M. ŞILEŢCHI
L. CURTA
C. CIOCHINĂ

A Model of Population's Interzone Migration in Romania

This model is meant to practical aims in planning the socio-economic development of the territorial-administrative units in a manner enabling prospective control and decrease of interzone migratory movement.

The harmonious and balanced development of national economy implies an adequate distribution of the productive forces on the territorry of Romania. In view of doing away with differences in the socio-economic development of the territorial-administrative units, such as they result from a long historical process, important investments have been made in counties weakly developed in the past, thus securing the rapid growth of their industrial and agricultural production in a short space of time. The improvement in the territorial distribution of productive forces is a long-term process; although the interzone migration of population has gradually decreased in intensity, it still is a natural, objective phenomenon.

Drawing up a model for the interzone migration of population in Romania is an attempt to substantiate, on scientific grounds, the existing relation between the level in the socio-economic development of the counties and the intensity of population's migratory flows in these zones, considered as final movements from their place of birth into the new settlements.

The premise from which we have started in this paper is that interzone migratory displacements do not occur by chance but take place under the action of socio-economic factors. Based on the analysis of the influence of the latter we have drawn up a diagram of the structure and connection among the various aspects of this particularly complex process. The mathematical representation of the diagram has allowed us to formulate a mathematical model

of interzone migration. The model of the migration process makes a series of special phenomena of an economic, demographic, social and cultural nature stand out, which can be connected with one another in various ways.

Likewise, it allows the group of more or less intensive correlations among variables to be made evident. The mathematical model built may acquire relative independence with respect to the factual and theoretical material from which it has been derived. As such, it may be used in drawing up the prospective plan which enables computations regarding optimization in the use of manpower on the territory of Romania.

Beyond the bounds of direct observations, the mathematical model must allow:

— to carry out a multifactorial analysis of the interzone migratory process of the population;

— to know the trends in the evolution of the prospective population's migratory movements;

— to improve the prospective methodology for planning the socio-economic development of the territorial-administrative units;

— to know the economic and social factors to be brought into play in view of modifying in the desired sense the existing migratory flow among the territorial-administrative units having a different level of industrial and urban development.

SUBSTANTIATION OF THE MATHEMATICAL MODEL

The drawing up of the mathematical model comprises three stages:

a. formulation of the system of regression equations;

b. computation of the correlation coefficients used in the correlation matrix;

c. construction of the mathematical model of the correlational relations within the structure of the migratory process.

The system of regression linear equations is written:

$$x_{11}k_1 + x_{12}k_2 + x_{13}k_3 + \ldots + x_{1n}k_n = y_1$$

$$x_{21}k_1 + x_{22}k_2 + x_{23}k_3 + \ldots + x_{2n}k_n = y_2$$

$$x_{31}k_1 + x_{32}k_2 + x_{33}k_3 + \ldots + x_{3n}k_n = y_3$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$x_{m1}k_1 + x_{m2}k_2 + x_{m3}k_3 + \ldots + x_{mn}k_n = y_m$$

where:

x_{ij} = level in the achievement of the main socio-economic indicators influencing the migratory movements of the population in the territorial-administrative units of Romania;

y_i = level reached by the indicator characterizing the intensity of population interzone migration in the territorial-administrative zones of Romania (migration coefficient);

k_j = coefficients of regression, appearing as unknowns in the system of linear equations:

$$\sum_{j=1}^{n} x_{ij} \times k_j = y_i, \quad i = 1, 2, ..., m$$

In matrix form, the system is written

$$X \times K = Y$$

where:

$$X = \begin{pmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \dots & x_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{pmatrix}, \quad K = \begin{pmatrix} k_1 \\ k_2 \\ k_3 \\ \cdot \\ \cdot \\ k_n \end{pmatrix}, \quad Y = \begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ \cdot \\ \cdot \\ y_m \end{pmatrix}$$

X represents the matrix of the system, K = the vector-column of the unknowns, and Y = the vector-column of the free terms.

