RM-76-68

DEMOMETRICS OF MIGRATION AND SETTLEMENT

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August 1976

Prepared for presentation at the British Section Meetings of the Regional Science Association, London, England, September 1976

Preface

Interest in human settlement systems and policies has been a critical part of urban-related work at IIASA since its inception. Recently this interest has given rise to a concentrated research effort focusing on migration dynamics and settlement patterns. Four sub-tasks form the core of this research effort:

I. the study of spatial population dynamics;

II. the definition and elaboration of a new research area called demometrics and its application to migration analysis and spatial population forecasting;

III. the analysis and design of migration and settlement policy;

IV. a comparative study of national migration and settlement patterns and policies.

This paper, the first in the demometrics series, argues the need for a theoretical foundation for large-scale modelling of demographic systems and calls for a unified application of mathematical and statistical methods to the study of demographic phenomena, particularly those of migration and settlement.

Related papers in the demometrics series, and other publications of the migration and settlement study, are listed on the back page of this report.

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August 1976

Abstract

Many of the systems analysis problems that have fostered simulation modelling seem to go through a methodological-theoretical progression that we call the theoretical transition. This transition begins when a few highly motivated individuals become converted to the belief that their field should adopt the more rigorous and quantified mode of research characteristic of the physical sciences and ends when the field achieves the metrics stage of development. Demography appears to be ready to enter this final stage and demometrics could be the outcome. The role of demometrics in research on migration and settlement is explored.

Acknowledgements

The author is grateful to John Miron and Frans Willekens for careful readings of an earlier draft and for a number of useful comments.

DEMOMETRICS OF MIGRATION AND SETTLEMENT

INTRODUCTION

The "population problem" in most parts of the world has two distinct dimensions: growth and spatial distribution. Concern about rapid population growth has focussed attention on fertility reduction and has fostered family planning programs in dozens of countries. The issue of population distribution, on the other hand, has only recently received serious consideration. A notable example appears in the work of the U.S. Commission on Population Growth and the American Future, which commissioned papers that directly addressed issues and problems of internal migration and human settlement:

> Major national attention and the Commission's primary focus has been on national population growth. But national growth implies local growth as additional population is distributed in the rural areas, small towns, cities and suburbs across the country. And choices we make about national population growth cannot help but have important meaning for local areas....
>
> Where people move inevitably affects the distribution of the population and the growth of local areas. As a result, any national distribution policy will, to some degree, try to intervene in the migration process by encouraging people to move to one place rather than another or not to move at all. [76, pp. xiv-xv, emphasis added.][1]

Despite a general recognition that migration processes and settlement patterns are intimately related and merit serious study, one nevertheless finds that the dynamics of their interrelationships are not at all well understood. An important reason for this lack of understanding is that demographers have in the past accorded migration a status subservient to fertility and mortality and have generally neglected the spatial dimension of population growth. Thus, whereas problems of fertility and mortality long ago stimulated a rich and scholarly literature, studies of migration have only recently begun to flourish. In consequence, one finds today a rather large and growing body of scholarly work on migration awaiting a systematic synthesis, e.g., the recent bibliographies of Greenwood [25]; Price and Sikes [55]; and Shaw [70]. The contributions of sociologists in identifying migration differentials (the "who" of migration), of geographers in analyzing directional migration streams (the "where" of migration), and of economists in examining the determinants and consequences of geographical mobility (the "why" and "so what" of migration) still have not been molded into a unified and general theory of internal migration.

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[1] The numbers in parentheses refer to publications listed in the References.

Out of the recently growing literature on migration, scholars at the International Institute for Applied Systems Analysis have identified and isolated four related research subtasks that are of particular relevance to IIASA's long-term research interests in human settlement systems. They are: the study of spatial population dynamics; the elaboration of a new research area called demometrics and its application to migration analysis and spatial population forecasting; the analysis and design of migration and settlement policy; and a comparative study of national migration and settlement patterns and policies.

This paper focuses on the second of the four subtasks--demometrics--and examines the fundamental role that theory plays in the development of quantitative models of spatial population growth and distribution.

THEORIZING ABOUT THEORY-BUILDING: THE THEORETICAL TRANSITION

The New Social Science

The past two decades have seen the emergence of a profound transformation in the ways in which social scientists have come to deal with data, theory, and quantitative modelling. This transformation has been variously referred to as the Quantitative Revolution or the Systems Analysis Approach, and some of its effects have recently become manifested in the explosion of new research areas bearing the term metrics, e.g., politimetrics [27], planometrics [86], and cliometrics [28]. Whether these new areas ever achieve the respectability currently accorded to econometrics, biometrics, or psychometrics, however, remains to be seen.

