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NOTES ON THE CONCEPT OF A POPULATION[1]

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ABSTRACT

This paper contains a description of the basic population model and a discussion of applications of the model to some problems of common concern to demographers and sociologists. The concept of a population is advocated as a frame of reference in investigations of population composition and process, in the resolution of differences between macroanalysis and microanalysis, and in the design of studies of social change.

There are many peculiar aspects to demography as an academic calling. In some senses it is a field of sociology; in other senses it is neither a field nor even sociology at all. On the basis of its elegant models and quantitative rigor it has a claim to be considered the most advanced area in social science, and yet it might be rejected from that realm altogether as consisting essentially of a form of macrobiometry. It has endured for three centuries as "Political Arithmetic." As sometimes described, its scope seems to encompass the whole world of social statistics, but many social statisticians have neither training nor interest in demography. In the United States, where it has had its most extensive development, it has status nowhere as an independent academic discipline. Most often the demographer is found inside the Department of Sociology, but it is not always clear that he is either a welcome or or a comfortable guest. When demographers gather, they manifest a host of varied and sometimes conflicting interests: natural and social, pure and applied, scientific and propagandistic.

This essay is an attempt to identify some distinctive characteristics of the demographic approach to social analysis, with emphasis on the contributions that can be made by the concept of a population. The effort has been prompted by several recent publications with similar intent but somewhat different conclusions.[2] In the first section of this essay the basic population model is introduced and described. This model is then used to provide a basis for distinguishing the demographer's special contribution to the study of population

[1] Revised version of a paper entitled "The Demographer's Ken," which was delivered at the annual meetings of the Population Association of America, Madison, Wisconsin, May, 1962. The writer wishes to acknowledge the financial support of the Social Systems Research Institute, University of Wisconsin, and the intellectual support of O. Dudley Duncan and George J. Stolnitz in the preparation of this paper.

[2] See the following papers in Philip M. Hauser and O. Dudley Duncan (eds.), *The Study of Population* (Chicago: University of Chicago Press, 1959): Philip M. Hauser and O. Dudley Duncan, "Demography as a Science," Part I, pp. 29–120; John V. Grauman, "Population Estimates and Projections," pp. 544–75; and Amos H. Hawley, "Population Composition," pp. 361–82. See also Leo F. Schnore, "Social Mobility in Demographic Perspective," *American Sociological Review,* XXVI (June, 1961), 407–23.

composition and population processes. The penultimate section introduces the concept of a population into the controversy concerning the interrelationships of microanalysis and macroanalysis. Finally, some suggestions are made concerning the contributions a demographic approach can make to the study of social change. The pervasive theme of the article is the way in which the concept of a population forces the sociologist to give time a central place in his theory and research.

I. THE BASIC POPULATION MODEL

The backbone of population study is formal demography. The demographer is equipped with a special type of mathematical model which is adaptable to a wide range of problems and which yields proposals that particular kinds of data be studied with particular techniques of description and measurement. Formal demography is the deductive study of the necessary relationships between the quantities serving to describe the state of a population and those serving to describe changes in that state, in abstraction from their association with other phenomena.[3] The central features of demography as a body of knowledge and methods may be approached by considering the population as a model. The generic concept of a population is an abstract view of a universe of phenomena comprising recognizable individual elements Although demography is concerned substantively with humans, it has formal affinity with the analysis of all such collectivities. The first contribution by Alfred J. Lotka, the man most responsible for modern demography, was a study of "the mode of growth of material aggregates."[4] In that paper, he presented the essence of demography in his opening observation that, in a material system, certain individual constituent elements may each have a limited life-period, but the aggregate of a number of such individuals may nevertheless have a prolonged existence, provided there is some process for the formation of new individuals as the old ones are eliminated.

The elements of the basic population model may be specified as follows:

1. The population is characterized as an aggregate of individuals which conform to a given definition. This definition is ordinarily at least spatial and temporal in specificity.

2. The central question concerns the change of the aggregate number of constituent elements through time. Population research is dynamic in this elementary sense.

3. The change through time in the aggregate number is conceptualized as the difference between the number of additions to, and number of subtractions from, that total during the time interval of observation.[5] Decomposition in this way is so characteristic of the demographer's behavior that it is often specified in a definition of the field.[6] If additions and subtractions are further distinguished as births and immigrations on the one hand, and deaths and emigrations on the other, the proposition becomes the so-called demographic equation.[7] In this section of the paper, the population is assumed to be closed to migration; in a subsequent section migration is given special attention.

4. The model is microdynamic as well as macrodynamic. That is to say, the passage

[3] Alfred J. Lotka, *Théorie analytique des associations biologiques,* Part 2: *Analyse demographique avec application particulière a l'espèce humaine* (Paris: Hermann & Cie, 1939).

[4] "Studies on the Mode of Growth of Material Aggregates," *American Journal of Science,* XXIV (1907), 199–216. The author emphasized the generality he intended by using biological terms like "birth" and "death" only in quotation marks.

[5] Boulding has called this proposition perhaps the most fundamental of all science (Kenneth E. Boulding, *A Reconstruction of Economics* [New York: John Wiley & Sons, 1950], p. 190).

[6] See, e.g., Hauser and Duncan, "Demography as a Science," *op. cit.*

[7] Kingsley Davis, "The Demographic Equation," in *Human Society* (New York: Macmillan Co., 1948), pp. 551–94.

of time is identified for the individual constituent elements as well as for the population as a whole. This emphasizes, in Lotka's terms, the distinction between persistence of the individual and persistence of the aggregate. Individual entries and exits are dated, and the difference between date of entry and date of observation, for the individual, is his age at that time. Age is the central variable in the demographic model. It identifies birth cohort membership (as discussed below). It is a measure of the interval of time spent within the population, and thus of exposure to the risk of occurrence of the event of leaving the population, and more generally is a surrogate for the experience which causes changing probabilities of behavior of various kinds. Age as the passage of personal time is, in short, the link between the history of the individual and the history of the population.[8]

5. Once increases and decreases are identified in terms of both personal and population time, attention is focused on properties of the system that determine the limitation of the life-period of the constituents and the formation of new constituents. The emphasis passes from the deaths and births that occur to the individuals, to mortality and fertility, which are cohort processes.[9]

6. The population model is completed by linking together three kinds of functions. The first of these is the number of person-years of exposure of the population within each age interval and time interval; the second is the number of births occurring within each age interval and time interval per person-year of exposure; the third is the number of deaths occurring within each age interval and time interval per person-year of exposure. In brief, they are the age-time structure of the population, and the age-time processes of fertility and mortality. These three functions represent a network of identities within a complete deterministic model. The formal theory of demography is concerned with working out the logico-mathematical relationships among these components and elaborating schemes for their analysis in terms suggested by the structure of the model.

