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The Cybernetic Model of Manpower

The general policy of our party, the building of the manysidedly developed socialist society has as a supreme aim the continous raising of the material and spiritual welfare of our whole prople, the increasing of the degree of civilization of the entire society life.

1. Although the population pre-eminently offers the characteristics of a system, the systemic interpretation in demography is of relatively recent date. In exchange, a number of other methods and techniques had earlier been applied in demography, being successively borrowed by other sciences too, within that fruitful exchange of methods so very characteristic of contemporary science.

The population has the characteristics of a system with a high level of integration when it is conceived especially as a national population; the world population being also a system is, however, characterized by a more reduced integration. In the following, we shall refer to the national population and to the national active population, generally, considered as the equivalent to manpower.*

The population can be conceived as a closed system; in this case, its condition at a given moment (P_t) is defined by a number and a structure noted with Σ; the inputs are given by the number of births in a conventionally agreed period of a year (N) and the outputs, in the same period of time, are given by the number of deaths (M). In these conditions, the status of the population in the next moment is determined by its natural movement:

$$P_{t+1} = P_t \pm (N - M).$$

Simultaneously with the number of the population, its structure is also changed. In the systemic concept the population has several structures, combined in keeping with several characteristics: age, sex, legal status, place of residence (urban and rural population), occupation and activity (active and inactive population), etc. All these structures can be conceived as subsytems. There are interactions and interdependences as well as "feedback" relations between the popultion as a system, with a certain degree of integration and

* There are differences between "the active population" and "manpower" or the "population employed". We use the first term for its generality.

the various "subpopulations" as subsystems. Each subsystem may be in relation with other systems, such as is the typical case of the active population. The school-aged population has relations with the "educational system"; the entire population is in relation with the "health system", the work-aged population is connected with the "economic system", namely with the work places, etc. A multitude of reciprocal and interdependent relations is thus formed whose description always requires multidisciplinary efforts.

The population may, however, be conceived as an open system; in this case, the inputs are given by births (N) and immigrations (I) and the outputs are the deaths (M) and emigrations (E). The successive conditions of the population are thus determined by two inputs and outputs:

$$P_{t+1} = P_t \pm (N - M) \pm (I - E).$$

While the inputs through immigrations are inputs from outside the system, the outputs through births are always from inside the system, since the number of births depends on a subpopulation (the female population of a fertile age, conventionally of 15—49 years of age) and on fertility specific of the groups of the fertile population:

$$N = \sum_{i=15}^{49} P_i^F f_i$$

Schematically, the population as a system can be represented as follows:

A "subpopulation" of the type of a county or town population is always determined by the two inputs and the two outputs; the internal migration

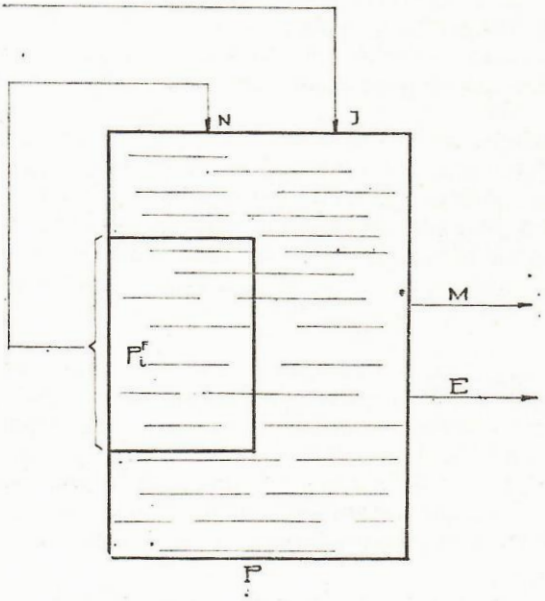


Fig. 1

(space or territorial mobility) is playing an important part in changing the number and structure of the total population of a territorial-administrative unit.