An important contributing factor to the recent quest for theoretical rigor and empirical quantification in the social sciences has undoubtedly been the development of large-scale computational facilities which have made the new approaches feasible. Another contributor to this transformation has been the postwar growth of interdisciplinary fields such as operations research, regional science, public policy analysis, urban planning, and management science. Finally, as today's social and environmental problems have dramatically moved to the forefront of public concern, it has become increasingly evident that energy, natural and human resources, economic development, and the quality of life are interrelated components that need to be dealt with holistically, with a proper recognition of their system-wide impacts. This has fostered a multidimensional mode of analysis commonly referred to as interdisciplinary research.

Interdisciplinary and Metadisciplinary Research

Because social and environmental problems do not fall neatly within the boundaries of traditional academic disciplines, it is not surprising that interdisciplinary collaboration is often held to be the appropriate approach for analyzing such problems. Since any nontrivial social or environmental problem will usually involve physical, social, ecological, economic, and political aspects,

> what is more sensible than to say, "Let us then get an expert in each of these fields, have the experts meet, present their special viewpoints and competencies, weigh the pros and cons as reasonable men, and as a body arrive at recommendations which are influenced by each of the contributing disciplines on each of the component problems"? [3, p. 169.]

William Alonso [3] argues convincingly that what at first glance seems like plain common sense, is in fact an inappropriate method for assembling a research team to study most social and environmental problems. He identifies four principal stumbling blocks to effective interdisciplinary research. First, a scientist is not a standard product capable of delivering his discipline's viewpoint on every subject. For example, the particular problem at hand may require the expertise of a benefit-cost economist, but the economist on the team might be an economic historian. Second, the system of institutional incentives and rewards in academia makes it very likely that the scientist will be either a mediocrity, a seniority, or an eccentric, because there are few scholars at the top of their field who are willing to take the time to contribute to an ad hoc interdisciplinary effort. Third, the indivisibility of scientific inputs to a team made up of representatives from each field contributes a certain degree of inflexibility to projects that may call for more work from one discipline and less from the others at different points in the project's lifetime. The typical consequence of this indivisibility is that one man is overworked while others may be idle. Finally, different intellectual species tend to use words differently and to attribute different degrees of importance to the various components of an overall study. They also hold different views about their own competencies and interests and those of their collaborators.

Alonso's alternative to the interdisciplinary team is a group of metadisciplinary individuals who "share a defined range of topics, a body of techniques, and certain standards of validation. They share, to a large degree, a technical language and competence, and they read much of the same literature." [3, p.171.] The principal distinction between interdisciplinary and metadisciplinary teams of scientists is that members of the former are assembled because of their diversity, whereas the latter are brought together because of their commonality.

Systems Simulation Modelling

A central element of many applied interdisciplinary research efforts has been the large-scale systems simulation model. Such models seem to be particularly appealing in studies of public investment decisions involving broad social goals, wide external system effects, and long-range planning horizons. Urban highway and mass transit proposals, land use plans, public works projects, demographic-economic development programs, environmental impact statements, and urban renewal analyses all have fostered computer simulation studies. It is argued that because the complexities inherent in such socio-physical systems almost always produce nonlinear relationships and feedbacks, traditional analytical methods are ineffective and recourse must therefore be made to the vast computational capabilities of the digital computer. And since the behavior of such systems depends on an intimate interplay of social, economic, political, and engineering considerations, prospects for their proper incorporation are said to be enhanced by an early adoption of a large-scale systems simulation model that interconnects their separate contributions in the form of linked "modules" or submodels. The underlying philosophy seems to be that if the behavior of parts is known by disciplinary experts then the behavior of the whole can be understood by appropriately linking the diverse individual components together into a larger (interdisciplinary) ensemble. Although the idea sounds as plausible as the rationale for interdisciplinary collaboration, it is equally flawed.

The fallacy that the unpredictable future behavior of a complex system can be adequately simulated, without a theory, by joining together submodels that describe the generally predictable behavior of a system's component interacting parts seems to have an expected lifetime of about ten years. Apparently it takes about a decade for those newly-engaged in simulation modelling to discover the disappointing truth that without a theory of system behavior there can be no firm conclusions about such behavior. A mere linking of statistically-established empirical regularities simply will not realistically simulate system behavior under changed conditions.

The Theoretical Transition

Many of the applied systems analysis problems that have fostered simulation modelling seem to go through a methodological-theoretical progression that is strikingly similar in character --a progression that in this paper will be referred to as The Theoretical Transition. The theoretical transition begins when a few highly motivated scientists become converted to the belief that research efforts in their particular area of concern would benefit from the adoption of the more rigorous and quantified style characteristic of the physical sciences. Mathematical curve-fitting exercises become popular, regression and factor

analysis are discovered, and a heightened sense of expectancy fuels the movement. This is the preconditions stage of the transition, and it logically leads into the second stage, which is the take-off stage. At this point the simulation paradigm is discovered and widely adopted, and limitations and extensions follow rapidly. Conferences are held, curricula are suitably modified and expanded and, occasionally, new journals are established.

