System approach in demography

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I would like to discuss in my paper an approach to an analysis of demographic phenomena based on certain ideas of cybernetics and the general systems theory. My purpose is not to propose more perfect methods of calculation or something of this kind, but to outline a certain framework for a theoretical consideration of the demographic reality. I hope this approach will be useful to demographers because it may help them to avoid an oversimplification , rather widespread now, in the interpretation of demographic tendencies.

For example, one may, as often happens, consider the level of fetility and its evolution as a function of factors such as wellbeing, nutritition of the population or environmental pollution. These factors do affect fertility, it is true, but their influence is far from being decisive. We know that demographic behaviour sometimes contradicts the common sense of demographers. They expect , for instance, the improvement of welbeing or nutrition to cause a rise in the fertility level , but in reality it is quite opposite.

It is my opinion that we should not confine ourselves to studying the influence of social, economic and other external factors on the demographic process. To make our vision of these processes wider and deeper , we may use certain systems ideas elaborated in biology, economics, etc, and apply these ideas to our purposes. We may consider the demographic subsystem of society as a certain entity, as a relativly independent object with its stable internal environment and combine the principle of causality in the explanation of demographic processes with the notions of its self-organization and goal-directedness.

What is a demographic system? I emphasize that the word " demographic " in this context concerns only the processes of human reproduction, of replacement generations. The word " population" also refers to an aggregate of people taken only with respect to their participation in the process of human reproduction. I propose to interpret " population" in this sense as a " demographic system ", that is, as a multitude of elements (people) $\vec{a}_i$ linked by the previously given relations $\vec{D}_j$ with its fixed properties.

These real relations, concerning the creation and preservation of human life - we shall call them "demographic relations" - are part of the whole social relations. They exist side by side other specific social relations as, for example, economic ones $\vec{E}_j$. The principal properties of demographic relations are predetermined by their social function which is to ensure the continuous prolongation of the human species. The fixation of demographic relations and of their properties is a result of a long historic development. Millenial experience makes it possible to select the most viable forms of relations and to fix them. The demographic relations and corresponding norms of behaviour are already formed when we are borne. We adopt these norms during the process of socialization as something immutable, that governs our demographic behaviour throughou our life.

So a demographic system consists of people and demographic relations $S_D = \{\vec{a}_i; \vec{D}_j\}$, just as an economic system for example consists of the same people but connected by the economic relations $S_E = \{\vec{a}_i; \vec{E}_j\}$.

How does this system function ? The reproduction of generations is a result of a mass of individual demographic events. We may distinguish several kinds of demographic results or demographic outcomes of an individual human life (I_k) (k is the ordinal (No of outcomes) : procreative outcomes I_k^P (number of births during the time of an individual life); vital outcomes I_k^V (individual lifetime); reproductive outcomes I_k^R (number of children surviving till the average age of parents). As usual in demography , we shall consider only the female population. The process of the demographic formation of outcomes could be called the functioning of the demographic system. Commonly used demographic measures - for example , life table functions or synthetic indices as gross-or net reproduction rates, intrinsic rate of natural increase , etc, could be considered as the indices of the functioning regime of the demographic system.

A demographic system is a stochastic one. Only one outcome of a particular kind is possible in an individual lifetime, But in the population as a whole a set of biologically possible outcomes can be realised. What matters is that the probabilities of the emergence of this or that outcome, i.e. the values of $p(I_k^P)$, $p(I_k^V)$, $p(I_k^R)$ may vary. Despite the fact that the potential variety of outcomes is rather great, as a rule they do not arise with equal probability. The unequal probabilities of various outcomes show that certain contraints exist and that the functioning of a demographic system is regulated. Entropy (of the set of probabilities) can serve as a measure of this regulation.

$$H = -\sum_k p(I_k) \log_2 p(I_k).$$

Let us assume, for example, that each woman in a certain population can give birth from 1 to 12 children or give

birth to nobody. Thus there are 13 possible outcomes I_k^P ($k = 0,1,2 \ldots 12$) Let us examine three different situations, shown in the table:

1) all outcomes are equiprobable;

2) the most probable is the birth of 3,4,5 and 6 children which corresponds to the situation of high fertility;

3) the most probable is the birth of 1,2 or 3 children which corresponds to the situation of low fertility.

Situation No 1 is characterized by maximum entropy (3,7 bits) and consequently by maximum uncertainity, irregularity of the procreative behaviour of people. But it is an artificial, unreal situation.