At several points above, reference has been made to the distinction between individual occurrences and cohort processes. The significance of this may be exemplified by reference to mortality. An individual has a lifetime of, say, x years, which is begun at birth and terminated by death. In the population accounts this is recorded as an addition to, and then, x years later, as a subtraction from, the aggregate of one unit. From the standpoint of population size as a function of time, the age of the individual at death is irrelevant. Only the fact and time of death enter the accounting procedure, since the question of which individual dies does not affect the size of the population. The individual is assigned to a temporal aggregate on the basis of his time of birth, because this offers some obvious arithmetical conveniences. Such an aggregate is termed a (birth) cohort.[10] The mortality process for the cohort is the distribution of its membership by age at death (and, since time of birth is identical among the members, by the time of death as well). This distribution is a characteristic of the cohort as an aggregate, but the argument of the function representing it is individual time. Thus the events of subtraction of individuals from the aggregate are trans-

[8] Age is only the most useful case of the general category of intervals, measured from the time of entry into particular kinds of subpopulations or quasi-populations. These are discussed in Sec. II.

[9] An important distinction can be made between biological populations, to which new members are added as a consequence of the event of parenthood occurring to existing members of the population, and other situations in which the population concept is applicable, but the additions are properties of the population as a whole and its total environment. Immigration is a case in point.

[10] The cohort approach has analytical as well as arithmetical advantages. See my "Cohort Analysis," *International Encyclopaedia of the Social Sciences*, forthcoming.

formed into rates for each age-time interval, the numerator of the rate being the number of occurrences of the event of death, and the denominator the area of person-years of exposure of the aggregate to the risk of occurrence of that event during the particular time interval. By this form of calculation the event which characterizes the individual is transformed into the process which characterizes the cohort.

In considering the demographic history of a cohort, there is an obvious cause-and-effect relationship between its mortality process and its age-time structure, that is, the distribution through time of the person-years of exposure. Considered as an age structure, the population at any moment of time is a cross-section of cohorts as age structures, when the cohorts are viewed diagrammatically as if they were stacked in uniformly staggered fashion, each atop its predecessor in time. The procedure for relating the parameters of these two kinds of age structures has been developed by the writer and named the process of "demographic translation."[11]

To complete the basic population model as a web of structures and processes, some fertility mechanism is required. The size of any cohort at birth is provided by the number of births in the period that dates the cohort. Those births that occur in any period may be viewed as a product sum of the age structure of the population in the period and the fertility rates of the cohorts that occupy the various ages of parenthood at that time. These rates are of the occurrence-exposure type elaborated for mortality.[12] Now the period age structure is a cross-sectional translation of the age structures of the successive participant cohorts, and the fertility rates are a cross-sectional translation of the fertility rates of the same cohorts. Thus the process of demographic translation between period and cohort functions is intrinsic to the establishment of interdependencies among all three functions of the basic population model.

To summarize, the system provides a way of generating changes in population size through time, because of the continual destruction and creation of members, as a joint product of population structures and cohort processes. As noted, the population structure in any period is a translation of cohort age structures, and these are in turn the outcome of cohort mortality processes. The circle of formal analysis moves from (1) individual acts of procreation and death to (2) cohort processes of fertility and mortality, and thence to (3) cohort age structures. These are translated into (4) period age structures which combine with period translations of the cohort vital processes to yield (5) the births and deaths which change the size of the population. This mode of analysis presents the problem of structural transformation in terms of the processes that shape and reshape the structure. Thus it is attuned to the tendency of present-day science to regard events rather than things, processes rather than states, as the ultimate components of the world of reality.[13] The contributions of Lotka[14] have established the determinacy of the population structure implicit in fixed processes of cohort fertility and mortality and have provided, at this level, a comprehensive representation of the stable equilibrium model. Work is now proceeding on the establishment of the structural consequences of systematic change in the cohort processes, in order to develop models which are

[11] See my "The Process of Demographic Translation" (paper presented at the 1963 annual meetings of the Population Association of America, Philadelphia), to be published in the *Demography Annual*.

[12] The process is purposely described here as if parenthood were monosexual or non-sexual, for reasons to be amplified in Sec. III.

[13] The philosophical term for this view is "actuality theory" (see "Actuality Theory" in *Encyclopaedia Britannica* (1957 printing), I, 138.

[14] *Op. cit.*, 1939.

dynamic in the customary sense of the term.[15]

II. POPULATION COMPOSITION

The basic population model presented above can be used in consideration of social composition and social mobility as topics for demographic inquiry.[16] Population composition has been defined as the relative frequency of any enumerable or measurable characteristic, quality, trait, attribute, or variable observed for individuals in a population, that is, as any view of an aggregate that recognizes any differences among its individual components. A list of such items would include residential location; ethnic group membership; religion; education; employment; occupation; industry; social roles and memberships; anthropometric, biometric, and psychometric traits; genetic constitution; health status; and attained skills.[17] From this vantage point the demographer's ken seems boundless. Perhaps it is impossible to draw a boundary line around demography and confine its scope to such-and-such phenomena and no others.[18] Perhaps the range of possibilities is limited only by convention, so that the choice of subjects for demographic purview is largely fortuitous.[19] And perhaps the criterion for labeling something as demographic is essentially the same as the criterion for its inclusion in the census, that is, any characteristic of an individual that is useful in administration and policy determination and that can be collected by non-professionals.[20] While such specifications may indeed be apt characterizations of what demographers do, they are less than satisfying as guidelines for the future development of the field. The concern in this section is to attempt to identify some criteria for drawing a line between demographic and non-demographic variables, in order to arrive at an understanding of what it is about demographic analysis that could distinguish it from any other kind of statistical social analysis.[21] The position to be advanced is that limits can be established for the sphere of demographic competence by considering not so much the substance of any characteristic as its adaptability to formulation in the terms of the basic population model.[22]

The argument begins with consideration of a distinction that has been proposed between characteristics that are fixed and characteristics that are changeable.[23] Some characteristics are determinable at birth and fixed for life. These may be distinguished for convenience as the genetic inheritance and the cultural inheritance, in both cases derivative from the parents. The most prominent representatives of the former are sex and color. Under the latter

[15] See my "The Translation Model of Demographic Change," in *Emerging Techniques in Population Research* (Milbank Memorial Fund, 1963), pp. 65–81.

