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Population and Settlement Structure
Analytical and Policy Approaches

Edited by

KAZIMIERZ DZIEWOŃSKI and PIOTR KORCELLI
with the assistance of
ZBIGNIEW RYKIEL

EDITORS' NOTE

This volume originates from a series of seminars on settlement systems and migration held during 1977. The meetings included the GDR-Polish Seminar (Leipzig), the Polish-Soviet Seminar (Toruń), and the Polish-Czech Seminar (Szymbark).
Due to space limitations only selected contributions to these seminars could be included in the present issue. The papers have been thoroughly revised and extended. They are representative of current research interests and the themes of the studies undertaken jointly by Czech, GDR, Polish, and Soviet geographers.

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DYNAMICS OF URBAN SPACES CONDITIONED BY HUMAN ECOLOGY

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1. SPECIALIZED URBAN SPACES

The shaping of the urban environment (UE) is influenced by many different factors. Firstly, it must create conditions for the development of a city-forming basis, i.e. industries and other elements of the national system. All of them shape the role of the city in the territorial division of labour. Secondly, the development of the UE depends on its infrastructure. This ensures the possibility of establishing ties between people and industries and also the metabolism of the UE. Thirdly, consideration should also be given to according city life with the mechanism of Nature. Natural reserves set up for this purpose are either included in the UE or stay adjacent to it. And, finally, there is the most important objective of creating convenient and healthy conditions for the population. The listed guidelines, while differing in the nature of their space transformations, exert a sophisticated influence on one another. And it is no easy task to secure their harmonious interaction. Harmony does not come about by itself.

The UE is marked by a special organization which we describe by the term 'purposefulness' guided by the theory of purposeful systems advanced by Akoff and Emery (1974). Analysing the nature of the UE in a number of works between 1973 and 1976 we see that the UE conceptual model includes structures with the third-order feedback.

The city institutions, its mechanisms and, above all, people act not only according to the pattern of 'stimulus and response' (the first-order feedback). It is the memory which acts as the central element in the actions. It helps shape, see and change the objective (the second-order feedback). Furthermore, actions necessitate scientific concepts of the accumulated experience and of the possible categories of objectives and ways and means of attaining them (Medvedkov 1975).

The purposeful systems have no inner automatic regulation observed in nature. Of course, they do possess their own inner tendencies and inertia which cannot be ignored. But on the whole development should always be founded on conscious notions of the objectives of development and of the ways and means of attaining them. This constitutes the role of what is known as the third-order feedback chains.

Among the scientific recommendations which help to co-ordinate various requirements of the UE, the results obtained by geographers are also important. These results are based on the comparative study of settlement, the assessment of changes

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in the natural territorial complexes, and in particular, on the realization of the measure of success achieved by the different versions of the scene of life tried by society at different times (Medvedkov 1976).

This article reflects efforts to put into practice requirements to the UE placed by human ecology, with the conceptualization of the real world being used from the positions of geography. That is why specialized spaces here represent the main category. Their commonly understandable essence can be identified with the room for the city-forming basis secured in the UE for the infrastructure and the beneficial natural forces. We pay special attention to the UE spaces which serve for the spiritual and physical development of man, the representative of the forces of society, the one who makes further changes in the UE.

The contents of the article boil down to setting out the basic principles of the UE model and subsequently outlining experiments with the imitation model we have made at the Human Ecology Laboratory of the Institute of Geography of the USSR Academy of Sciences. The article also analyses experience in calibrating models for Moscow and such cities as Kursk.

In order that the notions of human ecology should be fully reflected in the model we cover information on the distribution of the population in the specialized areas taking into account the pace of day-to-day life.

Attention paid to the problems of human ecology in geographical science is deeply rooted in the past. For a long time there have been researchers among geographers to support the idea that it was only correct to interpret practically the whole range of issues tackled by this science from the standpoint of human ecology (Hagget 1968, p. 27; Sochava 1970; Medvedkov 1974). It is believed that in present-day conditions efforts should be concentrated on research in the light of this idea. The commonly accepted essence of the requirements of human ecology is that it is necessary to secure a scene of life which should be healthy, of full value, and convenient for everyday activities. Negative aspects in human ecology can produce very painful damage and it is from this damage that society strives to have guaranteed, reliable protection. The best available way to do so is to make scientific predictions on the basis of the model experiments reproducing the situation of human ecology in the UE.

The model that is being used reflects the fact that actions to develop the city spaces take place every day. They are represented not only by the efforts of the city planners or builders but also by the practice of UE development by the city dwellers. Also the specialized city spaces change as the points of gravitation recombine into spheres of activities by various groups of the population (Horton and Reynolds 1971; Johnston 1972; Medvedkov 1976).

While geographers observed the formation of the spheres of activities it was human active ecology that came into their field of interest. This ecology covers the creative efforts of all the cells of society to make adaptive changes in the UE, the properties and connections of places, and their inclusion into the everyday pace of life. Geographers seldom permit themselves to attribute the problems of human ecology unjustifiably to biology. Even works on medical geographic research into these problems show a tendency, while accentuating passive ecology characterizing man's subjection to pathogenic sources, to point to the important role of society's active efforts (Reich 1976).

In modelling the dynamics of the UE spaces we rely on the ideas of the everyday, weekly and daily pace in the occupations of the population. Conclusions pointing to their important role have been drawn from a number of pioneering works on the social geography of the population (Raitviir 1975; Smith 1977). We also make use of the experience of discussing the UE models at scientific forums attended by US

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scientists who have proposed the ideas of factor ecology and behavioural geography (*The Urban Environment and Ways of its Optimisation*, 1977). And we try to put into concrete terms considerations on the workers' time budget, taking into account the research of those sociologists who have studied the development of cities (Borshchevsky et al. 1975).

Now, let us consider the spaces we singled out in modelling human ecology in town. The solution of this problem was a very important stage because it determined the main features of everything that followed.

The choice was determined by the following requirements: 1) it should reflect the morphology of the city and its functional zones; 2) it should cover places where activities represent the sum total of the time spent from the population's time budget in the everyday and weekly pace of life. We have used the objective procedures of the factor analysis to find out to what extent requirements 1 and 2 are combined. The factor analysis was employed to process data characterizing Moscow, the most complex city in the USSR (Barbash 1976). A polling of experts was also used not to overlook places of major, principal importance. The polling was held in the form of a statistical game organized by the author among the participants in a school seminar on the mathematical modelling of cities (Zvenigorod 1976). The statistical game revealed the possibility of obtaining a metricized scale of priorities for various types of everyday activities.

We chose the following specialized spaces to build our model: B – the city-forming basis, I – the infrastructure, N – nature, P – domestic life, R – people's social communication and spiritual development; and U – the suburban zone used within the radius of commuting of the population and making up for the shortcomings of the UE.

It is apparent that the quantity of specialized spaces retains practically the same level of detail (6 categories) which was adopted in Forrester's model of city dynamics (Forrester 1974). However, the purpose of our model is different: is has little in common with the structure of urbanized territory from which Forrester proceeded (factories, housing, and labour resources divided into three subgroups). The list of the specialized spaces we use contains all the points of gravitation in the city and the suburban zone ensuring the cycle of the population's activities in full measure. That is why the author is convinced that the proposed model can be used as a tool to test urban socio-economic development programmes after the analysis has been completed of the model's sensitivity to change in the parameters. As for Forrester's model, it should be remembered that since it reflected quite different social conditions it was used as a tool for programmes called upon to reduce the inflow of the jobless into a number of American cities.

Three types of digital characteristics can be used to measure the influence of human active ecology on the dynamics of the specialized spaces:

S_i – the size of i spaces measured in m^2; ($i = B, I, N, P, R, U$);

T_i – the importance of its groups under study measured by the time spent on activities in i space during the period of stay under review (a week, a year);

D_i – the density of activities measured in man-hours per 1 m^2 from the observations during the period under study.

What practical tasks are then required when it comes to the dynamics of the city spaces? The first practical task consists in measuring the degree of UE inertia. How stable are the proportions in the size of the spaces? Is the importance of various spaces constant in the rhythm of the population's activities? How great is the freedom of choice when changes occur in the UE? What is stable in a situation when people have to keep to the 24-hour pace in their lives? What is stable because of the restrictions in the infrastructure? Is there much room for increasing the density of the

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activities? How far can the radii of the people's movements to the places of their activities grow? What radius growth is blocked by the inertia of the daily cycle of activities?

The second important practical task consists in defining the trajectories of the steady growth of the UE spaces. What proportions cannot be preserved with the growth of city territory? Is it possible to find such trajectories of territorial growth under which correlations would be preserved in the size of the spaces, their importance, and the density of activities at any moment of time? Will the road to the trajectory of equilibrious development require very difficult measures suppressing inertia or will it be sufficient to change the inertial course of events slightly?

The third practical task is to prevent in good time the development of turning points in the growth of the UE spaces, their importance, and the density of activities. Part of the turning points emerge because society and its cells develop greater possibilities for a more active organization of the UE. Other turning points arise under the influence of the objective processes of UE development.

To simplify the essence of the turning point problem it is possible to mark the correlation in the sizes of the spaces for the present moment $V(t)$ and for the subsequent moment $V(t+1)$ in the form of

$$V(t+1) = A_{t+1}\, V(t). \tag{1}$$

The essence of the UE as a purposeful system consists in the fact that our ideas of the future influence our actions today and that is why A_{t+1}, the operator of development in the formula (1), is built proceeding from the level of the realization of the future; this is marked by the lower index $t+1$ for the operator. The practical problem is to replace one set of actions A_t by another A_{t+1} well in advance. Therefore the turning points should stem from the objectives of development put forward in society and not emerge suddenly as obstacles. Can we determine the time by which new directions in the development of the UE already become necessary (e.g., the building of blocks of flats)? Are there any early indicators for the coming turning points? How far ahead can we look to predict them? Do we know them for the space of the future time for which the structures being commissioned are intended?

2. THE URB DYNAMICS MODEL

The issues set out in part 1 are very topical. And they are sophisticated to an even greater extent. And one can hardly obtain answers with digital precision at all without relying on logic or the fast action of the computer. The method we use consists in building a laboratory structure copying the UE and the pace of the people's activities in specialized spaces. The structure is made from many programmes fed into the computer. The programmes set out notions of the interconnection between the sizes of the spaces, the importance of these spaces in the paces of the population's activities, and the emerging densities of activities in the UE.

The realistic character of the model can be traced by instructing the computer to reproduce the development of a concrete city on the basis of all the fed-in programmes and the initial digital values.

In a usual cycle of experiments the model is first calibrated for the trajectories of UE development known in the past. After that we check how fully we were able to convey to the computer the set of rules concerning processes in the UE the way we understand it. The check-up boils down to obtaining further trajectories of development – for a period for which there are observations of the actual consequence of events. For example, in testing the model for the city of Kursk we

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used data for 1957–1964 drawn from the respective statistical surveys (*The Economy...*, 1968) for initial calibrating. The computer working on this basis was able to calculate the growth of the city territory ($S_B + S_I + S_N + S_P + S_R + S_U$), the increase in the total length of the suburban bus routes (serving as an indicator for S_U), the increase of the areas under trees and shrubs in the city (S_N), the growth in the area taken up by the streets (indicator S_I), etc. Growth trajectories were calculated to 1977 and later an analysis was made of the causes of all the discrepancies between the calculated and real values.

To remove discrepancies more precise data are fed into the operator (A_{t+1}). The instruments of internal regulation are also specified. They are fed into the computer as subprogrammes and copy the purposefulness of the persons acting in the city. An example of the simplest internal regulation is the so-called proportional control whereby the rate of growth of the residential areas is sped up under the influence of the increasing density of the inhabitants in the earlier housing space.

Important circumstances of regulation are reflected in the URB model through calculating the probability of the expected UE spaces. The following 'rule of success' is used here. The probability of exercising activities in each element of the UE in accordance with its specialization is not constant. It increases as the frequency of choosing the element by the j-th person in his sphere of activity becomes greater and it declines when the element is included into the spheres of various persons ($j, k, \ldots, z$) simultaneously if the number of such persons exceeds a certain threshold limit (in this case $z - n > 0$).

At our laboratory the UE dynamics is reproduced with the aid of a mini-computer with a small operational memory (500 programme commands and 50 elements for digital matrices or vectors). This makes it necessary to use chains of programmes and subprogrammes introducing them into the computer from magnetic charts. The good feature of the mini-computer is that it can be used for long sessions of work lasting many hours directly at the control panel. In this case the NR9810A computer is convenient because it has the output of results fed into a noiseless recorder and a chart plotter (NR9862A) which plots the trajectories of UE development.

The preparation of all the necessary programmes went on for about 18 months (with interruptions). Over 20 programmes were needed and they had been compiled by the author. Part of them are auxiliary, for example, the printing of instructions for the operator on the input of magnetic charts with data and subprogrammes. The nucleus of the model is the URB–YM77 programme and the whole structure is also designated accordingly.

The URB programme formulates instructions for the computer on the use of the operator transforming the size of the spaces, their importance and the density of activities. The action of the operator is shown graphically in the network chart (Figs 1 and 2). The discreet signs of time ($t = 1, 2, \ldots, m$) are used and the action of the operator can be described with a system of 18 non-linear differential equations:

(1) $S_B(t+1) - S_B(t) = S_B(t) a'_B b_B + S_U(t) k_{BU}$,
(2) $S_I(t+1) - S_I(t) = S_I(t) a_I b_I + S_B(t) k_{IB} + S_N(t) k_{IN} + S_P(t) k_{RI}$,
(3) $S_N(t+1) - S_N(t) = S_N(t) a'_N b_N + S_B(t) k_{NB} + S_R(t) k_{NR}$,
(4) $S(t+1) - S_P(t) = S_P(t) a'_P b_P + S_B(t) k_{PB} + S_I(t) k_{IP} e^{jA}$,
(5) $S_R(t+1) - S_R(t) = S_R(t) a_R b_R + S_B(t) k_{RB} + S_I(t) k_{RI} + S_P(t) k_{RP}$,
(6) $S_U(t+1) - S_L(t) = S_U(t) a'_U b_U + S_I(t) k_{UI} + S_N(t) k_{UN} + S_R(t) k_{UR}$,
(7) $T_B(t+1) - T_B(t) = S_B(t) \dot{a}'_B \dot{b}_B + S_U(t) K_{BU}$,
(8–12) ... (analogous to equations 2–7),
(13) $D_B(t+1) - D_B(t) = S_B(t) \ddot{a}_B \ddot{b}_B + S_U(t) \ddot{K}_{BU}$,
(14–18) ... (analogous to equations 2–7).

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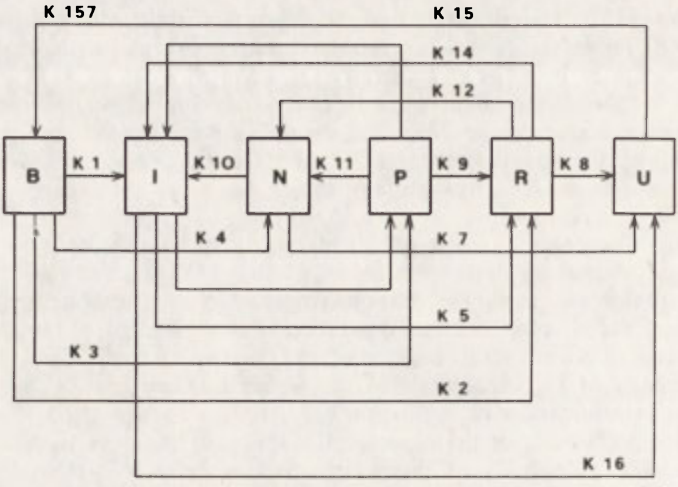

Fig. 1. A diagram of interconnections in the specialized spaces
The arrows in the diagram correspond to the non-zero factors of the dynamics operator in the model used

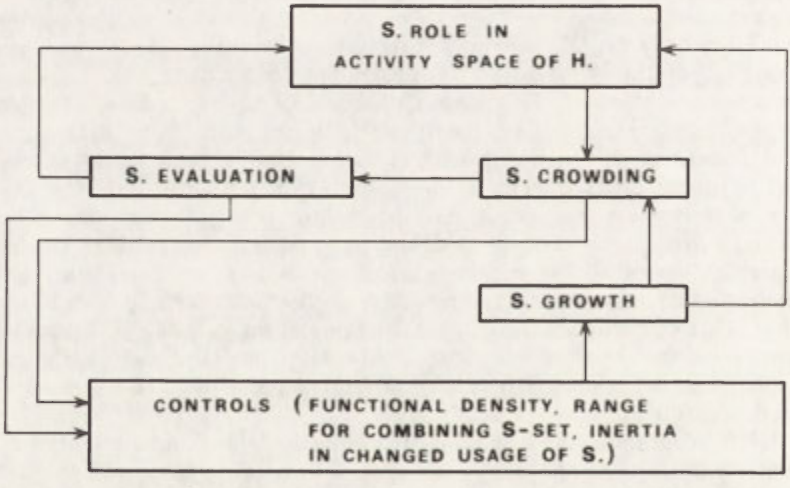

Fig. 2. A block diagram of the regulation chains used in the URB model
The arrows correspond to the controlling influences on the dynamics of spaces. Taken into account are influences from the density of actions when excessively low or high densities change the functional role of spaces. The influence of the objectives causing the priority growth of various spaces is also taken into consideration

The factors of the equations are calculated by procedures now well-developed in experiments with the imitation modelling of economic systems (Li et al. 1977).

If we exclude the factors of non-linear influences from equations 1–18 (which are very important in fact), we shall obtain linear equations which could be written in matrix designations:

1a. $$\Delta S(t+1) = \underline{A} S(t)$$

2a. $$\Delta T(t+1) = \underline{A}_1 T(t)$$

3a. $$\Delta D(t+1) = \underline{A}_2 D(t)$$

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Symbols ΔS, ΔT, and ΔD are used to designate 6-element vector columns. Factors k, K and $\dot{K}$ from equations 1 – 18 serve as non-diagonal elements for matrices A, A_1 and A_2; while single numbers are used as diagonal elements.

Equations 1a–3a reflect the principal idea of URB underlining the geographical nature of the model. This expresses the principle of the influence of specialized spaces on the development of the UE. It can be expressed by the following formula: "Requirements for the location of this or that specialized space depend on the earlier achieved total size of other spaces, the same yardstick is also used to determine changes in the importance of the spaces in the paces of the activities of the population and in the densities of the activities."

Of course this principle alone is not sufficient since it exaggerates the traditions of town-building solutions already materialized in the city. The possibility of fresh creative solutions changing the structure of the spaces is reflected in the non-linear factors of equations 1–18. The type of factors is such as to make it possible to implement the principle of intensified efforts to change the structure of the spaces: "The course of time increases the role of changes which do not fit in the inertial march of events stemming from the earlier established proportions in the sizes of the specialized spaces; the reshaping of the proportions is speeded up."

Equations 1–18 make it apparent that the URB model permits us to calculate the factors of the last 6 equations after the first 12 have been made known. It is also possible to limit oneself to using any six equations in making experiments, either 1–6 and 7–12 or 13–18. This opens the way to the stage-by-stage development of the model. The method of consecutive approximations closes the gap between the theoretical and actual trajectories. This is done first for values S_i and after that for those of T_i and D_i, then again for S_i, etc. Work with the computer is done in dialogue conditions when the operator has to think and compare a great deal proceeding from his knowledge of the object under study.

Experiments with this type of model can be regarded as a procedure of teaching for the computer and the operator alternately. First the operator tells the computer a number of rules on UE development which are understood by him. From the computer he learns that these rules are not sufficient; the degree of insufficiency is also indicated approximately. After thinking over the additional regularities the operator again feeds everything he has understood into the computer in the shape of programmes thus teaching the computer by this procedure. Again the computer produces answers helping the operator understand the UE processes more exactly. The cycles of mutual teaching are endless in principle.

3. PENETRATION OF DYNAMICS

The question arises whether the model of the dynamics of city spaces yields much fundamentally new information. In furnishing a reply we are going to rely on experiments with the model where the UE situation is reflected by figures summary for the city by vector elements S and T. The elements have been calculated from information published in the statistical surveys (*Moscow in Figures*, 1972, 1976; *The Economy of Kursk Region*, 1968). In dealing with the above-mentioned information it became necessary to put forward operational definitions of the size of the spaces (S) and the importance of the spaces (T):

S_I – the area of streets, embankments and squares in the city;

S_N – the area of green belts, public gardens and other unbuilt plots except for S_I;

S_P – residential areas weighted taking into account information on the distribution of the blocks of flats according to their heights;

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S_R – the area of cultural institutions, schools, soviets or councils of people's deputies, and public bodies assessed by the number of these institutions multiplied on the standard size of the buildings;

S_B – the area of the industrial zone and external transport calculated by the difference between the total city area and values S_I, S_N, S_P, S_R;

S_U – the area of 30-minute access strips along the routes of the suburban bus lines (the length of the route multiplied by 4 km); for Moscow and the 30-minute zones around the stations of the suburban railways this area lies outside the city limits;

T_I – the time spent on transport, in shops and public service establishments multiplied by the average daily number of the city transport passengers;

T_N – the time spent on recreation within the city limits multiplied by the number of visitors to stadiums, parks and public gardens (the calculation for Moscow is based on the number of visitors to the National Economic Achievements Exhibition indicated in reference books);

T_P – the time spent on sleep and household activities (10 hours a day according to an expert estimate) multiplied by the entire number of permanent city dwellers;

T_R – the time spent on study multiplied by the number of students in schools, specialized technical schools, colleges, and open universities; the time in which theatres, cinemas, museums, exhibitions, etc. are open multiplied by the average number of visitors per day;

T_B – working hours multiplied by the number of workers;

T_U – the time of out-of-town recreation multiplied by the number of those who make out-of-town recreation trips per day (the calculation has been made on the basis of data on the number of out-of-town children's pioneer camps given in reference books).

It is apparent that the elements of vectors S and T are actually assessed for a certain sample group of the population and the dynamics of city spaces is studied precisely with regard to this group. This includes, for example, the answer to the following questions:

- how far do the seasonal contrasts in climate influence the density of activities in spaces I, N, P, R, U?
- how does this density change in the days of bad weather or on particularly hot summer days?
- do the changes in the importance of space I, N, P, R, U arising from seasonal or weather conditions influence the human capacity to work?
- what is the extent to which the transport links among the spaces and the average radii of remoteness of the latter change all these processes?

It is evident that all these questions are gradually broadened to the level of the tasks defined at the end of part 1.

To judge the degree of certainty in the answers let us consider in greater detail some of the answers to the problem of the trajectories of the steady growth of city spaces.

There is a theory of such growth developed in the supposition that all the influences designated by arrows in Fig. 1 are made up in a linear manner, i.e., in proportion to the size of city spaces $S_R, S_I, \ldots, S_U$. It means excluding factors in our equations depending on time in a non-linear manner. This applies to equations 1–18 of the URB model. The principle of intensified efforts to change the structure of spaces is ignored in this case. Consequently the theory offers little satisfaction but its conclusions should be known in order to judge any improvements achieved, including those in the realistic nature of modelling brought in by URB.

Economists have developed the theory of steady or balanced growth with regard

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to the sectors of the economy. This theory is not difficult to interpret for the specialized city spaces either. In its classical economic interpretation the theory is set out in a monograph by Lancaster (Lancaster 1972). It is akin to the solutions in the sphere of the stability of movement in the mechanical systems proposed by A. M. Lyapunov as far back as 1892.

Let us assume that vector S of the size of spaces is changed from one moment of time t to another $t+1$ in accordance with the law $S(t+1) = \mathrm{A}\,S(t)$; hence $S(t+n) = \mathrm{A}^n S(t)$ where A is a matrix operator. In placing certain requirements to matrix A revealed in great detail it is possible to calculate vector S possessing a remarkable property: in a city with this correlation of spaces the entire subsequent development brought in by operator A will be taking place while retaining correlations that existed between $S_B, S_I, \ldots, S_U$. Development emerges in keeping with the formula

$$S(t+1) = \mathrm{A}\underline{s}(t) = \lambda \underline{s}(t),$$

where λ is a scale factor.

It is known that in this case

$$\lim_{n\to\infty} \frac{S_1(t+n+1)}{S_1(t+n)} = \lambda$$

and consequently development takes place for an indefinitely long time at a pace equal to $\lambda - 1$ for each of the specialized spaces. It is evident that λ is the dominating root of matrix A. The proportions of the spaces in a city for which a balanced steady growth is possible are calculated on the basis of matrix A. They are determined by vector s and the latter is nothing else but characteristic vector A corresponding to root λ.

How can one visualize the location of spaces on the plan of a city developing in accordance with the theory of steady balanced growth? It will be a 'linear' city with parallel lanes (their priority is not fixed by theory). The lanes grow in length only.

Can a city with a different form have steady balanced growth the way it is determined by theory? It can only if its proportions correspond to vector s calculated for the really observed operator matrix A. Mathematics permits of no other answer.

A set of programmes for the URB model has made it possible to calculate all the factor values for equations 1–18 and thereafter it was not difficult to find whether operator matrix A made up of such factors possessed properties permitting of growth by this law.

To prevent any of the specialized spaces from becoming negative it is necessary that matrix A should possess the properties of Frobenius matrices (Hantmacher 1967). In this case λ has only material values (the imaginary part of the dominating root is negligibly small).

It turned out that our empirically calculated matrices A fail to agree with the balanced growth theory. A case in point was a matrix shown in Fig. 3. Its diagonal elements are represented by values changing from year to year. In this case the properties of the Frobenius matrix can arise in one of the points of the trajectory of city development, yet there is no evidence of the long stability of these properties.

The changeability of the diagonal elements in matrix A can be seen from the following correlations determined for Kursk city:

$A_{11} = 0.0059(0.997t)$ $\quad A_{44} = 0.006 \quad (1.002t)$
$A_{22} = 0.0072(1.016t)$ $\quad A_{55} = 1.00007(1.052t)$
$A_{33} = 0.028 \quad (1.014t)$ $\quad A_{66} = 0.0013 \quad (1.033t)$

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	B	I	N	P	R	U
B	D1	.0035	.0559	.0192	.0005	
I		D2		.0556	.0066	-6.33
N		-.155	D3			1.030
P		.7104	.0327	D4	-.0024	
R		.0422	-3.369		D5	40.69
U	.0001					D6

Fig. 3. Frobenius Matrix Operator for 'URB-YM'
An observation of the trajectory of growth of the specialized spaces

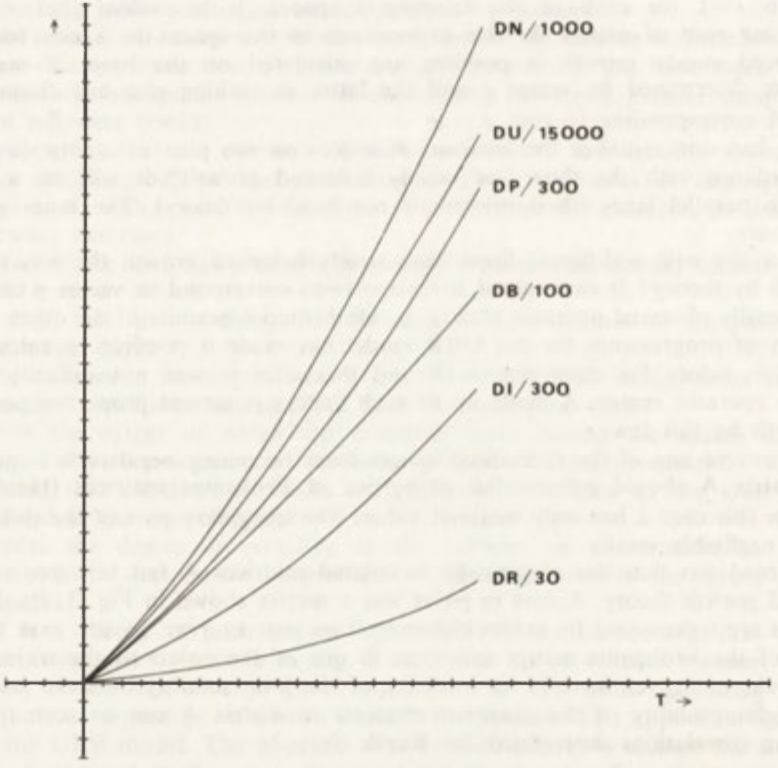

Fig. 4. The calculated trajectories of growth of the specialized spaces
The initial sections of the trajectories within 7 readings on scale T characterize the ability of the model to reproduce the actually observed picture of development known to the computer. The remaining largest sections of the trajectories show the prognosticating possibilities of the model. There is a very considerable similarity with Fig. 3

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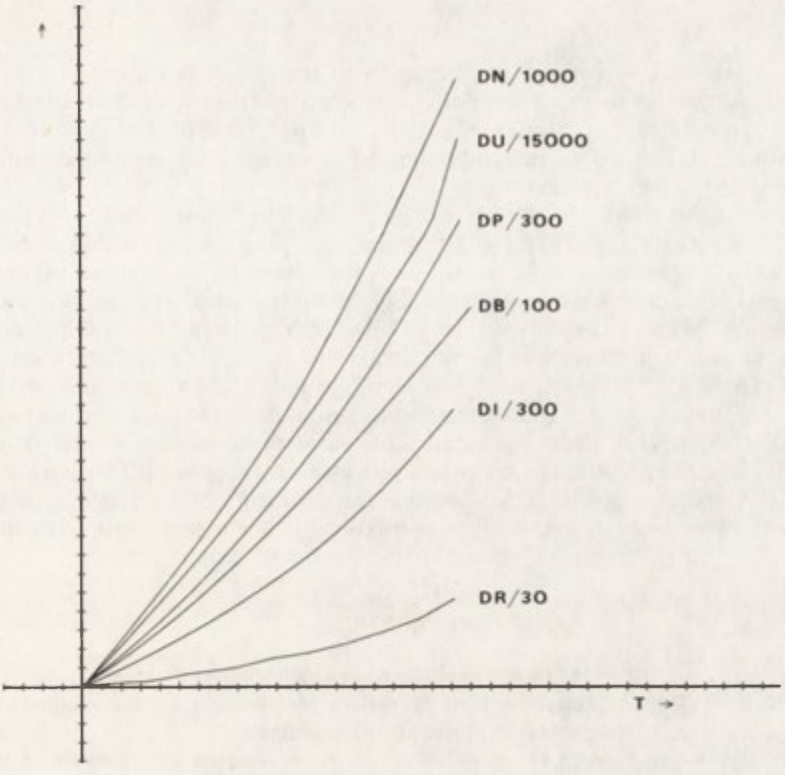

Fig. 5. The operator matrix used in the URB model
The zero elements are not indicated. The type of the diagonal elements is explained in the text (Cf. part 3)

Having taken the initial values of such elements, we calculated dominating root $\lambda = 1.235$. The specialized spaces showed no similarity in the paces of development with the value $\lambda - 1 = 0.253$. Diagrams shown in Figs 4 and 5 point clearly to the contrasts in the rates of growth for $S_N, S_I, \ldots, S_U$. These curves are levelled by interpolation. Their non-linear appearance shows the changeability of pace while discrepancies in the inclinations of different curves at the same moments of time indicate that it is impossible to accept the hypothesis of the balanced growth of spaces.

The URB model makes it possible to trace the development of a city in conditions for which there is no general theoretically obtained solution. The use of operator A calculated from the data for 1957–1964 mikes it possible to reproduce exactly the same growth trajectory for each of the spaces as shown in Fig. 5 (cf. Fig. 4 made by a computer wirh URB programmes).

The model of space dynamics employed has revealed a remarkable property, namely, that the type of operator A in the real conditions of development does not differ greatly from the Frobenius matrices. This ensures a certain range of possibilities for changing diagonal elements A in accordance with the principle of intensifying efforts. Despite the change in diagonal elements A development proceeds without degrading the size of the spaces – but only to a certain turning point. The model helps detect a point in the trajectory when the city must work out a new master plan and break the long-established proportions.

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4. CONCLUSION

In studying such a complex phenomenon as the city it is difficult to do without models supplementing one another. For example, economists solve their set of problems when they regard the dynamics of a city in the light of the balance between the inter-industry flows. This integrative model is intended for economic management and, particularly, for investments.

A geographical model of the dynamics of the city spaces makes it possible to see and, if necessary, to correct the population's pace of life within these spaces. In this case manoeuvre is ensured not only by changing the points of gravitation (the same investments have a part to play here) but also altering the motives of gravitation or the conditions of mobility. Considerable contrasts in weather conditions and clearcut seasonal differences in the climate are examples of influence on the pace of the population's life which does not stem from the city's economic model. This influence requires an additional explanation in geographical science and they receive it.

Of great interest is also the subject of parallelism in the model of the city spaces with the interpretation of the urban processes in economics. This parallelism due to the similarity of algorithms for solving the problems of balanced growth opens particularly favourable opportunities for linking further experiments with the model and the problem of the most probable trajectories of urban growth.

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THE ROLE OF GEOGRAPHY OF SERVICES IN THE STUDY OF URBAN SETTLEMENT SYSTEMS

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Geography of services is a comparatively young science in the Soviet Union (though the study of the distribution of individual types of services has been going on for quite a long time). Soviet geography of services has passed through its 'incubation' period as a part of population geography, while the close ties between geographical research into the service sphere and population topics were already observed in the first Soviet works devoted to geographical problems in this field dating from the 1960's (Kovalyov 1966, Kovalyov and Pokshishevsky 1967). Geography of services is still often seen as a branch of population geography,[1] though its independent subject of research has been recognized (Pokshishevsky 1972, p. 10 and 25).

With reference to this paper, it is important to stress the intrinsic kinship between the geographical study of service phenomena and that of territorial problems of settlement. "Analysis of the spatial organization and distribution of all establishments and enterprises servicing the population is most intimately connected with settlement and its spatial organization" (Kovalyov and Pokshishevsky 1974, p. 17). Soviet theoretical research into the service sphere has shown fairly conclusively that there are strong direct and reverse ties between this sphere and settlement: the former "rests on the network and spatial systems of populated localities, while the service sphere possesses a definite town- and settlement-forming power, giving rise to local service centres" (S. A. Kovalyov's paper in *Problemy Geografii*... 1974, p. 16). This has been confirmed by hundreds of concrete investigations into towns and service complexes.

It is pertinent to note that before Soviet geographers began to take a heightened interest in the service sphere, in all classifications of Soviet towns (Vorobyova, Knobelsdorf, Mints, Khorev and others) the type of town-service centre was either

[1] The reason for this may be seen in the fact that "outside persons receiving the service, the latter simply does not exist"; moreover, "a considerable part of services remain inseparable, as it were, from the individual who spends labour on rendering the particular service" (Pokshishevsky 1972, pp. 10–11); thus, the entire service sphere, from creation to reception, is bound up with the population, 'the main dramatis personae' in the process of social reproduction. The connection with the population as the subject and object of a service also passes through a time coordinate: "The consumption of many types of services is only possible at the time of their creation... Production and consumption merge here" (Pokshishevsky, Mints, Konstantinov 1970).

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ignored or euphemistically included in the category of 'town with less developed industrial functions', 'administrative and cultural centre', 'town of a mixed type', etc. The inconvenience caused by this particularly affected attempts to compile a general picture of urban development in the USSR. This can clearly be seen, among other things, in the thorough survey by Harris (1970).

Let us examine more closely the logic of consistently including data characterising services in the study of populated localities and the geography of settlement systems as a whole bearing in mind the works primarily of Polish and Soviet geographers.

In his very informative analysis of the development of concepts about the functions of towns K. Dziewoński (Dziewoński and Jerczyński 1971) points out the achievement of Soviet town planners G. V. Sheleikhovsky, V. G. Davidovich, D. I. Sheinis and others who even in the 1920's and 1930's differentiated clearly between the town-forming and town-servicing categories of town population. He notes the closeness of this differentiation to the earlier concepts of W. Sombart, M. Aurousseau and certain other economists and geographers concerning the presence in towns of exogenous and endogenous population groups (he finds it difficult to judge the extent to which the Soviet concept was influenced by Sombart's views or whether it emerged independently, but notes the substantial difference of latter concepts from these views). In Poland the division of the population into *miastotwórcza* and *uzupełniająca* was first thoroughly analysed (including the example of Warsaw for a number of years) in 1948 by S. Herman and J. Wilska (Dziewoński and Jerczyński 1971, pp. 27 and 29–30). In the USA the same concept was developed by Ch. D. Harris (on the example of Salt-Lake City, 1940), H. Hoyt, J. Alexander and others; it was presented in a most complete and sufficiently 'mathematised' form in Alexandersson's (1959) book originally published in 1956. A thorough theoretical analysis of Western variants of the concept of exogenous and endogenous urban population was made by M. Jerczyński (Dziewoński and Jerczyński 1971). He justifiably notes that it is not right to take the share of the population connected with different functions as commensurable in comparing towns in countries with different socio-economic systems and different levels of development. Many fundamental ideas concerning the functional interpretation of the urban population structure are contained in the numerous studies of K. Dziewoński.

All the above works deal with the share of the population engaged in services (on the whole and in individual types) as applied to towns taken as discrete units. This approach is particularly manifest in Alexandersson's book (1959).

Simultaneously, population geography was greatly influenced by the ideas of Christaller-Lösch, who essentially visualized towns as elements in a continuous network with a hierarchical structure of dependence on their 'centrality'. W. Christaller and A. Lösch (and also many of their followers: J. Brush, B. Berry, W. Garrison and others) connected this 'centrality' primarily with the sets of service enterprises at each point of the network.

The theory of 'central places' must be evaluated in two ways when constructing general concepts of national or regional settlement systems. Its rational (and rather weighty) kernel is the principle of studying towns invariably within the network, in their interactions with one another, the nature of this conjunction in the network being hierarchical. This positive aspect is offset by the unjustified stress on the role of the services, which tends to conceal the productive functions of towns, by making a fetish out of the mathematical proportions within the hierarchy of towns,[2] and the tendency towards abstract geometry in place of geographical reality.

[2] The hierarchical structure of the urban network has been associated by many Western authors with the 'Zipf rule', once rather fashionable. But from the barely sensible consideration that "the probability that a small town will grow is always greater than in the case of a big one" and that "only some towns reach considerable proportions", the supporters of the Zipf

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While one may reluctantly accept geometry, seeing it only as a sort of higher stage in generalization and a method of cognition through abstraction, the most strong objections should be made to underestimation of the productive role of towns. This underestimation is traceable to an incorrect interpretation of the nature of towns. A town is, above all, a spatial focus of the socio-territorial division of labour. A network of towns based only on service functions is just as impossible as a society where "people live by washing each other's linen". This purely service model may approximate to only separate sections of urban networks (those within which the socio-territorial division of labour ends in the dichotomy: "agricultural area – the rendering of services to the agricultural population"; close to this model of settlement are, for example, some places in the U.S. Mid West.

In Soviet literature on population geography there are a number of studies criticising these negative aspects of the theory of 'central places' which, at the same time, actively support the trend towards analyses of localities within the framework of networks where the functions of production and also service functions are distributed spatially (for example, Pokshishevsky 1962). It would be appropriate here to recall Soviet studies that have analysed production 'cycles' in conjunction with service function in order to define the stages in the development of towns conceived as systems. The works of Blazhko and collaborators (Blazhko, Grigoryev, Zabotin 1970; Blazhko and Rozina 1972) are examples of such works, standing between N. N. Kolosovsky's theory of production complexes and concepts about material 'equivalents' of almost any service type.[3]

The growth of structural-system approaches, so characteristic of our time, in economic-geographical methodology makes it possible to examine questions of population geography in the context, as it were, of continual 'fields of settlement', where towns are only foci of congestion of places of habitation and of human activity (which also implies that they receive an extensive set of services), their production activity, extensive and dynamically growing material funds, and converging 'lines' of the infrastructure and information flows. Forcefully revealed here is the intrinsic unity of spatial features of settlement and the territorial organization of production. The third and equally obligatory 'participant' in this unity is the service sphere, embracing the entire 'spatial field' and being of vital importance for the activities of the population and its normal functioning in the social reproduction process (including also man's own reproduction, both in the daily biological cycle and in the cycle of generations).

The Soviet geographers' modern concept of the 'service field' in its ties with the 'settlement field' may to a certain extent be compared with T. Hägerstrand's concept of 'time-space geography'. This concept has been aptly applied to social systems by Pred (1977). In Soviet literature there have likewise been suggestions for constructing such models (Listengurt and Pokshishevsky 1974) at different territorial levels (regional or nation-wide; within an agglomeration or a town) and with reference to various 'cycles', (daily, weekly, annual). Whenever it is possible to formalize strictly the

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rule draw far-reaching conclusions, bringing them almost to a gnoseological level. Yet, applied to reality the rule operates rather unevenly and its demonstration by the adherents of this whole concept often boils down to explaining deviations... I have already dwelt on this earlier (Cf. *Problemy urbanizatsii*... 1976, pp. 178–187) and can therefore confine myself to the above.

[3] "Even the types of service that seem the least material at first glance, in practice require definite material conditions for their emergence... From the standpoint of the specific traits of objects studied by geography of services, it is rather important to single out two extreme types, as it were: in the first, the main element of the service performed is the labour principle (the service of a teacher, doctor, etc.); various material funds are essential for such a service to materialize. In the other type, the essence of the service consists in providing material funds which acquire a consumer value for the population" (Pokshishevsky 1972).

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initial mass of statistical material (the difficulties arising here are the weak point in Hägerstrand's models), his methodology for graphical schemes may serve as a useful instrument for deepening and further elaborating of the concepts of the Soviet authors mentioned above.

All this range of scientific concepts is particularly relevant in analysing the increasingly widespread phenomenon of commuting within agglomeration systems (often referred to as 'temporary migrations'). Considerable attention is paid to such movements as a typical feature of settlement 'system' by Khorev in his works on population geography (1975), and many others. From the standpoint of geography of services, it is significant that commuters should be able to obtain services at various points in the space not only where they live, but also at places of work and along the entire route that they travel. The provision of transport for commuters is in itself an important type of services 'spread over' the entire correlated area (residence + + production) of settlement. Those types of services that may be received along the route, at changing points, etc., are similarly 'spread over'.

The continual concept of a 'field of service' introduces, along with the category of sets (and 'volumes') of individual enterprises providing various services (which are discretely 'distributed' between different foci), that of spatial accessibility (expressed in units of distance and also in the time required to reach the service point and to obtain the given service). This category permeates, as it were, the entire field of settlement (about this category see, for example, Popov's paper in: *Problemy Geografii* 1974; some explanations are also to be found in the study by Kovalyov and Pokshishevsky 1974, pp. 25–26). It materializes, in the first place, as transport accessibility. Differences in the provision of various types of transport within a territory make space itself, so to speak 'heterogeneous' from the standpoint of its role in providing particular types of services for the entire field of settlement.[4]

Long-term settlement schemes now elaborated in the Soviet Union on the one hand are correlated with master plans for the distribution of productive forces and, on the other hand, contain basic solutions for problems connected with the provision of essential services (see, for example, Fomin 1976) for the entire hierarchy of settlements (arranged mostly into regional and local systems).

In Poland, the forecasting of settlement systems, both at the national level and that of regional systems (or, rather, sub-systems) is, in principle, based on the same concept of the service sphere's role in forming settlement systems as the one established in the Soviet Union. True, Soviet geographers are, perhaps, ahead of their Polish counterparts in constructing a number of theoretical categories in this new branch; in the USSR, many concepts were defined, for example, at the First Inter-Departmental Conference on the Geography of the Service Sphere convened in 1974 by decision of the Fifth Congress of the Geographical Society of the USSR (see *Problemy Geografii*... 1974; *Geograficheskoye izucheniye*... 1976). But in departmental and, particularly, town-planning research, Polish scientists have evolved many concepts important for analysis of the service sphere. It is sufficient to mention B. Malisz's works widely recognized in the Soviet Union.

At the same time, considerable materials, accumulated during actual economic-geographical and economic research into Polish towns, throw interesting light on the way service enterprises function in various types of settlement, differing in size and

[4] The existence of mobile service establishments (especially effective in rural areas, in particular those with sparse populations) may likewise transform the field of settlement (cf. Kovalyov and Pokshishevsky 1967, the papers by L. B. Mikalyukina and D. N. Lukhmanov in *Geograficheskoye izucheniye*... 1976 and others). There is, however, a tendency for the share of services rendered 'by mail order' to increase (trade in samples, the execution of various commissions by post, telephone, etc.). This modifies the very concept of the need for personal contact in services and, thereby, also of the spatial accessibility to the entire field of service.

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'degree of centrality'. Among the earliest works of this series, which covered the whole of the country, mention may be made of Chilczuk's monograph (1963), which analyses the entire complex of lower 'socio-economic centres' (as defined by the author). Almost every later case study of the regional systems of Polish towns or problems of their functions within the framework of the national system has taken careful account of service factors (e.g. *Studia z geografii*... 1971). Polish geographers who participated in the First and Second Polish-Soviet seminars on urbanization have likewise referred to these factors (without, however, dealing with them specifically – *Geographia Polonica* vol. 27, 1973; *Geograficheskoye izucheniye*... 1976).

The programme report made by K. Dziewoński and M. Jerczyński to the 23rd International Geographical Congress in 1976 on urban agglomerations in the socio-economic space, especially within national systems of settlement (Dziewoński and Jerczyński 1976) is undoubtedly of great importance for the further development of research into settlement systems. The report is now conducted on an international scale and contributes to scientific cooperation between nations. It seems, however, that this report does not make full use of the experience accumulated by Polish population geography in studying the service sphere as a factor in the formation of settlement systems. This sphere is not given special mention in the report as an important system-forming link. Services are simply mentioned in several places and occasionally they figure as 'conditions of social development', etc.

Since the authors of the report themselves make the reservation that the concept developed by them is still very 'young', that it has not yet fully 'crystallized', it would now be appropriate to call for a fuller, direct and comprehensive consideration of service factors in further research in the direction indicated by the report. Closer attention to the service sphere in the study of national settlement systems is all the more justified since it is a highly 'social' sphere, exerting different influences on the formation of national settlement systems under the conditions prevailing in countries with different socio-economic systems (the specific features of the mechanisms operating there have been demonstrated in many Soviet and Polish works, including, for instance, the interesting collective work *Studia nad strukturą*..., 1973 containing articles by M. Jerczyński, Z. Siemek and others).

The author of the present paper expresses the hope that future studies on 'service fields' as a link influencing the formation of settlement systems will also be furthered through fruitful cooperation between Polish and Soviet geographers.

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INTERDEPENDENCE OF URBANIZATION AND DEVELOPMENT OF THE TERRITORIAL STRUCTURE OF NATIONAL ECONOMY

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As the entire national economic system becomes more complicated, forming a 'polystructural system' (Mayergoiz 1976) the interdependence of urbanization and the territorial structure of the national economy (TSNE) becomes increasingly a planned one. The significance of the 'urban component' in the production-territorial structure of the economy, in the territorial organization of society and its socio-economic space, is growing.

The increasingly important part played by urbanization, cities, and the urban component in general in the system of socio-economic development is reflected in the complicated character of the very term 'urbanization'. This word was first introduced in Spain in 1867, and not at the turn of the century as is usually thought (Capel 1975). For a long time this term primarily meant the growth of cities and towns and of the urban population. It is interesting that this approach is still preserved even today. For instance, at the XXIII Congress of the International Geographical Union L. Kosiński noted that the term 'urbanization' describes the level of urban development, the correlation between the urban and rural population, and the most interesting aspect of the problem is the demographic one (*Sovremennye Problemy Geografii* 1976, p. 297).

Numerous examples of the 'extra-spatial' approach to urbanization may be cited. In his historical geographical research on urbanization in England and Wales Brian T. Robson does essentially unearth an analysis of the change in the population of cities from the character of their functional base and the spatial aspects of urbanization (Robson 1973). Meanwhile, in the economic geography approach to urbanization where the very process is not taken as separate from its spatial manifestations and forms, an analysis precisely of the 'spatial progress' of urbanization (term of I. M. Mayergoiz) is extremely important.

In his well-known review on the geography of cities and towns which is a kind of anthology of the views of many US and West European experts, H. Carter concentrates mainly on the inner zoning of urban regions. The link between their centres and their hierarchy, and more complex systems is, as a rule, restricted by the interaction in the 'city-region' system (Carter 1972). This approach is to a certain extent limited, and by no means new. Several decades ago N. N. Baransky pointed out the necessity of analysing cities in the "city for a region (country) – region (country) for a city" system.

It is worth noting that the ekistic approach to the problems of urbanization is

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characterised by a certain static character with regard to city and economic systems. Doxiadis, the founder of ekistics, defined it "as the science of population distribution" (Christakis 1976, p. 227).

As soon as we talk about population distribution, it is appropriate to recall I. M. Mayergoiz's formulation of the question of the importance of studying the *distribution of industry*, that is, revealing the peculiarities of and principles governing the localization of various branches of the manufacturing industry in cities with a certain population. This approach which precisely pinpoints the distribution of industry as having a vital town-forming functional basis, as well as to that of other town-forming sectors, provides considerable opportunities for analysing the spatial-economic structure of countries and regions, for making an objective evaluation of the urban component of the TSNE.

All the above mentioned, other aspects of the urbanization process have a definite economic geographical slant and interpretation. Interesting and promising in this respect is the parallelism in the approaches to analysis of a single distribution system, of the Master Scheme for the distribution of the productive forces and of the comprehensive programme for transport development in the USSR (Khodzhayev and Khorev 1976). This approach is, in principle, important for the development of problem orientation in economic geographical studies. It lays special stress not on a component-wise description of the various elements, but on an analysis of the key problems involved in the complicated, dynamic system "territory – natural conditions – natural resources – production base – production infrastructure – population – distribution – social infrastructure – environment". An economic geographical analysis of the functioning of this system and its component parts is also of no small importance.

This complex and dynamic system, like any other system, develops *towards integrity*. According to K. Marx, a system as a cumulative whole has its prerequisites, and its development towards integrity consists in subordinating all the elements of society or creating from the society organs still lacking in the system. In the course of historical development the system thereby becomes an integrity (K. Marx and F. Engels, Collected Works, vol. 46, Part I, p. 229).

A similar trend, and to be more exact, a principle governing the development of systems *towards integrity* confirms yet again the correctness of a joint analysis of urbanization (scale, character, spatial distribution and forms) and of the TSNE. It is important that almost all the elements of the given system are directly linked with certain aspects of urbanization in the broad sense of this multidimensional process. This concept proceeds from the recognition of the secondary nature of urbanization phenomena, in spite of the fact that urbanization rests upon the main socio-economic development processes, and on the intensification of the scientific and technological revolution in the postwar decades. The above mentioned interpretation of urbanization presupposes the following: the ever increasing growth of the urban population; an increase in the number and a distinctive 'thickening' of the network of individual towns; the continual and increasingly important part played by large and especially major centres in all spheres of society's activities; the formation of increasingly complex urban systems; the growing pendulum-like population movement in areas gravitating towards large towns and cities.

These processes result in the formation of highly urbanized areas with a growing range of internal and external links and with the increasingly complex interaction of society and the environment. "From a geographical point of view the formation and development of this specific environment is the basic content of the urbanization process. It has a great influence on all sides of the material and spiritual life of society and on the complex 'society-nature' system" (Gokhman, Lappo, Mayergoiz and Mashbits 1976, p. 268).

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Extremely interesting from the point of view of the system of geographical sciences is the approach to urbanization as the emergence of spatial, multidimensional 'cells' of a highly urbanized environment where the interaction of society and nature which is continually becoming more complicated under the direct and mediated impact of the scientific and technological revolution, is acquiring a particularly intensive character and forms. The 'cells' mentioned are strategically important areas, a kind of 'ganglions' of polarized socio-economic space. It is precisely in these areas that the wide variety of ways of utilizing one territory or another is especially prominent.

The areas ('cells') of highly urbanized environment are often situated on the boundary between different physical geographical regions (foothills, the boundaries of natural zones, the confluence and estuaries of rivers, coastal areas, and so forth). Thus, this intensifies the part they play in polarizing not only the socio-economic space, but also in the geographical differentiation of all the developed territory (which also reflects the definite level of anthropogenic impact on the natural environment). It may be concluded that a combined (joint) analysis of the character of the socio-economic space polarization and of the natural physical geographical differentiation of territory is useful in elucidating the part played by the natural--resource and urban components in the TSNE.

It is well-known that the natural resource factor is becoming relatively less important in the epoch of the scientific and technological revolution (although in its absolute expression consumption of raw materials, water and energy has reached a huge, planetary scale and is rapidly growing; according to some estimates, it will amount to 100 milliard tons by the end of the century). The decreasing significance of the 'primary' industries is reflected in the structure of all industrial countries and of the world economy as a whole.

This circumstance is also reflected in the character of the interdependence of urbanization and the TSNE. In the previous stages of socio-economic development almost everywhere urbanization was closely linked with the exploitation of natural resources, especially with that of such combinations as iron ore and bituminous coal (on the basis of which many old industrial regions have come into being). The thesis of Karl Marx is well-known, that the territorial division of labour fixes certain branches of production in certain regions of a country (K. Marx and F. Engels, Collected Works, Vol. 23, p. 366). More often than not this 'fixing' resulted from certain natural resources.

The experience of the first decades of socialist economic development in the USSR is instructive. As G. M. Kzhizhanovsky noted, the GOELRO plan (1921) "envisaged production specialisation in economic regions and economic links between them which would ensure the complex development of regions on the basis of the extensive utilisation of natural resources" (*Voprosy Ekonomicheskogo Rayonirovaniya*, 1967, p. 5).

We emphasize that at the very first stage of working out the theoretical bases of sectoral and territorial planning, the part played by the natural resource factor has not become absolute. In economic regionalization and planning the distribution of the economy, attention is concentrated on the supply of skilled workers and their qualifications and experience ('population quality'), the concentration of the economy and population that has taken shape, the existing production and infrastructure base, and many other factors. All of them are to a certain extent linked with urbanization.

As the economy develops and becomes more complex, particurarly in the epoch of the scientific and technological revolution, the significance of the factors mentioned is continually growing. At the same time, factors of an extra-natural character stand out for their historical and genetic properties. N. N. Baransky correctly remarked that in economically developed countries similar historical factors in the

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development and distribution of the productive forces often play a more important part than natural-resource factors. In studying the interaction of urbanization and the TSNE, the polarized nature of the socio-economic space and the concentration of population and the economy in urban areas, the phenomenon of the territorial concentration of material and non-material production comes to the fore. It may be concluded that in the epoch of the scientific and technological revolution for many countries with different socio-economic development levels "the territorial concentration of national wealth is of no less importance where there is distribution of social production, than is the dislocation of natural resources" (Nemchinov 1967).

In the TSNE today the part played by the urban component is continually growing and often becomes a determining and decisive one. This is the result of many factors. Of no small significance is the lessening dependence of the important town-forming industries, the manufacturing industry and especially its latest highly scientific branches, on the natural-resource and energy base (which is linked by the rapid progress made in transportation). It may be said that the manufacturing industry is becoming more and more territorially concentrated and 'azonal' (although the extent of its concentration and the natural-zonal factors are of paramount importance for the study, forecasting and solution of complicated geographical and ecological situations).

The increase in the territorial concentration of material and non-material production, their tendency to 'distribution' in the large centres and agglomerations, which are better provided with an infrastructure and skilled workers, is also linked with the revolutionary changes in the structure of the productive forces. It is worth noting the manifold growth of the maximal capacities at enterprises of the basic industries, including ferrous metallurgy, chemical and petrochemical industry, and machine building. For example, metal works with a capacity of several million tons of pig iron, steel and rolled iron have been built not only in industrial countries, but also in developing ones. Each enterprise of this type with all the industries serving it causes a town to grow with a population of no less than 100–150 thousand inhabitants which becomes a local and sometimes even a regional development centre.

The constant growth of the scales and significance of intra-industry specialization should also be taken into account, especially in the manufacturing industry and frequently within the framework of international integrative groupings. This also enhances the role of large cities in the TSNE in the epoch of the scientific and technological revolution because it is precisely these towns which become organizing centres for intra-industry specialization. In the 'technology – distribution' system two stages in the interrelationship may be picked out: the preceding one (when technology creates the preconditions, and geographical factors determine urban development) and the present one, when geography creates the preconditions, and technology is the decisive factor in the development of urban systems (Lasuén 1973).

At the previous stages of socio-economic development towns also played a prominent part in shaping the sectoral and territorial organization of society, and in raising production efficiency. K. Marx outlined two main groups of factors with regard to the productive force of labour, natural conditions and the public work force. The latter involves production concentration, technology, cutting down time and space, science, production skills and so forth (K. Marx and F. Engels, Collected Works, Vol. 16, p. 128). All these factors, including natural resource factors, interact most dynamically in urbanized areas, strengthening their leading role in the development of both industry and the TSNE.

The level and tendencies of the productive forces, specialization in the economy and in its structure are very closely interrelated and interdependent. In countries of various types, in regions on any taxonomic level the internal economic structures

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take shape as a result of the interaction of internal and external socio-economic development factors.

But it is not only this interaction in itself that is important, but the correlation between external and internal factors at various stages of socio-economic development. The economic geographical peculiarities of the internal economic structures (including urban ones) in their most essential outlines, are determined by the trend in socio-economic development, provision with natural resources and the level of development in the territory, and by the character of utilization of natural resources and territory in one system of the international division of labour or another.

One of the most important economic geographical criteria indicating the level of economic development is the extent of the intrastate division of labour, both with regard to production and technology, and also to territory. The level of economic development is reflected in the character of the intrasectoral, intersectoral, intraregional and interregional links (and not only in gross yield and per capita parameters and indices of the volume of production and consumption). The character and level of development of urban systems are also of importance.

But the sectoral and territorial structure of the economy is not only closely interrelated, but also forms a dialectically integral system, which has an impact on certain territories. If there is a certain level of development of the productive forces, wrote Marx, then a certain amount of space is always needed... (K. Marx and F. Engels, Collected Works, Vol. 25, Part 2, p. 342). From this methodological premise it follows that a combined study of the sectoral and territorial structure of the economy should be made. This does not exclude the possibility of a separate study and analysis of both the sectoral and the territorial structure of the economy for research and practical purposes.

Even where there is dialectical unity of the sectoral and territorial structure, the varying level of persistence in their development and its asynchronous character should be taken into account. The sectoral structure changes much more dynamically than the territorial one, which takes shape over a long period and possesses a certain persistence. The asynchronous development of the vital elements in the production-territorial structure takes place against the background of the more dynamic development of cities and towns, urbanized areas and urban systems. This dynamism, boosted by the scientific and technological revolution, further increases the significance of the urban element in the TSNE.

The role of the urban component in the TSNE undergoes substantial changes in countries belonging to different socio-economic systems and differing in the character and tendencies of socio-economic development. This can be explained by the fact that the universal process of urbanization has also substantial typological and regional peculiarities.

In socialist countries, the members of the Council for Mutual Economic Assistance, the scientifically founded planning of the development of productive forces raises the efficiency of urban systems and optimizes them (overcomes any existing or emergent disproportions, improves the state and quality of the environment). In the 'old' regions the urban systems do to a certain extent 'take upon themselves' the functions of economic regions. These systems play an even more important role in intersectoral and intrasectoral specialization. Effective measures are taken to counteract the consequences of the particularly high concentration of the manufacturing industry and population in the largest agglomerations. For example, Cuba, the newest member of the CMEA, is the only country in Latin America where the exaggerated concentration of population and economic activity in the metropolitan area which was inherited from capitalism, is not increasing.

In industrially developed capitalist countries where there is a high level of urbanization, the conflict between urbanization and the pollution of the environment

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is becoming extremely acute. The outline of urban distribution has taken shape in practice like the hierarchically arranged urban systems. However, they merge primarily as a result of the development of transport and the saturation of the agglomerations and other urban structures by the manufacturing industry, especially by its most modern branches connected with scientific research and experimental design work. Often the urban systems do, as it were, replace the network of economic regions, and this boosts their role in the TSNE even more.

In the developing countries, which differ from one another much more than the industrial countries in the level and character of development, the growth of towns and the urban population is occurring very rapidly. But this growth is not provided with the corresponding town-forming functional base, and this greatly aggravates the disproportions in and spatial pluralism of their TSNE. In the developing countries, as a rule, the territorial concentration of the population and economic activity and the polarized character of the socio-economic space, are especially great. For instance, in Mexico and Colombia the three major agglomerations account for 70 per cent of the value of the manufacturing industry's output, and this is approximately their share in foreign capital investments as well. In a number of developing countries 70–90 per cent of the new industrial objects are being built in the major and large cities. This high level of territorial concentration deforms the TSNE, as if counteracting both the 'normal' development of the hierarchy and of the urban systems. For example, according to the estimates of experts there can be hardly any question of large regional centres appearing within a radius of 400 km from Lima in Peru, of 150 km from Caracas in Venezuela, and of 300 km from La Paz in Bolivia (Santos 1971).

Urbanization, the formation and development of urban systems of varying 'degrees of maturity', plays an important part in the shaping and transformation of the TSNE. This part has been growing particularly noticeably in the epoch of the scientific and technological revolution, when the development and distribution of the economy and also of the distribution systems are not only characterized by quantitative parameters (the category of 'economic growth'), but by deep-going, sometimes principal qualitative, structural changes (the category of 'economic development').

Urban systems are having an ever growing impact on the development of the TSNE on all hierarchic and territorial levels, from a global, world economy level, to a local one. The study of the interdependence of urbanization and the TSNE is an important trend in economic geographical theoretical research and the elaboration thereof in practice. This interdependence must be studied, both in order to raise the efficiency of the territorial organization of society and to resolve the vitally important problems of conserving and improving the natural environment.

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MODELLING OF SETTLEMENT SYSTEMS FOR REGIONAL PLANNING

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1. INTRODUCTION

The problems involved in the development of the settlement structure are extremely complicated, and counteracting trends make it difficult to assess them. It is therefore impossible or, at best, arduous to identify optimal directions in which the settlement structure may evolve without using calculation procedures.

A number of models have been set up in establishments dealing with regional planning and research in the GDR over the past decade, as aids for settlement structure planning. It has been characteristic of all this work that it was intended for direct use in planning decisions, and particularly in the housing construction program. On the other hand, it was largely separated from the content especially of settlement structure research. So far the results of model calculations have played no part in the discussion of basic problems in this field, the reason being that the models were not sufficiently developed.

Now that modelling work has become comparatively advanced and many results of calculation are available, it is time to bridge the gap. The following contribution is designed as a first step in that direction and deals with the substantial conditions on which the models are based explicitly or implicitly, rather than with their mathematical structure or the results that must be expected in view of the conditions and structure of the models. Conclusions are to be derived from the analysis and systematization of the theoretical foundations, for further modelling work and its association with the content of research.

The present study deals with seven settlement structure models developed in the GDR. Three of them, MTTKOS[1], PET[2] and KOMS[3] are the work of Offices of Regional Planning (*Büros für Territorialplanung*), while PRW[4] and RG[5] come from the Settlement Structure Department of the Building Academy (*Bauakademie*) and AMOS I and 2[6] from the Dresden Technical University.

[1] MTTKOS – Variant calculations of the costs for the development of the material and technological regional structure (= infrastructure).

[2] PET – Long-term forecast of the distribution of the population in the region.

[3] KÖMS – Integrated economic and mathematical stage model system.

[4] PRW – Model for optimizing the reproduction process for fixed assets in housing construction.

[5] RG – Model for optimizing the reproduction process with regard to public facilities.

[6] AMOS – Targets for partial models aimed at optimizing the settlement structure.

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2. THE MODULAR CONCEPT

The present contribution has as a starting point the modular concept of settlement structure models[7] worked out by the Research Coordination Centre for Regional Planning (*Forschungsleitstelle für Territorialplanung*) of the Planning Commission (*Staatliche Plankommission*). The concept has been improved to incorporate recent findings. The approach is such that models are set up in progressive steps giving simple and practicable models first. In this connection MTTKOS, PET and KÖMS should be mentioned. As soon as improved models are found which can be used to answer the same questions or others, they may supersede the old ones in planning practice. Such models are currently being prepared for practical use, among them PRW and Amos 2. In a third step the models are to be integrated at such a high level that conclusions can be derived on basic questions of the development of the settlement structure. Work is now proceeding in the field of model theory, and through experiments, to prepare for this step.

If this modular concept is to be implemented, the basic assumptions in all models must be correct.

As a comment of the third stage of the modular concept, we shall briefly touch on the theoretical foundations and substantial assumptions of the models under discussion.

3. SHORT DESCRIPTION OF THE MODELS

3.1 MTTKOS[8]

This was developed in 1970 by the Office of Regional Planning (*Büro für Territorialplanung*) in Cottbus and has since been applied on several occasions in all counties (*Bezirk*) of the GDR using standardized methods. It is based on the threshold theory according to professor B. Malisz and involves calculating expenditures in the infrastructure for specified variants of developing the settlement structure of a *Bezirk*. The variants consist of:

- the number of inhabitants for given locations, and
- industrial development for given locations

for a whole *Bezirk* and for one or more time periods. With regard to each variant n a sum of investment costs S_n is determined separately for backlog demand, replacement and expansion using specific requirement indices. By comparing the sums of the costs for 1 to n the approximate optimal variant for developing the settlement structure is determined.

The following operations are involved:

- Calculating the backlog demand with regard to the social infrastructure $N_{ijt_0} = B_{it_0} \cdot k_{jt} - F_{ijt_0}$
- Calculating the expansion requirement with regard to the social infrastructure $E_{ijt} = (B_{it} - B_{it_0})\, k_{jt} = \Delta B_{it}\, k_{jt}$
- Calculating the backlog demand and replacement and expansion requirement with regard to the technological infrastructure $G_{ijt} = B_{it}\, k_{jt} + I_{ijt} + A_{iit} - C_{ijt}$
- Calculating the investment costs for the social infrastructure $T^{(1)}_{ijt} = (N_{ijt_0} + E_{ijt})\, m_j$
- Calculating the investment costs for the technological infrastructure $T^{(2)}_{ijt} = G^{+}_{ijt} m_{ij}$

[7] Clemens G., Jänig R., Kind G., Stempell D., The joint approach of the AKAM, MTTKOS and AMOS I EDP programs for calculating the development of the infrastructure, *Informationen der Forschungsleitstelle für Territorialplanung*, No. 6, 1972.

[8] Representation according to *Modellierung*... 1971.

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– Calculating the total investment costs $S_{nt} = ij(T_{ijt}^{(1)} + T_{ijt}^{(2)} + D_t)$

where:

$i = 1 \ldots n$ locations $1 \ldots n$

$j = 1 \ldots m$ economic sectors in the infrastructure $1 \ldots m$

$t = 1 \ldots p$ time periods $1 \ldots p$

t_0 starting point in time

N_{ijt_0} backlog demand for social infrastructure at location i in the economic sector j at the point in time t_0

B_{it} population at location i at the end of the period in time t

k_{jt}^* guidance index with regard to the demand for services of the economic sector j in the infrastructure over period t

F_{ijt} capacities per location, economic sector in the infrastructure and period

E_{ijt} expansion requirement for social infrastructure, broken down for i, j, t

ΔB_{it} population growth for given locations over period t

G_{ijt} total requirement for new capacity to be installed in the technological infrastructure for i, j, t

I_{ijt} industrial demand for services to be rendered by the technological infrastructure for i, j, t

A_{ijt} installation of new capacity in the technological infrastructure to replace worn equipment by the end of period t for i, j

C_{ijt} capacity in the technological infrastructure available at the beginning of period t for i, j

$T_{ijt}^{(1)}$ cost of investment for requirements resulting from backlog demand and expansion of the social infrastructure for i, j, t

m_j investment costs for a capacity unit of the social infrastructure to be installed for j

$T_{ijt}^{(2)}$ cost of investment for requirements resulting from backlog demand, replacement and expansion of the technological infrastructure for i, j, t

G_{ijt}^* corrected total requirement G_{ijt} after placing it within the capacity thresholds resulting from the technological conditions

m_{ij} location-specific investment costs for a capacity unit of the technological infrastructure to be installed

D_t backlog demand and replacement requirement of the infrastructure of the combined groups of locations for t (see below).

So far the MTTKOS model has acquired the greatest practical value of all calculation procedures for settlement structure development in connection with regional planning in the GDR. Several years of work to compile the indices guidelines has resulted in a catalog the importance of which goes far beyond the model calculations.

The 'locations' in the calculation include the following:

– the most important industrial towns and all *Kreis* towns (e.g. 18 in the *Bezirk*);

– the sum of other important industrial sites as one location (for instance, in the *Bezirk* of Cottbus 36 industrial towns and rural settlement centres form location 19);

– the sum of all remaining communities in the *Bezirk* (for instance, more than 650 communities form location 20).

3.2. PET[9]

This comes from the Office of Regional Planning (*Büro für Territorialplanung*), and the principle used is the Basic-Nonbasic Concept.

[9] Representation according to Stempell (1971), the formulas for the model have not been published.

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In a first partial model OEW the 'number of workers tied up by the economy' is determined separately for 'site-related' particularly industrial, 'area-related' particularly agricultural and 'population-related' particularly infrastructural labour requirements. The population figures are reached from multiplication of the number of workers tied up by the economy, by family coefficients.

In the second partial model WOMO (utilizable accommodation) the proportion of space fit for habitation is calculated per community after a lapse of various periods, on the basis of a survey of apartments/houses listing the age, condition, amenities and number of rooms. The third partial model BVW (distribution of people) compares the results obtained from the first two partial models and then redistributes the population and apartments among the towns and communities. If in a community WOMO is smaller than OEW, there is a demand for accommodation which will be provided in the settlement centre. If in a community WOMO is greater than OEW, there is excess accommodation. This will be used for further calculation only in the settlement centres, whereas in the case of the other communities it is eliminated as unused space.

At the end of the calculation the demand for apartments is added up for each settlement centre, and the result is used in planning future housing construction sites.

In the PET model the individual communities in an area are assigned to settlement centres thus defining clearly delimited settlement systems.

The model is so designed as to ensure that, as a long-term target, all those employed live where they work. It contains, in a simple form, calculations which must be part of any settlement structure model and can therefore be used universally as a preliminary or partial model.

Use of the model in the *Bezirk* of Potsdam has shown that its results can contribute toward improving the planning of housing construction in a *Bezirk*.

3.3. KÖMS[10]

This model which comes from *Büro für Territorialplanung*, Dresden, has the following features distinguishing it from other settlement structure models:

– it aims at optimizing regional structures as a whole, i.e. including the production structure apart from the settlement structure;

– it is designed for direct application to the immediate problems of regional planning in a *Bezirk*.

From this arrangement and the progress made in modelling work it is clear that KÖMS cannot involve algorithms and therefore is a planning procedure backed up by calculation. It consists of the following six steps:

1. Determining the functional value of regions and parts thereof in order to identify their degree of integration. This step is a modification of conventional procedures for determining the centrality of settlements.

2. Determining the optimal function of settlement centres and their catchment areas taking into account the results of step 1. Essential qualitative aspects are added to the quantitative function assessment of step 1, and more weight is given to the characteristic functions.

3. Determining optimal development thresholds for regions and parts thereof. Here the threshold theory according to B. Malisz is applied to individual towns and extended to regional studies.

4. Determining the optimal size for elementary spatial units of the regional

[10] Representation according to Müller (1975).

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structure. Here a hierarchical system of central places and their hinterlands is established, particularly with a view to providing the best possible social infrastructure.

5. Determining the most favourable localities for branches and the division of functions according to regional structure. This involves an integrated approach to location optimization within the framework of the national economy and the industrial branch and for the determination of regional macrolocations.

6. Economic calculation of selected total approaches to the optimization of regional structures. This involves a variety of balancing and cost calculations with the aim of determining optimal long-term directions of development for regional structures.

The KOMS model which can only be described in its rough outlines and for which no algorithms can be given, indicates the complex problems involved in the planning of optimal regional structures. As regards the planning of the settlement structure a particular attempt is made to place more emphasis on elements of the theory of central places and the function of the settlements.

3.4. PRW[11]

This comes from the Institute of Town Planning and Architecture of the Building Academy of the GDR. It is the result of several years of work on questions of settlement structure modelling, is highly advanced with regard to theory and has been successfully tested on a number of occasions. Several other models from the same team can be regarded as preliminary work leading up to this model (e.g., *Optimierung von Siedlungssystemen*... 1971).

The model aims to provide decision-making aids for controlling the reproduction process with regard to buildings in a region over a long period. It is based on the assumption that a continuous improvement in living conditions and services, and a levelling of the differences in development between town and country, must be achieved through a planned approach to housing construction, repairs, modernization and demolition. The model requires that the development target for the end of a long period be identified, and the optimal sequence of the above operations is then determined, the criteria being construction costs and commuting distances.

Dynamic optimization (Bellman algorithm) is used. For this purpose the total period under review, T_0 to T_r, is subdivided into r time intervals Z_1. For each point in time T_1 variants V_{ml} are established which describe the possible condition of the residential buildings in the settlements.

A variant V_{ml} consists of the following information:

– New residential construction according to settlements;

– Modernization projects according to settlements and age groups for buildings;

– Repairs according to settlements and age groups for buildings. The following restrictions are applied, among others:

– The number of housing units available at any one time must meet the demand;

– Limits of capacity for new construction and modernization;

– Compliance with predetermined housing standards.

In order to solve the problem the variants are plotted in columns against a time axis (cf. Fig. 2). Connecting lines are then drawn between the variants for two consecutive time intervals, if they can succeed one another. A graph network is thus created whose edges (connecting lines) are assessed with the total costs incurred over the time interval Z_1. The latter include the costs for new construction.

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[11] Representation according to *Optimierung*... 1972 and Grundmann (1974).

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modernization, repairs and demolition, and the cost of commuting to work and obtaining specific services.

Dynamic optimization is then used in the network to calculate the shortest path via the optimal variants thus minimizing total expenditure.

3.5. RG[12]

This model has also been worked out by the Institute of Town Planning and Architecture and has the character of a partial model supplementing PRW. It is used to determine the capacities of public facilities necessary to satisfy demand, for locations (settlements) including any construction for their reproduction, on the basis of a given population distribution according to settlements.

The model is based on predetermined decision variants which incorporate alternatives for construction (new construction, modernization, repairs, demolition, conversion and extension) to be carried out in settlements. The principle used is zero-one optimization, and the combination of construction steps causing the least expenditure for building work and commuting is determined for a specific period, location and size.

In the form in which the model is now available, a complete calculation can be performed for every type (species) of public facility considered. The problem of inter-species relations has been dealt with theoretically, but no practicable solutions can be offered as yet.

3.6. AMOS 1[13]

Developed by a team of workers from the Technical University at Dresden, this is a modification of a type of model conceived in several countries (Hauke model and Shershevski-Shnurov model in the Soviet Union, Lowry model in the USA) and suited to the requirements of settlement structure planning in the GDR. It is a partial model which takes into account the time spent for commuting to work and obtaining specific services. The results have been used for the following purposes:

– as basic solutions for coupling Amos 1 with Amos 2 using an iteration procedure;

– as factors in assessing the suitability of sites for residential and industrial development (along with many other factors);

– as a basis for determining the cost of commuting in several models.

