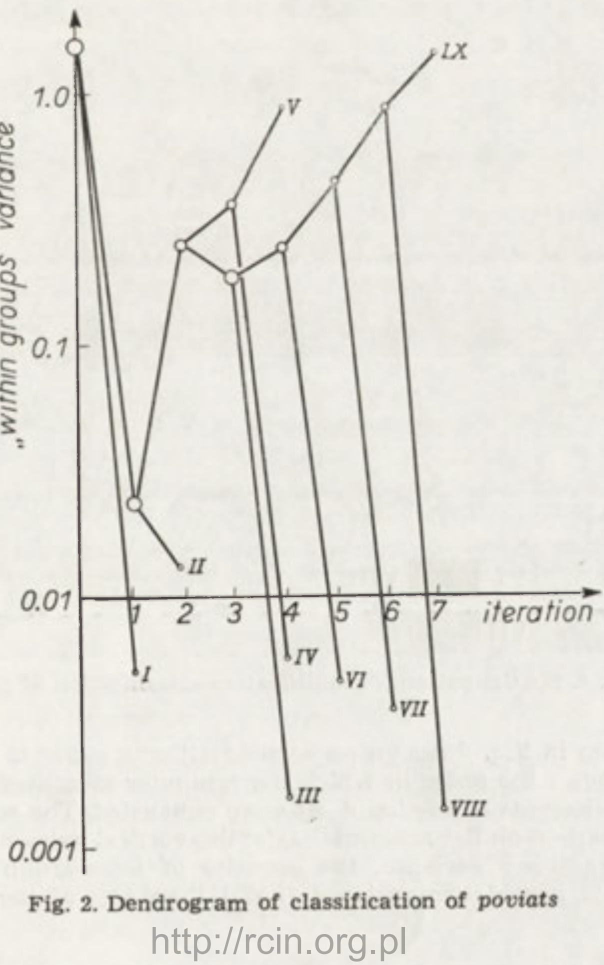


Fig. 2. Dendrogram of classification of *poviats*

The Table discloses the distinctive character of each group of units. By way of example, Figs. 1 a and 1 b present only two different subdendrites (groups IV and VII). Group VIII includes major independent *poviat* towns of similar characteristics. This compact dendrite contains a set of almost equal short edges. Group IV, instead, exhibits more varied edges of greater lengths.

Length of edge is what is taken as the distinctive feature in the identification of groups in the dendrite. This composite feature is not among the collection of initial features. Groups I, VI, and IV have similar indexes of variance of edge length. The fact that they form separate groups is due to the circumstance that they occupy areas in the multidimensional space of features that are remote from one another.

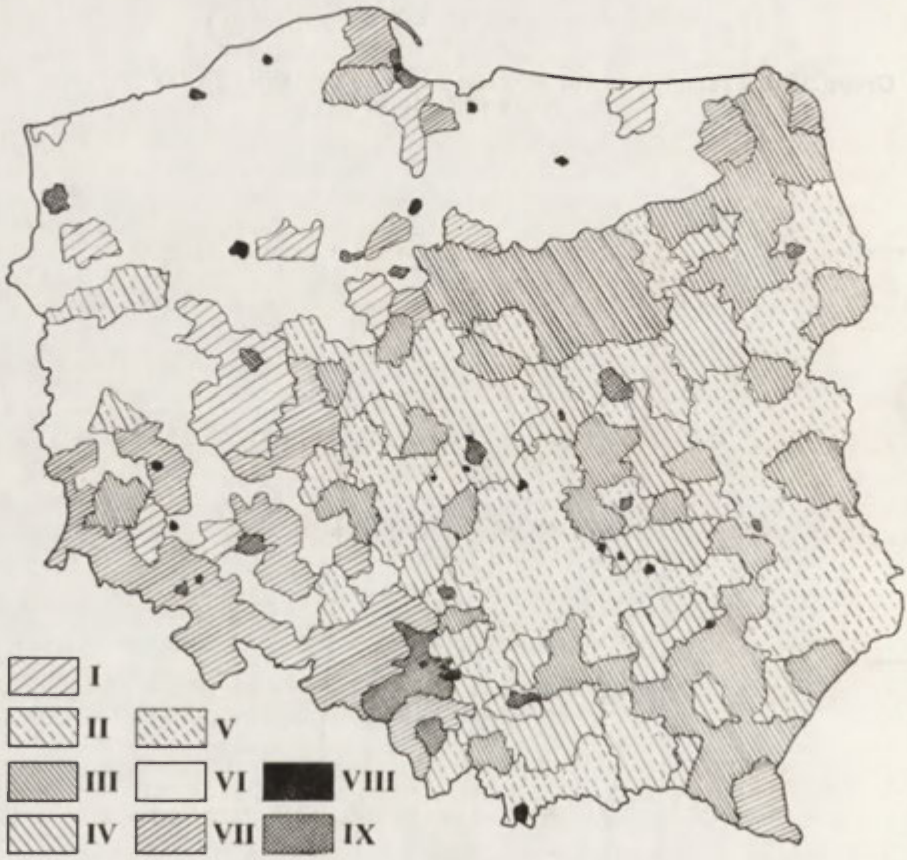


Fig. 3. Spatial pattern of multifeature classification of *poviats*

The diagram in Fig. 2 drawn on semilogarithmic paper is a modified dendrogram. It shows the order in which the computer identified the groups and in which the elements of the input set were exhausted. The sequence of iteration steps is marked on the horizontal axis; the vertical axis, instead, shows the values of intra-group variance, the opposite of intra-group similarity. The output dendrite has higher variance (1.573) than any of the identified subdendrites.

The horizontal axis is also a kind of screen placed, in our case, on the level of $S_d^2 = 0.01$. The almost homogeneous groups of territorial units, which are not further subdivided, have variance values equal to or lower than this threshold value. The best combination is when all twig ends of the hierarchic tree are below that axis. Fig. 3 shows a cartogram of the distribution in space of the territorial units of which the homogeneous groups are composed. The cartogram can be used to delimit regions that are homogeneous in terms of the adopted diagnostic features. A preliminary survey discloses the existence of at least six different homogeneous areas.

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