Then comes the crash, and disillusionment sets in. The models do not predict well, their costs escalate astronomically as they are continually expanded to serve a wider range of purposes and patched-up to produce "reasonable" outputs, little is contributed by them to theory-building or to policy evaluation, and their magic recedes mirage-like. It is concluded that systems modelling without the overall guidance of a credible theory is fraught with difficulties, and the movement becomes stalled until a new and different set of preconditions for take-off is satisfied. These new preconditions revolve around the emergence of one or more theoretical paradigms that command the support of a large enough body of scientists for the modelling movement to proceed once again (e.g., the Keynesian paradigm in macroeconomic modelling). At this point the movement enters the final stage of the theoretical transition--the metrics stage.

Not all applied social systems analysis areas have experienced, or will experience, all of the above stages from preconditions to metrics, but a surprisingly large number of them either have or seem to be in the process of doing so. Two areas, in particular, offer instructive lessons: land use simulation modelling and economic-demographic simulation modelling.

Land Use Simulation Modelling

A land use simulation model is a mechanism that allocates people and jobs to land located in the subareas or zones that together define a particular study region. The population may be disaggregated by age and income, and employment may be differentiated by industrial sector. The model begins with a base-year description of the system and proceeds to simulate its spatial dynamics by locating increments and decrements of population and employment on the basis of some set of rules such as the gravity law of social physics.

First-generation land use simulation models were born in North America in the early 1960s and effectively died there before the end of that decade. The preconditions stage occurred in the late 1950s, when pioneering studies such as the Chicago Area Transportation Study [11] first collected and summarized relatively large quantities of land use data by means of electronic computing hardware and statistical techniques. Entry into the take-off stage was signalled by the development and implementation of models such as the Lowry model [42] and the Chapel Hill model [19]. The crash occurred sometime before 1970 and the movement (at least in the U.S.) then turned to fundamental theory-building of the kind exemplified by the works of Beckmann [5], Mills [45], Muth [52], and Wheaton [81,82].

A sure sign that the crash stage of the theoretical transition has been reached is an attack on the movement by one of its own. In land use simulation modelling this occurred in 1973 with the publication of Lee's well-known article "Requiem for Large-Scale Models" [37] in which he asserts:

> these models were begun in the early 1960s and largely abandoned by the end of the 1960s. Considerable effort was expended on them, and a good deal was learned. Contrary to what has often been claimed, what was learned had almost nothing to do with urban spatial structure; the knowledge that was increased was our understanding of model building and its relationship to policy analysis [37, p. 163].

Economic-Demographic Simulation Modelling

Although different economic-demographic simulation models exhibit somewhat different peculiarities and emphases, they generally share certain distinct features. In all, the process of population growth and economic development proceeds according to model dynamics that have remained essentially unchanged for over two decades. A population disaggregated by age, sex, location, and other attributes such as income and education, is survived forward in time by the appropriate application of rates that are either assumed to vary in a certain way, or that are linked to variations in "explanatory" socioeconomic variables, some of which are internally generated by the model. Underlying most of the economic submodels is either a Cobb-Douglas production function or a dynamic Leontieff input-output system. Various behavioral relationships are built-in, and numerous feedback loops connect the population submodel with the economic submodel and vice versa.

The preconditions stage of economic-demographic simulation modelling occurred in the late 1950s, at which time contributions such as the pioneering 1958 Coale-Hoover study [15] provided the fundamental conceptual framework that spawned a host of successors in the 1960s. The take-off stage was entered in the mid-1960s, when simulation models such as General Electric's TEMPO-I model [73] became available. In the early 1970s the movement was in full flower and produced a second generation of much larger models such as TEMPO-II [10], the International Labor Organization models BACHUE-1 and BACHUE-2 [8,80] and the Rogers-Walz West Virginia model [62]. The crash stage has either already occurred or is due shortly. The preconditions for a second take-off appear to be forming as economists are establishing a firm intellectual beach-head in population economics, with a particularly spectacular recent spurt of theoretical work on the economics of fertility [39,68,69] and migration [9,17,75].

A reliable indicator that the crash stage of the theoretical transition has already occurred in economic-demographic simulation modelling is the recent appearance of a sharp critique of the movement. Arguing along lines that in many ways

resemble those of Lee [37], Arthur and McNicoll [4] conclude that large scale economic-demographic simulation models are of little use to planners because they are

> ...large, structurally inflexible, overdressed in side issues, and beyond proper validation. Largeness and algebraic complexity are not, in themselves, crimes: complex problems call for complex models, and simulation is well suited to such analysis. But the complexity of development problems puts a premium on the relevance and validity of model specifications and the wise use of economic theory. A model in which much is irrelevant to a particular issue, is likely to oversimplify and distort the issue. And a model that is concerned more with its own behavior than with the degree to which its constituent parts capture reality is not a trustworthy guide to policy [4 , p. 262].