The point of departure for the model is the accepted fact that the places of residence of those employed at a specific location are distributed over zones of distance from the workplace according to mathematical and statistical principles. These principles which are known as *teoreticheskoye rasseleniye* in the Soviet literature, and which Lowry calls the 'work-to-home-function', are used as a restriction in the model. Deliberate redistribution of the population to settlements through an iteration procedure is employed to work out that distribution which causes the least expenditure of time for commuting.

3.7. AMOS 2[14]

This is the result of a number of years of work on the modelling of the settlement structure and comes likewise from the Dresden Technical University. Just as MTTKOS it is based on the threshold theory according to B. Malisz but incorporates a number of improvements, as follows:

[12] Representation according to Grundmann (1974).
[13] Representation according to Kind (1975).
[14] Representation according to Kind and Steindorf (1973).

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– The smallest unit for calculation is the settlement or the urban borough.
– The calculations regarding the technological infrastructure are conducted for route networks.
– Commuting to work and to service facilities is included as a cost factor, and the time spent for these purposes is minimized using the partial model Amos 1.
– As an internal feature of the model, the population distribution causing the least expenditure in terms of the national economy is determined.
– The structure of the method makes it possible to include non-quantifiable factors.
– Calculations are made for a number of variants as regards the population of the settlement system. The results can be summarized to give expenditure functions of the settlement system for changes in distribution and for an increase in the total number of inhabitants (see Fig. 1).

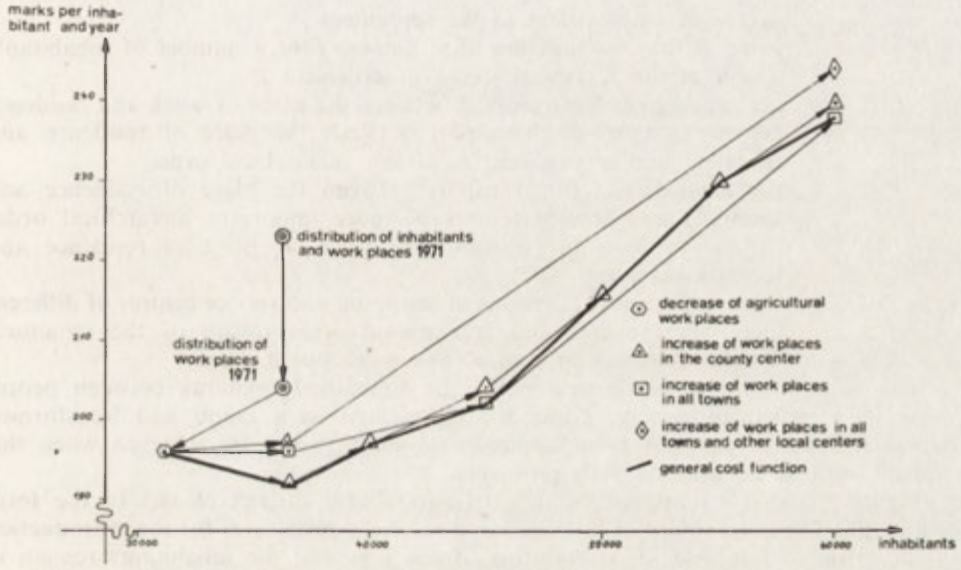

Fig. 1. Real cost functions for a rural county

The target function of the model is as follows:

$$K_m = \min \sum_i \left\{ \sum_j \frac{P_{ij}}{b_j} \left[w_j(x_j) + a_{ij} b_j + \min_q (a_{jq} + v_q) + \right. \right.$$
$$\left. \left. + \min_r (a_{jr} + v_r) + \sum_s (a_{js} + v_s) \right] \right\}.$$

Explanations of indices and symbols

Indices

m a variant, which consists of the number of workers and the distribution of working places within a settlement system
i the settlement as the site of working places
j the settlement as the site of housing

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q shopping and service centre of low hierarchical order
r shopping and service centre of more important hierarchical order
s recreational area

Symbols

K_m	total costs of the variant m
P_{ij}	the number of workers, who are working in the settlement i and living in the settlement j
$P_i = \sum_j P_{ij}$	the number of working places in the settlement i
$P_j = \frac{\sum_i P_{ij}}{b_j}$	the number of inhabitants of the settlement j
b_j	degree of employment in the settlement j
$w_j(x_j)$	value of the cost function of settlement j for a number of inhabitants (result of the threshold study of settlement j)
a_{ij}	per capita costs for transport between the place of work and residence
a_{iq}	per capita costs for transport between the place of residence and shopping and service centres of low hierarchical order
a_{ir}	per capita costs for transport between the place of residence and shopping and service centres of more important hierarchical order
a_{is}	per capita costs for transport between the place of residence and recreational areas
v_q, v_r, v_s	values of the cost functions of shopping and service centres of different hierarchical orders and recreational areas (result of the structural threshold studies of centres and recreational areas)

The solution has as a starting point the functional relations between people living in a settlement system. These are represented as a graph and transformed into a directed network. A good approximate solution can be achieved when this is dealt with as an optimal path problem.

Figure 1 shows its application for an agricultural district (*Kreis*) in the form of a graph. The initial point of intersection gives the expenditures for the reproduction of the infrastructure and for commuting, if the jobs and the inhabitants remain in the same locations as in 1971. The second variant starts from the distribution of jobs in 1971 and gives the optimal distribution of the inhabitants for this situation. All the other variants presuppose a drop in the number of those employed in agriculture, and different degress of growth in the number of those employed in industry in different locations. Taking all variants as a basis the 'most favourable' expenditure function can be determined for the *Kreis*. This makes it possible to take into account the conditions of development of the *Kreis* in planning the distribution of the productive forces. Several experiments have been conducted with the Amos 2 model.

4. THE THEORETICAL FOUNDATIONS AND CONTENT OF THE SETTLEMENT STRUCTURE MODELS

4.1. DIMENSION OF THE SETTLEMENT SYSTEMS MODELLED

So far optimization calculations for settlement structure development have been limited to counties (*Bezirk*), parts thereof, districts (*Kreis*) and parts thereof without giving compelling reasons for such demarcation. In most cases the criteria used were related to the infrastructure directly serving the population. In this approach it

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was presupposed that the basic requirements of the people including the need to work were satisfied within the boundaries of the specific area, which is doubtless a rather vague assumption for our calculations.

It results from the necessity to use indices guidelines with regard to the technological and social infrastructure and the degree of employment at the higher stages of the modular concept. Thus optimization calculations for the settlement structure may be made only for areas which have such a low level of external relations that the latter cannot influence the results. This applies to spheres of human activity and regional settlement systems alike. If this is not observed the results will be faulty, as has been proven in the course of calculations made for the Meissen district (*Kreis*) in the Dresden agglomeration.

In other words, research into regional settlement systems is an indispensable condition for modelling settlement systems.

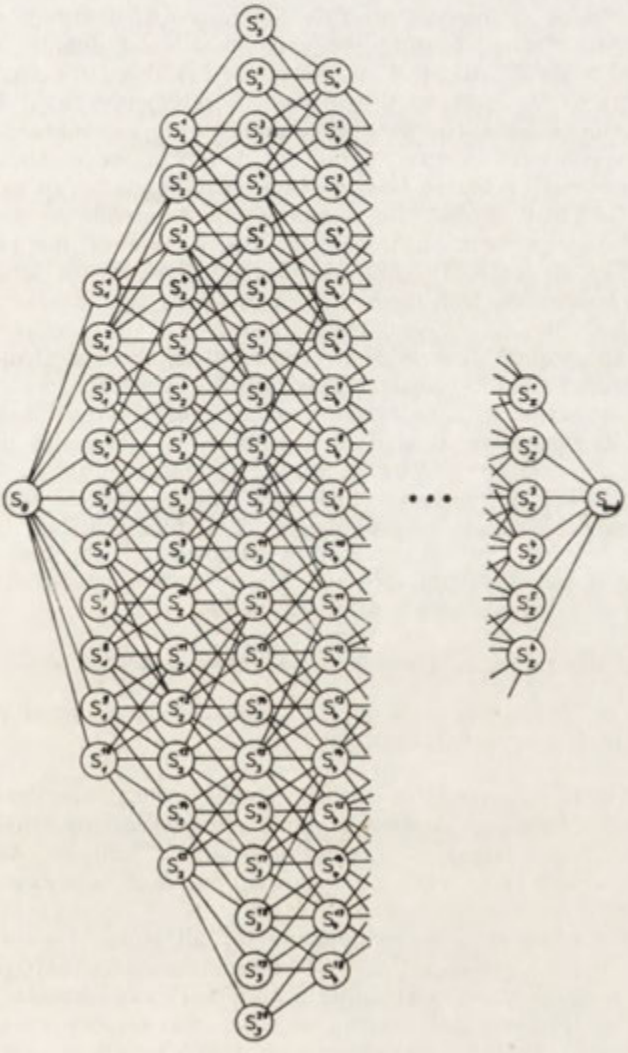

Fig. 2. Decision-making network of the development of the settlement structure – 3rd stage of the modular concept

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4.2. INTEGRATION INTO NATIONAL ECONOMIC PLANNING

The most substantial assumption in the models is their integration into economic planning. It is more or less clear in all models that they start from a predetermined development of the production structure and then go on to calculate the best possible development of a region using certain assumptions and target functions, with costs as the criterion in most cases. At the basis of the settlement structure models there is therefore the duality of a centrally planned production structure and a regionally planned settlement structure, the latter comprising the spatial arrangement of all elements of the social and technological infrastructure, the population and labour structure and the structure of the natural resources.

In order to integrate the settlement structure models into optimal economic planning at the third stage of the modular concept a way must be found of taking into account the expenditure for the further development of the settlement structure in calculations made at national level to determine the distribution (site planning) of the productive forces. Bearing the above-mentioned duality in mind, this is possible only if optimal settlement structures are calculated for a greater number of variants relating to the size and distribution of production sites. The results from these optimization calculations can be combined into expenditure functions which indicate the expenditures incurred if the population of the settlement system being studied changes. Each point in this function corresponds to an optimal settlement system (Fig. 1). These expenditure functions could provide an essential basis for economic optimization with regard to the distribution of the productive forces.

This leads us to a focal point in our future work on settlement structure models. As a matter of fact there are, theoretically, an infinite number of such variants. Of these, however, only a comparatively few are practicable. In the establishment of such variants use must be made of all the knowledge gained in the field of settlement structure research. This includes such concepts as the node-band arrangement, the strip city, the hierarchical settlement system and others. At the third stage of the modular concept it is proposed to solve this problem with the help of a decision-making network of the development of the settlement structure in time (Fig. 2). The point of departure is a current state S_0 from which the development toward alternative target concepts S_2^n is followed. Not until this calculation using the Bellman optimal principle is completed, is the best possible version selected with the aid of suitable criteria. For such decisions it is indispensable to know the concrete spatial models of the settlement structure.

4.3. THEORETICAL FOUNDATIONS OF SETTLEMENT STRUCTURE MODELS

Settlement structure modelling in the GDR can be grouped into concepts of spatial structure and economic concepts.

Concepts of spatial structure. Nearly all models include elements of the theory of central places. Preference is given to settlements which function as centres when it comes to the maintenance or extension of public facilities. Allowance is thus made for the problem of correlate group formation which is difficult to comprehend mathematically.

Some models which permit free location for all types of public facilities with the aim of minimizing construction and commuting costs may give unfavourable solutions. Thus to have a freestanding school half way between two settlements being served by it may cut costs but will be contradictory to the principles of a settlement policy. In order to be able to decide which elements of the theory of central places must be incorporated as restrictions in the models of settlement structures, one must have a thorough understanding of the variability of the central

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place functions of settlements. This can only be achieved by linking one's concepts with those in central place models covering the entire national territory. Such models have not been considered in the GDR so far.

Another theoretical starting point which has become firmly incorporated into settlement structure models is the concept of gravitation as found in the models of Lowry and Shershevski/Shnurov.

Economic concepts. The threshold theory according to B. Malisz occupies a central place in most settlement structure models, and it is our belief that it alone permits a consistent link-up of the technological, architectural and environmental requirements with the economic aspects of settlement structure development. The reservations which may be made particularly because expenditure for the social infrastructure cannot be compared for different populations, can be invalidated when the theory is applied to regional settlement systems. One drawback is that then algorithms cannot be used throughout. Employment of the theory must then include models, and it becomes particularly clear in this context that conceptual and modelling work must be dovetailed.

Other necessary elements in almost all settlement structure models are models of the reproduction process for buildings and the Basic-Nonbasic Concept.

5. SUMMARY

Settlement structure research in the GDR has reached a stage where, on the one hand, the conceptual basis of models must be strengthened and, on the other, results must be substantiated with the help of model calculations more than in the past. What is needed therefore is a closer link between conceptual research and modelling.

At the present time work is proceeding on the concept of a model-assisted procedure for optimal settlement structure planning. This calls for the involvement of a greater number of scientific disciplines.

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ON PLANNING AND CONTROL OF SETTLEMENT SYSTEMS IN THE USSR

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In working out a socio-economic policy for a developed socialist society, as one of the trends one may single out the policy with regard to population redistribution, regulating growth of cities and towns and controlling migration processes, as well as planning of development and distribution of settlements. Direct planning of the development and distribution of settlements is carried out on national, regional and local levels. In the USSR much experience has been accumulated on this field of planned control, and of state and public planning.

Control of population redistribution should proceed from knowledge of both more general laws and regularities peculiar to a given socio-economic formation as a whole, as well as of the specific ones for the field being studied. Four laws have been formulated which apply to population under socialism: 1) growth of the industrial population at the expense of the farm population; 2) population mobility; 3) proportionality of the urbanization level and the process of industrial development; 4) more even arrangement of the main (concentrated) forms of distribution throughout the national territory (Khorev 1975). These laws have been formulated directly from a number of theses in the works by Marx, Engels, and Lenin. Attempts to control development of the settlement network without taking into account the impact of the given laws, would be unjustified.

The effect of the specific laws of distribution under socialism is ensured by the economic laws of the given formation and primarily by public ownership of the means of production, by the influence of the basic law of the economy, the laws of planned and proportional development, distribution of the productive forces, and so on. Socialist society, which pursues the aim of satisfying the material and intellectual needs of all its members as far as possible and of ensuring the exhaustive and free development of personality, solves these tasks, as advances are made by its productive forces, in accordance with the level of development attained by the material and technical base.

Growth of the industrial population at the expense of the farm population should be mentioned as one of the first of the objective, significant, necessary and universal processes. An exhaustive analysis in this context for a country, which had entered upon the stage of capitalist development, was made by V. I. Lenin in his *Razvitiye Kapitalizma v Rossii* (The Development of Capitalism in Russia). The importance of this conclusion for that time can be seen from the fact that in Russia in 1913 the urban population made up less than one-fifth of the entire popu-

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lation, and was even less numerous at the beginning of the century. In 1976, the urban population in the USSR amounted to 61 per cent. In some regions urban population shared over 70 per cent (the level of highly urbanized countries).

The principle governing this process may be explained, firstly, by the need to increase the share of industrial production in the gross national revenue, thus calling forth the swelling of the ranks of the working class at the expense of the agricultural population. Secondly, increasing variety of human needs results in the growing share of those employed in the non-productive sphere, in transport, and so forth. Thirdly, increased labour productivity in agriculture makes it possible to release a surplus of the rural population.

Of course, there are certain limits to the law governing the growth of the industrial population at the expense of the agricultural one. On a certain level of development of the productive forces and production relations, when agricultural labour becomes a kind of industrial labour and equal working and living conditions are maintained for all, and the very concepts of 'town' and 'village' practically disappears, this law ceases to be valid.

The main content of the law of population mobility is formulated in works by Marx[1] and Lenin[2]. As it is important to examine mobility from the point of view of the functioning distribution, one can restrict here to one form of this concept, viz. migrational mobility.

Even some fifteen years ago migration was frequently regarded as an undesirable phenomenon that makes economic outlays necessary. Meanwhile, migration takes place, facilitating both economic growth and the development of personality. Administrative restrictions based on an empirical evaluation of the effect of the given phenomenon do, to a certain extent, influence the emergence of the law, but this law, objective in essence, carves its way and makes itself felt to an ever greater extent.

There are two extreme points of view with regard to migration processes in a planned economy. According to one of them migration does not substantially affect economic development and the distribution of labour forces. Migration studies are hereby ignored and the economy works without analyzing them. This viewpoint seems to be outmoded now. The other point of view, which is a reaction to the first one, exaggerates the scales and character of migration processes; it asserts that the migration process is spontaneous and uncontrollable.

Similar ideas about the process under study do not reflect its essence and, what is most important, do not facilitate taking correct decisions in putting economic, social and other measures into effect. It is important to understand the objective basis of this process and determine main principles governing it, the character of its influence on other processes, to find those tools with which development of the process can be controlled. The scale of migration may be compared from a historical and geographical point of view; in the former case, however, difficulties arise in connection with the lack of necessary statistical data for a long period. A country-by-country comparison shows that the level of migrational mobility in the USSR is still fairly low and will certainly increase (Khorev 1976a; Khorev and Moiseyenko 1976).

Migration control should be exercised, taking into account interdependence and interchangeability of the main forms of migratory movements, i.e. resettlement, seasonal migration, commuting, and paying attention to the character of any human movement (natural, spatial, social).

The law governing proportionality of the advance of urbanization to the process of industrial development means that under socialism the type of urbanization is determined by the planned character of the economy and by the planned develop-

[1] Marx K. and Engels F., Collected Works, Vol. 23, p. 498.
[2] Lenin V. I., Complete Collected Works, Vol. 3, p. 549.

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ment and distribution of industry, while proportionality is established both in development throughout the country as a whole, and in the interdependence of the two given processes from a regional point of view.

This law causes extensive possibilities to open up for planning the rational redistribution of branches of the national economy and determines the effect of the territorial production complexes on development of the settlement network, individual towns and cities.

Unlike the first two laws whose effect can be seen specifically in the conditions of both socialism and capitalism, this law, like the law of the more even distribution of the main (concentrated) forms of distribution, is typical merely for socialism as it was evidenced by Engels.

The course pursued in the USSR with regard to planned control of the growth of large cities and the formation of a unified settlement system (USS) involves directly 'the law of more even distribution', by virtue of the effect of certain objective and subjective factors emerging in contradictory forms in contemporary conditions.

Proceeding from an analysis of the principles mentioned above, and others, as well as from the evidence of sociological, economic, ecological and spatial bases of the theory of distribution, the scientific concept of the formation of the USS as the main way of scientific control of urbanization under socialism[3] has already been worked out fairly thoroughly in Soviet literature. The main theoretical and methodological theses of this concept were described quite recently in the literature (see, for example, Khodzhayev and Khorev 1971, 1976; Khorev 1975, 1976; Alayev and Khorev 1974, 1975a, 1975b).

Yet it is necessary to emphasize again that the solution of the problem of an USS, of developing a network of settlements in general should be regarded in the context of the problems of development and distribution of material and non-material production, technical and social infrastructure, territorial organization of population, territorial structure of the productive forces, territorial and systemic organization of society as a whole taking, of course, into account the peculiarities of the given socio-economic formation. Without this it is difficult to imagine development of the scientific, economic and demogeographic school that has taken place in the USSR under influence of N. N. Baransky and N. N. Kolosovsky, on the basis of Lenin's ideas with regard to economic regionalization; those ideas are also reflected in the works by G. M. Kzhizhanovsky, I. G. Aleksandrov and others. This has already entered the theory and practice of urban planning.

Meanwhile, one often skims publications in which questions of urbanization, development of forms of distribution are, as it were, regarded outside the framework of territorial organization of society as a whole and, spatial development and distribution of production; 'modern urbanization' is, in essence, interpreted as a self-developing process from lower to higher forms independent of the forms of ownership, and the social and political structure.

In reality, the transformation of old forms of division of labour, bridging gap between life in the town and village, the rational territorial organization of production and infrastructure, where there is a high level of development of the productive forces and production relations, should give rise to an USS where there will be a merging of the town and village.

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[3] Cf. the works by N. V. Baranov, E. B. Alayev, N. T. Agafonov, V. G. Davidovitch, S. B. Lavrov, O. P. Litovka, A. M. Kolotiyevsky, K. K. Seselgis, Z. N. Yargina, N. N. Kazansky, S. Ya. Nymmik, V. Yu. Tarmisto, A. V. Bogdanovitch, T. I. Raimov, V. R. Belensky, S. K. Vaitekunas, S. A. Polsky, V. P. Polonsky, I. K. Orfanov, L. L. Trube, Ye. L. Yanovitch, O. B. Ata-Mirzayev, N. F. Timchuk, V. V. Podkolzin, G. B. Rybin, A. A. Nesterov, A. G. Grishanova, S. V. Krikunova, S. G. Smidovitch, A. Saliyev, A. M. Lola, and others.

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According to some authors, it is already time to stop the planning of individual towns, cities and other settlements, owing to the development of 'new forms of distribution' (agglomerations and megalopolises, particularly characteristic of western countries). In reality, in attempting to form the USS in future, i.e. a structural and interrelated hierarchic network of all settlements in the country, developed according to certain principles and planned to meet the needs of society, at any given stage it is necessary to ensure the co-ordinated development, providing equal rights, of the various economically expedient types of settlement in this system.

The immediate task is that of ensuring the multifunctional development of the possibly largest number of settlements on each hierarchic level of the social and territorial system: republican and regional (*oblast*) centres, subregional (*okrug*) subcentres, centres of the initial territorial cells of a society of a different type. Only if there are sufficient exhaustively developed centres combined with the everyday inter-settlement links can the ekistic conditions in fact be ensured to satisfy the material and intellectual needs of every member of society as fully as possible.

In the last few years much attention has been paid to the problem of urban agglomerations in Soviet and foreign, in particular Polish, literature. One should, however, have a clear idea of the position of urban agglomerations in an individual settlement system and in social and economic regionalization of the country. In this context K. Dziewoński pointed out that if there is a question of the place occupied by urban agglomerations in a settlement system, it is only correlation of functions between the agglomerations and the provincial centres that reveals their real hierarchic role in relation to regional and local settlement systems. It remains unclear, however, if there exists in Poland a system of large urban agglomerations, which is an autonomous part of the entire settlement network. In other words: are the links between urban agglomerations more important, from a social and economic point of view, than those between agglomerations and their respective regions and its settlement? (Dziewoński 1973). One should stick to an approach according to which the projecting and planning of agglomerated (group) forms of settlement (large, medium-sized, and small) are organically combined with the integral socio-economic regionalization of the country on all hierarchic levels – macro-, mezzo-, and micro-regional.

In my opinion, formed regionalization on all hierarchical levels should primarily be based on current and future region-organizing centres of different rank. The main criterion with regard to boundaries and forms of regionalization on a macro--regional level is the formation of the regional production complex (RPC) with specialization on an interregional scale, and a large region-organizing centre. On the mezzo- and micro-regional levels the accessibility of the region-forming centre serves as the criterion; on a mezzo-regional level it works according to the organizational and economic, periodical culture and welfare service, recreational, migrational and reproductive links; on a micro-regional level – according to the everyday mass labour links. This means that on the mezzo- and micro-regional levels the main criteria are related to infrastructure and settlement. Their peculiarities make it necessary to analyze them separately in a special field of research which is, in my opinion, most logically reflected in the concept of the USS.

The above brings about the need for working out a methodology for identification of the infrastructure and territorial complexes (ITC) as territorial links in the RPC: the scientific basis of forms and boundaries of these complexes, may underlie the social and economic regionalization of the country on mezzo- and micro-regional levels. At present, on the basis of literature it is possible to have a much clearer idea of ways and parameters in forming an ITC on a mezzo-regional level. This is still rather obscure on a micro-regional level. Meanwhile, it is precisely on this level that the task arises to establish the scientific basis of the primary territorial cells of

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society, forming local links in the taxonomic system of the socio-economic regionalization of the country which should ensure a unity of economic and administrative regionalization. Moreover, the efficiency of the system as a whole does, to a decisive extent, depend on the efficiency of the local link (a law of cybernetics). The special feature of this approach to the problem of social and economic regionalization is that, in recognizing the importance of general economic regionalization, it is considered necessary to transfer the centre of gravity as a whole to the problems of regionalization on micro- and mezzo-regional levels. It should be taken into account that where there is rapid communication, mainly in the suburban zones of large towns and in resort areas, the micro- and mezzo-regional levels may fuse.

At present, in this field methods of regionalization have been adequately (but not fully) worked out, including the following: a demogeographic method of social and economic regionalization by determining the fields of demographic interaction of the region-forming nuclei in a territory, worked out by S. Ya. Nymmik (1970); methods of establishing the basis of sub-regional (*okrug*) divisions, based mainly on example of the Chuvash Autonomous Soviet Socialist Republic, the Gorki region (Maly Gorod 1972; Khorev 1971), Byelorussian Polesya (Yanovitch 1973, 1975, 1976); methods to determine basis of formation of the industrial node as the local economic region (e.g. Pushkaryev 1967), and others. An analysis of the methods used, which do, as a rule, relate to infrastructure and settlement, convinces a need to introduce the concept of ITC. The specific function of this concept consists in the fact that in the RPC system it should represent the production and social infrastructure (transport, distribution of workers, manpower resources, population movement, services, recreation, functional zoning and use of territories, energy supply, construction base).

The part played by the ITC on mezzo- and micro-regional levels does not work counter to the significance of the industrial nodes in forming basic economic regions, since, even where the industrial nodes are developed, the composition and boundaries of these regions are, as a rule, determined not according to production and economic links (the latter being usually of supra-regional character), but according to infrastructure links.

Taking into account the existing administrative and territorial division, the current structural model of social and economic regionalization in the USSR may be presented as follows: 1) the zone of gravitation to a local centre (rural area councils being located in the local centre) forms a basic administrative unit; 2) *okrug* (a number of basic administrative units); *oblast* (region) or republic without regional (*oblast*) division; (large) economic region. To identify a system of region-organizing centres of different rank within this model it would be desirable to analyze the following relationships between settlements throughout the territory of a large economic region: 1) demographic links (including migration); 2) production links; 3) system of public services; 4) transport; 5) system of natural environment; 6) information system; 7) system of management (Alayev and Khorev 1975). Such research is, however, extremely complex. Therefore, in identification of a network of subregional (*okrug*) centres, a less sophisticated method worked out within the framework of the USS concept, may be suggested (Khorev 1975; Yanovitch 1973, 1975, 1976).

The mechanism of formation of the *okrug* centre and its functional role are determined by four factors, i.e.: 1) development of industry as the main town-forming and region-forming factor; 2) development of the tertiary sector satisfying human needs both within the central city and its sphere of influence; 3) a network of communication; 4) local population mobility (commuting to work, public services and shopping) as a factor determining the boundaries of the system. It is worth to note that the *okrug* centre should have an interregional construction base.

First of all, it is necessary to identify the urban places liable to initial industrial

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development (accodring to the methods worked out by planners). Most of them should become *okrug* centres, and this makes it possible to avoid sharp territorial differentiation and to create the most favourable conditions for industrial and civil construction as well as for human life.

Formation of industrial nodes is the most important trend in development and redistribution of production. This makes it possible to decrease estimated costs of construction, built-up area, length of communication channels as well as those of exploitation. A combination of the schemes of the industrial nodes distribution with the schemes of the *okrug* centres formation may bring additional benefit to the national economy. Therefore, an analysis has to be made to redistribute the capital investments on production and select for dynamic growth urban places capable to become potential *okrug* centres.

Besides, the non-productive sphere will play in future a considerable role in economic structure of many towns. Even now urban places do already, to a considerable extent, provide rural inhabitants with services, i.e. they work as centres of gravitation. Research on the tertiary functions makes it possible to evaluate influence of a city on the zone of gravitation. A further analysis results in determining the place of the central towns in the supra-local services and establishing limits of their influence.

In building a model of a supra-local tertiary system a dispersion analysis can be used which allows to determine the extent of central functions of an urban place and its position in the system. The degree to which the various tertiary establishments in a given place are central is established, proceeding from the fact that they are related with a larger or smaller number of places. The extent of central functions of a place and its zone of gravitation is determined by various service establishments.

The levels of centrality for each tertiary establishment in urban places can be calculated, and coefficients of dispersion estimated (ratio of the number of urban places with the given establishments to the overall number of urban places in the region). The smaller the coefficient showing the number of places in which the given establishment is located, the greater the degree of their concentration (centrality). As the analysis showed, a number of tertiary establishments displayed a tendency to concentration (theatres, museums, music schools, sports schools, clubs, notarial offices, department stores, legal advice offices, markets, and clinics). Then the levels of centrality of the urban places are determined, since concentration of tertiary establishments is characteristic of the role played by the urban places in the supra-local system of cultural and welfare services. The urban places with high and highest degrees of centrality may be regarded as potential *okrug* centres.

The existing methods of identification of mezzo-regions on the base of the coefficient of centrality and of the demographic influence of urban places (Nymmik 1970) make it possible to determine some general parameters of the system. The most in-depth structural analysis is possible that base on a study of local population mobility, i.e. all everyday supra-local movements (between individual places) to satisfy human needs in labour, culture and shopping.

An analysis of the distances travelled and the time spent on trips reveals the definite boundaries of the system. These values depend on the production base and on a number of other factors: the regularity of the settlement network, the extent of communication, and the degree of development of social infrastructure. In studying the problem in this direction, first and foremost, it is necessary to determine parameters of the system in terms of their regularity. Information theory methods make it possible to describe them precisely in quantitative and qualitative terms.

One of the most important factors in the formation of *okrug* centres, which in many respects determine the boundaries of the mezzo-regions, is commuting which involves intensive cultural and welfare links between urban population and the zone

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of gravitation. An analysis of distance of commuting to work, of the part played by various forms of transport, time spent on travel, and the territorial peculiarities of trips, is rather important in determining the parameters. For large cities limits of the intensive links are 50–55 kms, for medium-sized towns – 25–30 kms and for small ones – 19–28 kms.

As the zone of influence of the settlements is determined by labour and intensive cultural and welfare service links, the zones of commercial gravitation of the urban places have to be defined. Their location may be based on accessibility of the urban places, i.e. on the given network of roads and railways (suburban passenger communication); on distance from other towns, especially large cities; on retail trade turnover and amount of retail trade enterprises. When towns are centres of retail trade, they increasingly become centres of wholesale trade, and this also determines their influence on the zone of gravitation.

The physically existing zones of gravitation determined on the basis of data on suburban passenger graffic and the zones of commercial attraction do overlap considerably. This makes it possible to suggest the most rational parameters of the zones of cultural and welfare service gravitation for urban places of different size, since one can only get the most complete picture of them when one determines them according to several indices (Table 1).

TABLE 1. Rational zones of cultural and welfare service gravitation towards urban places of different size

Population of urban places (,000)	Optimal distance of travel for cultural and welfare purposes (kms)	Zones of commercial gravitation (kms)
to 5	22	20
5–10	25	22
10–25	30	27
25–50	32	29
50–100	35	32
100–200	45	40
200 plus	50	45

A study of the four components (industry, services, communication network, population mobility) allows to determine the main parameters of the mezzo-region around the *okrug* centre: time taken to reach the *okrug* centre 1.5 hours; average radius of the zone of gravitation – 40–50 kms; optimal zones of commuting – 15–20 kms; optimal zones of cultural and welfare service trips – 20–50 kms; optimal zones of trips for trading purposes – 15–40 kms (Yanovitch 1975).

The research conducted in a number of regions in the European part of the USSR makes it possible to suggest a model for the *okrug* (Table 2). Taking the average population of an *okrug* as about 300 000, on examining the scheme for the first time, one can imagine a scheme of *okrug* divisions of the USSR (which has 255 000 000 inhabitants) consisting of 700 to 750 districts.

An analysis of the scheme of intra-*okrug* regionalization compiled on the basis of the materials in *Geografiya SSSR* has been conducted at the Centre for the Study of Population Problems at Moscow State University. Since intra-*okrug* regionalization

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TABLE 2. Characteristics of current *okrugs*

Indices	Densely populated region (Chuvashya)	Sparsely populated (Byelorussian Polesya)
Area (.000 km²)	3.3–6.3	5.5–8.0
Population (.000)	200–500	200–250
Average radius of gravitation to *okrug* centre (kms)	35–50	40–50

for the Ukraine is not discussed in this series, it has been carried out on the basis of an analysis of "The Recommendations for the Planned Development of Interrelated Settlements in the Ukrainian Soviet Socialist Republic" (1969), in which, besides 25 *oblast* centres, which are *okrug* centres as well, another 58 centres were additionally identified. Altogether, according to this regionalization, there are to be 567 intra-*oblast* areas, including 312 within the Russian Soviet Federal Socialist Republic (excluding the *oblast* of Kaliningrad) and 255 within other union republics. In 27 *oblast* (nine in RSFSR) no centres have been formed, while in three *oblast* there are two centres in each. Totally it amounts to 543 *okrug* centres throughout the USSR (305 in RSFSR).

In the Asian part of the USSR subregions frequently appear out of regions. The Asian subregions and intraregional areas, which are not divided into subregions, may correspond to a district (*okrug*).

According to more precise elaborations for the territory of the RSFSR worked out at the Centre, on this territory alone 410 *okrug* centres have been identified which may be formed in addition to the 76 centres of regions, *krays*, autonomous republics, and autonomous regions. Since these 76 centres should also be centres of the districts adjacent to them, then totally 486 districts are proposed on the territory of the RSFSR. A comparison of the given scheme with the scheme of economic 'microregions' of the RSFSR drawn up at that time by the Central Research Institute of Urban Planning shows that in the number of territorial units and their composition these schemes are extremely similar to one another which testifies to the objective existence of districts.

At present, schemes for the distribution of the productive forces have been drawn up for all the economic regions of the USSR, and schemes of regional planning have been compiled for many territories. An analysis of them makes it possible to identify the pattern of districts more precisely, in each of which equal conditions should be created for all inhabitants with regard to jobs and main services. In this case, more complex, multifunctional development is ensured for a much larger number of urban centres than in the case of the current regional system (approximately 700 units as against 150).

Abolition of the old district in 1930s occurred where there was a four-level administrative system (rural area council, local area, district, region) and brought regions devided into smaller units. Now there is a question of a new district formed by merging of several local areas in a three-level administrative system. The district will obviously be smaller than the former one. It is by no means a question of returning to the regionalization of the 1920s and the beginning of the 1930s, irrespective of its evaluation and subsequent changes within it (Alampiyev 1959, pp. 123–126, 167–168); but a question arises of further improvement of regionalization in the country on scientific bases.

The reconstruction of districts (mezzo-regions) is impossible without improving the local administrative system (administrative and economic micro-regionalization). As a rule, the districts comprise a group of local administrative areas (most often

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three or four). In the USSR there are more than 3000 areas of this type. As a rule, the local administrative area resolved questions regarding the organization of agricultural production and services for the rural population, corresponding to considerable extent to an enlarged rural area council. At present, there are more than 40 000 rural area councils, almost as many as the primary agricultural enterprises, the co-operative and state-owned farms. Currently, with development of intensive supra-local cultural and welfare service links, enlargement of co-operative farms, lack of a party link in management, insufficient funds, and so forth, the rural area councils are not active enough, their functions being often extremely limited. Like the primary territorial units of society, territories of rural area councils ought to possess a certain range of social and welfare tertiary establishments not attached to departments and accessible to all citizens, creation of which is only worthwhile where there is a certain minimum population to be served. Now services for the population in a village depend rather on the local co-operative farm or on allocation of the recreation base of individual enterprises and on links with the nearest city. In Poland this measure – abolishing the *gromada* and creation of the larger *gmina*, has been recently put into effect. The sub-regional unit (*powiat*) has been also abolished. In the Soviet Union the enlarged rural area councils and towns would constitute the future district. In this case the number of management units would also be close to optimal. It is noteworthy that, as distinct from questions of 'district division' the problem of primary regionalization has not yet been worked out properly and there is particular need of additional research in this respect.

Besides, as a preliminary formulation of the question the following model for future development is put forward (Khorev 1975a):

1. On the first level – enlarged rural area councils entrusted with some of management functions peculiar to modern administrative regions (however, it is difficult to state the overall number of reinforced rural area councils at present).

2. On the second level – no more than 600–700 (according to preliminary calculations) enlarged district areas, some centres having already been determined in practice, entrusting them with some of management functions common to modern regions; in future the overall number of units of the given rank may reach 1000, which is comparable to the future number of electoral divisions for the House of Union voting; the divisions may form a base of administrative regionalization.

3. On the third level – enlarged regions (obviously, only in such union republics as the RSFSR, Ukraine and the Kazakhstan) identical to economic regions of the highest rank with the corresponding management functions (except for the national autonomies). It should be noted that, in accordance with the Constitution, each union republic determines its own *kray*, region, district, and local area division and resolves other questions with regard to the administrative and territorial organization.

In working out regionalization for all levels, the specific features of various regions of the country should be taken into account. Thus, in the eastern and northern areas of the RSFSR the district division should, evidently, be left as it is. Designation of the territorial units of various ranks requires special consideration. The following version is suggested: commune (urban or rural) – district – region (or *kray*).

The construction and reconstruction of industrial enterprises, transport network, tertiary enterprises and establishments as well as water supply and sewage systems, communication networks, formation of a construction base should be determined within the framework of the model suggested. The territorial organization of the national economy may become an effective link in solving the complex of socio-economic development, improving territorial structure of the national economy and controlling the urban growth.

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Solution of both the methodological and practical questions of development and distribution of settlements in the USSR is inseparable from the problem of the regional distribution of the productive forces, development of regions. Urban and regional planning are, in fact, indivisible. It is only on this base that the practical tasks of forming an USS and managing settlement can be solved.

In the sixties and seventies in the Lithuanian SSR the possibilities of exercising scientifically founded control over the urbanization processes based on the USS model were checked, as it were, 'experimentally'. The USS model has been originally introduced during the eighth five-year plan. As a result, from 1965 to 1973 more than 70 per cent of the urban growth in the republic fell to the share of ten inter-republican (regional) subcentres, previously selected for preferential development, and the other 104 cities, towns and urban places accounted for only 30 per cent of the growth. Moreover, despite the existing limitations, population in large towns, especially in Vilnius, grew more rapidly than intended in the scheme. The population growth rates in the currently created regional centres (five out of ten) were approximately twice the republical average but shared only 10 per cent of the overall urban population growth (Yakushkiyavichius 1973).

One of the main questions to which the 25th Congress of the Party paid attention, was that of improving management of the economy. In his report L. I. Brezhnev pointed out urgency of the task 'of combining sectoral and territorial development more successfully' (this is the first time that this task has been set forth in this broad formulation since it was formerly a question of combining sectoral and territorial planning, uniting the sectoral management of the national economy with the territorial planning). It is precisely settlement, particularly towns but also regions, that are a link where sectoral and territorial development, planning, and management require greater co-ordination. In practice this looks like co-ordination of sectoral development plans by ministries and departments, which are in charge of the enterprises and establishments located in a particular territory, with territorial and intersectoral interests of the towns and regions.

At present, there are at least five types of regional and urban planning in the USSR ensuring in practice a combination of sectoral and territorial development: 1) sectoral national economic planning; 2) national economic programmes for regions; 3) regional planning; 4) master plans and projects for town planning; 5) planning of socio-economic development of cities and regions. They are not equally developed or interrelated.

To control urban development and settlement generally is not just to include planning. To combine sectoral and territorial development on this level means, if aiming industry at making it effective vertically, to concentrate the remaining tools of urban management by local administrations thus as to carry out planning and management horizontally as well. The problem can be solved in the following ways: first, by drawing up really comprehensive current and long-term national economic plans for urban development balanced in material and manpower resources; secondly, by gradual concentration management of infrastructure in a given territory by the local administration; thirdly, by transferring the economic interactions of the town under the local council power having its organizations in the branch of industry. Since the problem of manpower resources is increasingly appearing while interests of industry overlap with territorial and local interests, introduction of 'payment for manpower resources' may be recommended as the main way to solve the task of transferring the economic mechanism. Concentration of management of infrastructure by local administrations drawing up comprehensive development plans and working off economic mechanism might considerably enlarge the part played by the local councils in management of the national economy.

The processes of urbanization and human mobility have a growing influence on

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social and economic regionalization of the country, resulting in the Soviet conditions in formation of USS based on increasing of supra-local links, including resettlement and commuting. At the Centre for the Study of Population Problems at the Moscow State University a concept of USS has been worked out which presents a theoretical and methodological base of transition from autonomous development of towns and places to formation of an economically and socially founded system of developed centres with supra-local cultural and welfare service, labour, organizational and economic links. The concept of human mobility in its various forms has been put forward and crystallized wherein re-settlement, migration and commuting are regarded as a whole or processes complementary to and substituting one another. Proceeding from the given concepts and cognized empirical laws, the task is that of optimizing the entire system of supra-local links of various kinds.

The logic of scientifically set long-term directions with regard to the territorial distribution of the productive forces and development of a settlement network brings one to the following scheme: general principles in policy in this field — original schemes for future plans and projects for union republics and economic regions — more detailed schemes (projects) of comprehensive regional plans — general plans and projects for planning of individual towns, industrial, agricultural and resort areas and rural micro-regions, plans for social and economic development of towns and regions (all these being various forms of regional and urban planning worked out in the USSR, although to a certain extent not co-ordinated).

Special attention should be paid to raising effectiveness of regional plans, for only on this base it is possible to utilize the territory of the country for production and settlement. Planned regionalization of the whole country should be carried out; in each region *okrugs* and *okrug* centres should be identified in which large industrial enterprises, construction bases and tertiary establishments are to be located, taking into account utilization of labour and public services of the area. New industrial enterprises need to be built precisely in *okrug* centres in form of inter-sectoral 'industrial nodes' which are much more economical than individual location; in this case there is a saving both from the scheme of the industrial node and from this of the *okrug* centre. In formulating problems of urban distribution and development one should proceed, first and foremost, from the urban typology, i.e. from the fact that there is a number of specific types of settlements and of various solutions for towns of different types. In this context it is necessary to introduce into practice statistical inventory-making, territorial and regional planning, and a scientific method of structural, functional and hierarchic typology of urban places. The parameters of the rational size of towns of different types have to be determined.

In the case of rural settlement the following questions need to be further elaborated: formation of settlement systems within the framework of respective rural administrative regions, optimization of economic systems and the ways to change over from the existing forms of rural settlement to the future ones. Methods and criteria of evaluating both the economic and the social efficiency of concentrating the rural population should be carefully worked out.

In the governmental plan of the most important scientific research projects the following subjects, with regard to settlement problems, are to be carried out during the tenth five-year plan:

1. Forecasting the main directions in development of settlement systems within large regions.
2. Social and economic problems involved in management of settlement (scientific report on the socio-economic base and regionalization of settlement).
3. Scales and trends in migration.
4. Methodological problems of socio-economic development planning of large towns.

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5. Problems of socio-economic and demographic development of the country-side. These are the main trends in research of settlement in general.

Leading organizations dealing with this research are the Central Research Institute of Urban Planning (Moscow), the Centre for the Study of Population Problems, Moscow State University, the Institute of Sociological Research, USSR Academy of Sciences (Moscow), the Institute of Socio-Economic Problems, USSR Academy of Sciences (Leningrad), and the Institute of Economics and Organization of Industrial Production, Siberian Division of the USSR Academy of Sciences (Novosibirsk). Numerous other academic, higher educational and departmental scientific institutions are involved in this work. First and foremost, research works on the above mentioned subjects are to be better co-ordinated and "increasing interdisciplinary co-operation in the study of urbanization problems" is to be provided for (*Resheniya I i II Mezhvuzovskikh Nauchnikh Seminarov*..., p. 8). There is a need to create an interdepartmental scientific council to deal with problems of settlement and urbanization in the developed socialist society, under the auspices of the State Committee for Science and Technology of the USSR, Council of Ministers with the participation of the State Planning Committee, USSR, the State Committee for Construction, USSR, the USSR Academy of Sciences, and the Ministry of Higher Education. Only by joint, organized efforts can the science of socialist and communist distribution be successfully developed.

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BASIC ASPECTS OF SETTLEMENT STRUCTURE PLANNING IN THE GDR

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1. METHODOLOGICAL REMARKS

If settlement structure is to be planned, it must be incorporated into the system of management and planning for the national economy, as a comparatively stable and complex form of the spatial structure/organization of society and its reproduction. Certain relations exist both within settlements and between settlements belonging to individual categories, as regards the elements of the social reproduction process – population, and particularly labour potential, production facilities, infrastructure and natural resources. These relations can be measured in the form of proportions and must be considered in management and planning in order to make the process of social reproduction as efficient as possible. At the same time the ecological balance in the natural environment must be preserved. These proportions must be determined at central and regional level, so that the social functions of settlements can be defined within the framework of the settlement structure as a whole. They must be expressed in indices of management and planning and put into practice at central, regional and local levels of management and planning while keeping in mind the relation between the development of industrial branches and regional development. Since the above-mentioned proportions are complex factors which can be influenced over long periods only and vary considerably from region to region, a strategic policy must be worked out for the planning of settlement structures.

In defining this strategy, the target of building a mature socialist system must be borne in mind, and therefore there must be also a unified economic and social policy. In this connection, great attention should be paid to long-term studies and calculations. Findings from settlement structure studies will be incorporated in the materials compiled as a result, and in the approaches worked out. Such long-term work makes it possible to apply the results to planning. It is not by accident that long-term settlement structure planning at national level under the auspices of *Staatliche Plankommission* (National Planning Commission) is done by *Forschungsleitstelle für Territorialplanung* (Research Coordination Centre for Regional Planning). Similarly, at the level of the *Bezirk* (county) there is the *Büro für Territorialplannung* (Office of Regional Planning) which plays a prominent role in the long-term planning of settlement structure. These institutions in turn work closely together with the research establishments of academies, universities and technical colleges. Geography has become a major subject in this type of interdisciplinary research co-operation. As a result, the settlement structure aspect has been included in the domain

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of long-term planning at national and regional level, not least due to the impact of economic and geographical studies. The following factors are essential in determining the long-term development of the settlement structure:

– Government policy with regard to settlements, as it is implemented at national level, and at the level of the *Bezirk* and *Kreis* (district).

– Qualitative and quantitative findings with regard to settlement structure, arrived at in the course of long-term planning for the geographical distribution of the productive forces up to 1990. These include guidelines and regional balancing calculations for the capital, Berlin, and another 142 cities (all *Bezirk* cities, important industrial cities and almost all larger *Kreis* towns which are more or less Kreis centres as determined in settlement geography studies), and their hinterlands.

– The General Plan for the capital, Berlin, including its hinterland.

– General building construction plans which will be worked out in the course of time for the 142 cities on the basis of plans for their political, economic and social development.

– Guidelines and calculations regarding the long-term development of the remaining towns, primarily small towns and rural settlements, differentiating between individual settlement categories and specific potentials and requirements for regional development.

In connection with these central projects, plans for the development of settlement structures will be compiled at *Bezirk* and *Kreis* levels.

THE IMPLEMENTATION OF LONG-TERM PLANS AND GUIDELINES THROUGH MEDIUM-TERM AND SHORT-TERM ECONOMIC PLANNING

Long-term plans, targets, guidelines and calculations must be reflected in the five-year plan for a *Kreis*. The GDR has 28 urban districts (*Stadtkreise*), and these cover almost all cities with populations of more than 50 000. Long-term targets must also be incorporated in the annual economic plans for the communities where important aspects of the social infrastructure are planned by Council departments. This whole process naturally depends to a large extent on the distribution of financial investment. A longer-term and integrated approach is necessary for the latter, keeping in mind the relation between the development of branches of industry and regional development. A factor which must also be taken into consideration here is the use of labour potentials in the various branches of industry and the various regions. At the present time efforts are being made to find a more integrated and continuous approach to this planning procedure. The aim is to harmonize economic, social, construction, design and ecological aspects, and for this to be achieved interdisciplinary research must continue.

One specific problem results from the need to establish a connection between long-term studies and planning procedures at the various levels of planning and management. Settlement categories have proved to be methodical aids in this connection from a national, regional and local point of view. They cover groups of settlements having similar functions, infrastructures and sizes. These categories provide the basis for comparisons at national level, between counties and regions, and for informational calculations, the calculation of variants and rough balances, all of which precede the planning process as such. They can thus be used to improve the latter. Apart from the capital, Berlin, there are at the present time seven such settlement categories and seven sub-categories. Work is continuing to identify the latter more clearly. Deficiencies have been noted in this context with regard both to quantitative aspects and also to regional differentiation. However, it must be stressed that no other research project dealing with settlement structures has as yet reached a stage where

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its findings may be applied directly to settlement structure planning, and they can thus not be used to improve planning practice.

In this connection geography may greatly contribute to further research on settlement structure. Three main areas may be mentioned where more detailed studies should provide decision-making aids for settlement structure planning:

– More detailed studies into the division of functions between settlements at different regional levels.

– Investigations of the regional differentiation of settlement structure development bearing in mind factors whose influence varies regionally.

– The study of settlement regions, for example in terms of regional and local settlement systems.

This means that geographic research can make substantial contributions towards integrating settlement structure into national economic planning and management, in the wider context of planning economic and social processes.

2. THE MAIN DIRECTIONS OF SETTLEMENT STRUCTURE PLANNING IN THE GDR

One essential element in the long-term strategy for the geographical distribution of productive forces is that the targets pursued in the further building of a mature socialist system apply to all parts of the country. This principle is not, however, sufficient in itself but calls for long-term regional planning and strategies. A major trend in this context will be the regional concentration of productive forces and the conditions for their development. However, theories which see regional concentration as an aim in itself must be clearly rejected. Rather, the object is to raise the efficiency and output of material producton, to improve the entire process of social development, and to increase living standards through integrated economic and social policies. This is the purpose of the ongoing division of labour in society and, therefore, between regions. This also involves a higher degree of integration, and the two aspects are clearly reflected in the concept of regional concentration. In this process, two elements can be identified in the opinion of the author. These are objective in character, they are interrelated and can be subjectively controlled through management and planning:

– The economic element which arises from the advantages inherent in concentration and combination as a way of extending and intensifying development of works, branches of industry and areas of material production, and fields outside it.

– The social element which results from a desire of parts of the population and especially younger people who are being trained or who are working, to make use of a wider range of job opportunities, better facilities for training and advanced training and for satisfying other material and cultural needs, and to live comfortably in modern conditions in the locations where regional concentration takes place.

The qualitative and, in some respect quantitative development of the cities according to plan reflects their growing political, economic and social role as centres of the working class, as nuclei for the regional concentration-of people and particularly labour potentials, and as centres of concentration for production, scientific establishments and infrastructure. With their hinterland functions cities help to improve working and living conditions not only for their own inhabitants but also for the people living in the rural settlements around them. In this connection great importance must be attached to planning the relations between city and hinterland. For these relations to be incorporated in the process of planning, the many results provided by geographic research must be evaluated and better interpreted so that a more integrated approach is possible.

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The following two criteria apply in determining the extent to which cities, or their populations, may grow quantitatively:

– The development of political, economic, social and cultural functions, and especially the productive function of the cities, as required by society as a whole and depending on the resources available from the national economy.

– The development of population potential in city catchment areas and of that provided by supraregional migration, particularly by way of vocational training. The situation should be that the necessary labour is not withdrawn from jobs in production and the infrastructure outside the cities when people migrate from rural areas to the cities.

Here, too, it is obvious that city development cannot be separated from regional aspects, and this is substantiated by the results of research also in the field of geography.

The decisive criterion for population growth in the cities, therefore, is the use of labour potentials at certain sites, as required by the national economy and as made possible by regional conditions. This means that the populations in many cities will be growing, due to the more intensive use which is to be made of the highly productive basic funds of existing production facilities, and as a result of the extensive development of some industries including those providing domestic raw materials and energy. It has been planned for the period until 1990 that the natural increase in labour potential will mostly be, utilized in the capital, Berlin, and the other 142 cities.

At the present time almost 50% of the population of the GDR (48.5%) live in these selected cities, and regional balancing by the Bezirk Planning Commissions, and coordination with the National Planning Commission, has resulted in a slight increase as planned averaging just over 10% for these locations, when the period from 1960–1975 and from 1976–1990 are compared. However, there will be marked regional differences, depending on the existing degree of urbanization and the available resources. Over the period from 1960–1975 the 142 cities had a population growth of 8.4%, and the projected increase is to occur within the following economic and demographic framework:

– It can be assumed that over the period 1976–1990 the same slight decrease in the population of the GDR will be experienced as between 1960 and 1975.

– The reduction in the number of people employed in agriculture will be much less drastic between 1976 and 1990 than over the period from 1960–1975.

– The projected decrease in the number of people living in small towns and rural settlements is larger than for the period between 1960 and 1975.

– The overall growth in the available labour potential will be somewhat greater than between 1960 and 1975.

– There will be a somewhat lower increase in the number of those to be employed in industry, but concepts have been developed for a slightly stepped-up expansion of industry.

– Housing construction is to expand over the period 1976–1990.

In view of the continued trend of population development, the higher growth in the available labour potential and in the number of households, and in view of intensified housing construction to solve the housing problem (as a social phenomenon), a slightly higher concentration of people in the cities may be expected.

On the other hand, the following factors make a process of higher concentration appear problematic:

– the policy of intensification throughout the national economy, which aims at making the most efficient use of existing workplaces, primarily through rationalization;

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– the much reduced need for withdrawing labour from agriculture, compared with the period 1960–1975; and

– the negative effects that must be expected on the age and social structure of the population in regions, cities and rural settlements suffering continued migration losses which are to be even higher than those between 1960 and 1975.

Thus the role of migration for the process of differentiation in settlement structures will be still greater, both as regards the growth of some cities and the decrease in the population of many small settlements. Under the conditions prevailing in the GDR migration has had a considerable effect in the past, and this is continuing into the future.

What is involved is not so much the quantity or absolute volume of migration, but its impact on the process of differentiation in settlement structures, and this is becoming greater in comparison with the time between 1960 and 1975.

In this connection marked regional differences can be found as regards the trends of, and potential for, development in the industrial agglomerations in the areas of Karl-Marx-Stadt, Leipzig, Dresden and Halle on the one hand, and the areas with a stronger agrarian structure on the other. Particularly unfavourable demographic conditions with regard to the patterns of development of the labour potential and population required by the national economy have resulted in the case of the majority of the industrial centres in the south of the country from a natural decrease in the population and continuous supra-regional migration losses. It must be assumed that these factors will largely continue during the period of up to 1990. Their impact with regard to natural population trends is mostly predetermined by the age structure. In other words, there will be fewer people of working and child-bearing age in these areas after 1985. With regard to supra-regional migration losses this negative trend can only be reversed step by step through long-term integrated plans for an improvement of working and living conditions. With the exception of the Halle *Bezirk* the growth of the selected cities in these regions has been forecast to be below the national average until 1990.

Already over the period 1964–1975 the cities in the agglomerations had a below-average population growth. At this point the problem arises that the population decrease is greatest in the small towns and rural settlements of the agglomerations in the south. This trend which emerged between 1960 and 1975 has been calculated to increase in the future. This leads to a number of questions regarding the demographic and socio-political consequences of the phenomenon (see also: H. Kowalke and others, this volume).

Appart grom the deterioration of the demographic situation which has also occurred in the northern areas of the GDR which have a primarily agrarian structure, these areas are particularly affected by the extremely high degree of fragmentation in the settlement network. This creates obstacles for the implementation of the country's integrated economic and social policies. As far as the demographic situation is concerned, fertility rates in the north are now getting close to the national average, which means that an above-average decrease has occurred. Furthermore above-average relative migration losses have been observed for parts of the northern areas/in this respect the Neubrandenburg *Bezirk* leads the others by a wide margin; see also A. v. Känel, this volume. The economic prospects for gradually overcoming the fragmentation of the settlement network by concentrating on settlement centres and abandoning very small settlements which do not offer satisfactory living conditions are limited for the period until 1990.

More research and planning is needed in the light of the existing settlement structure problems which differ from region to region, so that decision-making suggestions can be worked out which promote regional development when incorporated into long-term planning, and five-year and annual economic plans.

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SELECTED ASPECTS OF THE INTERNAL ORGANIZATION OF A SETTLEMENT SYSTEM

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In the structure and/or interdisciplinary design of different subsystems of the socio-economic space we can see the entirely marked position of the settlement subsystem. Its organization is certainly affected by the arrangement of the settlement structure in a narrow sense, i.e. the structure of settlements (i.e. their size, functions, etc.). But this primary basis does not play such a decisive part in the settlement subsystem as does, for instance, the structure and dislocation of industry in the industral subsystem or the characteristics of the production types, subtypes, etc., in the subsystem of agriculture. The settlement subsystem as the territorially most universal component of the socio-economic space is modelled relatively strongly by processes originating in the structure of industry, services, agriclture, etc., and has retroactive modifying effects on these 'more specialized' subsystems. The study of settlement must therefore necessarily deal even with questions of the geography of transport, recreation, industry, agriculture, etc.; and the present paper was compiled taking account of this fact.

Still, it is concerned with some questions referring directly or indirectly to the settlement subsystem; the region and the hinterland of the town of Brno and in some cases even the whole territory of the Czech Socialist Republic were chosen to demonstrate the conclusions.

THE SYSTEM ELEMENTS OF THE INTERNAL INTERRELATIONS OF SETTLEMENT STRUCTURE[1]

Internal relations in the settlement structure are mutually linked by the time-space; they interpenetrate and affect each other. Their complex is of a system structure; an interference with one type of interrelations manifests itself by various consequences in the other types.

The inter-settlement relations of a generally cooperative character are defined essentially by:

1. commuting to work,
2. movements of the population to service facilities,

[1] The section in based on a paper by Jan Bína.

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3. movement for recreation purposes,
4. economic co-operation.

It is typical that the majority of relations manifest themselves by the movement of population which is the common denominator of various socio-economic processes.

The realization of interrelations in the settlement structure is a factor in the development of economic-geographical regions and the hierarchy of regional systems. From this point of view the relations in question can be divided into:

a) linkages and flows proceeding from a greater number of settlements towards a reduced number of centres,

b) linkages characterized by spatial dispersion.

The first type is represented by commuting to work and the movement of population to service facilities. The direction of the inter-settlement movements to service facilities is almost exclusively up the city-size hierarchy; trips to places of lower order than the community of residence are negligible and conditioned perhaps only by the specific aspects of the quality of services supplied, by the distribution of local handicraft, etc. But the verticality of the movements is much more frequently manifested by the direct influence of the centre of higher order even in those activities where satisfaction of demand is possible by a centre of lower level.

Commuting to work affects a smaller group of inhabitants when compared with the number of persons travelling – although occasionally – to service facilities, but displays a much higher and more regular periodicity and a high degree of compactness over space. Connections between those processes (e.g., shopping by commuters to work in their workplace) should be considered too. Commuting to work, due to its constraining character, is a controlling factor in this respect. For these reasons it should be evaluated as an important regional process integrating the centres with their hinterlands.

As opposed to the trips to service facilities the nodality in the commuting to work patterns is more pronounced even though here too a major share of destinations is accounted for by regional centres and by urban places in general. There are cases of single-activity centres situated near better equipped urban places, the former forming a functional unity with the latter. Good examples are: Sezimovo Usti near Tabor, Hrusovany near Židlochovice, Straz nad Nisou near Liberec, etc.

Due to a wider spectrum of job opportunities available, the commuting to work to urban centres is usually well-balanced as to industrial branches. This is an example of the effects of the concentration of service facilities and their attractive power. The share of persons employed in industry among in-commuters and/or out-commuters can be used for documentation in the present discussion. For 274 communities in the Brno region out of which at least 10 inhabitants commute to work to the city of Brno, there are only 16 communities (5.8%) in which out-commuting to Brno industry is represented by 67% trip origins or more; for the remaining destinations the respective share is represented in the case of 128 communities out of the total of 281, i.e. 45.6% (J. Bína, 1976). In the district of Gottwaldov 14, 989 persons were commuting to the city of Gottwaldov (of this number 9437 to industry – 63.0%), while to other centres respectively 6142 and 4429, i.e. 72.1%. A difference of almost 10 points appears even here in spite of the strongly industrial character of the district centre. A similar situation occurs in a district with less industrialized hinterland – České Budejovice. In České Budejovice 45.6% of all in-commuters are employed in industry, in the other centres their share reaches 57.1%. As could be expected the respective values are still greater in regions with a greater dispersion of industry, e.g., in the district of Liberec the proportions being for the town of Liberec 42.3%, for other destinations 70.3%.

A new feature in the commuting to work is the increase of the movements in both directions between towns (Macka, Králová, 1977). Larger towns are sometimes

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'passive' in this exchange not only of employees in industry but of all economically active persons participating in commuting. The town of Blansko is, for example, included in the commuting zone of Adamov (out-commuting from Blansko to Adamov involves 813 economically active persons, vice versa 70 persons, i.e. 11.6 times less). There are several examples of such pairs with an unfavourable ratio for the place of higher order, such as Olomouc-Lutín (1:10.3), Praha-Vodochody (1:8.4), Pardubice-Semtin (1:9.1).

A different type of relationships between individual settlements and urban places is displayed by the movements related to relation and economic co-operation. Within this category, the tourist traffic is characterized by specific nodality-orientation towards settlements with tourist attrations, such as famous castles, caves, etc. But due to a seasonality of this type of movement and its low periodicity in the human activity patterns, a greater significance in the system of inter-settlement relationships should be attributed to the relatively regular journeys, mainly by the inhabitants of larger towns, for the purpose of recreation in a more narrow sense.

According to the Research Institute of Construction and Architecture about 15–20% of the inhabitants in towns with 10 000 inhabitants, 30–35% in those with 50 000 inhabitants, and 40–45% in cities of over 100 000 inhabitants tend tu leave the towns for week-end recreation. The significance of this phenomenon in the region of Brno is described by J. Vystoupil later in this paper. Thus the movement from towns for recreation has become equivalent in numbers to the in-commuting to towns from their regions (in 1970 the total share of persons commuting to work among economically active population was 37.7% in the Czechoslovak Socialist Republic).

The recreational trips have not been investigated in detail so far but the territorial interrelations can be derived with certain accuracy from the distribution of cottages and summer houses, whose number in the CSSR was 166 000 in 1971.

A characteristic feature of development is the increase of the area in which the recreation facilities of the inhabitants of the respective town are situated. Whereas, for example, around 1945 the week-end recreation zone of Praha covered mainly the region of the lower Sázava River, the region of the Vltava River and the forests of the Brdy Mts., at present the recreational establishments of the inhabitants of Praha are spread over the whole Bohemia. The concentration is of course still substantial owing to the pattern of summer-houses (in contradistinction to the recent use of cottages). For instance, of all privatly-owned units in the South-Moravian Region (24 946 in 1971) 10 877 units, i.e. 43.6% were situated directly on the territory of the city and the district of Brno.

Economic (i.e. inter-industry) linkages differ essentially from other regional processes conditioned by the movements of population. The incomparably higher internal diversity and the "qualitative" character of industrial linkages are very expressive. A quantitative description (e.g., integration by 50%, etc.) is not sufficient here with respect to the unique functions of all partial raw materials, fuel and/or semi-finished articles – if they do not occur in proximity they must be transported over a greater distance. For most industrial branches such flows do not manifest themselves as region-forming elements; in fact, they cover the whole territory of the CSSR, extend even beyond the state frontiers and are mostly conditioned by other than regionally-integrating factor (J. Mares, 1973). Of course, the regional significance is greater in the case of food processing and wood-working industries, i.e. of branches utilizing raw materials occurring in proximity to manufacting units.

On the other hand, the organizational linkages in agricultural production have become in recent years a still more important region-forming element of the rural space. The production base of non-urban settlements is significantly affected at the present time by its situation in territorial co-operation groups (the main role being

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successively shifted to agricultural co-operation districts with an average size of about 30 000 hectares of agricultural land). An important task from this viewpoint is the integration of the territorial-administrative organization with the interests of local agricultural co-operation. A common element in the two processes is that larger settlements, with better infrastructure are becoming centers of new large-scale agricultural complexes.

It is necessary to mention an essential general feature of the development of inter-settlement linkages in the after-war period. It is the expansion of interconnections to the lowest links in the internal structure of industrial and even non-productive (e.g., commercial) enterprises. A production-organization unit – national enterprise and/or factory – often consists of branch plants located in different settlements. As opposed to a greater autonomy of former smaller private enterprises the interconnection among the plant units within the national enterprises, and accordingly among settlements, have been growing markedly.

On the example of the Brno region an overlap of the commuting zones can be clearly observed. For the metropolitan ring in-commuting is five times greater compared with out-commuting if trips to the core are excluded (out-commuting twice as high as in-commuting). For the whole agglomeration we receive a balanced pattern of flows, the in-commuting representing less than 3% in relation to the total journey to work within the area.

Interrelations between journey to work and to services manifests itself also quite distinctly in the region investigated. They can be traced in the changes of the structure of in-commuting and in the composition of the retail turn – over per one inhabitant in the communities situated near the metropolitan centre. For instance, even in urban communities within the agglomeration this turnover is lower by 1% than in the rural communities of the broad hinterland of Brno.

For investigations of the interrelations in the settlement structure the conditions in the hinterland of the metropolis are simpler in the sense that the integration with a strong nucleus obscures to a certain extent the heterogeneity of the interrelations. More attention will be devoted to those questions in our further research.

NEW PHENOMENA IN COMMUTING-TO-WORK AND IN THE SETTLEMENT SYSTEM[2]

The development of Czechoslovak society in the past decade, mainly in the period of the 4th and 5th five-year plans have resulted in significant qualitative changes of the different social and economic phenomena. The commuting to work and its various qualitative changes are treated here from this perspective.

The most striking phenomenon of the period between the censuses of 1961 and 1970 is further concentration of the population in urban places connected with a significant absolute decrease of population of all size groups of communities below 2000–5000 inhabitants. During this period the urban population in communities with more than 5000 inhabitants increased in the ČSSR by 20.5%, of that in the Czech Republik by 16.4% and in the Slovac Republic by 35.2%. On the whole a population decrease occurred in places smaller than those of 2000–5000 inhabitants both in the ČSSR and in the ČSR (see Tables 1 and 2).

The extensive process of the concentration of population in towns was made possible by accelerating housing construction within the frame of which altogether 614 000 of apartments were made available for use. Of that number the major part was accounted for by urban areas, similarly as in the foregoing five-year plan.

[2] The section is based on a paper by Miroslav Macka.

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TABLE 1. Number of population in 1970 as per cent of 1961

Size groups of towns (,000)	ČSSR	ČSR	SSR
up to 0.2	75.7	74.3	88.1
0.2– 0.5	87.4	85.8	92.4
0.5– 1.0	95.4	95.3	95.4
1.0– 2.0	95.8	92.8	99.8
2.0– 5.0	95.3	92.0	100.0
5.0– 10.0	101.0	102.6	97.6
10.0– 20.0	116.1	114.9	118.8
20.0– 50.0	127.1	105.3	192.4
50.0–100.0	168.0	185.4	64.0*
100.0 and above	117.4	108.9	177.2
Total	104.5	102.5	108.8

* The anomaly in the SSR in the category of towns with 50 000–100 000 inhabitants is due to the shift of the town of Kosice into the category of large towns

Mass transport to work was also improved considerably; here further shift in favour of bus transport took place. The frequency and number of connections increased. Furthermore, the utilization of the private means of transport for trips to work emerged as a new phenomenon in travel to work, although it is still seasonal and of a secondary importance.

What was the effect of the increased number of urban population in the commuting to work patterns? Conceptually, the concentration of economically active population in towns is simultaneously a precondition for the decrease of commuting to work whose main components are rural-to-urban trips.

The observed patterns of commuting to work developed in the years 1961–1970 in the following way: In 1961 altogether 2 351 240 persons were commuting to work in the CSSR, of that number 1 644 977 in the ČSR and 706 293 in the SSR. In 1970 altogether 2 630 274 persons were commuting to work which means an increase by 11.9%. In the CSR 1 769 102 persons (increase by 7.5%) and in the SSR 861 172 persons (increase by 21.9%) were commuting to work in the year mentioned.

A certain increase of commuting is undisputably the result of structural changes. Above all they include the further decline of agricultural population and the successive concentration of the production in larger centres and the expansion of the sphere of services in those centres. But, if the state is analysed in a greater detail the increase can only be partly explained in terms of the existing level of urbanization and population concentration, from the point of view of the core-hinterland relationship.

The first significant change which took place in the period investigated is the concentration of commuting to work in the vicinities of commuting-destination centres. The concentration has two aspects. First of all, a long-distance commuting, representing simultaneously above all the non-everyday travel has decreased distinctly in the period investigated. This applies, for example, to commuting between the two republics; there has been an especially distinct decrease of commuting to work from the Slovak Socialist Republic to the Czech Socialist Republic, namely from 88 000 persons in 1961 to 48 000 in 1970. This is due to the fact that in most Slovak districts the relationship between labour resources and the number of job

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TABLE 2. Number of population in 1961 and 1970

Size groups of towns (,000)	ČSSR		ČSR		SSR		ČSSR		ČSR		SSR	
	number	%	number	%	number	%	number	%	number	%	number	%
	1961						1970					
up to 0.2	314 219	2.3	282 014	2.9	32 205	0.8	237 925	1.7	209 538	2.1	28 387	0.6
0.2– 0.5	1 415 646	10.3	1 084 196	11.3	331 450	7.9	1 237 047	8.6	930 709	9.5	306 338	6.8
0.5– 1.0	2 037 460	14.8	1 309 997	13.7	727 463	17.4	1 943 154	13.5	1 248 950	12.7	694 204	15.3
1.0– 2.0	2 073 536	15.1	1 162 774	12.1	910 762	21.8	1 987 401	13.8	1 078 739	11.0	908 662	20.0
2.0– 5.0	2 253 234	16.4	1 322 351	13.8	930 883	22.3	2 147 498	15.0	1 216 503	12.4	930 995	20.5
5.0– 10.0	1 182 057	8.6	799 221	8.4	382 836	9.2	1 193 972	8.3	820 134	8.4	373 838	8.2
10.0– 20.0	991 981	7.2	701 883	7.3	290 098	7.0	1 151 249	8.0	806 561	8.2	344 688	7.6
20.0– 50.0	989 671	7.2	742 470	7.8	247 201	5.9	1 257 530	8.8	781 908	8.0	475 622	10.5
50.0–100.0	554 932	4.0	475 580	5.0	79 352	1.9	932 432	6.5	881 640	9.0	50 792	1.1
100.0 and above	1 932 841	14.1	1 691 045	17.7	241 796	5.8	2 269 349	15.8	1 840 783	18.7	428 566	9.4
Total	13 745 577	100.0	9 571 531	100.0	4 174 046	100.0	14 357 557	100.0	9 815 465	100.0	4 542 092	100.0

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opportunities improved in the period investigated. The greatest part of the commuting is accounted for by the North-Moravian Region (mining, metallurgy) which attracts 36.8% of all in-commuters from the Slovak Socialist Republic travelling to the Czech Socialist Republic. But even the relatively very dispersed and professionally differentiated commuting from the CSR to the SSR decreased from 6100 to 5000 persons.

The concentration process manifests itself naturally even in the case of distant (i.e. irrational) daily commuting to work. The data for one of the most significant regions of the CSR, i.e. the South-Moravian Region, can be given as an example. If the decrease of out-commuting from this region to other regions of the CSR is valuated, it appears to have decreased to 66.2% in the course of the period under investigation. It is therefore possible to talk about a general increase of the concentration of commuting to work.

From the viewpoint of the theory of the nodal region another question has arisen in connection with the facts mentioned above. The question was to find out if and to what extent the commuting sheds of regions of different centres were stabilized; this phenomenon should have manifested itself prevailingly by stronger relationships among the individual hinterlands and centres. But on the other hand, we had to take into account the fact that the process of concentration has not yet finished and in such a case extensive shifts between the zones of influence of different centres could exist.

It was found that the changes which occurred in the decade under study were immense (Macka and Kralova, 1977). From the total number of 7511 communities in the CSR the reorientation of linkages were registered in the case of 2013 communities, i.e. 26.8% of all communities in the ČSR. The changes were investigated in both directions, i.e. the number of communities added to the regions of individual centres and the number of those lost in favour of another region. Positive changes were registered for 1260 communities, i.e. 62.6%, and negative for 753 communities, i.e. 37.4%. It can be said in general that the changes manifest themselves locally and regionally with different intensity.

Main changes take accordingly place in the border areas of the regions of commuting; towards the centres the increase of the concentration of commuting prevails in general. This means that the process of the regional stabilization of commuting to work has proceeded successfully. The state of commuting in 1961 reflects the great boom of the industrialization of the ČSR in the fifties, the following decade being a period of consolidation of the core-hinterland relationships: it can be concluded from the trends registered so far that the process of consolidation has already achieved a high level.

But it would be difficult to explain the absolute increase of commuting only on the basis of structural changes, since the consolidation process mentioned above is not related directly to this phenomenon. This is why an analysis of the movement of commuters was carried out according to the size categories of communities. In spite of the fact that the research was limited in the first phase to one of the regions of the ČSR, the South-Moravian Region, since it is the largest and most populous region, we arrived at similar conclusions for the whole territory of the CSR. It was established that of the absolute increase of in-commuting the decisive source is no longer the core-hinterland relationship but the links between centres of various levels grouped into regional complexes. While commuting in the ČSR increased by 7.5% and the urban population by 16.4%, the inter-urban commuting increased by 24% in the same period.

It follows from the facts alluded to above that the new (and from the viewpoint of the settlement system decisive) factors in commuting in the CSR and also CSSR have become the relationships between regional groups of urban places which are

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becoming still more intensely interlinked in the territorial distribution of work. It also means that a higher degree of the manifestation of this principal and dynamic factor of the settlement structure takes place. The core-hinterland interrelationships are nested within the patterns of relationships between the centres in intensively interlinked regions of higher type.

From the viewpoint of the further development, both of the settlement structure of the CSR and that of the ČSSR. it is accordingly possible to project and plan the dislocation of the new housing stock by core-hinterland breakdown. It appears that the so-called stabilization of commuting to work must be planned in the sphere of housing construction not only with respect to the share of the housing stock by core-hinterland division, but even more necessarily with respect to core-to-core relations.

INDUSTRIAL NODE, THE ECONOMIC BASE OF AN URBANIZED REGION[3]

The growth of industrial production in recent years resulted in many countries in essential economic changes. They manifested themselves both in the economics of those countries and in their regional structure. Within individual regions the hitherto existing industrial centres have expanded, their branch structure was enriched, and new individual centres emerged in formerly less developed regions. The density of industrial centres increased considerably. Production linkages developed, and the contacts between the centres and their hinterlands were intensified.

This process resulted in a successive integration of originally isolated industrial centres into larger regional complexes, sometimes labelled as industrial nodes (Maiergoiz 1964; Kovalska et al. 1972). The industrial node is an agglomeration of several industrial centres, based on interrelations following from industrial production processes. In the simplest case, for instance in a weakly industrialized territory with a low density of industrial centres, even a single industrial centre with a developed branch structure can be considered a node (Ivanička 1971). But basically, it is a group of industrial communities located within a given territory.

There are many relationships between industrial centres, including customer--supplier relationships, the technological interrelations and a mutual exchange of labour between individual centres (i.e. commuting to work). The identification of relationships is rather difficult and this is why the methods used in grouping of industrial centres are rarely formalized.