[16] See Schnore, *op. cit.*, for the ideas which prompted this section.

[17] United Nations, Department of Economic and Social Affairs, *Multilingual Demographic Dictionary*, English Section ("Population Studies," No. 29 [New York, 1958]); Hauser and Duncan, "Demography as a Science," *op. cit.*

[18] Hauser and Duncan, *op. cit.*

[19] Schnore, *op. cit.*

[20] Hawley, *op. cit.*

[21] One of the beginnings of sociology as an academic discipline in the United States was the quantitative treatment of social problems. Some such departments were first called "Statistics" but later changed their name to "Sociology." "Population problems" gradually became identified as a major subdivision of these departments (F. Lorimer, "The Development of Demography," in Hauser and Duncan [eds.], *op. cit.*, pp. 124–79).

[22] An analogous approach has been adopted in the study of the economics of capital (see Boulding, *op. cit.*, p. 189).

[23] Grauman, *op. cit.*; Schnore, *op. cit.* Status ascription is a process which ties some changeable characteristics to some fixed characteristics. Status achievement is a process which ties some changeable characteristics to other changeable characteristics.

heading come such non-biological characteristics of parents as ethnic origin, mother tongue, and place and date of birth. The last of these, which identifies cohort membership, is usually represented by age, which is, of course, an invariant function of time and in this sense a fixed variable. Other characteristics are subject to change throughout the course of an individual's life, such as educational attainment, marital status, and the various attributes associated with economic activities.

Now this distinction between changeable and unchangeable characteristics is an important convenience at an operational level, but it is scarcely defensible from the standpoint of the significance of such identifications for behavior, and it conceals a facet of almost all census questions which can be exploited by the demographer. Thus there is merely a distinction of degree rather than kind between inherited and acquired characteristics, since virtually all phenotypic characters manifest the interaction of genetic and environmental factors. From a sociological standpoint sex, race, age, and other "biological" characteristics are learned roles. Although the various types of non-biological identification that can be used to label a person at birth may be regarded as having a persistent influence on his lifetime behavior, their fixity is only a convenient approximation to a much more complex and dynamic reality.

There are several senses in which the changeable characteristics are fixed. Many of them endure for extended periods of time, and are frequently permanent within or beyond particular age limits. Thus educational attainment is by and large established during prematurity; marital status tends to be fixed for lengthy periods within each stage of the sequence of single, married, and widowed; labor-force participation for many involves a single entry early in life and a single departure late in life; religion and citizenship are fixed for life for the majority. Now it is not disputed that changes can and do occur in these variables. But the significant point for the student of the population as an aggregate is that these changes tend to occur within a narrow age range for most of the population.

This aspect of temporal persistence in most census characteristics is manifest in and enhanced by census practice. Thus it is accepted procedure to attempt to record those who habitually live in an area (including absentees and excluding transients) in order to get at "usual residence" —the place were a person "lives." A population is considered as consisting of inhabitants, a term that implies both spatial fixity and temporal endurance. Occupation and place of residence are among the characteristics that a person changes most frequently. But census procedures ordinarily involve the attempt to establish what these are usually rather than momentarily. This is a partial explanation for the fact that the census is primarily a classificatory rather than a measuring instrument. In the same way, migration is identified as only those changes of residence that carry some implication of permanency. In summary, population characteristics are for the most part the results of attempts to achieve relatively enduring labels by definitional devices, and changeable characteristics may be distinguished by the extent to which they manifest temporal persistance.

A further type of fixity in the realm of changeable characteristics concerns fixity of sequence. Several important population characteristics have high probabilities of change, but in relatively restricted ways. The classic case is age (which departs from its fixed sequence only through age misstatement, a form of intercohort migration). Reproductive parity and educational attainment in terms of years of schooling fall under the same heading. Likewise, specific marital statuses can only be changed, by law, into a limited number of particular other marital statuses. Some occupations can be arranged in career sequence, particularly if the earlier occu-

pation is in some sense apprenticeship for the later. Sometimes one variable is characteristically sequential with another, for example, the close relationship between certain levels of education and certain categories of occupation, which in turn are closely related to income levels.

The aspect of fixity of characteristics and sequences has been stressed here because it makes possible the application in analysis of the array of demographic techniques based on the concept of a population. The argument is, in a sense, a generalization of the implications of Grauman's observation that the principal relevance of the distinction between fixed and changeable characteristics is that population segments which have the same fixed characteristics can be treated by estimating methods analogous to those which are employed in estimating population totals.[24] It is the writer's view that the special contribution of the demographer to social analysis is focused on those items of individual information which can be thought of as defining quasi-populations, because they endure. Thus a characteristic may be viewed as an individual's residence over a period of time. The time interval has a beginning and an end for the individual—an entry into and an exit from that particular quasi-population—and within the interval the individual is exposed to the risk of occurrence of various events, in particular, that of departure from that quasi-population. It is at least operationally conceivable that not only an enumeration of the individuals within these quasi-populations at successive times can be obtained, but also a registration of entries and exits. Full utilization of the power of the population model would also require determination of the length of time each individual has spent within the quasi-population. The most commonly used interval is age, and it ordinarily serves as a surrogate for more precise interval determination. Age is the outstanding representative of a large class of measurements of the length of time elapsing since the occurrence of a cohort-defining event, but is a satisfactory substitute for the particular duration only to the extent that there is small variance in age at entry into the quasi-population in question.