A Summing Up

The birth and development of the "new social science" in the postwar years has fostered a more rigorous, analytical approach in studies of a wide variety of social and environmental problems. Early interdisciplinary analyses of such problems often produced large and complex computer simulation models which failed to meet most of the goals that brought them into being. Growing recognition of the fundamental importance of theory and a gradual evolution of metadisciplinary scientists have combined to channel research activities away from a simple linking-up of statistically estimated empirical regularities toward a form of theory-building that is characterized by its successful marriage of theory, mathematics, and statistical interence. This final stage of the theoretical transition may be called the metrics stage of a field's development, and an obvious example of a social science that is well into this stage is economics. Other fields are at the point of entry; still others are either in the preconditions stage or have long ago entered the take-off stage. Demography appears to be poised to enter the final stage--one identifiable as demometrics.

DEMOGRAPHIC THEORY AND DEMOMETRICS

The resolution of several major population policy issues hinges on the answers that theory can give to fundamental questions about national and regional development. Will the per capita income of a poor country increase faster if its fertility is reduced? Should such a country invest heavily in family planning programs, or can it safely assume that fertility will decline rapidly once the income of its population is raised sufficiently beyond a subsistence level? Are certain major cities becoming excessively large, and should their inmigration rates be reduced? Or are large cities "engines of development" that generate benefits which increase with city size

more rapidly than do costs, and is population decentralization and dispersal an automatic ultimate consequence of affluence and modernization? Is rural-to-urban migration a determinant or a consequence of economic growth? Should countries such as India continue to invest a large proportion of their resources in the industrial sector, or should some of this investment be redirected toward agricultural development programs that might keep more of the rural population in the villages and away from the squatter settlements of major urban centers?

Answers to questions such as these will need to draw on a theory that as yet does not exist. The absence of a convincing theoretical analysis of these questions may explain much of the disagreements that seem to increasingly characterize international debates on such matters, e.g., the discussions at the 1974 World Population Conference in Bucharest [85]. So long as the relationships between population dynamics and socioeconomic development are shrouded in mystery, policymakers are unlikely to act against their intuition and self-interest in establishing population policies.

Demographic Theory

Following the precedent set by economics, the emerging concepts, generalizations, and paradigms that collectively might be viewed as the first bits and pieces of a demographic theory fall into two principal categories: macro and micro. Macrodemographic theory examines the behavior of global aggregates, for example, the relationships between various populations defined with reference to age, sex, and location and indicators of industrialization, modernization, and economic well-being. Microdemographic theory studies the behavior of decisionmaking units such as the individual or the family.

A starting point in the macrotheory of population is the so-called theory of demographic transition, which elaborates the principal theme that in today's developed countries a decline in death rates was followed, after a certain lag, by a decline in birth rates. The search for an explanation that could satisfactorily relate the decline in mortality and fertility to specific socioeconomic changes has fostered a vast literature but little in the way of theory.

Development, wherever it occurs, seems to eventually bring about a lowering of the rate of population growth. This has been the historical record in the developed world, and there are indications that it also is becoming true of certain less developed countries. The transition begins with a decline in mortality, which may be attributed to advances in medicine, public health measures, and improved living conditions. It ends with a delayed but matching decline in fertility, the reasons for which are the subject of some dispute among economists and sociologists. The delay produces a sudden spurt in population growth.

A geographer recently asserted that demography has only two theoretical paradigms: the theory of demographic transition and the laws of migration [87]. He elaborates on this idea and comes up with an intriguing hypothesis which he calls the mobility transition:

> There are definite, patterned regularities in the growth of personal mobility through space-time during recent history, and these regularities comprise an essential component of the modernization process [87, pp. 221-222].

The hypothesis of the mobility transition seems to be in accord with recently available empirical evidence. Larry Long, for example, finds that the expected number of lifetime moves for an American has been around 13 since 1960, whereas the corresponding measure for a Japanese has increased from about 4 moves in 1960 to over 7 moves in 1970 [40,41]. The lifetime quota for the British seems to have stabilized around 8 moves per capita while that of the Irish is less than half of that total. A simple plot of these migration expectancies against such proxies of development and modernization as per capita income indicates a decidedly positive association.

Studies currently in progress at IIASA suggest that the spatial dimension of the mobility transition hypothesis also has considerable validity. Specifically, it appears to be the case that the transformation of a low-income, principally agrarian economy into an high-income industrialized modern economy may be characterized in terms of spatial migration expectancies that disaggregate expected moves and lifetimes by places of birth and residence [57,58]. Such indicators of geographical mobility may be used to show that rural-urban migration grows and dominates during the early stages of development, then levels off and ultimately declines as inter-urban migration becomes the principal form of interregional migration. More recent trends indicate that the last stage in this transition is one of deconcentration and dispersal [41].