The determination of the correlation coefficients used in the correlation matrix includes:

— computing the statistical means of the characteristics studied, ($\bar{x}_j$ and $\bar{y}$):

$$\bar{x}_j = \sum_{j=1}^{m} p_i x_{ij}; \quad \bar{y} = \sum_{j=1}^{m} p_i y_i$$

where: p_i = ratio of the population in the administrative zone vs. total population;

— computing of mean square deviations (σ_x and σ_y);

— proper computing of correlation coefficients (r_{jl}):

$$r_{jl} = \frac{\sum_{i=1}^{m} p_i x_{ij} \times x_{il} - \bar{x}_j \bar{x}_l}{\sigma_j \sigma_l}$$

where:

x_{ij}; x_{il} = correlated characteristics by pairs of variables;

$\bar{x}_j$; $\bar{x}_l$ = mean of correlated characteristics by pairs of variables;

σ_j; σ_l = mean square deviations of correlated characteristics;

— formulating the matrix of the correlation coefficients:

$$R = \begin{bmatrix} 1 & r_{12} & r_{13} & \dots & r_{1n} \\ r_{21} & 1 & r_{23} & \dots & r_{2n} \\ r_{31} & r_{32} & 1 & \dots & r_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & r_{m3} & \dots & 1 \end{bmatrix}$$

The formulation of the mathematical model of the correlational connections in the structure of the migration process makes the following computations imperative:

— computation of the standardized coefficients, (a_j), of the regression equations, based on the system of equations

$$\begin{aligned} r_{1y} &= a_1 + a_2 r_{12} + a_3 r_{13} + \dots + a_n r_{1n}, \\ r_{2y} &= a_1 r_{21} + a_2 + a_3 r_{23} + \dots + a_n r_{2n}, \\ r_{3y} &= a_1 r_{31} + a_2 r_{32} + a_3 + \dots + a_n r_{3n}, \\ &\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ r_{ny} &= a_1 r_{n1} + a_2 r_{n2} + a_3 r_{n3} + \dots + a_n; \end{aligned}$$

— computation of the regression coefficients k_j and k_0 by means of the formulae

$$k_j = \frac{a_j \sigma_y}{\sigma_j}; \quad k_0 = \bar{y} - \sum_{j=1}^{n} k_j x_j,$$

where

$$j = 1, 2, \dots, n$$

— computation of the multiple correlation coefficient, (R_y), by means of the formula

$$R_y = \sqrt{r_{1y}^2 + r_{2y}^2 + r_{3y}^2 + \dots + r_{ny}^2}$$

— formulation proper of the mathematical model in the form of a linear regression equation:

$$y = k_0 + k_1 x_1 + k_2 x_2 + k_3 x_3 + \dots + k_n x_n$$

where:

y = migration coefficient of population in the framework of the administrative zone (in the equation y is a dependent variable);

x_j = level of mean characteristics (in the equation, x_j are independent variables bearing an effect on the dependent variable y);

k_j = regression coefficients (parameters of the mathematical model).

BASIC ELEMENTS OF THE MATHEMATICAL MODEL

The mathematical model of the population's interzone migration is based on statistical data referring to the 16 regions existing before the improvement brought to the administrative-territorial organization in 1968. Based on these data, it was reckoned that the variation of the correlation coefficients showed the intensity of the socio-economic processes taking place in these administrative-territorial zones of Romania *.

The socio-economic indicators (computed for each territorial-administrative unit) used as $x_j (j = 1, 2, ..., 12)$ variables in the linear regression equation of migration are:

x_1 — degree of urbanizing

x_2 — value of fixed capital investments in industry, per inhabitant;

x_3 — value of fixed capital investments in agriculture, per inhabitant

x_4 — value of investments, per inhabitant

x_5 — agricultural surface, per inhabitant

x_6 — gross industrial output, per inhabitant

x_7 — gross agricultural output, per inhabitant

x_8 — proportion of wage earners from total number of inhabitants of the administrative-territorial region

x_9 — proportion of workers from total number of inhabitants of the administrative-territorial zone

x_{10} — amount of retail sales of goods through socialist trade, per inhabitant

x_{11} — amount of expenses for socio-cultural purposes, per inhabitant

x_{12} — natural increase of population.

The migration coefficient (y_i) was computed for each administrative-territorial zone in part, by means of the formula:

$$y_i = \frac{N_i - N_0 - n + d}{N_i}$$

where:

N_i — population in the current year

N_0 — population in the previous year

n — births

d — deaths

---

* The parameters determined on the basis of the statistical data obtained by regions may only be used, as order of size, at the level of the counties.