To summarize this section, the cutting edge of methodology has been used to guard against the presumptuous position that the demographer is sole custodian of census materials. In the writer's view, the talents of the demographer are most usefully employed in considering such items of information about individuals as can be conceptualized as quasi-populations by virtue of their property of persistence through time. This perspective is designed not so much to inhibit the expansiveness of the demographer's statistical work as to suggest a program for extending his activities into areas in which his contribution is unique.

III. POPULATION PROCESSES

The position has been advanced that the criterion which identifies those situations in which the demographer has something special to offer is methodological rather than substantive. To exemplify further this viewpoint, the present section examines the applicability of the population concept in the study of the three processes that are clearly integral to the field of demography considered substantively—fertility, mortality, and migration—and to the closely associated process of nuptiality. The outcome of the presentation is that the basic population model is tailor-made for mortality analysis, plays an important but incomplete role in the measurement of nuptiality, has proliferated in several analytically advantageous ways in fertility research, and finally is appropriate for answering questions about one kind of migration but not about another.

The prototpe of statistical analysis in demography is the life-table. A cohort is taken from birth throughout the lifespan, with its numbers reduced age by age on the basis of the mortality rates, the ratios

[24] Grauman, *op. cit.*

of occurrences of death to person-years of exposure to the risk of death. The area of exposure in each age and time interval is reduced successively by occurrences which depend in turn on previous areas of exposure and their mortality rates. Whatever other subpopulation or quasi-population may be studied, the events that reduce membership must include mortality as well as the departures that are specific to the particular definition of membership. The elegance of the system of life-table functions has inspired the whole array of attempts to convert other processes, often substantively quite dissimilar, into analogues of mortality.

In the sphere of nuptiality analysis, the parallel with mortality is readily drawn and the basic population model successfully applied. Every person begins life single and most persons suffer "death" as a single person by experiencing the event of first marriage, an event that is irreversible provided a strict definition of the single state is maintained. Similarly the successive stages of married life may be studied as attrition processes, for example, the dissolution of marriage by divorce or widowhood. But the population model is restricted in its usefulness to the situation in which the event may reasonably be considered as occurring to an individual. Now marriage is in fact an event that occurs to two persons simultaneously, and the exposure to the risk of occurrence of marriage is a function not only of the personal characteristics of the man and woman involved, but also of the general state of the marriage market—the relative availability of spouses of either sex. This problem has proven completely intractable to conventional modes of demographic analysis.[25] This is the reason for specifying above that the basic population model is non-sexual or monosexual. The relationships between probabilities of marriage and the sex-age composition of the unmarried population are not expressible in terms of formal interconnections between occurrences and exposures. This is a clear-cut case of the need for measurements of properties of the aggregate in determination of probabilities of individual behavior, as discussed in more detail in Section IV.

In fertility research, one important improvement in methodology has been the extention and generalization of the basic notion of a cohort from its original signification of birth cohort to cohorts identified by common date of occurrence of other significant events. The variables that have been exploited in modern fertility measurement are number, age, marital status, marital duration, parity, and birth interval. These six variables may be grouped in three pairs, in order, each pair consisting of a status—which identifies quasi-population membership—and a time interval since acquiring that status—"age" within the quasi-population. The demographic characteristics pertinent to the act of parenthood are most succinctly identified as a series of time points: date of birth of the prospective mother; date of her marriage; date of birth of each preceding child; and date of current birth. The intervals, then, are the differences between pairs of successive time points. The statuses imply membership in various types of cohort: the birth cohort, the marriage cohort, the first parity cohort, and so forth. Temporal aggregation afresh on the basis of the most recent event in the reproductive history provides a mode of efficient analysis of the frequency and the time distribution of the next succeeding event.[26] The only formal problem in this sequence is the formation of marriage cohorts out of birth cohorts, as discussed in the preceding paragraph.

Migration is clearly the most complex demographic process to discuss from the standpoint of the basic population model. The problems that arise are discussed here first for external migration and then for inter-

[25] See my "Bisexual Marriage Rates" (paper read at the annual meetings of the Population Association of America, 1961).

[26] See my "La mesure des variations de la fécondité au cours du temps," *Population,* XI (January–March, 1956), 29–46.

nal migration. Immigration and emigration, the terms generally used in distinguishing the two directions of external migration, are on an equal footing with fertility and mortality as modes of entry and exit from the total population. This circumstance follows from the fact that the population is customarily defined in spatiotemporal terms: immigration and emigration represent the crossing of spatial boundaries just as fertility and mortality represent the crossing of temporal boundaries. The parallel may be extended to the conceptualization of emigration as a type of mortality. There are no unique difficulties of a formal kind in considering exposure to the risk of occurrence of emigration from the population, with a determination of the probabilities of emigration in each time interval, for members of successive birth cohorts, following the life-table format. Furthermore emigration, like mortality, is a process of exit from the total population, and therefore from every constitutent subpopulation of quasi-population.

When attention is turned to immigration, the analogy immediately dissolves. This may indeed be an important mode of addition of new members to the receiving population, but the events that constitute it do not occur to members of the receiving population. In contradistinction to fertility, the initiation of immigration is exogenous to the population being studied and can be built into the model only on an *ad hoc* basis because the exposure to the risk of immigration lies outside the defined population. For this reason, immigration research has not been able to exploit the measurement techniques that emanate from the basic population model. The characteristics of the population which yield various patterns of immigration are characteristics of the aggregate rather than of individuals within the aggregate. In this sense, immigration is a subdivision of the general study of ecosystem interchange, a branch of population theory which is much more developed for nonhuman than for human populations.[27]

The process of internal migration may be regarded on the one hand as a special application of the quasi-population concept, or on the other hand as the prototype of a different but related kind of population model. If the territory that defines a population is divided into subterritories, each with its own subpopulation, then the movement of an individual from one subterritory to another is formally analogous to passage from any one status to another. If the focus of interest is the subpopulation itself, then in-migration and outmigration are at that level analogous to the processes of immigration and emigration as discussed above for the total population. But if the total population within which the movements are occurring is the focus of attention, then it is more natural to speak of the movements not so much in terms of entry into and exit from particular subpopulations, as in terms of interstitial movement between subpopulations.[28] This way of describing the process places the subject within the reach of the theory of Markov chains, a type of mathematics that possesses great potentialities in demographic research. An initial distribution and a terminal distribution, termed column vectors, are related to one another by a square matrix of transition probabilities. These are the conditional probabilities of moving to a particular terminal location, given a particular initial location.[29]

[27] Boulding, *op. cit.*, chap. i.