Patterns that seem to be clear at the macro level often become somewhat blurred at the micro level. For example, the most common generalization suggested by the accumulating census and survey data on fertility is that lower birth rates tend to be associated with higher economic status. Per capita income is negatively correlated with fertility. Yet the early empirical studies of fertility and development show a positive association [1,79] and common-sense considerations argue that increased affluence leads people to consume more rather than less of most goods. What is the answer? The new microeconomic theory of fertility provides an interesting explanation. It argues

> ...that increased affluence causes people to buy more of most things, the exceptions being labeled inferior goods. Since no one considers children inferior goods, many argue that children and income "really" are positively related, but the relation is concealed by the intervention of other factors. The better-off have access to contraceptives of which the poor are ignorant; the better-off have higher quality (that is, more expensive) children, and so can afford fewer of them [32, p. 280].

Although this general model of the determinants of human fertility is not fully persuasive to some non-economists (who might argue, for example, that the major contributing factors to changes in fertility behavior are changes in tastes, attitudes, and nuptiality patterns) it does nevertheless demonstrate the importance of a microtheoretical assessment of empirical trends. Similar illustrations of this sort may be found in some of the recent efforts to develop a microtheoretic explanation of migration using the concepts of imperfect information, job search, and investment in human capital [17, 46,54].

While the effects of development on population growth are reasonably clear and the links of causation seem to be in general accord with the empirical evidence, the same cannot be said with regard to the inverse question concerning the effects of population growth on development. Here there is much confusion and controversy.

The negative consequences of rapid population growth on development are several. Rapidly growing populations have proportionately many more children and higher dependency ratios. Children have to be fed and educated, and this diverts resources that otherwise could be applied towards industrial development programs. Larger populations, it has been argued, give rise to diminishing returns to fixed factors of production--resource and capital limitations combining to guarantee that more people will have fewer resources per capita to work with. Finally, excessively large flows of rural to urban migrants in developing countries create rapid rates of urbanization and increasing levels of urban unemployment. The phenomenal growth of urban areas has strained the urban infrastructure and has fostered congestion, pollution, and an assortment of other human and social ills.

But these simple neoclassical, Malthusian, and physical planning paradigms are increasingly being challenged in today's development literature [31,38,53]. The impacts of population growth on the quality of the labor force, on the rate of technological progress, on savings behavior, and on the amount of technical change embodied in new capital goods all are important considerations that have not been adequately incorporated into the theoretical discourse. And the question of optimal human settlement patterns and hierarchies is a hotly contested

issue which badly needs the kind of illumination that a good theory brings [2 , 7 ,78]. Thus, despite the large and growing literature on the relationships between population dynamics and socioeconomic change, our understanding of these matters is still woefully inadequate with the result that

> There is an embarrassing gap between the confident assertions by prominent statesmen and international organisations which blame population growth for most of the evils of the world, and the hesitant and circumspect positions taken by those economists and demographers who have not turned crusaders.... In fact, one is tempted to say that the more rigorous the analysis and the more scrupulous the examination of the evidence, the smaller is the role attributed to population as an independent source of economic problems [53, p.3].

Ohlin attributes the underdeveloped status of demographic-economic theory to the fallacious tendency to "distinguish between the study of the determinants of fertility or population growth, which was left to sociologists, and the consequences of population growth, which were supposed to be explained by economists" [53, p.4]. Irrespective of whether he is right or wrong, it is clear that an adequate demographic theory will have to recognize and interact with the broader themes of socioeconomic growth and development. In consequence, the rate of theoretical progress is likely to be very slow, because to

> appreciate the impact of population growth implies an adequate theory of economic development. As long as most of the variance in economic growth remains unexplained, there is no reason for us to expect to understand very much more when we consider the impact of an additional complex nonstandardized macro variable [38, p.233].

The Importance of Theory

Despite the popularly held belief that "the facts speak for themselves", it is nevertheless true that the most important causal relationships in demography cannot be established without an underlying theory. Indeed the dictum "no theory-no conclusions" is the central fact of scientific research.

Consider, for example, the economist's proposition that migration is a response to differential economic opportunities --notably in employment. Is this proposition in conformity with the frequently observed positive correlation between a region's inmigration and outmigration rates [44, 72]? Does the existence of such a correlation invalidate the view that internal migration is a response to various "pushes" at the region of origin and "pulls" at the region of destination? Cordey-Hayes

[16] seems to argue that it does:

> Areas with the highest in-migration rates also had the highest out-migration rates...this is clearly not in agreement with the hypothesis that in- and out-migration per capita are inversely related; it suggests that most migrants move from a position of economic strength rather than weakness, and consequently imposes significant reservations on push-pull approaches to migration [16, p.806].