On the contrary, situations No2 and No 3 are quite realistic. Entropy is considerably lower in situation No2 (3,26 bits) and especially in situation No3 (2,64 bits). It means that the outcomes are subject to contraints, the functioning of the system is regulated. This regulation, the absence of equiprobability of emergence of demographic outcomes indicate the existence of control which diminishes the entropy of the system and thus ensures its survival, maintains its qualitative definiteness and the fulfilment of its function. The object of control is the individual demographic (in our case - procreative) behaviour. But what is the subject of control? Where does it originate?

Economic, demographic and other similar systems could be considered as functional subsystems of a more complicated supersystem namely : society (S):

$$S_E \subset S; \quad S_D \subset S; \ldots$$

All these systems, including the system in question, are open ones. The demographic subsystem of society permanently

exchanges its matter, energy and information with the supersystem and with other subsystems, for example , with the economic one. Therefore all these subsystems , as well as the supersystem constitute the external environment of the demographic system. To be sure the changes taking place in this external environment affect the state and behaviour of the demographic system. But usually the reactions of the system are considerably weaker than the fluctuations of the environment, and in most cases they are reversible. The system always tends to return to the equilibrium upset by external influences. Even if the changes in external conditions are stable , irreversible and the system must adapt iself to new conditions, its reactions often lag behind, and for a certain period it continues to live according to its own laws.

The weak dependence of the functioning of a demographic system upon external influences , as mentionned above, indicates that the system has an internal environment and is capable of homeostasis that is , of maintaining the permanence and the stability of the internal environment even if there are disturbancies in the external one. Of course , this capability maintains itsel only when the external changes do not go beyond certain boundaries - the limits of the homeostasis.

The internal environment of a demographic system consists of demographic relations and socio-cultural structures which these relations generate ; institutions, norms, patterns or rules of behaviour, values, moral attitudes, etc, which exert a direct influence on human demographic behaviour.

Thus the system itself is first of all the subject of a control due to the existence of the internal environment, possessing emergen

properties. These properties originate from the vital activity of the system as a whole , which cannot be reduced to the properties of the components of the system. They manifest themselves in the presence of a feedback mechanism which reduces the probabilities of certain forms of individual demographic behaviour does not permit a system to approach the limits of homeostasis. Then the control of the functioning of the demographic system is above all self-control, , self-regulation.

Individual properties and peculiarities of the internal environment of a demographic system are a consequence of its long interaction with the slightly changing external environment, their mutual adaptation. With some idealization of the situation we may say that the demographic system is usually in a state of internal equilibrium, as well as in a state of equilibrium with its external environment. But in reality we may only speak of a relative equilibrium. Even to maintain this relative equilibrium, great social energy is required to neutralize the permanent contradictions in the inside of the system as well as between the system and its internal environment. These contradictions are the origin of changes in the conditions of maintenance of the equilibrium. The changes accumulate gradually and sooner or later , they require a fundamental transformation of the interaction between the system and its external environment as well as a fundamental modifications of the internal structure of the system. The limits of homeostasis move and new functioning regimes of the system become possible and necessary.

The process which includes the functioning of the demographic system , the accumulation of minor quantitative changes and the following transition towards new, usually higher quality of functioning may be called the development of demographic system.

Such a development is a consequence of the development of society as a whole and at the same time one of its premises. For example , the modern demographic revolution is a consequence of deep socio-economic , cultural and other changes which constitut the principal content of modern history. At the same time the demographic revolution itself contributed profoundly to these changes. Thanks to its ability for self-organization , the demographic system is not destroyed , and does not lose its qualitative definiteness even under very profound irreversible changes in the social life. The elements of its inner structure and the means of their arrangement can maintain themselves when the external environment is relatively steady and adapt themselves to the changes in the external environment when these changes are significant. The term " self-organization " has a broader meaning than " self-regulation" as it can be applied to the description of both the functioning and the development of the system. It indicates the objective character of the processes in the demographic system and at the same time emphasizes that we consider not the simple reactions to external influences but the neutralization or forestalling of these influences by means of the feedback mechanismes within the system.

The idea of self-organization of the system cannot be separated from the idea of its goal-directendness. In the process

of self-organization , the system tends to some terminal state which may be interpreted as a goal of the system. This goal is objective and stems from the functions of the system and the means of their fulfilment. In the case of a complex developing system, it is often impossible to formulate only one goal. That is why in biocybernetics, for example, one uses the concept of several goals of biosystems and their hierarchy. This concept can be useful for studying a demographic system. The most important goal of this system as well as of any other complex system is survival self-maintenance. The system in its behaviour tends to avoid the regimes of functioning which threaten its existence and lead to depopulation. This goal is characteristic of all biological, self reproducing populations and, as a rule, this goal is reached. However, if a population contents itself with survival at " any coast" ,as in the animal world on the earlier stages of evolution, and if its reproduction is not subjected to any supplementary restrictions, the efficiency of reproduction process is very low because of its strong dependence on external stresses.