Consequently, the national population or of a territorial-administrative unit is a "demographic system" which is described as follows [1]:

Table 1

Characteristics and processes of a demographic system

Characteristics of elements	Processes of elements	Characteristics of elements	Processes of element
Person	Birth, deaths and migration	Characteristic of the Size of the population (P)	Growth: increase by natality (N) and immigration (I) and losses by deaths (M) and emmigration (E)
Age	Ageing (change in age)	Structure on age (Σ_v)	Redistribution of the population according to age
Sex	—	Structure on sex (Σ_s)	Redistribution of the population according to sex
Place of residence	Internal migration	Distribution of the population according to residence (urban and rural population)	Redistribution of the population according to place of residence

The population cannot be defined only as a demographic system reduced to events, such as: birth, deaths, change in the place of residence. The status of the population is determined by a big number of characteristics: health, education, social, economic, etc. which leads to the setting up of as many subsystems of the population connected, this time, with systems outside the population. In the first case, by demographic system we mean the population reduced to its specificity as a system determined by demographic variables and consequently forming the object of demography proper (of formal or pure demography); in the second case, the subpopulations constituted in keeping with social, economic characteristics become the object of interdisciplinary sciences: social demography, economic demography, geographical demography, etc.

For example, economic demography might be the intersection between two systems: the economy and the population, according to the diagram.

The active population (P_a) in relation to the total population (P), as a demographic system, is its subsystem: $P_a \varepsilon P$ Consequently, the active population is subject to the demographic determinations: it is dependent on the number and demographic structure of the total population:

$$P_a = f(P;\Sigma);$$

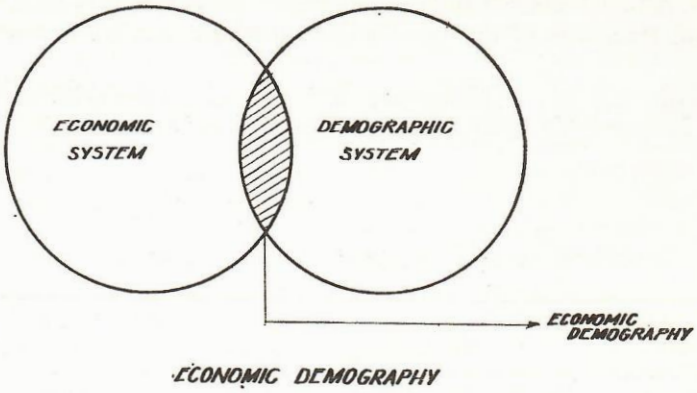


Fig. 2

on the other hand, being in relation to the „economic system", the active population is dependent on it through values called activity rates (i_a) showing the proportion in which the population of a given age participates in the economic activity. For example, the rate of general activity of the population of Romania in the 1966 census was of 54.2%.

Consequently, the following relation is established:

$$P_a = f(P; \Sigma; i_a).$$

showing the belonging to two systems: population (P; Σ) and economy (i_a).

The activity rates are also dependent on the degree of development of the national economy, on the existence and characteristic of the work places, on tradition, cultural assets, etc. The activity rate also depends on age: entry into the activity, ending the activity, participation in the activity according to age. The conditioning of the "active population" subsystem on the two (demographic and economic) systems can be represented as follows: Fig. 3

The active population changes its status due to the inputs and outputs mainly as an age function: the entry into the active population from the inactive population and the definitive going out from the active population (by deaths) and the passing into the inactive population (pensioning). The active population (P_a) and the productive fixed assets (F) are the two production factors from whose combination in "the economic system" (E) as an operator, the national income (VN) results, distributed into consumption fund (C) and accumulation fund (A). The process and relations may be described by the production functions of a Cobb-Douglas type, in the most general way.

In this way, the active population can be conceived as a system, having the respective characteristics [1].

This systemic representation of the total population and of the active population generates a number of methodological consequences aiming at their description, analysis and prognosis.