Does the positive correlation between outmigration and inmigration rates invalidate the economic push-pull theory of migration? Decidedly not. Cross-sectional analyses prove nothing concerning longitudinal changes. Simon [71], for example, has demonstrated that the negative association between fertility and income, often observed in cross-sectional data, is not inconsistent with the positive association observed in (short-run) time series data. His arguments are equally applicable to migration.

Several demographers have put forward the view that migration may be a self-generating process in which today's inmigrants are tomorrow's outmigrants. This focus on migration-prone individuals appears, for example, in the work of Goldstein [24], Lee [36], and Morrison [49]. If such a view is valid, then it can be readily shown that a positive correlation between outmigration and inmigration rates is not inconsistent with the push-pull hypothesis. Indeed, the sign of the correlation depends on the interactions of certain "hidden" variables such as age and employment. To see this more clearly, one must engage in a little bit of theorizing. For ease of exposition we shall restrict our attention to the simplest static models and will always omit the error term at the end of each equation.

Demographers have long recognized that migration is strongly age selective. Most migrants are young, and typically over half of the individuals in any internal migration stream are under 25 years of age [56]. Hence a region with a relatively young population is likely to also have a relatively mobile population. Thus if O is a region's outmigration rate and C is the proportion of its population that is under 25 years of age, then

$$O = a_1 + a_2 C \qquad a_2 > 0 \tag{1}$$

Because most migrants are young, it seems reasonable to suppose that

$$C = b_1 + b_2 I \qquad b_2 > 0 \tag{2}$$

where I is the region's inmigration rate.

Substituting (2) into (1) gives

$$O = (a_1 + a_2 b_1) + a_2 b_2 I$$
$$= A_1 + A_2 I \qquad A_2 > O \tag{3}$$

and yields a positive correlation between outmigration and inmigration.

Now assume that demographers and economists are both correct, and suppose that a region's outmigration rate, O, may be expressed as a linear function of its inmigration rate, I, and unemployment rate, U:[2]

$$O = a_1 + a_2 I + a_3 U \qquad a_2 > O \tag{4}$$

Let the inmigration rate be a simple linear function, with a negative slope, of the region's unemployment rate:

$$I = b_1 - b_2 U \qquad b_2 > O \tag{5}$$

Using (5) to eliminate U in (4) gives

$$O = \left(\frac{a_1 b_2 + a_3 b_1}{b_2}\right) + \left(\frac{a_2 b_2 - a_3}{b_2}\right) I$$
$$= A_1 + A_2 I \tag{6}$$

It is readily apparent that the correlation between O and I will be positive if $a_2 b_2 > a_3$ and negative if the inequality sign is reversed. As it stands, therefore, Equation 6 alone can tell us nothing about the validity of the push-pull hypothesis.

It may be instructive, at this point, to expand our simple example to recognize possible reciprocal causations. Let us adopt the perspective of an anti-theoretical empirically-minded social scientist who throws in a large number of

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[2]We shall frame our arguments around the unemployment rate as an indicator of the economic health and attractiveness of a regional economy. This may not be the best indicator, but any other would not appreciably change our principal arguments and conclusions.

potential explanatory variables into a regression equation with the idea of selecting that subset of variables which accounts for the largest proportion of the variance. Such an approach might begin with the following pair of equations:

$$O = a_1 + a_2 I + a_3 C + a_4 U \tag{7}$$

$$I = b_1 + b_2 O + b_3 C - b_4 U \tag{8}$$

Observe that, once again, a positive correlation between O and I reveals nothing about the push-pull hypothesis, since in using (8) to eliminate C in (7), for example, we return to the relationship set out earlier in (4) and arrive at the same basic indeterminacy that appeared in (6).

But Equations 7 and 8 also illustrate a more general fundamental problem--one which econometricians have defined to be the problem of identification [20].

When an econometrician is engaged in estimating the parameters of a behavioral or technological relationship put forward by a mathematical economic theory, he is engaged in what is known as structural estimation. Very frequently, the structural equation to be estimated is part of a system of such equations all of which are assumed to hold simultaneously. In such a case the parameters of any single equation cannot logically be determined on the basis of empirical data alone. Some a priori assumptions are required in order to reduce the number of unknown items of information so that the "true" equation can be distinguished (i.e., identified) from all of the mathematically equivalent alternatives that imply the same empirical results. The logical source for such a priori information is a theory.

> Indeed what makes an equation "structural" is the existence of a theory which predicts a relationship among variables which appear therein. That theory provides necessary a priori information without which the very existence of a structure to be estimated would not be perceived...it does not suffice to know that the equation to be estimated contains precisely a specified list of variables. It is also necessary to know what variables are contained in other simultaneously holding equations or to have other information about the equation in question. Without such additional information, structural estimation is a logical impossibility. One literally cannot hope to know the parameters of the equation in question on the basis of empirical observations alone, no matter how extensive and complete these observations may be [20, pp. 1-2].