[28] Similarly immigration and emigration may be considered as species of internal migration from the standpoint of the population of the world. Indeed the world population as a model has considerable theoretical convenience because, thus far at least, there is only one mode of entry and one mode of exit.

[29] The approach has been applied with success in solving some residual difficulties in stable population theory: see, e.g., D. G. Kendall, "Stochastic Processes and Population Growth," *Journal of the Royal Statistical Society*, XI (1949), 230–65; Alvaro Lopez, *Problems in Stable Population Theory* (Princeton, N.J.: Office of Population Research, 1961). Applications to the study of intergenera-

The basic population model and the transition matrix model are variants of a single formal system, which have their own special advantages for two different categories of problems. The basic concept of a population has been characterized as spatiotemporal. Accordingly, two types of changes may be distinguished: metabolism, or replacement in time, characterized by the processes of fertility and mortality; and migration, or replacement in space. An emphasis on metabolic transformation leads to a preference for the model of entry, exposure, and exit, as discussed above. An emphasis on migratory transformation leads to a preference for the transition-matrix model. The two types of models share one important feature. If the matrix of transition probabilities is held fixed, it may be shown that the column vectors move toward an equilibrium state which represents the latent structural propensities of the processes characterized by the matrix. This is, of course, a precise analogy to stable population theory. Both mathematical models direct analytic attention away from the consequent structures and toward the determinant processes. But a distinction of degree or emphasis remains. In considering the various census characteristics in the preceding section, it became clear that some of them were more adaptable to the quasi-population concept than others, and that the degree of adaptability hinged on the frequency of entry and exit, or, said otherwise, on the degree of temporal persistence. It seems reasonable to propose that those characteristics that are too variable from time to time to be usefully conceptualized in quasi-population terms can be accommodated methodologically within the transition matrix approach. As an alternative mode of division of labor between the two models, it may be suggested that the transition-matrix approach is more suitable for comparative cross-sectional analysis, which focuses on short-run period-by-period changes in the population structure, while the population approach is more suitable for the study of behavior associated with the life-cycle, which focuses on long-run cohort-by-cohort transformation. But these should be considered as tentative and probably premature forays beyond a fecund methodological frontier.

IV. MACROANALYSIS AND MICROANALYSIS

The study of population comprises not only a system of formal relations but also various systems of substantive relations between parameters of the population model and other variables.[30] Now the parameters of the population model are expressed as concrete phenomena rather than as analytic abstractions. In its substantive component, demography is an observational proto-science, and the concrete objects of observation may be examined through various frames of reference and from various analytic perspectives. The study of systems of analytic relations between population parameters and other variables lies within the purview of the various abstract sciences. The term "analytic relations" is used here to convey the sense of appraisal of probabilistic covariation within a particular frame of reference rather than analysis in the literal sense of decomposition.

Various consequences follow from the

tional occupational mobility have been less successful because the column vectors can be uniquely specified neither in temporal location nor in constituents. See, e.g., S. J. Prais, "The Formal Theory of Social Mobility," *Population Studies,* IX (July, 1955), 72–81, and his "Measuring Social Mobility," *Journal of the Royal Statistical Society,* Series A, CXVIII (1955), 56–66; Judah Matras, "Comparison of Intergenerational Occupational Mobility Patterns: An Application of the Formal Theory of Social Mobility," *Population Studies,* XIV (November, 1960), 163–69, and his "Differential Fertility, Intergenerational Occupational Mobility, and Change in the Occupational Distribution: Some Elementary Interrelationships," *Population Studies,* XV (November, 1961), 187–97.

[30] Lorimer (*op. cit.,* p. 165) has asserted that the concept of "pure demography" is an illusion except as the skeleton of a science.

circumstance that the parameters of the population model are defined concretely. (1) Population studies may be located within the realm of any of the abstract sciences. In particular, the subject straddles the biological and social sciences. The term "science" is used to mean an abstract area of empirical inquiry determined by a particular orientation and frame of reference, as distinct from proto-scientific approaches to concrete phenomena in all their aspects, like geography, ethnography, and, as generally defined, demography. (2) The professional demographer is almost always identifiable also as a substantive specialist with competence in a particular science. The circumstance that most American demographers are also sociologists is somewhat fortuitous, but does help to explain the tendency to define demography by contiguity as a field within sociology. That this is an incomplete view is indicated by the array of different kinds of scientists found in the International Union for the Scientific Study of Population, and even in the Population Association of America. (3) The diffuseness of substantive interest in questions defined by the population model and the narrow limits of the formal core of the discipline are sufficient to explain why it does not have the dignity of academic autonomy as a department of university instruction. For convenience, demography is housed within particular other departments, the choice being to some extent historical accident and varying considerably from country to country.[31] (4) The concreteness of content and the sophistication of the special methodology account for the continued tolerance of the demographer as a resident alien within different disciplines. The data with which the demographer works are grist for almost everybody's mill, and the models he employs are adaptable to a wide variety of situations, although the former type of usefulness to colleagues has been much more widely exploited than the latter. Indeed, the neglect of demographic concepts by non-demographers is one justification for the present piece. The demographer's work, in other words, yields problems for investigation by various scientific disciplines and provides an orientation for the solution of these and other isomorphic problems. (5) Under the circumstances, the demographer is likely to participate in interdisciplinary research—because the limits of his subject extend into the provinces of various disciplines—and he is useful as a channel of scientific communication between otherwise disparate orientations. (6) Finally, the concrete definition of the subject makes the demographer more immediately useful than the abstract specialist in the realm of policies directed toward practical, as distinct from intellectual, problems.