A review of methods applied has shown that they are unsuitable for a detailed study of the industrial nodes in the CSR and, obviously, in other industrial countries with a high density of industrial centres and with the dominance of processing industry. Generalizations are mainly achieved by the use of simple methods, based not so much on concrete territorial relationships as on various indirect criteria (Korcak 1960; Leszczycki 1961; Secomski 1962; Strida 1964, 1969; Kawalec 1965; Blažek 1965, Misztal 1970, Mládek 1972; Bolek and Steinbach 1975, etc.). But neither the method of co-operation and technological linkages (e.g., Chardonnet 1953; Kolosovsky 1974) could be applied since, owing to the large number of centres and their developed branch structure, the relationships are directed at many centres all over the country and do extend over long distances, beyond city hinterlands. Only the small and less important local centres (with dairies, sugar factories, brickworks, etc.) obtain the raw materials and deliver their products within the nearest environments. The decisive part of large industrial centres co-operate with industrial plants over the whole territory of the CSSR. Various technological linkages such as common

[3] The section is based on a paper by Jaroslav Mares.

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power facilities, water mains, gas lines, casting houses, sidings, etc., connect on the contrary only industrial works inside individual centres and do not extend over greater distances.

The links between industrial centres can be demonstrated relatively reliably by referring to another production factor, i.e. labour. For instance, in the CSR more than one half of industrial labour are commuting to work. In the course of the analysis of industrial commuting to work it appeared that a great part of the total number of in-commuters to industry, in average more than 40%, but in some regions more than one half of the total number commute between industrial centres, while the remaining part travel from non-industrial to industrial communities. It means that the inter-centre flows of labour are considerable in the Czech industry, well represent the relationships between industrial centres and can serve as an indicator of the existence of industrial nodes.

Thus, in the analysis of the structure of industrial nodes of the CSR commuting to industry between industrial localities was used as one of the measures (Mares 1969, 1973, 1975). Data on inter-centre movement to industry were collected for all industrial localities in the ČSR.

The intensity of the inter-centre movement was measured as the quotient of the inter-centre flows MP and the sum of industrial job opportunities of both localities investigated. It was expressed by the following formula:

$$I_{ab} = \frac{MP_{ab}}{P_a + P_b} 100,$$

where I_{ab} is the intensity of the movement between the localities A and B, MP_{ab} is the inter-centre movement to work between the localities A and B, P_a is the number of job opportunities in industry in the locality A, P_b the number of job opportunities in the locality B.

On the basis of the frequency of the values obtained the threshold value for the integration of industrial localities into nodes was established. Namely, the movement between two localities in the node had to involve at least 100 workers its intensity being at least 1% of the job opportunities of both places.

In the case of the cities of Praha and Brno the intensity of the inter-centre movement between those towns and some places situated in their hinterlands did not reach the limit of 1% in spite of the fact that the inter-centre movement was very substantial. This was caused by the considerable weight of the job opportunities of Praha and Brno in the formula. In such cases those industrial places were considered elements of a node whose intercentre movement was greater than 500 workers without any respect being paid to the second of the two intensity criteria.

For those communities which are connected with industrial centres by municipal transport commuting has not been investigated. These industrial communities were automatically affiliated to the centres and municipal transport was considered a sufficient measure of connection between the two places.

On the basis of commuting to industrial jobs it was possible to determine the distribution of industrial nodes on the territory of the ČSR (Mares 1976). The results of the analysis are significant in many respects and have distinctly a more general validity.

First, the high intensity of interrelations between industrial places was proved. Industrial nodes account for most of the industrial localities in the ČSR including all significant centres. Apart from two exceptions (the towns of Pelhrimov and Humpolec) the total of 711 centres, each having more than 3000 workers are clustered into 81 industrial nodes. The nodes account for more than 88% of all workers and 90% of the production of the Czech industry were concentrated.

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The industrial nodes can be divided into 6 types according to size, spatial arrangement and orientation of production. A group of 11 largest nodes forming the cores of our most significant economic regions is outstanding as to extent, number of constituent industrial centres and the complicated inter-centre relationships. Their employment is generally over 50 000 persons. To this grup belong the following nodes: Praha, Ostrava, Brno, Usti n. L., Plzen, Gottwaldov, Liberec, Olomouc, Pardubice-Hradec Králové, Sokolov and Náchod.

The second type is formed of a group of 19 morphologically well developed nodes of medium size. They consist of several significant industrial centres and a number of secondary industrial localities grouped around them. They have about 10 000 to 30 000 industrial jobs. Typical for this group are the nodes of Kolin, Prerov or Mladá Boleslav.

The third group represents a type of nodes consisting only of several large centres without secondary centres. Ten nodes representing this type employ about 2500 to 8000 workers in industry (for instance Havlickův Brod, Vyskov).

The fourth type accounts for 13 single nodes, in which one centre dominates over several, considerably smaller industrial communities. They are very different as to size (České Budějovice, Jihlava, but even Turnov or Jesenik). The last two types are insufficiently developed nodes. They consist always only of two industrial communities, sometimes of comparable size.

The diversity of individual types and the high concentration of large industrial centres in the nodes prove that at the present time in the CSR isolated individual industrial cores practically do not exist any more, that a characteristic feature of the dislocation of Czech industry are territorial agglomerations, the so-called industrial nodes.

The formation and development of industrial nodes is not only of a scientific but also of an economic significance. In the exchange of qualified labour between different places within the node a new type of agglomeration economies originates.

A typical example of agglomeration economies is the relationship of the towns of Unicov and Šternberk in the node of Olomouc. The industry in both towns developed as late as after 1945. Over a relatively great distance of over 20 km more than 500 persons are commuting to industry every day. In commuting to Šternberk women prevail, in that from Šternberk to Unicov mostly men are commuting. This is connected with the orientation of the industry in both places and the dependent qualification structure of labour. While in Unicov more than 3/4 of men are employed in the production of machines and equipment, 2/3 of them working in the fifth and higher qualification category of the state catalogue of work, in Sternberk the employment of women prevails, only 1/5 of them attaining the fifth and higher qualification categories.

Agglomeration economies resulting from the inter-centre exchange mentioned include those accrued due to a higher utilization of labour force, those in housing construction and the construction of civil facilities, as well as those resulting from a better utilization of infrastructure. Agglomeration economies are indisputably a benefit for the industrial works in both places. On the territory of the CSR several similar cases can be quoted. Purposeful planning of agglomeration economies, deliberate control and regulation of the development of industrial nodes is one of the ways of increasing the social efficiency of resource utilization and, simultaneously, the social productivity of work.

To conclude, industrial nodes are the economic base of our urbanized territories. Studies on economic-geographical regionalization have shown (Blazek 1977) that urbanized regions delimited according to different and more complex criteria than those referring to the notion of industrial nodes are dislocated around the main industrial nodes – those of the first type, as identified in the present section.

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Intensive urbanization processes are expected to characterize also the territory of lower-order types of industrial nodes, mainly the second and the third type, though to a smaller extent. The application of the concept of industrial nodes in planning is therefore important and purposeful not only from the point of view of a higher quality of the regional structure of industry, but also of a rational development of the settlement network.

MIGRATION AS A FACTOR OF URBANIZATION[4]

Migration as a manifestation of spatial mobility occupies a significant place in the socio-economic system. It is a factor of change in the settlement structure, in the changing distribution of the population, hence it plays a significant part in the process of urbanization.

Predictions on changing population distribution are closely linked with the knowledge of the process of geographical mobility. The latter manifests itself in the commuting to work (an oscillating motion) and migration (a simple motion). Both phenomena are focussed on urban centres. The role of both types of motion is affected by the distribution and economic significance of industrial centres and centres of tertiary sector.

Geographical mobility predictions are quite difficult. One of the principal reasons is the insufficient knowledge of laws governing the population movements which relate not only to the socio-economic and political situation in a given region but also to social development conditioned by the subjective points of view of an individual or a group of people. A problem in the establishment of the rules of migration is their incomplete statistical investigation. Migrations were recorded only on district scale (migration streams between the districts) up to 1971. Migration by smaller territorial units has not been registered before 1971, data on directions being not available at all.

The importance of the knowledge of factors governing the migration movements prompted efforts to study migration streams. This extensive work was carried out between 1963–1964 and 1971–1973. On the basis of the results the absolute migration size and migration streams for any centre or community could be established. The difficulties of processing the migration data are due to administrative changes carried out in various periods. The administrative shifts in the town of Brno of 1971 resulted, for instance, in a population increase by 7000 persons and a migration increase by 300 persons in the course of one year.

The investigation of migration streams can be carried out in several ways: a) according to the smallest territorial units – the communities, b) according to larger units (districts) with respect to the distance of migration, c) study of the migration between the different centres either of equal significance, closest centres or among all selected centres.

But for prediction purposes the migrations should be analyzed in their whole extent – in all elements of the socio-economic sphere and the reasons proper of migrations must be taken into consideration.

The evaluation of migration flows to centres according to districts and distance shows that greatest attraction is displayed by the communities proper within a district and those of neighbouring districts (without respect to the region), followed by other districts of the same region, the districts of the other Czech regions and/or the Slovak regions. Migration between towns or different important economic centres confirms the mutual attraction of centres of equal or similar economic significance.

[4] The section is based on a paper by Bozena Novakova.

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But a certain part is played here also by the hierarchy of centres and distance between them.

Investigations of migration according to the smallest units – the communities – enable us not only to delimit the immigration hinterlands of individual towns but also to contribute to the delimitation of urbanized territories. From the analyses carried out so far it appears that the core of the immigration hinterland does not change and that the intensity of the movement decreases slightly with distance. In the core migration conforms with commuting to work, in a more distant territory differences occur. It was established further that in the later of the two periods studied regions were more compact, which is probably due to the longer time interval investigated. This fact justifies the conclusion that in studying migrations one-year and two-year time-periods are not suitable; at least five-year periods should be used. The periods selected (with almost 10 years intervals) were expected to replace a many years' time series in the study of migration.

In delimiting the hinterland of individual towns an overlap of the influence of different centres must necessarily be considered, the fact due to the high density of the urban network in the ČSR. The overlapping zones must be carefully studied since in the course of development no other than these regions will be the decisive factor in the formation of settlement structure. The extent of attraction zones and the power of migration opportunities of individual towns can be established by means of gravitation models. In establishing the boundaries of migration regions the following values were used:

a) absolute (size of migration),
b) relative (number of migrants to the centre from the community in % of all emigrants from the community), and
c) intensity (size of migration to the centre from the community – by 1000 inhabitants of the community).

This last factor correlates to a certain extent with the density of population. On the basis of these three indices and a suitably selected scale it was found out that in the case of towns with 50 000 inhabitants the area of the hinterland overlaps basically only in the low-values intervals.

Migration investigation cannot be limited to the study of immigration; it is also necessary to follow the outflows both from towns and larger territorial units. Out-migration, however, has a similar spatial behaviour, creating a hinterland around the town, although much smaller than the in-migration hinterland.

Let us pay attention to the migration tendencies on the example of the in-migration region of the town of Brno in the periods of 1963–1964 and 1971–1973. The inflow to Brno increased from 13 800 to 18 300 (the latter figure includes 300 arrivals to the communities annexed in 1971). 21.9% of all moves originated in the closest surroundings of Brno – the district Brno-province. But there are several larger immigration centres in this district, the largest being Tisnov with more than 400 immigrants per year, and Kurim, Ivancice – more than 200 immigrants per year. Other centres have an immigration of more than 100 persons per year. The number of migrants from the communities mentioned to Brno is decreasing but most of them still display greatest migration to Brno (Tisnov, Kurim, Ivancice, Šlapanice).

A so far insufficiently analysed factor in the study of migration process are the migration reasons. However, those have been statistically recorded since 1965 and one can use this material without further investigations. Data on migration reasons enable us to explain partly the social and socio-economic aspects of population movement in spite of the fact that only one principal reason is given for each move. A majority of migrants give the housing situation as the reason of move (in the case of Brno 44%), in the second place marriage is given and only in the third place it is the change of the place of work. But the change of the place of work and other factors are often closely connected.

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The knowledge of the factors governing migration and the development of suitable prognostic models of migration, urbanization and concentration of population require not only a complex investigation of migration itself but also of the characteristics of economically active population, the age structure of inhabitants and migrants, the number and dislocation of job opportunities, the distance between the districts, the level of technical and social service equipment of the region and of some other economic characteristics. This fact re-confirms the significance of the migration component in the development of settlement structure.

The studies of migration carried out so far allow a following summary to be made:

(1) The volume of migration depends on the size and economic significance of the respective centre or region;
(2) The migration is affected by the number of job opportunities, as well as the economic and social attraction of the place;
(3) The housing factor plays an important part in the study of migration. Migration cannot be expected to increase in the case of stagnating housing construction or in that of unsuitable quality of the apartments;
(4) The volume of migration movements decreases with respect to distance;
(5) Migration and commuting are in a close relation. The streams of commuting precede in certain cases the migrations and commuting regions may be replaced by migration regions;
(6) The higher the concentration of urban population the slower is the growth of population and its migration shifts.

WEEK-END HOUSE RECREATION OF METROPOLITAN POPULATION ON THE EXAMPLE OF THE CITY OF BRNO[5]

In the course of the last two decades tourism and recreation have become a significant component of the socialist mode of life. The following data indicate an intensive development of recreation activities. In 1970, 68 million domestic tourist moves were recorded, and in 1976 this number increased to 106 million (Bulletin WCR, 1976). The majority of moves are in the form of short-time recreation (more than 95%), and about 90% are accounted for by individual recreation. The data are confirmed by the structure of hotel and week-end house facilities, out of the total number or 1.04 million beds available in 1976, 10% are in all-purpose hotels and pensions, 17% in institutional facilities and 73% – in private week-end and summer cottages.

One of the principal problems in planning the further development of the recreation system in the ČSSR is the definition of the role and prospects for individual short-time recreation, mainly the week-end house recreation.

In general, two significant rules of the spatial distribution of recreation buildings may be identified:

(1) A great concentration of week-end houses in the surroundings of the largest towns. For instance, in the districts of Praha-East, Praha-West and on the territory of the capital Praha 28 841 week-end houses (19% of all such houses on 2.0% of the territory of the ČSR) were found in 1971; in the districts Brno-city and Brno-province the respective values were 10 877 (7.5% on 1.7% of the area of the CSR).
(2) Location of the week-end houses in most attractive (from the viewpoint of nature) regions (mountains, banks of water reservoirs and streams).

The prevailing part of private week-end houses are owned by inhabitants of large cities. In 1971 the inhabitants of the towns of over 100 000 population owned ower

[5] The section is based on a paper by Jiří Vystoupil.

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60% out of the total number of 156 402 week-end houses (the inhabitants of Praha accounted for 38% of all week-end houses in the ČSR. with the ratio of 7.1 households per one week-end house; in the case of Brno the respective figures were 10% and 8.6%, Ostrava – 8% and 8.3%, Plzen – less than 5% and 9.1%. In the period between 1970 and 1975 additional 350 000 households were considering the construction of a week-end house of which more than 3/4 were from towns with more than 10 000 inhabitants. At the present time inhabitants of 7 main regional centres in the CSR are owners of about 70% of all week-end houses.

These data show basic tendencies in the development of the week-end house recreation in the CSR. Its more particular problems will be demonstrated on the example of the city of Brno and Brno-province.

In terms of intensity, expressed by the absolute number of 6775 week-end houses located in an area of 229 km^2 (the mean density being 30 structures per km^2) the week-end house recreation in the district of Brno has practically no analogy in any larger town in the ČSSR. This is possible above all due to a sufficient quantity of suitable areas for gardening and construction of week-end houses in the peripheral, and even some inner quarters of the city as well as the occurrence of a recreation water resorvoir on the territory of the town; almost 2000 week-end houses have been located around this water body.

Several different development stages of week-end house construction can be distinguished. The development began as late as after 1930 (till that time there were but 70 week-end houses in Brno) with a slow rate of construction of about 50 week-end houses per year in the thirties and forties. At the beginning of the fifties, the construction accelerates successively; in the mid-fifties the average annual addition was more than 120 week-end houses, and towards the end of the fifties – about 220. After 1965 an expansion of the recreation activity is expressed in the development of 2650 week-end houses between 1966–1971. The main trend was to build cottages near the water reservoir and in areas suitable for gardening. This is confirmed by the type of utilization of the week-end houses, 40% of which are used only during the summer, 25% at week-ends, about 20% in the course of the week for the greater part of the year, and the remainder quite irregularly.

The intensive construction of individual recreation houses has been partly related to limited public recreation facilities. In spite of the progress achieved, there is still an under-equipment of recreation and sport facilities which precludes a better utilization of the extensive recreation potential of municipal parks and gardens. Provisions for development of public facilities including zones of health, public bathing pools, water reseroirs, sports-recreation centres, etc. are made in the new territorial plan of the town of Brno and the Brno agglomeration. Attention is paid also to the increase of the area of parks and gardens in the surrounding of the recent housing estates.

The positive consequences of the week-end house development include: the utilization of areas which are not earmarked for further development, additional supply of the town with product of gardening and optimum mode of the utilization of the leisure time of a considerable part of the population. Among the negative effects one can list: occupation of potential building sites and public recreation areas (in 1971 private recreation plots occupied as much as 2% of the total area of the town), the overloading of the capacity of recreation facilities, and merging of the recreation zones with built-up areas, reduction of the aesthetic and utility values by the production of waste.

Main suggestions for the future of the week-end house recreation in Brno include:

(1) Prohibition of the week-end house construction in the immediate proximity of the town centre and in areas of expected urban development,

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(2) Control and cutting back of week-end house construction at the river dam and its surroundings as well as in zones at the stage of the degradation of the recreation function,
(3) Construction of necessary hygienic facilities in all existing week-end house areas.

At the present time there are over 5000 individual week-end cottages in the suburban recreation zone identified for the purpose of this study with the district of Brno-province. The early areas of week-end house recreation were the regions most attractive from the point of view of nature, in the immediate proximity of the city and close to the main thoroughfares to Svitavy and Tisnov. Soon after 1930 the formation of the presently main zones was under way, above all in:

– southern part of the Drahanská vrchovina in the Svitava River valley,
– region of the Českomoravská vrchovina at the Svratka River,
– region of the Bobravská vrchovina at the Bobrava River valley, Rokytna and Jihlava Rivers valleys,
– wider surroundings of the Brno river dam.

The consequences of recreation activities can be traced also in the changes of the socio-economic functions of communities, especially after 1965. New types of communities emerge, so far present mostly around the city of Praha, the communities in which the number of holiday-makers surpasses the number of resident population. This fact is important for the planning of local settlements and their role in the present process of urbanization. Recreation moves will represent an important dynamic factor of the settlement structure. Again, the planning implications include:

(1) Prohibition of further construction of private week-end houses in regions displaying a degradation of the recreation function,
(2) Restriction of the construction of week-end houses in large communities,
(3) Directing the development to those local communities in which the construction of week-end houses has been already started or in which one will not succeed in controlling the increased demands for such facilities. From the point of view of the whole society further construction of week-end houses in the agglomeration of Brno is undesirable. The reason is the need to protect the natural environment potential in the suburban zone of Brno which – according to urbanization prognoses – is expected to grow by 70 000 – 80 000 inhabitants up to the year 2000. Favourable conditions will have to be provided for the optimum utilization of free time of those new inhabitants,
(4) Shift of the location of the week-end house construction to the neighbouring districts, above all those of Trebíc and Jihlava, within the optimum reach of one to one-and-half hour travel time from Brno.

Similar conclusions are essentially valid for the majority of big cities in the ČSSR.

An analysis of the development of the week-end house recreation in the CSR confirms the following facts:

(1) the high share of urban population in the ownership of individual week-end houses,
(2) direct proportion between the size of the town and the number of week-end houses owned by the inhabitants of the respective town both in absolute and relative figures.

Initially the area of the immediate recreation hinterland of the town of Brno was about 350 km^2, around 1945 it was already about 620 km^2, in 1955 – 880 km^2, in 1965 – 1000 km^2 and has attained the size of about 1500 km^2 at the present time. The former development of the week-end house recreation in the agglomeration of Brno can be characterized by a logistic curve, with the phase of maximum gradient at the present time. Its further development can be affected by:

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– The regulation of the development of week-end houses (two resolutions have already been passed by the government of the CSR in 1971 and 1973 concerning the control of the construction of week-end houses) which can mostly affect the spatial dislocation and not – in the nearest future – the size of this significant social phenomenon, originating as a consequence of present-day civilization processess.

– An increased provision of recreation opportunities for a sufficient number of the inhabitants of Brno and its wider hinterland which appears to be much more efficient and to have long-lasting validity. According to preliminary prognoses the minimum number of participants in short-time recreation trips is supposed to reach approximately 220 000 persons (41% of the total population) in the Brno agglomeration by the year 2000 in comparison with the present-day 140 000–150 000 (1/3 of the population). The balance of the possibilities of meeting the demands of the inhabitants of the agglomeration is positive. For the future the construction of the cascades on the Svratka, Bobrava and Ricka Rivers is planned with a zone of recreation water reservoirs (capacity for about 120 000 persons) while by regulating other smaller streams recreation possibilities for additional 13 000 persons will be created (Kucera B. 1976).

THE DEVELOPMENT OF ROAD TRAFFIC IN THE SOUTH MORAVIAN REGION UNTIL 1990[6]

Transportation is an important component of socialist planned economy since it is an indispensable factor of the territorial distribution of production and the formation of economic regions.

A serious problem in transportation planning is the fact that the future development of traffic-generating factors depends on general trend of the development of economy and the technical progress which means in its consequence that non-recurring changes are of basic significance in long-lasting development. The traffic prognoses should be therefore based on an analysis of all primary factors, political ones included. But the basic analytic and prognostic materials from this sphere do not attain the necessary completeness or are sometimes missing altogether. Their replacement by theoretical hypotheses and subsequent definition of expected changes of the traffic-generating and other respective factors in synthetical prognostic models of road traffic used at the present time brings along a risk that those changes will not take place or that they will display a considerable shift in time in comparison with the assumptions made.

In the present study the hypothesis concerns the near future, i.e. the period of 15 up to 20 years ahead. In the analogical prognostic model traffic is expected to develop in the future analogically to the development occurred so far. This is why the prognostic method was applied based on the application of the logistical function and limited by objective long-term ideas on the development of motorization. A non-negligible contribution is in our case the possibility of a future gradual comparison of the results with actual values and thus the possibility of an estimation of the influence of the changes of selected factors which will occur in the future on the development of road traffic.

The prognosis was carried out separately for passenger cars and heavy motor vehicles for the reasons of different character of respective traffic streams. It was elaborated in the first phase on the basic static traffic-generating factor, i.e. the number of vehicles, and in the second phase on its dynamic projection into the traffic streams by means of the traffic network. The development of passenger car

[6] The section is based on a paper by Milan Viturka.

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ownership war calculated using the values of the bound parameters A and D of the logistical function. The D value indicates the lower limit of the development of car ownership and is accordingly zero. The establishment of the value of parameter A is based on the assumption on the future interdistrict differences in motorization following from the conception of a gradual decline of differences in the standard of living and style of life, and corresponding to the existing development. This balance cannot, however, be complete since the effects of the structural settlement systems must be taken into consideration, mainly with respect to greatest settlement concentrations where a higher degree of car ownership can be supposed to occur even in the future. This fact is also indicated by a number of reasons connected with the so-called 'social climate of big towns', for instance a higher share of inhabitants with a higher income level, a smaller size of households in comparison with the average, higher demand for short-time recreation trips, etc. The value of parameter A for the period of saturation was established in agreement with the present-day deliberations on the development of car ownership at 333 passenger cars per 1000 inhabitants (one car per three persons). For the town of Brno one should reckon on the basis of the deliberations mentioned with a perspective degree of motorization of 1:2.5. The A and D values are given in advance and represent in the regressions 14 points – the numbers of passenger cars per 1000 inhabitants in the districts of the region in the period 1961 to 1974. The projected values for 1990 range from 1:4.1 (districts of Blansko, Gottwaldov, Kromeriž) to 1:3.4 (joined territory of the districts of Brno-city and Brno-province); the average for the South Moravian Region is 1:3.7. The free parameters M and S are important values. The value of parameter M indicating in our case the point of time from which the growth of car owner-ship will start to slow down ranges from 1978, 95 (Jihlava) until 1982, 72 (Kromeriž). Parameter S indicates the steepness of the curve, i.e. in our case the rate of the increase of car ownership by the weighted value of parameter A (upper asymptote) and is accordingly important in the estimation of the needs of investments in the road network and the automobile services in the respective district. Its value ranges between 10.85 (Gottwaldov) and 14.02 (Breclav).

In the second stage a prognosis of passenger traffic on a selected road network of the South Moravian Region was carried out for 1990. Basic data were obtained from the analysis of the growth of traffic on the roads of 1st and 2nd category in the period of four road traffic censuses taken on the territory of Czechoslovakia in 1959, 1963, 1968 and 1973. In the calculation altogether 301 census points were included, located on roads on which the decisive part of the total volume of road transport in the region has taken place. A basic assumption for carrying out the prognosis is – in the case of the chosen method – the establishment of the y-value of the intensity of the stream of passenger cars at the point of inflexion around which the logistic function is symmetrical. The x-coordinate of the inflexion point (time) was taken over from the prognoses of the growth of passenger car ownership in the respective district. The period between 1968 and 1973 was chosen as a base. The calculated absolute values of traffic intensity for different census points at the point of inflexion were multiplied by two and thus the values of parameter A were obtained. The regressive logistic function comprised at least the necessary 4 points – the intensities of the passenger cars traffic at census locations. This procedure is accordingly not so much a pure trend extrapolation as a conditional projection using some concepts limited by objective perspective of the development of passenger vehicle ownership.

In the second part of the study predictions concerning heavy motor vehicles were elaborated. Such prediction is more difficult to make than that related to the development of private car ownership. This is caused by several factors, for example, differentiation of the category of heavy vehicles into various types and different

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modes of utilization, the organizational structure of public passenger and freight transportation, territorial differentiation of socio-economic activities, and the division of transportation functions between the railway and road transportation. The value of parameter A was established on the basis of economic studies which determined the total number of heavy vehicles in the ČSR at the time of saturation. From this value the values for individual districts were derived, different for industrial, mixed and agricultural districts. The calculated value of parameter M ranges within narrower limits than that in the case of passenger cars i.e., 1972, 28 (Jihlava) to 1973, 35 (Hodonin). The value of parameter S (absolute values of the number of heavy vehicles were taken into consideration) ranges from 42.81 (Vyskov) to 251.52 (joined territory of Brno-city and Brno-province). The procedure used in the projection of freight traffic was similar to that used in the preceding case.

It should be stressed that projections are concerned here with selected parts of the road network. Inter-district comparisons are affected by the selection of the census points. But the comparison of the projection results complies with the picture of basic regional differences in the intensity of road traffic since they show inter-district variations which do not take account of the marginal parts of the districts. In justified cases (proximity of centres, continuity of the flows of road traffic) the projections were completed with an estimation of future intensities at supplementary census points (altogether 49)

The results obtained can be summarized in the following way:

(1) Passenger car traffic on the selected road network in 1990.

In the period between 1973 and 1990 an increase of traffic can be expected on a regional scale on roads of 1st category by approximately 245% and on those of 2nd category by 265%. Highest increase on the roads of 1st category was registered in the districts of Hodonin and Gottwaldov, on the roads of 2nd category in the districts of Hodonin, Blansko and Uherske Hradiste. The corresponding smallest increase can be expected in the districts of Jihlava and Trebic and/or again Jihlava and Zdar nad Sazavou (roads of 2nd category). According to the mean traffic intensity over the 24 hours on workdays the districts can be divided into 3 groups. The 1st group includes the districts of Brno-province and Gottwaldov with a mean intensity of more than 6000 passenger cars during 24 hours, the 2nd group comprises the districts (arranged according to the attained values) with an intensity greater or equivalent to 5000 vehicles – Vyskov, Uherske Hradiste, Hodonin, Breclav, Blansko and Prostejov, the 3rd group consists of districts with an intensity of less than 5000 vehicles – Znojmo, Kromeriz, Zdar n. S., Trebic and Jihlava.

(2) Freight traffic on the selected road network in 1990.

The total increase of the intensity of heavy vehicle traffic in the period between 1973 and 1990 on the regional scale in expected to take place on roads of 1st category (66%) and on those of 2nd category (53%). Highest increase should occur in the districts of Zdar n. S., Brno-province and Znojmo (roads of 2nd category). Smallest increase can be expected in the districts of Trebic and Vyskov (roads of 1st category) and Zdar n. S. (roads of 2nd category). According to the mean traffic intensity (24 hours on workdays) the districts can be again divided into 3 groups. The first group comprises the districts with a mean intensity surpassing 1700 heavy vehicles per 24 hours. These include Brno-province, Uherske Hradiste and Gottwaldov (the districts are again arranged according to the attained values). The 2nd group consists of the districts with an intensity exceeding 1400 heavy vehicles – Vyskov, Breclav, Hodonin and Znojmo; the 3rd group is formed of the districts with an intensity smaller than 1400 heavy vehicles – Kromeriz, Prostejov, Blansko, Trebic, Zdar. n. S. and Jihlava.

(3) Total traffic volume including both passenger cars and heavy vehicles.

The expected total increase of the intensity of traffic on selected, roads of 1st

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category in the South Moravian Region, 1973–1990, in 'unit' vehicles (lorries represent 2 units) is approximately 150%; in the absolute number of vehicles – 180%. For the selected sections of the roads of 2nd category the respective figures are 142% and 178%. In the mean annual volume of traffic in 1990 two districts, i.e. Brno--province and Gottwaldov display an intensity greater than 10 000 'unit' vehicles (u.v.) per 24 hours. More than 7500 'unit' vehicles are projected for the districts (arranged according to the attained values) of Uherske Hradiste, Vyskov, Hodonin and Breclav; more than 5000 u.v. for the remaining districts except that of Jihlava. In the structure of traffic volume, a significant change can be expected as to the share of passenger cars and heavy vehicles. While this ratio (passenger cars/heavy vehicles) was on roads of 1st category 1:0.58 in 1973 and 1:0.71 on roads of 2nd category the expected ratio is 1:0.28 for 1990 on roads of 1st category and 1:0.30 on roads of 2nd category. It should be stressed that the projection did not consider motorcycles, owing to considerable difficulties as well as relatively small share of these vehicles in the total volume of traffic, especially towards the end of the projection period.

To conclude, the projections have shown that a substantial increase of inter-district traffic on the roads of the South Moravian Region can be expected till 1990. Besides supplying the results applicable for institutions dealing with the formation and protection of natural environment, it makes possible to judge roughly the demand of adapting the technical parameters of principal roads to the increasing traffic by individual districts of the region. It also allows to evaluate the process of a gradual equalization of motorization in different parts of the South Moravian Region. Thus some material for traffic plans in the region and for general planning is obtained.

A CONCEPT OF THE LONG-TERM DEVELOPMENT OF THE SETTLEMENT OF THE CSSR AND THE ROLE OF THE HOUSING STRUCTURE[7]

Evaluations of the settlement structure in the CSSR have shown that the process of the concentration of production had outstripped that of the concentration of the population and has called forth an excessive amount of commuting to work. Persistence of this state of affairs could complicate the future socially efficient economic development. In fact, the allocation of such investments as housing construction, social and technical equipment is not concentrated in the same degree and their undesirable dispersion takes place to small settlements which do not display any clear perspectives as to their further development.

As early as in 1962 measures were accepted for the concentration of housing construction, civil and technical equipment in those rural settlements with good prospects for economic, social and cultural development and which perform definite functions in the settlement network or are a centre of the district comprising a certain number of smaller settlements. Housing construction outside of the settlements identified could be permitted only in the case of the sites of prospective agricultural enterprises for people working in agriculture and forestry.

The results obtained on the basis of application of those measures have shown that the process of concentration of settlement cannot be easily controlled by exclusively administrative methods unless certain advantages favouring the concentration, such as cheaper building plots, financial assistance, etc. are offered in the developing settlements. It was therefore decided to elaborate gradually a proposal of the long-term development of settlement which would supply a basis for a planned reconstruction of the settlement network and the concentration of investment activities in developing settlements. It has been assumed that under the conditions of the

[7] The section is based on a paper by Václav Tousek.

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CSSR it would be most advantageous to concentrate the long-term development of settlement in a three-stage system of selected central settlements located suitably on the whole territory of the state.

The aim of a central settlement system is the creation of such a settlement structure which would make it possible, by a gradual concentration of civil and technical equipment, to ensure an optimum environment for the whole population, the economics of the construction and operation of the necessary facilities, with the needs of production being respected, and which would better correspond to the present-day tendencies of the concentration of industrial and agricultural production into larger units.

Two basic functions of settlement centres follow from the above assumptions:

(1) the cultural-social function which can be ensured most efficiently by the central settlement system,

(2) the economic function whose development is conditioned to a certain extent by the locational and technical factors.

In the settlement structure as a whole a distinct tendency of the optimization of the relationship of static and dynamic elements is considered. The categorization of settlements, i.e. their classification into centres of local, district and regional significance and the division of non-central settlements into permanent and other settlements represent a basis for the policy of the allocation of investment activities in all spheres of economic and social life.

A basic orientation for this policy is supplied in the Czech Socialist Republic by the Principles of the realization of the long-term development of settlement in the CSR, approved in 1971. The principles impose the control over further development of the settlement in such a way as to be in agreement with the expected tendencies in the style of life in a socialistic society and so that the further development corresponds to the present-day and expected concentration of economy and thus contributes to a faster and more economic growth of the national income and the standard of living. But here some specific conditions depending both on the degree of economic development and on the degree of the utilization of the existing production and housing funds should be taken into consideration. The principles presume the concentration of industrial production in the district and regional centres. Similar aims are established by these principles for the construction of housing, technical and social equipment

The major part of new housing has to be allocated in accord with the needs of the national economy in the district and regional centres. Housing construction in the centres of local significance is to take place only up to the level necessary to ensure the development of the centre to a size proportionate to its wider hinterland. In the local settlements no construction of state housing with demands on public facilities can be admitted. Proposals concerning housing development carried out by enterprises, cooperatives and individuals, should take into account relationships of residents to the places of employment; the aim being to shorten the excessive commuting to work and to follow the planned settlement structure.

The effect and implications of housing policies were studied for the period between 1961–1970 (i.e. before the issue of the document mentioned) and between 1971 and 1975 (i.e. after the issue of the principles of the long-term development of settlement – A. Andrle, M. Pojer, 1976). The authors compared the housing construction in the district centres with that in the remaining communities. They included in the analysis, in addition to the district centres (252 towns), 16 other towns with more than 10 000 inhabitants.

In the ČSSR 260 000 housing units (i.e. 59.9% of total housing construction) were built in centres of district significance between 1961 and 1965. In the period 1966–1970 the volume of new housing increased to 265 000 units, in the years 1971–1975

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an increase to 387 000 dwellings (i.e. 62.9% of total housing construction) was registered. In spite of the fact that housing construction increased even in the non-central communities (index of the increase of the construction 1971–1975/1961–1965 = 131.0:100.0, whereas the value of this index in district centres is 148.6) it can be stated that the directives mentioned above have been fully respected all over the country.

The questions of how the tasks following from the concept of the long-term development of settlement are fulfilled and to what extent is the concentration of housing construction related to the concentration of investment activities in the production sphere are answered by V. Havlik (1974). That author was also dealing with the problems of prefabricated housing whose share (56% of total housing construction between 1971 and 1975) is to be increased to 64% in the following five-year plan. This type of housing was located (1971–1975) predominantly (86%) in the district centres and for 1976–1980 this share will increase to 89%.

The quality of housing can increase much faster in urban as compared to rural areas owing to the concentration of housing construction mainly into centres of higher order. Such considerations must be based on the evaluation of the housing situation in the ČSSR since the end of World War II. Of the total number of 3.6 million housing units (in 1950) about 2 million units were older than 70 years. Dwellings constructed before 1920 were mostly small and of low quality, and those built between 1920 and 1938 did not reach on the average the level of equipment of newer housing.

In the first years after the war the urgent tasks of the construction and reconstruction of industry absorbed most of building capacity and required great financial and material means. The increase of the housing construction was therefore slow. At the same time population was growing rapidly and the rate of household formation was high. In 1959 the solution of the housing problem was started on the basis of the resolution of the Central Committee of the Communist Party of the ČSSR and the directives of the 12th Congress of the Communist Party of the CSSR. The issue has become permanent; the solution of the housing problem is included in the economic policy and focusses attention of the party and government institutions.

Considerable effort has been made towards the equalizing of the housing standards in Bohemia and Moravia and in Slovakia. The high share of the Slovak Socialist Republic in the housing construction (of the total after war construction almost 40% of develling units have been built in the SSR) has contributed substantially to the reduction of the original differences.

The present differences in the standard of dwellings in urban and rural areas are small. This is demonstrated by the values given in Table 3 which presents

TABLE 3. Valuation of the dwelling standard in the settlements of the Brno agglomeration

No.	Standard of dwelling (degree)	1	2	3	4	5	6	7	Total
	Centres of:								
1.	regional significance					1			1
2.	district significance				4	2	1	1	8
3.	local significance		3	18	16	1	4		42
4.	Non-central settlements								
(a)	permanent	3	67	122	21	2		1	216
(b)	other	4	42	57	5	1			209
	Total	7	112	197	46	7	5	2	376

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data for the communities of the Brno agglomeration (the districts of Brno-city, Brno-province, Blansko and Vyskov) from the point of view of the approved settlement classification. The valuation of the housing standard is based on the following factors:

a) age of housing, b) category, c) running water, d) warm water supply, e) size, f) number of inhabitants, g) common life of households.

Accordingly, only those factors are judged which affect the so-called internal dwelling milieu. One of the aims of the present study was to determine a complex index of the dwelling standard of a community. The values of the complex index are divided into 7 degrees (degree 1 – lowermost, degree 7 – uppermost standard of dwelling).

Table 3 shows that differences in the dwelling standard between centres of various orders are rather insignificant. In 1980 the dwelling standard can be expected to be higher in all categories of communities; it will increase quickly mainly in the regional and district centres.

CONCLUSIONS

The discussion enables us to point to the changes occurring in the settlement system and to new tendencies in its formation and arrangement.

(1) The process of concentration is expressed in the growth of a selected group of the centres of higher orders. The growth manifests itself, among others, in a fast improvement of their housing stock. Expansion of those centres is due predominantly to immigration from their immediate hinterlands.

(2) The settlement system identified represents the backbone of the settlement structure.

(3) Dynamic elements of the settlement structure are characterized by the transition from the unilateral hinterland–centre relationships to relationships between individual urban centres. This is a major phenomenon in the formation of urban nodes and urban agglomerations of various types.

(4) The knowledge of the processes mentioned is of great significance in the planning practice, i.e. in the optimalization of the regional utilization of labour and the dislocation of the housing fund from the point of view of agglomeration economies.

(5) The pattern of geographical dispersion as expressed in the week-end recreation, has a distinctly hierarchical character. Within the hinterlands of big towns it leads to a functional transformation of former agricultural and/or industrial-agricultural settlements into recreation-service settlements. But simultaneously a hierarchization, i.e. its dependence on larger centres, results in a deterioration of the environment mainly in the vicinity of those centres.

(6) On the basis of the facts mentioned above it is testified that an open settlement system can be planned and regulated under socialist conditions its positive elements being emphasized and strengthened.

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MAIN FEATURES, TRENDS AND PROBLEMS OF HUMAN SETTLEMENT IN THE USSR

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Problems of human settlement are a part of a more general problem, i.e. territorial organization of social life. These problems become more complicated and acute with the passage of time, therefore their importance increases as well as the need to solve them.

The national economic base of settlement is being constantly developed and changed: large territorial-production complexes emerge, new resource areas develop, huge transport routes, ports and electric power stations are built, and plans to transform Nature are elaborated and implemented over vast territories. All this imparts unprecedented dynamics to human settlement.

The tasks to improve settlement cannot be reduced merely to removing shortcomings and intensifying positive elements. It is also essential to master the process of urban and rural settlement reorganization and formation of towns and their systems, as well as to direct it along postulated channels.

The first essential step in controlling the mechanism of settlement is to grasp its essence. A study of settlement problems must be aimed, first, at analysing appropriate processes and revealing trends within them and, secondly, at identifying causes behind them.

URBAN STRUCTURE OF THE USSR

Let us first point out the specific features of urban structure of the Soviet Union and changes taking place whithin it. Over fifty years, from 1926 to 1976, urban population of the country increased from 26.3 to 153.1 million or by 480 per cent, while the rural population decreased by 20.5 million (17 per cent). Now 64 per cent of the Soviet population lives in urban places (Table 1).

Thus in the period under review the number of towns increased by 180 per cent, the number of large cities growing by 690 per cent (respective populations increased by 490 and 790 per cent).

The share of large cities in urban population of the USSR increased from 36.3 per cent in 1926 to 57.0 per cent in 1974. Smaller towns, which comprise almost a half of the total number of towns of the country (975 out of 1999 in 1974), account for merely 6.7 per cent of the urban population. Even so, their number increased by 150 per cent and their total population by 140 per cent.

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TABLE 1. Growth of the number of urban places and their population, 1926–1974*

Urban unit	Number of urban places				Number of inhabitants (million)			
	1926	1959	1970	1974	1926	1959	1970	1974
Urban settlements total	1925	4619	5505	5699	26.3	100.0	136.0	149.6
Towns	709	1679	1935	1999	21.7	82.9	116.3	128.7
Towns 100 000 inhabitants plus	31	148	221	238	9.6	48.6	75.5	85.4

* Compiled from the statistical abstract *Naselenive SSSR. 1973* (The population of the USSR. 1973). Statistika. Moskva 1975.

Modern urban structure of the USSR, resulting from the developing urbanization processes, reflects geographical conditions of the country and specific features of its economic, political and cultural development. Of all countries of the world, the USSR has the largest number of large cities. It has a ramified network of large cities and a considerable proportion of total urban population. The urbanization process within the country has been sufficiently and dynamically developed.[1]

A rather considerable role played by large cities in the national economy of the Soviet Union is evidenced by a high concentration of various types of activity, including industrial production, in these cities. The high concentration of diverse functions in large cities creates a basis for centripetal shifts of population throughout the country, the population being attracted by the socio-economic foci; a complex settlement system has been formed in which large cities constitute main elements.

It is possible to describe recent trends by showing the distribution of population growth by categories of towns. From 1959 to 1975 (or, arbitrarily, the period of the scientific and technological revolution) the Soviet urban population increased by 50 per cent or 49.7 million. The process developed very unevenly as far as individual categories of towns are concerned (Table 2). Thus almost three quarters of the total

TABLE 2. Distribution of urban population growth 1959–1974 by categories of urban places

Size of urban places (.000)	Under 3	3–5	5–10	10–20	20–50	50–100	100–500	Over 500	Total
Growth (million)	0.430	0.500	1.397	2.438	4.268	3.728	19.287	17.563	49.611
Share of total increase (per cent)	0.867	1.008	2.816	4.914	8.603	7.514	38.876	35.401	100.0

increase of urban population were accounted for by large cities; this was conditioned by planned control when various measures were taken to direct the urbanization process.

Migratory increase is a main source of urban population growth. Towns and settlements lie along huge migratory paths, part of which lead to towns, especially large cities. In recent years some ten million people moved to towns and some

[1] A country is considered to be highly urbanized if its large cities concentrate at least one-third of the total population (in the USSR their share is 34 per cent).

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eight million left them (net migration being two million). Between 1950 and 1973 urban population increased by almost 39.5 million through migratory increase.

Taking into account urban population of suburban zones of 63 large urban agglomerations in 1970, which comprised about 21 million (a minimal 'agglomeration adjustment'), the population of highly urbanized areas of the Soviet Union reached almost 100 million in 1970, or 70 per cent of the urban population and about 40 per cent of the total population of the country.

A growing complexity of settlement forms is characteristic for the advance of urbanization. Emergence and development of a network of large cities signified a qualitative step in settlement, which was due to the specific features of their functional and planning structures and the nature of their interaction with environment. The 100 000 level involves a qualitatively new stage in functioning of a town. From the economic-geographical viewpoint, a large city is a specific entity, first of all due to its important and complex economic-geographical position and its ability to form its own position, and to the diversity of its functions and distinctive planning structure. A large city is socially heterogeneous, which is a direct consequence of its multiple functions and a factor largely explaining its attractiveness for population.

As it develops further on, a large city approaches its second qualitative threshold. Its specific features become more fully and expressively developed. Processes of 'self-development' are manifested more and more strongly. Conditions for an agglomeration to emerge accumulate. A large city can no longer cope with its expanded duties without becoming more complex in its planning organization. It gives way to a more comprehensive and flexible form of urban agglomeration.

Development of large cities is a direct expression of a trend towards concentration prevailing in the national economy. Growth of large cities is impelled by requirements of the national economy and striving of people for still fuller satisfaction of their needs. An analysis of functional structure and planning organization of large cities, their state and dynamics, testifies to social needs, economic expediency and ecological feasibility of their further development (only particularly large cities are to be restricted in their growth).

The Soviet Union is characterized not only by development and growth of existing large cities, but also by a continuous increase in their number. In the recent 20 years the number of large cities in the country was doubled. It can be assumed that in future there will be no less than double of the present number of large cities in the USSR (the process will be limited only by the size of the country's population).

A rapid increase in the number of large cities is an expression of dispersed concentration, which is characteristic of the present stage of economic development of the Soviet Union.

AGGLOMERATION PROCESSES IN SOVIET HUMAN SETTLEMENT AND THEIR CONSEQUENCES

While the first wave of urbanization brought large cities into being, the urban agglomeration is a result of the second, still higher wave. The same reasons that led to development and growth of large cities have contributed to development and growth of urban agglomerations. Under the scientific and technological revolution, these reasons and causes operate with greater force and on a greater scale. Agglomerations have been brought into life by a higher level and larger scope of needs of the national economy and population.

The scale of agglomeration in the USSR is imposing. Taking as mature those agglomerations that arose around towns of more than 250 000 inhabitants and that have a sufficiently developed suburban zone (at least 10 per cent of the total population of the agglomeration and an agglomeration coefficient of at least 0.10), one

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finds that in 1970 the Soviet Union had 63 large urban agglomerations, embracing 1274 urban places and concentrating 71 million urban inhabitants (about 50 per cent of the total urban population of the USSR), of which 71 per cent were in central towns and 29 per cent in the suburban zone.

Dynamics of the process is characterized by the following figures. Between 1959 and 1970 the total increase of the population in the 63 large urban agglomerations came up to 19.7 million, 66.2 per cent of which was accounted for by the core and 33.8 per cent by the suburban zone. During the same period nearly 200 new urban settlements with a total population of 1.6 million emerged within large agglomerations.

The prevalent trend is for the centre of large agglomerations to grow: only in seven of them the suburban zone has outpaced the core in absolute growth. The reasons are as follows: 1) core cities have not exhausted their growth potentials; 2) they require additional development of their city-forming base; 3) their suburban zone is not prepared sufficiently for more intensive development due, in particular, to low saturation with infrastructure means; 4) in overall living conditions the city centre is more attractive for most of the population.

The rise and development of urban agglomerations and formation of their network is extremely important in development of human settlement. Urban agglomerations have become the leading form of settlement, not only on account of the high concentration of the population and of most active elements of productive forces, which is highly important in itself, but also due to their transforming role in development of human settlement. The latter may be said to have created an effective mechanism for self-regulation. The agglomeration is a means to solve the problem of restricting the growth of large centres and related problem of animating smaller towns, a means of regulating settlement at various territorial levels. Agglomerations have broadened the freedom of economic manoeuvre and serve as a reserve of growth which may be rapidly brought into operation and yield the desired results as the need arises.

Attention should be drawn to three characteristic circumstances:

1) The formation of large urban agglomerations proceeds rapidly (as distinct from the usual scheme of transition from the already existing core city) on the basis of powerful territorial-production complexes. Examples of this are the agglomerations of Togliatti and Naberezhniye Chelny (over a longer term the group of towns and settlements around Naberezhniye Chelny will have over a million inhabitants) and subsequently the Sayan-Shushenskaya, Stary Oskol and other agglomerations.

2) A group of quite large agglomerations has been formed with more than a million inhabitants each. In 1970 their number topped 20, half of which have cities with population of over a million as their cores. Appearance of large satellite towns has been a significant development.

3) Areas of concentration of urban agglomerations have been crystallized.

FORMATION OF CLUSTERS OF AGGLOMERATIONS. CONDITIONS FOR MEGALOPOLIZATION.

As compared with Western Europe and the United States, the Soviet Union has a rather dispersed network of large urban agglomerations. In the East of the country, nearest agglomerations are separated by many hundred kilometres. In the European part of the country suburban zones of agglomerations are not, as a rule, contiguous, but in areas with the highest concentration of economic relationships and stronger economic density, agglomeration complexes emerge in form of basins and belts. There neighbouring agglomerations come close together and their suburban zones overlap. Two types of regions are characterized by such clusters: the resource complexes (coal basins) of the Donets and Kuznetsk basins, and transport junctions with a high concentration of cargo flows in the areas of the Samara Loop and the

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Middle Dnieper reaches. The features of both regions are combined in the Ural Mts., where a powerful resource base and crucial transport-geographical position in the system of basic East-West links act as joint stimuli for development of agglomerations and their clusters. References have already appeared in the Soviet literature to the formation of a 'Ural megalopolis'. The emergence of megalopolises, which are created by the next wave of urbanization, requires a combination of special conditions. In many areas of the Soviet Union there is hardly any likelihood for a megalopolis to emerge by development of the territorial structure of the national economy. The actual number of population of the country will likewise act as a limiting factor. The prospective number of inhabitants in the country will not suffice to fill a large number of megalopolises. In some sectors of the chief economic axes, however, powerful urbanized formations of the megalopolis type may indeed appear.

Having examined the evolution of leading settlement forms, one can now describe their territorial distribution, mutual location and interaction.

Formation of the basic framework for settlement is one of the main achievements of urbanization. This is of great importance in any country. Due to its specific geographical features, the Soviet Union experiences special need for a developed and effective basic framework: 1) The USSR is a country of long distances and its territory may be economically integrated through the impact of very large multi-functional centres; 2) Owing to the diversity of natural, historical, national and demographic conditions, the territory of the USSR is distinguished by great economic differentiation and therefore experiences a particular need for powerful nodes ensuring territorial-economic integration of the country; 3) the immensity of the tasks arising in the building of the material base of communism determines the need to create a system of large support centres ensuring the fulfilment of complex national economic programmes; 4) the settlement reconstruction necessitated by the aims of socio-political development must rest on a combination of transforming centres; 5) the economic, ecological and social advisability of territorial concentration of the economy, which together with trunk routes serves as a means of overcoming great distances, requires the primary development of concentration centres and areas. At the 24th Congress of the Soviet Communist Party Leonid Brezhnev pointed out that it was essential for concentration of the economy to become more intense.

As a result of the steady increase in the number of large towns, the overall space covered by their networks almost trebled from 1926 to 1974.

With the growth in the number of large towns and the formation of urban agglomerations, these, as the main foci of socio-economic space, accentuate by their distribution the principal features of the territorial structure of the national economy. Analysis of the way their networks are formed shows the regularity in the acceleration of the spatial rhythm of their distribution. This may be illustrated by the Volga and Dniepr 'chains' of large towns and by the selection of Stary Oskol, Volgodonsk, Naberezhniye Chelny, Cheboksary, etc., as 'growth poles'. The basic framework accentuates the close connection (unity) of settlement and the territorial structure of the national economy, and expresses the characteristic features of the distribution of the productive forces of the country. By its development, it may be said to support the spatial allocation of the national economic activities. The basic framework underlies a system of measures to perfect the human settlement.

An essential feature of the settlement in basic framework in the Soviet Union is the way organization of its links is allocated to definite areas as integral parts of the whole territorial structure. These include: a) main areas of a basin type, concentrated locations of basic heavy industries (operating on local resources); b) core areas of major nodal areas serving as main workshops and centres of scientific and technological progress; c) strongly developed zones of concentration of population and economy along major economic axes.

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TRANSFORMATION OF SETTLEMENT NETWORKS INTO SETTLEMENT SYSTEMS

V. V. Pokshishevsky has suggested a generalized scheme for evolution of human settlement: 'field-network system'. A transformation of a network into system indicates a transition from extensive to intensive urbanization, i.e. to the stage reached at present by population distribution in the Soviet Union. The network of centres is transformed into the system in two basic ways: consolidation of national and regional basic frameworks and formation of local systems in areas having favourable conditions.

EMERGENCE AND ROLE OF NEW TOWNS

New towns play an important role in forming systems at various levels, especially local systems. O. K. Konstantinov estimates that, over the 45 years from 1927 to 1972, 1034 new towns were founded in the USSR (now there are about 2000 towns). Every year (with the exception of the 1940–45 period), over 20 new towns emerged. Konstantinov believes that about 30 per cent of all new towns had not any earlier urban core. A high degree of restructuring of urban networks within individual republics is rather indicative. Emergence of new towns in areas where natural resources have been undertaken indicates 'in-breadth' urbanization; on the contrary, concentration of new towns within urban agglomerations indicates 'in-depth' urbanization. In addition, formation of new towns on the basis of rural places is an important component in transformation of the rural settlement.

Location of a considerable number of new towns along major transport routes testifies to the important role played by the routes in forming territorial structure of the national economy and to importance of developing routes reaching out to resource regions. It is significant that, among new towns, there are also large ones serving as nodes for the basic framework and which have become growth poles in the development of new territories, such as Norilsk, Karaganda, Shevchenko, Bratsk, Komsomolsk-on-the-Amur, Magnitogorsk, etc.

New towns serve as models of urban development and planned growth because they progressively introduce principles of urban environment organization and creation of an effective urban network (Zelenograd, Sosnovy Bor, Shevchenko, Navoi, Naberezhniye Chelny, etc.).

PRINCIPAL FEATURES AND DYNAMICS OF SETTLEMENT IN THE USRR

Growing complexity of settlement forms, formation of the basic framework and transformation of networks into systems are to be seen as principal processes of human settlement in the USSR. The main features of settlement dynamics in the country are reflected in development of the basic framework for settlement.

In the Soviet Union there exist highly distinctive macro-zones of settlement, reflecting complexity of natural, historical, national and demographic conditions and their spatial differentiation. Each of these zones is to be distinguished by its own combination of factors and conditions, the nature and orientation of economic development processes and problems of settlement reconstruction. The zones stretch latitudinally, following in a distinct way natural-geographic zones. Alternation of zones with different levels of economic activity and economic density, from north to south, is to be seen: the Far North, the Central Zone of economic activity, Semi-Desert and Desert Zone, Piedmont Zone of dense settlement, Mountain Zone.

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PROFOUND CHANGES OCCURRING IN RURAL SETTLEMENT

Enlargement of rural places is accompanied by reduction of their total number. Rural places are being saturated with service centres, which form hierarchically organized networks. Rural places in urbanized zones are strongly modified. Changes in the economic bases of rural places are of decisive importance; creation of agrarian-industrial complexes are to be especially emphasized. The size of inland regions is shrinking and their character is changing. Despite the gradual reduction of the rural population, it still numbers nearly 100 million. However, living conditions both in towns and country-side are coming closer together.

Formation of the basic framework, development of complex local systems, uneven distribution of new towns and outflow of the population from areas between urban agglomerations have strongly augmented contrasts between individual places. Economically active territories have polarized into parts with sharply different urbanization levels. There is a growing differentiation of economic landscapes, revealing urbanized belts and districts of a predominantly rural character, deconcentration of basic production and dispersed settlement.

Concentration of functions in the economic foci of various ranks (from huge super-agglomerations to local centres in agricultural and timber-producing areas) has drawn the population to these centres and predetermined large scale commuting, involving, according to estimates by V. G. Davidovich, over 12 million people.

At present, about 40 per cent of the total Soviet population and almost three-fourths of the urban population live in areas of high population density (in large towns and suburban zones of large urban agglomerations).

PROBLEMS OF SETTLEMENT IMPROVEMENT

Evaluating the present state of settlement and the main development trends, one can draw the following conclusions.

1. The settlement network (that represents the distribution of population), a component of territorial structure of the national economy, has grown in importance as a factor in the distribution of productive forces. Basically, it forms the foundation for the further development of the territorial structure.

2. The settlement network calls for thorough reconstruction embracing all its tiers.

3. The prevailing tendencies lead, on the one hand, to the rationalization of settlement but, on the other, create in some cases a danger of deterioration of living conditions.

4. The formation of territorial structure of the national economy leads to increase of positive conditions for settlement improvement and for its adjustment to the provisions of the Communist Party programme (advancement of labour productivity and creation of a proper environmental conditions for a harmonious personal development). An important condition for this lies in creation and consolidation of the basic settlement framework as well as in development of large urban agglomerations as basic for transformation of settlement networks. By and large, the ecological aspects have become rather prominent now in the problem of settlement.

KEY TASKS IN THE IMPROVEMENT OF SETTLEMENT NETWORK

Key tasks are following:

1. Control of the growth of large cities, necessitated by their high dynamism, a task stressed in the decisions of the 24th and 25th Congresses of the CPSU.

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2. Animating of small and medium-sized towns, a task which is primarily social for the whole country and, on the contrary, mostly economic at the regional level.

3. Reorganization of the rural settlement on the basis of a substantial restructuring of their economic base and, in particular, through formation of agrarian-industrial complexes.

4. Formation of basic framework on national and regional levels; its growth in connection with development of territorial structure of the national economy.

5. Effective use of the economic role of urban agglomerations (leading on the national level) and stimulation of their rational development.

The general direction of the settlement development in the Soviet Union is conditioned by the continuing processes of urbanization. This is due not only to the fact that the country still possesses very large potential to urbanize, but also to the social advisability to make the best use of the process, largely contradictory but generally progressive in interests of man and his activities. Behind modern urbanization the processes of specialization (differentiation of human activity in general), integration (at different levels) and comprehensive concentration exist.

The diversity of the tasks involved in studying urbanization and settlement problems may be reduced to three groups.

1. Elaboration of a theory of human settlement.

2. Studies of development and functioning of settlement systems, interaction within systems and between them, identification and assessment of trends and their consequences.

3. Scientific bases for reconstruction of settlement network. To construct a frame for settlement strategy, principles for its conscious formation as well as evaluation concepts of integrating them to obtain social development.

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DEVELOPMENT OF THE NATIONAL SYSTEM OF CITIES AS RELATED TO MIGRATION

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INTRODUCTORY REMARKS

The problems of population size, population distribution and socioeconomic activity have long been a main concern to students of the development of settlement systems. Population growth, which is determined by a variety of social, economic and political processes, displays a significant spatial differentiation. That differentiation coincides with definite changes in population distribution that account for the subsequent relations of supply and demand. These latter in turn tend to induce changes in functional structures and raise or attenuate the attractiveness of individual areas, thus affecting the regional structure and organization. It is the historically developed and functionally and spatially differentiated network of urban centres of various sizes that is the principal catalyst of those changes. Therefore it may prove useful to look at the spatial patterns of population growth and distribution through an analysis of urban network.

The customary procedure in the analysis of complex spatial systems is to use scientific description which, depending on the degree of complexity of the analysis, takes generally one of the following three forms (Berry 1968; Simmons 1974):

(a) the attribute matrix, which takes account of the structural characteristics (variables, properties) of the spatial units studied (cities, urban regions, planning regions) such as size, functions, demographic or social characteristics, facilities available and so on;

(b) the behaviour matrix, which represents the interaction patterns between the spatial units studied (cities, regions) in the form of flows of population, commodities, information or capital, each at varying intensity, frequency or direction;

(c) the matrix of growth and change, which shows the way in which changes in one element of the given system induce changes in its other elements and indicates the growth model specific to that system.

It is the properties of spatial units that has so far attracted the attention of researchers. Most of the empirical studies in this line pertain to this type of analysis. What such studies do yield are as a rule typological and regionalization procedures imlpying homogeneity (structural similarity) and spatial proximity.

Much less advanced are studies concerning behaviour matrices. In the structure identification procedure, the aspects of homogeneity and proximity are replaced by

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definite measures of intensity of interaction between the studied units. In this case the student is interested not in which spatial units display similar characteristics but which of them contact one another. Proximity in space implies a relatively more intensive interaction, yet this is in fact often all but a straightforward relationship. With the development of specialized transport and communication systems, which are channels of contact of the highest intensity, proximity tends to lose its deterministic impact as a factor decisive of the formation of spatial structures.

It is in studies of growth processes and of changes in complex spatial systems that we have advanced the least yet.

While substantial progress is indeed possible within each of these individual approaches, it is in the integration of them that we should expect the most productive line of research. Such an integration can well be attained on the ground of studies in the development of the urban settlement network in combination with population migration. Especially useful to this end seems to be the notion of national system of cities.

The studies in this line of research started with assessments of the role natural gain and migration play in population growth and of the relations and links there may be between these components and some properties of urban settlements such as size, functions, or location. Once the migration component has been shown to play so significant role attention is to be focused on the dependences between some structural characteristics of definite types and forms of settlement and the types of their population growth on the one hand, and the direction, intensity and spatial structure of migration on the other. The present paper reports the preliminary phase of study in this line.

THE COMPONENTS AND TYPES OF POPULATION GROWTH. SPATIAL DISTRIBUTION IN MACROSCALE

The total increase of urban population is a function of three components: natural increase, the balance of migration (internal and abroad), and increase due to administrative alterations (granting or withdrawing town status, expanding city boundaries by incorporating the surrounding rural areas). The proportions of each of these components in urban population increase over the past quarter-of-a-century are given in Table 1.

TABLE 1. Components of urban population growth, 1951–1975

Years	As in the base year	Net increase			Balance of administrative alterations	As in the terminal year
		total	natural increase	migration balance		
	,000					
1951–1977	9243	7950	4471	3479	2795	19988
1951–1955	9243	1678	1050	628	1146	12067
1956–1960	12067	1393	1055	338	941	14401
1961–1965	14401	1144	704	440	136	15681
1966–1970	15681	1192	559	633	215	17088
1971–1975	17088	1753	730	1023	189	19030
1976–1977*	19030	790	373	417	168	19988

Source: Statystyczna charakterystyka miast (Statistical characteristics of cities). in: *Statystyka Polski* Nr 85. GUS. Warszawa 1977.

* Statistical Yearbook 1978. GUS. Warszawa 1978.

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Natural gain proves to have contributed most to urban population growth over the 27 years studied (42%). Migration and administrative alterations contributed 32% and 26% to that increase respectively. The considerable contribution of administrative alterations can be interpreted as envisaging the factor of planning in the development of the national system of cities. One manifestation of effect of the planning factor is the widely varying total number of cities in Poland (751 in 1945, 889 in 1960, 836 in 1973, 814 in 1975, and 803 in 1977). Of a total of 644 administrative decisions regarding town-status issued in postwar Poland, 348 were grantings and 296 withdrawals. While the net outcome of those decisions marks an increment in the total number of urban units, since 1973 onwards the overall tendency has been to reduce it as seen in the 1973 decision to repeal the category of "urban settlements" or in the integration of neighbouring towns into larger urban complexes.

The significance of the three components of population increase varied greatly with time. Whereas natural increase and administrative alterations accounted for the bulk of the growth, since 1967 the migration component has become the principal factor in this respect. Without going any deeper into the methodological difficulties involved in the estimation of the individual components of urban population growth, especially the most challengeable factor of administrative changes let us observe here that the most suitable procedure for this type of comparisons in time series is to consider the urban units within unchanging boundaries.

With this assumption, an attempt has been undertaken to assess the role the components of natural increase and migration played in urban population growth in 1971–1975. The analysis comprised the entire set of the 814 urban units accordingly with the new administrative division instituted on 1 June, 1975. The preliminary exploratory part of the analysis was carried out using the method evolved by J. Webb. In this method, the relationships between the positive and negative values of the two components furnish the basis for distinguishing eight types of population changes (Table 2).

The pattern of these types in the case of individual cities must however be preceded by remarks on the population development as it is nation-wide and in the first-order territorial units of the administrative division now in force (49 voivodships, 1973–1976).

The basic types of population growth by voivodships are shown in Fig. 1c. The figure shows that total population increase was due mainly to high immigration in two cases only (the Warsaw and Łódź voivodships).

One group of 11 voivodships, whose distribution in space largely coincided with the pattern of large metropolitan centres and currently high investment activities, displayed a type of population development relying both on positive values of natural increase and migration, with the former predominant. The nation-wide dominant type was one in which population losses induced by negative migration balances were offset in excess by natural gain. This type was recorded in 34 voivodships. Two voivodships – Łomża and Zamość – displayed a negative net population increase over the interval of the study as natural gain was too small to compensate for migration-induced population losses. The net nation-wide increase totalled over the 1973–6 interval 1 323 000 people.

As regards rural areas, all voivodships recorded negative migration balances (Fig. 1a), Only 14 voivodships which, except for the Gdańsk and Szczecin voivodships, form continuous stretches of land in the southern, south-eastern and central-western parts of Poland had natural gains large enough to secure positive net population increases. The remaining 34 voivodships recorded declining absolute figures of rural population. Due to emigration the rural areas lost over the study period 861 000 people and, notwith-standing the high natural gain (716 000), they recorded a net population loss of 145 000 people.

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TABLE 2. Types of urban population growth in virtue of natural increase and migration

Types of population change	Natural increase		Balance of migration	Total increase
	values of components			
A Natural gain exceeds net out-migration. Population increase.	+		−	+
B Natural gain exceeds net in-migration. Population increase.	+	>	+	+
C Net in-migration exceeds natural gain. Population increase.	+	<	+	+
D Net in-migration exceeds natural loss. Population increase.	−		+	+
E Natural loss exceeds net in-migration. Population decrease.	−		+	−
F Natural loss exceeds net out-migration. Population decrease.	−	>	−	−
G Net out-migration exceeds natural loss. Population decrease.	−	<	−	−
H Net out-migration exceeds natural gain. Population decrease.	+		−	−

In the light of what has been said so far the rising importance of urban settlement forms as areas of population growth and its spatial concentration becomes fully conspicuous. The increase in urban population (1 469 000 people) exceeded the nation-wide average and migration accounted for 55% of it. The two-partite division of Poland appears clearly in the spatial distribution of the components of urban population growth, which are viewed as an aggregated set of units within each voivodship (Fig. 1b.). In 33 voivodships of eastern part of Poland (except for four voivodships) cities owed their population increases mainly to immigration. In the west (the Poznań and Legnica voivodships are two exceptions there), cities increased their populations mainly owing to natural gains. The Wałbrzych voivodship was the only case in which cities recorded a negative migration balance. Migration-induced population loss was there offset by natural increase.

The distribution of voivodships in which urban population growth was due mainly to in-migration correlates significantly with the spatial pattern of voivodships displaying losses in rural population in absolute figures (type C for cities and type H for the

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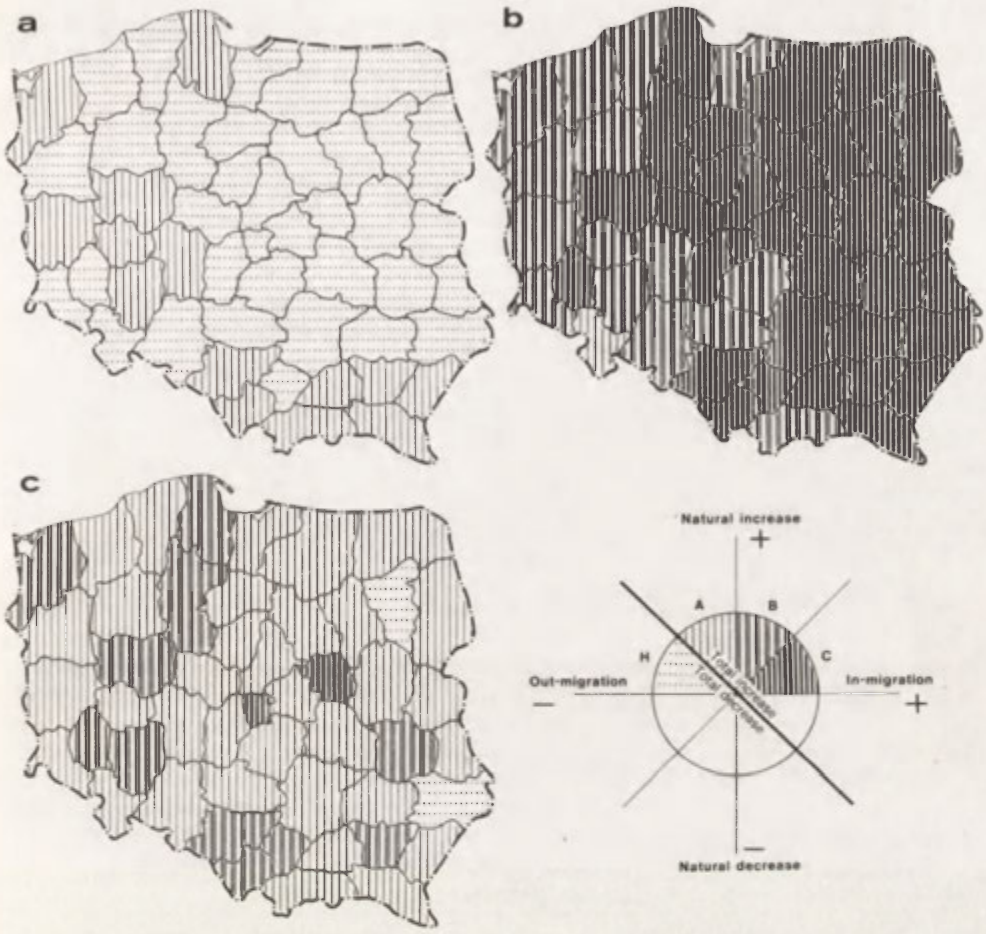

Fig. 1. Types of population changes by voivodships, 1973–1976
a) rural population; b) urban population; c) total population.

rural areas). The two distribution patterns in turn coincide with the distribution of the least urbanized voivodships, especially in eastern and central Poland, as well as with that of the biggest concentrations of urban population there.

THE COMPONENTS AND TYPES OF POPULATION GROWTH IN THE NATIONAL SYSTEM OF CITIES

Population growth viewed as the result of interaction of natural gains and in-migration is the combined product of a number of complex phenomena and processes whose mechanisms are still poorly known. The character of each type of urban population growth is no doubt strongly determined by the demographic structure of cities. This latter in turn is mainly a consequence of mass-scale migration movements – in case of the Western and Northern Territories the migrants were mainly young and carried with them the tradition-bound model of family with several children. At the high degree of urbanization in those areas, these structural characteristics of the migration movements account for the very high birth rates

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TABLE 3. Types of urban population growth in Poland by size classes, 1971–75

City size* (.000)	Types of growth of cities** (number of units)								
	Total	A	B	C	D	E	F	G	H
less than 5	288	105	99	41	5	–	1	4	33
5– 10	194	46	82	58	1	–	–	–	7
10– 20	159	18	77	63	–	–	–	–	1
20– 50	110	11	36	63	–	–	–	–	–
50–100	35	3	13	19	–	–	–	–	–
100–200	14	2	5	7	–	–	–	–	–
more than 200	14	1	3	10	–	–	–	–	–
Total	814	186	315	261	6	–	1	4	41

* As on 1 June, 1975.
** For explanations see Table 2.

subsequently recorded there. Since the death rate was much less differentiated nation-wide, the ultimate natural gains in those areas exceeded the national average significantly. The consequences of those processes find their expression in the structures that exist today, though the continuing processes of urbanization and industriali-

TABLE 4. Components of urban population growth

City size (.000)	Number of cities	Population as on 31 Dec. 1970	Natural population movement			Internal migration		
			births	deaths	natural increase	immigration	emigration	balance
1	2	3	4	5	6	7	8	9
less than 5	288	840 489	71 716	33 969	+37 747	130 999	119 964	+11 035
5– 10	194	1 260 686	118 073	51 558	+66 515	222 913	173 327	+49 586
10– 20	159	1 994 027	194 130	78 786	+115 344	366 724	260 066	+106 658
20– 50	110	2 961 407	277 101	112 728	+164 373	544 560	334 662	+209 898
50–100	35	2 240 203	195 038	94 585	+100 453	357 451	207 560	+149 891
100–200	14	1 890 461	152 111	76 764	+75 347	251 722	162 486	+89 236
more than 200	14	6 074 303	434 223	262 373	+171 850	587 929	265 910	+332 019
Total	814	17 261 576	1 442 392	710 763	+731 629	2 462 298	1 523 975	+938 323

Source: Own estimations based on materials of the Central Statistical Office.

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zation together with the concomitant migration keeps modifying those structures considerably. One essential change-inducing factor in this respect is the investment activity launched in new industrial districts and centres or in connection with the modernization of industry and the technical infrastructure in the old types of urban settlements. The population growth and its differentiation is also partly due to the characteristics of individual urban settlements and the place they occupy within the spatial and hierarchical structure of the entire settlement system.

In terms of a number of towns, the 1971–75 interval was dominated by type of cities with a prevalence of the natural increase component over migration-induced increase as the most frequent type of population growth; there were 315 units of this type (Table 3). The migration component dominated in 261 cities. If we consider that this component dominated also in the total urban population increase we can conclude that it was characteristic of the larger urban centres. These two basic types of cities were complemented by a third in which a positive natural increase more than offsets population losses due to emigration (type A). These types (A, B and C) of cities claim 94% of the entire set of urban units. The population decline in absolute figures found for 46 cities is almost exclusively a function of high emigration (type H).

Observe too that while nearly all Polish cities (803 units) recorded positive natural gains, positive migration balances were found for 582 urban areas. Emigration prevailed over immigration in 232 units (types A, F, G, H). If we measure the size of those cities by their population we see that these were the smallest urban units. Cities with less than 10 000 population accounted for 84% of this group, while those with less than 5000 population for 61%. The bigger cities that fall into this group (type A) are few, and they belong mostly to the Walbrzych, Jelenia Gora and Katowice voivodships (Fig. 2). In the former two voivodships, the emigration is due mainly to the obsolete structure of industry in need of modernization. As regards the

by size classes, 1971–1975 (classes as in 1975)

External migration			Total migration balance	Absolute population increase 1970–75	Population as on 31 Dec. 1975	Population growth rate 1970–75 (%)
immigration	emigration	balance				
10	11	12	13	14	15	16
210	2 082	−1 872	+9 163	+46 910	887 399	105.6
333	3 373	−3 040	+46 546	+113 061	1 373 747	109.0
477	4 278	−3 801	+102 857	+218 201	2 212 228	110.9
845	5 755	−4 910	+204 988	+369 361	3 330 768	112.5
699	4 115	−3 416	+146 475	+246 928	2 487 131	111.0
550	6 445	−5 895	+83 341	+158 688	2 049 149	108.4
2 882	29 572	−26 690	+295 329	+467 179	6 541 482	107.7
5 996	55 620	−49 624	+888 699	+1 620 328	18 881 904	109.4

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Katowice voivodship, this was so because its towns are situated in a big functionally integrated urban complex (with the concomitant changes in its internal spatial structure) on the one hand, and because of the relatively high level of emigration abroad on the other.