The migration coefficient computed by means of this formula may have a positive or a negative sign, according as the population in the zone considered undergoes a process of immigration (+) or of emigration (—).

The level of the indicators x_i and y_i was established for 1966 on the basis of the statistical data concerning the 16 regions. These data were used in the computations made to determine the parameters of the model (regression coefficients).

ANALYSIS OF INFORMATION SUPPLIED BY MODEL

The quantitative analysis of the multiple correlations entails the quantification of the special processes (economic, demographical, social and cultural) which bear an influence on the interzone migration process of the population.

The correlational connections among the variables which characterize the socio-economic migration process, can be analyzed by means of the correlation coefficient matrix r_{jl} (Fig. 1) of the table of connections (associations) (Fig. 2) and of the graph of correlational connections (Fig. 3).

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	y
x_1		0.43	0.19	0.44	-0.19	0.64	-0.08	0.95	0.93	0.83	0.78	-0.63	0.73
x_2			-0.30	0.22	-0.31	0.75	-0.36	0.40	0.50	0.23	0.04	-0.05	-0.04
x_3				0.46	0.68	-0.13	0.87	0.36	0.36	0.33	0.14	-0.44	0.69
x_4					-0.13	0.32	0.18	0.52	0.49	0.37	0.45	-0.48	0.62
x_5						-0.33	0.77	-0.08	0	-0.11	-0.39	-0.16	0.11
x_6							-0.26	0.82	0.85	0.64	0.52	-0.36	0.47
x_7								0.12	0.15	0.12	-0.14	-0.24	0.48
x_8									0.98	0.86	0.77	-0.69	0.86
x_9										0.84	0.66	-0.67	0.79
x_{10}											0.76	-0.46	0.77
x_{11}												-0.56	0.75
x_{12}													-0.64
y													

Fig. 1. Matrix of the r_{jl} correlation coefficients

The matrix of the correlation coefficients r_{jl} (Fig. 1) supplies information on the intensity of the correlation connections existing among the variables. The intensity of these connections is expressed by the correlation coefficient, which may vary in absolute value between the limits:

$$0 \leqslant r_{jl} \leqslant 1$$

The absolute values of the correlation coefficient comprised between 0 and 1 reflect a wide range of correlational connections which are distinguished according to their intensity. Since the correlation coefficient r_{jl} reflects the degree of strength of the correlational connection existing between the variables x_j and x_l, we distinguish the following categories of connections:

— $0.01 \leqslant r_{jl} \leqslant 0.10$ (of very weak intensity);
— $0.11 \leqslant r_{jl} \leqslant 0.30$ (of weak intensity);
— $0.31 \leqslant r_{jl} \leqslant 0.70$ (of mild intensity);
— $0.71 \leqslant r_{jl} \leqslant 0.90$ (of strong intensity);
— $0.91 \leqslant r_{jl} \leqslant 1.00$ (of very strong intensity).

Using this grouping of the correlational connections in view of interpreting the correlation matrix we shall obtain the table of connections (associations) in Fig. 2.

In the boxes of the table of connections the negative sign of the correlation coefficients makes reverse correlations stand out, i.e. the relations inversely proportional to the variation of the correlated characteristics. The other connections make the direct correlations stand out, i.e. the relations directly proportional to the variation of the correlated characteristics.

Studying the data in this table, the degree of strength of the correlational connections existing among the variables examined can be made to stand out more suggestively by a graph or by a network graph (Fig. 3).

The analysis of the graph shows the existence of essential correlational connections between the following indicators: degree of urbanizing and proportion of workers and wage-earners in total population; degree of urbanizing and amount of goods sales; degree of urbanizing and expenses for socio-cultural purposes; equipment of industry and industrial production; equipment of agriculture and agricultural output; agricultural area and agricultural output; proportion of wage-earners and workers in total population and amount of goods sales, and so on.

Concomitantly, non-significant correlational connections appear among the following indicators: equipment of industry and endowment of agriculture; equipment of industry at a given moment and yearly volume of investments made; equipment of industry and amount of goods sales; equipment of industry and expenses for socio-cultural purposes, and so on.