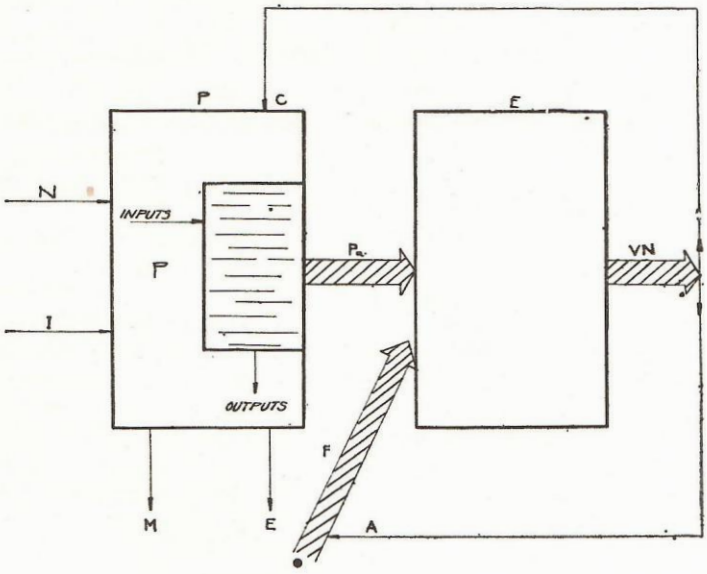


Fig. 3

Table 2

Characteristics and processes of the active population system as an aggregate social system.

Characteristics of elements	Processes of elements	Characteristics of the system	Processes of the system
Person	Inputs and outputs	Size of the active population (P_a)	Growth (inputs minus outputs)
Age	Ageing	Structure on age (Σ_v)	Redistribution of the active population according to age
Sex	—	Structure on sex (Σ_s)	Redistribution of the population according to sex
Occupation	Occupational mobility	Occupational structure	Redistribution of the active population according to occupation

3. The point in question being about conditions and transitions, their description is made with the aid of the Markov chains. For the total population, such a description is made after the following formula [2]:

$$V \times M,$$

where V — the initial number of the population distributed on years of age (0 ... 100 years) (vector);

M — the matrix representing the fertility and mortality factors.

In detail, this matrix consists of the following:

a) on the upper line, the fertility factors according to age from the left to the right, as age function (the age from O to 14 being excluded);

b) on the second line, the survival probability at O years of age (p_0), followed by a series of zero-es;

c) on the third line, the first column 0, then the survival probability for the second year (p_1), followed by a number of zero-s.

d) on the fourth line, 0, p_2, 0_2,...0

In this matricial representation, the demographic projection can be made after the morphological method (of the components). This method has started being applied during the last few years, with the aid of the computer, for a longer period of time, which enables to measure the rate of growth in the limit condition and to identify the asymptomic tendency (Nathan Keyfitz, Ansley J. Coale, etc.). Consequently, the indispensable methodological element is the mortality table, a classical instrument in demography and the probabilities of growth from an age to another, expressed through the matrix of these probabilities.

The active population is a more complicated case. First, its belonging to two systems requires a special instrument which is the activity table, as a combination between the mortality table and the activity rates, which, in fact, is a combination of the classical biometrical functions with the economic functions [3, 4]. Thus, the stationary active population, the active survivors, the probabilities of entering the active population and the probabilities of coming out of the active population, the expectation of active life at various ages, the indices of replacing the active population (an index of the potential of the active population growth similar to that of P. Vincent for the total population) and the relation of replacement are obtained in succession. The application of this method to the population of Romania on the basis of the 1966 census has yielded significant results [5].

Unfortunately, the calculus was made only for the male active population in 1966. *)

On the other hand, within a national active population, the inputs may be given not only by persons coming from the inactive population but also from the rural population. This has led to a much more complex matricial representation [6], including: probabilities of entering the active population, probabilities of withdrawing from the active population, probabilities of

* Two diploma papers at the state examination at the Faculty of Economic Computation and Economic Cybernetics (Fl. Micu-Suciu and V. Socoleanu) worked out such activity tables for the female population in 1966 and for the male and female population at the 1956 census.

migration, probabilities of survival and, of course, probabilities of birth, since both the active and inactive population forms the total population whose inputs (as a closed system) are given by births.