The type of urban units displaying absolute population losses (types F, G, H) comprises small units only. Most of them occur in central-western, south-western and south-central Poland. They are either components of larger metropolitan complexes or are situated in areas that form dense and regular networks of small towns going as far back as to the Middle Ages. These settlements, which often furnish few non-agricultural job opportunities and have high proportions of employment in agriculture, gradually lose their positions in the hierarchy to the benefit of the bigger and stronger competitors situated in their neighbourhood.

With rising urban-size the significance of the migration factor as a component of population growth rises too. While types A and H were most characteristic of the smallest urban units and type B (prevalence of the natural increase component) of cities in the 10 000–20 000 population size class, type C (dominance of migration) is most frequent in cities with populations exceeding 20 000. Of a total of 28 cities with population exceeding 100 000, seventeen units owed their population net increases to the migration component while 8 to the dominance of natural increase. These latter include the cities of the Upper Silesian Urban complex and Wroclaw and Szczecin. Negative migration balances were found for the period in question for Zabrze, Wałbrzych and, less distinctly, for Rybnik. Once more let us emphasize the role of investment activities as the factor differentiating the types of urban population growth. This fact is illustrated by cities such as Katowice, Bielsko-Biała or Tychy (type C) on the one hand, and other urban units of the same size class in the Upper Silesian Urban Complex (types B and A) on the other, as well as by Kielce (type C) and Radom (type B).

The type of population growth correlates too with the functions urban units fulfill. The distribution of cities functioning as job centres or as residence areas shows that the stronger the former function (high positive balances of work-journeys) the greater the contribution of the migration component to the total urban population. An analogous correlation is certainly to be expected as regards the functional structure and the degree of its diversification.

Finally, the migration factor tends to promote the demographic development of cities, as can be seen from the comparison of the types of development with the growth-rates of urban units in 1971–5 (Table 4).

THE ROLE OF MIGRATION IN THE FORMATION OF THE STRUCTURE OF THE NATIONAL SYSTEM OF CITIES

One important problem in the analysis of the spatial distribution of population growth is the identification of the sources and areas of emigration to urban centres. At the present stage of analysis this problem can be represented on regional scale (for individual voivodships).

It has already been mentioned that the net balance of rural to urban migration in 1973–6 was almost 900 000 people. Figure 3 illustrates the proportions of each voivodship in that emigration. It appears that the largest "exporters" of the rural population were: the Kielce voivodship (4.1% of the nation-wide total emigration from rural areas), the Olsztyn voivodship (3.9%), and the Siedlce voivodship (3.7%). The spatial distribution of the size of that emigration (in absolute figures) by voivodships diplays high dispersion. Suffice it to say that the first ten voivodships

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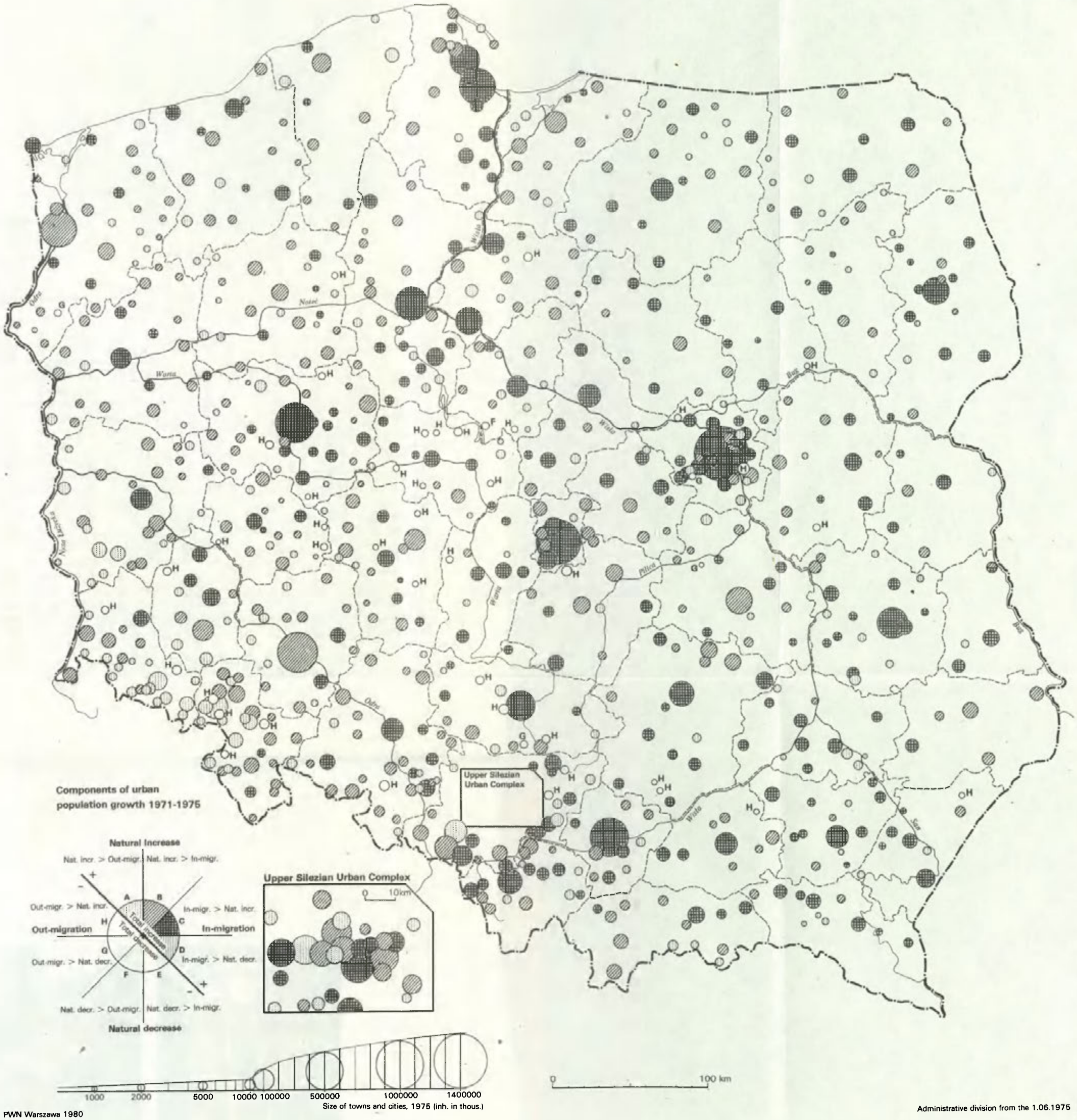

Fig. 2. Types of population changes in the urban system of Poland, 1971–1975

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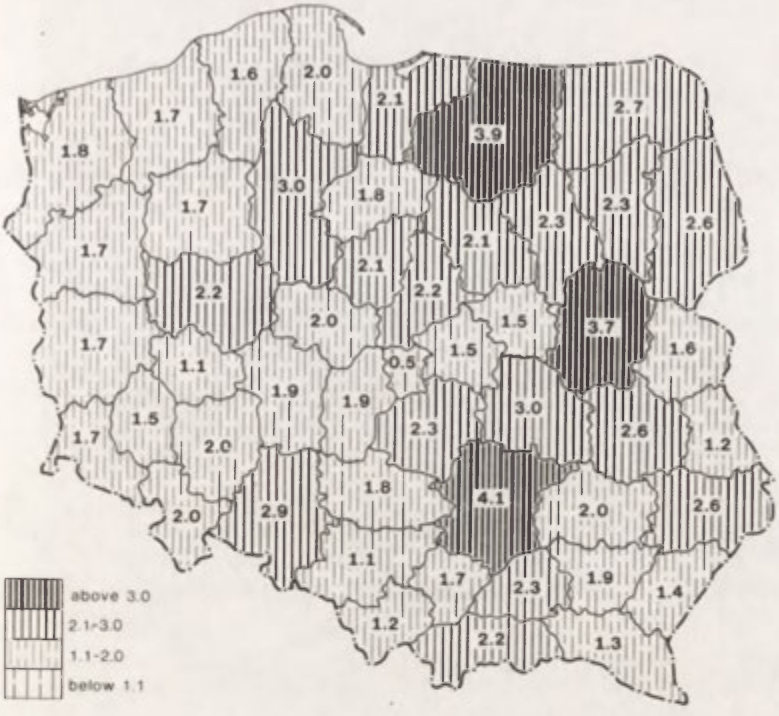

Fig. 3. Share of voivodships in the national rural emigration, 1973–1976 (national rural emigration = 100%)

characterized by the highest migration-induced losses claimed only one-third of the nation-wide emigration from rural areas.

The spatial distribution of the proportions of individual voivodships in the total in-migration to urban centres furnishes an entirely different picture (Fig. 4). In this case three voivodships alone (Warsaw, Katowice and Gdansk) concentrated nearly one-third of the nation-wide urban immigration, while the first ten voivodships accounted for as much as 56% of it. The highest immigration gains display a spatial correlation with the location of major metropolitan centres and areas of intensive industrialization more distinctly here than on the other maps. The Legnica voivodship (copper district) furnishes an outstanding illustration to this. Though none of the cities in that area exceeded the 100 000 population size, the proportion of the urban centres of the Legnica voivodship in the nation-wide immigration total was higher than for instance those for the Szczecin or Wroclaw voivodships (Szczecin 380 and Wroclaw 590 thousands of inhabitants respectively). But the case of the Legnica voivodship is still less of a surprise than that of the Olsztyn voivodship, which recorded a high immigration amounting to as much as those found for the Lublin or Bydgoszcz voivodships.

The spatially differentiated urban population growth due to immigration from rural areas has been more and strongly affected by urban-to-urban migration in recent years. Since 1975 onwards this type of migration movements rank second as to size in the pattern of population movements in the four main directions ($R \rightleftarrows R$; $R \rightarrow U$; $U \rightarrow R$; $U \rightleftarrows U$).

The structure of urban-to-urban migration displays a certain hierarchy in connection with the size (rank) of the urban units. Indirect evidence of this is the number

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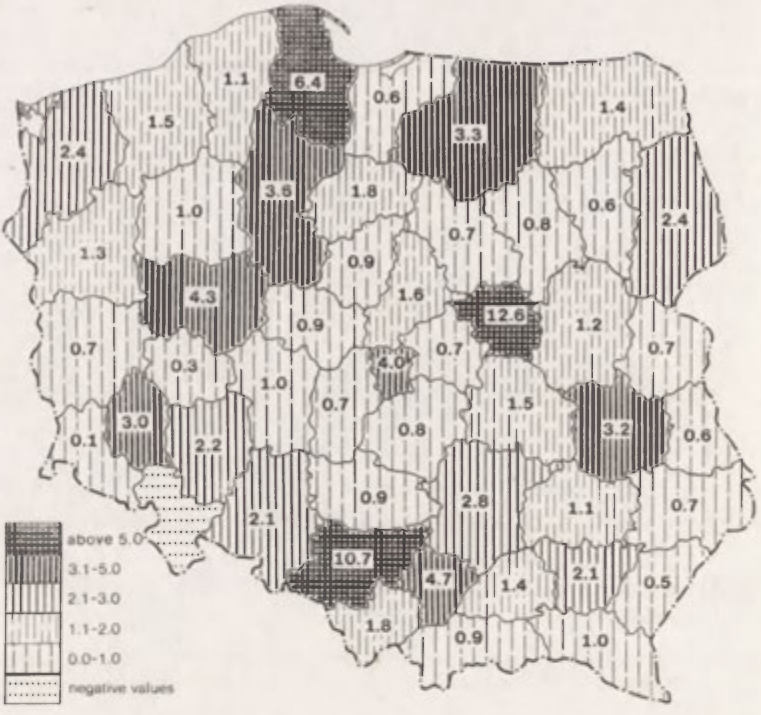

Fig. 4. Share of voivodships in the national urban immigration, 1973–1976 (national urban emigration = 100%)

of persons leaving a unit per 100 people arriving to settle in it or the measures of migration effectiveness (Table 5). These measures show that with growing urban size the indicator of emigration declines while the migration effectiveness rises too. The smallest units (with population less than 5000) afford especially conspicuous evidence of this relationship in that they record a nearly complete turnover of the migrating population (89 persons leave one such unit against 100 people settling there). This trend toward a rise in the emigration volume seems to be gaining in importance in this size class of cities. Whether or not this is really so can however only be established by analysing statistics for longer time series.

This trend does not recur in the 20 000–50 000 size class of urban units whose migration balances are close to those for the bigger size class of 50 000–100 000

TABLE 5. Number of persons emigrating per 100 new settlers and effectiveness of migration by size classes, 1971–1975

	City size (.000)						
	Total	Less than 5	5–10	10–20	20–50	50–100	more than 100
Persons emigrating per 100 newcomers	61.9	88.9	74.7	70.8	59.8	60.3	49.4
Effectiveness of migration	23.5	5.9	14.5	17.1	25.1	24.8	33.8

Source: Materials of the Central Statistical Office.

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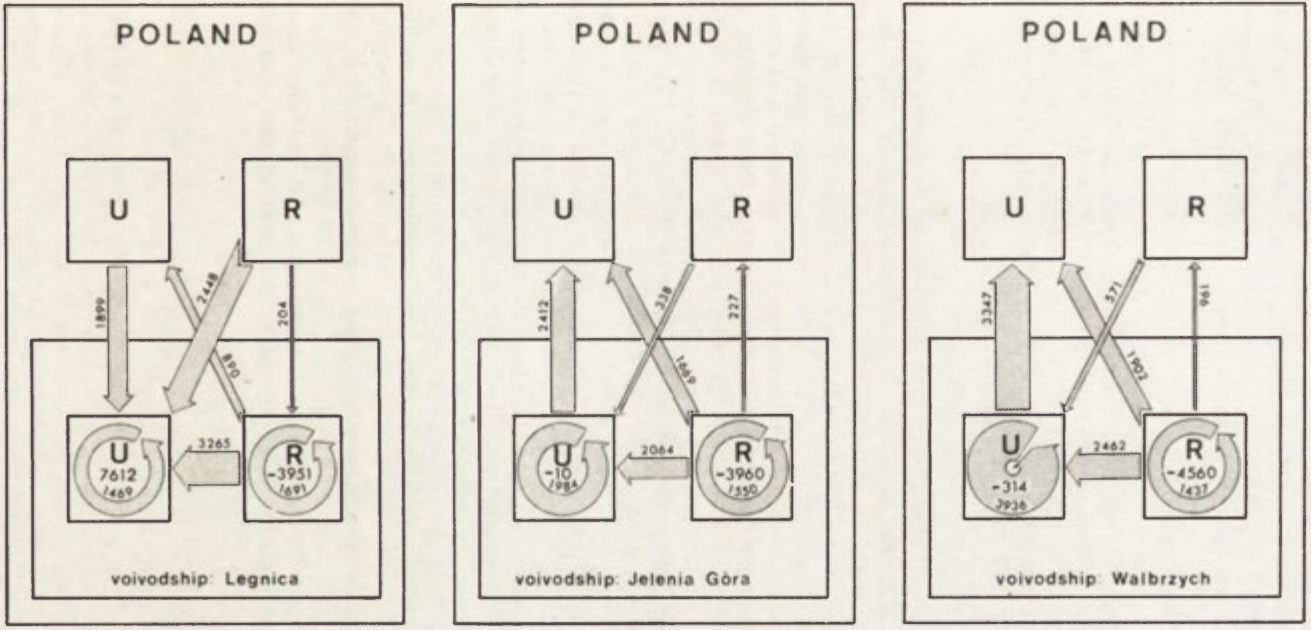

Type C **Type B** **Type A**

Fig. 5. Types of population changes and patterns of migration in: Legnica (type C), Jelenia Góra (type B), and Wałbrzych (type A) voivodships, 1976.

U – urban areas R – rural areas

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population. This is probably due to the occurrence of highly dynamic industrial centres with very absorptive labour markets in this urban size class.

Another exception to the above rule provide cities whose functioning and development rely on interaction and complementarity and which are situated in polycentrically patterned urban complexes. Nonetheless the high attractiveness of the biggest urban units as areas of terminal migration is however unquestionable, if we consider that the cities with more than 100 000 population account for nearly 50% of the total urban migration gain.

The problems of the relationships and interdependences between the structural characteristics of the various types and forms of settlement and their growth models on the one hand, and the direction, intensity and spatial structure of migration has only recently become topics of intensive research. Graphically the above problem is shown on the example of the cities of three neighbouring voivodships representative of extremely divergent types of population growth: the Wałbrzych (type A), Jelenia Góra (type B), and Legnica (type C) (Fig. 5).

* * *

The changes currently taking place entail a process of continual spatial reorganization of society and national economy. Within the context of the national urban system this manifests itself in definite shifts of the urban centres both in the structure of hierarchical links (changes in functional rank) and in that of spatial links. The current functional-spatial organization is driven by forces and mechanisms of competition and cooperation. The former consist in the strongest and most dynamic urban units endeavouring to prevail over the weaker centres together with their hinterlands. This tends to reinforce a division of Poland into functional urban regions whose centres most often are largest cities and agglomerations. Government policies are very important factor conducive to such divisions. The latter type of mechanisms in turn secure a cooperation of the various areas and contribute to their integration within individual regions as well as on national scale. Poland's urban system displays precisely this type of dual structure. It is marked by the coexistence of strongly integrated centres through specialized functions of weak hierarchical relationships (the effect of intensive industrialization as the dominant developmental trend in the post-war period) with service-type cities operating like typical central places (based on principles of threshold and extent).

If this field of study is cast against a wider international context we face an extensive range of research problems. The specific evolution of national urban systems which concur with definite stages of socio-economic development (these manifest themselves in definite models of urban systems organization: the frontier model, the industrial specialization model, or the social change model) is certainly bound up with definite phases of change in the vital and mobility characteristics of population. The analysis of these complex and multi-aspect inter-relationships seems to be an interesting domain of study.

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IMPACT OF SPATIAL ORGANIZATION ON THE DEVELOPMENT OF SYSTEMS OF TOWNS

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1. THE THEORY OF THE SPATIAL ORGANIZATION OF SYSTEMS OF TOWNS

In the science and practice of town administration much depends on the level of knowledge concerning the differentiation of towns by growth rate. Research is concentrated on the elucidation of laws governing growth rates, formulated precisely and definitely what ensures the forecasting of events arising as a result of settlement control measures. This level of perfection in forecasting methods became necessary in this field in connection with the elaboration in the USSR of new aspects of national economic planning in accordance with the 'Master Scheme of Settlement in the Territory of the USSR for the Period up to 1990' (Fomin 1976). Similar demands have been also made on science by administration in a number of other countries (Korcelli 1974; Lüdeman 1974).

Regrettably, in scientific literature so far there is no uniformity or the necessary precision in conclusions on the group features of populated localities with specific, say, maximum growth rates. The gamut of statements about Soviet towns with maximum growth rates is illustrated by the following:

a) "In the most general form, the town growth trend is this: the larger the population of a town, the more intensively it attracts population" (Pivovarov 1976, p. 36).

b) "Towns with a population ranging from 100 000 to 500 000 inhabitants rank first in absolute and relative migration balances. These towns ... have become the 'main figure' in urban settlement" (Davidovich 1976, p. 11).

c) "The highest growth rate (per 1000 people of the average annual population) is characteristic for towns with a population of 50 000–100 000" (Moiseyenko 1976, p. 30).

These statements, remarkably different, are given in this order to indicate the way to eliminate the contradictions and to demonstrate the increasing precision in the character of growth and of specific groups of towns.

A fuller and more comprehensive coverage of growth conditions makes it possible to draw more accurate conclusions concerning growth trends. At the same time, however, this increases the risk of getting lost in the numerous concrete types of change occurring in each of the populated localities. An essential condition for successful research is an orientation on theories containing an integral interpretation of events.

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Let us try to isolate a number of geographical theories with their geographically specific emphasis on shifts in the spatial organization of system of towns. Another aim of the article is to ascertain the contribution made by these theories to explaining the growth of existing systems of towns. This contribution is measured by using material on growth processes in three large systems of towns within the Ukraine, Poland and the German Democratic Republic.

The fulfilment of this task required the use of regressive and dispersion analysis and also computer-based iterative procedures for selecting the empirical formulae most suited to the theories. Operational representation of theories in the form of mathematical formulae has been carried out in many variants, with the calculation of measures (F – Fisher criterion) demonstrating the extent to which the facts correspond to formulae and theories. Tests were made of all variants admissible that considered the need to identify trends from among the 'noise' occurring in the bodies of actual data, according to the laws of statistical sampling. Thus, all subjective influences on the results have been eliminated as far as possible.

The term 'spatial organization of system of towns' is applied to two related, but different, phenomena: real performances of towns and their reflection in abstract scientific concept. In each case the context makes it possible to differentiate between them quite definitively.

With respect to the real performances of towns, let us agree on the following definition to be used in this article: The spatial organization of system of towns is expressed in the interconnected development of the elements of this system of towns, streams and channels of ties between them, with the advantages of the economic-geographical situation having a determining influence on the processes of the growth of elements.

Let us also formulate the definition we use as a guide in the field of the results and theories of the science: The spatial organization of system of towns is one of the aspects of the scientific interpretation of settlement, its dynamics and correlation with the laws of nature and society, when fundamental geographical concepts develop in accordance with the system orientation of science in the interest of integral analysis of urban development. This has the aim of elucidating the development patterns constructively applicable in practice, and also those manifestations of development of knowledge which contributes to the formation of an inter-disciplinary theory of complex systems with distributed parameters.

Both definitions are constructed as lists of the basic aspects of the subject matter, which ensures the reader the opportunity to judge the concepts forming the theoretical foundation of the given paper. These concepts are tied in with the main idea of the whole group of works being considered, that attempted to formulate geographical theories as definitively as possible (Medvedkov 1965; Topchiyev 1974; Blazhko and others 1977; Arkhipov, Grigoryev 1976). Which theories have been chosen for examination and empirical testing? The nature of the ideas that interest us may be defined as: 'fundamental' and 'geographical'. In order to choose something definite according to these traits, we have had to make a rather prolonged survey of current scientific results (1974–1976). The choice is based on a review of recent publications.

Virtually all the investigations we know of settlement and town systems may be reduced to three theories, each with its own approach to the identification of the spatial mechanism of the intra-system interaction between towns.

These three theories are set forth in the most explicit way in the works of the Polish geographers S. Leszczycki, K. Dziewoński and B. Malisz. In their initial formulation, these theories were connected with the tasks of working out programmes for planning and controlling the settlement system in Poland (Cf. *Geographia Polonica*, vol. 32), but go far beyond solving the concrete planning tasks for the country's

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settlement network. The concepts throw light on fundamental aspects of the organization of geographical space. One of the concepts stresses space structuralization under the impact of an entire totality of towns, the leading role played by a major centre. This theory deals with the forces of influence which fade very slowly as the distance from the initial active mass increases. Another concept lays emphasis on space structuralization under the influence of several urban agglomerations. This action is of a local character and spreads from active masses, fading rapidly. The third concept proceeds from the important role of mainline beams of ties established between the most active masses, compelling all other masses to gravitate towards these corridors of ties. Mainline ties are taken as fading very little.

Venturing to set forth the essence of the three theories in a very concise and general form, we have tried to show more clearly that real situations are rather combinations of all the three pictures of space structuralization. Each of the theories reflects but a part of reality. Thus these theories are each an attempt to conceptualize one component of space structuralization, and it would be useful to know the share of each component in every geographical system under examination.

Taking I to be the force of the active mass, for instance, the commodity output of a particular town, and R the remoteness from this active mass, all three macro-theories postulate $dI/dR \leqslant 0$, i.e., that the stream of influence does not increase with the distance; the macro-theory similar to K. Dziewoński's concept asserts, besides, that

$dI/dR < 0$; $d^2I/dR < 0$ – the absence of an asymptote to the line of the graph as it approaches the distance axis.

In the model fitting S. Leszczycki's concept, the assertions are different:

$dI/dR < 0$; $d^2I/dR < 0$ – slowness of the fading of streams with increasing distance from the source, including the possibility of asymptotic fading.

Lastly, the theory coinciding with B. Malisz's concept presupposes anisotropy of space in which $I = f(R, \beta)$, where β is the azimuth for the direction of the tie stream. It is stated that $d\beta/dR$ affects the sign of the second derivative $d^2I/dR < 0$ and the stream entering a corridor creates a situation where $dI/dR < 0$; $d^2I/dR < 0$, while outside the corridor the following is true:

$$\frac{dI}{dR} < 0; \quad \frac{d^2I}{dR} \geqslant 0.$$

An examination of the symbols used suggests that the three theories supplement one another exhaustively. The entire range of possibilities for streams which do not increase with the distance from active masses is covered. For this reason, it is hard for investigators of settlement systems to lose touch with the pivotal directions on which the theories are built.

The integrity of scientific results obtained in the study of settlement systems will improve, and the control recommendations based on them will be argued with more confidence, if a 'weight' making one of the three theories justifiable is given for each concrete national system of towns. It should be stressed that, in principle, none of the theories runs the risk of being rejected. Establishing the 'weight' of the theories means measuring one of the three components in the structuralization of geographical space, while the components are essentially so general that they are inevitably included by settlement with its structuralization of territory.

While stressing the theories' extremely general nature, also valid outside settlement phenomena, yet, at the same time, wishing to highlight the role of Polish scientists in

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their formulation, we propose, henceforth, to use the following symbols for measuring the 'weight':

L – concerns the structuralization of the country-wide system of towns in conformity with S. Leszczycki's concept; here the theory admits potential interaction between all settlements, with primacy of the capital and taking account of fading as space is covered;

D – reflects the structuralization of the country-wide system of towns in conformity with K. Dziewoński's concept; here the theory aims to embrace local ties around sizeable towns (in agglomerations) and, in particular, it reflects the commuting of the population, the maximum radius of which is restricted by the daily rhythm of human life;

M – embodies B. Malisz's concept, i.e., a theory in which the presence of streams in corridors of ties rests on the mutual exchange between towns of output created in accordance with the country-wide specialization of production nodes.

Our next task is to find measurable indicators for the components *L*, *D* and *M* in the structuralization of space, taken within the framework of the three country-wide systems of towns. The contribution of each of the components to explaining the rate of population growth in individual towns between the last censuses is then defined.

2. THE METHOD FOR MEASURING COMPONENTS

The method used always depends on the specific features of the object and the required precision of results. Precision requirements are a priority, for the more confidence the 'weight' is assigned to the components *L*, *D* and *M*, the greater is the possibility of using each of the theories for settlement control. If we do not know the relationship between the components *L*, *D* and *M*, the application of the theories risks the settlement system responding to control actions when not required and with unexpected force.

It was easier for us to obtain exact results for those of the three country-wide systems of towns that had been studied earlier (Medvedkov 1975a, b, c). In this case the choice of variables characterizing the components *L*, *D* and *M* could be based on the earlier factor structuralization of large bodies of information and on a multi-dimensional typology of all towns. All this applies to all the towns of the Ukraine, Poland and the GDR, which may be regarded as sufficiently representative for drawing new conclusions about the contribution of the components *L*, *D* and *M* to the structuralization and development of the settlement system.

In an earlier investigation the areal unit, which may be defined as a country-wide system of towns, included 175 towns for the Ukraine, 79 towns for Poland and 105 for the GDR. The study covered all towns with a population of over 20 000 at the last census; in the case of Poland it was required that a town had the status of poviat (this is connected with the availability of regularly collected and published statistical data).

For the present task a more limited list of towns was taken: 25 for the Ukraine, 17 for Poland and 15 for the GDR. The framework of national systems of towns formed by administrative centres of regions (Ukraine), voivodships (Poland) and districts (GDR) is studied. In all these cases, the role of the administrative centre coincides with that of chief economic node within the corresponding region, voivodship or district.

We judge the weight of the components *L*, *D* and *M* by the response of the system of towns in its development. As a characteristic of the development of a system we use *T*, the rate of change in the population size of each town. The calculation of *T*

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covers sufficiently long periods of time to exclude short-term fluctuations in urban population size. For the Ukraine, the values of T refer to the period from 1959 to 1970; for Poland, from 1960 to 1971, and for the GDR, from 1964 to 1973. Each value of T taken separately characterises a particular town, not the system of towns as a whole. The values of T had to be generalized in such a way as to reveal the trend for a system of towns as a whole. This was done by using a regression model.

The suitability of formulae was checked by dispersion analysis, which reveals the deviations of individual towns from the trend expressed by the regression surface or the line of response. The sum of the squares of such deviations is compared with the sum of the squares of deviations taken care of by the surface or line of response. Necessary adjustments are made for the cumbersome regression formula and for the total number of observations used in the calculations. Taken as a whole, all this leads to the well-known F criterion (Fisher).

This criterion was applied in such a way as to ensure that the decision on the adequacy of a formula took the form of a test of the statical hypothesis, with the aim of making the analysis more painstaking. The risk of a deviation of suspicions on the unsuitability of formulae, when such suspicions are correct, exceeds a 0.05 probability.

The method for determining the weights of the components L, D and M is based, wherever possible, on objective calculation procedures used in the exact sciences for processing empirical material. The risk of subjective decisions is represented chiefly in the proposed set of indicators for the components L, D and M. Use is made of an informative set of indicators with magnitudes that are measured with great precision. This does not, however, rule out the existence of better indicators for rendering the essence of L, D and M.

Two indicators reflecting the situation for the remote ties potentially possible for every town in the system are used for the L component:

R – the distance to the capital measured by rail;

V_s – the potential of the settlement field calculated by the formula:

$$jV_s = \frac{H_i}{R_{ij}}$$

where H_i is the population size of the i-th town;

R_{ij} is the distance from i to j. Let us recall that V_s is taken as a measure of advantage in the geographical position in the urban settlement field. To stress the aspect of attraction due to the action of the masses of the population outside a given town, it is assumed that $R_{ii} = \hat{\infty}$. Thus, V_s is calculated in the form of an *induced* potential (Lipets, Chizhov 1972). Concerned with the informativeness of V_s, we made calculations including information about the population size of all towns with a population of over 20 000, i.e., 175 towns for the Ukraine, 79 poviat centres for Poland, and 105 towns for the GDR.

The indicator for the D component has been selected in such a way as to reflect the situation for effecting the short ties of the administrative centres of regions, voivodships and districts. Let us again use the potential of the settlement field applying as a magnitude

V_e – the potential of the local settlement field, calculated on the basis of all towns with a population of over 20 000, but within the limits of the corresponding region, voivodship or district.

The calculation formula for V_e is similar to that for V_s, but it is assumed that $R_{ii} = 1$. This ensures calculation of the complete potential, with emphasis on the

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'pull' of regions, voivodships and districts. In the calculations we also tested two other indicators for the component:

O – the number of beams of roads and railways extending from a town;

A – the coefficient of agglomeration, i.e., the number of neighbouring towns with a population of over 20 000 within a radius of 60 km.

In none of the cases did the indicators O and A lead to suitable regression formulae for having their influence on the town growth rate. They were not, therefore, included in later experiments in the successive choice of the most important components and their indicators.

As an indicator for the M component calculation was made of a magnitude borrowed from the works of transport geographers, who resort to the theory of graphs to characterize mainline and nodal advantages of towns in the network of main roads (Vasilevsky 1964). We employed the Konig number, also known as the measure of deviation or eccentricity (Hagget, Chorley 1969; Harari 1973, p. 51), but modified it by metrization. The indicator was tried:

W_1 – metrizated Konig number given by the formula:

$$W_{1i} = (K_i \times R_{ij})/(H_i \times H_j),$$

where K is the maximum number of towns in the studied system to be avoided along the shortest routes leading from a given town to the town most distant from it; R_{ij} is the distance of the closest neighbourhood by roads of the highest or next category (km); H_i – the population size of the town to which the value of W_{1i} refers; the size of the population of the nearest neighbour is designated by the symbol H_j (,000). Experiments in selecting the non-metrizated indices proposed in the ·v of graphs to characterize the M component were not successful. Thus, formulae to determine the weight of the M component were not suitable.

der to define the contribution of components about 150 regression formulae ɔ be calculated. We used the method of exclusion of multiple regression, ,ich is justly characterized in handbooks on applied regression analysis as being ɜimilar in effect to step regression (Draper, Smith 1972). On the whole, calculations required 20–25 hours of working sessions with the HP9810A computer. The preparation of programmes took much longer, but the effort will not have to be repeated later.

3. RESULTS

Prior to discussing general results, let us use one small example to demonstrate the succession of regression formulae and indications obtained and expressed in the F criterion, concerning the adequacy of particular statements about the weight of components. The illustrations refer to a Polish system of towns consisting of 17 voivodship centres.

1. The combined effect of the components L, D and M on the town growth rate is $T = 0.5948 + 0.21496\ W_1 - 2.321\ (E-4)\ V_e - 1.227\ (E-4)\ V_s - 2.037\ (E-4)\ R$;

71% of the dispersion of T is covered, as indicated by the determination coefficient $R^2 = 0.707$; the adequacy of the formula is high, as shown by the F criterion equal to 7.234, exceeding the 'threshold' tabulated value of $F = 3.26$ (for a 5% risk of unjustified trust in the formulae with four T pre-indicators and 17 initial observations). The order in which the components, L, D and M are represented by their indicators in the formula does not have any effect on the figures $R^2 = 0.707$ and $F = 7.234$; it can only be felt when some indicator is excluded. The reason is the correlation between indicators shown in Table 1.

Multicollinearity thus complicates the calculations, but its effect on the precision

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TABLE 1. Correlation between indicators of components in Poland

	W_1	V_e	V_s	R
W_1	1	−0.491	−0.651	0.497
V_e	−0.491	1	0.783	−0.489
V_s	−0.651	0.783	1	−0.772
R	0.497	−0.489	−0.772	1

with which the regression coefficients are determined is weakened by the electronic computer's capacity to operate to 12 decimal places at all stages of the calculation and also by the statistical normalizing of all magnitudes provided in our programme.

2. Indicators R and then V_s must be excluded from the formula, because their residual share of coverage of the dispersion of T is small, as shown by the values of partial F criteria. In the formula with four indicators for R, $F_R = 1.36$; after the exclusion of R, when V_s occupies the last place, its partial criterion $F_{Vs} = 2.43$. We get a formula reflecting the influence of just two components (M and D) on the rate of town growth: $T = 0.4125 - 0.8264\ W_1 - 3.242\ (E - 4)\ V_e$. This covers 61% of the dispersion of T with $R^2 = 0.6125$, and the adequacy of this more compact explanation of trends for T is now higher than before: $F = 11.07$, with the tabulated level of 3.74.

3. A still more compact explanation of trends for T is obtained by excluding the indicator W_1. Despite the fact that, in covering the dispersion of T this indicator appears first in the calculations, in the competition between components M and D it had the lowest partial criterion $F_{W1} = 7.91$, while $F_{Ve} = 14.23$. We get a formula reflecting the contribution to the trends of T made by the D component and also the indirect influence of components L and M reflected in this component: $T = 0.4346 - 3.4945\ (E - 4)\ V_e$. In this case 60% of the dispersion of T is covered by $R^2 = 0.6028$. The value of the F criterion more than four times exceeds the threshold tabulated value: $F = 22.76 \gg 4.54$. In applied regression analysis, as shown in the works by Box, Draper and Smith, this excess makes it possible to recommend the formula in forecast calculations with certainty (Draper, Smith 1973). The applicability of the D component, reflected by the indicator V_e, for forecasting the growth of towns is a result of substantial practical significance.

Changing the succession of indicators in calculating regression formulae, as already explained in part 2, we obtained the results shown in Table 2.

It should be noted that only the system of towns in the Ukraine is characterized by separation of the components L, D and M, which explains trends for T with any succession of indicators and with a gradual transition from the formula with four indicators to that with one indicator. This primary observation, based on a summary of the results in Table 2, has very general and practical important consequences. In town administration practice it is necessary to have methods for forecasting town growth. In this respect, Table 2 reveals a considerable difference between the systems of towns of the Ukraine, Poland and the GDR.

A high precision of forecasts for the Ukraine may only be achieved by the joint use of the three theories. On the other hand, in Poland, compact formulae for forecasting are difficult to obtain through the joint use of the theories. At the same time, equally precise forecasts are guaranteed for Poland by formulae characterizing the contribution of the L and D components separately. For the GDR it is equally difficult to combine the three theories within the framework of regression formulae, and only indicators for the L component guarantee a sufficiently precise interpretation of trends for T, making possible the use of the corresponding formulae for forecasts.

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TABLE 2. Established contribution of components L, D and M to the growth of towns in the Ukraine, Poland and the GDR

Components and their succession	Component indicators and types of regression	R^2	Adequacy	
			F	F tab.
Ukraine (a system of 25 regional centres):				
M, D, L	$T = f(W_1, V_1, V_s, R)$	0.667	**9.99**	2.87
M, D, L	$T = f(W_1, V_1, R)$	0.641	**12.5**	3.1
M, D, L	$T = f(W_1, R)$	0.318	5.13	3.44
M	$T = f(W_1)$	0.278	7.95	4.28
D, L, M	$T = f(V_1, V_s, R, W_1)$	0.667	**9.99**	2.87
D, L, M	$T = f(V_1, R, W_1)$	0.641	**12.5**	3.1
D, L	$T = f(V_1, R)$	0.318	5.14	3.44
D	$T = f(V_1)$	0.294	9.54	4.20
L, M, D	$T = f(V_s, R, W_1, V_1)$	0.667	**9.99**	2.87
L, M	$T = f(V_s, R, W_1)$	0.514	7.39	3.03
L	$T = f(V_s, R)$	0.318	5.14	3.44
L	$T = f(V_s)$	0.294	9.54	4.28
Poland (a system of 17 voivodship centres):				
M, D, L	$T = f(W_1, V_1, V_s, R)$	0.707	7.23	3.26
M, D	$T = f(W_1, V_1)$	0.612	11.07	3.74
D	$T = f(V_1)$	0.603	**22.76**	4.54
L, M, D	$T = f(V_s, R, V_1, W_1)$	0.707	7.23	3.26
L, D	$T = f(V_s, R, V_1)$	0.707	10.42	3.41
L, D	$T = f(V_s, V_1)$	0.605	10.41	3.74
L	$T = f(V_s)$	0.596	22.11	4.54
M	$T = f(W_1)$	0.265	4.11	3.681
GDR (a system of 15 district centres):				
L, M, D	$T = f(V_s, R, W_1, V_1)$	0.604	3.82	3.48
L, D	$T = f(V_s, R, V_1)$	0.603	5.58	3.59
L	$T = f(V_s, R)$	0.600	9.02	3.89
L	$T = f(V_s)$	0.582	**18.17**	4.64
M, D, L	$T = f(W_1, V_1, V_s, R)$	0.604	3.82	3.48
M, D	$T = f(W_1, V_1)$	0.454	4.99	3.07
D	$T = f(V_1)$	0.440	10.31	4.28
M	$T = f(W_1)$	0.179	2.85	3.81

Note: Shown are all results of calculations making it possible to define the contribution of components with certainty, as indicated by data on the F criterion. The last line alone gives a negative result, indicating a small weight of the M component as reflected by the W_1 indicator for the system of towns of the GDR under investigation.

In evaluating the forecasting capacity of the formulae given in Table 2 we proceed from the following postulate established, perhaps in the most distinct form, by D. M. Wetz who worked under Box (1964): "For an equation to be considered satisfactory for the purposes of forecasting (in the sense that the range of predicted values of response will be considerably greater than the standard response error), the observed value of F... should not just exceed the selected percentage point of the F distribution, but exceed it *approximately four times*" (Draper, Smith 1973, p. 74).

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The ability to forecast the growth of towns on the basis of the indicators for the components *L*, *D* and *M* that were tested stems directly from the information, contained in the indicators, about the individual contribution of each of the three theories to the interpretation of the town growth mechanism.

Table 2 gives an idea about the overlapping influence of the *L*, *D* and *M* components on the growth of towns:

	Ukraine	Poland	GDR
L indicator taken separately explains *T* by	29%	60%	60%
D indicator taken separately explains *T* by	29%	60%	44%
M indicator taken separately explains *T* by	26%	27%	18%
All indicators combined explain *T* by	67%	71%	60%
The sum of separate explanations shows an overlapping of	17%	76%	62%

It must be explained that all the figures characterize the coverage of the dispersion of *T* in a particular system of towns, where it naturally amounts to 100%. The sum of the three separate explanations suggested by indicators *L*, *D* and *M* would be 84% for the Ukraine, if there were no overlapping. We know, however, that the joint coverage of the dispersion by indicators *L*, *D* and *M* is lower than 84%, equalling 67% (29+29+26 minus overlapping). Thus, it is possible to calculate the values constituting the bottom line in the Table.

Information about the overlapping influence of the components again points to differences in the organization of the three systems of towns. For the Ukraine, this overlapping is minimal, for Poland it is very great, and for the GDR slightly lower. This result must be taken into account in administration measures aimed at influencing one of the components separately.

Indeed, if there is a considerable overlapping, any measure altering one component will be weakened by the continuing considerable influence of the other two. The internal inertia when isolated actions are taken on the components in the three systems of towns is, evidently, rather different. It is high in Poland, slightly lower in the GDR and relatively small in the Ukraine. Changes in one of the components only make sense in relation to Ukrainian towns, but are hardly justified in Poland or the GDR. What is needed it is coordinated change in all components simultaneously.

4. DISCUSSION OF THE RESULTS

Discussion of the results obtained arises in connection with the desire to supplement scientific recommendations for the sphere of settlement control. To what degree is it possible to control the development of towns by intensifying or weakening the components *L*, *D* and *M*?

Control of the settlement system means something more than just planning measures in relation to separate links of settlement. Earlier, in discussing Table 2, we have already pointed out common features of the location and size of towns in the Ukraine, Poland and the GDR, which is more or less successful in attempts at influencing just one of the three components. A concrete numerical expression has been found for the specific features of the organization of systems of towns: contrasts in the influence of the components and the overlapping of influences. Apparently, proofs have been received with a high degree of reliability and initial information

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and processing methods, showing the need for two different approaches to town growth control. The first approach promises well for the Ukraine, but not for Poland or the GDR. This approach is isolated action on one of the three components. This action is more easy to organize and ensures a high effect and better manageability of resources channelled to a particular limited sector. Besides, it is possible to choose the best correlation between inputs and results required in the rate of urban growth.

As an example, which is purely illustrative and not, therefore, supported by calculations of input and effect, let us point to the relative ease of measures to intensify the *D* component in the system of towns. Effective measures consist in improving suburban transport, managing building lots, encouraging the integrated development of enterprises and all manner of ties within agglomerations. This may have the same effect on the growth of towns as other more capital-intensive and slow transformations (e.g., a considerably higher density of the road network or development of a network of new towns).

Comprehensive action on all the three components, despite its complexity, evidently becomes inevitable at certain stages in the development of town systems. The completeness of the information used about systems of towns in Poland and the GDR is doubtful. This information leads to the conclusion that comprehensive actions on all the three components in the settlement systems of Poland and the GDR play an important role. But this conclusion must be taken as tentative, the last word here belonging to students of settlement systems in these countries. They have, of course, a fuller and deeper grasp of the problems of their own countries and possess the necessary information support for drawing conclusions. Our calculations are an attempt to outline directions of research; practice and science tend to examine the processes of settlement development in different aspects arising in many countries.

The present research convinced the author that the three macro-theories enabling us to see the *L*, *D* and *M* components in the development of systems of towns are highly promising and universal. It would be useful to extend the range of countries to be investigated. This is particularly important in connection with the formulation of conclusions with a practical orientation.

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DEVELOPMENT OF SETTLEMENT SYSTEMS IN RURAL REGIONS OF THE GDR

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Rural areas in the GDR are making rapid progress, as regards both their economic and social development. On the one hand, there is a continuing process of industrialization which has reached impressive dimensions in some locations as a result of intensification and extensive growth. On the other hand, there are the qualitative changes in agriculture which make a major contribution to this progress. The rapid transition to industrialized farming creates new conditions for the development of the productive forces and the settlement structure. As work has changed, requiring new standards of education and training, so have the needs of country dwellers which are now more or less the same as those of people living in cities. A contributing factor has been the change in the employment structure which occurred during the post-war years. With the massive exodus from the country more people are now working outside agriculture, since the proportion of human labour in the agrarian production process has continuously decreased. These new jobs of a non-agricultural character were either made available in the locality, or people started to commute to the cities. The picture of the village has changed profoundly, and many new facilities have been added to its infrastructure in answer to the multifarious needs of people. An intensive pattern of exchange exists with the cities, and public transport is available for those who cannot satisfy specific needs in their locality.

Despite all these advances there still exist certain regional differences in working and living conditions. For one thing, the transformation of agriculture has not yet been completed. There is still a lack of facilities to satisfy a number of needs in the countryside, and the existing facilities are not always sufficiently equipped. For practical reasons, not all the public transport can be provided that would seem necessary. However, in view of the progress made so far, and this includes the economy, it appears to be realistic to seek to overcome the last remaining differences between town and country and between various regions in the GDR. A contributing factor in this connection should be the higher level of consciousness among the population which would induce people to help shape their living conditions not only in the immediate neighbourhood but also beyond it.

This will go some way towards implementing the policy adopted by the 8th and 9th Congresses of the Socialist Unity Party (SED) in its *regional aspect*. The social implications of this policy have, in recent years, required a great deal of research into questions of the settlement structure in general and problems relating

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to the rural areas in particular. At the same time, a wide field has opened up for geography and its social aspects.

One of the central issues in this connection is that of the settlement systems, their development and rational organization. It is part of the wider process of urbanization which is going on in all parts of the country, but the following deals especially with the northern part of the GDR.

THE CENTRES

The efficiency of settlement systems depends to a large extent on their centres and particularly the bigger urban cores which play an essential part in the development of the productive forces. It is the size, infrastructure and dynamics of a centre, and therefore its influence, attractiveness and diffusion of innovation patterns, which more or less determine the entire settlement structure of a region. At the same time the centres are responsible for most of the concentration of people and urbanization itself.

City-hinterland studies conducted in the GDR have brought to light considerable regional differences between rural areas and other parts of the country, particularly with regard to the distribution, functions, infrastructure and accessibility of efficient centres.

A look at the cities in categories 1 and 2 (see Kluge 1975; Ostwald 1975) established in the macrostructure of the settlement network in connection with strategic settlement structure planning shows that they lag behind expectations in one important point – their distribution is not so equal as to make it possible for everyone living in their hinterlands to reach them in about 60 minutes net travelling time (which is considered justifiable).

On the other hand, neither the economic nor the demographic conditions (limited population growth) seem to exist for giving very many centres, e.g. all *Kreis* towns, the status of relatively developed nuclei of production with an advanced infrastructure and, possibly, educational or research potential.

It would, therefore, seem logical to *select* from these *Kreis* towns a number where investment should be concentrated and where the hinterland has the potential for providing a continuous influx of people settling in the centre. These would form "basic centres" or cores of settlement systems into which the other centres would be integrated with regard to their function or priority. At this juncture it is worth noting that even in areas with a stronger agrarian structure the principle of the hierarchy of central places is becoming ever less valid. The systems of regional relationships become more complex, and settlement systems achieve a degree of relative openness. Nevertheless, the above-mentioned approach can still provide useful guidance in the planning of settlement systems.

The *Bezirk town* obviously heads the hierarchy in a *Bezirk*, not only because of its administrative status and the related concentration of functions, but also due to a systematically developed production function and infrastructure. Up until the 1960s Neubrandenburg and, in some respects, Schwerin did not dominate the settlement system in their *Bezirk* sufficiently to play such a role. In rural areas there seems to be a kind of regular pattern in that they require an outstanding centre for a given *Bezirk*. When one looks at the example of the *Bezirk* of Rostock which has a relatively high degree of urban concentration, and when one considers similar rural areas in northern Poland, the Baltic Soviet Republics and southern Sweden, then the rule seems to be that the *Bezirk* town, or its equivalent, should concentrate within its limits between one-fifth and one-quarter of the total population living in the area which it serves. Neither Schwerin nor Neubrandenburg have as yet achieved this

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status, but their fast rate of development indicates that they will soon have the functions, and population, to fill their role.

The following applies to the development of settlement systems around *Bezirk* towns:

– There are several degrees of intensity of impact on the hinterland, the outer limit coinciding with the border of the *Bezirk*. Any influence beyond this line (as is the case with Rostock) is due to the specific location of the centre.

– Adjacent districts with small *Kreis* towns become directly involved in the *daily influx* of people into the *Bezirk* town.

– The small towns in the daily commuter area which have no *Kreis* town functions change their structure to become residential satellite towns, in some cases with subcontracting industries.

– Patterns of suburbanization emerge even in areas whose historical and geographical development in the past has not provided any basis for this[1].

– In connection with suburbanization there is a trend toward a differentiation of spatial population development according to hinterland zones.

The next category is that of the Kreis towns which, at first glance, would seem to be of equal standing, due to their basic functions, resulting from the administrative structure of the state and society. However, the vast differences in population, between 5000 and 75 000 in the northern part of the GDR, indicate a considerable variation in the degree to which these towns can serve their hinterlands.

Three groups of *Kreis* towns can be identified, in the light of their weight in a settlement system built around them, and in which they have a minimal function as administrative centres:

(a) *Kreis* towns whose importance goes beyond the *Kreis* (district) and sometimes rises to the level of the *Bezirk* (county), e.g. Stralsund, Wismar, Greifswald and, to some degree, Güstrow and Neustrelitz. These have a *wider hinterland* which includes parts of neighbouring districts and, with regard to some functions, whole neighbouring districts. Apart from the Bezirk town they are the centres of industrialization (present examples include Greifswald and Güstrow) and, together with the latter, they account for nearly all the establishments of research and higher education in the northern part of the country.

(b) Fully developed centres of a *Kreis* which clearly dominate their administrative district.

(c) Less fully developed centres of a *Kreis* whose administrative district is more or less integrated in higher-ranking settlement systems.

In contrast to the more densely settled areas of the GDR there are so few centres with a diversified infrastructure and range of functions (*Bezirk* towns and *Kreis* towns of group (a)) that wide areas can be found which cannot be integrated at all, or only insufficiently, into the settlement networks of these centres (so that travelling time is no longer than 60 minutes). This makes it necessary to develop more *Kreis* towns to give them a status which would come close to that of centres in settlement category 2.

It would seem desirable to adopt specific measures in the case of two *Kreis* towns of group (b) in the *Bezirk* of Rostock, three to four in the *Bezirk* of Schwerin and six to seven in the *Bezirk* of Neubrandenburg so that they could form, together with the above-mentioned centres, a *basic network* of cities. This would produce catchment areas enabling the remaining districts to enter into reasonable relations with the basic network cities, as regards both distances and travelling times.

[1] It should be noted that this otherwise widespread phenomenon was very limited in the GDR during the postwar years, for a number of reasons. Thus communities in areas around larger cities where big estates had prevailed in the past had only negligible numbers of commuters until the 1960s (e.g., around Wismar, Güstrow, Greifswald, Neubrandenburg).

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A number of cities in group (b) have already been assigned the role of centres according to settlement category 2 (according to Kluge, 1974) and work is proceeding to strengthen their structure and especially their production functions (Parchim, Prenzlau, Waren).

With only a small degree of variation from *Bezirk* to *Bezirk* the average area these centres would serve in the basic network is 1280 km^2. In the case of the smaller towns settlement systems of this size cannot really be described as viable. On the other hand, this is the minimal area required, in the light of the low population density prevailing in these regions, which has the number of inhabitants (approximately 50 000) necessary for central functions of a higher order to be concentrated in these towns. At the same time there would be then the potential for these centres to grow to the status of medium-seized towns (population above 20 000).

In contrast to the southern part of the country, where a comparatively dense network of medium-sized towns is available for development as centres of the next lower order after the *Bezirk* town, a great deal remains to be done in the agrarian regions, where from the large number of small towns some will have to be selected which would be developed as medium-sized towns, sufficiently equipped to serve as centres in *settlement systems covering more than one Kreis.*

The principle, therefore, should be one of "decentralized concentration". The limiting factor here is the number of people living in these areas who can be concentrated only by way of *redistribution*, usually through the allocation of jobs and housing.

As a result of the overall decrease in the population there is only a limited potential for development, and this is why *continuous* growth cannot be expected for *all Kreis* towns. However, housing construction continues to be concentrated in the small *Kreis* towns too, including those in group (c). These have secured stable populations for themselves in recent years, a situation which should continue into the future. In some cases industrial production is responsible for a period of accelerated growth which then makes a *comparatively strong* impact because of the small size of the town. As a rule such expansion will be due to the tapping of local resources, especially of female labour, by existing establishments. On the other hand, towns of this size can be expected to feel the effects of rationalization in a socialist agriculture, which play a decisive role in the next lower categories of centres. All this helps to stabilize their position in the settlement system of the *Kreis*.

The latter is true only to a limited degree for *Kreis* towns which are situated more or less in the hinterland of *Bezirk* towns (Bad Doberan and Ribnitz-Damgarten near Rostock, Gadebusch and Sternberg near Schwerin, Altentreptow and Strasburg near Neubrandenburg).

The area served, or to be served, by a centre in the basic network is much too large for the latter to dominate the employment structure. Especially in the peripheral parts the need arises for *supplementary centres* which should offer an *industrial pattern of employment*. This role is now being filled by a number of small towns with populations between 8000 and 13 000 and, of course, the remaining *Kreis* towns which are not part of the "basic network". These are centres of employment having positive balances of commuters and serving about 20 000 people.

The next group of *small towns* is clearly of a lower order with regard to regional impact, most of them with populations under 5000. This group accounts for the majority of urban settlements which originated from country towns as they were usually situated in underdeveloped agricultural areas. Their functions were fairly equally distributed and included general services, small industries, markets and accommodation for rural workers.

As a result of changes which have taken place in the agrarian regions of the

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GDR there are now considerable differences between the individual towns in this group, as regards their economic structure and their position in the settlement system. The structure of these towns if characterized by the following:

– a strong agricultural basis whose statistical order of magnitude, however, often depends on "arbitrary" incorporation,

– a comparatively similar infrastructure which, as a rule, dearly reflects the services rendered to the hinterland,

– high negative balances of commuters in almost all cases, and

– a certain industrial basis consisting of small and medium-sized establishments.

All these elements are represented in varying degrees so that this group of towns can be subdivided into certain types (see v. Känel 1975).

Nearly all of these country towns below the level of *Kreis* towns are important cores for a large number of rural settlements. They have emerged in the course of history to serve a specific hinterland which may cover parts of a *Kreis* which vary in size. Together with this hinterland they form "elementary systems" or "micro-systems" in the settlement structure of rural areas (cf. Albrecht 1972; v. Känel 1970), i.e. settlement systems of the lowest order which retain a comparatively high degree of cohesion.

On the one hand, the country towns satisfy the elementary needs of the rural people living around them for *urban communication* and are centres of urbanization in purely agricultural areas. On the other, they depend strongly on centres of a higher order, usually their *Kreis* town, which makes their settlement systems open, to a certain extent.

The commuter balance in these towns is often negative despite a sometimes considerable influx of labour from surrounding communities, because the nearest centre of a system of a higher order in turn attracts large numbers of commuters. In one respect this expresses the structural changes affecting these towns, but it also results from a decentralization of many new functions after 1945 to a number of *rural* settlements. This has led to a degree of instability in the micro-systems, a decrease in population and the phenomena which have been discussed in the literature as "the problems of the small towns".

Recent development guidelines for the settlement structure have clearly defined the role of the country town within a region. The towns in this group almost invariably belong in category 4 (according to Kluge, 1975) and therefore, as rural settlement centres, have a key role to play in catering for the needs of the rural people and, not least, in production. The transition to industrialized methods in socialist agriculture changes the rural settlement structure and centres mainly on the country towns. These become the sites for production installations, agricultural services and food processing establishments, and headquarters for specialized co-operative farms and state-cooperative crop production units. In this connection they also become eligible as centres of associations of parishes. For many of them this has meant a rise in status, and some have even extended their hinterland. Housing construction and private home-building are carried out on a larger scale, and even though regular growth is limited by time, a stable population would bring a reversal in the situation. This desirable because latent migration pressure exists in the light of the close affiliation to jobs in higher-order centres. However, migration losses could then be compensated for by attracting people from the hinterland in the course of the process of concentration.

Not all country towns will diversify their functions equally. A certain amount of commuting will be retained and justified in the future. Industrial production sites retain their importance, and a trend can also be seen towards expansion or the establishment of manufacturing sites offering jobs specifically for women. This is because the country towns are in a critical position when it comes to *daily commuting*,

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and already the proportion of women commuting to higher-order centres is falling.

Apart from these towns there are a number of rural settlements which provide central functions to a varying extent. A relatively integrated "basic infrastructure" (cf. Kluge 1975) seems to exist in settlement category 5 comprising large villages which are the most important centres of production and infrastructure after towns. Some of these owe their comparatively central position to a long process of small town development in areas remote from towns, but most were assigned certain functions according to plan after 1945. There are many more settlements providing individual functions for several communities, but the pattern is not as integrated as in the centres. A variety of relations have thus developed between communities through a division of labour, which do not always conform to a hierarchy.

THE HINTERLAND

The rural settlements are part of the hinterland of the urban centres which can themselves belong to a hinterland, depending on their position in the system.

Hinterlands can be differentiated depending on the situation and infrastructure of the settlements, and zoned to express the intensity and radius of central functions (cf. the contribution of Krönert). Their dialectical interaction with the centres creates settlement systems of differing structure, order and cohesion.

The following hinterland categories can be identified for the agrarian regions considered here:

1. The "immediate hinterland" – it occurs with respect to all urban centres, primarily in two stages of dimension/integration:

– The immediate hinterland around towns which do not have the status of a *Kreis* town, where the Size is limited and where some functions are performed by a *Kreis* town; this means that the settlement systems are comparatively open.

– The immediate hinterland around the *Kreis* towns, which has a larger area and is more strongly orientated toward *one* centre.

2. The area of the Kreis – this must be given the status of a hinterland category in view of the multitude and importance of functions performed by the *Kreis* town, and of the fact that the boundaries of the *Kreis* represent significant passenger traffic divisions.

3. The "wider hinterland" – it comprises well-defined areas outside the district around a *Kreis* town and is thus an indication of the *regional status* of such a town.

The *Bezirk* towns have closer relations with their hinterlands, which end at the boundaries of the *Bezirk*.

The centre and hinterland combine into settlement systems which are subject to change but stable over shorter periods. The most important change going on at the present time is the migration of people from smaller to larger settlements. This has an effect above all on the working and living conditions of the population in rural areas, but in the long run the structure and function of settlement systems will also be involved.

Strictly speaking this process has been going on since the beginning of industrialization, but in contrast to what happened in the past most rural settlements are not now increasing their populations any more.

Concentration results from the inevitable development of production (and particularly industry) and the infrastructure in connection with the scientific and technological revolution. It also answers the need for the intensification of production and enables the most efficient use to be made of the national income.

Apart from this economic aspect there is also a social one. When people live dispersed as they do in agrarian regions, the need arises to provide more and more

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of them with the advantages and amenities of working and living in settlements having a diversified structure and infrastructure.

Under conditions where the population is stagnating or even decreasing, concentration means an absolute reduction in the number of people living in most settlements, so that an increase in their number is comparatively slight.

The process of concentration is a long-term one, controlled by a number of interrelated factors (cf. Kanel 1970). Its characteristics differ from region to region, and in the agricultural areas the contrast is primarily between the big centres with their dynamic growth and facilities for satisfying a variety of needs, and the many small and very small settlements which do not offer these amenities.

A team at the Research Coordination Centre for Regional Planning (*Forschungsleitstelle für Territorialplanung*) of the National Planning Commission has dealt particularly with the problems of small towns and settlements in an interesting report. It may be assumed that the most significant findings will be published.

Even now the average population of the rural settlements in the northern part of the GDR is below 200. This represents a minimum for providing such basic facilities as stores selling goods for everyday use, etc. If the current trends continue, the population in the villages can be expected to drop by another 20–30% by about 1990. A planned approach to the problem must aim at preventing an equal and linear reduction in all settlements at the same time Depending on size, functional importance, situation, the condition of buildings, etc., different approaches must be taken ranging between stagnation (or even growth) and abandoning settlements.

Large-scale industry-type farming in socialist agriculture has taken away from many settlements their production function. Today a very small number of settlements would suffice to maintain crop farming where people cover distances stretching the limits of the elementary settlement systems in their work. Animal husbandry will continue to be connected with a number of decentralized sites for some time, but the site planning for new installations clearly indicates a trend toward concentration. Agricultural services will also be concentrated in a few places within a *Kreis* (cf. Scherf 1975).

In complete contrast to the advances made by the productive forces, people still live in scattered old buildings. While it will not always be possible to wait for natural attrition to end the lifetime of these buildings, they cannot be abandoned all at once either, for economic and other reasons.

However, the numbers of people living in these places are continuing to diminish, and this makes it possible for those being left behind to acquire more living space at comparatively low cost and to modernize existing old buildings. On a regional scale some of these old buildings are being converted into holiday homes or second homes, although this can only solve part of the problem.

More and more settlements are losing people beyond the critical limits for the efficient utilization of infrastructural facilities. A variety of transitional arrangements must be made such as divided schools, visiting doctor's surgery, mobile selling units, etc. A specific problem is presented by the provision of water supply and sewage treatment facilities. These require high capital investment and must be provided in many small settlements, just as in larger ones. An acceleration of resettlement which might be more efficient in the long run both for society and the economy, is not under serious discussion at the present time. It can be imagined, though, that more people will begin to leave these settlements as soon as a certain limit – which may be variable – is surpassed. The reason would then be that partial abandonment of a village creates living conditions which are incompatible with human needs in a developed socialist system. This would seem all the more logical since *fundamental* problems exist with regard to the redevelopment of the majority of the settlements in

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the northern part of the GDR (which were mainly for tenant farmers and, after the war, for new farm settlers; their lay-out is extremely unfavourable).

Another undesirable phenomenon which occurs with a rapid exodus of people ending in the abandonment of settlements, is the high percentage of aged people left behind when primarily young people leave the villages.

A compromise must therefore be found between the *theoretical potential* which derives from the developing of the productive forces, and the practical policies that can be justified in terms of the national economy. The concrete *structure of settlement systems* should come into play here, because it provides a starting point for approaches which may differ from region to region. Thus concentration should be furthered particularly in the settlement systems of the country towns with the aim of stabilizing the centre and a few selected villages. One aspect of the situation of the small settlements is that the local people suffer from a dual handicap – the infrastructure is weak and they are comparatively far away from the nearest centre. The same applies to some degree to the peripheral parts of the immediate hinterlands of *Kreis* centres. The answer here must be associations of parishes which control the process of concentration so that housing construction becomes possible on one or more sites within the framework of a division of functions. On the other hand, development in those parts of a *Kreis* town which are near the centre may more or less follow the rate of depreciation charge for buildings.

In other words, the necessity for stabilizing settlement systems through concentration arises primarily in peripheral parts away from the centre. It can help to maintain a minimal level of population density. However, concentration cannot be the sole concern of agriculture any longer. For this and other reasons (such as the variety of trades and professions) commuting can be expected to continue. It should be remembered in this connection that stable commuting patterns call for the concentration of commuters in larger villages with a developed infrastructure and adequate public transport. At the present time, however, the residential pattern is fragmented with many people, travelling for long periods or over long distances, and the overall spatial structure appears to be inefficient and not very stable.

The basic aspect of concentration, with differing characteristics from region to region, is modified by other traits of the urbanization process. One of these is the phenomenon of suburbanization which did not emerge around the larger centres until very recently. It can also be observed along important roads between major cities. The desirable aspect of this is that the node-band concept involves the bundling of communication routes thus making services more efficient particularly in thinly populated areas. The *Bezirk* of Rostock in particular enjoys conditions which are favourable for implementing this concept, but they also exist in other areas.

Something that cannot be foreseen yet is the way in which differentiation will occur between settlement systems in areas which specialize in certain branches of agricultural production (cf. Kluge 1976). For instance, concentration in the settlement system should be higher in areas where only crop farming is done, as compared with those specializing in animal production. Settlements should be retained in regions which are to be used for recreation.

The present trend which is clearly toward concentration, is of truly historic dimensions, in view of the fact that the prevailing tendency at all times has so far been to make the settlement network denser. In the 19th and 20th century scattered settlements reached their limits. Under socialist conditions the ideal of the family farm in the middle of the fields, which was pursued in the capitalist countries right up to the mid-1960s, was made an anachronism in the course of but a few years.

Large-scale industry-type farming calls for industry-type site planning to be used by medium-sized and large agrarian producers and their cooperative partners. This runs parallel to the development of human needs as reflected in the current urbanization

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phenomena. It is the larger settlements which offer the best possible conditions for satisfying these needs. In view of the more intensive division of labour between town and country and the growing unity between the city and its hinterland this does not have to result in a mass exodus to the urban areas. On the other hand, a high degree of communication must be ensured for the rural settlements. This can be achieved through the development of centres, concentration of the infrastructure and services in a smaller number of villages, and by an improved exchange between the towns and the country. The gap is thus being bridged between the working and living conditions here and there, and this will be the essence of future policies toward settlement systems in agricultural regions.

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CERTAIN ASPECTS OF TRANSFORMATION OF SETTLEMENT IN MOUNTAINOUS AREAS

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The territorial organisation of the population is closely linked with social and economic development and its problems should be studied in conjunction with the economic tasks carried out in every country in actual historical conditions. All the quantitative and qualitative changes in settlement are inter-dependent. They occur under the influence of numerous factors, and natural geographic conditions play a role of no small importance among them.

Undoubtedly natural factors most often influence settlement for reasons of production and that is why this influence is not always clearly visible. Nevertheless, their role in settlement formation should not be ignored. This applies above all to mountainous areas where settlement is closely linked with the specific features of the natural geographic environment. Let us now examine the principal distinguishing features of the natural and economic conditons in mountainous areas and the characteristic traits of settlement stemming from them.

1. *A limited area fit for cultivation and settlement.* Depending on how many mountains there are in the given territory the share and per capita size of such areas may vary a great deal. For example, in the Republic of Georgia the per capita size of the land fit for cultivation is only one-fourth of the country's average (0.24 and 0.95 ha respectively). Although soil and climatic conditions make it possible to develop more intensive farm production in Georgia, nevertheless the limited surface of land narrows the area of settlement and man's economic activity.

2. An extremely *irregular territorial distribution of the population and settlement.* There are entire regions completely unpopulated or very sparsely populated. As a rule, most of the population is concentrated in lowlands or uses mountain plateaus and dales where relief, soil and climatic conditions are relatively favourable. Such areas are often overpopulated and are extremely short of land not only for farming but also for the location of settlements and also industrial, transport and other economic facilities.

3. Increasing *ties between settlement changes and the migration processes.* Cities are concentrated in areas with the most favourable economic and geographic conditions. Those of them which attain a comparatively high level of development become centres of attraction for the population. A similar situation exists in the countryside. As a result, there is an increasing flow of the population from underdeveloped rural and urban settlements to the more developed centres. Under these circumstances migration assumes an undesirable character because depopulation affects not only individual

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settlements but also entire mountainous regions which were relatively well populated not so long ago. For example, over the past 100 years mountain villages in France have lost three quarters of their population.

4. The problem of *providing mountainous areas with modern types of transportation* becomes more difficult. Since a number of mountainous areas are difficult to reach they are not provided with modern means of transportation functioning all the year round. The construction and maintenance of mountain roads requires large investments. As a result, countries with a comparatively low level of productive forces are in a particularly difficult position. To make matters worse, the construction and maintenance of mountain roads often proves to be unprofitable. In consequence of this their construction is often postponed for many years and in the meantime the out-flow of the population continues on a large scale and some of the mountainous areas become completely deserted.

5. In many cases the *nature of settlement in the mountains fails to meet the increased requirements of the population.* The scattered nature of settlement in the mountainous areas is not conducive to set up an entirely satisfied service sector. Many settlements in the mountains are spread over a large territory as a rule, and each of them numbers just several dozen inhabitants, sometimes even fewer than that. As a result, in a settlement of this kind it is impossible to set up a school, a shop, a community centre, a post office or other elements of the social infrastructure. This circumstance often causes the population's emigration to more developed and conveniently situated centres.

6. *The narrow range of labour employed.* Most of the mountainous areas have no natural resources for intensive farm production; sometimes farming is absent altogether while livestock breeding is based on natural pastures not marked by high productivity. In these conditions the sphere of labour employed is not expanded, and farming has a very pronounced seasonal character; surplus labour moves gradually to other areas.

7. *Diversity of settlement types* both functional and morphological. Mountainous areas possess linear and cluster settlement patterns, star-like and ring-shaped settlements, and combinations of their various types. All that besides the alternating densely and sparsely populated areas and those completely unpopulated create a rather complicated territorial organization of the population.

Since large areas are unfit for settlement or direct economic use, it is necessary to determine what part of the territory is actively used by the population. Loosely, we can describe it as populated territory. This includes the territory of the populated areas, all the cultivated land, and also pastures, hayfields and forests, adjacent to the settlements, or scattered among them or cultivated plots of land which is used systematically by the inhabitants. The unpopulated area includes land unfit for the above-mentioned purposes, and also forests, summer and winter pastures used seasonally and staying outside the areas of everyday economic activity.

The degree to which a country or any of its regions is populated can be determined using the index of populated territory:

$$K_p = \frac{S_p}{S}$$

where K_p is index of the populated territory, S_p is the area inhabited and S is the entire area.

There is one clearcut relationship emerging from this formula: the more mountains there are in the area and the more broken its terrain, the index is lower. The value of index may vary a great deal inside any country. For example, in Georgia it ranges from 0.593 to 0.056 for various areas of settlement.

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In the Soviet Union's Southern mountainous regions the number of population gradually decreases as terrain rises higher and higher above sea level. And one can observe a reverse picture in those regions of the world where the living conditions of the population are improved with the rising altitude.

A study of the latest trends in mountainous settlement in the Republic of Georgia has revealed the following substantial changes:

(a) the total number of rural settlements is becoming smaller while the size of the rural population is decreasing or remaining stable;

(b) number of small rural settlements as well as their average population size are decreasing;

(c) large centres have become even more populated which has led to their greater role in the settlement system;

(d) the impact of the cities and industrial centres on rural settlement is increasing;

(e) urban and rural settlements are gradually coming closer together in a number of spheres, as many-sided ties between them are becoming stronger;

(f) the area of settlement is being gradually reduced and the upper limit of the spread of permanent settlements is going down;

(g) many permanent settlements in the Alpine zone are turning into seasonal ones.

The above-mentioned trends result from the development of social productive forces and can be regarded as positive on the whole. However, not every aspect of the current transformation of settlement is progressive. Not infrequently this transformation takes place on such a scale that it warrants definite control to remove the negative aspects. In particular, one should not ignore the continuing out-flow of the population from the mountainous areas which leads in many cases to the sharp reduction in the absolute number of population. As a result, the uneven territorial distribution of the population is enhanced. On the one hand, the lowland areas become overpopulated while on the other, large areas of the mountainous zone are left without any population and actually remain outside the economic turnover. In this situation the consequences of the existing shortage of land make themselves felt with an even greater force. To make matters worse, the territorial expansion of the cities is increasing and in the process accelerated urbanization is taking up valuable farmland.

Consequently, a number of characteristic shortcomings in the territorial organization of the population in the mountainous countries are making themselves increasingly felt. In view of this, the need arises to transform the present settlement pattern. The main tasks of transforming the settlement in the mountainous areas are following:

(a) the territorial organization of the population should secure the best possible conditions for the development of social productive forces, creating prerequisites for the intensification of production and the all-round development of the individual;

(b) the nature of settlement should help a steady increase in living standards; any settlement in the mountainous zone should be accessible all the year round;

(c) the development of the production, social and public catering infrastructure should provide the population with full adequate services;

(d) the improved forms and types of settlement units should become part of a unified settlement system to combine optimally settlements of various ranks and functional types; the whole system should eliminate inequalities in the population's living and working conditions;

(e) it is necessary to prevent the depopulation of the mountainous regions; the most suitable areas should be used to build enlarged rural settlements, which in future should become centres of production and attract the population;

(f) the spontaneous out-flow of the population from the mountainous zone should be opposed by the development of mountainous areas in a comprehensive and planned manner.

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Until productive forces reach a certain level of development society does not possess sufficient material resources to make large investments in the development of both the lowlands and mountainous areas simultaneously. At the earlier stages attention was focussed on the former, which are much more densely populated and which yield higher profit per unit of investments. This approach to the territorial organization of production in the USSR's southern mountainous areas has been quite justified until recently. However, already in the near future the mountainous areas can receive more investments and develop at a higher rate.

The problem of building a road to reach every small village lost in the mountains still remains very difficult. Such villages lack potential because they are only sparsely populated and cut off from the transport arteries. In this connection the effort to enlarge rural settlements is becoming very important. Villages situated in relatively convenient areas should become centres of concentration for the people moving from small, remote villages, whose prospects are not sufficiently good. This organizational intervention based on a voluntary principle is quite justified because it harmoniously combines the interests of the potential migrants with those of society as a whole.

The transformation of mountainous settlement, runs into a number of difficulties. One of them consists in choosing adequate territory for the location of large villages. A number of regions in the mountainous Caucasus (Hevsureti, for example) have no relatively flat areas for the location of large villages or even those with several hundred inhabitants. Steep slopes, snow avalanches and mud slides create insurmountable obstacles for the enlargement of villages in many mountainous areas. However, a number of them do have large villages (Daghestan is an example) and natural conditions make it quite possible to set up new settlements of this size.

The effort to enlarge villages requires the corresponding expansion of the sphere of the application of labour. One of the ways of doing this is to intensify farm production. Besides this, mining industries can develop and expand using the local natural resources and they in turn give rise to small centres of manufacturing industries. Maximum use should also be made of the possibilities of developing Alpine health resorts, tourism and mountain climbing. There are considerable potentialities for expanding or restoring local handicrafts to give a boost to the souvenir industry.

If a settlement has a large population this is a factor conducive to its development. And in the large villages it will be easier to set up a complete range of services. Their inhabitants make use of many modern leisure and holiday facilities, amenities and means of transportation; it is easier for the large villages to maintain links with other settlements; and their living conditions are closer to the towns. Spontaneous migration from small mountain villages often settle down in large rural townships and, last but not least, these localities are most fit for the large-scale forms of modern farm production.

However, the enlargement of villages should not be taken as a drive to standardize all rural settlements. The hierarchy of populated areas and their co-subordination will undoubtedly remain both in urban and rural settlement; and so will a number of small rural villages whose enlargement is not purposeful for various reasons.

In unified settlement system an important role will be played by what is known as local centres. They represent an intermediate group between rural and urban settlements. One of their specific features is a gradual decrease in the number of people engaged in farming and the growing number of those employed in the service industries. Material objects and the appearance of the settlements also change accordingly. There emerge urban-type develling-houses, well equipped schools, public catering, utility, trade, transport and communication facilities, entertainments and medical centres. Major changes also take place in the nature of labour: non-

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agricultural activities are rapidly expanding, the whole pattern of social and cultural life is being transformed, the links with other settlements and the exchange of information are becoming much more intensified, and labour efficiency is rising, etc. All this signifies urbanization of rural areas, the spread of the urban way of life everywhere.