The writer has described elsewhere an example of the way in which a concrete object of the demographer's attention may have its various aspects allocated among different abstract disciplines.[32] Research on fertility can be divided into the contribution of substantive analysis in the biological realm—using data about fecundity and fertility regulation to explain observed fertility—and the contribution of substantive analysis in the realm of the social sciences—using data about individuals and groups to explain observed fertility regulation (and even to some extent fecundity). Within the latter realm it is useful to distinguish between psychosocial and sociocultural research, or—to identify more precisely the point to be discussed—between microanalytic and macroanalytic inquiries. The relationships between these two levels of inquiry deserve attention because they are of peculiar relevance to the demographer and because the concept of a population contributes to their clarification.

Much of the discussion of analytic

[31] David V. Glass (ed.), *The University Teaching of Social Sciences: Demography* (Paris: UNESCO, 1957).

[32] See my "Fertility," in Hauser and Duncan (eds.), *op. cit.*, pp. 400–436.

strategies in fertility research has consisted of assertions of the relative importance of microanalytic and macroanalytic levels of inquiry for the explanation of fertility. Thus Vance has called macroanalytic explanations inadequate because they fail to specify the ways in which macrovariables are translated into individual motivations.[33] In their commentary on this assertion, Hauser and Duncan have labeled the psychosocial variables as superficial, and proposed that the deep-seated macroanalytic causes underlie them.[34] The difficulty of adjudicating competing claims like these is that the criteria of relative success differ. If the individual is the unit of analysis, then success is measured by explanation of variance among individuals; if the population is the unit of analysis, then success is measured by explanation of variance among populations. The issue has not been confined to the field of fertility. Several influential demographers have decried the circumstance that most migration analysis ignores the study of the motivations behind particular individual movements by its macroanalytic focus on net migration.[35] Schnore has taken the opposite stand concerning sociological interest in mobility.[36] He has expressed concern that the majority interest in the correlates of individual behavior means short shrift for macroanalytic inquiries into interdependencies of population composition and social structure. In the field of mortality research, the microanalytic approach is winning by default, because almost no student of the subject seems interested in asking macroanalytic questions.

A final controversy deserves mention. The variables in individual correlation are descriptive properties of individuals; the variables in ecological correlation are descriptive properties of populations (although they are computed by deriving summary indexes of the properties of individual members of the respective populations). Robinson has asserted correctly that individual correlations cannot be inferred from ecological correlations, and has asserted incorrectly that the purpose of ecological correlations must be to discover something about the behavior of individuals.[37] This debate has special pertinence for the demographer because of one characteristic feature of the population concept. Given the definition of a population as an aggregate of members, it appears superficially that the characteristics of the population are merely derivative from the characteristics of individuals by summation. The situation is in fact much more complex than that. Just as the properties of individual members may be used in aggregate form as properties of the population, so the properties of a population may be used as properties of its individual members.[38] The macroanalytic level of inquiry consists of propositions or statements of relationships among the properties of the population as the unit of reference. The microanalytic level of inquiry consists of propositions

[33] Rupert B. Vance, "The Development and Status of American Demography," in Hauser and Duncan (eds.), *op. cit.*, pp. 286–313.

[34] *Op. cit.*

[35] Donald J. Bogue, "The Quantitative Study of Social Dynamics and Social Change," *American Journal of Sociology,* LVII (May, 1952), 565–68; Vance, *op. cit.*; C. Horace Hamilton, "Some Problems of Method in Internal Migration Research," *Population Index,* XXVII (October, 1961), 297–307.

[36] Schnore, *op. cit.*

[37] W. S. Robinson, "Ecological Correlations and the Behavior of Individuals," *American Sociological Review,* XV (June, 1950), 351–57; H. Menzel, "Comment on Robinson's 'Ecological Correlations and the Behavior of Individuals,'" *American Sociological Review,* XV (October, 1950), 674. See also L. A. Goodman, "Ecological Regressions and Behavior of Individuals," *American Sociological Review,* XVIII (December, 1953), 663–64; O. Dudley Duncan, and B. Duncan, "An Alternative to Ecological Correlation," *American Sociological Review,* XVIII (December, 1953), 665–66.

[38] J. A. Davis, J. L. Spaeth, and C. Huson, "A Technique for Analyzing the Effects of Group Composition," *American Sociological Review,* XXVI (April, 1961), 215–25.

or statements of relationships among the properties of the individual as the unit of reference. In general it is invalid either to transform a proposition about populations into a proposition about individuals or to transform a proposition about individuals into a proposition about populations. The relationship among individual characteristics, expressed as a regression equation linking individual variables, will generally have different parameters from one population to another. Now most sociological theory is pitched at the microanalytic level and therefore requires a test based on observations of individuals. This does not imply that macroanalytic theory is a lesser breed of theorizing, nor that it is merely derivative and a temporary substitute employed for the sake of convenience.

The question of the relationships between macroanalysis and microanalysis is important in current economic thought. Most theories in economics (as in sociology) are microtheories, while most empirical descriptions contain measurements of macrovariables which are functions, such as averages, of microvariables. The parameters in the macroanalytic regression equations are weighted averages of the parameters in the microanalytic regression equations because the former system is dependent not only on the latter but also on the composition of the population.[39] One prominent direction of resolution of this and other problems which exploits the magnitude of the latest computers is the microanalysis of socioeconomic systems, an attempt to generate aggregate properties from properties of individuals.[40] As a general rule, the theoretical systems of the economists have not encompassed the problems of differences between systems *qua* systems through time or space.[41]

There is another respect in which the microanalytic and macroanalytic levels of inquiry differ in character, and it leads to an important example of the utility of the population concept. The properties of distributions of variables are specific to populations rather than to individuals. An important question about a population is how to explain the differential distributions of various populations in terms of some individual-specific characteristic. Now microanalytic relationships are of the form: If an individual has characteristic A, then he has a probability p of having another individual characteristic B. This may be used to predict the distribution of B, given the distribution of A, but it does not answer the question: What determines the distribution of A? The approach that uses the basic population model emphasizes the events of acquiring and losing some characteristic. From the standpoint of the individual, movement into and out of categorical locations is placed in the perspective of the life-cycle; from the standpoint of the population, the distribution by categories is viewed as a consequence of processual parameters of fertility and mortality, using these terms in the broad as well as the narrow sense. More specifically, attention is directed to the movement from one structure to another by means of two questions: "Given this kind of exposure, what is the probability of the occurrence of departure from exposure?" and "Given departure from exposure, what is the consequence for subsequent exposure?" Thus this approach places emphasis on changes through time. More precisely, the emphasis is on long-run time, or time as the biology of evolution considers it, as distinct from short-run time, or time as used in the equations of physics. The latter is the analogy

[39] H. Theil, *Linear Aggregation and Economic Relations* (Amsterdam: North-Holland Publishing Co., 1954).