But even during the biological evolution the reproduction of populations becomes more and more independent of external stresses. It is well known that living organisms with a short life-span and a high fecundity are much more sensitive to short-term fluctuations of the external environment. Their number increases or decreases hundred and even thousand fold in several days. At the same time, the population having a longer life span and lower fecundity are relatively insensitive to changing environemental conditions due to their ability for homeostasis.

In other words, at a certain stage of biological evolution beside the goal of population survival , a new and higher goal appears, ~~i.e.~~ , that of maintaining homeostasis of the population's reproduction even under considerable fluctuations in external conditions. The attainment of this goal substantially contributes to the improvement of the quality of the reproductive process and enables to fulfill a greater number of tasks related to the vital activity of a species.

By their nature homeostatic mechanisms are oriented towards the maintenance of already established relations (particulary relations between the population and the environment) and of the stability of the system's functioning processes. But the biological and especially social systems are subject to continuous directed changes, ~~i.e.~~ that is to the processes of development. A general line can be observed in these changes: improvement in the quality of functioning of biological and later social systems. In particular we may speak about the historical trend of the improvement of the quality of functioning of the demographic system. That is why we must indicate the third level of a system's goals. The survival and the homeostasis remain as goals but a higher rank goal appears , which includes the two former ones and overlaps them. This goal is improvement of the quality of functioning.

What do we mean by quality of functioning? This notion makes it possible to compare the regimes of functioning, to evaluate which of them are "better" and which are " worse", which are more advantageous or less advantageous from the standpoint of wider tasks which society as a whole faces. Generally speaking,

the problem of the evaluation of the quality of functioning of complex systems -biological or social - can hardly be considered as already solved. With respect to the demographic process, such intuitively comprehensible (but which it is not always possible to formalize) characteristics of its quality as the ability to ensure the necessary result, stability , controlableness, efficiency may be used. For example, the efficiency may be measured by the relation of the gross reproduction rate to the net reproduction rate, that is by the average number of girls to be born per woman to ensure a simple replacement of maternal generation. We know that this relation (which can be called "a cost of simple replacement"), has lowered significantly during last one or two handred years. One may interpret it as improvement of quality of functioning. But in the cases of other characteristics the measuring is more difficult.

A more general definition of the quality of functioning may be proposed if we relate its criteria to the place occupied by the demographic activity in the overall activity of the supersystem, that is to say the whole social system . The more localized the demographic activity and the more, as a consequence , the universal potential of society , the higher the quality of the demographic processes (provided, of course , we keep the same results in terms of the replacement of generations).

In spite of the seeming abstractions of our considerations , they can be very useful for the theoretical understanding of real processes. Let us take , for example, such an important process as the <u>modern demographic revolution</u>. This revolution is the turning point of the development, the transition of a demographic system from one qualitative state to another. The quality of functioning rises rapidly, its regimes become much steadier than before the transition. The proportion of time, forces and energy spend by every family and by society as a whole for the

process of human reproduction is reduced considerably.

The demographic revolution proceeds under the influence of profound socio-economic , cultural and other historical changes. These changes induce a sharp decrease of mortality , which upset the demographic equilibrium maintained for a very long time. It requires a transition towards a new type of equilibrium , an inner transformation of the demographic system as well as changes of interactions between the demographic and other social subsystems.

The changes of economic , social and other relations which modify the external environment of the demographic system, affect of course, its transformation from the traditional to a modern state, ~~the so called~~ " demographic transition" or " demographic revolution". This kind of influences is well-known. The mechanism of transformation of the internal environment of the demographic system is not less important, but it attracts much lesser attention on the part of the demographers.

Let us remember that the internal environment of a demographic system consists of demographic relations and corresponding socio-cultural structures. These relations and structures evolve in such a way that they are usually adequate to the conditions of human demographic being. The prinipal force of this evolution is selection. Of course, I do not mean the selection of human beings. It is a socio-cultural selection. Its object is the relations and corresponding norms , patterns, values, etc. which puts limits to socially acceptable demographic behaviour.

The idea of selection as the main mechanism of self-organization and self-development of complex systems was formulated in biology in the frame-work of Darwin's evolution theory. However this mechanism is now often seen as universal, acting at both — prebiological and postbiological (that is to say social) levels of development.

In nature, as well as in society, selection has two principal functions: moving and stabilizing. If the demographic relations and corresponding socio-cultural structures are adapted to the objective conditions of demographic being and these conditions are steady or change very slowly , then selection obstructs socio-cultural innovations , is aimed at maintaining demographic status quo during long periods of human history.