The transformation of settlement is also closely linked with the industrialization of production. As various sectors of the economy, including agriculture, are being put on an industrial footing, this leads to corresponding changes in the territorial organization of the population. The old forms of settlement no longer correspond to the enterprises set up in rural localities such as poultry and dairy farms, farm machine installations, agrarian industrial complexes or various non-agricultural facilities. The spread of such enterprises on a large scale while signifying the intensification of production substantially alters the nature of work of the rural population.

A study of mountainous settlement in the Caucasus makes it possible to arrive at the following general conclusion: when natural and economic conditions are not conducive to keeping the population in mountain villages, an organized shifts of labour power to lowlands is quite justified because these areas possess more favourable conditions for expanding the sphere of the application of labour.

The uneven territorial distribution of the population in the mountainous areas, in particular the concentration of its vast majority in the well-developed lowland zone makes for very high density of population there. Most of the urban settlements are also situated in that zone. As a result, the lowlands also have a high settlement density, including cities. In these conditions favourable prerequisites arise at a certain stage of urbanization for the emergence of urban agglomerations. Georgia is a case in point. Since most of her population is concentrated in the valleys hemmed in by mountains and on the Black Sea coast, this has led to wide spreading of clustered forms of settlement. The Republic's capital, Tbilisi, with a population of one million, and other big cities, Kutaisi, Batumi and Sukhumi, have become nuclei of large urban agglomerations. These four agglomerations now account for about 75 per cent of the urban and 29 per cent of the Republic's rural population. They were formed a comparatively short time ago and are still in the initial stage of their development. Undoubtedly, the population of these urban agglomerations is going to increase even more in the near future and they will be playing a greater role in the Republic's political, economic, social and cultural life.

A number of cities in the Republic function as regional centres. They hold leading positions in the intra-republic economic regions or sub-regions (as a rule, these are groups of administrative districts). The established territorial production complexes are shaping out under the region-forming influence of the regional centres standing out because of the advantages of their economic and geographic positions and a high rate of development. Such centres in Georgia are the cities of Gori, Zugdidi, Telavi, Akhaltsikhe and Tskhinvali. At the same time they have become major points of attraction for the population and, besides their industrial functions, also have cultural and educational importance.

Increasing urbanization in the mountainous areas has led to the emergence of more developed forms of settlement. While attracting a steadily increasing flow of the population from rural areas and small towns, the nuclei of the emerging agglomerations and regional centres are exerting a major influence on settlement as a whole. This circumstance and the higher mobility of the population stress the need to regulate the transformation of settlement, since, if this process continues spontaneously it will entail many undesirable consequences negatively affecting the development of social productive forces and the population's living conditions. The effort to devise the most efficient system of settlement includes the formation of the multi-stage hierarchy of settlements of various sizes and functional structures. All

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the supreme achievements of the intensification of labour both in production and in the non-productive sphere stemming from the most developed urban centres should be brought within the reach of the entire system so that it should have no settlements whose way of life would be little conducive to the development of the individual.

The deliberate regulation of migration processes remains one of the important tasks in this field. To reduce the irrational flow of migration substantially, it is necessary to increase investment in the economic and cultural development of the mountainous areas and regions with a low level of urbanization. The equalization of the population's living conditions in the settlements of different hierarchical ranks also remains an important task in the goal-seeking transformation of settlement as a long-term prospect.

It is also very important to bring still closer the rural and urban settlements in the level of amenities and living conditions of the population. While transforming settlement it is also necessary to ensure the solution of the key social and economic problems. The growing urbanization of the countryside is linked with the attainment of a still higher level in the intensification of farm production, the development of the industrial and social infrastructure, and the spread of the urban way of life in the rural areas of the mountainous regions.

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CITY-HINTERLAND REGIONS OF LARGE CITIES AND MEDIUM-SIZED TOWNS IN THE GDR

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As in other countries the settlement structure in the German Democratic Republic is becoming ever more urbanized. This is obvious from the growth of part of the cities and rural settlement centres, and from the increasing extent to which settlements become integrated. One of the challenges of urbanization is the need to make progress in overcoming the present differences in working and living conditions existing at the level of regions and beyond. In this connection conflicting trends toward concentration and dispersion can be observed. More detailed research is needed to identify those forms of settlement structures which can be employed most favourably to implement the fundamental socio-political objectives of a socialist system.

It is desirable that the settlement structure be efficient from an economic and social point of view, and the following is primarily a look at social aspects of regional settlement systems and city-hinterland regions. The aim is to show the way in which different types of cities have links with their hinterlands through the movement of people, and to demonstrate the social functions of city-hinterland regions. Special importance must in this connection be attached to the area within easy daily reach of the centre. A discussion is needed on what types of centres and regional features result in a comparatively contained daily communication area. In the latter the overall level of the working and living conditions depends decisively on the qualitative and quantitative patterns of functions the centre provides. The question may then be asked whether these patterns can satisfy advanced demands, whether they may be extended in view of present or future population development within the region or whether the region will have to give up its comparatively self-contained existence and become integrated into the regions around other cities.

DEFINITION OF THE CITY-HINTERLAND REGION AND THE INNER STRUCTURE OF THE LATTER

The city-hinterland region is the spatial unit consisting of the urban centre and its hinterland, integrated by the movement of people. Its structure essentially depends on the settlement and population structure, and the central city takes priority as the political, economic and cultural centre of the region. The principal function of the

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city-hinterland region is to satisfy certain categories of needs such as work, housing, education, catering and services, and recreation. City-hinterland regions can be interpreted as regional settlement systems. At the same time they are areas of action and communication for their inhabitants in the pursuit of the above-mentioned needs.

From a spatial point of view the city-hinterland region involves a number of interrelated functions, and our study is concerned with such aspects as the retail trade, services, public health and commuting to work.

The area covered by city-hinterland regions and the inner structure of these regions depend decisively on the type of urban centre, i.e. the degree to which it fulfils functions necessary for the hinterland. At the same time there is an influence from the structure of the hinterland and especially the secondary centres with their functions and situation relative to the main centre. Specific zones can be distinguished in city-hinterland regions as a result of the gradation of the demand for satisfying people's needs and the opportunities existing in this connection in the main and secondary centres and in the other hinterland communities.

The areas covered by city-hinterland regions around various types of centres roughly compare with politico-administrative units as follows:

1. The capital, Berlin – Many highly specialized functions extend over the areas of several counties (*Bezirk*).
2.a. Major centres – Many highly specialized functions extend beyond their own administrative Bezirk.
2.b. *Bezirk* centres – Many specialized functions extend over an administrative *Bezirk*.
3.a. Regional centres[1] – Several of their special functions extend beyond the area of an administrative *Kreis*.
3.b. *Kreis* centres – Many functions which are frequently required extend over a *Kreis*.
4.a. Partial *Kreis* centres – Some functions which are frequently required extend over a *Kreis*.
4.b. Local centres – These serve part of a *Kreis*.

The hinterland of urban centres can be subdivided into zones which become fewer as the rank of the centre and therefore its range of functions decreases. It can be empirically shown that *Bezirk* centres and regional centres have three hinterland zones, *Kreis* centres and partial *Kreis* centres two and local centres only one. Zoning depends on the intensity of the relations with the hinterland, although considerable difficulties have been experienced in an attempt to express in just one value what this intensity is for a range of city-hinterland relations. One approach for model studies has been published (Krönert and Schmidt 1974).

Figure 1 illustrates the inner structure of the hinterland relations of a regional and two *Kreis* centres. The hinterland zones are further subdivided according to the intensity of the relations, and the map shows how secondary centres influence the extent to which zones are formed.

On the basis of the model studies mentioned above, a simplified method has been developed for delimiting the inner hinterland zones of *Kreis* centres and other order (Table 1).

These criteria have been used to delimit the inner hinterland zones around 55 cities in the GDR (15 Kreis centres with more than 40 000 inhabitants and 40 centres of a higher order), and to subdivide these zones and conduct more detailed

[1] Some *Bezirk* towns have been classified as regional centres, i.e. those which still lack a number of highly specialized facilities (such as colleges and universities, hospitals serving the entire area of the *Bezirk*, and theatres). They naturally perform political and administrative functions for the whole *Bezirk*. There is a strict distinction in terminology between a *Bezirk* town and a *Bezirk* centre. The same applies to a number of *Kreis* towns which are only partial centres or local centres regarding the overall pattern of functions performed for the hinterland (cf. Grimm and Honsch 1974).

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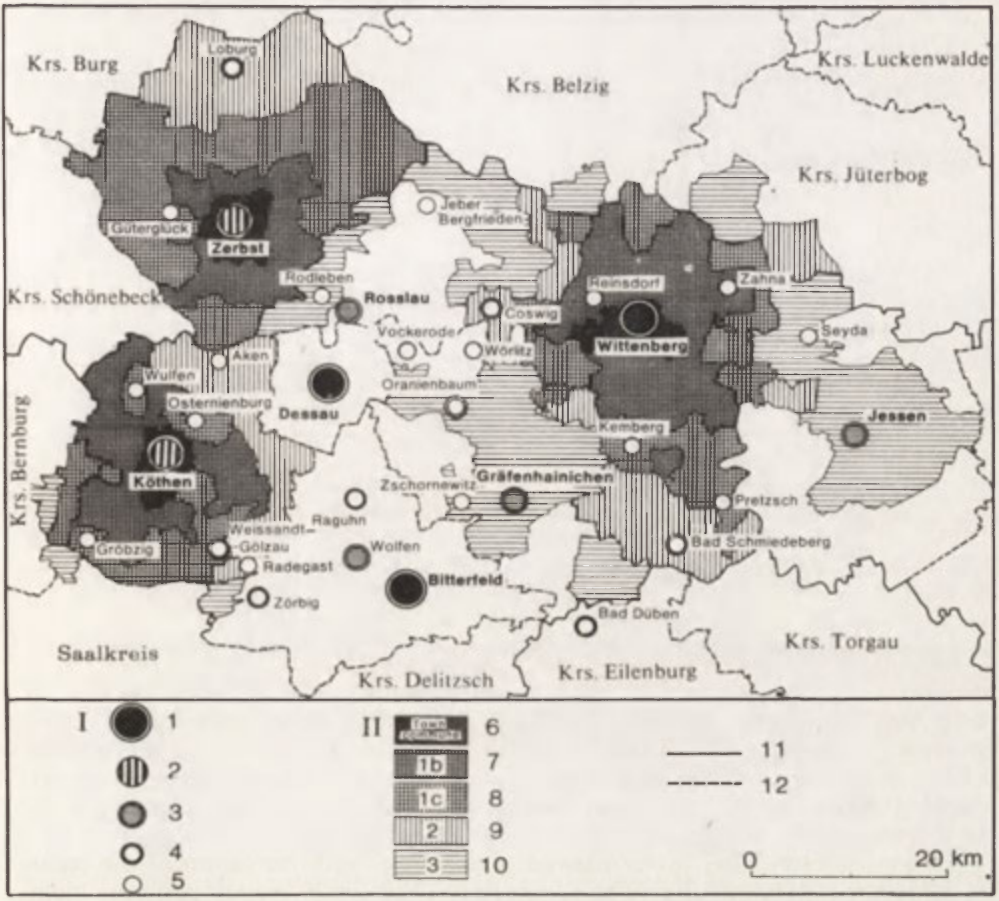

Fig. 1. Hinterland relations of the Wittenberg regional centre and the Kothen and Zerbst Kreis centres (as for 1971)

I. Types of centres according to their significance for the hinterland (indicated for the research area only): 1 – regional centres, 2 – Kreis centres, 3 – partial Kreis centres, 4 – local centres, 5 – other central places

II. Zones of the town-hinterland intensity relations. Zones of intensity levels (6–10 as indicated on the Figure). 11 – Bezirk boundaries, 12 – Kreis boundaries

studies with a view to structural features (Kronert 1977[2]). The structural diagrams derived from this analysis (Fig. 2) show the basic characteristics of city-hinterland regions for *Bezirk* centres, regional centres and large *Kreis* centres.

The following characteristics apply to the individual hinterland zones:

Hinterland zone 1 has the greatest intensity of relations with the centre of the region as far as the movement of people is concerned. The outward relations of the hinterland communities are dominated by the centre. Zone 1 is shaped almost like a ring and is situated inside the administrative *Kreis* surrounding the centre. The centre performs functions satisfying some of the more basic needs of the communities in the zone, and it is the primary place of work for commuters from the zone.

Hinterland zone 2 has relations of medium intensity with the centre as far as the

[2] The work lists the literature used and some more specialized literature.

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TABLE 1. Criteria for delimiting the inner hinterland zones of *Kreis*- and other centres

Zone	Sub-zone	Percentage of outward-bound commuters to total outward-bound commuters	Percentage of outward-bound commuters to employed residential population	Density of inhabitants and employed persons[a]	Ratio of employed persons working at the location to employed persons living at the location
1	a	above 60	above 15	above 600	above 0.5
		„ 50	„ 30	„ 600	„ 0.5
	b	„ 60	„ 15		
	c	30–60	„ 5		
2	a	10–60	5–15	above 200	above 0.5
	b	10–30	above 5		
3	a	above 10	2– 5	above 200	above 0.5

[a] Inhabitants and employed persons per km²

movement of people is concerned. With the exception of secondary centres the communities are not primarily orientated toward the centre but rather toward local centres in zone 2 or neighbouring centres of a higher order. The centre mainly provides services satisfying some of the less basic needs and is an important supplementary place of work for the inhabitants of the zone. Zone 2 is not ring-shaped for *Kreis* centres but consists of communities arranged around local centres.

Hinterland zone 3 has a low intensity of relations with the centre of the region as far as the movement of people is concerned. The centre mainly performs highly specialized functions for the hinterland and is the place of work for only a very limited part of the employed population in the zone. These commuters come from dispersed settlements and primarily from a number of towns situated along the main routes of traffic. In this zone around regional centres and others of a higher order there are at least partial *Kreis* centres or full *Kreis* centres performing specific functions for the hinterland. Typically, there are always several *Kreis* centres or *Kreis* towns in zone 3 around *Bezirk* centres, which have more intense relations with the *Bezirk* centre. The influence of the latter also reduces the catchment areas of these *Kreis* towns.

Regional centres are normally *Kreis* towns having several specific functions. This is why they begin to develop a hinterland zone of type 3 which does not extend very far, thus exerting some influence on a neighbouring *Kreis* centre. The hinterland zones 1 and 2 of those regional centres are clearly limited in comparison with those of *Bezirk* centres.

Kreis centres with more than 40 000 inhabitants can be found primarily in agglomeration areas. Their sphere of influence is encroached upon by neighbouring centres of a higher order, or there is a trend towards overlapping with adjacent regions. In two cases their regions are completely absorbed in city-hinterland region zones type 2 around agglomeration cores (Freital near Dresden; Schönebeck near Magdeburg).

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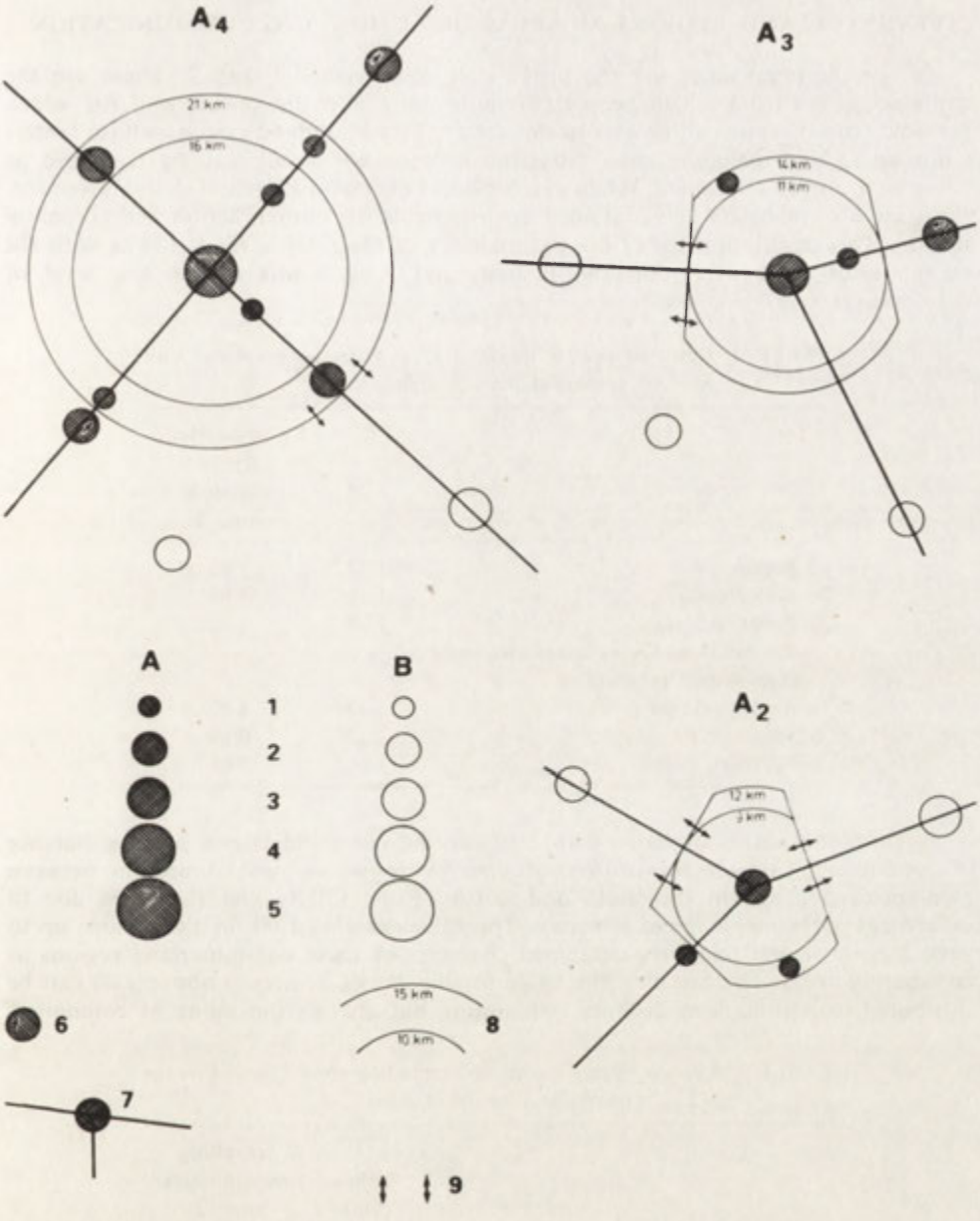

Fig. 2. City hinterland regions for Bezirk centres (A4), regional centres (A3) and large (above 40 000 inh.) Kreis centres (A2)

A – Main- and sub-centres up to the 3a intensity level.

B – Centres outside the 3a intensity level (the links being not so distinct)

1 – local centre, 2 – Kreis centre, 3 – regional centre, 4 – Bezirk centre, 5 – major centre, 6 – second order centre of the 3a intensity level, 7 – communication accessibility – main routes of railways and/or motorways (highways), 8 – average range of zone 1 (e.g. 10 km), and zone 2 (e.g. 15 km), 9 – overlapping tendency

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CITY-HINTERLAND REGIONS AS AREAS OF ACTION AND COMMUNICATION

Of specific importance are the urban core and regions 1 and 2. These are the contained areas from which people commute daily into the centre, and for which periodic requirements can be met in the centre. City-hinterland regions whose hinterlands up to and including zone 2 overlap little or not at all, can be described as comparatively self-contained. When one considers the possible area of daily movement, these are also relatively self-contained environments for human action and communication. This description today fits the majority of the GDR's *Kreis* towns with the exception of those in agglomeration areas and *Kreis* towns with a low level of development.

TABLE 2. Ratio of people working in a given geographical unit to employed persons living there

	City	City-hinterland region including zone 2
1 Berlin	1.12	1.03
2a Major centres	1.10	1.02
2b *Bezirk* centres	1.20	1.02
3 Regional and *Kreis* centres with more than 40 000 inhabitants		
a Agglomeration areas	1.33	1.02
b Southern part	1.22	0.99
c Northern part	1.16	1.01

In this table ratios of more than 1.10 for the cities indicate a positive balance of commuters. Considerable differences can be found in this connection between medium-sized towns in the south and north of the GDR, and these are due to differences in the employment structure. The values around 1.00 for the regions up to zone 2 point to the relatively contained character of these city-hinterland regions as commuting areas. The fact that the value for the *Bezirk* centres is above 1.00 can be attributed in part to long-distance commuting but also to the influx of commuters

TABLE 3. Average radius (up to and including zone 2) and average travelling time from zone 2

	Radius (km)	Travelling time (minutes) zone 2 only
1 Berlin	41	76
2a Major centres	20	50
2b *Bezirk* centres	21	62
3 Regional and *Kreis* centres with more then 40 000 inhabitants		
a Agglomeration areas	12	35
b Southern part	13	44
c Northern part	17	55

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from nearby *Kreis* towns which are situated in zone 3. In general this also expresses a trend towards the extension of the hinterland zone 2 around *Bezirk* centres.

It is remarkable how the range of city-hinterland relations extends as one moves up the scale (Table 3). For the same types of cities the geographical range is greater in the northern part of the GDR than in the southern part where the network is denser. In some cases the inhabitants of hinterland zone 2 are prepared to put up with long travelling times in order to work and use services offered in large cities and medium-sized towns without having to change their place of residence. These long travelling times from zone 2 are a reminder that the hinterland zone in question can hardly be extended without substantial improvements in transportation.

TABLE 4. Number of inhabitants and population density

City-hinterland regions	No. of inhabitants in .000 (1971)		Population density per sq. km (averages)	
	City	Region including zone 2	City	Region including zone 2
1 Berlin	1086	1523	2696	578
2a Major centres	543	824	3182	690
2b *Bezirk* centres	189	345	1459	278
3 Regional and *Kreis* centres with more than 40 000 inhabitants				
a Agglomeration areas	51	144	1863	328
b Southern part (without agglomerations)	57	122	1404	218
c Northern part	53	101	907	113

These figures give an idea of the order of magnitude of the population potentials in various types of city-hinterland regions (Table 4). The lower limit for city-hinterland regions including zone 2 of fully developed *Bezirk* centres is about 200 000, for the regional and large *Kreis* centres about 80 000 to 100 000. When one considers regional and large *Kreis* centres as prototypes of cities which should be daily accessible in the future if required, then conclusions can be drawn with regard to the selection, situation and population development of these cities and the number of inhabitants in their regions. These conclusions should also be drawn from the analysis of communications relating to the figures mentioned, and from the related concepts for the areas to be covered by hinterland zones 1 and 2.

The data on population density very generally expresses the different loads on an area inside a city-hinterland region. As the density grows, so do the requirements for land to be used for residential construction, industrial buildings and infrastructural facilities. Multiple use must be made of areas, and various factors may interfere with utilization.

These figures (Table 5) indirectly point to significant differences in the social structure. They express not only the expected contrasts in the proportion of those employed in agriculture but also indicate that relatively fewer people are employed in industry and construction in *Bezirk* centres and centres of a higher order, than medium-sized towns. On the other hand, more people are employed in spheres outside agriculture, forestry, industry and construction in these former centres. This indicates their great importance as centres of communication, science, culture, distribution, public health, economic management and planning and social activities.

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TABLE 5. Employment structure

Area	Employed in agriculture and forestry per 1000 inh.		Employed in industry and construction per 1000 inh.		Employed in other spheres per 1000 inh.	
	City	Region including zone 2	City	Region including zone 2	City	Region including zone 2
1 Berlin	5	12	210	189	339	296
2a Major centres	6	20	270	260	279	230
2b *Bezirk* centres	5–17	17–82	169–326	138–314	276–421	207–292
3 Regional and *Kreis* centres with more than 40 000 inh.						
a Agglomeration areas	7	38	366	293	269	158
b Southern part (without agglomerations)	13	54	327	242	272	178
c Northern part	15	76	253	177	195	207

These functions are performed far beyond zone 2 of the city-hinterland region. This is especially so in the case of the capital, Berlin. The situation outlined is reflected also in the data for the city-hinterland regions including zone 2. The regions around the medium-sized towns and the *Bezirk* towns have more agricultural and central functions in the northern part than in the south of the GDR. Conversely, more people are employed in industry and construction in the southern regions.

Naturally, the data given in the tables indicate only general trends, and individual cities and their regions may considerably deviate from these.

DEVELOPMENT ASPECTS OF CITY-HINTERLAND REGIONS

The close functional integration of settlements in city-hinterland regions makes it increasingly more imperative to coordinate and plan the development of the settlement structure and the working and living conditions for the people in an integrated manner. The regular patterns of organization could be points of departure for establishing planning regions. Thus the city and hinterland zone 1 might form a first planning area, and the two plus hinterland zone 2 – a second planning area. Concepts for the latter are reinforced by ideas developed in other countries, such as the hypothesis of a uniform settlement system proposed by Khorev and other Soviet authors. The city-hinterland regions for *Bezirk* centres and centres of a higher order, but in some cases also for regional centres, clearly extend beyond the administrative districts (*Kreis*) assigned to them if zone 2 is included, and therefore such planning regions should always cover several districts having functional relations with a viable centre. Whereas much generalized experience has been gained in the cooperation of communities in the form of associations of parishes with the aim of improving working and living conditions as quickly as possible, it is the opinion

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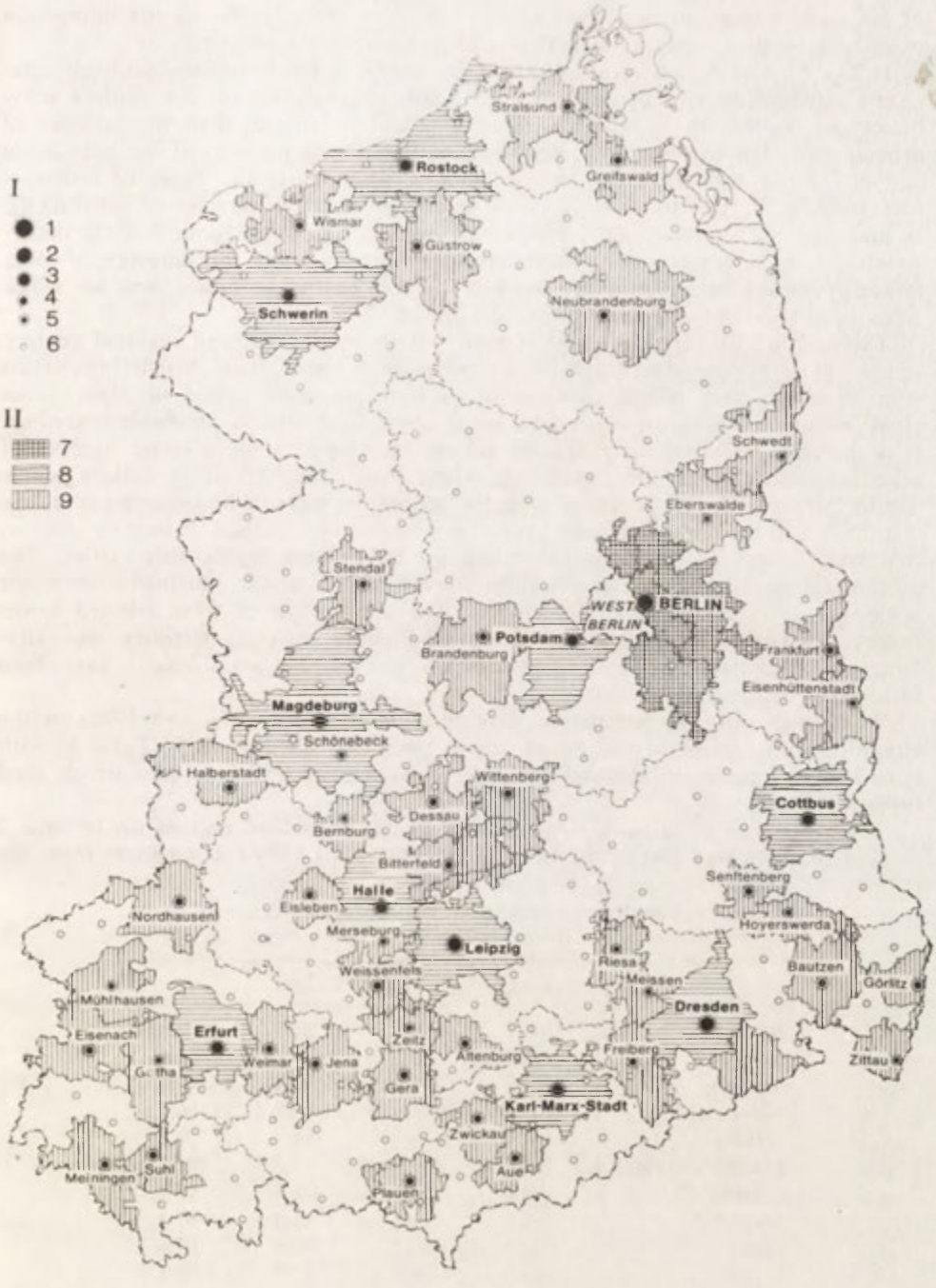

Fig. 3. City-hinterland regions of capital, major centres, Bezirk centres, regional centres and selected Kreis centres

I – Types of towns according to their significance for the hinterland
1 – capital, 2 – major centre, 3 – Bezirk centre, 4 – regional centre, 5 – Kreis centre (population over 40 000 inh.), 6 – Kreis town

II – Closed areas of city-hinterland relations (of zone 1 and 2 or boundary of the dominance of a centre)
7 – capital, 8 – major centre and Bezirk centre, 9 – regional centre and Kreis centre

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of the author that not enough attention has been given so far to the interaction of districts with a view to integrated settlement structure planning.

It has been said that most of the *Kreis* towns today form comparatively contained city-hinterland regions as regards daily accessibility of the centres (city-hinterland regions up to zone 2). This is bound to change with the advance of urbanization. The reasons are to be found in the growing mobility of the population and in the fact that there can only be limited additions to the range of functions performed by centres in city-hinterland regions with a low number of inhabitants. In addition, the latter are most affected by decreases in population. A clear understanding is therefore necessary which areas are already under the influence of more powerful centres, which may be assigned to these centres in future, and for which areas attractive centres remain to be developed.

The map of the city-hinterland regions (up to zone 2) around regional centres, centres of a higher order and *Kreis* centres with more than 40 000 inhabitants (Fig. 3) shows that people in large areas have no daily access to higher-order cities, except if they are prepared to spend more time than is justifiable travelling. It is therefore necessary to guarantee priority development for a larger number of other centres which can then gradually extend their orbit. About 11 million people live in the areas shown as linked with the 55 centres there. When one looks at the distribution of the remaining areas with a population of 6 million, it become obvious that only some of these can be linked up to existing higher-order cities. The official settlement policy is to concentrate investment in about 140 towns while not neglecting other categories of settlements. The distribution of these selected towns makes it possible to incorporate almost the entire national territory into city-hinterland regions up to zone 2. Areas left out of this arrangement have been identified.

When one looks at population developments (between 1971 and 1975) in the city-hinterland regions of the *Bezirk* towns (including their zone 3; Table 6) with regard to existing city-hinterland concepts, a number of problems arise which need further study.

Table 6 shows population developments in city-hinterland regions up to zone 2 around *Bezirk* towns and in the hinterland zones 3 for different distances from the

TABLE 6. Population trends in the city-hinterland regions of Berlin and other *Bezirk* towns, 1971–1975 (GDR average 98.5%)

	Zone	3a	3b	3c
Berlin	100.7	98.2	99.9	no data
Rostock	103.7	96.3	–	99.5
Schwerin	109.2	96.8	97.4	96.2
Neubrandenburg	107.4	95.5	95.9	96.4
Potsdam	101.0	–	98.0	98.2
Frankfurt/Oder	105.8	99.7	98.3	101.0
Cottbus	104.4	98.7	101.8	97.1
Magdeburg	101.0	94.8	96.4	97.4
Halle	103.9	94.2	95.6	97.6
Erfurt	102.0	98.0	97.3	98.4
Gera	99.9	95.3	–	100.9
Suhl	104.3	98.5	99.3	97.8
Dresden	100.1	96.6	97.2	96.6
Leipzig	96.5	97.2	98.9	96.0
Karl-Marx-Stadt	98.2	95.3	96.0	95.4

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Bezirk town. The data shows a remarkable trend in comparison with the national average (98.5%): the *Bezirk* towns and their hinterland zones 1 and 2 developed more favourably than the rest of the *Bezirk*, and many even gained more inhabitants. From a general point of view this trend is to be welcomed because it enhances the performance of the *Bezirk* towns. At the same time, however, a proportional

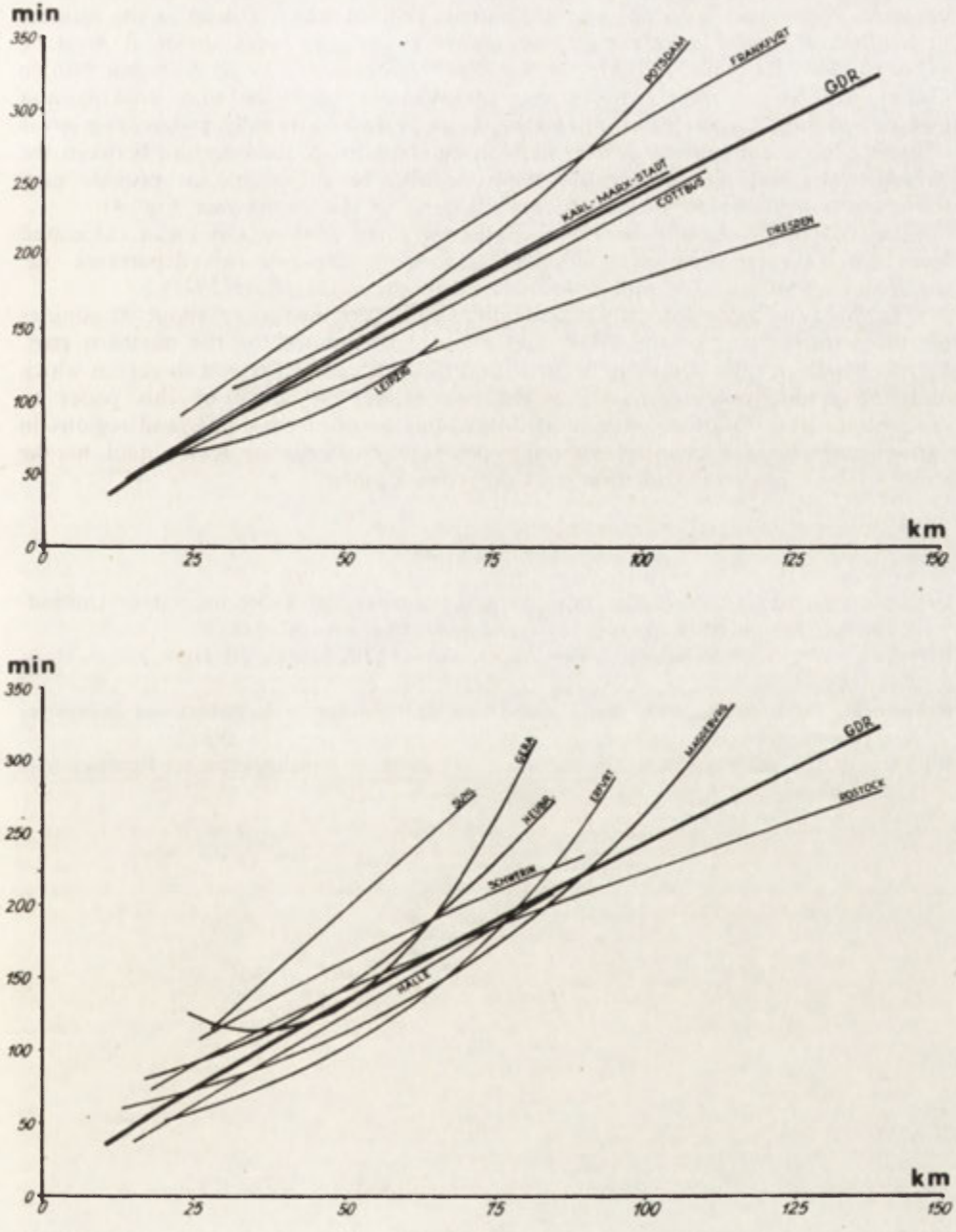

Fig. 4. Relations between travel time and distances (connections of Bezirk towns and Kreis towns)

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development must be ensured for other centres and their regions. This does not seem guaranteed at the present stage. An especially unfavourable tendency can be seen in the inner zone 3 of the city-hinterland regions around *Bezirk* towns, but the situation is more or less alleviated as far as working and living conditions are concerned, by the relative proximity of the *Bezirk* town. The peripheral parts of most counties (*Bezirk*) are experiencing quite undesirable trends which should not be allowed to continue. Although we do not know the limits beyond which a drop in the number of inhabitants would cause regional settlement systems to break down, it must be expected that once these limits are reached these regions would be an economic burden if they were to be stabilized. Another disadvantage might be that working and living conditions cannot keep abreast of developments in rapidly progressing areas elsewhere in the country. In view of the current status of communication between the *Bezirk* towns and the *Kreis* towns it would also be impossible to provide easy transportation to the *Bezirk* town from all parts of the *Bezirk* (see Fig. 4).

The compound measure used here is the weighted arithmetical mean calculated from the travelling time plus half the time spent between two departures, i.e. the frequency of travel is indirectly included in the value (Rutz 1971).

The threshold value for daily accessibility can be assumed to be about 90 minutes for the southern part of the GDR and about 120 minutes for the northern part. Figure 3 indicates the considerable structural differences from region to region which must be gradually overcome. It would go beyond the scope of this paper to describe in detail the many structural distinctions between city-hinterland regions in various parts of the country, although this is a challenge at least equal to the study of basic regional structures and their development.

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AN INVESTIGATION OF CITIES OF MACROSTRUCTURE OF THE SETTLEMENT SYSTEM OF THE GDR

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1.

International research conducted by the IGU Commission on "National Settlement Systems" has prompted this survey of the progress made so far in the investigation of the national settlement system of the GDR. At the same time my own country is to be used as a test case to find out whether the hypothesis of the existence of national settlement systems is applicable. Such an approach soon leads us on to questions which are important for an understanding both of the settlement system of the GDR and of the national settlement systems of other countries.

A basic problem in examining the hypothesis of the existence of national settlement systems is that proof must be furnished of the internal cohesion and homogeneity of such a system within national boundaries. The question will be discussed in the following as to whether a subsystem exists in the national settlement system of the GDR, which comprises the larger cities and is characterized by specific functions of these cities and specific interactions between them. For the time being, this subsystem will remain hypothetical, and its structure will be called the macrostructure of the national settlement system of the GDR. This macrostructure is assumed to consist of the essential cores (cities) and interrelations in the settlement system.

Once it is assumed that such a subsystem of larger cities is an indispensable condition for the homogeneity of the national settlement system, it can also be assumed that it is of vital importance to know this macrostructure subsystem for the purpose of assessing and planning the entire settlement system of the country and for making long-term forecasts.

The following questions would seem to be of prime importance in determining and investigating the macrostructure of the settlement system, both for advancing the theory of settlement geography and for government planning and long-term forecasting with regard to cities and settlements:

- What are the specific features of the cities in the macrostructure, particularly their functions and functional relations in the settlement system?
- What are the specific features of the macrostructure subsystem?
- What kind of internal organization exists in the macrostructure subsystem, and what relationships can be found?

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– What trends of development exist in the macrostructure subsystem, and what optimal approach can be taken to implement the socio-political and economic objectives of a mature socialist system according to plan?

Too little progress has so far been made in research, so that no answer can be given to these questions at this stage. Some rather general concepts can, however, be developed and the directions indicated as to where the solutions may lie.

2.

If our larger cities – or all cities – form their own subsystem in the national settlement system, then they must be characterized above all by specific functions and relationships within that subsystem, and by specific functions and relationships with regard to the rest of the settlement system. (Closely associated with these

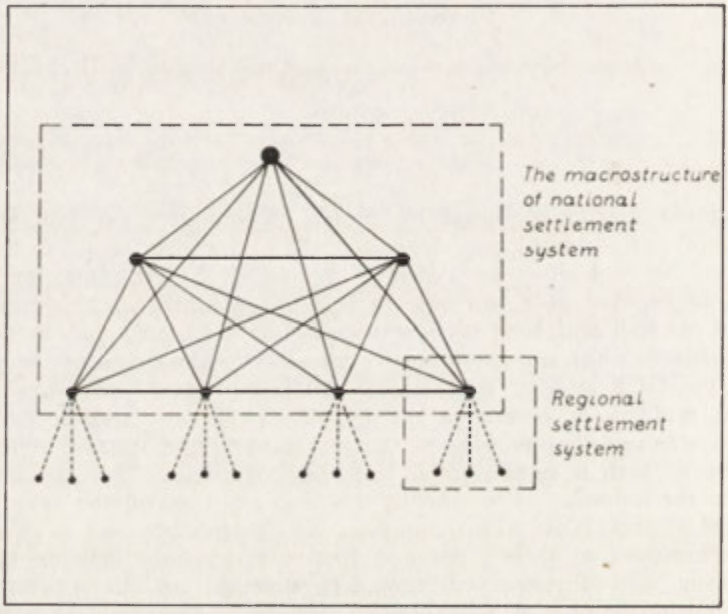

Fig. 1. The hypothetical scheme of the national settlement system and its macrostructure subsystem

external functions of the macrostructure cities are specific internal functions). The following is a discussion of what has been achieved so far with regard to our knowledge of, and concepts for, the specific character of the macrostructure of the settlement system. We shall consider the politico-administrative, social and production functions of cities, as well as the traffic flows.

The politico-administrative functions of cities in the GDR clearly derive from the pattern of administration. The GDR has 15 counties (*Bezirk*), with Berlin as a separate *Bezirk*, and 219 districts (*Kreis*), among them 28 urban districts. This situation has remaind almost unchanged since 1952. The *Bezirk* and *Kreis* towns are the political, social and administrative centres for their countries and districts. Their central position has been consolidated in 25 years of consistent development, and particularly by planning and managing the national economy on the level of the

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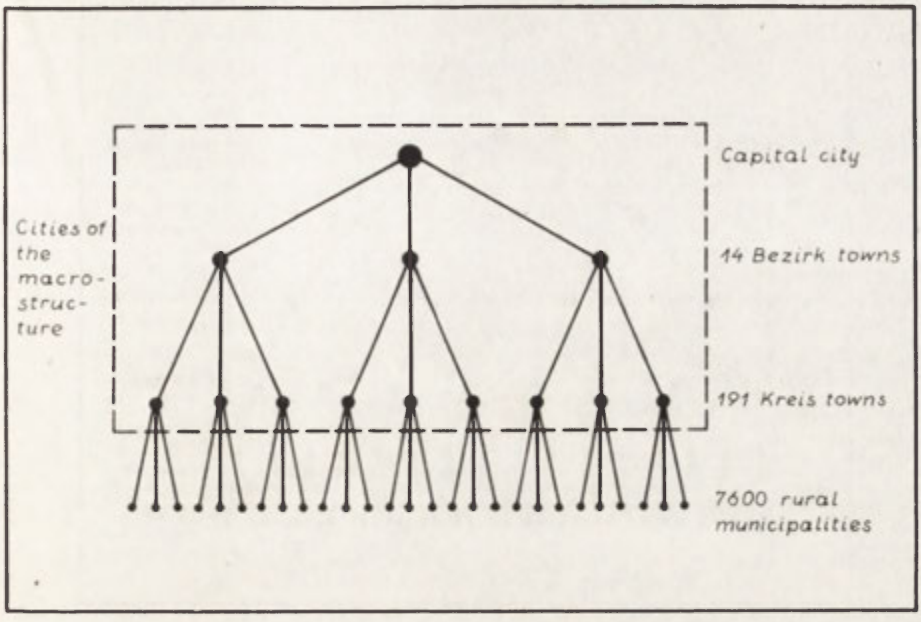

Fig. 2. The scheme of the political-administrative urban functions in the GDR

Bezirk and *Kreis*, by providing them with facilities for an entire *Bezirk* or *Kreis*, and through the establishment of a communication network centred on these towns (Grimm 1974).

According to the principles of democratic centralism the territory of the GDR has a homogeneous structure. Political and administrative functions for the entire country are concentrated in Berlin, and for a *Bezirk* in the *Bezirk* town. Usually politico-administrative relations between the *Bezirk* town and the settlements of its *Bezirk* are arranged with the help of the *Kreis* towns. At the same time the *Bezirk* towns are "half way houses" for the functional relations between settlements in the *Bezirk* and the capital, Berlin.

By analogy, the Kreis towns are the political and administrative centres for a district and "half way houses" for the functional relations between its settlements and the *Bezirk* town (Grimm 1974). These specific features which are the same for all *Bezirk* and *Kreis* towns speak in favour of including all 15 *Bezirk* towns, or all 194 *Bezirk* and *Kreis* towns in the macrostructure of the settlement system.

More research is needed to identify the importance of the political and administrative role in relation to the other functions of a city. This role has often been underestimated in the past.

The socio-spatial functions of cities have been in the centre of our studies of city-hinterland relations, so that satisfactory findings can be reported for all towns in the GDR (Grimm and Hönsch 1974; Känel 1975; Krönert 1977). The areas dealt with include employment, retail trade, public health, education, culture and recreation. As a result of detailed city-hinterland studies we have found a clearly defined hierarchy with regard to the socio-spatial impact of our cities (Grimm and Hönsch 1974), not only in the range and quality of their functions but also in respect to the size and structure of the hinterland (Krönert 1977). Each type of city has its own "type of hinterland". The following types of cities can be found in the GDR, as far as their role for the hinterland is concerned:

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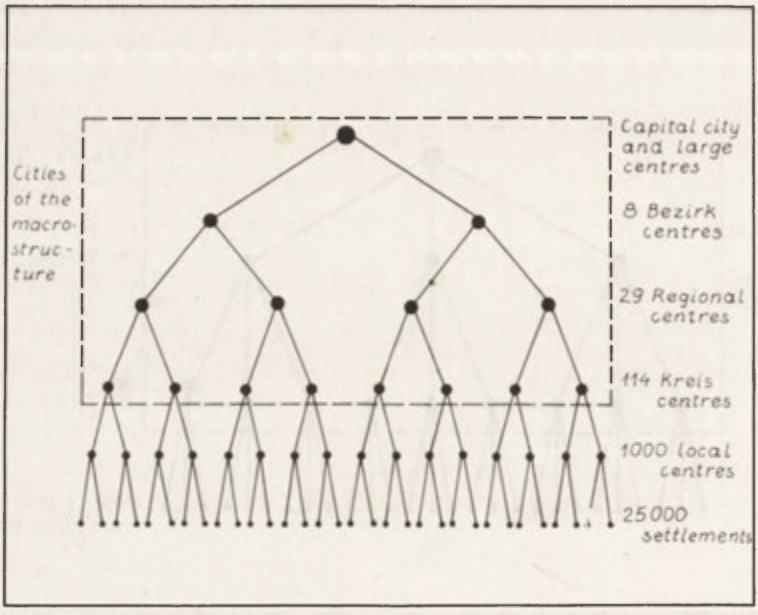

Fig. 3. The scheme of the social hinterland functions in the GDR

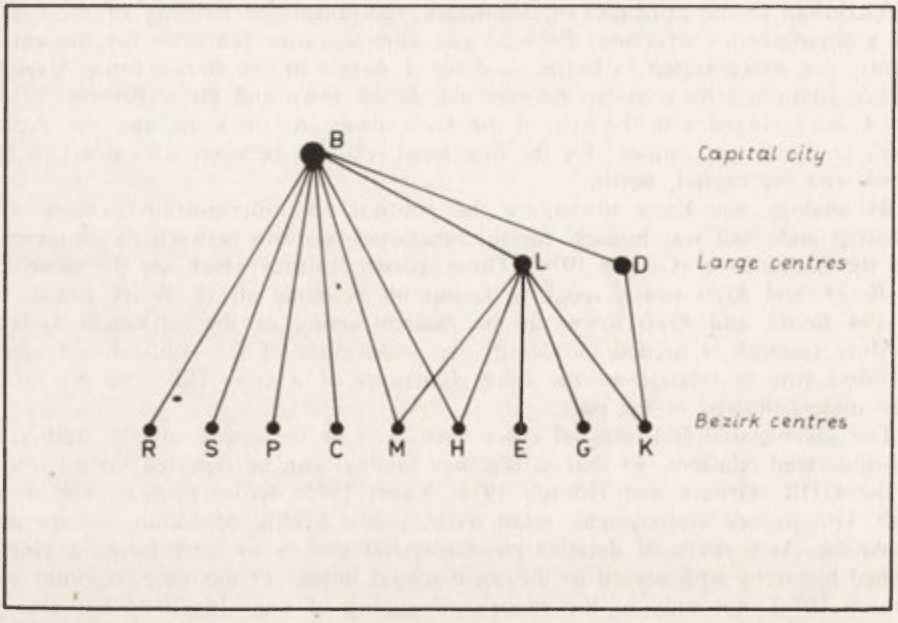

Fig. 4. The position of large urban centres of the intermediate level between the capital and the county (*Bezirk*) cities

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1. *Bezirk* centres and centres of a higher order. These include 11 cities which cater fully for their *Bezirk* when one considers all the social functions essential on this level. They have three fully developed hinterland zones of which one, Zone 3, is outside the specific *Kreis*. A special status must be given to the capital, Berlin, and to Leipzig and Dresden as large centres which are of importance for more than one *Bezirk*.

2. *Kreis* centres and regional centres. These include 146 cities which cater fully for their Kreis when one considers all the social functions essential on this level. They have two fully developed hinterland zones in the specific *Kreis*, and the regional centres show a tendency to develop a third zone. The *Bezirk* towns in this group and some other large cities are in the process of becoming group 1 cities.

3. Local centres and central places which have a limited hinterland with a single zone. In this group are 41 *Kreis* towns which perform political and administrative functions for their district but cannot be described as *Kreis* centres from a social point of view (Grimm 1974).

Our analyses have shown that the social impact of a city is closely connected to its political and administrative role. Consolidation has been observed in those types where the weight and scope of social functions corresponds to the politico-administrative role, i.e. in the capital and the *Bezirk* and *Kreis* centres. On the other hand, problems have been encountered in planning and developing the social functions of the other units – the Leipzig and Dresden conurbations, the regional centres and the local centres.

Criteria for determining the macrostructure on the basis of the social functions of a city can be derived primarily from the general concept of building a mature socialist system in the GDR, and especially from the proposed elimination of the differences still existing between working and living conditions in town and country (as formulated in the SED Program). Major attention must be paid in this connection to centres which are of daily importance for people's working and living conditions, i.e. the *Kreis* towns catering fully for their districts (*Kreis* centres) and the centres of a higher order (Grimm 1974). This would place about 150 cities in the macrostructure of the settlement system of the GDR.

It has been calculated that 95.8% of the population of the country live in *Bezirk* and *Kreis* towns, or in communes from where they have daily access to these towns (maximum travelling time 60 min. by public transport). The great majority of these towns are *Kreis* centres according to their social hinterland role (including centres of higher order). When one considers such criteria as spatial distribution and the present and possible relations between city and hinterland, then it can be assumed that a relatively homogeneous network of about 159 *Kreis* centres (including centres of higher order) will be required in order to create equal social conditions for the great majority of our people, insofar as these conditions are influenced by daily city-hinterland contacts.

Involved in the production function of the city are two main factors which play a part in identifying the macrostructure subsystem:

- industry provides the economic foundation for a city and its development, and
- industry causes a wide range of interactions with other cities.

For both factors it would be desirable to investigate whether specific quantitative and qualitative features exist for cities in the macrostructure. However, not enough progress has been made so far, so that we must limit ourselves to formulating questions.

The essential role of industry in urban development has never been questioned. Indeed, some authors have treated it as virtually the only force involved (Schmidt-Renner 1964). Insufficient research has been devoted to the specific role of industry

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in macrostructure cities, which cannot be limited to the size (number of workers, net output) of an establishment. Attention must also be paid to the interaction with research institutions, management and administrative bodies, other industrial enterprises and the wholesale trade, and to the use made of a wide range of information and contacts. "In the case of big enterprises and combines it may be enough for the management and administration to be situated in a place which is conducive to the establishment of contacts and communication, i.e. in a large city. Production itself may take place in a different location which offers specific advantages from the viewpoint of technology, supplies and marketing, and the environment" (Scherf 1975). From this it can be concluded that criteria for identifying macrostructure cities using their production function, should be sought primarily in industry-related management, planning, research and development. A powerful industrial base and a wide range of jobs must also be present. The available statistics for those employed in industry in a given city do not permit more than a first and very rough approximation toward covering specific aspects of industry with regard to the macrostructure of our settlement system.

Other criteria for determining the macrostructure of the settlement system can be expected from an analysis of traffic flows and the purposes behind them (i.e. urban functions). It should be possible to identify specific flows of people, goods and information within the macrostructure subsystem, and from the macrostructure cities to other cities/settlements. To do this, the traffic flows must be broken down sufficiently and assigned to individual urban functions. This is why our work in the field of the geography of communication now concentrates on the flow of goods between production sites (in cooperation with the Dresden Teachers' Training College), commuting, and business journeys (in cooperation with the Dresden College for Transport and Communications). Research conducted so far on the communication function of cities indicates that this is most developed in the largest centres. The two central rail junctions are Berlin and Leipzig-Halle, and six other main junctions have also been identified (Dörschel 1974). In a category of the second order settlements there would be about 40 cities, and another 100 or so in a third-order category (Gericke 1976). These cities numbering almost 150 would then belong to the macrostructure of the settlement system from the viewpoint of communications. They are distinguished from other cities/settlements by the absolute amount of incoming and outgoing traffic and by the fact that the latter prevails over through traffic.

3.

This survey shows that the urban functions, functional relations and traffic flows discussed so far provide points of departure for determining the macrostructure of the settlement system. The question then arises whether a first hypothetical diagram of the macrostructure subsystem can be outlined at this stage. This would have to make allowance both for the hierarchical structure of the settlement system with its central places (Christaller 1933), and the non-hierarchical relationships mostly based on production (Kolosovsky 1947). Dziewoński and Jerczyński (1976) proposed to develop such a model using the hierarchical order of the settlements as a basis:

"In view of the fact that towns and cities represent functions of both types (regional and supraregional, central and specialized) it seems that at present the most realistic model of spatial organization of the national settlement system can be obtained by integrating (a) the hierarchical model with (b) some elements of functional links of non-hierarchical character" (Dziewoński, Jerczyński 1976, pp. 7–8).

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If this concept is adopted, the following stages of research will be necessary:

1. Determining the hierarchical features of the macrostructure of the settlement system;
2. Determining the proportions of hierarchical and non-hierarchical functions/relations in the macrostructure;
3. Combining the hierarchical and non-hierarchical functions/relations into models of the macrostructure of the settlement system.

Ad. 1. Thanks to city-hinterland research done so far, the hierarchical patterns in the settlement system of the GDR are well-known. They reflect above all the social and politico-administrative urban functions (Krönert 1977, see also chapter 2). This hierarchical outline provides a vital point of departure for compiling models of the macrostructure of the settlement system in the GDR.

Ad. 2. Long-distance functions and relations are mostly of the non-hierarchical type. There is less data available in this field. As a first step toward analytical determination the proportions of internal, hinterland and long-distance functions in the entire set of urban functions were calculated in 1976 for the 320 most important cities in the GDR, including all those in the macrostructure. The calculations were based on the structure of employment in the individual cities and used the minimum-requirement method (Alexandersson 1956; Illeris 1964; Dziewoński 1971; Jerczyński 1972). In the calculation of long-distance relations we used available data on the currently existing traffic flows and junctions, which indicated the scope and direction of long-distance functions/relations.

Ad. 3. The result of combining the presently known hierarchical and non-hierarchical urban functions and interactions into first diagrams of the macrostructure can only be a working hypothesis. The latter above all serves as a starting point for research into selected aspects of the macrostructure. It will be continuously tested, specified and modified, if required, in the course of research projects which have now begun and will extend over several years. The diagrams start from the hierarchical organization of the national settlement system as a first conclusion on the politico-administrative and social functions and relations of the cities. It can be assumed that this organization would also include part of the production structure. Non-hierarchical urban functions and relations, often identical with production functions, were expressed by giving the number of persons employed. In other words, a non-hierarchical long-distance function was regarded as having the same importance as a hinterland function when the same number of employed was found. This simplification seems to be justifiable since the hypothetical diagrams merely serve to illustrate the concept.

It should also be pointed out in this connection that the results of analysis obtained so far deal almost exclusively with cities within their administrative boundaries.

However, certain cities were taken as a basis for the hypothetical diagram of the macrostructure from a functional point of view, and these are at the same time understood to be the points of concentration and culmination in their region.

Even at present a macrostructure of the settlement system can be sketched which consists of several levels and is not appropriately described by the concept of a "macrostructure of the settlement network" (Kluge 1974; Bönisch, Mohs and Ostwald 1976) which prevails at the present time in the approach to regional planning in the GDR.

The top level of the macrostructure of the settlement system consists of the three agglomerations with more than a million inhabitants: Berlin (1.8 million), Leipzig-Halle (2.1 million) and Dresden (1.1 million), and their specific functions and functional relations. The agglomerations have one dominant city each (or two in the case of Leipzig and Halle) with a strong industrial basis, which is also

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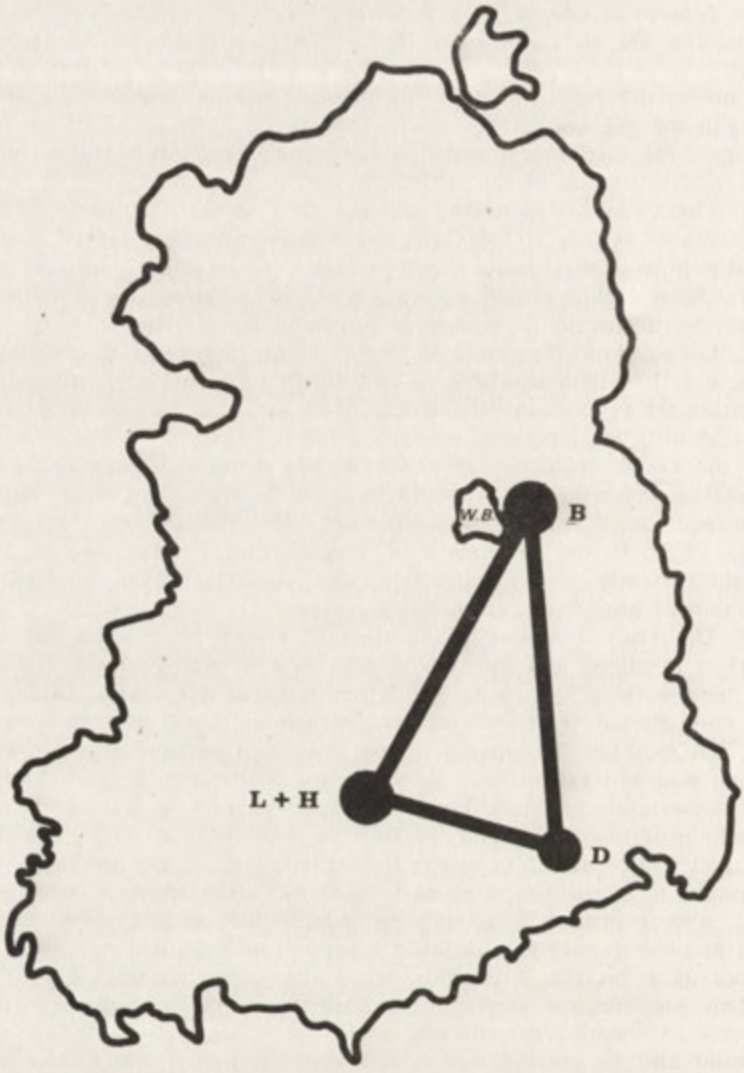

Fig. 5. The 1st level of the macrostructure subsystem (hypothetical scheme)

a centre of management, planning, research, the retail trade and traffic and communications. Large and dense populations offer a versatile potential in view of new economic and social requirements. No analytical study has as yet been made of the specific character of the interaction between these agglomerations, and of their functional relations with the rest of the settlement system. Apart from commodity flows there should also be specific flows of people and information. Each of the three agglomerations would then have to be approached as a unit in regional planning, and an attempt at this has been made in the General Plan for Berlin. No similar approach can as yet be reported for the Leipzig-Halle region. Geographical research into the regional settlement systems of the one million agglomerations is conducted primarily at the universities of Halle and Berlin. Allowance

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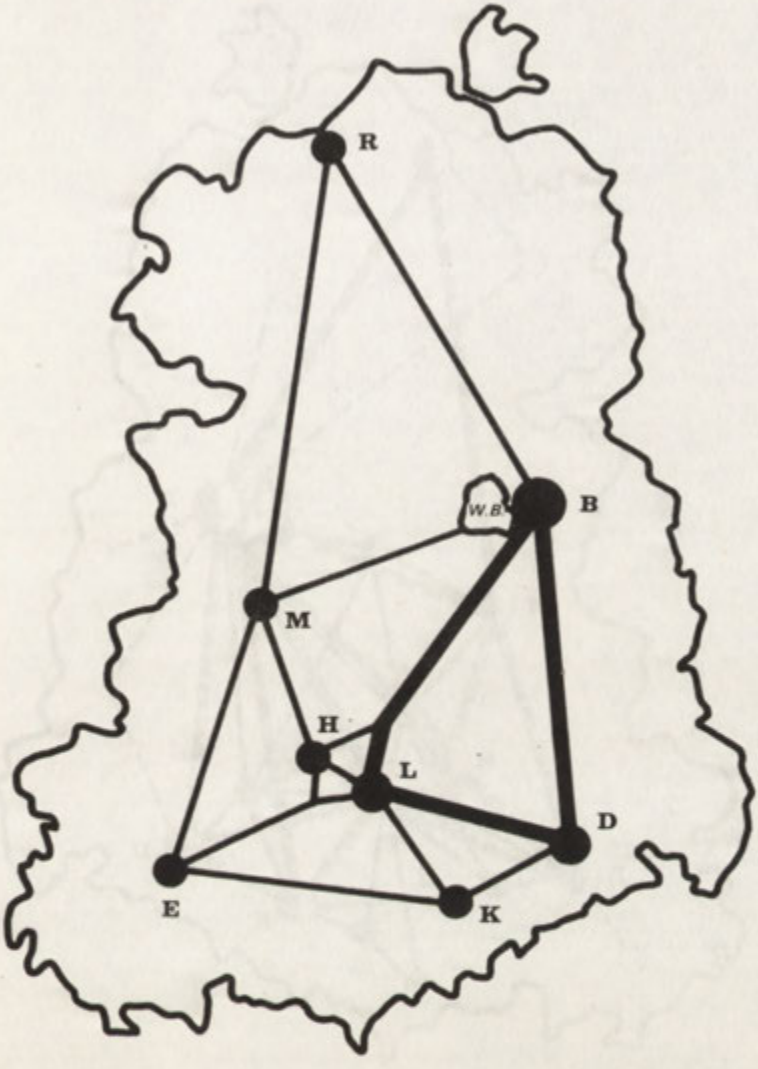

Fig. 6. The 2nd level of the macrostructure subsystem (hypothetical scheme)

has been made for the specific needs of providing transport between these agglomerations by improving rail connections and by building the Leipzig-Dresden motorway.

From what is known so far, the second level of the macrostructure consists of eight large-city agglomerations around cities with more than 200 000 inhabitants (including Berlin, Leipzig and Dresden), with their immediate hinterlands, i.e. Halle with Leuna and Buna, Leipzig with Böhlen, Magdeburg with Schönebeck, etc. For this purpose the Leipzig-Halle agglomeration is subdivided into smaller functional units. These eight agglomerations are clearly distinguished from other cities/agglomerations by the scope and range of their functions. They are of superior importance as regards both their industrial potential and management, planning,

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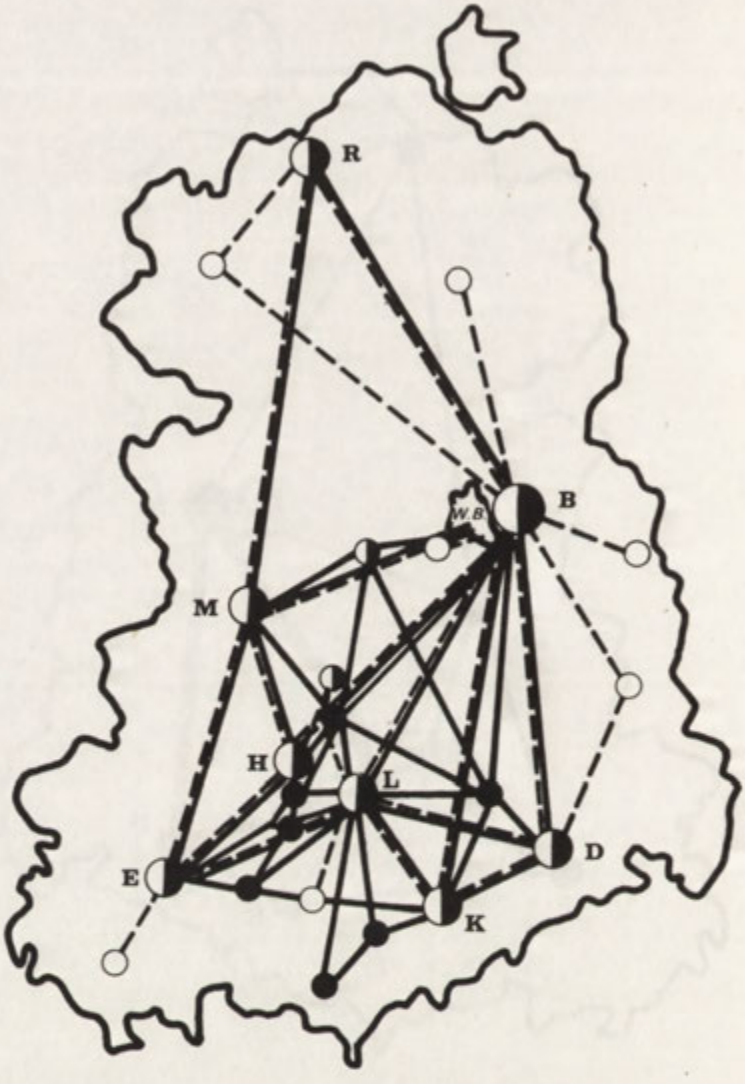

Fig. 7. The level 2a of the macrostructure subsystem (hypothetical scheme)

research, distribution and communication. It can be expected that their specific functions give rise to specific functional relations among themselves and with other cities. Our future research aims at investigating these aspects.

Supplementing the second level are a number of large urban and industrial agglomerations whose functions in part are of almost the same importance as in the eight large-city agglomerations. As far as politico-administrative and social functions are concerned, these are the remaining *Bezirk* towns. With regard to the production function, Bitterfeld should be mentioned as the outstanding industrial site. It is therefore conceivable that the eight large-city agglomerations and the about 16 partial centres (agglomerations) form a level 2a in the macrostructure of the national settlement system. In this connection, however, much more analytical research

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is needed, as well as more detailed concepts regarding the interaction of social, politico-administrative and production functions in the settlement system. For the time being, those production centres have been entered in the hypothetical diagram of the macrostructure as centres of equal importance, which have about the same number of people employed in industry as the eight large-city agglomerations.

By analogy with the second level, the third level of the macrostructure in the national settlement system should be composed of those types of cities or towns which have been identified as regional centres and *Kreis* centres due to their social role (Grimm and Hönsch 1974). Their position with regard to the hinterland is separately detailed in the contribution of Krönert (1977). In the case of these towns (agglomerations), too, a diagram may be drawn up which shows partial centres in a level 3a.

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URBAN AGGLOMERATIONS IN THE SOCIO-ECONOMIC SPACE OF POLAND: SOME ANALYTICAL QUESTIONS

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The original task that had been kept in mind before the empirical analysis was begun, was to investigate the structure of urban agglomerations in Poland and delimitate them according to the state in 1970. It was intended, however, to treat the investigation of the structure and delimitation not separately but rather in close mutual relationships. It is, however, rather complex to do so in practice; making any delimitation, as results from economic region theory, implies a previous recognition of the regional structure; on the other hand, however, it is impossible to analyze the structure of a given area that was not previously delimited, at the very least implicity. Such a vicious circle describes rather well difficulties taking place whenever an open system approach is attempted to be operationalized. To reach a realistic closeness becomes therefore, as Langton (1972) stresses, a basic problem in applications of system concepts. This postulate is possible to be fulfilled by the transition from open systems, of which are individual urban agglomerations, to a relatively self-contained system, superordinate to these systems. It is the socio-economic space of a (national) state that can be given as a relatively self-contained system.

If, after S. Herman and P. Eberhardt (1973), one can assume that the socio-economic space of a state is a megasystem, it will be possible to identify two macrosystems within it, i.e. the macrosystem of locations and the macrosystem of movements and interrelationships. Within the former one can identify, in turn, the surface, network, and nodal systems, respectively, whereas the latest is a conceptual equivalent of the settlement system. Thus the settlement system is a subset of socio-economic space. Investigation of socio-economic space contributes therefore directly to cognition of the settlement system.

To fullfil, in a comprehensive way, the analytical task mentioned at the beginning of the paper is rather complex. The objective of the analysis that was carried out was in result only partial when compared to the original task, viz. to recognize the spatial scale of urban agglomerations in Poland, i.e. to precise a place of the agglomerations in the socio-economic space of the country. The empirical task such defined was simultaneously a part of another, although not quite separate problem, i.e. the investigation of the Polish settlement system. This paper concerns merely

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to a portion of the investigation of the settlement system, viz. the investigation of the structure of the system.

In this analysis the socio-economic space of Poland was taken as the system being investigated. In an empirical analysis it is not practically possible to tackle the full set of elements. In practice it is necessary to reduce the number of elements in the set: either by omission or by aggregation. In the case of omissions, certain elements of the system under investigation are recognized as non-important in given circumstances. Aggregation of elements of a spatial system can be done either on the basis of functional linkages or on the basis of administrative criteria. The former way of aggregation, however more desirable from the theoretical point of view, has the weakness that it demands the functional linkages to be previously recognized. Thus aggregations based on administrative criteria are more often used for, however "artificial" they are, have the advantage of recognizable pragmatism. In this analysis 396 areal units were taken as elements of the system, i.e. poviats and county-boroughs[1]. Ss variables of the system, 38 scalar-like characteristics were taken that, according to the author's opinion, were to be appropriate indices of the urban-rural dichotomy.

From the viewpoint of investigation of a settlement system it is important to corroborate the spatial scale of integration that is taking place: regional or supra-regional. The answer to this question is connected with another one, viz. whether the Polish settlement system tends to create a set of city regions or a superagglomeration (megalopolitan) system. After Dziewoński (1971b) it may be hypothesized that the Polish settlement system consists of a system of urban agglomerations and regional settlement systems. To verify the hypothesis that a common system of urban agglomerations exists it would be necessary to prove that economic and social relationships between individual agglomerations are stronger and more important than those of each of them with its region and its regional settlement network.

According to the scheme provided by Chojnicki (1974) there exist two different approaches to structural investigation of socio-economic space: analytical and synthetic. In the analytical approach the socio-economic system is assumed to be a whole defined by a set of socio-economic characteristics. Spatial representation of the system belongs to the category of general socio-economic space; factor analysis is the method used to describe the category. The method identifies the latent structure of general socio-economic space (time-space) and thus realize the postulate to investigate basic patterns that examined together provide an exact enough picture of the structure. It is factors that represent substantial spatial patterns which could be identified as partial spaces. To be sure, these patterns do not exhaust the whole collection of partial spaces, however the patterns are substantial as far as the importance and stability of the represented phenomena are concerned. They could be treated therefore as stable patterns which condition a structure to emerge.

An element of a system is *ex definitione* a non-disaggregative entity in given circumstances. That is to say that on the basis of given elements of the system it is possible to reason merely about those subsystems that are not smaller than an element. In the analysis of the socio-economic space of Poland with poviats as elements of the system, it is therefore possible to observe only such urban agglomerations that are not significantly smaller than the poviat. The agglomerations which could be identified in analyses with poviats as elements of the system were called throughout this paper *macro-urban agglomerations*.

As a result of factor analysis (principal component model) that was carried out for 38 input variables, four factors were obtained with eigenvalues greater

[1] Poviats, county-level administrative units, were abolished during the administrative system reform of 1975; so were county-boroughs.

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than one. However, as it was mentioned above, only the factors analyzed together represent an adequate enough structural picture of the system. As a synthetic measure the Perkal index was used, being the arithmetic mean of the factors considered. The application of the Perkal index to principal components possesses a number of theoretical deficiencies, analyzed in more detail elsewhere (Rykiel 1978). It confirms Isard's (1971) observation that we have to use some models, despite their weaknesses, because we have nothing better to use instead.

The areal pattern of the Perkal index did not confirm the anticipated urban-rural dichotomy; instead it showed rather strong macro-regional differences between the post-Russian and post-Austrian areas on the one hand and post-Prussian on the other. Only two distinctly marked urban agglomerations were to be observed, i.e. the Warsaw agglomeration and the macro-agglomeration of the South.

Such an areal pattern of the Perkal index was caused to a considerable extent by the pattern of factor one. It was thus supposed that it was connected in a way with the question of multicollinearity. From the original input data set 11 highly intercorrelated variables were therefore deleted and 27 characteristics re-analyzed. Although the factor structure somewhat changed, the factor pattern remained substantially unchanged. Similar results were obtained after a reduction of the input data set to 16 and 12 characteristics, respectively. In each case merely two urban agglomerations were distinctly identified in the space of the Perkal index, viz. the Warsaw agglomeration and macro-agglomeration of the South. Although other agglomerations were also to be seen, one could not identify them on the basis of any absolute score but rather of the size of gradient. Generally a SW to NE slope of the structural surface could be seen whereas it referred also to urban agglomerations. With absolute scores used the urban agglomerations in eastern and northern Poland could then be identified on the basis of lower scores, or less sharp criteria than those in the western and southern part of the country. In this context a hypothesis was made on the regional character of urban agglomerations.