[40] Guy H. Orcutt, Martin Greenberger, John Korbel, and Alice M. Rivlin, *Microanalysis of Socioeconomic Systems* (New York: Harper & Bros., 1961).

[41] The problems of distinction between analyses of individuals and of aggregates are not confined to the social sciences. For a brief view of the parallel dilemma in physics see William Feller, *An Introduction to Probability Theory and Its Applications* (2d ed.; New York: John Wiley & Sons, 1957), I, 356.

for the study of covariation of individual and population characteristics; the former is the analogy for the study of population dynamics.

In the area of conjuncture between the macroanalytic and microanalytic approaches to the study of behavior, the cohort as a population element plays a crucial role. It is a device for providing a macroscopic link between movements of the population and movements of individuals. The conceptual gap between individual behavior and population behavior is provided with a convenient bridge, in the form of the cohort aggregate, within which individuals are located and out of which the population as a function of time is constructed from the sequence of cohort behavior patterns. Thus the cohort is a macroanalytic entity like the population, but it has the same temporal location and pattern of development as the individuals that constitute it. It seems to the writer that the analysis of cohort structures and processes is a valuable intermediary between the analysis of individual behavior and the analysis of population behavior, in attempting to increase the possibilities of cross-fertilization. The concept of a population, which is closely allied with the concept of a society, is brought closer to the concept of an individual, when the latter is viewed as a member of a cohort aggregate which is in turn a constituent of a population. Thus one avenue is provided in sociology for the perplexing questions of the relationships between the individual and the society.

To conclude this section, a note seems worthwhile concerning the partnership of demography and human ecology, a partnership manifest in the central position within each discipline of the concept of a population and in the frequency with which particular scientists have interests in both areas. Human ecology may be characterized as the study of social organization as a property of a population in interaction with its environment.[42] The characteristic method of this study is employment of the spatiotemporal orientation to provide dimensions for the observation and measurement of organization. The concrete definition of a population within both demography and human ecology implies that the two principal definitional axes of each are space and time, and that each discipline will have an expansive view across various spheres of learning. To some extent there has been a division of labor between the ecologic and the demographic orientations: the former has focused more on variations in space, and the latter more on variations in time. The central concept of the ecologist has been the community, defined minimally by spatial co-occupancy. To some extent it is possible to make the parallel assertion that the central concept of the demographer is the cohort, defined minimally by temporal co-occupancy.[43] The approaches converge in orientation and bring the demographer and the human ecologist together as the ecologist begins to ask dynamic questions and the demographer concerns himself with spatial distribution. The parallel between the cohort and the community is not to be pressed too far because the community is viewed by the ecologist as capable of being considered a self-sufficient societal organism, whereas the cohort is for the most part a statistical plural with common characteristics stemming from its definitional basis of temporal location but without the integration implicit in various community properties.

[42] Hawley, "Human Ecology," *International Encyclopaedia of the Social Sciences,* forthcoming.

V. SOCIAL CHANGE FROM A DEMOGRAPHIC PERSPECTIVE

The purpose of this section is to present some ways in which the concept of a population may contribute to the analysis of social change. The first type of contribution is related to the definition of change. It is common in discussions of the topic to con-

[43] It is interesting to observe that the word "cohort" originally had a spatial referent, because it identified a type of community. This etymological tie is manifested in its kinship with words like "garden" and "girdle."

fine the term "social change" to transformation of the social structure, in contradistinction to the patterned sets of phases in the life-cycles of individuals and other relatively invariant systems of action and interaction.[44] Two contributions to this distinction may be drawn from stable population theory. In the first place, structural transformation is caused by a discrepancy at any point of time between the extant structure and the processes which are responsible for creating that structure. In the second place, life-cycle changes for individuals can be summarized by various indexes of cohort behavior as a function of age (or other appropriate interval). The definition of social change prompted by these considerations is the modification of processual parameters from cohort to cohort. Thus social change occurs to the extent that successive cohorts do something other than merely repeat the patterns of behavior of their predecessors. Given the far greater availability of structural than of processual data of all kinds, knowledge of the nuances of interdependency of period and cohort functions of fertility, mortality, and age distribution (or their analogous forms, if a quasi-population concept is employed) is likely to be essential in research on social change.

The proposed definition of social change is incomplete because it does not distinguish long-run from short-run change. Statistical contributions to the separate measurement of each for quantitative materials have been unimpressive because the distinction to be drawn does not actually hinge on the length of time elapsing but on the consideration that such changes have different determinants, and this can only be supplied by a person with knowledge of the content rather than the form of the data. Again the basic population model provides one direction of resolution of the difficulty. If functions of process are examined for a series of cohorts over their age spans, two distinct types of changes may be observed. One of these is the manifestation of a period-specific event or situation which "marks" the successive cohort functions at the same time, and thus at successive ages of the cohorts in question. Frequently such manifestations take the form of fluctuations, in the sense that a counteracting movement occurs subsequently which erases the impact of the situation in the eventual summary for the cohort. The other type of change is characterized by differences in functional form from cohort to cohort other than those betraying the characteristic age pattern of the period-specific event. With full recognition of the incompleteness of the view, it is suggested that among the various sense of "short run" and "long run," an important part of the distinction can be captured by statistical operations designed to segregate the period-specific and cohort-specific variations as functions of age and time. As a not entirely parenthetical remark it may be suggested that one contrast between demography and other types of quantitative sociology has been the emphasis of the former on long-run change and of the latter on short-run or no change.[45]

Throughout this essay, attention has been focused almost exclusively if implicitly on the level of the total population and its less tangible partner, the society. But the concepts introduced are clearly applicable with little modification to the other levels of social organization. In particular the demographic approach provides some methodological resources for a dynamic approach to organizational structure. Any organization experiences social metabolism: since its individual components are exposed to "mortality," the survival of the organization requires a process of "fertility." The problem of replacement is posed not only for the total organization but also for every one of its differentiated

[44] T. Parsons, "Some Considerations on the Theory of Social Change" (1960). (Mimeographed); Hawley, "Change and Development," in *Human Ecology* (New York: Ronald Press Co., 1950), p. 319.