To solve the mathematical model, a program was elaborated for a small computer, the computation of the arithmetical weighted mean being carried out on the basis of this program, as well as the computation of the mean square

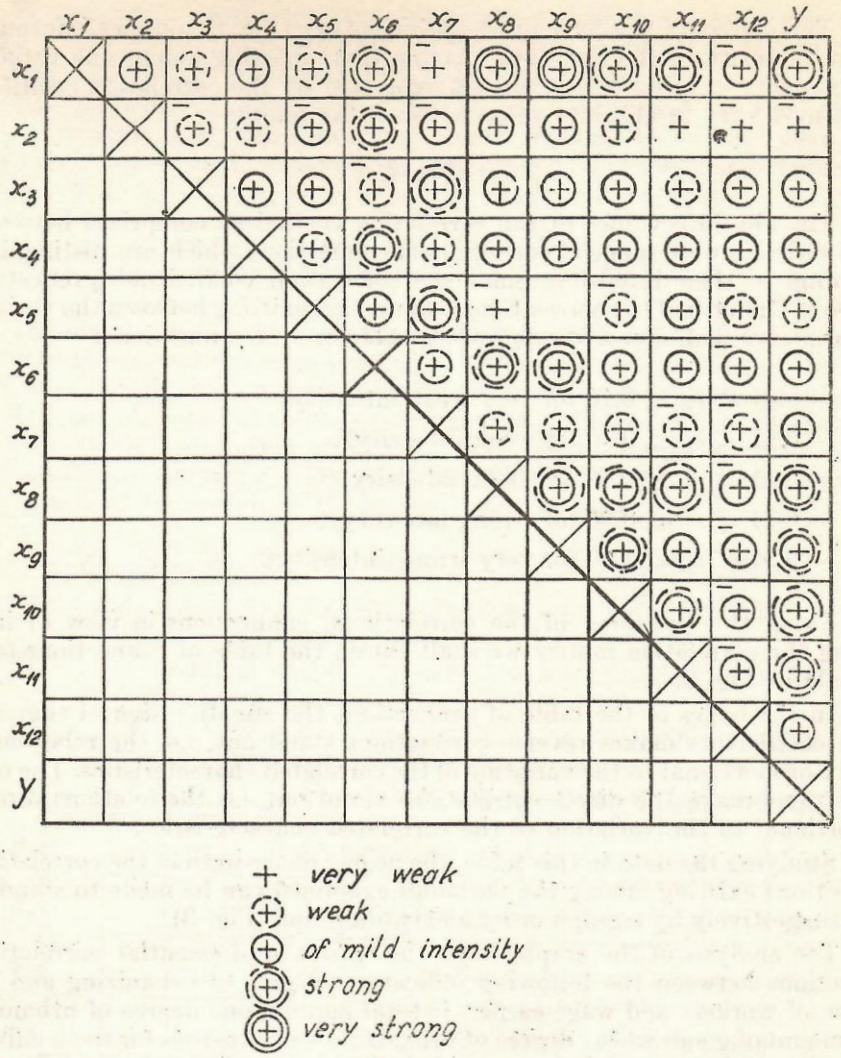


Fig. 2. Table of connections (associations)

deviations, that of the correlation coefficients between pairs of indicators, the solving of the system of equations, the computation of the regression coefficients, and the computation of the correlation coefficients.

★

Under the present existence of a relatively high level of interzone population migration in the territory of Romania, the necessity appears to know as accurately as possible its prospective evolution in order to be able