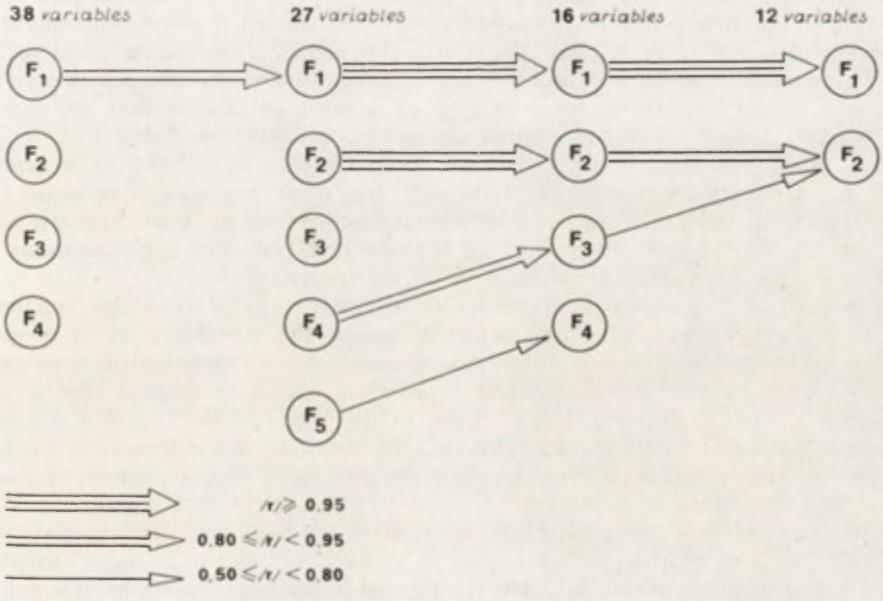

Fig. 1. Transfiguring of factors throughout reduction of input variables set — "real" structure of the system

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Having done four successive factor analyses based on successively less numerous sets of input variables it was possible to reason about the "real" structure of the system (in a dialectical sense of the term). Correlation coefficients computed for factors resulting from the successive analyses showed considerable stability in the resultant picture of the structure (Fig. 1). Four basic structural dimensions were identified: 1. occupational differences and technical infrastructure, 2. demographic and economic differences, 3. modernization (of traditional rural areas), 4. syndrome of the post industrial society. The areal pattern of the first dimension showed large-scale differences in terms of the level of socio-economic development between post-Russian and post-Austrian areas on the one hand and post-Prussian on the other. The second dimension contained two strata: one shaped by the pre-1939 versus re-gained areas demographic differences, and the other, economic, certainly newer, superimposed upon the former in the hill-like manner with its top in the voivodship of Katowice, and as such showing certain similarities to the population potential map. The third dimension differentiated Poland to her southern and mid-eastern (and to a lesser extent also west-and-north fringe) versus mid-western and eastern part. The fourth dimension, not very distinct, seemed to show the metropolitan-industrial dichotomy.

The graph presented in Fig. 1 served also as a basis to choose the "best" picture of the structure, although – as Johnston (1968) put in – an objective method to choose the classification being indeed the best of a number of alternatives does not exist. If it is desirable to choose out of the four analyses the one to keep all relatively stable structural dimensions, not contain, however, additional specificities, it is possible to point merely to the 16-variable analysis, although differences between the results of three latest are in fact rather slight. Further research was therefore based on the 16-variable analysis.

The hypothesis on a regional scale of urban agglomerations was verified by trend surface analysis. The Perkal index scores for factors of the 16-variable analysis were being approximated by successive polynomials until that of the fifth degree; the difference between the fourth and fifth degree polynomials was besides rather slight. In operational terms the hypothesis could be verified if urban agglomerations emerged out of the space of residuals from a polynomial power series trend surface.

Trend surface analysis is a sequential procedure; to find out the polynomial that fits "well enough" a given surface occurs on a basis of criteria that are external to the method itself; a comparison of the criteria is shown in Table 1.

Results of the trend surface analyses confirmed the hypothesis of a regional character of macro-urban agglomerations only partly for in spaces of residuals from polynomials of individual degrees individual agglomerations were appearing and disappearing alternately. It was only the Warsaw and Katowice agglomerations that were appearing in spaces of residuals from each polynomial.

Highly significant spatial autocorrelation of residuals from both the fourth and fifth degree polynomials that was detected implies the possibility to fit a spatial function to the residuals. It was found out, however, that to approximate polynomials of still higher degrees is non-efficient, one could therefore suspect that a more efficient fit could be obtained after a change of the nature of the function, e.g. using harmonic function. In theoretical terms it involves another reformulation of the hypothesis; viz. a modified hypothesis can be put on a "local" nature of macro-urban agglomerations.

Harmonic functions were used to approximate residuals from polynomial trends of the fourth and fifth degree, respectively. The hypothesis on a "local" nature of macro-urban agglomerations would be confirmed if the agglomerations emerged out of spaces of residuals from harmonic functions. In the space of residuals from Fourier series block I urban agglomerations marked rather distinctly (especially

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TABLE 1. Criteria of defining "good enough" approximation of polynomial trend surfaces

Criterion	Notes	Used in the analysis?	What result? (+, −)
Regarding polynomials themselves:			
1. a priori assumed degree of polynomial	traditionally third degree was taken	no	
2. a priori assumed level of variance to be accounted for	80% level was taken	yes	−
3. stabilization of spatial pattern		yes	+ (?)
4. test of significance for polynomials of individual degrees	according to the formula by G. B. Norcliffe (1969)	yes	−
Regarding coeficient of determination or residuals:			
5. decrease of increment of coefficient r^2 to an assumed level	1% level was taken	yes	+
6. sudden increase of increment of coefficient r^2 instead of incessant decrease		yes	−
7. test of significance for differences between successsive coefficients r^2		no	
8. spatial autocorrelation of residuals	according to generalized Moran's statistic for residuals from regresion	yes	−

the Warsaw and Katowice agglomerations, however); that implied their "local" scale. Analyzing until block IV enabled the function to be entirely fitted. This is to say that the overall structure of the socio-economic space was able to be represented by just one mathematical formula, although rather complex.

In essential terms the harmonic analysis confirmed generally the hypothesis of a "local" nature of urban agglomerations. In the space of residuals from the harmonic function agglomerations were to be seen relatively distinct although one was not able to separate very clearly urban agglomerations from industrial conurbations in the resultant picture. Where the "local" scale of macro-urban agglomerations has been referred to, inverted commas have been used rather intensionally. It was the scale of several elements of the system that was kept in mind; if poviats are the elements, however, the scale can be defined, without inverted commas, as mezzo-

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regional. The term "local", as well as "regional", was used in the context of a three-fold decomposition of geographical series according to a formula:

$$x_a = u_a + v_a + e_a, \tag{1}$$

where

x_a – analyzed geographical variable, in the analyzed case the Perkal index for factors out of the 16-variable factor analysis, i.e. the synthetic structural measure of the socio-economic space,
u_a – large-scale (national) trend, identified by regression polynomial models,
v_a – cyclical regional fluctuations approximated by Fourier series,
e_a – local error terms.

Using poviats as elements of the system, the geographical series was thus decomposed into three components: national, macroregional, and mezzoregional; macro-urban agglomerations turned out to be referred to the latest. Only two agglomerations: the Warsaw agglomeration and macro-agglomeration of the South could be referred to the supra-regional (national) scale. Therefore only the two entities could be called *great urban agglomerations*.

Because of the size of the basic analytical unit, i.e. the element of the system, which was poviat, the conclusion on the mezzoregional scale refers explicitly to great urban agglomerations. In a deductive way it can be, however, extended for *all* urban agglomerations in Poland: If it is *even* macro-urban agglomerations that are of the mezzoregional scale, the more all smaller agglomerations, if any exist, will be of this scale.

In systemic terms the analytical results suggest that urban agglomerations do not form an integrated subsystem within the Polish settlement system. One can suppose that the Polish settlement system is to be found in a stage of transition from the state of the past in which individual urban agglomerations were contained in regional settlement systems to a state of the future when urban agglomerations as such create a common subsystem in the national settlement system. Beginnings of the subsystem are being emerged through entities called in this paper great urban agglomerations, i.e. the Warsaw agglomeration and macro-agglomeration of the South. It can be assumed therefore that the Polish settlement system tends to create a set of city regions rather than a superagglomerative (megalopolitan) versus peripherial system.

No fully developed theory of urban agglomeration exists at the moment. If, however, one connected the concept of urban agglomeration with the concept of the city as an economic region, developed explicitly by Dziewoński (1971a), and presume that to break off the regional settlement network is a necessary condition for any urban agglomeration to exist, it would be necessary to corroborate that there are as many urban agglomerations in Poland as entities called throughout this paper great urban agglomerations, i.e. two.

The conclusion on the mezzoregional scale of urban agglomerations means that it is at this scale that delimitations of urban agglomerations should be essentially made. A decision to take the national scale is admissible although it has to involve making criteria of delimitation individual. Every urban agglomeration is to a considerable extent an individual entity, therefore each of them is to be identified out of its setting on the basis of different criteria. The conclusion is strongly underlain by economic region theory according to which delimitations of a region should be based on a *local* maximization of closeness (Dziewoński 1967).

The present paper, as any analytical piece of work, contains a number of limitations and simplifications; a duty of the author is to point to them.

The spatial scale of urban agglomerations in Poland was tried to be identified

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by decomposition of geographical series. It is not, however, practically possible to separate effects of individual spatial scales. It is due to assymetry of relations between the spatial process and the spatial form; although it is possible to deduce the spatial form if the process under investigation is known, it is not the case where the opposite direction is concerned, i.e. a given surface form can result from different processes (Bassett 1972). It is in this context that reasons of empirical inability to separate urban from industrial systems are to be sought, i.e. urban agglomerations versus industrial conurbations, that were recognized as separate entities on theoretical grounds (Feldt 1965; Lefebvre 1970).

On the basis of the analysis that was carried out one can identify macro-urban agglomerations in Poland. Besides, the identification is not based on premises on size of the central city or of the whole agglomeration. The identification is based, however implicitly, on the autocorrelation rule: in operational terms it is possible to identify an urban agglomeration in the national socio-economic space if and only if the analyzed variables have higher scores within the agglomeration than in any neighbouring unit; besides, the critical value of the difference depends on the class intervals adopted in the map. Probability for an agglomeration to appear depends therefore, among other things, in the reverse way, on how many neighbouring poviats it has.

Identification of urban agglomerations was not, however, a goal of the analysis; rather it was a means to define their spatial scale. Some elements of reasoning based even, implicitly, on a presumption that number, distribution and rough boundaries of Polish urban agglomerations were known. It was so because a dialectical contradiction exists between a continuum of settlement form, from which the development of urban agglomerations results, and a rural-urban dichotomy, being the theoretical basis for identification of urban agglomerations. Discrete division of the space in which variability of analyzed characteristics is observed, favours dychotomic divisions to appear and impedes, on the other hand, spatial continuum to be observed. This relation is a direct function of the size of the basic areal unit. Thus in an analysis of relatively large units, i.e. poviats, structural peculiarity of urban agglomerations against their hinterlands was seen as relatively marked.

It was merely scalar-type data that were analyzed in this paper. What was possible to find out in this type of analysis was the prevalence of interregional over urban-rural differences, i.e. it was possible to identify the spatial scale of urban agglomerations. Reasoning on subsystems within the settlement system was, on the contrary, rather speculative in character. It arose from the identification, in the operational sense, of socio-economic space with the settlement system throughout this paper. In reality strong interrelationship exists between socio-economic space and the settlement system, which, however, is not an identity. Reasoning on the actual character of subsystems within the settlement system need to be supported by an examination of vector-type relations of individual urban agglomerations both at an intra- and interregional scale. In this paper reasoning on social and economic relations of urban agglomeration was based on an assumption that an interrelationship exists between patterns of interconnections and patterns of locations. This interrelationship is, of course, one of a relative nature; thus conclusions on interconnections drawn from analyses of stock data should be received with certain caution. Conclusions on subsystems of the Polish settlement system received, however, certain support in analyses of flow data. The analysis of migration patterns made by Zurkowa (1978) supported conclusions of this paper on the regional character of Polish urban agglomerations; it was only the Warsaw and Katowice agglomerations that were of a national scale.

A scheme of decomposition of geographical series (formula 1) underlay a fusion of several analytical techniques into a coherent research apparatus that made it

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possible to explain the investigated problem in detail. What was a leading principle was a dialectical unity of contradictions between the alternative and complementary character of analytical models. It was individual factor analyses, polynomials of individual degrees in trend surface analysis, and individual blocks of Fourier series, respectively, that were mutually alternative. Individual analytical techniques – factor analysis, trend surface analysis, spatial autocorelation analysis, harmonic analysis – were, on the contrary, complementary to each other. Therefore T. Hagerstrand's (1969) wide-known opinion that urban and regional research, and implicitly science at all, looks like a market place rather than a place of construction seems to be only partly reasonable. More justifiable seems to be a comparison to a mosaic making where individual elements of different shapes and colours form the total composition, more or less fine. It is dialectical contradiction between the alternative and complementary character of models that is the propulsive mechanism of sequential development of science.

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A STUDY OF THE SETTLEMENT STRUCTURE OF AGGLOMERATION REGIONS IN THE GDR WITH SPECIAL REFERENCE TO THE HALLE-LEIPZIG AGGLOMERATION

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1. GENERAL SOCIAL AND RESEARCH ASPECTS

Particular attention has been paid very recently by researchers and planners to the process of urbanization and the development of settlement networks, in connection with the overall target of building a mature socialist system in the GDR. As was emphasized again at the 9th SED Congress, one of the essential aspects of the party's policy is to overcome gradually all the remaining distinctions between town and country (as has been formulated in the party program).

A planned approach to urbanization is of special importance for the agglomeration regions (*Ballungsgebiete*) in the GDR with their large economic potentials and high population concentrations – almost 40% of its people live on about 13% of the country's territory and they produce more than 50% of all its industrial goods. These large and highly urbanized areas, while affected by specific problems, also present favourable conditions for their solution. In contrast to a number of other countries including Poland, the specific characteristics of agglomeration regions in the GDR include the following:

1. They are not only big city conurbations or urban regions but extend over large areas measuring between 2000 and 4000 km^2, and their structure includes, apart from cities and medium-sized towns, a great number of small towns and urbanized villages. The total degree of urbanization is extremely high – between 75 and 95%.

2. The structure of the population in the agglomeration regions clearly reflects the negative demographic trends in the country. While the population is growing in some cities, especially in the agglomeration cores, the agglomeration regions as a whole have for years been losing people both as a result of negative natural balances and through migration.

Under these conditions the experience gained on an international scale may well be used for comparison but cannot be immediately applied in planning strategies designed to deal with development problems in the settlement structure of these regions.

As far as work for the coming years is concerned, we shall use as our base results obtained so far with regard to the structure of industries and the population, and on earlier settlement geography studies. The aim is to analyze the basic

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settlement types in the agglomerations and then, later, the settlement structure in its entirety. At the present time, varying degrees of progress have been made in individual studies. The following gives an idea of the theoretical and methodological starting points, and some of the findings will also be reported.

2. THE STRUCTURE OF THE SETTLEMENT NETWORK IN THE AGGLOMERATION REGIONS

One of the outstanding features of the settlements in the agglomeration regions is their high degree of urbanization. This is by no means expressed only in the comparatively large number of big and medium-sized cities (of which 39 out of a total of 114, or 34%, each with a population of more than 20 000, were situated in agglomeration regions in 1975). Another typical feature is the large number of small towns, workers' housing estates and industrial communities, often with populations of more than 1000 and many urban traits in their economic and social structure and the design of buildings.

A *quantitative approach* reveals the dominant position of the big-city cores. In the Halle-Leipzig agglomeration Leipzig (pop. approx. 710 000), Halle (pop. approx. 312 000) and Dessau (pop. approx. 116 000) account for some 56% of the total population, and the proportion for the Karl-Marx-Stadt – Zwickau agglomeration is 32% and for the Dresden agglomeration as high as 65%.

The next category after the big-city cores is the medium-sized towns, the majority of them smaller, with populations between 20 000 and 50 000. In the Halle-Leipzig agglomeration there is a group of 6 "typical" medium-sized towns (average pop. 50 000) and a group of 5 "small" ones (average pop. 21 000).

Similar hierarchy patterns for larger medium-sized towns can be found, although less pronounced, in the Dresden agglomeration (average pop. 45 000 and 20 000). In the Karl-Marx-Stadt – Zwickau agglomeration, however, the "typical" size is missing, but a complete range of towns with populations from 33 000 downward to small towns can be found. On the other hand, there are local agglomerations of small towns and almost medium-sized towns whose combined populations are equivalent to a city or large medium-sized town (Schneeberg – Aue – Schwarzenberg with 130 000, Crimmitschau – Werdau with 74 000, Glauchau – Meerane with 56 000 and others; see also Hecker 1979, p. 85).

Small towns and large, urbanized villages are an important factor in the settlement structure of the agglomeration regions. No detailed study has as yet been made about their relative size, but rough estimates for the Halle-Leipzig agglomeration dating from 1971 indicate the following (Table 1).

It will be seen that small towns with populations between 5000 and 10 000 form an important group in the overall structure of the settlement network in the agglomeration region, both as regards their number and the relative weight of their populations. On the other hand, the majority of the communities (some 87%) are small and very small settlements, and while their overall share of the population is limited, they represent the basic fabric of settlement as such. Similar data were obtained by Meyer (1971) for parts of the Karl-Marx-Stadt – Zwickau agglomeration (Table 2).

Three different sources (Känel 1971; Grimm and Hönsch 1974; Neumeister and Süss 1971) are available at the present time for an assessment of the economic basis of a settlement or community using standardized criteria. When these are compared for the Halle-Leipzig agglomeration, the following points emerge:

1. Känel describes the economic structure of the employed population living in

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TABLE 1. Settlement structure of the Halle–Leipzig agglomeration

Population group	Number of communities		Population in 1971	
	absolute	per cent	absolute	per cent
more than 20 000 (agglomeration cores with suburbs)	15	3.2	1 569 000	76
10–20 000	5	1.1	64 000	3
5–10 000	24	5.2	156 000	7
3– 5 000	17	3.6	66 000	3
communities above 3000	61	13.1	1 855 000	89
communities below 3000	405	86.9	233 000	11
all communities	466	100	2 088 000	100

urban communities with as few as 20 000 inhabitants as consisting of the following main groups:

Agriculture and forestry	less than 20%
Industry and crafts	50–70%
Distributive trade, transport, non-material production	30–50%

This structure of employment is typical of cities in industrial areas. Only in two cases out of a total of 17 is the percentage of those working in the non-material sphere higher than given above (Halle and Delitzsch). Among the smaller towns (pop. under 10 000) there is a type with a proportion of more than 70% employed in industry (see also item 3, below).

TABLE 2. Settlement structure of the Karl-Marx-Stadt–Zwickau agglomeration

Population group	Percentage of communities	Percentage of population
under 500	22.6	1.3
500–2000	35.3	8.0
2000–5000	21.3	12.2
above 5000	20.8	78.5

2. In accordance with these structural characteristics the larger cities are described as types A–D by Grimm and Honsch (A: major centre, only Leipzig; B: major *Bezirk* centre, only Halle; C: major regional centre, Dessau, Wittenberg, Eisleben; D: major *Kreis* centre). The C centres and the CD transitional types belong primarily to the group of the "typical" medium-sized towns with populations around 50 000. The D centres normally are "small" medium-sized towns with populations from 20 000–30 000. The small towns are mostly of type E (local centre).

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3. Among the small-town communities (pop. 2000–5000) and rural communities the dominating structural type is that of the industrial settlement or workers' housing estate, where more than 50% or as many as over 70% are employed in industry. This type is found primarily along a number of major lines of communication (e.g., Halle-Naumburg, Leipzig-Zeitz, Leipzig-Altenburg and Bitterfeld-Dessau) and in the vicinity of industrial centres. A last group, communities where less than 50% of the population work in industry and a relatively high proportion (more than 30%) in agriculture, consists of smaller urban settlements with population of less than 1000. This group can be found mainly in those parts of the agglomeration where there are no larger industrial sites and which are situated at a certain distance from major roads.

As far as there are any urban centres in the areas just described, they consist of local centres and central communities with limited catchment areas. In addition, there are in some parts of the agglomeration communities with more than 5000 inhabitants, which are of hardly any importance for their hinterlands. Most of these are residential towns.

4. The rough outline given in items 1–3 of the economic structure of the settlement network in the Halle-Leipzig agglomeration can be supplemented impressively by classifying the communities into types according to land utilization patterns (on the basis of the economic register). Neumeister and Süss (1971) used factor analysis to establish eight types of communities which can be grouped into three main categories: (a) agricultural communities (2 types), (b) urban communities (3 types), (c) mining communities (3 types).

When these are marked on a map, giving all eight types, the structural patterns in the settlement network emerge as described above.

When one looks at the situation of the cities in the agglomeration and their resulting relations, they can be described as cores of different rank in the overall settlement system, and also as centres of partial or sub-systems. This network of centres which arose in the course of history as a comparatively balanced system of central places in the Christaller sense (see also Arnhold 1951) was transformed as a result of industrial agglomeration, as follows:

– A comparatively higher density occurred in higher-ranking centres. At the same time their hinterlands diminished in size and their importance increased as residential centres. These centres of a higher order, now primarily medium-sized towns and smaller places with the functions of *Kreis* towns, form secondary cores in relation to the agglomeration cores in the settlement network.

– An above-average growth occurred in all those former rural settlements which attracted the majority of the population living in the agglomeration region, as a result of urbanization induced by the large industrial centres and because they were situated along the major lines of communication. These now form continuous settlement strips (or bands).

– Many rural settlements in between the settlement strips and outside the immediate vicinity of the agglomeration cores and industrial centres were left behind in relative terms or experienced absolute stagnation and some of them a drop in population.

The settlement network in the Halle-Leipzig agglomeration – and with a degree of modification also in the Karl-Marx-Stadt – Zwickau and Dresden agglomerations – can then be described as a large polycentric structure in which the basic features of a node-band pattern exist side by side with rural central place systems. The following relations of interdependence exist between the settlement types described so far and their territorial structure on the one hand, and the structural patterns prevailing in agglomeration regions as identified by the Research Group on the other (see also Scholz 1972; Schmidt and Rosenkranz 1972; Mohs, Schmidt and Scholz 1976):

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Agglomeration cores	Big city centres with many suburban residential settlements, some of them large and small-town centres of local settlement systems
Agglomeration field, Type FG	Small industrial towns, residential towns and urbanized villages in the immediate vicinity of large industrial centres and along major roads
Type FV	Urbanized villages with a high degree of industrialization and small industrial towns, primarily in settlement strips
Type FA	Urbanized villages where the agricultural and residential functions prevail, mostly with limited populations, and small towns, often integrated into local settlement systems
Agglomeration fringe	Rural settlements with a diversified structure, most of them residential and agricultural settlements normally integrated into local settlement systems consisting of small and medium-sized towns

The medium-sized towns which form secondary cores cannot be assigned to any one of the structural types alone but occur in all of them, both at the junctions of individual settlement strips and as central towns in these strips.

3. ASPECTS RELATED TO THE BASIC SETTLEMENT TYPES

If a planned approach is to be taken to the further development of the settlement structure in the agglomeration regions then the basic problems involved must be known. Progress made so far can be summarized in the form of tables (see Annex). From these results highly diversified trends can be expected for the basic settlement types in agglomeration regions, which can be roughly outlined primarily on the finding that structural transformation will prevail over growth processes. The following features should be mentioned in this connection:

1. Trends towards concentration can be observed in the agglomeration regions, which will above all lead to a redistribution of people in favour of the larger urban centres (agglomeration cores, medium-sized secondary and tertiary cores). Only in isolated cases will this result in further spatial density growth, or in an increase in the area occupied by a settlement.

2. These is a clearly defined tendency toward a specialization of functions, which is accompanied by a widening range of functions in the larger urban centres, whereas the scope of functions offered by the small settlements is usually narrowed.

3. As far as the spatial structure of the settlement network and the individual settlements as expressed in land use are concerned, trends toward concentration can be seen. Some new differences in the level of development are currently emerging between those parts of the settlement structure dominated by new buildings and others where old buildings prevail.

4. Especially in the basic stratum of small settlements the organizational patterns of local settlements are becoming ever more accepted (particularly in connection with the establishment of associations of parishes and vast agricultural production complexes). However, similar trends have not been found as yet to operate on the level of higher-ranking centres.

Apart from these aspects of structural change other general sets of problems may be expected, which will be primarily of a technical and town planning nature and apply to the whole settlement structure of the agglomeration region. They relate above all to the infrastructural sphere and result from imbalances with regard to demand, existing facilities, years in operation and reliability.

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4. CONCLUSIONS FOR FUTURE RESEARCH

The progress made so far in the investigation of the settlement structure of agglomeration regions is not sufficient for the formulation of practicable suggestions for development. First of all the basic aspects identified above with regard to the settlement network and individual settlements must be studied in greater detail. This calls for continued analysis of the structure of the settlement network, the structure of individual groups of settlements, but also for general research into such fields as the production structure and infrastructure. On this basis and through a comparison with experience gained on an international scale, concepts can be developed which have the character of target models and which can be used to guide and coordinate concrete planning. From what is known so far the desirable pattern for the GDR is a polycentric node-band structure which combines elements of the urban region model and the strip city with those of central place settlement systems by way of a regional node-band structure.

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ANNEX: Essential structural characteristics and development problems of settlements in agglomeration regions in the GDR

Structural characteristic	Big-city agglomeration cores	Secondary and tertiary cores in the settlement network	Non-urban small settlements
1	2	3	4
Position in the settlement network, situation	Dominat centres in the national and regional settlement network, most of them centrally situated, with far-reaching hinterland relations	Secondary cores: typical medium-sized towns, often at the fringe of an agglomeration field. Tertiary cores: small medium-sized towns in the agglomeration field. Both primarily regional centres, but with a comparatively limited hinterland region	Basic stratum of the settlement network, at least one stable function, organized in local settlement systems with small-town centres, or in settlement strips
Range of functions	Polyfunctional, full range of functions including highest order	Polyfunctional, narrower range, in part highly specialized	At least one, maximum four basic functions (agrarian, industrial, services or residential).
Development trends with regard to functions	Extension of central functions in the non-material sphere and of the residential function, specialization of the industrial function	Extension of special functions, additions to lower-order functions, rapid expansion of residential function	Reduction in the agrarian function, expansion of the residential function depending on the situation in the agglomeration field.
Resources	Scarcity of land and water as a result of often wasteful use, heavy environmental pollution in part	Still sufficient as a rule, some water scarcity, considerable environmental pollution in some places	Sufficient, with the exception of settlements near open mines or without a central water supply
Population structure	Percentage of old people much too high, negative balance largely compensated by migration. Diversified high level of qualification	Favourable composition with natural balance, high migration gains in most cases	Percentage of old people too high in part, trend toward increase
Population trend	Growing/stagnating due to migration gains, highly dependent on housing construction	Slow but steady growth, migration gains primarily from own hinterland	General decrease (0.5–1.5% per year), sometimes growth in settlements with large investment projects

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1	2	3	4
Technological infrastructure	Excellent or well-equipped but mostly outdated, strong need for modernization and extension	Well-equipped as a rule, mostly outdated in city centres	Not sufficiently equipped as a rule, diversification depending on size and type of settlement
Social infrastructure	Basic facilities and housing not sufficient, enough specialized facilities	Sufficient facilities in most cases	Basic facilities exist as a rule
Internal structure differentiation	Extreme differentiation and fragmentation, often with considerable differences between individual boroughs	Well developed. Despite fragmentation in some case not too involved in general, with only negligible differences	Beginnings exist
General trends	In general further rise in level of functions, some sprawl, temporary aggravation of disproportions	Slow growth with partial extension of functions and further specialization (particularly in industry), concentration in housing construction	Further shift in functions structure toward residential function, steady contraction and trend toward higher proportion of old people
Basic challenges to regional planning	Enhancing functionality through elimination of existing structural deficiencies, regional rationalization and structural reorganization, development of satellite centres in the hinterland	Enhancing the functionality of old town cores, thorough renewal and extension of technological infrastructure, addition of more functions, improving links with settlements in the hinterland	Detailed planning of specialization and contraction processes, establishment of local settlement systems (on the basis of associations of parishes), improving links with higher-order centres

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TOWARDS A THEORY OF INTRA-URBAN STRUCTURES OF POLISH CITIES

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More than thirty years of intensive development of the Polish People's Republic have had a very strong impact on the inherited dense settlement network formed in the previous historical periods. Settlement network and particulary intra-urban patterns were slowly reconstructed according to the new economic, political and social demands. The most radical structural changes have occured in cities which had been heavily destroyed during World War II and have been reconstructed afterwards, and in cities with tremendous population growth stimulated and accelerated mostly by intensive industrialization policy. It led to several new phenomena and spatial patterns in intra-urban structures which could be regarded as characteristic for the future Polish cities or in broad terms as typical features of the future socialist cities. Investigations of the intra-urban structure within the framework of developing planned economies have been introduced in Poland by sociologists (Pióro 1962; Braun 1964; Ziółkowski 1964; Piotrowski 1966; Jałowiecki 1968; Kaltenberg-Kwiatkowska 1973).

In spite of the existence of limiting factors imposed by the political system, the action of the classical ecological processes characteristic of capitalist cities as have been found still persists. For example, the process of selective allocation of immigrants according to their occupational qualifications and origin (country born versus city born) have been observed. These conclusions were made in the investigations undertaken just after World War II and in the 1950's of medium sized cities. If we take into account the inertia of the socio-spatial patterns, the results of such research may be explained to a large extent by the pre-war situation not yet fully superseded by the new socialist socio-economic relations.

In the early 1970's research undertaken in Warszawa and Wrocław on the socio-spatial patterns of Polish cities was based on factor ecological methods and analysis. These kind of investigations were made possible thanks to the accessibility of very detailed statistical data from the National Census of 1970. In spite of some methodological problems of adjusting input data to the ecological concept, several dimensions differentiating socio-economic space in Polish cities were identified. Such research proved that the revaluation of the social structure which took place in the 25 years of the PPR (up to 1970) was followed by a revaluation of intra-urban space. It is possible to state that there has been a general decrease and relative smoothing of commercial and social differentiation of specific residential locations

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in city space. Just after the war, in conditions of progressive reconstruction connected with urbanisation and tremendous uncontrolled migration from the country, the key problem for migrants was to find living accomodation in the city, but their particular location in the city was less important.

With the general improvement of housing conditions in cities the phenomeron of the structuralisation again become evident, but within the framework of totally different criteria. Structuralisation of intra-urban space hasn't developed according to the needs of any social classes or groups, but mostly according to the needs of the whole community. This doesn't mean that in our conditions allocation occurs without any conflicts. Competition between different social groups for a better location in space in the city does exist (Jagielski 1978). On a large scale it is evident in the struggle between diverse actors – firms, institutions and factories for better location and quality of housing for their own staff. On a smaller scale it is manifested by the individual households who go to the private market with preferences for certain locations and in illegal housing construction, frequently of a substandard level, on the fringe of big cities and in smaller suburban settlements.

One of the most important factors influencing the new restructuralisation of intra-urban space is housing policy, which has the largest impact on changes in living conditions and allocation for particular social groups. During the post-war settlement period those socio-occupational groups which were the most needed at any given stage of economic development (key workers) have obtained better housing allocation.

Broadly speeking therefore the essential element of structuralisation of the intra-urban space may be identified as the social value of the labour force, according to which housing policy has been generaly adjusted. The research amassed so far allows us to a partial answer to the question, what determines the social pattern of the city under the conditions of a planned economy.

Admittedly, the intra-urban structure of capitalist cities has been the most popular subject of scientific research on urban geography. Nevertheless a comment that is often expressed in contemporary geographical and sociological literature is that the theoretical explanation of residential differentiation is over simplified. These theories are limited to the statement that similar people like to, or even do live close to each other (Harvey 1975). Besides these theories, very general arguments are presented about interrelationships between broadly defined social structures and intra-urban patterns (Hawley, Duncan 1957; Robson 1969; Timms 1971; Johnston 1971; Eyles 1978). However industrial cities in capitalism were the topic of interest of social workers and scientists from the very beginning of their existence (e.g. Engels 1844). It is no wonder that the most important research centre has emerged in the United States (the Chicago school of urban ecology in the Department of Sociology and Geography of Chicago University) where urbanization and industrialization has taken place at a rapid rate and on an enormous scale. Up to 1945 three models of the intra-urban structure had been formulated: Burgess' (1925) zonal model, Hoyt's (1939) sectoral model and Harris and Ullman's (1945) multiple nuclei model. In the 1950's the concept of "social area analysis" was formulated by Shevky and Williams (1949), and Shevky and Bell (1955). In the 1960's the general concept of factorial ecology was formulated and developed (see Supplement to 47th volume of *Economic Geography* 1970).

The 1970's have been characterized by the development of radical or institutional urban geography (Harvey 1973) which in the west is considered to represent marxist geography (Peet 1977; Johnston 1977). In their opinion, concentration on the forces which determine the forms of conflict in capitalist societies has the decisive impact on the emergence of the new paradigm in urban geography.

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The majority of works based on the above concepts refer to the highly developed countries of North America, Western Europe and Australia. However, the forms of spatial differentiation of the cities of other continents possess (beside the fact of lower stage of economic development) also their own cultural and regional differentiation. Schnore (1965) suggests that the reversed concentric zones pattern of Burgess is characteristic of Latin American cities, as the model of the city before industrial revolution. For McGee (1967) the double structure of the 'colonial city' is the result of the impact of the western capitalist economy on the traditional Asian culture. The works by Johnston (1972), Friedmann and Wulff (1976) are a more thorough discussion of the intra-urban structure of the Third World cities.

More recently, in geographical literature, topics about nineteenth century capitalist cities (Goheen 1970; Dennis 1977; Pooley 1977; Shaw 1977; Tunbridge 1977) have become very popular. Feudal cities (i.e. the pre-industrial city concept, Langton 1975, 1977; Vance 1971) with some very well known generalizations (such as Sjoberg 1960, 1965) have also been investigated.

Division of the feudal urban society into the small elite on one side and much larger lower class on the other created a very strong spatial dichotomy of cities. The elite was concentrated in the centre and segregated from the remainder of society. The surrounding larger areas, in which social status diminished outwards, were organized into different occupational districts which reflected the spatial association of craftsmen-retailers, poor transport facilities and social organization into guilds (Langton 1975; Sjoberg 1960). For Sjoberg, the spatial and social patterns of the pre-industrial city were shaped by the level of technology. Vance (1971) represents a different point of view. In his opinion the key factor was at a certain phase of development the means of organizing production. The feudal city was organized by the guilds system which determined the social structure, economic system and spatial pattern. Allocation of the occupational districts cannot be explained in terms of general economic factors because the value of land had the value of social association. Places of living and work were located in one guild's quarter because they could produce and sell within the framework of this system. Thus the spatial structure of the city was differentiated according to occupation. As the master, his family, servants, journeymen and apprentices lived in one house where his shop and store rooms were also located, vertical space residential structure was differentiated socially in vertical dimensions.

In view of the above studies a statement, although not confirmed by a homogenous theory, that each mode of production system creates a specific system of spatial differentiation in cities (Lefebvre 1970) seems justifiable. In fact the structure of socio-economic space in any city can be considered as an expression of the mode of production (Castells 1975) under which a given city has developed. However the fact that intra-urban residential differentiation has been shaped by a specific mode of production in various socio-economic formations through various sets of processes and forces can be seen in Table 1.

The empirical studies of socio-ecological structure of nine Polish cities represent an attempt to test the above assumptions as the next step towards understanding the emerging intra-urban patterns of cities in planned economies. Are the results obtained in investigations of the intra-urban structure of Warsaw and Wroclaw (Węclawowicz 1975, 1977; Jagielski 1978) that the main factor differentiating the space of the urban area and thus the distribution of the city population is the social value of the labour force and its impact on housing policy applicable to the case of other cities? Is it true that spatial differentiation of cities is based on the criterion of value represented by professional occupation? Did the groups of higher value in the labour force receive a better location in space in other cities?

The notion of intra-urban structure will refer, in this particular case, to the

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TABLE 1. Intra-urban pattern in cities of different socio-economic formations

Socio-economic formation	Predominant form of socio-spatial patterns in the city	Processes and forces of the mode of production shaping social pattern in the city
Feudalism	Horizontal segregation according to occupation, ethnicity and religion. Vertical segregation according to social position	Production structure. Level of technology and guild's system
Capitalism	Spatial (horizontal) segregation of social groups according to class, ethnic and religious origin (zonal sectoral, multiple nuclei models)	Power structure Social status Rent of land
Socialism	Decline of the socio-spatial segregation. Emergence of mosaic patterns. Differentiation of occupational-stratas	Social value of labour force. Housing policy

residential differentiation of social, occupational and demographic groups, the structure of households and dwelling conditions.

The method of investigation used was the technique known as principal component analysis. The calculations were made for the same set of 40 variables taken from the National Census of 1970 for each individual city (Table 2). As the number of spatial units differed from case to case, the information (input) matrix in each city had different dimensions. For Łódź there were 40 variables for 673 spatial units and respectively, Cracow 40 for 709, Lublin 40 for 392, Częstochowa 40 for 202, Radom 40 for 126, Olsztyn 40 for 119, Rzeszów 40 for 50, Opole 40 for 91, Słupsk 40 for 60.

The analysis carried out enabled us to distinguish seven components which then were submitted to varimax ortogonal rotation. The basic dimension of differentiation of social and economic intra-urban space in the studied cities was formed from the components called 'socio-occupational position' explaining between 21.9% in Olsztyn and 31.6% of total variation in Opole (Table 3). In the case of Rzeszów the component structure seemed to be exceptional as the dominant explanatory component was the 'dwelling conditions of households' explaining 32.4% of the variation. For interpretation purposes, the list of variables most highly correlated with components were taken into consideration. It was found that the stable set of variables was closely associated with all the components formed from 'socio-occupational position'. The highest association concerning social and occupational structure variables had the greatest interpretative value. The second highest association was the level of education and dwelling conditions. It was found that socio-occupational components were also highly associated with one or two additional variables that define the form of ownership i.e. dwelling and age, the size of households, origin of the population and service workers (Table 4).

Just as the sporadic occurence of some variables, their hierarchic arrangement of

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TABLE 2. Index of variables

1. People aged under 14 years in % of total population
2. People aged 15–24 years in % of total population
3. People aged 25–64 years in % of total population
4. People aged over 65 years in % of total population
5. Female population in % of total population
6. Working women in % of total female population
7. Occupation – managerial and highly professional staff in % of total employees
8. Occupation – specialists and middle professional staff in % of total employees
9. Occupation – clerks in % of total employees
10. Occupation – workers in % of total employees
11. Occupation – service sector workers
12. Social position – manual workers in % of total employees
13. Social position – white-collar workers in % of total employe
14. Social position – contract or commission agents in % of to employees
15. People with university or equivalent education in % of populati aged 15 years and over
17. People with secondary education in % of population aged years and over
18. People with standard education in % of population aged years and over
19. Native population – people born in the present place of re dence in % of total population
20. Country born population of % of total population
21. Country born population living 0–4 years in the town in of total population
22. Country born population living 5–9 years in the town in of total population
23. One-person households in % of total households
24. Two-person households in % of total households
25. Three-four person households in % of total households
26. Five-person households or larger in % of total households
27. Women in one-person households in % of total househo
28. Two or more households in one dwelling in % of total househo
29. Privately owned dwellings in % of total dwellings
30. State or local authorities owned dwellings in % of total dwelli
31. Co-operative housing organizations owned dwellings in % f total dwellings
32. Dwellings built before 1944 in % of total dwellings
33. Dwellings built in 1945–1960 in % of total dwellings
34. Dwellings built in 1961–1970 in % of total dwellings
35. Number of persons per room
36. Living space of dwellings in m^2 per person
37. Dwelling with central heating in % of total dwellings
38. Dwellings with water closet facility in % of total dwelli s
39. Dwellings with running water facility in % of total dwellings
40. Dwellings with gas in % of total dwellings

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TABLE 3. The percentage of explained variation

	Component I		Component II		Component III	
	%	Name	%	Name	%	Name
Łódź	30.3	Socio-occupational position	17.0	Dwelling conditions of households	10.9	Housing
Cracow	25.6	Socio-occupational position	21.7	Dwelling conditions of households	11.8	Demographic and migrational position
Lublin	26.5	Socio-occupational position	14.4	Dwelling conditions of households	10.7	Housing and demographic situation
Częstochowa	29.4	Socio-occupational position	18.3	Dwelling conditions of households	11.5	–
Radom	29.7	Socio-occupational position	19.4	Dwelling conditions of households	15.9	Demographic and migrational position
Olsztyn	21.9	Socio-occupational position	14.5	Demographic and migrational position	11.1	Dwelling condition of households
Rzeszów	32.4	Dwelling conditions of households	18.7	Socio-occupational position	14.7	Demograhic and migrational position
Opole	31.6	Socio-occupational position	16.9	Demographic and migrational position	15.0	Dwelling conditions of households
Słupsk	28.6	Socio-occupational position	22.7	Demographic and migrational position	10.3	Dwelling conditions of households

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and the names of interpreted components

Component IV		Component V		Component VI		Component VII	
%	Name	%	Name	%	Name	%	Name
7.9	Demographic and migrational position	5.6	Housing and demographic situation	4.2	Population origins	3.3	Socio-occupational position II
5.6	Housing and migrational position	4.4	Housing and demographic situation	4.1	–	2.9	–
6.9	Population origins	5.3	Demographic and housing situation	5.0	–	3.4	Socio-occupational position II
8.5	Housing	5.3	–	4.0	Population origins	3.3	–
7.8	Population origins	4.5	Housing	3.4	–	2.9	–
8.1	Housing and demographic situation	6.5	–	5.4	Socio-occupational position II	3.8	–
8.8	Housing	5.1	Housing and demographic situation	4.1	–	2.9	–
6.2	–	4.8	Housing	3.3	Housing and demographic situation	2.9	–
6.1	Housing	5.6	–	4.6	Housing and demographic situation	4.4	–

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TABLE 4. Loadings of the socio-occupational components

Variable No.	Łódź	Cracow	Lublin	Częstochowa	Radom	Olsztyn	Rzeszów	Opole	Słupsk
1	2	3	4	5	6	7	8	9	10
1.	–	−0.30	–	–	0.37	–	–	–	–
2.	–	–	–	–	–	–	–	–	–
3.	0.35	–	–	–	0.34	–	0.37	–	–
4.	–	–	–	–	–	–	–	–	–
5.	–	0.34	–	–	–	–	–	–	–
6.	–	–	–	–	–	–	–	–	–
7.	0.86	0.78	0.82	0.86	0.88	0.70	0.80	0.87	0.81
8.	0.91	0.88	0.83	0.88	0.87	–	0.76	0.86	0.78
9.	0.80	0.71	0.76	0.81	0.91	0.76	0.69	0.83	0.70
10.	−0.86	−0.89	−0.69	−0.91	−0.87	−0.31	−0.89	−0.88	−0.73
11.	−0.36	–	–	–	–	−0.36	–	−0.56	−0.39
12.	−0.90	−0.92	−0.70	−0.93	−0.90	−0.49	−0.88	−0.91	−0.93
13.	0.93	0.93	0.95	0.92	0.97	0.60	0.93	0.94	0.93
14.	–	–	–	–	–	0.43	–	–	–
15.	–	–	–	–	–	–	–	–	–
16.	0.92	0.83	0.82	0.88	0.89	0.46	0.88	0.83	0.75
17.	0.84	0.79	0.67	0.87	0.89	–	–	0.80	0.72
18.	−0.72	−0.74	−0.57	−0.61	–	–	−0.51	−0.84	–
19.	–	−0.34	−0.45	0.42	−0.38	–	0.48	−0.70	0.35
20.	−0.38	–	–	–	–	0.55	–	–	–
21.	–	–	–	–	–	–	–	–	–
22.	–	–	–	–	–	–	–	–	–
23.	–	0.38	–	–	–	–	–	–	–
24.	–	–	–	–	–	–	–	–	–
25.	–	–	–	–	0.38	–	–	0.31	0.57
26.	–	−0.45	−0.41	–	0.56	–	0.60	−0.51	−0.53
27.	–	0.37	–	–	–	–	–	–	–
28.	–	–	–	–	–	–	–	–	–
29.	−0.32	–	−0.71	−0.34	−0.71	−0.31	−0.46	−0.64	–
30.	–	–	0.41	–	–	–		0.40	–
31.	0.39	0.32	0.57	–	0.60	–	0.51	0.41	0.36
32.	−0.31	–	–	–	–	–	–	−0.48	−0.59
33.	–	–	–	–	–	–	–	–	–
34.	–	–	0.40	–	–	–	–	–	0.54
35.	–	–	–	–	–	–	0.31	–	–
36.	–	–	–	–	–	–	–	–	–
37.	0.44	–	0.73	0.42	0.65	0.63	0.45	0.63	0.68
38.	0.55	0.56	0.89	0.59	0.84	0.88	0.60	0.85	0.81
39.	0.47	0.57	0.85	0.57	0.81	0.79	0.62	0.77	–
40.	0.51	0.58	0.82	0.48	0.83	0.71	0.52	0.79	–

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loadings in particular cities is the result of the development of a specific intra-urban structure.

The highly positively associated variables were the higher social and occupational groups when compounded with variables concerning better education and better dwelling conditions, but with lower associations. The highly negatively associated variables were lower social and occupational groups compounded with variables concerning the worst education and dwelling conditions. In the case of Olsztyn there was a reversal of the general hierarchy – the most highly correlated with the first component were variables representing dwelling conditions. In several cities (Opole, Słupsk, Lublin) the variables of dwelling conditions were mixed with those of social and occupational structure.

Together with the similar composition of first components in Warsaw and Wroclaw, the above results prove that the basic dimension differentiating intra-urban space of the Polish cities is formed by socio-occupational position.

But to what extent are the identified dimensions the same and how far do they differ from each other? In the case of Warsaw and Wroclaw the component structure possesses different though overlapping sets of input variables. As a result we can compare only generally the results obtained for them and for the above described cities. A more detailed statistical comparison was possible between 9 cities under investigation. The same set of input variables allowed us to even measure the similarity between the component structures these cities.

The coefficients of correlation have been used as a measure of similarity. Coefficients shown in the Table 5 were evaluated from nine socio-occupational position components. The whole matrix of correlation showed a very strong relationship which in this case was interpreted as a similarity between components of all cities with the exception of Olsztyn and Słupsk. All these components were in fact quite similar or they overlapped by at least 75% ($r^2 \times 100\%$). The socio-occupational component in the case of Olsztyn was less similar to the other components but still overlapped with them by at least 57.29% ($r = 0.7569$), the same was true for Słupsk at the 59.14% level ($r = 0.7690$). Thus the components for Łódź, Cracow, Lublin, Częstochowa, Radom, Rzeszów, Opole represent a first, Słupsk a second and Olsztyn a third sub-type of socio-occupational positions.

TABLE 5. Coefficient of corelation between socio-occupational position components

	Łódź	Cracow	Lublin	Częstochowa	Radom	Olsztyn	Rzeszów	Opole	Słupsk
Łódź	×								
Cracow	0.9350	×							
Lublin	0.9003	0.9183	×						
Częstochowa	0.9504	0.9508	0.8734	×					
Radom	0.9119	0.9232	0.9621	0.9304	×				
Olsztyn	0.7789	0.7569	0.8264	0.7620	0.8358	×			
Rzeszów	0.8897	0.8850	0.9184	0.9162	0.9165	0.7710	×		
Opole	0.9476	0.9132	0.9490	0.9342	0.9399	0.7770	0.9160	×	
Słupsk	0.8963	0.8163	0.8325	0.8892	0.8704	0.7690	0.8867	0.8906	×

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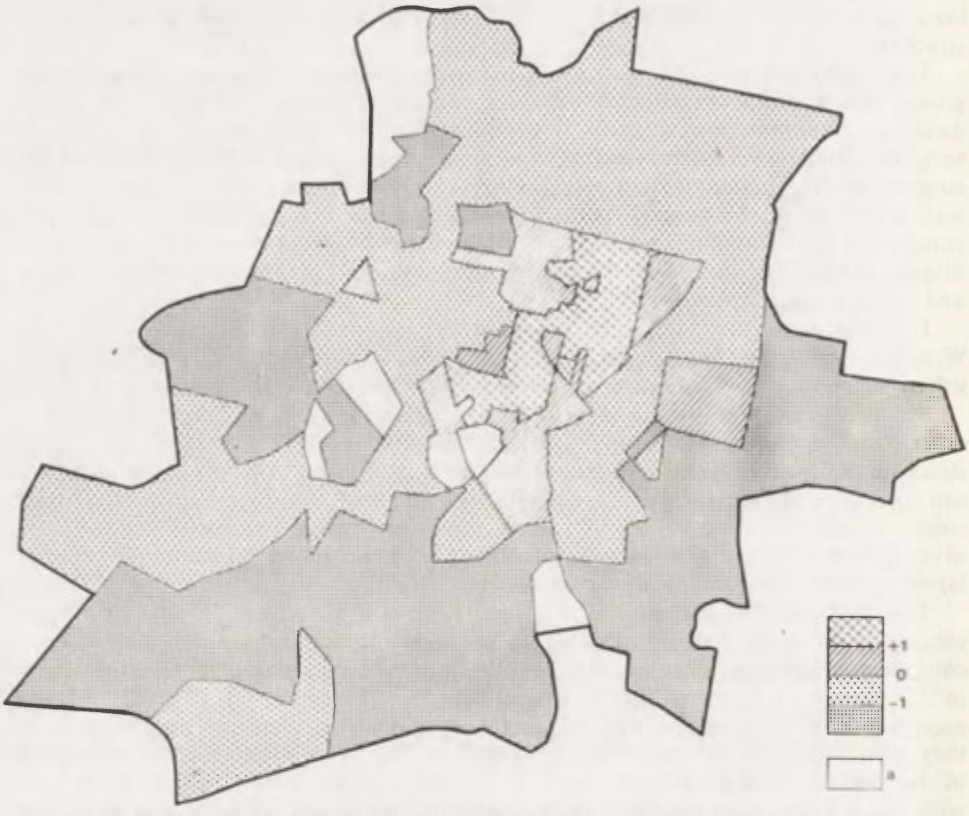

Fig. 1. Distribution of I component scores in Radom. Socio-occupational position
a – unpopulated areas

The spatial pattern of components scores of socio-occupational positions possessed in each city both common and specific features. It is generally true that the areas with relatively high socio-occupational position (over + 1 component scores) are located near the city centres, whereas the areas of lower socio-occupational position are in the suburbs. Such a pattern is the result of the reconstruction and revaluation of destroyed centres as well as of tradition and special attachment to rich in architectural heritage parts of cities.

The city of Radom has the clearest spatial pattern (Fig. 1). The central part of the city represents an integrated area (component scores of over+1) of highest socio-occupational position surrounded by areas of lower scores. A similar pattern occurs in Częstochowa (Fig. 2) though some deconcentration of the areas of higher scores is evident. Cracow represents a different spatial structure. The areas of the highest scores (over +1) of socio-occupational positions are concentrated in sectors to the west and east of the Old Town (Fig. 3). The areas of high scores (from 0 to +1) cover nearly the whole centre and remaining spatial units of western and eastern sectors and some units in the northern part. The eastern part of Cracow – Nowa Huta has also a separate sector of high scores. The remaining units of high and highest scores are scattered within the southern parts of Cracow. Spatial units of low and lowests scores surround the whole city.

Lublin represents also the sectoral pattern of highest values of socio-occupational position (Fig. 4). As in Cracow, the majority of units of highest scores are

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Fig. 2. Distribution of I component scores in Częstochowa. Socio-occupational position
a – unpopulated areas

located to the west of the centre. The central part itself, however, is of more mosaic character and rather higher in socio-occupational position than the centre of Cracow.

The sectoral pattern of high and highest scores was found also in Opole (Fig. 5), though the sector and the centre are dotted with units of lower socio-occupational position.

The pattern of socio-occupational position in Łódź (Fig. 6) is characterized by the concentration of high and highest scores units in the centre, and the occurence of a few isolated bigger areas to the south, west and north of the central part of the city. The latter, however, is of more mosaic character with numerous low score units in its northern part.

Specificly, mosaic structures of spatial pattern of socio-occupational positions are represented in Słupsk (Fig. 7), Olsztyn (Fig. 8) and Rzeszów (Fig. 9). In Olsztyn and Rzeszów there is an evident specific lack of concentration of units of the highest scores.

The second dimension tracable in almost all cities was found to be the component named 'dwelling conditions of households'. The basic set of features of significant loadings composing these components concerns the structure of households, dwelling conditions and demographic structure. In classical studies of factorial ecology this set of variables is usually called 'family status'. In the present paper a different name

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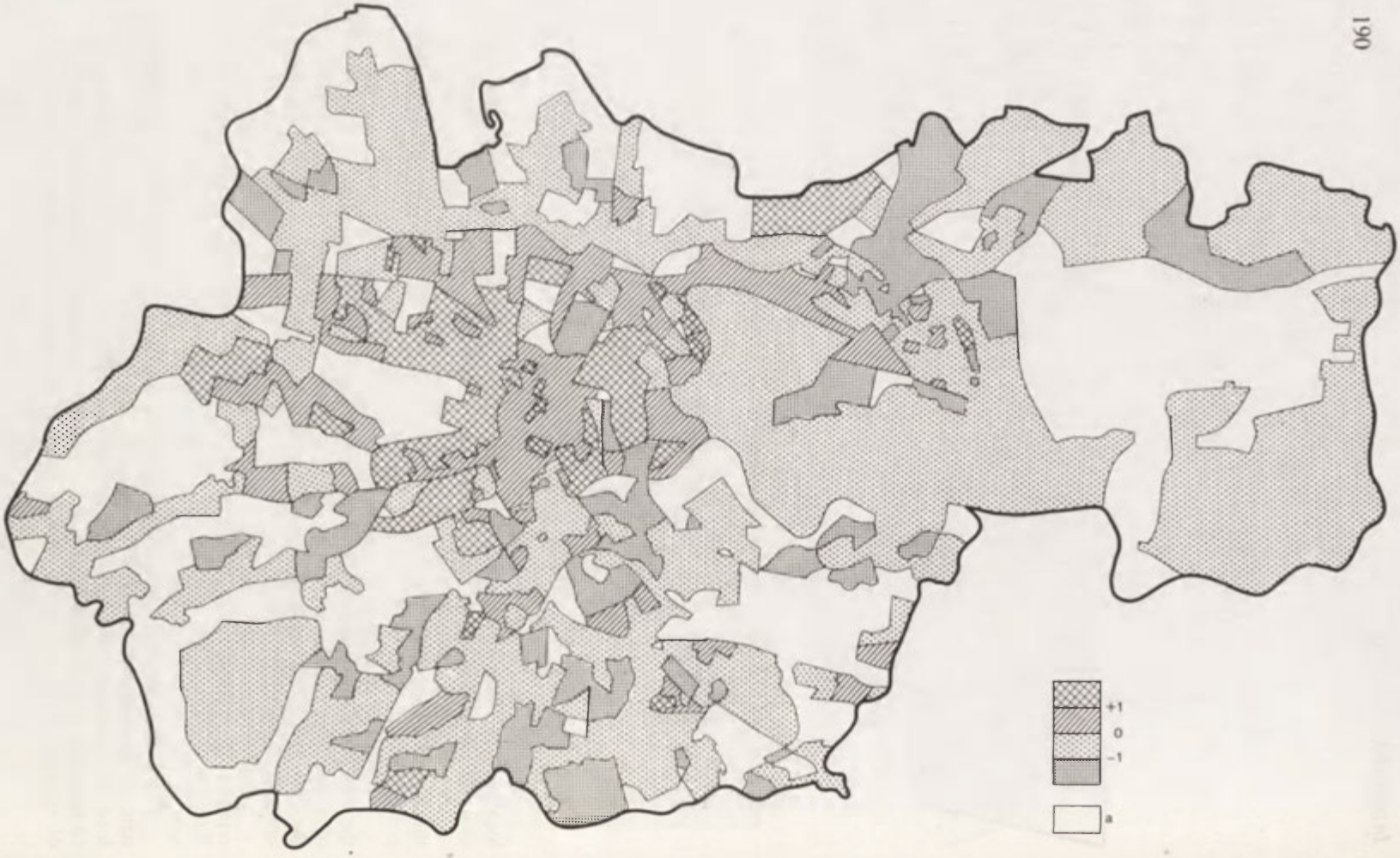

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Fig. 3. Distribution of I component scores in Cracow. Socio-occupational position
a – unpopulated areas

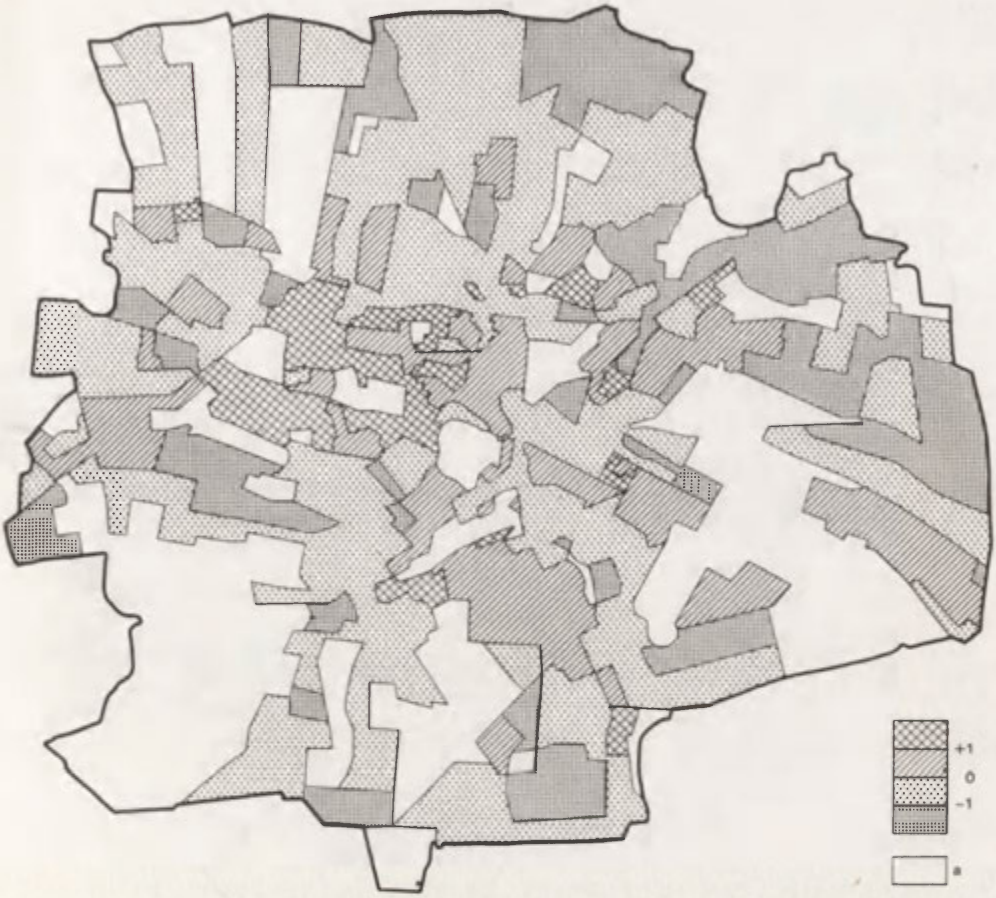

Fig. 4. Distribution of I component scores in Lublin. Socio-occupational position
a — unpopulated areas

has been given because the statistical data for the structure of households cannot be identified universally with the family structures. According to the definition of the Central Statistical Office – a set of related persons living together from a joint maintenance, is called a household. Cases where persons who are not related but live together and on joint maintenance are also included in this category. On the other hand, related persons on a separate maintenance are not treated as one household. Single people on their own maintenance are treated as one-person households. Thus the most dominant criterion on the basis of which persons are grouped in households is joint maintenance. Nevertheless the 1970 census structure of households, seems to be the most reliable source of statistical information of family structure.

The presence in one component of the highly associated variables concerning the size of households together with age groups and the age of dwellings makes it possible to interpret generally the dwelling conditions of households, which is identified with family status in other works on factorial ecology. For example, in Cracow the component of dwelling conditions of households indicates that there are more people over 65 years of age and small households with single female tenants

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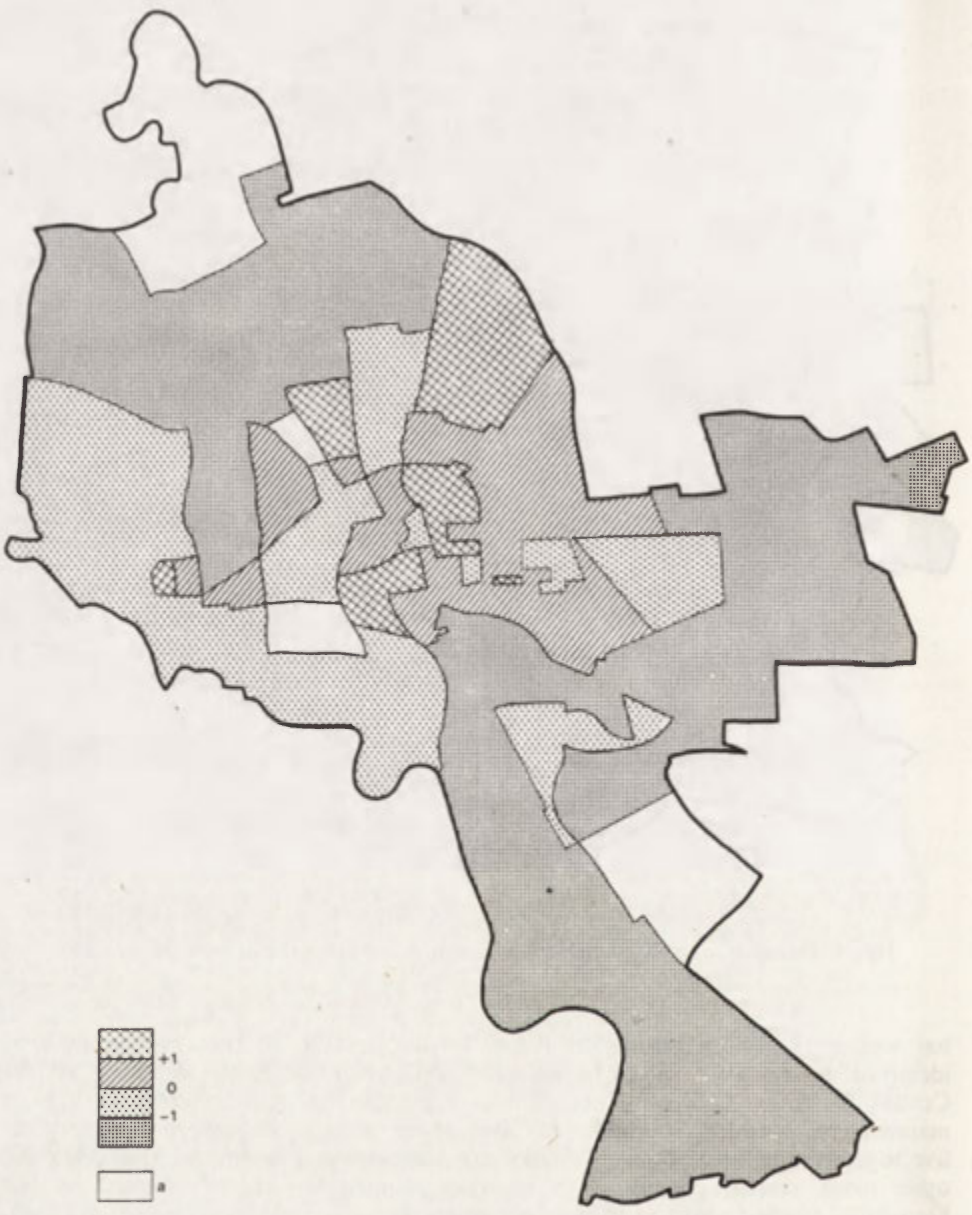

Fig. 5. Distribution of I component scores in Opole. Socio-occupational position
a – unpopulated areas

as well as more congested flats in old houses, and on the other hand that there are more children and bigger households in the dwellings built in 1960–1970.

The situation is much the same in Częstochowa, Radom, Rzeszów, and Łódź (Table 6). However, in Lublin, Opole, Olsztyn and Słupsk the same set of highly associated variables are accompanied only by similar age groups and households. In all the cities the variables concerning big households and large number of

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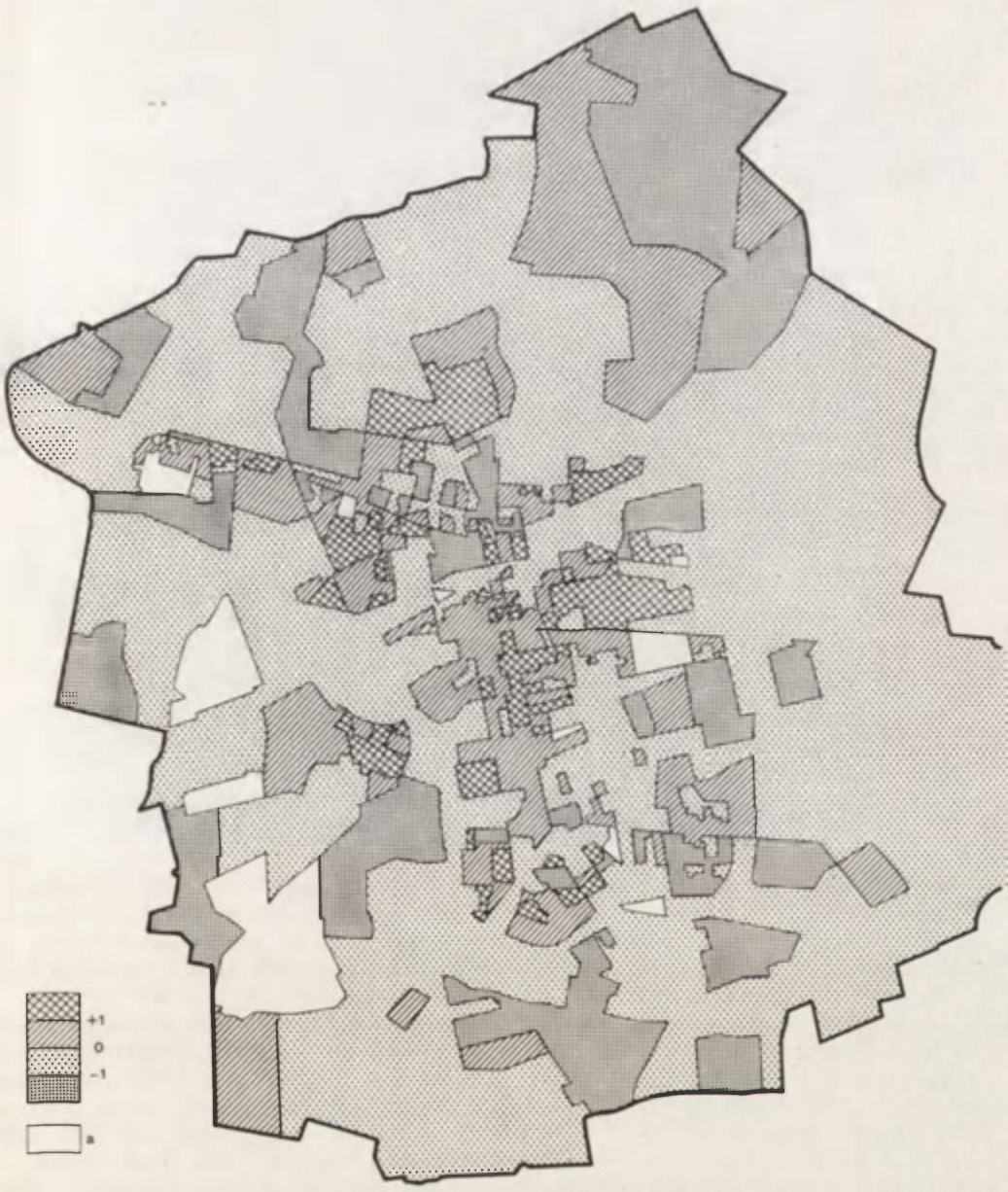

Fig. 6. Distribution of I component scores in Łódź. Socio-occupational position
a – unpopulated areas

children are accompanied by variables concerning dwellings built in 1960–1970, and in Częstochowa to dwellings built in 1945–1960.

The joint occurence of variables of age structure, size of households and age of buildings is a result of specific housing policy and natural social processes. Dwellings built in 1960–1970 were allocated first to the young, especially to young couples, and to the big families rather than for old or single people. Bigger dwellings enabled

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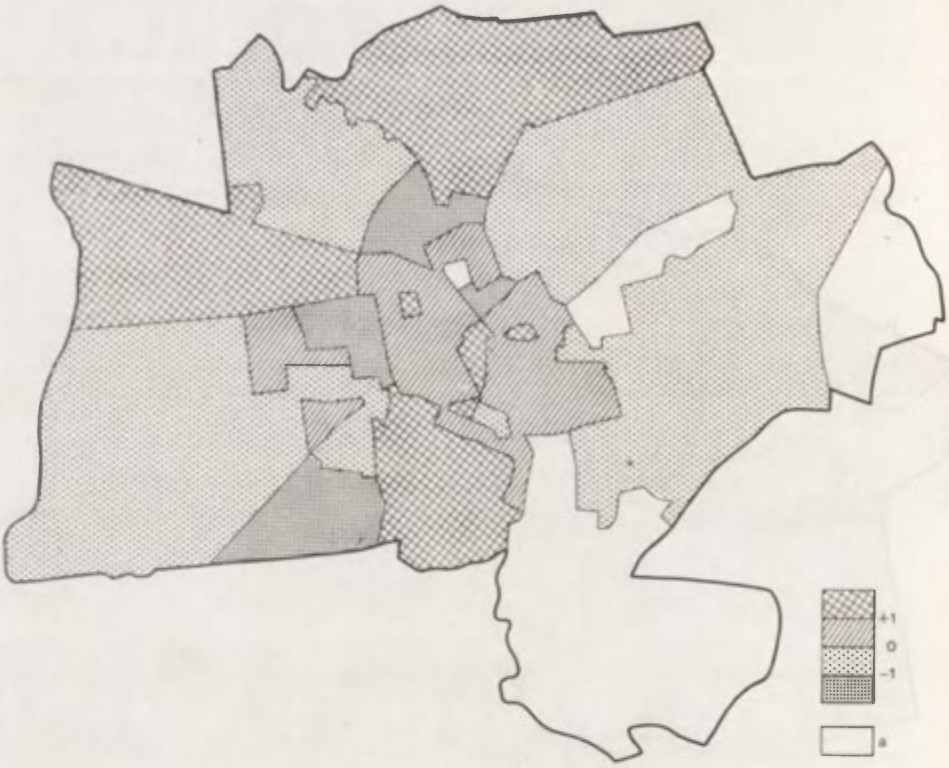

Fig. 7. Distribution of I component scores in Słupsk. Socio-occupational position
a — unpopulated areas

these families to expand. This was revealed by the same high loadings of variables concerned with 0–14 years age groups and with bigger households. On the other hand, old people cannot move easily to new dwellings. This was revealed by the occurence of the same high loadings of such variables as people aged 65 years and more together with old houses. Thus the age of buildings marks, in a way the age of their tenants. Obviously, this phenomenon does not exist in such a pure form as is implied in Shavky and Bell's theory. However, the structure of components called 'dwelling conditions of households' shows that the intra-urban structure of Polish cities is differentiated also in respect of the life-cycle of their inhabitants. This may be considered as analogous to what Shevky called 'urbanization', and Bell – 'family status'. Among the variables, which represent in statistics the family status, this component also includes the variables defining age and sex, the percentage of working women and the number of persons per household.

The component of 'dwelling conditions of households' is a second basic dimension, especially in the biggest cities. In the case of Rzeszów this dimension explains even more variation than the 'socio-occupational position'. However in smaller cities, which are located in the western and northern territories regained after the war (Olsztyn, Opole, Słupsk) the same component, is only the third most important. This is probably the result of the different past of those cities. The third ranking of dwelling conditions of households is due to the fact that in these cities the population was exchanged after the Second World War. For 25 years (till 1970) no strong

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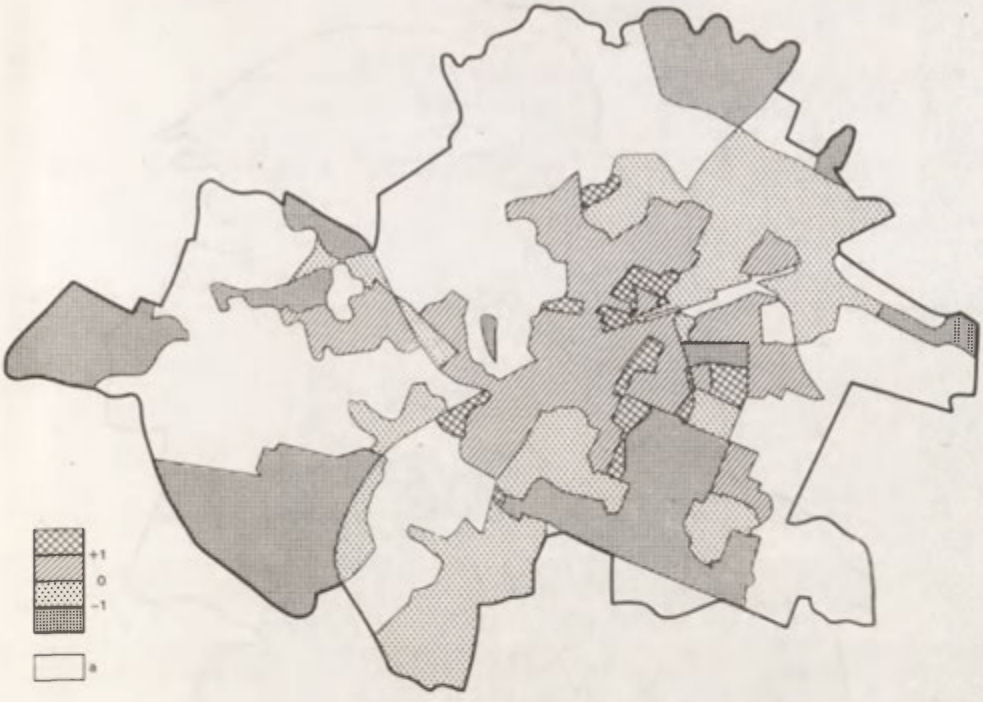

Fig. 8. Distribution of I component scores in Olsztyn. Socio-occupational position

spatial relation between the size of household and the demographic structure and type and size of dwelling developed, as in other cities. Such an interpretation of the phenomena is backed by the fact that although demographic and migrational components are ranked second in the components structure of these cities, the pattern of component scores for this dimension is irregular and mosaic: Słupsk (Fig. 10) can serve as an example for this conclusion.

The components of demographic and migrational position are the third basic dimension that differentiates the social and economic space of cities. The next dimension, though not equally common, were the components called 'housing'. They are, generally, ranked fourth in the component structure – in Łódź, however, they are third, prior to demographic and migrational position and in Radom and Opole – fifth (Table 3).

The next, very important dimensions are formed by the components called 'population origins', which occur in 4 cities: Łódź, Częstochowa, Lublin and Radom.

The components called 'Housing and demographic situation' are a relatively common dimension. These are: component 4 in Olsztyn, 5 in Łódź, Cracow, and Rzeszów, 6 in Opole, Słupsk and component 5 called 'demographic and housing situation' in Lublin.

The remaining dimensions are of a more varied composition being determined by the specific character of a given city. In some of the cities among the last two components there occurs the second dimension of 'socio-occupational position' – as in Olsztyn (component 6), Łódź and Lublin (component 7).