[45] Cf. Boulding, *op. cit.*, p. 26; Lorimer, *op. cit.*, *passim*.

components.[46] The ineluctability of social metabolism is from one view a problem that any organization must solve in the interests of continuity and from another view a continual opportunity for adaptation and change.[47] Furthermore, a plausible case can be made that the processes of "fertility" and "mortality" provide revealing insights into the present character of an organization as well as predictions of its future shape. As a final note on the demography of organizations, it is evident that they themselves can be treated as individuals within a population of organizations of like type, to approach the changing structure of the larger society from another viewpoint.

It is probably true that many sociologists view population data with less than excitement because these seem to provide distributive descriptions of aggregates rather than structural information about groups. This perspective ignores the interdependency which must exist between the functioning of organizations and the demographic characteristics of the aggregates of members of these organizations. The institutional structure rests on a population base, in the sense that particular functions are dependent for their performance on the presence of particular categories of persons. The most elementary recognition of the point comes in the commonplace research practice of distinguishing three types of variables—dependent, independent, and control variables—with demographic data falling under the third heading. The implication is that the composition of the population plays a necessary role (almost tautologically so), but not a sufficient one, as a set of constraints on the degree and direction of change in the institutional structure.[48] Now abstracting from the population composition through the use of the control technique may be a useful practice in the static analysis of covariation, but these parameters become variables as time passes and the questions of social change arise. For analogous reasons, economic theory was able to progress without demographic variables only so long as economists failed to raise questions about economic development. Inquiry into the relationships between population composition and institutional structure promises large rewards for the person interested in developing a dynamic theory of society.

Finally the population model offers a strategy for helping to resolve one of the most frustrating methodological issues in the study of social change. Two modes of conceptualizing and describing change may be distinguished, termed loosely the qualitative and the quantitative. The former mode ordinarily appears as an approximately ordered sequence of discrete complexes which somehow replace or displace or merge with their temporal neighbors. Analysis relies on before-and-after comparisons or at the most on some variant of the idea of stages. With such conceptualizations it is most difficult to achieve operational precision, let alone statistical data. The latter mode of the study of change most commonly yields a precisely dated series of measurements of one or another particular element of a qualitatively homogeneous type. Precision of observation is achieved at the cost of qualitative richness. In some ways the demographic approach is a combination of these two procedures. The concept of a population suggests the examination of a succession of overlapping stages, based on elements of various qualitative (categorical) types, quantified in

[46] A penetrating early contribution to this discussion, which seems to have been ignored, is P. A. Sorokin, and C. Arnold Anderson, "Metabolism of Different Strata of Social Institutions and Institutional Continuity" (Comitato Italiano per lo studio dei problemi della popolazione [Rome: Istituto Poligrafico dello Stato, 1931]). Cf. Georg Simmel, "The Persistence of Social Groups," *American Journal of Sociology* (1897–98), trans. Albion W. Small; abridged in Edgar F. Borgatta and Henry J. Meyer (eds.) *Sociological Theory: Present-Day Sociology from the Past* (New York: Alfred A. Knopf, Inc., 1956), pp. 364–98.

[47] Ryder, "Cohort Analysis," *op. cit.*

[48] Cf. Hawley, *op. cit.*

terms of the frequency of each and the temporal distribution of individuals within the type, and the progression of aggregate indexes for the total population. A satisfactory dynamic theory of society requires a frame of reference that can establish propositions relating quantitative changes in "inputs and outputs" to the organizational transformations that they manifest and induce.[49] One such frame of reference is the concept of a population.

The case for the demographic contribution to the study of social change can easily be overstated. Clearly there are alternative procedures of great promise which have no particular connection with the population model. For example, there are many aggregate data of major significance for structural transformations such as the content of material and normative technology, and there are compositional data based on units of observation such as roles or norms rather than individuals, which require different kinds of model. But at the very least, population change provides a reflection of social change, conceived in any way, a reflection that deserves a place in efficient research because its data are well defined and well measured and its methodology is sophisticated.

VI. CONCLUSION

In this essay the demographer has been characterized as an agent for a particular type of model, the use of which implies particular kinds of measurements and particular directions of substantive inquiry. The influence the population concept might have on the shape of social analysis is threefold. In the first place, the demographer's mode of conceptualization never strays far from the mathematical in substance if not in language. This emphasis implies not only quantification but also persistent attention to some of the necessary components of explanation of societal behavior. Second, the demographic approach is both aggregative and distributive. The basic model is macroanalytic in form, and inclines the student toward a view of social systems in their totality. Nevertheless the model is so designed that it offers a convenient confrontation with some central issues of theorizing at different levels of organized reality. In particular the cohort provides an aggregative format within which the phases and facets of the individual life-cycle are imbedded, and through which the events experienced by the individual may be translated into the population processes that shape population structures. Finally the questions that are of central interest to the demographer are by definition dynamic. He is forced by his methodology to ask not so much about the association of characteristics as about the correlates of changes in characteristics, or, in his terms, about the perpetual interplay between occurrence and exposure. The central place of time in the demographic schema is most evident in the conceptualization of structure as a consequence of evolving process. Now these emphases all require qualifications, and particularly warnings, about what they neglect, but the same is true of any model. In the long run the utility of any approach to research is determined by the test of survival as measured by the fruits of inquiry in its image. To this writer the concept of a population has a high probability of high fertility.

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[49] T. Parsons, and Neil J. Smelser, "The Problems of Growth and Institutional Change in the Economy," in *Economy and Society* (Glencoe, Ill.: Free Press, 1956), pp. 246–94.