But if the overall conditions of human existence and respectively the conditions of functioning of the demographic system change substantially, the targets of selection also change. In this new situation it must not preserve the stability of existing relations, norms, values, etc. On the contrary , it must , with the utmost efficiency , eliminate the elements of demographic relations and the corresponding socio-cultural structures which are obsolete and not adequate to the new situation, make place for the propagation of socio-cultural innovations more fitting to the new conditions. Finally, it must contribute to the fundamental adapatational transformation of the internal environment of the demographic system.

At different epochs of human history , the role of the various types of the socio-cultural selection , which creates the internal environment of a demographic system , varies. During more or less long periods of the existence of established ,mature

socio-economic systems (for example Western European feodalism) the slow accumulation of quantitative changes does not lead (up to a certain time) to fundamental modifications of life condition In these periodes the stabilizing selection predominates. It protects established, accustomed demographic relations , condemns all divergencies as heresies, sins, violations of the law , and in this way, does not permit them to become social norms.

Only at relatively rare crucial moments of history, the activity contradicting the established norms, which have become obsolete under the influence of irreversible historic changes, can be successfull. Common, customary demographic relations, enter a period of severe crisis and their replacement or transformation becomes inevitable. Then the moving selection comes to the fore. This is what happens in the case of demographic revolution. Its main task is precisely to replace old demographic relations by new ones, to create an internal environment of the demographic system, apt to ensure its existence in a changing external environment.

There is a close connection between the action of selection mechanismes and the goals of a demographic system. The selection is always directed towards these goals , that is the guarantee of survival ,homeostasis and the highest possible quality of functioning under given conditions. The degree of adequacy to these goals determines the selective value of some these or other demographic relations and the varying role of the main selection types.

This explains in particular the inevitabilty and universa-

lity of a modern demographic revolution. It starts when the objective possibility for the transition to a new higher level of quality of functioning of the demographic system appears. At the same time , the selective value of the demographic relations, norms, attitudes, etc. corresponding to the new conditions , rises sharply. Many of them could exist for a long time ~~treated~~ as reprehensible anomalies but they were unable to compete with traditional relations and norms of behaviour.

Very often, however , the higher selective value of new relations is not immediatly recongnized. This explains the lagging reactions of a demographic system to changed external conditions. The demographic trends of the last decades in the developing world is a good example of such lagging. In this connection the question may arise of the possibility of affecting somehow the process of social-cultural selection, for example by means of some population policy? On the one hand, we insist on the idea of self-organization of a demographic system as an objective process. On the other hand, we want to affect this process, for example, to accelerate it or to slow it down, to influence demographic trends with the help of subjective activity? Some will perhaps find a contradiction in our logic.

or demographic policy as we prefer to call it. What is the answer?

But it is only a seeming contradiction. The main mechanism of self-organization of a demographic system - the selection of demographic relations - always touches the interest of people, who never remain indifferent to possible or actual changes. Any kind of activity in human society finally enters into the system of its social institutions, acquires its own advocates, ideologists, etc.

Thus the processes of self-organization in a social system include conscious human activity which can support both stabilizing and moving socio-cultural selection.

The degree of awareness of the real processes may vary from vague ,intuitive negation of out-of-date or, on the contrary, just arising patterns of demographic relations and demographic behaviour to scientific knowledge about general tendencies of demographic development and precise projection of future changes. But in any case, the preferences manifested by individuals or by groups with respect to certain forms of relations or norms of behaviour are capable of accelerating or of slowing down the selection process. And when these preferences receive the support of influential social institutions, for instance of the state , the church, political parties, etc., they determine the directions of the demographic policy and their selective role rises still more. Thus, a demographic policy is the highest manifestation of the self-organization of a demographic system. This is conscious and organized human activity aimed at fixing or transforming some or other socially sanctioned demographic relations or norms of demographic behaviour.

The possibilities of a demographic policy are rather high but by no means unlimited. Only a policy which corresponds to the goals of a demographic system can be successfull. This policy supports the kind of socio-cultural selection which is moved forward by history. There is an intermediate link between the objective goals and the subjective activity (demographic policy). The

objective goal must be reflected in the conscience (mass conscience, policy makers' or legislators' conscience). It is important therefore that this reflection be correct and the goals of demographic system at every stage of its development be adequately interpreted. Only then , will the demographic policy more efficiently contribute to an easy and fast adaptation of the internal environment to new goals than a selection process by trial and error. Otherwise the demographic policy can be an obstacle to self-organization.