The heart of the problem lies in the inability of data alone to distinguish between the "true" system of relationships and the many other systems of relationships that can generate the same observations. For example, if one takes λ times Equation 8 and adds the result to Equation 7, the resulting equation, when solved for O will be indistinguishable from Equation 7 so far as the data are concerned. Similarly, if one multiplies Equation 7 by μ and adds the result to Equation 8, the resulting equation, when solved for I, will be indistinguishable from Equation 8. The "false" equations will be

$$O = \left(\frac{a_1 + \lambda b_1}{1 - \lambda b_2}\right) + \left(\frac{a_2 - \lambda}{1 - \lambda b_2}\right) I + \left(\frac{a_3 - \lambda b_3}{1 - \lambda b_2}\right) C + \left(\frac{a_4 - \lambda b_4}{1 - \lambda b_2}\right) U$$

$$= A_1 + A_2 I + A_3 C + A_4 U \qquad (9)$$

and

$$I = \left(\frac{b_1 + \mu a_1}{1 - \mu a_2}\right) + \left(\frac{b_2 - \mu}{1 - \mu a_2}\right) O + \left(\frac{b_3 + \mu a_3}{1 - \mu a_2}\right) C - \left(\frac{b_4 - \mu a_4}{1 - \mu a_2}\right) U$$

$$= B_1 + B_2 O + B_3 C - B_4 U \qquad (10)$$

Without further information, so long as $\lambda b_2 \neq 1 \neq \mu a_2$ and Equations 9 and 10 are independent, the "true" equations in (7) and (8) cannot be distinguished from any other pair of equations given by (9) and (10) and various values of λ and μ.

Suppose, however, that we have a priori information given to us by a theory that allows us to ignore the influence of unemployment in (7) and that of age composition in (8). Then

$$O = a_1 + a_2 I + a_3 C \qquad (11)$$

$$I = b_1 + b_2 O - b_3 U \qquad (12)$$

and the two equations are identifiable. Solving for the "reduced form" of the system in which each endogenous variable is a function only of the exogenous variables, we find

$$O = \left(\frac{a_1 + a_2 b_1}{1 - a_2 b_2}\right) + \left(\frac{a_3}{1 - a_2 b_2}\right) C - \left(\frac{a_2 b_3}{1 - a_2 b_2}\right) U$$

$$= A_1 + A_2 C - A_3 U \qquad (13)$$

$$I = \left(\frac{b_1 + a_1 b_2}{1 - a_2 b_2}\right) + \left(\frac{a_3 b_2}{1 - a_2 b_2}\right) C - \left(\frac{b_3}{1 - a_2 b_2}\right) U$$

$$= B_1 + B_2 C - B_3 U \qquad (14)$$

Now, clearly, we can identify (11) and (12). Given consistent estimates of A_1, A_2, A_3, B_1, B_2, and B_3, we can "recover" the consistent estimates of a_1, a_2, a_3, b_1, b_2, and b_3. For example, given A_2 and B_2, we can solve for b_2:

$$b_2 = \frac{B_2}{A_2}$$

and, given A_3 and B_3, we can derive

$$a_3 = \frac{A_3}{B_3} \quad .$$

The question that now may occur is whether structural estimation is really so important as to warrant such careful attention. If theory is unavailable or is of questionable validity, might not it be better to simply observe historical correlations among a set of variables and then predict the future by assuming a continuation of past relationships? Why not avoid making any prior assumptions altogether and simply use the least-squares estimates that come from the fitting of Equations 7 and 8 (or, equivalently, Equations 9 and 10) to observed data?

The answer is that this does not provide us with an adequate explanation of the relationships. So long as the basic situation does not change and if simple short-run predictions are the principal goal of the exercise, a statistical-correlational extrapolation may indeed be adequate. But if anything happens to alter the basic situation (i.e., if a "turning point" occurs), theoretical knowledge about structural relationships is indispensable. Without it we can have no idea what to expect from a sudden change in the value of a structural parameter or of an exogenous variable. For example, what would be the effects on a region's migration rates if fertility were suddenly to rise, increasing the value of C in the model described in Equations 7, 8, 9, and 10? Since the "true" effect given by a_3 and b_3 is confounded with other influences in the estimates A_3 and B_3, we cannot anticipate the consequences.

But there is also a very practical objection to simple correlational predictions. Theory-building is very often undertaken in order to aid policymakers in evaluating the

probable consequences of alternative interventions into social and environmental systems. To foresee such consequences one must have reasonably accurate estimates of the system's structural parameters.