The analysis of the component matrix and preliminary interpretation of the

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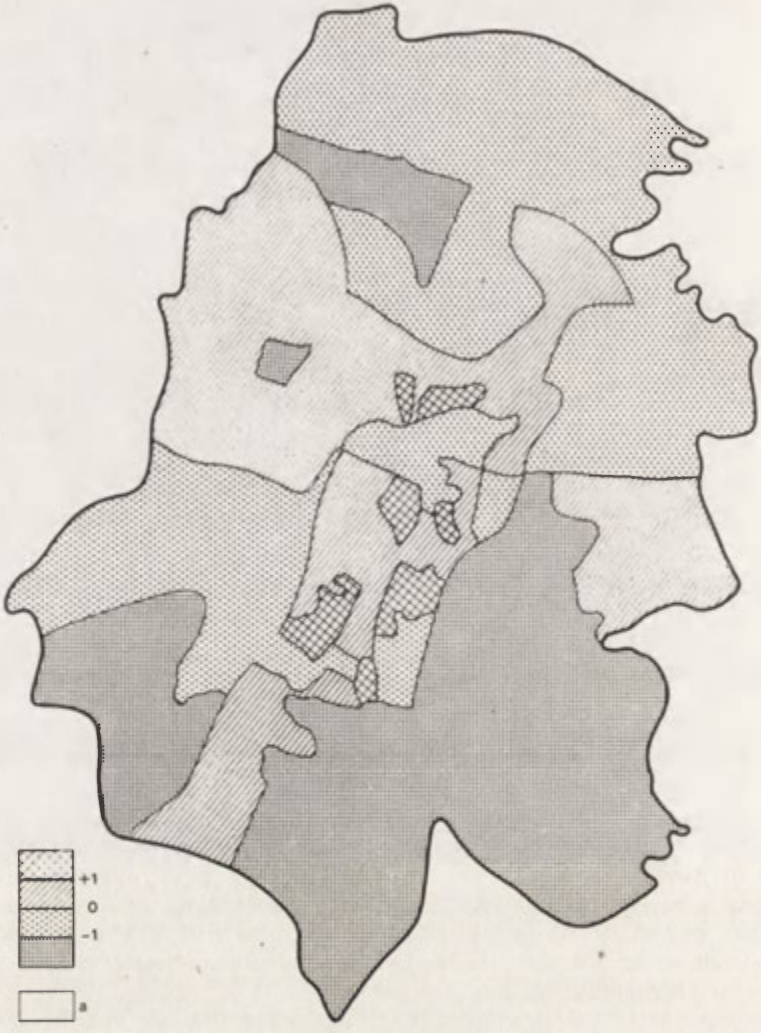

Fig. 9. Distribution of II component scores in Rzeszów. Socio-occupational position

components allows us to state that the basis of spatial social and economic differentiation in Polish cities there are some common dimensions. These are as follows: socio-occupational position, dwelling conditions of households, demographic and migrational position, population origins, housing, housing and demographic situation.

The above dimensions explain the majority of spatial variation in intra-urban patterns. Although individual cities possess their own differentiation expressed by specific components, their share in the explanation of variation seem relatively weak.

The preliminary and general analysis of the spatial structure of the cities were limited to the most important components. At the present stage of analysis, the cities may be only generally classified into sectoral or concentric patterns. However, a more detailed analysis of the first two components reveals numerous elements of a mosaic character in these spatial patterns. A varying but high occurence of mosaic elements indicates that Polish cities do not fit to classical patterns.

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TABLE 6. Loadings of the dwelling conditions of households components

Variable No.	Łódź	Cracow	Lublin	Częstochowa	Radom	Olsztyn	Rzeszów	Opole	Slupsk
1	2	3	4	5	6	7	8	9	10
1.	0.81	−0.74	–	−0.43	−0.72	−0.29	−0.54	−0.33	–
2.	–	–	–	–	–	–	–	–	–
3.	–	–	–	–	–	–	–	–	–
4.	−0.84	0.78	–	0.60	0.71	–	0.85	0.32	–
5.	−0.48	–	0.28	0.42	0.31	0.47	0.45	0.34	0.25
6.	0.50	–	−0.29	–	–	–	–	–	–
7.	–	–	–	–	–	–	–	–	–
8.	–	–	–	–	–	0.21	–	0.21	–
9.	–	–	–	–	–	0.29	–	–	–
10.	–	–	–	–	–	–	–	–	–
11.	−0.36	–	0.30	0.45	0.32	–	0.69	0.26	0.37
12.	–	–	–	–	–	0.21	–	–	–
13.	–	–	–	–	–	–	–	–	–
14.	–	–	–	–	–	–	–	–	–
15.	−0.36	0.43	0.60	–	0.49	0.41	0.62	0.68	0.29
16.	–	–	–	–	–	–	–	–	–
17.	–	0.33	–	–	–	–	–	–	–
18.	−0.39	–	–	0.30	0.39	–	0.35	–	–
19.	–	–	–	–	–	–	–	–	–
20.	–	–	–	–	–	–	–	–	–
21.	–	–	–	–	–	–	–	–	–
22.	–	−0.32	–	–	–	–	0.33	0.57	–
23.	−0.90	0.77	0.86	0.83	0.79	0.87	0.90	0.93	0.91
24.	−0.74	0.57	–	0.49	0.84	0.50	0.77	0.27	–
25.	0.90	−0.71	−0.73	−0.46	−0.69	−0.69	−0.84	−0.68	−0.62
26.	0.37	−0.52	–	−0.78	−0.55	−0.41	−0.34	−0.26	−0.29
27.	−0.88	0.76	0.79	0.84	0.76	0.83	0.92	0.87	0.92
28.	−0.35	0.66	0.69	–	0.67	0.67	0.60	0.55	0.48
29.	−0.31	0.48	0.37	–	0.40	–	0.39	–	–
30.	–	−0.33	−0.35	–	–	–	–	–	–
31.	0.53	−0.40	–	–	−0.43	–	–	–	–
32.	−0.85	0.81	0.35	0.68	0.84	0.24	0.89	–	0.21
33.	–	−0.38	−0.32	−0.53	–	−0.21	−0.41	–	–
34.	0.84	−0.61	–	−0.29	−0.77	–	−0.48	−0.21	−0.20
35.	–	–	–	–	–	–		–	–
36.	–	–	–	–	–	–	–	–	–
37.	0.76	−0.65	–	−0.31	−0.65	–	0.73	−0.35	–
38.	0.61	−0.31	–	−0.24	−0.33	–	0.52	–	–
39.	0.29	–	–	–	–	–	–	–	–
40.	0.45	–	–	−0.28	–	–	−0.46	–	–

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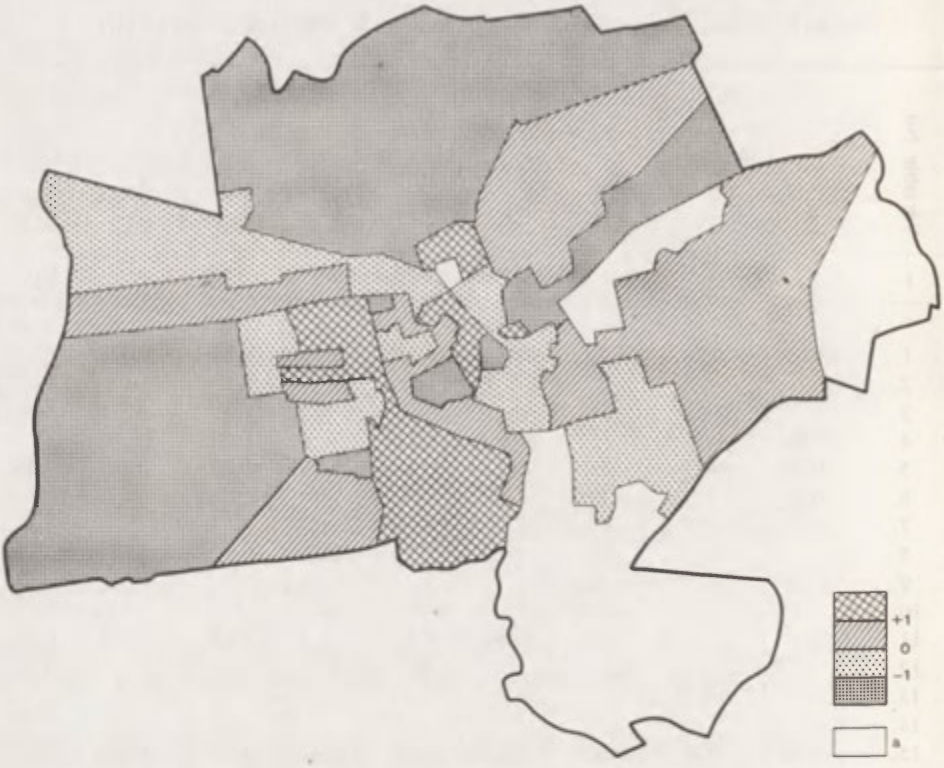

Fig. 10. Distribution of II component scores in Słupsk. Demographic and migrational position

It seems to me that we are witnessing the formation of a new, probably mosaic pattern of general intra-urban patterns. Probably it is a typical pattern for the future socialist city. The main processes differentiating intra-urban patterns are found in housing policies developed according to the social value of labour force and family structure of population.

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SPATIAL STRUCTURE OF RETAIL TRADE IN WARSAW

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1. INTRODUCTION

One major prerequisite for generalizations concerning the internal structure of a city, which is viewed as a relatively isolated settlement system composed of interlinked subsystems, is to have an adequate knowledge of the structural regularities specific for each of the subsystems. The steadily rising importance of the service sector vindicates paying special attention to the structure and development of that subsystem. If we consider that retail trade tends to have a focus-creating effect on the emergence of service centres in cities it seems useful to pinpoint the interest of empirical studies in this respect on the search for the regularities governing the distribution of shops.

2. THE PURPOSE OF THE STUDY

The causes of the differentiation of the particular service functions (including retail trade) from the point of view of their locational specialization are not to be analysed here; discussions of this question can be found in the studies by Christaller (1933), Berry (1963, 1967), Gardner (1966), McCarthy and Lindberg (1969) or Lange (1973). The present study was intended to describe the spatial structure of retail trade in the concrete conditions of a socialist socio-economic reality. This analysis is the first step in a more comprehensive study of the dynamics and spatial optimization of a city's retail trade network. Its specific purpose is to present the hierarchical spatial structure of retail trade in a big city (on the example of Warsaw).

To this end the area of the city has been divided into a set of areal units and the relations of similarity (or dissimilarity) between these areal units in view of the retail trade functions each of them fulfills are to be analysed. A hierarchical classification of the retail trade functions (as defined by the official classification of retail trade) in spatial terms will be obtained by arranging the whole set of areal units ordered by analysed features (functions) into groups characterized by functions with similar values of the measure adopted. The rank the group has is higher the higher the values of the measure adopted for the functions characterizing the given group are. Moreover, higher up the hierarchy there appear positive (> 0) values in the functions that did not occur in the lower ranks of hierarchy. By determining the differentiation in the distribution of the functions depending on their specialization (the extents of their markets) we may be able to establish certain regularities in their spatial location.

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The definition of functional groups in retail and other services in virtue of the extent of their service areas has been known for quite some time now. The division of commodities into convenience and special goods, which is most common in the literature of the subject, is however not fully adequate. Bucklin's (1964) classification into three groups: convenience goods, shopping goods and speciality goods is also too coarse. The most precise classification for a big city under socialism has been given by Polarczyk (1974), who on the example of Poznań-city distinguished between the groups of convenience services, shopping (local) services, lower-order specialities, and higher-order specialities. His division is certainly adequate for the study of the spatial structure of services in a big city (of about half a million population), yet if we apply Polarczyk's scheme in the case of twice or three times as big a city we may not obtain satisfactory results, if only for the simple fact that the set of 35 features (retail functions) he used for Poznan-city fails to include a number of functions that do exist in Warsaw.

3. THE METHOD OF THE STUDY

It is to be pointed out that, considering the results of the studies carried out so far, this definition of the purpose of this study tacitly implies that the spatial structure of retail trade in a city is in fact hierarchized. More still, it suggests that the character of the hierarchy and the number of its ranks depend on the qualitative and quantitative differences in the locational specialization of the particular retail trade functions and on the size of the city in question (functional specialization rises with city size as does the volume of turnover recorded for each function).

This hypothesis has been tested in the study by means of cluster analysis. Without going any deeper into the problems of cluster analysis and the variety of classification procedures, which are surveyed for instance by Cormack (1971), let me only outline its purpose and the successive steps of its procedure.

The purpose of the technique employed was to group the 127 traffic microregions of Warsaw[1] (viewed here as objects) characterized by means of 116 retail trade functions (viewed as variables) into classes so as to obtain as similar microregions within each class as possible and to produce classes that are as dissimilar to one another as possible. We know neither the number of classes or their specific properties nor the number of microregions each of them contains.

The first step of the grouping process consisted in measuring the degree of dissimilarity (distance) between all pairs of microregions and arranging them into a symmetric similarity matrix (a matrix of distances). The most common Euclidean distance

$$d_2(Q_i, Q_k) = \left[\sum_{j=1}^{m=116} (x_{ij} - x_{kj})^2 \right]^{1/2}$$

was taken as the numerical measure of dissimilarity, where x_{ij} denotes the value of the adopted measure[2] of the j-th retail trade function in the i-th microregion.

[1] For the purposes of the analysis Warsaw has been divided into traffic microregions (homogeneous in terms of traffic accessibility); the division had been made by the Bureau of Planning the Development of Warsaw in 1969 with a view to studying the city traffic pattern. Traffic accessibility is one of the most essential factors of location of services (Garner 1966).

[2] The measure was defined by the formula

$$x_{ij} = \frac{z_{ij} - \bar{z}}{\sigma}$$

where z_{ij} stands for turnover in zlotys.

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TABLE 1. Hierarchical classification methods

Method	Distance between the clusters S_q and S_r	Parameters			
		α_q	α_r	β	γ
(1) Single linkage	$d_{qr} = \min\limits_{\substack{x \in S_q \\ y \in S_r}} d_{xy}$	$\frac{1}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$
(2) Complete linkage	$d_{qr} = \max\limits_{\substack{x \in S_q \\ y \in S_r}} d_{xy}$	$\frac{1}{2}$	$\frac{1}{2}$	0	$\frac{1}{2}$
(3) Average linkage	$d_{qr} = \sqrt{\frac{1}{n_q n_r} \sum\limits_{\substack{x \in S_q \\ y \in S_r}} d_{xy}^2}$	$\frac{n_q}{n_q + n_r}$	$\frac{n_r}{n_q + n_r}$	0	0
(4) Centroid sorting	$d_{qr} = d(\bar{x}_q, \bar{x}_r)$ where: $\bar{x}_q = \frac{1}{n_q} \sum\limits_{x \in S_q} x$	$\frac{n_q}{n_q + n_r}$	$\frac{n_r}{n_q + n_r}$	$-\frac{n_q n_r}{(n_q + n_r)^2}$	0
(5) Gower's method	$d_{qr} = d(\bar{x}_q, \bar{x}_r)$ where: $x_q = \frac{1}{2}(x_p + x_s)$; $S_q = S_p \cup S_s$	$\frac{1}{2}$	$\frac{1}{2}$	$-\frac{1}{4}$	0
(6) Ward's method	$d_{qr} = \sqrt{E_{qr} - E_q - E_r}$ where: $E_q = \sum\limits_{x \in S_q} [d(x, \bar{x}_q)]^2$	$\frac{n_q + n_p}{n_p + n_q + n_r}$	$\frac{n_r + n_p}{n_p + n_q + n_r}$	$-\frac{n_p}{n_p + n_q + n_r}$	0

and $Q_i = (x_{i1}, \ldots, x_{i116})$ is the vector of measures of all retail trade functions in the i-th microregion.

Looking for a hierarchical structure composed of a definite number of possibly homogeneous groups, in the second step of the procedure six hierarchical classification procedures have been employed (Table 1)[3]. One feature common to all of these procedures is that they start the grouping process with n classes (127 in our case) each containing one object. At each step of the algorithm we looked for the most similar pair of classes which had the smallest distance d_{qr} $(r < q)$ in the distance matrix. By grouping the classes q and r together we reduced the number of classes by 1. Simultaneously with this, the distance matrix was being updated by determining the distances between the newly obtained class and all the remaining ones. This procedure was iterated 125 times until all microregions formed two clusters.

To avoid the necessity of a continual return to the matrix of base data we employed the recurrence formula developed by Lance and Williams (1967)[4] which

[3] The first of these has been used in an analogous study by A. Rogers (1972).

[4] G. N. Lance and W. T. Williams (1967) devised it for the first five methods (cf. Table 1). D. Wishart (1969) observed that Ward's method too conforms with this scheme.

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enabled the author to determine a new distance measure by a relevant selection of parameters for each of the classification procedures applied in the study. The distance between class t, which emerges from the integration of classes q and r, and class p was defined generally as

$$d_{tp}^2 = \alpha_q d_{qp}^2 + \alpha_r d_{rp}^2 + \beta d_{qr}^2 + \gamma |d_{qp}^2 - d_{rp}^2|.$$

The values of the parameters α_q, α_r, β and γ vary depending on the procedure applied (Table 1).

The classified microregions can be envisaged as points in a 116-dimensional feature space, with retail trade functions as the features. Classes are groups of points between which distances are smaller than those to the other point groups.

4. RESULTS

The results obtained by the first five methods of hierarchical classification (Table 1) turned out to be unsatisfactory because of their high generality and since they indicate but the overall trends in the studied problem. Only a few microregions with the most specific internal structure were identified as separate clusters, whereas all the others were joined into one big group from which one can detach further, predominantly one-element, clusters together with the decline in minimum distances in the successive steps of the procedure. As expected (Anderberg, 1974), much better results were obtained by applying Ward's method.

The procedure for creating classes and the hierarchy of clusters obtained in result of the classification are as a rule presented in the form of a dendrogram. Figure 1 presents a dendrogram of the hierarchical classification of the 127 microregions obtained by the application of Ward's method. The values of minimum distances in the successive steps are given in Table 2.

It can be seen in Fig. 1 that the relatively well-isolated separate classes form seven clusters marked I–VII. The most numerous cluster I, composed of 83 microregions, ranks lowest in the hierarchy. The next ranks in the hierarchy pertain to clusters II, III, IV, V, VI and VII composed of 8, 26, 6, 1, 1 and 2 objects, respectively. Let me point out again that whether any particular microregion is classed with a given cluster depends not on the number or character of the retail trade functions in it alone but also on the volume of turnover they record, which is normally conditioned by the size of the retail unit and the product mix it offers.

Cluster I consists of 10 subgroups (marked *a–j*) whose internal similarity is based on slightly different features: basically it results from the insufficient number of shops, even those offering the most indispensable goods to customers, in many microregions. Food stores and shops and kiosks with newspapers and tobacco constitute the main body of this cluster. Most of the objects are also characterized by the meat shops, and about one-third of the total number of microregions in the cluster include additionally the alcoholic-beverage shops, groceries, and pharmacies. The occurrence of other retail trade functions is but sporadic: the stores are small and record low turnovers.

The following functions are the characteristics of the objects of cluster II: food, newspapers and tobacco, meat, groceries, pharmacies, dyes and chemicals, paper, haberdashery, clothes, electric equipment, flowers, stationery and toys, general books. This cluster comprises exclusively microregions of the city-centre, which is specific in that its retail trade network comprises largely not only these functions but also many others specific for the higher ranks in the hierarchy.

The features characterizing cluster III are much more numerous. In addition to the first ten functions mentioned above as characteristics of cluster II, there are the

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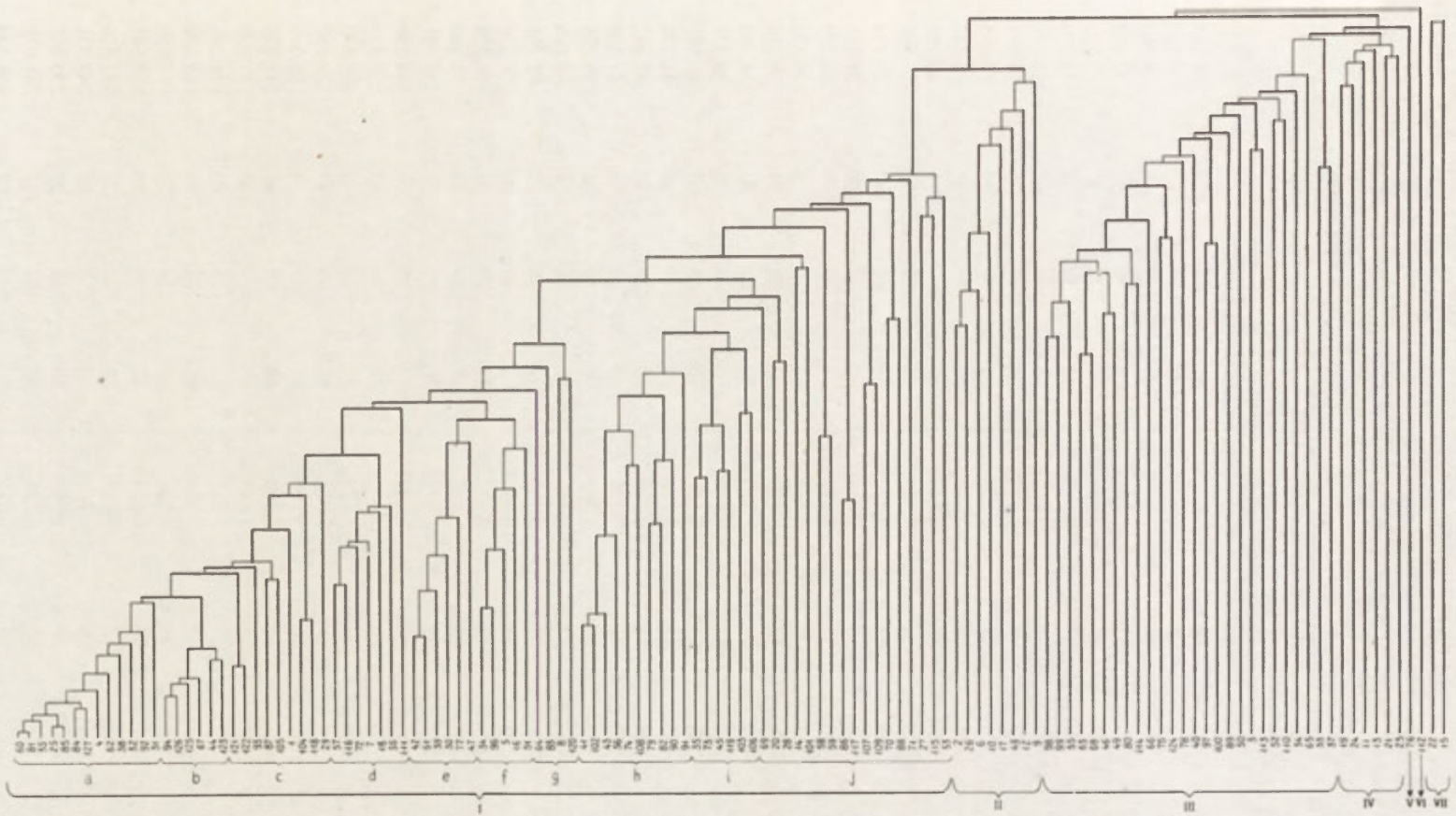

Fig. 1. Dendrogram of the hierarchical classification of the 127 microregions

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TABLE 2. Minimal linkages in the successive steps according to Ward's method

Step No.	Clusters linked		min $d(A, B)$	Step No.	Clusters linked		min $d(A, B)$
	A	B			A	B	
1	2	3	4	1	2	3	4
1	81	60	0	47	108	74	6.685
2	85	25	0	48	90	82	6.926
3	95	81	0	49	127	116	8.206
4	95	85	0.001	50	96	51	12.952
5	127	84	0.003	51	77	47	13.620
6	127	95	0.015	52	59	58	14.576
7	126	94	0.018	53	108	102	15.297
8	127	4	0.023	54	119	73	17.193
9	126	125	0.024	55	96	77	17.485
10	126	67	0.038	56	106	103	18.347
11	127	62	0.047	57	127	111	20.958
12	122	121	0.067	58	127	96	21.588
13	123	44	0.077	59	108	90	23.774
14	127	38	0.079	60	127	64	24.311
15	126	123	0.084	61	109	107	24.339
16	127	32	0.133	62	120	8	28.856
17	61	42	0.150	63	108	91	29.314
18	127	92	0.150	64	127	83	34.703
19	102	41	0.155	65	28	20	39.371
20	118	104	0.158	66	68	63	40.685
21	102	43	0.272	67	119	106	41.230
22	96	34	0.278	68	127	120	45.802
23	127	31	0.297	69	99	98	47.300
24	127	126	0.301	70	119	108	55.225
25	61	39	0.399	71	26	2	63.865
26	116	57	0.402	72	88	70	67.261
27	105	87	0.449	73	49	46	74.270
28	127	122	0.635	74	119	69	76.326
29	127	93	0.988	75	99	55	77.349
30	127	105	1.074	76	119	28	87.391
31	61	30	1.199	77	26	6	104.656
32	96	5	1.351	78	114	80	108.433
33	116	72	1.779	79	127	119	109.340
34	116	7	2.987	80	68	49	123.180
35	102	56	3.169	81	101	14	125.609
36	127	1	3.308	82	99	68	141.933
37	82	79	3.379	83	127	101	157.709
38	77	61	3.435	84	114	99	178.286
39	116	18	3.435	85	100	97	188.839
40	116	36	4.339	86	124	75	195.856
41	117	86	4.554	87	26	10	197.541
42	127	118	4.637	88	127	59	242.416
43	96	16	4.761	89	114	66	242.531
44	127	29	5.394	90	115	27	250.767
45	73	35	6.326	91	127	117	261.938
46	119	45	6.515	92	127	109	264.534

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1	2	3	4	1	2	3	4
93	115	53	269.775	110	124	110	476.387
94	127	88	273.273	111	124	54	522.877
95	124	114	273.794	112	24	19	533.065
96	127	71	275.849	113	48	9	558.213
97	127	115	281.297	114	124	65	579.724
98	37	33	304.080	115	127	48	601.217
99	124	78	309.032	116	24	11	669.394
100	124	40	312.218	117	23	21	722.251
101	13	3	318.891	118	24	13	728.125
102	26	17	319.183	119	24	23	923.321
103	124	100	323.758	120	124	37	930.789
104	124	89	377.456	121	124	24	1145.468
105	48	26	386.863	122	124	76	1420.854
106	110	52	395.802	123	22	15	1676.111
107	124	50	399.547	124	127	124	2102.688
108	48	12	446.334	125	127	112	2858.153
109	124	113	472.522				

Note: The highest numbers of the microregions belonging to clusters A and B have been taken as the designations of those clusters.

following functions: confectionery, fish, wine and confectionery, alcoholic beverages, scents and soaps, textiles, textiles and clothes, shoes, household articles, and books. Relatively frequent are in cluster III also ready-to-cook foods, delicatessen, gas stations, knitwear, leather articles, metal articles, radio and TV appliances, furniture, tourist and sports equipment, eggs and poultry products, bakery and dairy products, soaps and chemicals, photographic equipment and ophthalmological articles, and fuel stores. The microregions of cluster III are also marked by a well-developed network of kiosks and stands with groceries, foodstuffs, nonalcoholic beverages and sweets, food and agrarian produce, manufacturing products and flowers.

Cluster IV comprises six microregions with a very diversified retail network; apart from the set of features characterizing the previous cluster (without the household articles shops) there are also clothes stores and fashion houses, bookstores, commission shops, clothes and fancy goods shops, musical shops, fur, watches and jewelry, souvenir shops, handicraft and antiques.

The two one-element clusters V and VI are both entirely different from the other clusters and mutually dissimilar. The two microregions display nearly the full range of features to be found in the objects occurring in cluster III (without the textile-clothing shops and delicatessen shops; cluster V lacks moreover shops with textiles, knitwear or tourist and sports articles, while cluster VI has no shops with haberdashery and fancy goods, ready-to-cook food, radio and TV sets, furniture, eggs and poultry products, bakery and dairy products, or soaps and chemicals). In both there are the watches and jewelry shops and commission shops. Of the remaining retail trade functions specific for the higher level of the hierarchy (cluster VI), cluster V has the clothing and small wares shops while cluster VI a warehouse and the musical shops. Yet the internal structures of these clusters specifically display a high concentration of various functions which, to be true, occur also in some other microregions of Warsaw but are strongly dispersed. In cluster V those are such categories as seeds and gardening articles, herbs, technical and rubber goods, food

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and agrarian produce, automobile goods, bed sheets and decorative textiles, electric household appliances, a warehouse and toy shops, while in cluster VI there are the following functions: seeds and gardening articles, underwear, shoemaker's goods, synthetics and fibre products, post-stamps, devotional articles, fodder, building materials, building materials and fuels, bakery and small wares. The specific character of cluster V is also largely determined by the high turnover recorded by the big food supermarket localized in that microregion, while in cluster VI there is a large open-air market of supralocal importance which comprises 350 food and industrial stands and kiosks.

The highest rank in the hierarchy is occupied by cluster VII, which is composed of two complementary adjacent microregions which together fulfill nearly all the functions mentioned above for cluster IV (only confectionery, fur and clothing shops are lacking there). This area displays a very high degree of concentration of shops of various functions, which occur in the other microregions but sporadically. They include functions such as toys, bed sheets and decorative textiles, automobile articles, herbs, seeds and gardening articles, underwear, post-stamps, devotional articles, clothing and footwear, foreign newspaper and journal stores, department stores, medical articles, antiques, pets, and bee-keeping articles. There, too, are localized the only specialized department stores in Warsaw (ladies' clothes, teenager equipment, articles for children) and a big footwar store. The shops are as a rule big and record very high turnovers. This cluster has also a well-developed network of retail trade operating seasonally (second-hand books, flowers, grocery stands, ice-cream kiosks, soda-water sales etc.).

5. CONCLUSIONS

A study carried out in 1970 showed that the spatial structure of retail trade in Warsaw is essentially hierarchical: each rank in the hierarchy is characterized by an appropriate set of retail trade functions. Their differentiation in space will be submitted to a detailed analysis in the next step of the research procedure.

In Fig. 2 it is seen that the hierarchical spatial structure of retail trade in Warsaw is mainly a monocentric system of open (from the south-east) rings of retail units of varying quantitative and qualitative importance; the rings encircle cluster VII, the centre of that system. Microregions with high trading attractiveness belonging to cluster IV, which subsequently pass into areas of lower (cluster II) or even much lower (cluster Ia, b[5]) concentration of the retail network, adjoin directly the centre. In the next open ring of microregions (cluster III) retail trade attractiveness rises again. In that ring one can distinguish two microregions with a very specific internal structure (clusters V and VI[6]), which differ both from one another and from the remaining objects. The next ring of lower retail trade attractiveness comprises apart from areas with a relatively diffuse retail network (Ia, b) also microregions without any retail units at all (areas of industrial establishments, economically undeveloped areas, aforested areas, airport, cemetery etc.).

Though the above picture of the spatial structure of retail trade in Warsaw in

[5] Within cluster I we distinguished the microregions that have no shops at all except tiny retail units (kiosks and stands) – these have been designated Ia. The remaining trade objects in cluster I were defined as Ib.

[6] The two specialized microregions constituting clusters V and VI have been marked on the map with the same hachure. The microregion identified as cluster V is to the south of the centre (which immediately indicates the situation of cluster VI).

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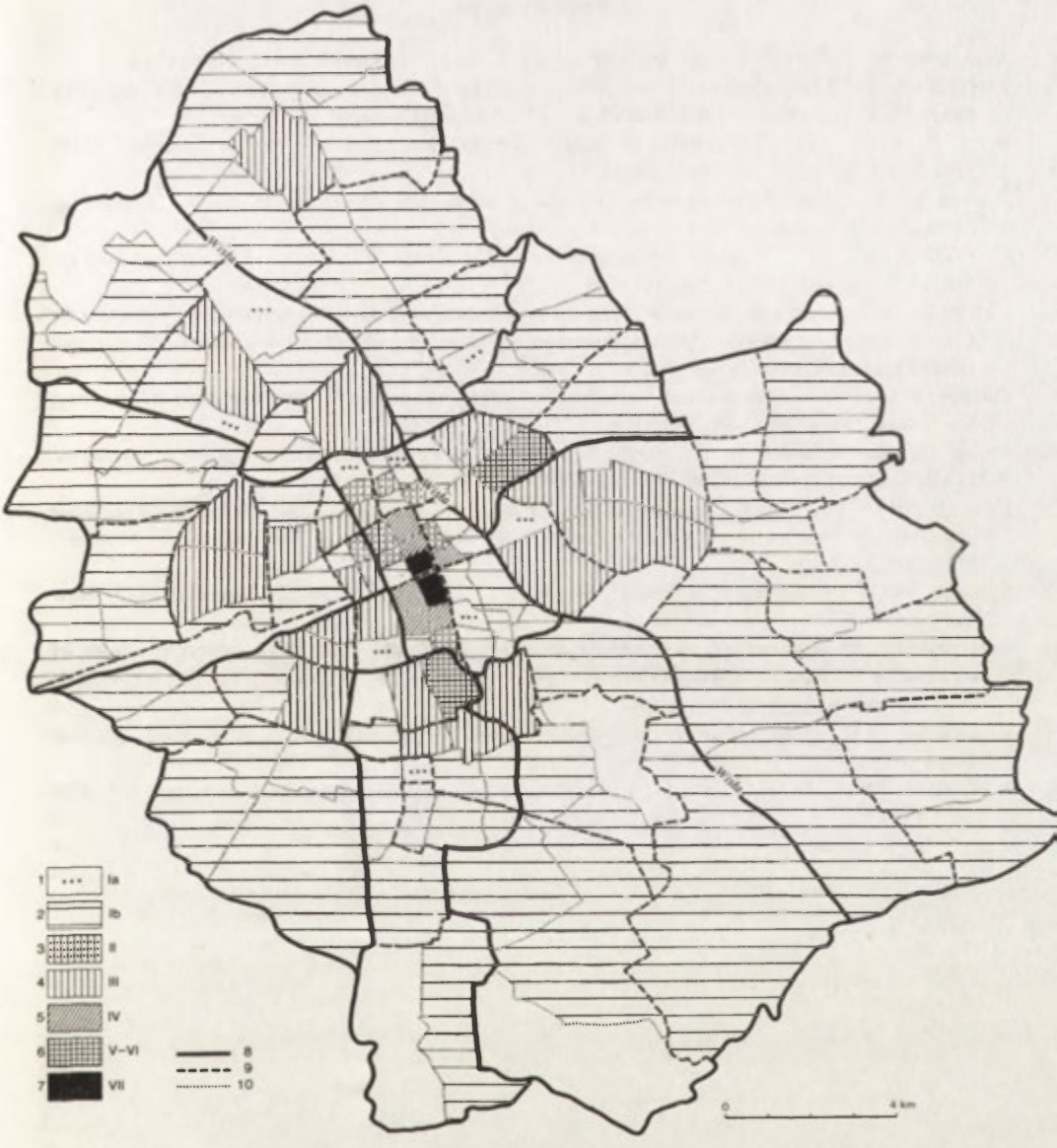

Fig. 2. Hierarchical spatial structure of retail trade in Warsaw

1–2 – areas with a relatively diffuse retail network (cluster Ia and Ib) and microregions with no retail units, 3 – areas of lower concentration of retail network (cluster II), 4 – areas of higher concentration of retail network (cluster III), 5 – microregions with high trading attractiveness (cluster IV), 6 – microregions with a specific internal structure (cluster V and VI), 7 – central shopping area (cluster VII), 8 – boundaries of the traffic sectors, 9 – boundaries of the traffic regions, 10 – boundaries of the traffic microregions

the early seventies is distinctly monocentric in its pattern, it seems advisable (in view of clusters V and VI) to take account of a possible trend in the future toward a polycentric pattern. Thus it may be interesting to carry out an analogous analysis for several years in the future. Further investigations should also furnish comparisons of the spatial structure of the retail network with other spatial systems, especially with the pattern of population distribution.

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SPATIAL DISTRIBUTION OF INTRA-URBAN COMMUTING TO WORK: A CASE STUDY OF THE CITY OF ŁÓDŹ

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Journeys to work are a common phenomenon which gain in intensity with advances in technical, economic and social development. This type of population displacement constitutes a special problem within towns, particularly in big metropolitan areas, and are as important as the commuting of hinterland-dwellers to town, mainly because of the poor transportation conditions.

Analyses of commuting to work within towns are both theoretically and practically significant. They provide prerequisites for evaluating the spatial organisation of a town, job and habitation location, and the effectiveness of the transportation network. Furthermore, they may serve as a basis for the identification of intra-urban spatial and functional inter-linkages and of the spatial structures of various units, institutions and enterprises.

Against the background of numerous publications devoted to rural hinterland-urban commuting the studies of intra-urban commuting are little advanced, which is mainly caused by the insufficiency of appropriate statistical data.

While analysing intra-urban commuting to work and its conditioning one should not forget that each town, besides the features common to all urban areas, has also its own, individual characteristics. In the case of Łódź one can mention its exceptional spatial organisation layout. Various elements of the spatial setting were formed in Łódź both in a planned and spontaneous, random manner, depending on the historical period, first according to a concentric, then to a centrifugal scheme, related to city magnitude, its economic functions, position in the hierarchy of settlement units within the region and the country, social structure and population's standard of living. The modern appearance of the city is still decisively shaped by its industrial character, related to a weakly diversified functional structure, amplified by a strong specialization in textile industries, particularly cotton, together with an underdevelopment of the service functions. Another specific feature of Łódź is exceptionally strongly concentrated ring-like spatial layout of workplaces. Dwellings are organized in a similar, but somewhat less concentrated, layout. The high degree of concentration of workplaces and dwellings is reflected by relatively small spatial spread of job-related commuting. The limited extent of these spatial movements does, however, enable us to analyse their fundamental characteristics in a simple layout, not disturbed by a more complicated spatial and functional urban structure.

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Until the end of the fifties stagnation characterised the spatial structure of Łódź. Essential changes in the spatial organization of the city occured only in the later years. Lively and gradually intensifying construction activities resulted in the creation of many large, peripherically located housing areas. Reconstruction of the downtown part was initiated. Simultaneously new industrial zones were created in the suburbs. Hence the functional-spatial structure of the city became diversified. This in turn entailed an intensification of mass job-related commuting. It should be emphasised that job-related commuting dominates the overall daily trips' structure of the metropolitan population. It has been demonstrated by the transportation-oriented poll carried out in the Łódź agglomeration that the trips from home to work and back constitute up to 43.5% of total population movement.

The purpose of the present paper is to analyse the spatial distribution of distances and directions of intraurban commuting to work and then to identify the spatial setting and discriminate the more important factors influencing the distributions mentioned, using the example of the city of Łódź.

The main propositions submitted in the paper are the following:

– specific features of intra-urban commuting to work are reflected in the distance and direction distributions, and in the changeability of these characteristics, as well as the factors which influence them; with the diversity of distances and directions of commuting much larger than could result from differentiation in locations of workplaces and dwellings,

– leading elements in the structure of distances and directions of commuting to and from work constitute separate spatial layouts within the urban areas, dominating distances are distributed according to a concentric model, with the shortest displacements in the central zone, while resulting directions are distributed according to a sector-shaped model, in which the lines dividing individual sectors of directions converge in the cenre of the town,

– locations of dwellings and workplaces do not explain fully the total variability of distances and directions of job-related commuting. The spatial distribution of commuting depends as well on a number of factors related to transportation, work and habitat environment, social and demographic relations etc. differing in their strength of influence,

– determinants of distance and directions of commuting act selectively along the spatial cross-section of the town – usually stronger in the sub-central zone, and weaker in the central zone, with the areas of stronger and weaker influence of various factors not always consistent.

All the propositions mentioned refer to concrete conditions – of time and space – in which the study was done.

The notion of spatial distribution of commuting is understood here as a classification of commuter trips according to real distances and directions, determined with regard to the dwelling location of inhabitants.

Detailed analytical techniques were used in correspondence with the above definition. Various statistical mathematical methods, being especially relevant to such types of quantitative studies, were used in the general and spatial analyses of distribution of commuting distances. Classical and positional variability measures were mainly used, complemented with assymetry and concentration measures. It appeared that only by combining measures of central tendency, absolute and relative variety, assymetry and concentration, the entire picture of the differentiation of the structure of the distances of journeys could be obtained.

The investigation of the dispersion of the commuting directions required a different approach. The vector method was applied. In order to establish the typical commuting directions and the degree of their dispersion the resultant vectors were

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determined. The vector mean and the vector deviation of directions were calculated analytically.

Having the accurate values for a series of angles of commuter trips the resultant vector was determined according to the following formula:

$$\operatorname{tg} \alpha = \frac{\sum_{i=1}^{n} \sin \alpha_i}{\sum_{i=1}^{n} \cos \alpha_i},$$

for $i = 1, 2, \ldots, n$,
where α_i is the angle of the i-th commuter trip.

A relative measure of vector variability is the relation of vector deviation to the total number of angles:

$$L = \frac{\sqrt{(\sum_{i=1}^{n} \sin \alpha_i)^2 + (\sum_{i=1}^{n} \cos \alpha_i)^2}}{N} \times C,$$

where C – constant equal to 100.

Having commuter trip angles ordered and grouped one can determine the vector average from the formula:

$$\operatorname{tg} \bar{\alpha} = \frac{\sum_{i=1}^{n} f_i \sin \alpha_i}{\sum_{i=1}^{n} f_i \cos \alpha_i},$$

where f_i is the number of items in the i-th class of directions of commuting.

The vector variability is, in turn, calculated with the formula:

$$L = \frac{\sqrt{(\sum_{i=1}^{n} f_i \sin \alpha_i)^2 + (\sum_{i=1}^{n} f_i \cos \alpha_i)^2}}{\sum_{i=1}^{n} f_i} \times C.$$

The vector method was used with appropriate modifications to evaluate the distance-directional dispersion of commuter trips. This vector approach proved again, as in the analysis of directions of commuting, to be much more useful than the statistical measures of position and dispersion.

The direction of the resultant vector for a given distance-directional structure can be determined from the formula:

$$\operatorname{tg} \bar{\alpha} = \frac{\sum_{i=1}^{k} (\sum_{j=1}^{ki} f_i^j d_i^j) \sin \alpha_i}{\sum_{i=1}^{k} (\sum_{j=1}^{ki} f_i^j d_i^j) \cos \alpha_i},$$

with

$$f_i^1 d_i^1 + f_i^2 d_i^2 + \ldots + f_i^{ki} d_i^{ki} = \sum_{j=1}^{ki} f_i^j d_i^j,$$

where: f_i^j is the number of commuter trips of j-th distance class in the i-th directional class.

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d_i^j is the j-th distance value in the i-th directional class,
$i = 1, 2, \ldots, ki$.

The vector variability can for this type of data be determined via the following formula:

$$L = \frac{\sqrt{\left[\sum_{i=1}^{k}\left(\sum_{j=1}^{ki} f_i^j d_i^j\right)\sin\alpha_i\right]^2 + \left[\sum_{i=1}^{k}\left(\sum_{j=1}^{ki} f_i^j d_i^j\right)\cos\alpha_i\right]^2}}{\sum_{j=1}^{ki} f_i^j d_i^j} \times C.$$

In the analysis of factors conditioning the dispersion of distances and directions of commuting 38 variables were arranged in the four groups describing respectively:

1. The work environment, 2. The habitat environment, 3. Transportation conditions and 4. Socio-demographic relations.

Since dependant variables were measurable, and independant variables both measurable and non-measurable, and since there could be both linear and nonlinear correlation, the strength of influence of individual factors on distances and directions of commuting was measured via the correlation ratio:

$$e_{yx} = \frac{S\bar{y}(x)}{S(y)}$$

where $S\bar{y}(x)$ denotes standard deviation of conditional arithmetic averages, and
$S(x)$ denotes general (boundary) standard deviation of values of a dependant variable.

Besides the correlation ratio, conditional averages, conditional coefficients of variation, total variation and explained variation were used for describing existing relations.

Because adequate statistical information was lacking the raport is based mainly upon the results of representative local inquiries. Within the territory of the town 5000 working people were chosen at random. The random choice was made according to the two-degree sampling without replacement scheme. The basic local studies were carried out in Łódź from 1970 to 1972. They were preceded by polling surveys of commuting to work in Prudnik in 1968, and Kędzierzyn in 1970. During the gathering of the source data the sociological technique of questionnaire-backed inquiry was applied. Source data, gathered with this technique, were additionally complemented with the results of cartometric analysis and with statistical materials, current and archival reports of various institutions and enterprises, as well as with information from the publications related to this subject.

Abundant information thus acquired (more than 200 000 data units) was then coded and tabulated in punched cards, and put into working tables (more than 360 tables) with the help of tabulating machines. Some more time-consuming and complicated operations were carried out with the help of a special computer program, written in Algol language, run on the Odra 1304 computer.

The analysis indicated that commuter trips in Łódź are usually not made over long distances. Almost 3/4 of all trips have distances of 0 to 4 kms, and only 7 per cent of all trips exceed 8 kms. The average distance was 3.92 kms. The typical variability range was 1.35 to 6.49 kms, accounting for about 2/3 of all trips. The structure of the distance is strongly differentiated ($V_{s(x)} = 65.6\%$). The empirical distribution of distances approximately conformed with the normal logaritmic distribution. Along with the increase of distance the number of commuters initially

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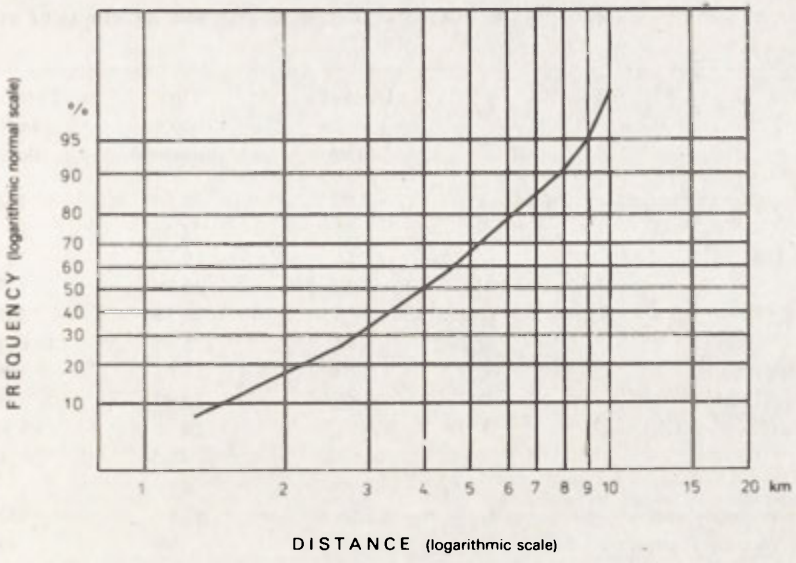

Fig. 1. Distribution of distances

increased as well but then dropped abruptly. In the longest distance classes the numbers of commuter trips decreased slowly.

It is very characteristic that there was a relatively low number of trips for the shortest distances. One could expect a particularly high intensity of commuting from the areas located close to the workplace. This tendency is impaired by the lower surface capacities of the imminent neighbourhood zones, as compared to those farther away. A similar role is played here by the spatial-functional division of the urban areas. Psychological factors can also be of importance here. Apparently, people do not want to live in the neighbourhoods of plants and enterprises. Spatial isolation of dwellings from workplaces creates better conditions for recreation, enabling dissociation from professional problems not only in time, but also in space.

The share of the long distance commuter trips, which are therefore also lengthy in time, however small, does constitute an important socio-economic problem. Such trips often cross the whole city, from one end to another. Lack or inconvenience of peripheral transportation connections result in these trips, between outer-area districts, most frequently passing through the centre. The cumulation of massive streams of commuter trips to and from work originating in the outer-area districts and in the centre itself over the downtown transportation lines is one of most important causes of the transportation difficulties which are so characteristic for many big towns. Looking at the commuting distances along the spatial cross-section of the city one notices a gradual increase of trip distances with the increase of distance from the centre. There is a decrease in distance dispersion along the same direction.

An inefficient pattern of transport services causes disproportionately long trip times while the average distance is small. The average trip time is 28.6 minutes. This value is quite near the upper commuting time limit defined by the Standing Communication Committee working within the International Federation of Housing and Spatial Planning.

The determined resultant vector of directions have correctly emphasized the actual "specialization" and diversification of the directions of journeys from the different parts of town. The layout of the resultant vectors of directions in the peripheral

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TABLE 1. Indices of differentiation of distances, time durations and directions of commuter trips

Parametre name	Symbol	Distance indices (km)	Time indices (minutes)	Directional indices (degrees)
Weighted arithmetic average	$\bar{X}$	3.92	28.64	185.43
Mode	D	3.75	22.56	162.39
First quartile	Q_1	2.06	16.57	115.24
Median	M_e	3.52	25.49	177.74
Third quartile	Q_3	5.29	38.38	275.06
Variance	$S^2_{(x)}$	6.61	275.45	10 008.45
Standard deviation	$S_{(x)}$	2.57	16.61	100.04
Quartile deviation	Q	1.62	10.91	79.91
Typical range of variability	X	$1.35 \leqslant x \leqslant 6.49$	$12.04 \leqslant x \leqslant 45.24$	$85.39 \leqslant x \leqslant 185.47$
Classical variability index	V_S	65.56	57.9	53.95
Positional variability index	V_{Me}	46.02	42.80	44.95
Classical assymetry index	A_S	0.066	0.366	0.230
Positional assymetry index	A_O	0.096	0.182	0.218

and intermediate zones is well ordered. All the resultant vectors uniquely indicate the centripetal direction of the job-related commuter trips. The considerable length of these vectors demonstrates that the structure of directions is highly homogeneous, and simultaneously it is a testimony to the limited spatial opportunities to find a job in this territory.

In the downtown areas the layout of resultant vectors of the directions of journeys is in turn inorderly and chaotic. Their small length indicates strong differentiation of the directional structure.

The variation of the commuting directions, defined by the vector deviation, changes in space as the variation of the distances and times of commuting change, i.e. it decreases for greater distances from the centre of the city. Disproportions in the variation of the directions between the various areas of town are, however, much bigger. The value of the vector deviation of commuting directions nears the lower limit of the range of this indicator's values $L = 9.23$. The great variation of commuting directions in the whole town is a particularly characteristic feature of intra-urban job-related movements. It is in an important degree determined by differences in locations of individual habitation areas, since directions of commuter trips originating in various areas, especially outside the centre, are complementary.

The specific distribution of the distances and directions of commuter trips in the separate parts of town results in a relatively uniform distance-and-directional classification of all the trips. As far as the distance structure is concerned the central, intermediate and peripheral zones are mutually complementary. This results from the predominance of shorter trips in the central zone, and longer trips in the other two zones. The spatial structure of trip directions is more complex. In all areas of the central zone this structure is strongly differentiated. Outside the centre its layout becomes more homogeneous. Each area has usually its own predominate commuting direction. Because of that, however, the outer-area zones treated as a whole, have a complex directional structure, as in the central zone. In effect the overall urban structure of the distances and directions of job-related commuter trips represents a very diverse picture.

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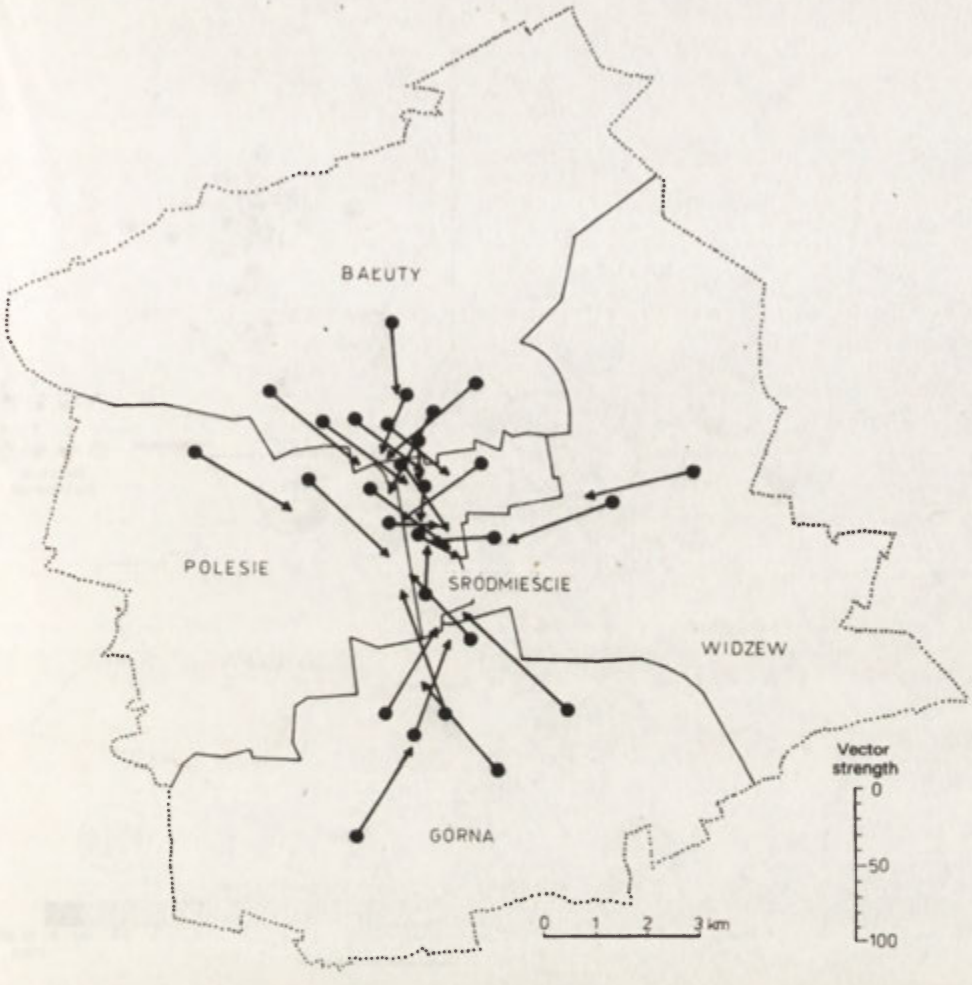

Fig. 2. Resultant vectors of directions

The degree of the distance-direction dispersion of all the commuter trips, evaluated with the relative vector deviation ($L = 8.42$) is higher with regard to the directions of trips alone. Since the distance and direction variation add up, the exceptionally high overall differentiation should be treated as an essential and significant feature of intra-urban commuting to work.

The vector averages excellently illustrated the predominance of the centripetal trip layouts over virtually the whole of the city. It was found that as in the case of the distance and direction variation, the distance-directional variation is a function of distance from the centre, successively decreasing with the increase in this distance.

The analysis of the leading elements of the spatial structure of the distances and directions of commuter trips showed that the relatively predominant distances represent a concentric layout model with minimal distances in the central zone, and maximal distances in the peripheral zones. An entirely different model is observed for the relative dominance of directions. It is a sector-shaped model, in which the lines

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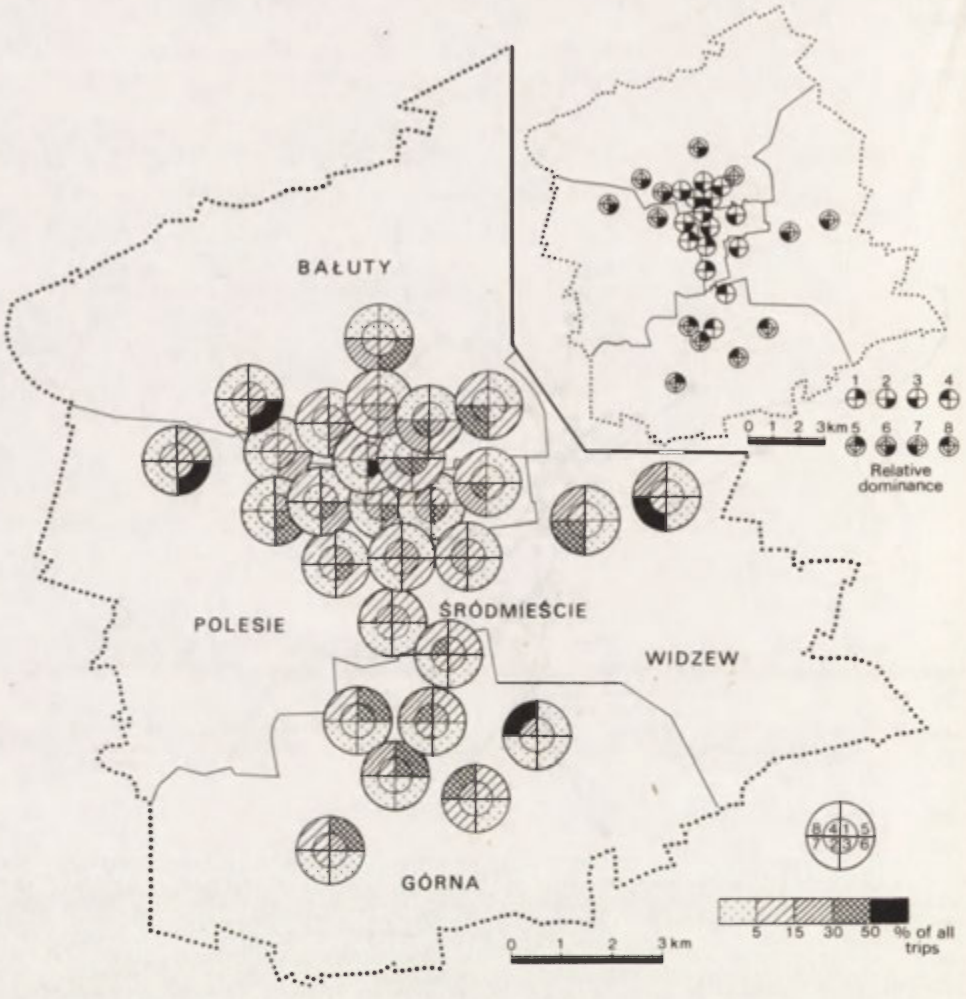

Fig. 3. Distance-directional structure

dividing individual directional sectors converge almost in the geometric centre of the city. Trips from each sector are decisively oriented towards the centre.

On the basis of the average relative variation of distances and average relative vector deviations of directions the four following area types were distinguished:

1. commuting areas with high variability of distances and low variability of directions,
2. commuting areas with high variability of both distances and directions,
3. commuting areas with low variability of distances and high variability of directions,
4. commuting areas with low variability of both distances and directions.

The most typical and frequent are the second and fourth area types. Areas of high variation in distance and direction of commuter trips are located primarily in the centre. The areas of low variation in trip distance and direction occur exclusively outside the centre, with the immediate vicinity of the centre and far-off peripheries

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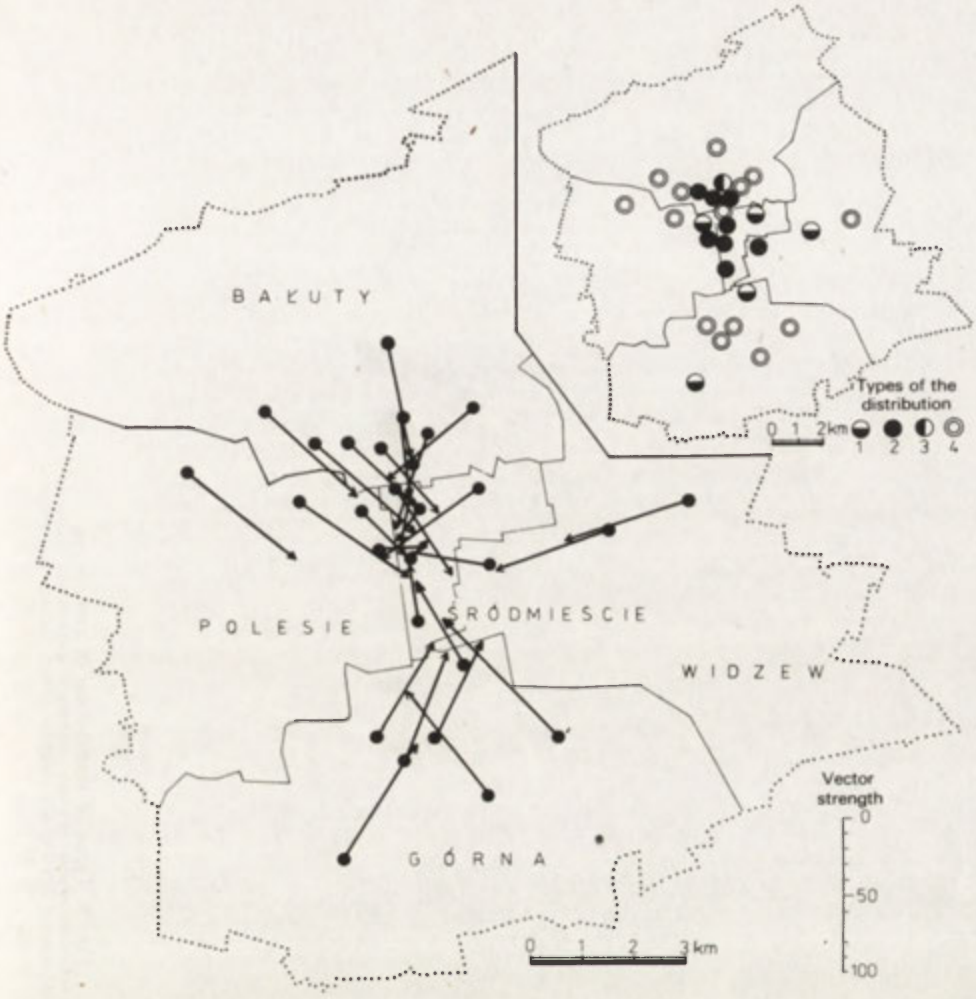

Fig. 4. Resultant vectors for a distance-directional structure

containing commuting areas with high differentiation of distances and low differentiation of directions. These areas, similarly to areas of low differentiation in distance and high differentiation in direction, are usually located within the sphere of influence of two or more bigger concentrations of workplaces which are in different directions or different distances with regard to a given habitation area (e.g. Ruda Pabianicka, Podgórze, Szlezyng, some parts of Baluty).

In the light of analyses conducted it appeared to be unrealistic to try to identify one decisive factor uniquely determining the differentiation of distances and directions of commuting. The intra-urban job-related commuter trips accur within a context of manifold spatial, economic, social, demographic, psychological, cultural etc. conditions. The separate determinants of the trips do not act in isolation, but in a strict mutual interrelationship. Among the 38 independant variables accounted for in this study the following factors could be treated as those most strongly differentiating the distances and directions of journeys: the location of the place of residence and work, the

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Fig. 5. Types of distribution of commuting
A – Commuting area with high variability of distances and directions.
B – Commuting area with low variability of both distances and directions

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number and type of transportation media used in commuting, the branch structure of the textile industry, the structure of higher educated professional groups, the length of stay in the present place of residence, as well as the professional and spatial mobility of the population. The first two factors have obvious supremacy over the other ones, resulting from the strength of their influence on both distances and directions. They do not explain sufficiently, though, the total variation of distances and directions of commuter trips. Thus, the influence exerted by housing and work location can be compared with the influence of all the other factors. The latter can be treated as one set of various conditions having altogether essential significance for the spatial layout of job-related commuting. It seems that this juxtaposition of influences exerted on the one hand by locations of dwelling and work, being by the very nature of things the direct cause of commuting, and on the other hand by a whole range of factors such as the transportation, work and habitat environment, or the social and demographic conditions, does adequately express the specifics of conditions for all, not only intra-urban, commuter trips to and from work.

The factors studied usually influence equally strongly on the distances and directions of trips. Some of them, however, exert stronger influence on the variation of distances than on the variation of directions or vice versa. This can be illustrated with locations of dwelling and work, exerting much stronger influence on the variation of directions than on the variation of distances of commuter trips ($e_{yx} = 0.7$ and $e_{yv} = 0.5$, respectively). It should be noted at this point that the location of dwelling alone influences in a greater degree both distances ($e_{yx} = 0.44$) and directions ($e_{vx} = 0.65$) of trips, when compared with location of work ($e_{yx} = 0.37$ and $e_{yx} = 0.47$, respectively) which appears to be understandable in view of the greater dispersion of dwelling locations than of work locations.

It was observed that the factors considered usually act selectively along the spatial cross-section of the city. Some factors exert a stronger influence within the peripheral part of the city, while others do so within the downtown areas. This can be illustrated by differences in the spatial effects of the sectoral and branch structures, of age/sex and education structures etc. It was, however, generally observed that the relations looked at were more distinct outside of the central areas.

The relatively strong influence of transportation conditions is also worth emphasising. It influenced most strongly the length of trips. From the independant variables analysed, means of commuting has the strongest influence on the variation of distance ($e_{yx} = 0.58$). One should not forget, though, that this one is at least partly a more formal relation, rather than causal one, since trip distances decided upon may determine the transportation means utilized. A similar influence can also be exerted by other transportation factors (the number and type of transfers, costs of trips, the convenience of transportation connections and so on).

The analyses carried out indicated the existence of direct and inverse relations among independant and dependant variables. For instance, a direct relation exists between the distance of trip and the professional and spatial population mobility. In turn, the distances of commuter trips are inversely related to i.e. they depend upon the age of place of work and of housing, the age of commuters, size of their households, numbers of professionally active in their households, durability of family ties, duration time of marriages etc.

None of the relations studied have a functional nature. This seems to be justified by the subject of research. Determinants of socio-economic processes and phenomena rarely act with great force. Functional relations can rather be attributed to *a priori*, deductive, formal and technical studies.

One should pay attention to the important role of these variables out of the group of factors influencing differentiation of distances, which are determinants of the objectively defined urban spatial structure and of elements directly defining

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TABLE 2. Factors influencing distribution of distances and directions of commuter trips

Name of factor (x_i)	Influence on distribution of distances (y_1) of commuting	Influence on distribution of directions (y_2) of commuting
	Correlation coefficient (e_{yx})	
1	2	3
WORK ENVIRONMENT FACTORS		
Distribution of workplaces	0.3701	0.4656
Division of workplaces according to sectors of economy	0.1124	0.0869
Division of workplaces according to branches of industry	0.1099	0.1415
Types of jobs in textile industry	0.1785	0.1452
Occupational groups with basic skills	0.1014	0.1083
Basic textile workers	0.1416	0.0952
Occupational groups with medium skills	0.1091	0.0392
Occupational groups with higher skills	0.1592	0.1173
Non-productive positions	0.0807	0.0593
Status of industrial workers	0.0355	0.0279
Wages	0.0528	0.0594
Length of stay within present enterprise	0.0703	0.0644
Professional mobility	0.1388	0.0850
HABITAT ENVIRONMENT FACTORS		
Distribution of housing	0.4401	0.6497
Number of rooms per apartment	0.0812	0.1039
Apartment surface in sg.m.	0.0893	0.0833
Habitation density (persons/room)	0.1017	0.0816
Age of housing	0.1173	0.0297
Duration of stay in the present dwelling (in years)	0.1319	0.1690
Changes of dwellings	0.1368	0.0608
INFLUENCE OF TRANSPORTATION CONDITIONS		
Types of transportation media*	0.5809	0.0658
Number of transfers	0.1124	0.1179
Type of transfer	0.2431	0.2275
Costs of trip (in zlotys)	0.2674	0.1414
Distance of traffic (in kms)	–	0.0714
Duration of trip (in minutes)	0.7196	0.0853
Direction of movement (in degrees)	0.2227	–
Inconvenience of transportation connections**	0.1595	0.0948
INFLUENCE OF DEMOGRAPHIC AND SOCIAL CONDITIONS		
Sex	0.0591	0.0061
Age	0.0741	0.0637
Civil state	0.0161	0.0629

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Length of married life (in years)	0.0647	0.0570
Level of education	0.0388	0.0175
Magnitude of households	0.0560	0.0457
Professional activity in households	0.0251	0.0360
Direction of education	0.0270	0.0113
Social origin	0.0335	0.0493
Number of professionally inactive in households	0.0354	0.0259
Kinship	0.0584	0.0530

* together with segments of trip made on foot
** approximately measured by margin of time before the start of work

properties of activity space of individuals, their information stock and way of gathering knowledge in the urban environment. The analyses conducted testify that the most essential in the group of factors thus conceived are – besides the location of habitation and work places – professional and spatial mobility, age and sex, economic status, territorial and social origin, and the sectoral structure of the economy.

To summarize the above considerations let us state that in view of the differentiated layout and spatial structure, the great variation of the structure of distance and direction, job-related commuter trips in the city of Łódź are organized in the form of a complicated system of functional-spatial connections determined by an intricate complex of factors, defining work and habitat environments, transportation conditions and socio-economic relations. Small numbers of job-related trips to and from the city make that the system is virtually closed. The problems considered here should be looked upon in the light of both individual and legislative features of a city.

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SPATIAL MOBILITY OF THE POPULATION IN POLAND AN ATTEMPT OF AN INTEGRATED APPROACH

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So far our studies have been almost exclusively concerned with permanent migration of population. Special attention has been paid to migration from rural to urban areas as it has been considered that "actually the nature of permanent internal migration can be reduced to this direction of migration" (Latuch 1970), especially due to their importance:

– for the development of the national economy (rational use of manpower resources),

– as a factor generating changes in the distribution of population and urbanization processes,

– in the processes of social change.

Undoubtedly, migration from rural to urban areas still perform a number of socio-economic functions, but their role in the generation of changes in the urban settlement network is not, or possibly will not be in the near future, as essential as it would seem from the interest taken in this kind of migration. This is due to the gradual exhaustion of underemployed manpower in rural areas which is a function of the present age structure of the population, the existing agrarian structure and the level of the organization of work in farmers' holdings.

Not denying the importance of the village-to-town migration one should appreciate and pay attention to the role played by other spatial migration movements in the development of the urban settlement network.

An attempt to define the importance of these movements is not easy due to at least the following reasons:

– insufficient progress in research concerning the spatial behaviour of man[1] and the concept of population mobility,

– lack of uniformity of views on the notion of migration and its place among other types of spatial mobility,

– insufficient state of knowledge of other types of moves and ways and methods of their research with regard to conditioning and connection.

The UN-sponsored *Multilingual Demographic Dictionary* of 1958 defined migration thus: "Migration is a form of (...) spatial mobility between one geographical unit and another, generally involving a change of residence from the place of

[1] It is noteworthy that a new science of man's spatial behaviour – proxemics is formulating within social anthropology (Cf. Edward T. Hall, The Hidden Dimension, New York 1966).

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origin or place of departure to the place of destination or place of arrival. Such migration is called permanent migration and should be distinguished from other forms of movement which do not involve a permanent change of residence (...) on the basis of the length of absence from the previous residence or the duration of stay at the new residence. "Whereas the first part of this definition makes room for a broader interpretation of the notion of migration, the second sentence narrows migration down to movements involving a change of residence."

In a number of studies a wider scope of the notion is accepted and commuting to work and temporary movements are defined as a specific type of migration (Kosiński 1967; Stpiczyński 1972). This broader interpretation of the notion of migration finds its counterpart also in the Soviet studies (Khorev 1973, 1974, 1976).

A. Jagielski (1969, 1977) represents a slightly different approach by introducing the notion of displacement of population which is superior to migration. Literally, a displacement "is each change of location of man or an object irrespective of distance (e.g. a change within a room, building, locality or between continents), its causes and motives" (Jagielski 1977, p. 218). In the suggested formulation migration is a displacement "connected with a change of the place of residence", whereas the one which is not connected with a change of the place of residence is qualified as daily displacement (commuting to work and journeys of educational and training character) or daily occasional displacement.

The advantage of this classification is that it comprehensively covers all types of displacement, but a strict application of the proposed terminology still meets several obstacles in practice and arouses theoretical reservations due to the existing dependencies among different types of displacement and an occurrence of transitional forms. Therefore, it is perhaps wiser to employ another terminology and to take care in its correct interpretation assuming at the same time that given statistical data are accepted with reservations.

The greatest influence on the development and alteration of the urban network of settlement is exerted by permanent migration, temporary migration and commuting. This is expressed in a number of publications. What is not noticed, however, is the significance of commuting for educational purposes (to schools in towns), and still to a greater extent occasional displacements to towns (e.g. commuting for shopping or to service sector). Though they may constitute, to a great extent, an initial phase of commuting to work – and consequently temporary migration and permanent migration to towns.

The results of questionnaire research of commuting to work indicate the occurrence of explicit tendencies of changing this form of displacements into permanent migration. 50 to 75% of people commuting to work in towns shows migrational preferences (Olędzki 1967; Rajkiewicz 1971; Cegielski 1974, 1977) which increase as the distance and arduousness of commuting increase. On the other hand, there is no analogical research regarding people commuting to towns occasionally. Also, there is no research concerning the population living in towns at present which would be carried out from the point of view of their previous participation in commuting to schools or to work.

All types of displacements among units of settlement both proper migration and temporary moves (daily displacements) contribute to spatial mobility of population. Due to the lack of an efficient definition jointly including all the movements we are not able to state exactly the extent of population mobility.

We can however become aware of the scale of the mobility of the population on the basis of, for example, data regarding public transport (not including those who use municipal means of transport). Thus, in 1974 there was an average of ninety five rides per person and an measured distance of commuting of 27 km. The total mobility of the population in towns can be estimated in a similar

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way. In 1974 there was an average of 319 rides a year, i.e. 0.9 rides a day per person in towns (including the population of towns without municipal transport). On the other hand, there was an average of 1.25 rides a day per person in towns with municipal transport (in Warsaw 915 rides, i.e. 2.47 per day).

It seems that on the basis of the existing statistics of migration of population, i.e. censuses, records and single investigations, two different attempts to estimate the spatial mobility of the population can be presented.

On the basis of the data gained from the latest Population Census of 7 December, 1970, such a possibility is created by one of the variants of the coefficient of residence method. This method specifies the relation between the population born outside the present place of residence (town or village) and the population resident in this location (town or village); it actually specifies the percentage of immigrant population, compared to the total residence (a town or a village).

This method is not perfect because: – it identifies as migrants people residing in the same place for many years but born somewhere else and – it does not identify as migrants people who had left their place of birth but returned there before the Census.

With all the weak points of this method we can agree that it identifies the different types of spatial displacement that had occurred if, finally, they assumed the form of permanent migration.

According to the data of the latest Census the population of Poland amounted to 32.6 million people including 15.5 million people born outside the present place of residence; this means that the immigrant population constituted 48% of total population. In towns lived 17.2 million people including 55% of immigrant population (9.4 million people), whereas 15.4 million people lived in villages and 39% of them were newcomers.

The spatial distribution of the estimated mobility of population is shown in Fig. 1. The greatest shares of immigrant population (low degree of residency) in towns were characteristic of the western and northern voivodships, and, particularly, of the voivodships of Legnica (72.5%). What is above all reflected in this distribution is the process of populating the 'demographic waste' of those regions in the first post-war years by repatriates from the Soviet Union, people from the central Poland and returned emigrants from the West. It is worth mentioning that according to the Census of 1950, which is methodically comparable, the immigrant population in the area of the so-called Northern and Western Territories constituted 84% of total inhabitants.

In the towns of central and southern Poland the shares of immigrant population ranged from 44.6% in the voivodship of Piotrków to 54.2% in the voivodship of Przemyśl. These regions, then, were populated by an almost equal numbers of those born and resident in the same town and immigrants. In the towns of the eastern voivodships, on the other hand, the immigrant population was greater than that in central Poland.

The shares of immigrant population in villages were more clearly visible and corresponded to our hypotheses. They were great in the areas of voivodships populated after the Second World War, small in the central and eastern Poland and smallest in the south-eastern part of the country (from 20 to 25%).