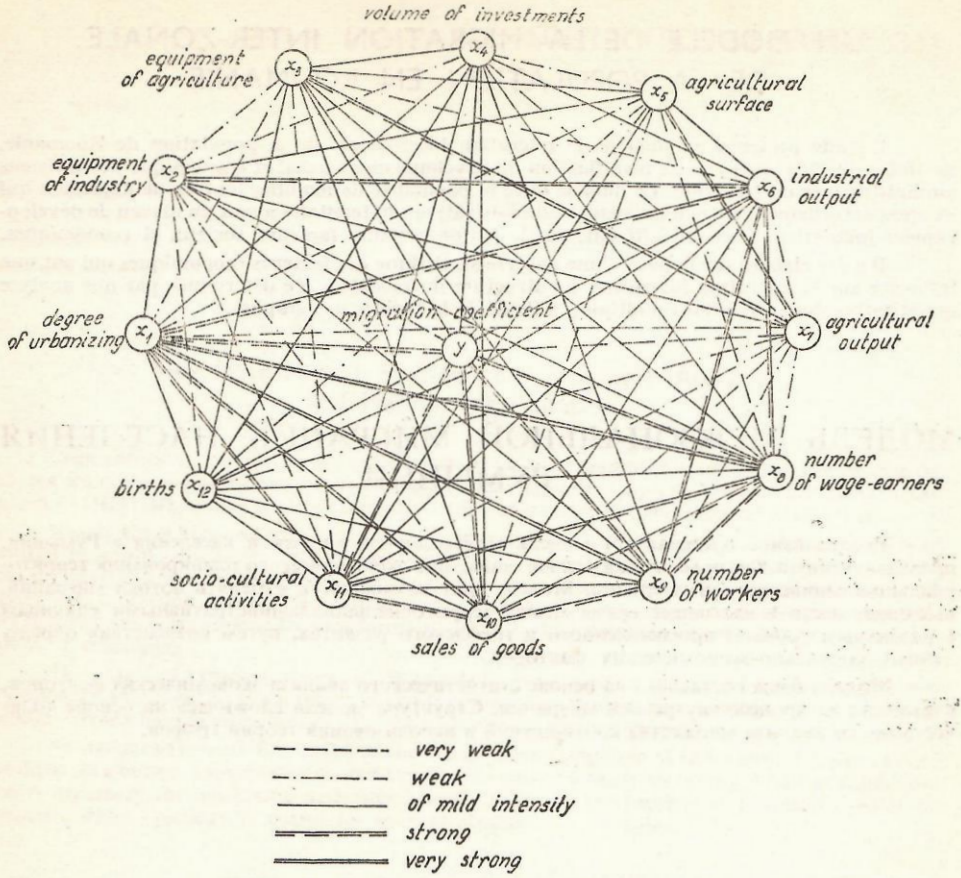


Fig. 3. Graph of connections (associations)

to take it into account in the planning activity and particularly in determining future tasks in a territorial aspect.

The possibilities of planning and controlling the process of interzone population migration are derived from the fact that they represent a process of "compensating", of "balancing", between the level and the distribution of the productive forces and the distribution of the population on the national territory. Due to this fact, the changes forecast in the territorial distribution of the production forces may determine the appearance of migratory flows of manpower, flows which, in turn, modify the geographical distribution of population as well as its structure by age and sex in the territorial-administrative units. This explains why, when substantiating the figures in the plan concerning the prospective development of investments, of industrial and agricultural production, etc., it is necessary to take into account in each territorial-administrative unit the level and intensity of population migration. Concomitantly, the elaboration of several plan variants providing for a different level of migration depending on the socio-economic development which the respective zone may acquire, is imperative.

UN MODELE DE LA MIGRATION INTER-ZONALE DE LA POPULATION EN ROUMANIE

L'étude présente un modèle de migration inter-zonale de la population de Roumanie, destiné à des fins pratiques de planification du développement social et économique des divisions administratives du territoire. Ce modèle offre la possibilité de modifier les flux de migration qui existent actuellement entre les divisions administratives du territoire ayant un niveau de développement industriel et urbain différent, par le jeu de certains facteurs sociaux et économiques.

Il a été élaboré sur la base d'une analyse statistique des facteurs économiques qui ont une influence sur la migration intérieure. La structure du modèle a été déterminée par une analyse quantitative des corrélations multiples, à l'aide de la théorie des graphes.

МОДЕЛЬ МЕЖЗОНАЛЬНОЙ МИГРАЦИИ НАСЕЛЕНИЯ В РУМЫНИИ

Исследование представляет модель межзональной миграции населения в Румынии, предназначенную для практических целей социально-экономического планирования территориально-административных единиц. Модель дает возможность изменять потоки миграции, имеющей место в настоящее время между территориально-административными единицам с различным уровнем промышленного и городского развития, путем воздействия определенных социально-экономических факторов.

Модель была составлена на основе статистического анализа экономических факторов, влияющих на процесс внутренней миграции. Структура модели сложилась на основе количественного анализа множества соотношений и использования теории графов.