4. The systemic interpretation of the total population and of the active population requires not only the use of the mortality table as a fundamental mathematical model for the renewing processes, but also the establishment of some observations of a longitudinal type [7]. The registering of the successive conditions with the aid of this method which has also become classical in demography allows the successive calculus of the probabilities of deaths (decreasing) and of survival, of input or output as well as the calculation of values of the main tendency of the type of total or active life expectation at various ages.

5. In its turn, the longitudinal survey in the context of the systemic approach to the population is connected with the new idea of demographic accounts and social accounting, in general [8]. In fact, the life of a person from birth to death (from 0 to ω) may be decomposed into sequences marked by demographic, educational, economic and other events whose mass can be statistically processed in the form of transitions: from an age to another, of entering education of a certain degree, of entering the active population, of marriage, of going out of the active population, of decease. Such social accounts based on the registering of all main sequences would ensure the relations between the population, as a system, the subpopulations as subsystems and all other systems: education, health, economy, etc. The setting up of permanent registers of the population — a desideratum which is fully justified today — would considerably facilitate the implementation of such accounts and of the matrical representation of the passing to various conditions.

6. Two domains would particularly benefit by the systemic interpretation of the active population: economic demography and demographic projections. More exactly, the activity table and the related functions would allow the application of the methods of potential demography [9]. It would be of great use to build the production and consumption function by taking into consideration age. For example, the level of the national income as a function of age. An experimental application has shown the utility of this method [5], revealing the economic implications of structure indices on age of the population, such as demographic ageing. Economic pyramids could also be built according to age and, consequently, one would come to the grouping of production and consumption according to age.

As regards demographic projections, the most recent literature [3] attests to the penetration of matricial methods in the modern methodology of demographic prognosis. Generally, the new afore-mentioned methodology have started being consistently applied during the last few years in demographic description and analysis [10, 11].

The effort to renew the methods of analysis of the active population, of its various subpopulations (active urban and rural population, employed population, active industrial, agricultural population, etc.) as well as the changes affecting them must, in our opinion, go on the line of the deepening of the systemic outlook, the widescale application of methods and techniques, such as the activity table and the active stationary population, longitudinal

analysis, matricial description, demographic accounts, potential demography and demographic, morphological and normative projections in modern variants. The profit ensured by the analysis and planning of this important productive force which is labour is beyond any doubt. Obviously, marked interdisciplinary efforts are necessary for the implementation of these important objectives.

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LE MODELE CYBERNETIQUE DE LA FORCE DE TRAVAIL

On essaye pour la première fois de représenter la force de travail sous forme de système comportant des entrées et des sorties, des flux et des états, ainsi que leur interdépendance. Le système cybernétique de la force de travail est conçu en tant que sous-système de la population et se trouve intégré comme tel dans un système de variables démographiques, sociales et économiques.

Dans ces conditions, le modèle est celui de la population active, dont les entrées et les sorties sont décrites par les probabilités d'entrée et de sortie de la population active, associées à un modèle de tableau de mortalité. Finalement on obtient la population active stationnaire ayant des fonctions biométriques, telles que l'espérance de vie active à l'âge de x ans, la courbe d'activité basée sur les probabilités respectives. De la sorte la voie est frayée à un nouveau chapitre de la démographie économique par l'application de l'interprétation systémique et probabiliste de la force de travail.

КИБЕРНЕТИЧЕСКАЯ МОДЕЛЬ РАБОЧЕЙ СИЛЫ

Впервые делается попытка системного представления рабочей силы с соответствующими увеличениями и уменьшениями, состояниями и потоками, а также их взаимозависимости. Кибернетическая система рабочей силы разработана как подсистема населения и, как таковая, входит в систему демографических, социальных и экономических переменных.

В этих условиях модель относится к активному населению, увеличения и уменьшения численности которого выражаются вероятностями увеличения и уменьшения численности активного населения вместе с моделью таблицы смертности, в результате чего в конечном итоге получается численность стационарного активного населения с биометрическими функциями, а также продолжительность активной жизни в возрасте X лет, кривая активности на основе соответствующих вероятностей. Таким образом, открывается перспектива нового раздела экономической демографии путем применения системного и вероятностного толкования рабочей силы.

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