The presented picture of differences in the degree of mobility of the population in general is created above all by migrational processes which occurred at least 25 years ago.

This is also confirmed by the distribution of immigrant population shares presented in Fig. 2. In the northern and western voivodships the shares of population born in 1945 and earlier outside the place of the present residence in relation to the resident population in this age group are great. For example, in the towns of the

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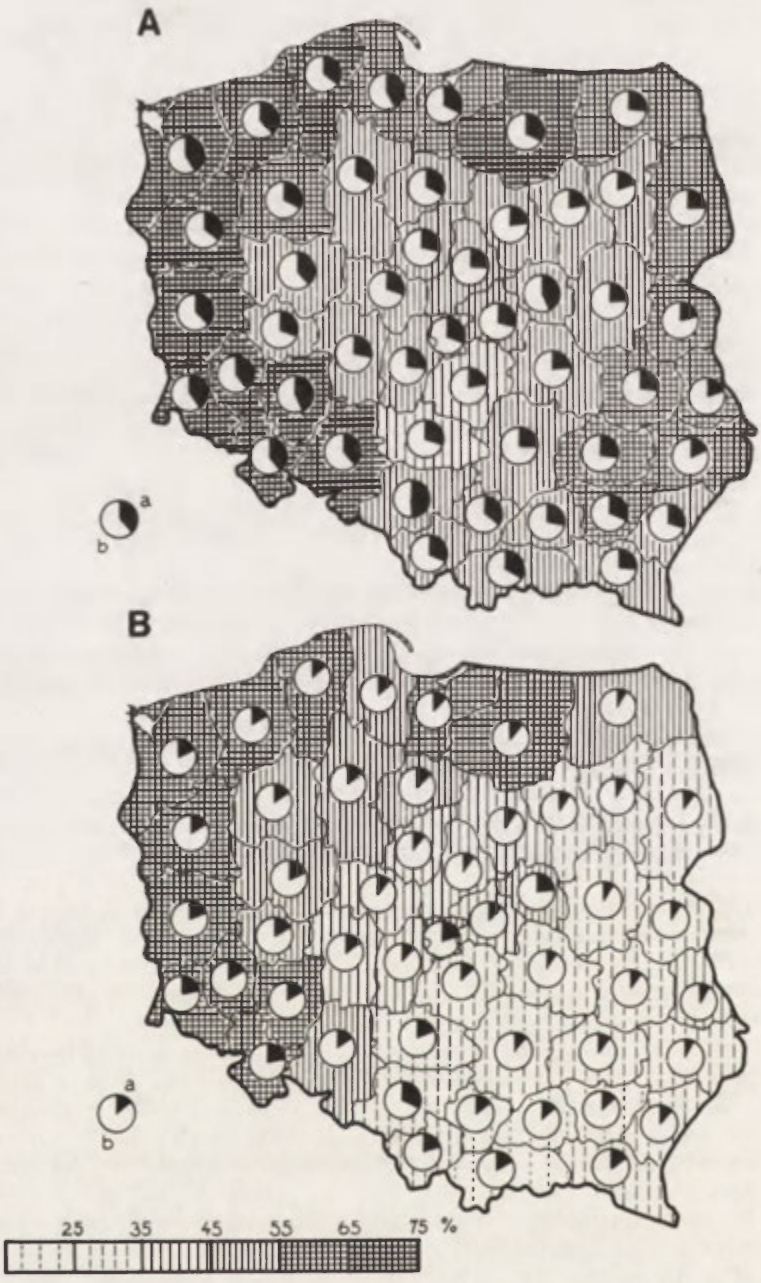

Fig. 1. Shares of immigrant population in towns (A) and in villages (B) in percentages of population according to voivodships on Dec. 7th, 1970
a – share of immigrant population from towns, b – share of immigrant population from villages

voivodship of: Elbląg, Wroclaw, Jelenia Góra, Szczecin, Koszalin and Legnica more than 99.5% of the population at the age of 25 and more (at the time of the Census) was the population born outside the present place (town) of residence.

In general, the presented spatial distribution of immigrant population in the

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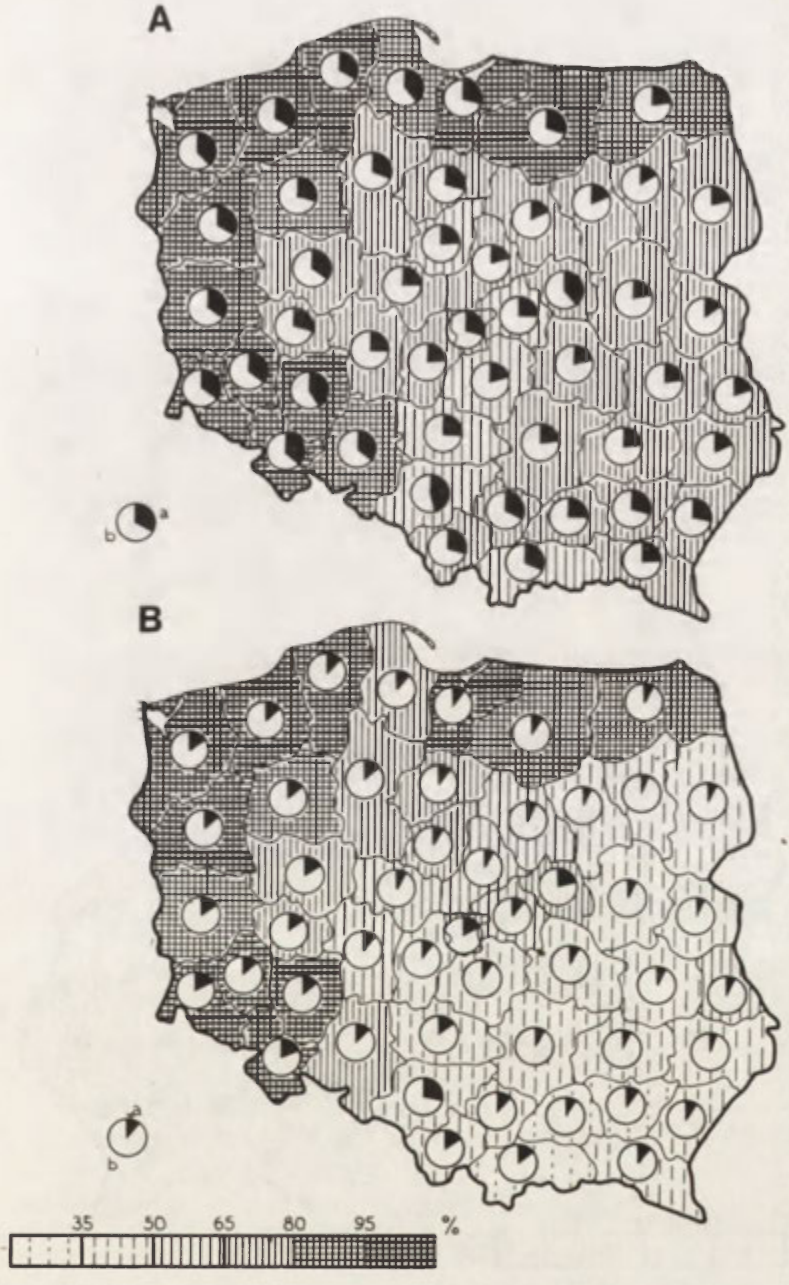

Fig. 2. Share of immigrant population at the age of 25 and more in towns (A) and villages (B) in the percentages of population in this age group according to voivodships on Dec. 7th, 1970
a – share of immigrant population from towns, b – share of immigrant population from villages

western and northern voivodships results from the past impulsive migrational processes and the picture we obtained was modified by flows from the following years only to a small extent.

The materials of the latest Census converted to the new administrative division

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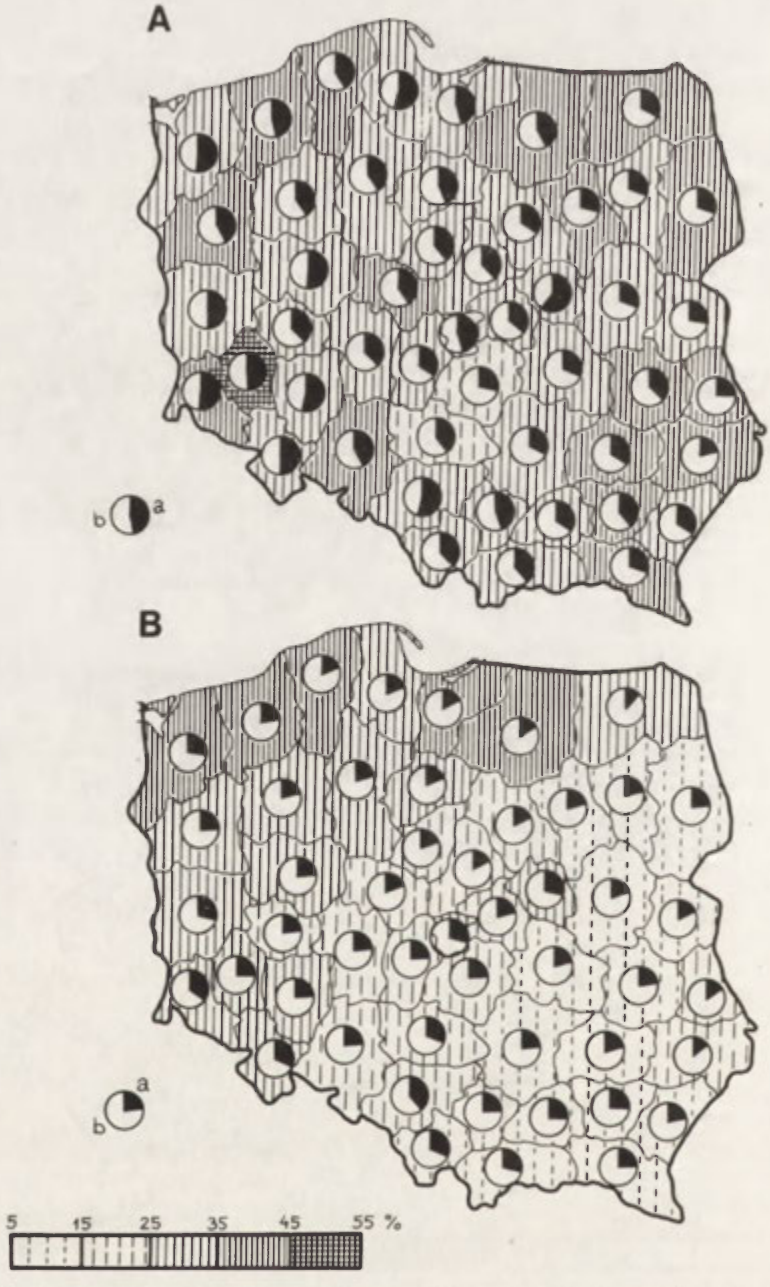

Fig. 3. Share of immigrant population at the age of 24 and less in towns (A) and villages (B) in the percentages of population in this age group according to voivodships on Dec. 7th, 1970
a – share of immigrant population from towns, b – share of immigrant population from villages

make still another fragmentary estimation of mobility of the population possible by stating shares of population born in 1946 and later outside the present place of residence in relation to the population in this age group (Fig. 3). Large shares of immigrant population in towns (45 to 55%) occurred in the eastern areas more

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frequently than in the western ones. In this distribution are both contemporary flows to the towns of, for example, the sulphur basin in the Tarnobrzeg voivodship, lignite coal basin in the Konin voivodship or copper basin in the Legnica voivodship, and the old migrational flows of the parents' generation populating the western and northern areas together with their children who had been born in the previous place of residence. It is more clearly visible in the distribution of shares of immigrant population in rural areas (Fig. 3B).

To conclude, the attempt to estimate the spatial mobility (more precisely migrational mobility) of the population on the basis of coefficients of residence reveals the above-mentioned weak points which are increased by the peculiar character of the population in the western and northern regions. A serious disadvantage of this method is the estimation of mobility of population only by in-migration. Since central, eastern and south-eastern Poland are largely areas of out-migration, they are defined in this formulation as areas of low mobility. That is why the coefficients of residence cannot be interpreted as an objective estimation of mobility.

A method of estimation of migrational mobility of population that is much more frequently applied is the coefficient of migration turnover, also called the mobility coefficient. This can be defined as:

$$W_r = \frac{I+E}{L} C$$

where I is the number of immigrants during the year, E is the number of emigrants during the year, L is an average yearly number of population, C is constant (1000).

This coefficient is most frequently used to define the frequency of migration of the whole migrating community of people in the country and makes a retrospective estimation of migrational mobility possible. On the basis of censuses carried out since 1951/52 we can state that there has been a gradual decrease in migrational mobility from 54‰ in 1954 to some 25‰ in 1974.

Assuming that spatial mobility of population is the result of total displacement leading to a change of the place of residence regardless of the character and permanence of a displacement we should not limit the scope of the notion of spatial mobility of population to permanent migration alone.

Special single investigations of temporary migrations (migrations for a temporary stay of more than two months and records of departure from the temporary stay), commuting to work and schools, which were carried out periodically, make it possible to include displacements of this type in considerations on the total spatial mobility of the population in Poland. It can be analysed on the basis of the investigations of 31 October, 1973, regarding commuting to work of those employed in the socialized economy according to towns and communes (*gminy*), and on the basis of the data on temporary migration in 1974 according to towns in the administrative division of 1 June, 1975.

The scope of the analysis has been limited, out of necessity, to three types of displacement[2] and refers only to towns.

What is suggested to be taken as the measure of mobility is the global mobility coefficient:

$$K_m = \frac{I_p + E_p + I_r + E_r + I_c + E_c}{L} 1000$$

[2] The latest investigations of pupil's commuting to schools were carried out in the school year 1971/1972 in the administrative division valid at that time.

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where I_p is the quantity of permanent migration in-flow to town in 1974
E_p is the quantity of permanent migration out-flow from town in 1974
I_t is the quantity of inflow to town for temporary stay in 1974
E_t is the quantity of outflow from town from temporary stay in 1974
I_c is the number of commuters to work to town on 31 October, 1973
E_c is the number of commuters to work from town on 31 October, 1973
L is the average number of population in a town[3].

The measure was accepted though its imperfections had been realized, but at present it is the only method of global estimation of population mobility from the point of view of a town. The joining together of measures of mobility of different types of displacement into one common coefficient can arouse doubts due to the different spatial structures of displacement under consideration or the fact that commuters to work are related to the total urban population. Some terminological-interpretative difficulties also arise because we do not define the mobility of urban population, as each of the types of migration movements to towns (from villages and towns) and from towns (to towns and villages) are taken into consideration. It should be, then defined as *spatial mobility of population to and from towns* rather than mistakenly refered to as mobility of urban population.

Undoubtedly, the separate estimation of mobility according to particular directions and types of displacement would be methodologically more adequate, but in such a case we would obtain a series of separate distributions of mobility and not the only one general distribution of mobility as it is presented in Fig. 4.

The average national coefficient of mobility of population (*to and from towns*) amounted to 327‰ in 1974 (6028.3 million gross displacements to 18 605.5 million inhabitants of towns). In the total number of gross displacements permanent migration constituted 16%, temporary migration – 28% and commuting to and from towns – 56% (structural differences are shown in the diagrams).

The spatial mobility of population to and from towns in the voivodships situated in the western and northern parts of the country and partially in the centre was lower than the average (25 voivodships were below the average). Low mobility was accompanied by low effectiveness of displacements to towns (from 2% in the Elbląg voivodship, 8% in the Konin voivodship, 10% in the Wałbrzych voivodship, 12% in the Gdańsk voivodship and 14% in the Jelenia Góra voivodship to 30% for the remaining western and northern voivodships).

The highest mobility was recorded in the south-eastern voivodships, and particularly in the voivodships of: Krosno – 613‰ (effectiveness – 60%), Rzeszów – 582‰ (69%), Tarnobrzeg – 535‰ (36%), Nowy Sącz – 455‰ (44%), Tarnów – 445‰ (56%) and Bielsko – 542‰ (49%) and around Warsaw in the voivodships of: Ostrołęka – 459‰ (28%), Siedlce – 431‰ (31%) and Skierniewice – 431‰ (18%).

On the basis of shares of particular types of mobility in the percentage of the general mobility presented by the structural diagram we can state that the high mobility in the south-eastern Poland derives from the considerable amount of commuting to and from work in this area, as in the remaining mentioned above voivodships. On the other hand, in the north-western voivodships characterized by low mobility our attention is attracted by high values of the intensity of temporary migration (gross).

One can presume that considerable differences in the degree of mobility between the south-eastern and north-western areas reflect different possibilities of migration in regions and people's attitudes towards the choice of the form migration (displace-

[3] Due to lack of data the number of population was replaced by the number of population at the end of 1974.

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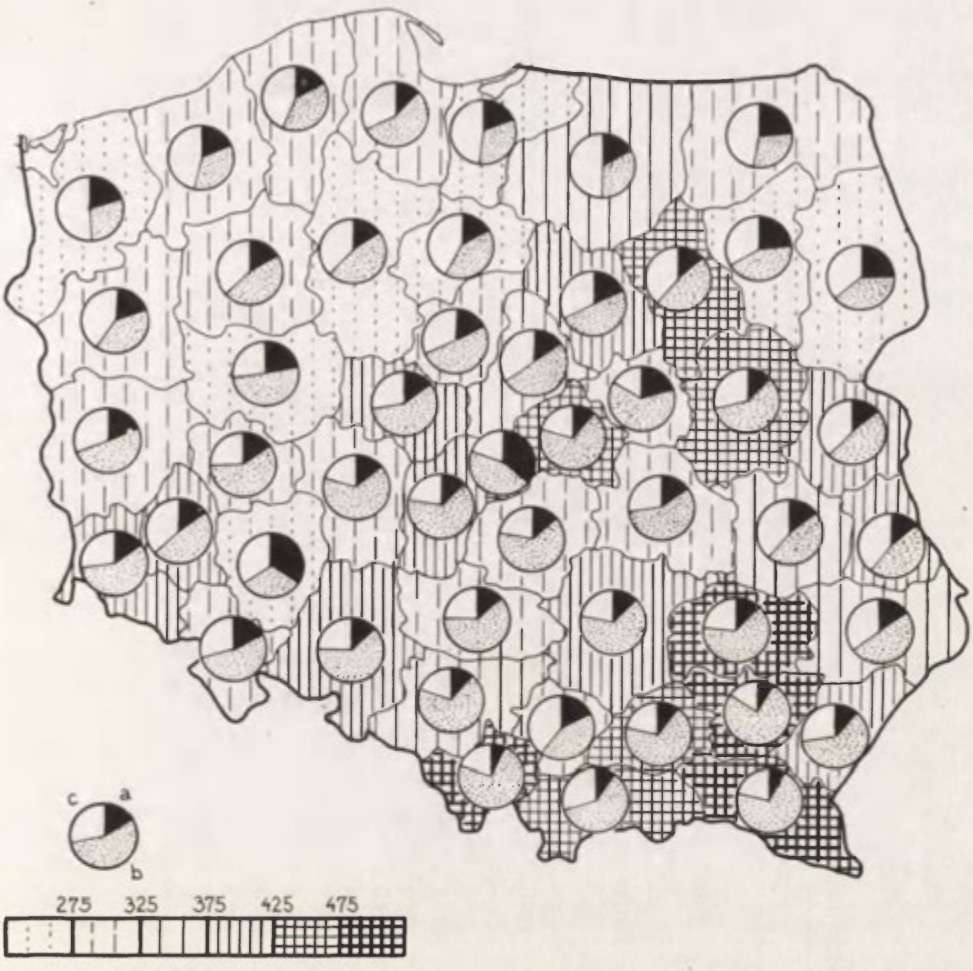

Fig. 4. Global coefficient of mobility of population to and from towns according to voivodships in 1974 (per 1000 urban population)

a – share of permanent migrations (gross). b – share of commuting to and from work (gross). c – share of temporary migrations (gross)

ment). Though this supposition is not well-founded, the dissimilarity of migrational processes in south-eastern Poland is generally recognized, however not explained.

Those voivodships which attract migrants and concentrate great numbers of commuters (mainly the voivodships of Katowice, Warsaw city and Gdańsk) are not distinguished by higher mobility as this measure is relative. One should also remember that until 1974 restrictions in registration were in force in a number of towns (in Warsaw they will be valid till the end of 1980), which influenced the level of mobility to a great extent and lowered the shares of gross permanent migration in relation to the areas where those restrictions were not binding.

Interesting differentiation in the mobility of population occurs for towns according to their size (Table 1). The highest global mobility occurred for towns from 5 to 50 thousand inhabitants and the lowest one for the biggest cities. However, the effectiveness of particular types of displacement increased together with the size of towns. The effectiveness of temporary migration for towns up to 20 thousand

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TABLE 1. Types of population displacements by size of towns in 1974

Towns by size (,000)	Number of towns in 1974	Population on Dec. 31, 1974	Employees according to the actual place of employment in 1973	TYPES OF POPULATION DISPLACEMENTS									Global mobility coefficient (per 1000 population)
				1974 Permanent migration*			Commuting to work in 1973			1974 Temporary migration			
				in-migration	out-migration	balance	arrivals	departures	balance	in-migration	out-migration	balance	
				in ,000									
Poland		33 845.4	10 558.4	798.0	798.0	×	2 845.0	2 845.0	×	·	·	·	·
Towns with the number of population:	814	18 605.5	8 853.0	477.1	294.2	182.9	2 381.7	994.2	1 387.5	890.5	794.6	95.9	314
below	294	909.5	8 306.9	28.9	23.2	5.7	114.7	72.2	42.5	40.2	44.1	−3.9	355
5– 10	194	1 379.1	606.1	53.0	39.5	13.5	224.2	110.4	113.8	71.2	75.9	−4.7	416
10– 20	161	2 266.3	1 023.0	82.4	57.8	24.6	358.0	179.1	178.9	121.4	126.1	−4.7	408
20– 50	102	3 109.2	1 513.9	109.7	66.6	43.1	523.3	238.7	284.6	172.9	166.8	6.1	411
50–100	36	2 543.8	1 248.0	57.8	33.3	24.5	349.8	144.2	205.6	122.3	102.4	19.9	318
100 and more	27	8 397.6	4 155.1	145.3	73.8	71.5	811.7	249.6	562.1	362.5	279.3	83.2	229
Village	×	15 239.9	1 705.4	320.9	503.8	−182.9	463.3	1 850.8	−1 387.5	·	·	·	·

* Not including migration movements between districts of towns

Source: The author's calculations were based on the data of the Central Statistical Office (*GUS*), the Demographic Yearbook. 1975 and published results of the employment census in 1973.

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inhabitants was negative; in the two following categories it was positive but low, and for the biggest cities it amounted to only 13% whereas for permanent migration it amounted to 33% and to 53% for commuting to work.

It is noteworthy that partial mobility coefficients according to types of displacement keep a constant relation to one another irrespective of the category of towns' size, and only with slight variations the mobility coefficients remain in the relation 1:2:4 (permanent migration: temporary migration: commuting to work). One can take the risk of stating that those relations reflect *the model of spatial mobility of population. The mobility of population migrating temporarily is twice as high as the mobility of population migrating to stay, and the mobility of population commuting to work is four times as high as the mobility of population migrating to stay.* Those relations divided into component elements of movement are presented in Fig. 5.

It seems that in the present conditions this model reflects quite faithfully the examined spatial displacements of the population. The next stage of research stating the reliability of this model precisely, should be a detailed analysis of towns. On the other hand, broadening the scope of the model by other movements is not possible because of lack of data. We can only suppose that the mobility of the population participating in occasional daily displacements is, for example, six times as high as the mobility of the population migrating to stay.

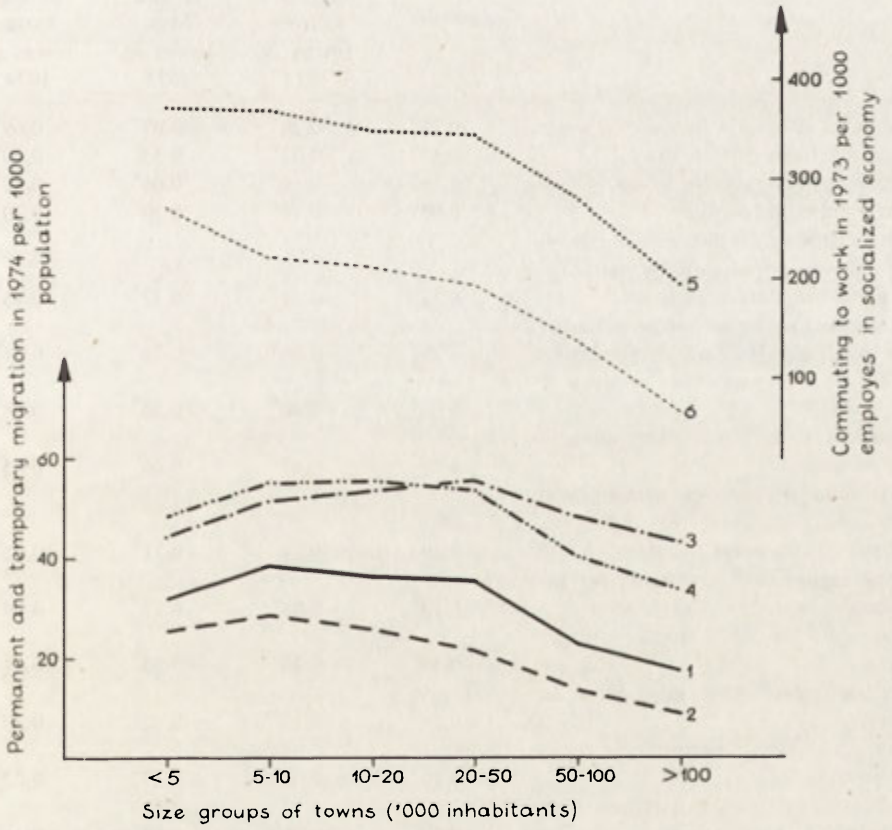

Fig. 5. Force of spatial shifts according to types and size of towns in 1974
1 – migration flow for permanent residence in 1974 per 1000 population. 2 – migration outflow for permanent residence in 1974 per 1000 population. 3 – registrations for temporary residence in 1974 per 1000 population. 4 – records of departure from temporary residence in 1974 per 1000 population. 5 – commuters arriving to work in 1973 per 1000 employees according to the place of employment. 6 – commuters leaving for work in 1973 per 1000 employees according to the place of residence

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On coming back to the attempt to estimate the general mobility of population to and from towns according to voivodships (Fig. 4) one can raise a question whether it is possible to notice the relevant relationships between mobility coefficients on the one hand and demographic and socio-economic features of towns by voivodships on the other. To gain the initial discernment a simple analysis of correlation was carried out on the basis of data which was easily attainable and converted into the new administrative division. For some features this data refers to voivodships in general, therefore the dependencies obtained may be doubtful. The list of features and the correlation coefficients obtained are presented in Table 2.

The correlation coefficient values indicate the occurrence of considerable statistical

TABLE 2. The coefficients of correlation of population mobility with chosen features for towns by voivodships in 1974

Features	Global mobility coefficients	Mobility coefficients according to types of displacements		
		permanent migration to/from towns in 1974	commuting to and from towns in 1973	temporary migration to and from towns in 1974
Crude rate of natural increase in towns	0.17[a]	0.20[a]	−0.07[a]	0.69[c]
Crude marriage rate in towns	−0.55[c]	0.02[a]	−0.53[c]	−0.10[a]
Female fertility rates in towns	0.18[a]	−0.10[a]	0.06[a]	0.40[b]
Female ratio in towns	0.05[a]	−0.11[a]	0.19[a]	−0.30[b]
Global coefficient of the burden put on productive population by non-productive population in towns	0.32[b]	−0.24[b]	0.32[b]	0.13[a]
Employment in the socialized economy in towns per 1000 urban population	0.73[d]	−0.20[a]	0.78[d]	−0.01[a]
Coefficient of engagements to work – in general	−0.06[a]	0.40[b]	−0.30[b]	0.58[c]
Coefficient of dismissals from work – in general	−0.26[b]	0.47[c]	−0.46[c]	0.45[c]
Gross value of permanent equipment per one inhabitant in thousands zlotys – in general	−0.29[b]	0.21[b]	−0.31[b]	−0.05[a]
Capital expenditure in industry per inhabitant in zlotys – in general	0.13[a]	−0.08[a]	0.13[a]	−0.04[a]
Private cars per 1000 people – in general	−0.40[b]	0.16[a]	−0.30[b]	−0.41[c]
Population per retail sale point in towns	−0.51[c]	0.13[a]	−0.42[c]	−0.39[b]
Average number of persons per room in towns	−0.10[a]	−0.05[a]	−0.17[a]	0.22[b]
Physicians per 10 000 population – in general	−0.40[b]	0.26[b]	−0.33[b]	−0.36[b]

Source: the author's own calculations based on the publications of the Central Statistical Office (*GUS*)

Explanations: The coefficient of engagements to (dismissals from) work was calculated as a proportion of the number of engagements (dismissals) in the socialized economy in 1974 and the state of employment in the socialized economy on Dec. 31st. 1973.

Degree of dependence: [a] dependence of almost no importance, [b] evident but slight dependence, [c] significant dependence, [d] dependence of great importance.

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dependence only between the mobility of population participating in daily commuting and the amount of amployment in the socialized economy. Only in a small number of cases are the correlations important, in the majority of the examined relationships they are of little or almost no importance at all.

Some of the correlations can be partially interpreted. A significant correlation occurring between the mobility of population migrating temporarily and the degree of natural increase in towns may be the result of a considerable 'turnover' of women who migrate temporarily to take real or apparent care of children. At the same time one should pay closer attention to the occurrence of both a large degree of natural increase and that of the mobility of those migrating temporarily, which is characteristic mainly of towns from 5 to 50 thousand inhabitants. That is why when interpreting this correlation one should take into consideration the different structures of the size of towns according to voivodships.

The moderate correlation between the 'turnover' of those migrating temporarily to towns and the female fertility rates in towns can be explained in a similar way.

A significant negative correlation between the mobility of population commuting and the crude rate of marriages (gross) in towns is justified by the fact that the highest coefficients of marriages occur in the areas with a young demographic structure of population, and at the same time with low intensity of commuting to work (western and northern voivodships). A contrary situation occurs in the urban areas of highly industrialized voivodships.

No relationship was revealed between the crude rate of marriages and the mobility of population migrating to stay in/outside towns ($r = 0.02$), although marriage is the reason for a part of migration – mostly from a village to a village.

The supposition that the heavy burden put on the population at the productive age by the population at the non-productive age in towns (which is to reflect indirectly the situation on the labour market) should be revealed in a significant dependence on migrational mobility cannot be confirmed in the analysis due to the way data for towns has been aggregated (by voivodships).

The next five features representing the socio-economic situation of voivodships in general were introduced in order to broaden the scope of the analysis after it had been admitted that general values could be treated as replacement ones due to lack of such data for towns. The dependencies between them and mobility are of little or no importance at all, and in case they are significant we are not able to interpret them at the present stage of the analysis.

The analysis does not prove either that the degree of car ownership has a stimulating influence on migrational mobility of population. It should be supposed that such a dependence would be revealed if the migration for tourist and recreation purposes were included in migration research. In the present form the slight (for commuting to work) and significant (for temporary migration) negative dependence should be linked together with the occurrence of a higher car ownership level in the voivodships with large urban centres characterized at the same time by low mobility coefficients (compare Table 1).

A similar situation occurs in the case of the dependence between mobility and the degree of development of the network of retail trade. In the strongly urbanized voivodships with a considerable number of large cities the mobility coefficients are low, and simultaneously a greater number of inhabitants come to one retail unit.

The outlined analysis of interdependencies should be considered as an initial attempt at gaining discernment in this respect.

To conclude, from the two presented methods of estimation: migrational mobility on the basis of the coefficient of residence and "general" spatial mobility on the basis of the global mobility coefficient the second method, in the author's opinion, reflects the real mobility of population more accurately, though it cannot be considered perfect.

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TENDENCIES IN DEVELOPMENT OF MATHEMATICAL MODELLING OF HUMAN MIGRATION

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Principles of modelling of human migration have been developed alongside with progress achieved in mathematics, physics, physiology, sociology, and cybernetics as well as in studying regularities inherent in the phenomenon itself. Usually ideas and methods of modelling developed in the following way: first, certain durable interrelationships and parametres were empirically observed, then a formal version was proposed for the mechanism of stability, usually by analogy to regularities known in other disciplines; finally, new facts allowed to verify and rebuild the original model or to change it for a new one, a synthesis of many ideas and methods taking place at the same time. Recently there has been a marked tendency to model using regularities taken not by simple analogy to other disciplines but rather derived directly from analysis of human migration, the regularities that differ substantially from the former analogies.

The most substantial aspect of migration modelling consists of the compact formal, static and dynamic approaches. Most of the models combine all these four features to different extent. There are very few which could be characterized by only one of them.

Nevertheless, one could try to single out chronologically basic stages in development of migration modelling, viz.:

1840 – everyday rational principles (or the 'common sense');
1850 – principles of formal analogies to regularities from other disciplines;
1875 – principles of using concrete regularities (steady parametres, tendencies and interrelationships) of migrations;
1890 – principles of dynamic relationships between simultaneous phenomena;
1898 – formal deductive principles of probability;
1929 – formal approximation type principles;
1957 – formal optimization approach;
1967 – formal models based on the principle of entropy maximization;
1967 – principle of spatial self-organization of population.

In this paper there is no room to report the gradual progress in migration modelling in detail; this will be done elsewhere. What is done in this paper is merely an outline of characteristic features of this process.

Although the modelling principles based on common sense originated a long time ago, they still exist in many proposed patterns in a hidden form. This type of models first of all includes:

– models of forming a flow in mastering it by a new type of transportation;

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in original models of this type cartage was transferred to railway transport without taking into account the fact that the new traffic conditions generated new flows which had not existed before; similar mistakes also happen frequently at present, i.e. in the long-term distribution of traffic in several types of transportation, e.g., in railway and air transport;

– extrapolatory models with historical time used as various analytical functions (linear, power, exponential, including those of compound interest and logistic ones) have spread particularly wide in calculations of forcast traffic intensity in individual sectors of non-urban railways and highways; these methods produce good results only in short-run forecasts (usually up to five years) and it is only if there are no substantial changes in distribution of the population, production, services and transportation infrastructure since the consideration of functional links between changes of flows and historical time, rational in its essence, have no thorough base unless statistical correlation is possible which is rather variable over time;

– models of a strict labour balance, the so-called labour settlement in cities, when it is rationally presupposed that if capacities of the places of work and residential places are maintained even in the city the flows of labour will be fully confined within the city or district; this principle had been predominant in town-building till the 1960s and it was only under the pressure of irrefutable facts that its supporters ceded their positions.

Desire to break away from the original simplistic level and approach scientific understanding of the phenomenon and, on the other hand, dire need to make likely calculations of forthcoming traffic intensity, led at first to transfer of well-known laws, principles, models and methods which had proved to be efficient in other disciplines to the field of migration.

The following analogies have been consecutively accepted in modelling: Newton's law of gravity, Ohm's, Coulomb's and Kirchhoff's laws of electrostatic interdependence; the law of diffusion (penetration) in different media; the Weber-Fechner principal law of psychophysiology; the law of absorption; and the law of refraction. Originally these analogies were used in deterministic form, later on taking probabilistic interpretation. Modelling based on these analogies gave rise to a new era in development of methods to forecast migration and aid to accept a scientific approach to replace the prevailing primitive rationalism. Perhaps it is only due to the attempts to create formal analogies that complexity of actual migration became possible to be gradually discovered and attention paid to many aspects of the phenomenon which might have been otherwise ignored.

A number of researchers who knew their subject very well and who possessed considerable empirical material wished from the very outset to set themselves against the supporters of formal analogies in modelling principles as far back as the second half of the last century. However, the objective was unattainable because there were no mathematical tools at that time adequate for modelling complex, developing and balanced systems. That is why the successes of scientists anticipating possibilities attained by science were transformed into reality only in the form of empirical evidence. In particular a very important aspect of development of migratory streams was noticed, viz. that they increase along S-shaped curve with a certain level of saturation as it is determined by a given transportation means. At present it is known from cybernetics that this is the most striking expression of the interaction 'flow – system of transportation – flow' whereby a positive feedback is replaced by a negative one. At that time, however, it was not possible to model this process mathematically.

One has dwelt here on a characteristic example of the original services done by those who championed the study of concrete regularities. They observed many other important stabilities which could be noticed and assessed in most cases merely

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through modern concept and abstract generalization. When we refer to the work of the past it appears to be not only of historical interest. It should also provide deductive and empirical information to solve the most urgent problems of the current development. Yet it is necessary for this purpose to approach the analysis of the past work from another perspective to create a cumulative scientific potential that would not be subjected to various fluctuations in other areas of development of the society.

The principle of dynamic links between phenomena stems directly from certain regularities governing development of certain phenomenon taken not in isolation but as a part of an interrelated system, with processes taking part simultaneously. Since the end of the 19th century this principle has underlain modelling of human migration.

In 1890s empirical evidence concerning transport mobility in cities confirmed the observation that percentage of its growth is greater than squared percentage of population growth. Many projects had been based on this rule until World War I. Later there was a change to study levels of migration mobility by socio-demographic groups and types of areas. The idea that there was a connection between horizontal mobility of population and level of per capita income was put forward in the mid-1920s and confirmed empirically in the early 1960s. Separate studies were made for factors of mobility (number of trips or movements), distance and time spent on movement. A tendency was discovered in the 1950s which indicated that time spent on inter-urban movement tends to stabilize. This tendency proved to be of special interest. A hypothesis was also put forward of stability of what is known as absolute mobility of urban population (number of visits to various objects per migrant per time unit). It was found later that the hypothesis held valid for one type of personal transport. The general amount of time on movement and, in particular, the amount of energy spent on them proved to be more stable. In the first half of the 1950s a formal approach was adopted for heuristic methods of forecasting interrelated processes. It was taken as a basic to develop a wide-spread system of methods to calculate dynamics of a matrix of population movements. The system proved to be good for conditions of consecutive development without currently developing objects (development of new lands, construction of new residential and industrial centres, etc.).

Since the first half of the 1960s the principle of dynamic relationships has been developed successfully in comprehensive models of urban dynamics where necessity exists to foresee the future flows of population. In this context the possibility of scanning future trends proved to be particularly attractive. Nevertheless, the likelihood of the future states depends not only on experience and ability of the modeller but also on adequacy of the dynamic links fed into such models from the very beginning. The problem of non-linear dependencies and feedback loops is still very far from being satisfactorily solved although models of these types do constitute a progress in this direction.

Introduction of formal deductive probability principles into science constitutes the next stage in migration modelling. Unlike direct analogies to the laws of physics or physiology this phase reveals a desire to understand the process-generating mechanism on the basis of achievements in mathematics. It must be pointed out that direct analogies to physical laws in veiled, modernized form are still being supplied with unremitting intensity to the market of modelling of migration. For example, already in the first half of the 1970s it was proposed that the Focker-Plank differential equation and the principal correlations of Einstein's theory of relativity should be used for these purposes.

The probability approach in the field under review was used for the first time in the end of the 19th century to determine the distribution function for distances

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between two independent and random points in a figure of a definite form. Later, in the first decade of the 20th century, the distribution of migration intensity with normal distribution of errors was used in a number of models. The probability meaning was imparted to the formula of mutual correspondence in 1924 and in 1936 it was supplemented by a certain procedure of levelling out imbalances and survived to this day in this shape. The probability meaning was later imparted to other methods of mutual correspondence calculation based on other analogies to the laws of physics and physiology. The year 1952 was particularly productive as far as modelling was concerned. At that time a principle of stochastic discrete migration distribution was proposed. This principle was taken as a base for a whole system of differential and integral equations. The Poya urn pattern was proposed to describe the distribution of migrants by lengths of their trips. Earlier this pattern had proved to be very adequate for describing processes of ecological multiplication or the spread of epidemics (with aftereffects). It must be pointed out that return is to be observed to the Pascal and Poya-Appley distributions in context of model processes of the stochastic formation of 'mother' nests from which spread continues already under a different law, i.e. that of more distinct concentration. The same year there emerged a proposal to model diffusion of innovations, migration being viewed as a special case, by using consecutive discrete probability models. Later the Monte Carlo method was successfully used for this purpose.

The distribution of the most important parameters of movement and commodity flows, i.e. distance, specific capacity of the passenger flow, intensity of movement, etc., has a positive value by its very nature. To describe the distribution of these values functions of the distribution of substantially positive values have been used since the mid-1950s. These include the normal logarithmic distribution, the Maxwell distribution, the Raleigh gamma and beta distributions, the Waybull distribution, etc.

A transition probability matrix for movement of labour within certain areas was suggested in the mid-1950s. This being based on the Markov chains, this trend in modelling of migration became particularly wide-spread in the late 1960s with regard to the definitive migration. To describe the dynamics in residential and job turnover within the city as well as migration turnover within certain areas a number of models based on differential equations has been suggested. The key parameters of these equations are calculated through probabilities. To modell the dynamics of migration a series of models was proposed in the mid-1960s based on the stochastic games of consecutive states with the aid of the Monte Carlo method.

The next type of models is based on the formal approximation principles. Unlike the above-mentioned types the approximation pattern of models does not offer any definite mechanism of forming a phenomenon. Rather, its purpose is to create, as precisely as possible, a model, picture or replica of reality by statistical algorithms. In this sense the method is similar to instant photography. This is both the advantage and disadvantage of such models because they describe the existing state with the maximum precision but they cannot be used to forecast development, in particular, for long-term prediction. The most outstanding of such models are the Gramm-Charlier, Johnson, Pearson approximation distribution systems of migration. Rather close to them as far as the prognostic abilities are concerned are also the static equations of multiple correlation, widely employed in the field under review. Recently efforts have been made to overcome the formal descriptive nature of such models by analysing changes of the variable factors in time and thus creating multiple correlation dynamic models.

The formal optimization approach penetrated the migration modelling in the second half of the 1950s, i.e. simultaneously with the wide-spread use of the so-called transport task of linear programming for calculating optimal cargo traffic. However, the calculation of migration streams by the minimum expenditure of time and

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resources revealed a substantial inadequacy of the results soon after. What is most important, unlike the case of cargo, even in ideal conditions, it was impossible to fix migration for definite origin and destination areas. In this sense the optimization models when applied to migration could not produce more than was yielded by the very first 'common sense' models. Nevertheless, several dozen of papers have been written that used methods of linear programming for the distribution of passenger flows. However, the principle of formal optimization of the transport task type had been fully discredited in the field under review by the late 1960s. Yet perhaps the negative result of that search helped direct the efforts of reasonably efficient teams of mathematicians and economists interested in applied methods, to synthetize the formal and compact approaches towards modelling migration.

Evidently, it was not accidental that three papers appeared simultaneously and independently in the USSR and Britain on this subject precisely in 1967. The papers were written by professional mathematicians. They showed that the real picture of the internal movements in the city was given by the models of the entropy maximization type. Although only a decade has passed since then, the proposed entropy approach is being discussed and expanded in most of the studies on modelling of migration. So many excellent reviews have been written on the subject that there is no need here to present details. It seems necessary, however, to emphasize two factors. The entropy approach as applied to social phenomena as interpreted by the information theory and statistical mechanics was discussed for the first time in 1957. It was proposed as an idea and unsophisticated formalizations in 1960 to be applied to modelling of migration in terms of thermodynamics. The principle of the maximization of entropy expressed the task of calculating passenger flows and, later, distribution according to the routes in a form understood by specialists engaged in the study of operations. Therefore, it made it possible to use the earlier developed numerous algorithms for solving non-linear optimization problems and, at the same time, to draw mathematicians into the effort and to employ computers on a large scale.

To follow the trends in migration modelling it would be logical to dwell on the possibilities of using the latest achievements of mathematics in this field. These include the theories of stochastic processes, the theory of games, the theory of reliability, the theory of ultimate automata, and theoretical cybernetics and systems techniques. Some of the above-mentioned trends are already being partially used in modelling of migration. However, one would like to dwell on another problem of fundamental importance for the progress of the theory of migration and the whole issue of territorial interactions in the settlement systems. This concerns the problem of adequacy of the theoretical structures.

It has been mentioned that transport workers and town builders dealing with the practical problems of designing, construction and operation, as far back as the last century noticed a substantial interaction between the population and its socio-technical infrastructure, the adaptation of the population to the changing conditions. This served as a basis for a number of hypotheses and intuitive opinions about a stable correlation between the development of traffic speed and the maximum territory of cities at a level of 30 minutes spent on travelling from peripheral districts to the centre. Later the hypothesis spread wide yet till very recently it has been without sufficient empirical evidence and, most important, without any theoretical explanation of the origin of this stability.

The author has attempted, in a series of papers since the mid-1960s, to use representative empirical material covering a period from the origin of public transport to the present day in order to show the actual stability of the maximum and average time spent on movement. First it was done for the largest cities and agglomerations, and later for cities with different number of population. The author

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has studied the following indicators: the average and maximum time spent by people on commuting to work and to the city centre, the overall time spent on all the daily and weekly movements per every commuter. It was proved that these indicators differed according to the city size but the levels tended to stabilize for the cities with a population over a million. It was also found that these indicators differed according to social and demographic factors. Furthermore, a link was established between a historical tendency towards increasing absolute time spent on movements and changes in the time budget, mainly length of the working day.

The method used to study the dynamic regularities was to establish a direct link among the observed dynamic series of indicators so that it should be possible to replace historical time as the argument of the functions studied (as is accepted in the dynamic models of trends and autoregressions) with dynamic links between indicators possessing a content basis, i.e. instead of $a_t = f_1(t)$ and $b_t = f_2(t)$ the link $a_t = f_3(b_t)$.

This research was taken as a basis to formulate the principle of the transport regularities of settlement or dynamic equilibrium in the development of the transportation system, population distribution and human movements. The principle was formulated in 1965. Later, in 1969 the author formulated a principle of statistical spatial self-organization of the population according to the amount of time spent on movements. It is clear now that the other principle is of more general character than the first one which is a consequence of the spatial self-organization of the population. It is possible now to have a closer look at these and other notions linked with them which were introduced a comparatively short time ago. This analysis would be useful to get a better idea of their possibilities in modelling of migration and in more general models of spatial interaction in the settlement systems.

Trends in transport within settlement systems. The emergence of this notion stems from the fact the time spent by population on migration is the main parameter of the spatial interaction between settlement and transport. In view of the considerable concentration of industries in large cities it is impossible to accomodate all the workers employed in large factories or works within a walking distance from them. As a result, the settlement schemes are inevitably orientated to passenger transport. Moreover, since there are members of families working elsewhere and since all of them want to live in a particular environment, all that testifies about the importance of the transportation factor.

And since this is the case, a rule comes into force which was observed even when passenger transport was just coming into being. This rule says that in establishing working relations and others, population, with other conditions being constant, depends on time and not distance. Therefore, the speed of movement ensured by passenger transport assumes great importance. This is exactly what constitutes the nature of mutual links between transport and settlement or the transport-orientated regularities in settlement systems.

Dynamic equilibrium in the development of transport and settlement stems directly from the relationship between the development of transport and settlement. At first the progress of society ensured concentration of production and an increase in the urban population. Later it became impossible to settle all workers close to the expanding enterprises. All this prompted the development of passenger transport which, in turn, became an extremely powerful stimulus not only for the demographic but also for the territorial growth of the cities and their perspective change for large urban complexes or agglomerations. And at every stage of its development transport-created quite definite conditions of accessibility determined by its attainable average speed.

If there are no rigid limits in the profile of a daily time budget, the development of transport would enable population to spread in a very intensive way. In reality,

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however, these limitations maintain a dynamic equilibrium (steady state) between the development of transport and settlement.

Feedback loop in the development of transport and settlement. Dynamic equilibrium in the development of transport and settlement is also maintained because there is a feedback loop between them. One influences constantly the other. At any moment changes in settlement or transport systems due to their feedback initiate compensatory development in one or the other system interchangeably.

A negative feedback loop leads to an unchangeable state in the settlement-transport system, i.e. to keeping all of its parameters constant. A positive feedback loop leads to an increase of the parameters of the system while maintaining the most substantial values within a narrow range to keep the system in the steady state. The feedback mechanism, homeostatic in its essence, is the most important component of the interaction between settlement and transport.

Statistical spatial self-organization of the population according to the time spent on movements. A steady state is maintained in the system under review while normal conditions are maintained in the distribution of industrial and non-industrial construction as well as development and improvement of transport. Besides this, the population itself, adjusting to the changing conditions, seeks to alter its links in such a way (principally those between the places of residence and work) that the time spent on movements should remain within the acceptable range. This requirement stems from the stability of the activity cycles, especially, the daily ones.

Time is spent whithin the acceptable range through changing either the place of work or residence at individual initiative. Such possibilities can be materialized only if there is a large number of places of residence and of work, that is merely in large cities only where the choice is considerable. This circumstance points to the probabilistic character of the spatial self-organization process of the population under review.

The speed of the spatial self-organization of the population. A comparison of aspects of the steady state in the development of transport and settlement, and the spatial self-organization of the population has made it necessary to measure the intensity or velocity of adaptation of the population thus helping to accelerate the process of dynamic equilibrium between the development of transport and settlement.

Velocity of such adaptation can be measured by the number of changes in the links which occur in a time unit. It is also convenient to use the indicator of time or the deadline for self-organization connected with that. This indicator is equal to a period of time within which the system is reduced to the level of its former parameters after the disturbance. This reduction is achieved through self-organization.

Stability of the spatial self-organization of the population. This is the amount of time spent on movement most of the population seek to achieve in establishing constant and regular links which is the result of the self-organization of the population. As it has been written, this parameter has no absolute stability. Rather, it tends to stabilize durably in the largest cities and urban agglomerations or in smaller similar socio-economic conditions. The maximum amount of time spent on movements shows a greater dynamic stability.

It is important to underline also aspects other than stabilization of a certain level of the average and maximum amount of time spent on movements. The type of function used for the distribution of migration totals according to the amount of time spent also remains approximately unchanged, which makes it close to the generalized Raleigh distribution. In the case of the largest cities and urban agglomerations this is well fit by the one-parameter Raleigh distribution.

One should also pay attention to the following:

– the striving of the population not to the absolute minimum (as was accepted

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in a number of migration models and was most explicitly expressed in the models of optimization trend) of time and means used to effect the spatial distribution of regular links but to a certain standard in this respect;

– the striving of the planning, designing and operating organizations to maintain a steady state with necessary and interrelated development of settlement and transport in such a way as to arrive again at the same standard or constant which would be acceptable and convenient for the majority of people.

This discussion of principles of dynamic equilibrium in settlement and transport systems and the spatial self-organization of the population is necessary in order to create adequate models of migration. The author has followed a number of steps on modelling with the use of these principles since 1967. For example, a model has been developed and calculations have been made with regard to the prospective flows of labour from the suburban areas to Moscow which based on the stable amount of time spent on such migration. Simultaneously a model was proposed to calculate interrelationships taking into account the overlapping fields of interaction fixed by number of people consecutively entering the zones of stable maximum amount of time spent on movement or migration. However, those initial models were essentially static and roughly distorted the actual process of dynamic equilibrium and self-organization. Therefore, further steps should be aimed at developing migration models of the type of special stochastic processes, whose substantial variables, constants and mechanisms could evolve through the distinguishing features of the phenomena.

It should be pointed out that important features have been recently discovered, i.e. establishment of working relationships in cities and urban agglomerations. These features are vital for the adequate modelling of the process. It is worthy of notice that the self-organization of the population takes place in two consecutive and interrelated stages, as it were. First the choice is made by an individual in a family (usually its head), who is followed later on by other members of the family. An increase in number of economically active members of the family leads to a greater dispersion in the amount of time spent on their movements although the average amount remains stable. The net outmigration from the area is stabilized regardless of its balanced capacity of jobs and housing. Besides this, a quantitative link has been established between the level of imbalance or the territorial situation of the area and the type of the distribution of migrants according to the amount of time spent on migration. The quantitative characteristics of velocity of the spatial self-organization of the population have also been revealed.

Consequently, this is a complex self-adjusting stochastic process. It is very far from the primitive models in which the principal qualities of the phenomenon, the feedback loop (transport flows), spatial self-organization and, in particular its velocity, were either totally ignored or disregarded in their obvious form. And if these specific features are taken into account, this will make it possible in future to obtain models with maximum approximation to reality.

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SPATIAL STRUCTURE OF INTERNAL MIGRATION IN POLAND

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SUMMARY[1]

At the current stage of research on human migration in Poland there is a lack of studies on the national scale which would use the concept of the national settlement system. This is, among other things, because such a study requires quite detailed data, i.e. those of boroughs and communes. Such a set of data was compiled for 1974, i.e. a time just prior to a considerable change in the administrative system of Poland. Basic material comprise of a matrix of permanent flows of population from boroughs and communes to boroughs and communes, containing about 3000×3000 administrative units. A lack of studies on functional links within the national settlement system made it necessary to adopt in the present study modified assumptions of the National Plan of Physical Development. In the subsequent stages when research on the national system will be developed further, it will be necessary to adopt more precise spatial patterns.

Simmons (1977), for example, analysed migration patterns in the Canadian urban system with 124 urban regions as reference areal units including all towns of over 10 000 inhabitants), ordered in 11 subsystems and 5 hierarchical levels. The subsystems and hierarchical levels were specified on the basis of central-place relationships. The analysis of migration links enabled the author to compare the migration patterns and central-place patterns.

In the present study as basic areal units, for which a detailed analysis of migration ranges has been made, the following urban areas have been taken:

– 9 developed urban agglomerations (Bydgoszcz-Toruń, Gdańsk, Katowice, Cracow, Łódź, Poznań, Szczecin, Warsaw, Wroclaw),

– 9 developing agglomerations (Białystok, Bielsko-Biała, Częstochowa, Legnica-Głogów, Lublin, Opole, Rzeszów, Kamienna Valley, Wałbrzych),

– 28 development centres of national importance, including a set of towns aggregated into five settlement complexes.

Administrative units of the remaining part of the country was grouped into two classes:

– remaining urban, and

– remaining rural

[1] This is a brief version of the paper published in Polish in *Przegląd Geograficzny*, vol. 52 (1980), 1, 81–102.

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The selected inflow areas for which the migration ranges have been investigated almost exhausted the set of towns of over 50 000 (Inowrocław, Gniezno and Świdnica being omitted) and include a considerable part of the set of towns sized over 25 000. Having adopted the simplified assumption of the National Plan of Physical Development five hierarchical levels in the national settlement system were introduced. The detailed cartographical representation of migration sheds of individual agglomerations as well as the development centres of national importance and settlement complexes was made. A two-fold character of links between individual agglomerations and the remaining part of the country is evident. Links of the first kind form a continuous zone, or migration shed, containing inflows from boroughs and communes of hinterland of urban agglomerations. The migration sheds are of a local or regional range, the Katowice and partly Warsaw agglomerations being the only exceptions with their national scale. The hinterland of an urban agglomeration constitutes therefore its spatially continuous migration shed. Migration sheds of urban agglomerations correspond considerably to the boundaries of the functional urban regions as delimited by Korcelli on the basis of commuting to work (Korcelli 1977). Subsequently, the migration sheds change into discontinuous leap-like links, mainly between individual urban agglomerations and large and medium-sized towns in the country. The links suggest that there exists a subsystem of migration flows between Polish cities (Rykiel and Żurkowa 1979). Yet relationships of individual urban agglomerations with their hinterlands are dominant in quantitative terms; these streams account for over 75% of the total migratory links of the agglomerations considered. Hence a thesis was formulated that the dominant gross migratory movements in urban agglomerations are migrations of a local and regional range. This statement should be made precise by pointing to the differences in spatial patterns of individual socio-economic groups of migrants.

At the lower level of the analysis, i.e. that concerning the development centres of national importance and settlement complexes, as defined by the plan, it was found that migration has strictly local links, comprising 75% of the intra-national migratory relationships. It is with towns of the higher hierarchical level that more distant migratory relationships of the towns under consideration applies. As it was indicated elsewhere, the towns under consideration gain positive net migration due to relationships with their immediate umland, population surpluses being transferred up the hierarchy; it is in this way that migratory macro-regions are being formed (Żurkowa 1980).

As regards migration theory, it is possible to conclude that an areal pattern of migration in Poland can be explained by a combined gravity and intervening opportunities model, i.e. by size, friction of distance and competition of neighbouring centres.

Further development of research on migration in Poland depends on theoretical and methodological progress within the framework of the national settlement system. The hypothesis by Dziewoński (1979) on the system of main cities in Poland can be viewed as an interesting basis for further development.

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DIFFERENTIATION IN STRUCTURE OF EDUCATION OF URBAN POPULATION IN POLAND

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In our times, which are often called the period of scientific–technical revolution, a particular role is played by science. It has become one of the basic factors of economic and social development in the modern world.

The development of science, and the consequent emergence of highly qualified groups of personnel are all fairly strongly connected with the process of urbanization. The links between that multi-aspect process of scientific development with the process of urbanization is revealed in the spatial structures of various aspects of social life.

One of the typical symptoms of transformation in the spatial structure of the economy and of other forms of social activities is the development of towns and the concentration of productive work and services for the population which systematically develop in them. This fact, in turn, results in a considerable differentiation in social activities, contributing to scientific development and the increasing importance of science in the life of the nation. It has an influence upon the system of tuition and the development of the population, upon the shape taken by professional lines ever more numerous and specialised.

The Soviet researcher O. N. Yanicki [1] states that modern urbanization is connected with the scientific-technical revolution first because of the changing character of contacts (communication) which, in turn, are a function of the changing character of socialist work. He states that during the period of industrialization, urbanization "followed" industrial development and that because of it the urbanization forms were determined mainly by the distribution of material production. This, of course, had an impact upon the distribution of the population, distribution of qualified personnel and differentiation in the education level of the population.

In modern times, because of the progress in scientific-technical revolution, the production of material goods and of services of all the types depend more and more on science, on the compilation of knowledge and on the population's educational level.

The necessity of preserving the proper pace of transformation or of self-adaptation to the pace of transformation in other regions results in the ever more increasing demand for various types of information, their transformation and generalization which are the result of scientific activities as well as a result of the demand for

[1] O. N. Yanitski, Tendentsii urbanizatsii v usloviyakh nauchno-tekhnichnoy revolutsii, in *Geograficheskiye aspekty urbanizatsii*, Moskva 1974.

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personnel specialized in various fields and with various different levels of professional qualifications.

In such a situation, towns, and especially large cities become the key places of information flows (the accelerators of information flows) being, at the same time, centres concentrating differently qualified personnel. It is in such cities that we find the concentration and intensification of contacts and social links, which are the complex expression of differentiated labour forms.

It is generally known that the development of human society took place as a result of the development of production forms and the development of the social division of labour. The development of production as well as social development has contributed to the concentration of the population and this, in turn, to the concentration and intensification of inter-human contacts and the flow of information of any type. In our times, owing to the far-reaching division of labour and, at the same time, action of powerful forces that integrate all forms of social activities, the accumulation, processing and flow of information (science being one of information forms) have become the independent effect of social activity which even groups considerable numbers of workers. Moreover, the need for the concentration of science and people with appropriate qualifications that are connected with it results, as well, from the fact that scientific research is more and more based in modern times on powerful technical equipment which is fairly costly and often labour intensive. In addition to this, one essential factor of scientific development and qualified personnel concentration in towns is the scientific knowledge base, that eases the introduction of any new scientific-technical innovation in major productive enterprises and other economic units. Because of it, scientific development as well as that of various sectors of the economy and of other forms of human activities can take place, in modern times, only under the conditions of a determined concentration of population, a determined structure of its shaping and of fairly different forms of inter-human contacts. Those different contacts between people are in the form of the flow of information between particular persons and social groups which, at the same time, lead to certain activities which result in the crystallization of a new knowledge.

The development of organizational forms of science, the concentration of personnel with various qualifications connected with scientific development and various social activities on the one hand, and — on the other hand — development of settlement network and its transformation, especially the development of towns, have many common properties which give the possibility of formulating a general conclusion that the development of science and progress of urbanization are inseparable, that there exists a strong dependence between the urbanization level of a given territory and its population education structure. A characteristic phenomena is that a systematically increasing concentration of urban population, especially in big cities is paralleled by a concentration of usually highly educated working personnel.

The education structure is not often tackled by researchers as an independent problem. In publications concerning demography, sociology, economy of labour or geography, the problem of education structure is treated rather superficially. Interesting information and remarks on qualifications of the population and of the education level of qualified personnel and on their distribution can be found in the works by Rajkiewicz,[2] Charkiewicz,[3] Kluczyński,[4] Pietrucha,[5] and other authors. In the majority

[2] A. Rajkiewicz, *Zatrudnienie w Polsce Ludowej w latach 1950–1970. Dynamika i struktura* (Employment in Poland in 1950–1970. Dynamics and structure), PWE, Warszawa 1965.

[3] M. Charkiewicz, *Kadry kwalifikowane w Polsce* (Qualified staff in Poland), PWE, Warszawa 1961.

[4] J. Kluczyński, *Kwalifikacje a rozwój gospodarczy* (Qualifications and the economic development), PWN, Warszawa 1970.

[5] J. Pietrucha, *Kadry kwalifikowane województwa katowickiego* (Qualified staff of the Katowice voivodship), SIW, Katowice 1969.

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of cases, however, these deliberations and information are presented, only marginally (generally as analyses and deliberations concerning manpower resources and their use). The structure of education of the Polish population in general terms in a national scale as well as in regional terms and a division into urban and rural population still has not been undertaken and researched.[6]

Statistical data compiled during the general census in 1960 and 1970 can be used for research work on the structure of education. However, no analysis on the basis of the above-mentioned material has been made, on the transformation taking place over time (a somewhat different classification of education levels in the two censuses and different systems of grouping age groups have been an obstacle in this respect). The results of statistical analyses made during the censuses have been published in the form of tabulated comparisons in special publications by the Statistical Office (*GUS*) and in statistical annals.

The spatial differentiation in the level and structure of the Polish population can be found in the publication elaborated by a group under the leadership of K. Dziewoński.[7] In my view it is the most complete picture of the spatial differentiation in the education level of the Polish population.

The problem of education and qualifications for those working in the socialized sector of economy has been taken into consideration in the employment censuses of 1958, 1964, 1968 and 1973. Information compiled during these periods is not, however, fully comparable because of the different levels and types of education. The differences resulting from the administrative division of the country in particular periods are very important.

We wish to focus attention on the structure of education of the people employed in the socialized economy – in the institutions and enterprises that existed in urban territories in 1973. After certain reservations have been made, this could be considered as an analysis of the employment structure of the urban population. Our attention is focused on the differences existing in the structure of education between the particular size groups of towns.

In 1973, as it can be seen in statistical information, there were 815 towns in

TABLE 1. Structure of town sizes

Size groups of towns (.000)	Number of towns	% of the total number of towns	Number of population	% of total urban population
below 5	293	36.0	902 625	4.9
5– 10	194	23.8	1 391 634	7.5
10– 20	163	19.9	2 266 360	12.2
20– 50	103	12.6	3 152 499	16.9
50–100	35	4.4	2 498 503	13.4
100–500	22	2.7	4 456 756	23.9
above 500	5	0.6	3 940 816	21.2
Total	815	100	18 628 459	100

Notice: The estimates take into consideration the changes that have resulted from the reform of administrative division. Statistical yearbook 1975 for 1973 gives 836 towns with 18 148 300 inhabitants.

[6] Very interesting but general remarks on the level of education of the population are to be found in some studies by E. Rosset (Cf. for example *Demografia Polski* (Poland's demography), PWN, Warszawa 1975, pp. 373–407.

[7] K. Dziewoński et al., *Rozmieszczenie i migracje ludności a system osadniczy Polski Ludowej* (Sum.: Distribution, migrations of population and settlement system of Poland), Prace Geograficzne 117, IGiPZ PAN, Ossolineum, Wroclaw 1977, pp. 78–90.

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Poland, inhabited by more than 18 million people. Table 1 shows the size-structure of the towns. The large number of small towns in the total number of Polish towns is the characteristic feature of their size structure. The towns with a population below 20 000 inhabitants amounted to 70 per cent of the total number of towns, but contained less than 25 per cent of the total urban population. On the other hand, big cities with more than 100 000 inhabitants, amounted to 27 only (3.3 per cent of the total) but contained more than 45 per cent of the total urban population. Moreover, we have observed for many years a diminishing amount of the population in both the small and very small towns as well as a quickly rising share of the population is very large, large and medium towns.

The small towns are not very attractive either for migrants from the countryside or the urban population – they don't offer a large quantity of jobs, or the possibility of professional choice and they give no attractive possibilities for leisure time. Because of this, the majority of these towns are stagnant (both economic and demographic recession occurs in them sometimes), or they develop fairly slowy.

The changes in the size structure of towns that parallel the economic transformation of towns are expressed, first of all, by a systematic increase in the number of employees in the socialized sector of economy – both in manufacturing and service employment. According to the employment census of 1973 approximatively 10.6 million persons were employed in the socialized economy[8] taken as a whole, and almost 84 per cent of them worked in enterprises and institutions located in urban areas. People working in the socialized economy in rural areas amounted only to 16.2 per cent of the total rural population.

It would be difficult to determine the number of people working in towns in the non-socialized sector of economy (agriculture, private artisan workshops, small industry, retail trade and the so called free occupations), because of the lack of precise information and statistical data concerning this group. It can be assumed that their number is not high, though, in certain towns it certainly is significant. At the national scale, for every 100 inhabitants – 47.9 are employed in the socialized sector (including commuters from rural areas). In any particular size-group of town, the number of employees in the socialized sector per 100 inhabitants is not the same. In the very small towns it is 33.9 persons per 100 inhabitants, and in the very large cities this share amounts to 50.7 persons (Table 2).

The quoted figures show that the role of the socialized economy increases in parallel to the increase of the size of town. In this respect, a distinctive trend can be observed, being somewhat disturbed in the case of Polish towns with a population between 100 000 and 500 000, where the number of people working in the socialized

TABLE 2. Number of persons employed in the socialized economy per 100 inhabitants of towns

Size groups of towns (,000)	below 5	5–10	10–20	20–50	50–100	100–500	above 500
Number of persons employed in socialized economy per 100 inh. of towns	33.9	43.5	45.1	48.7	49.1	48.4	50.7

[8] In 1960 12.4 million persons were engaged in the Polisn national economy (of whch 7.2 persons were involved in the socialized economy). In 1970 – 15.2 million persons were engaged (10.3 in the socialized economy) and in 1976 over 17 millions (12.3 in the socialized economy).

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economy, per 100 inhabitants, is somewhat lower than in both the next higher and lower groups. There may be various reasons for this, however, but it would be difficult to give a decisive answer to this problem without special studies.

There emerges the regular tendency that the bigger the town the higher the share of people employed in the socialized economy. The share of those employed in the socialized economy is lower in small towns, being especially low in the smallest towns of less than 5 000 inhabitants each. In towns of this group a large role is played still by agriculture (individual) which is, for instance, the case of some towns in the east of the country, a considerable role be private handicraft. There is a small number of socialized enterprises and they are small in size. Moreover, the socialized services are poorly developed, as well. Worthy of attention is the fact that those small centres in which the socialized economy plays a considerable role, are located in areas with intensive industry, deprived, on the other hand, of a properly developed infrastructure, which is especially true of the housing situation; (i.e. in the voivodships of Kielce, Tarnobrzeg, Rzeszów and Krosno). The situation in the medium, and especially, large towns, is different. Agriculture and the private sector play here a minor role which is, sometimes, simply marginal. The inhabitants of those towns as well as people commuting to work from other towns and from rural areas find employment in the state or co-operative industrial enterprises, in administration and in the socialized services of various types.

From the total of some 8.9 million persons employed in the socialized economy, in the enterprises located in towns, the shares of particular quantitative groups are as in Table 3. The figures quoted in comparison with the share of particular groups of

TABLE 3. Share of particular size groups of towns in the employment in the socialized economy

Size groups of towns (.000)	below 5	5–10	10–20	20–50	50–100	100–500	above 500
% of employed in the socialized economy in enterprises located in towns	3.5	6.8	11.6	17.3	13.9	24.3	22.6

town sizes show distinctively that the share of small towns (up to 20 000) in the total of employment in the socialized economy has diminished and the share of medium and big cities has increased. This fact is probably connected, as well, with the functional differentiation of particular towns. However, the formulation of this conclusion in such a categorical way would require more thorough research.

The size of towns and their position in the life of the socialized economy is closely linked to the structure of education, especially to the structure of the education of the people employed in the socialized economy. The employment census of 1973 took into consideration the following levels of education: higher, post-college, secondary professional, secondary general both completed and non-completed, the basic professional and basic (both completed and non-completed). The employment structure in towns was, as is shown in Table 4.

As concerns the people employed in the urban socialized economy, more than 56 per cent are men. The decisive preponderance of men is noted among the workers with higher education, as well as among those with basic professional education and general basic education (both completed and non-completed). In three groups, namely: the post-college, completed and non-completed general secondary, women are preponderant, the state of balance being seen in the group of workers

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TABLE 4. Employment in socialized economy in towns according to sex and the level of education

	Total	Education level							
		higher	post college	secondary vocational	sec. general completed	sec. general uncompleted	basic vocational	basic completed	basic uncompleted
Total	8 853 051	566 731	213 857	1 127 986	514 237	155 315	1 777 099	3 633 428	864 398
Men	5 000 356	346 425	50 466	570 784	158 249	54 076	1 193 766	2 127 578	499 012
Women	3 852 695	220 306	163 391	557 202	355 988	101 239	583 333	1 505 850	365 386

Source: *Wybrane dane o kwalifikacjach i dojazdach do pracy zatrudnionych w gospodarce uspołecznionej* (Selected data on qualifications and commuting to work of people employed in the socialized economy). Statystyka Polski No. 71. Warszawa 1976.

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with secondary, professional qualifications. The share of particular groups of towns in the total of employees in the enterprises of the socialized economy is fairly differentiated in the distinguished size groups of towns (Table 5). The quoted figures show that workers with different education levels are concentrated in both large and very large centres, the share of small and smallest centres being minor.

TABLE 5. Distribution of employment according to the education level in particular size groups of towns

Size groups of towns (,000)	Share of workers with education							
	higher	post college	secondary vocational	secondary general		basic vocational	basic	
				completed	uncompleted		completed	uncompleted
below 5	1.6	4.8	2.7	3.0	3.2	2.8	3.9	4.8
5– 10	3.5	7.7	5.5	7.8	7.0	5.7	7.4	8.5
10– 20	6.7	12.5	10.2	10.2	12.5	11.9	12.1	13.6
20– 50	11.2	20.3	16.5	13.6	15.9	18.7	17.9	18.8
50–100	10.1	12.0	15.5	21.8	12.7	15.6	14.3	13.6
100–500	26.8	21.0	25.1	19.5	21.0	25.4	24.7	18.3
above 500	40.1	21.7	24.5	24.1	27.8	19.9	19.7	22.4
Total	100	100	100	100	100	100	100	100

This is an obvious assertion because the distribution of workers with different levels of education and qualifications is essentially proportional to the urban population and to the number of people employed in the socialized economy. This conclusion requires verification once we confront the share of particular groups of town sizes within the total of the employed in the socialized economy with the share of workers with different levels of education in the same groups of towns. Thus, the workers with higher education are concentrated, first of all, in the large and largest cities. The existing state of affairs should be explained by the fact that in the towns of this group there exist higher schools, various scientific institutes dealing with research as well as central institutions of administration and economy which employ the workers with high qualifications, namely, in the majority of cases, those who graduated from higher schools.

A similar pattern can be seen in the case of workers with secondary vocational education, though in this case the highest concentration is in the group of towns with the number of inhabitants amounting to 50 000–100 000. This fact is explained by industrial distribution. The staff with secondary qualifications (vocational) are channeled to places with industrial enterprises and productive services, and the activities of such a type are connected, first of all, with the group of medium-size and larger towns (50 000–100 000 inhabitants) and with the group of both large and largest cities.

The workers with post-college education are distributed in a relatively uniform way within the particular town-size groups. They occupy special positions in the very small towns as well as in small and medium sized ones.

The workers with general secondary qualifications, thus, those essentially having no vocational qualifications and making up in the majority of cases the army of clarks, are concentrated in the town groups with the number of inhabitants 50 000–100 000, 5000–10 000 and more than 500 000, thus, to a great extent, in administration centres or in towns with complex functions.

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The workers with non-completed general secondary education are distributed within the particular town-size groups in the same manner as the workers belonging to the former group. Just as those, they often make up the core of the clerical staff.

The numerous group of workers with basic vocational education is relatively most strongly concentrated in urban industrial centres and in administrative centres of rather small regions (former district towns).

Finally, the groups of workers with the lowest qualifications and employed in the socialized economy (both completed and non-completed basic education) are distributed in a relatively uniform way. Their relatively higher share, however, occurs in very small towns.

The picture of the educational structure of employees in the socialized economy located in towns of different size can also be obtained from an examination of the number of workers of various groups of education that can be found per 100 employed in the socialized economy.

In this case we have only taken into consideration six categories of education (not including persons with basic education both completed and non-completed). The data in Table 6 shows in an unambiguous way that there exists an unquestionable

TABLE 6. Education structure of workers in socialized economy according to the size group of towns (in %)

Size groups of towns (.000)	Higher	Post college	Secondary vocational	Secondary general		Basic vocational
				completed	uncompleted	
below 5	2.9	3.5	10.1	5.6	1.6	16.1
5– 10	3.3	2.8	10.6	7.6	1.8	16.5
10– 20	3.7	2.7	11.5	5.9	1.9	20.3
20– 50	4.1	2.9	12.4	5.2	1.6	21.2
50–100	4.7	2.2	14.7	10.5	1.6	22.1
100–500	7.0	2.2	15.4	5.3	1.5	20.5
above 500	11.4	2.4	17.2	7.1	2.1	17.4
Average in towns	6.4	2.5	13.1	6.6	1.7	19.7

dependence between the share of persons with both higher and secondary vocational education and the size of town. In the group of small towns the share of persons with higher and secondary vocational education is lower and, together with the increase of town group population, the share of persons graduated from higher schools and with secondary professional qualifications is increasing.

As concerns the remaining levels of education, we have no obvious dependences here though we can assume a somewhat higher share in the group of medium-size towns.

The above-presented facts are not enough to come to any general conclusions. The investigation that we are carrying out has a character of initial orientation. Undoubtedly a deeper analysis should be made taking into consideration not only the size of towns but their dominant functions as well, their distribution (location in regions) and other properties. In making an analysis of the state of education in particular groups of towns, an explanation should be given of the various factors on which this state depends and an endeavour to evaluate them.

In conclusion one should be able to give – on the basis of studies – the answers to the following questions, with a certain degree of certainty:

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1. Is the existing system (education structure), advantageous from the point of view of the realisation of definite social tasks?
2. Which structure of the population education in particular size groups of towns can be considered as optimal from the point of view of the fulfilment of determined functions?
3. What should be done in order that the education structure in particular size groups of towns and particular functional types of towns be optimal?
4. What social costs should be borne in order that the education structure is as close as possible to optimal?

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