Take the case of the "chicken-egg" controversy in the recent migration literature [43,51]. What is the relationship between migration and employment growth? Are differential rates of migration induced by differential rates of growth in employment, or is it the other way around? Proponents of the first view--the demand view--argue that it is the external ("export") demand for a region's outputs that creates jobs and these new jobs induce labor-force inmigration. Supporters of the second view--the supply view--argue that it is local labor-market dynamics that chiefly determine a region's growth in jobs. Recent evidence suggests that migration and employment growth each affect and are affected by the other, with the former effect dominating the latter [26,30]. Such a conclusion cannot be established without a convincing theory, and policies directed toward improving conditions in underdeveloped and declining regions, for example, cannot be truly effective without the understanding provided by such a theory.

Demometrics

A growing dissatisfaction with the qualitative-deductive character of economics led to the founding in 1930 of the Econometric Society with the avowed purpose of relating theory to observed data by transforming the discipline into a quantitative-empirical one. Growing interest and achievements in population research suggest that an analogous situation could well arise in demography during the next decade, even perhaps to the extent of the founding of a Demometric Society and the establishment of a journal entitled Demometrica.

Literally, demometrics means demographic measurement, and measurement forms an important part of demometrics. But purely descriptive statistics about population compositions or growth rates and nonmathematical theorizing are not demometrics.

The essence of demometrics is the union of demographic theory, mathematics, and statistics. Mathematical demographic theory studies the relationships between demographic and socioeconomic variables in algebraic terms- these relationships become part of demometrics when they take on numerical values that are estimated from observations. Statistical methods and techniques deal with relationships between variables, but unless these variables include variables from demographic theory, the results are not part of demometrics. Demometrics is distinguished by its fusion of the deductive approach of mathematics, the inductive approach of statistics, and the causal approach of demographic theory. Its principal objective is to establish quantitative statements regarding major demographic variables that either explain the past behavior of such variables or that forecast (i.e., predict) their future behavior.

In striving to explain the past behavior of demographic variables, demometrics necessarily deals with the formulation and empirical determination of demographic hypotheses and with the specification and estimation of systems of relationships. Thus it plays a pivotal role in demographic theory-building, using numerical data to verify the existence and define the form of relationships such as those postulated in the hypotheses of the demographic and mobility transitions, the fertility-income function, the push-pull and the chicken-egg arguments of migration, and other such "laws" of population growth and change.

Demometrics also has an important role to play in demograhic forecasting. When in 1938 the U.S. National Resources Committee carried out a major demographic projection of the future U.S. opoulation, it adopted a set of "reasonable" assumptions with regard to future fertility, mortality and net immigration and then projected the total U.S. population in 1980 to be 158 million [77]. The U.S. population passed the 158 million mark less than fifteen years later and today exceeds 210 million individuals.

It is difficult to fault such projections, for it is unlikely that any competent demographer, faced with the same situation, would have come up with radically different results. How then, can demometrics improve the accuracy of such exercises in social prediction?

The projection by the U.S. National Resources Committee, like most projections, did not link demographic variables with economic variables. Until very recently, this has been a standard practice in both disciplines. That is, demographers typically have given economic variables only cursory treatment in their models, and economists have accorded demographic variables a similar status. In the words of Hoover [29]:

> Purely demographic and purely economic models...are multitudinous and often highly complex. This makes even more striking the relatively primitive state of the art that prevails in the linking of demographic and economic variables [29, p. 73].

Much of the future work in demometrics, therefore, will undoubtedly be directed toward advancing the state of the art in consistent demo-economic forecasting. It is likely that this work will borrow extensively from the successful example set by econometrics, and macrodemometric forecasting models will probably reflect many of the characteristics of macroeconometric models of national and regional economies.

Macrodemometric models are systems of equations that represent the fundamental relationships between, and the behavior over time of, such major demo-economic variables as birth rates, migration rates, labor force participation rates, unemployment rates, employment, output, investment, and population. Such models may be used for forecasting and also for policy analysis.

The variables in a "reduced form" macrodemometric model belong to two different classes: those that appear on the left-hand side of the equations and those that do not. The former are called endogenous variables, and their values are determined by the model (the number of equations in a macrodemometric model, therefore, is equal to the number of endogenous variables). The magnitudes of the latter variables, the predetermined variables, are set outside the model[3]. Associated with each set of predicted values for the predetermined variables is a model-generated solution for the endogenous variables called a forecast.

There are two important reasons for studying relationships among demo-economic variables: the forecasting reason and the policy analysis reason. Policymakers need accurate population forecasts in order to scale investment decisions made in response to, or in anticipation of, population-generated demands. They also need a reliable tool for pretesting the probable consequences of alternative courses of action. These two objectives are not necessarily incompatible, and it should be possible to construct macrodemometric models that satisfy both.

MIGRATION AND SETTLEMENT

The central focus of this paper has been demographic theory-building and demometrics. In the Introduction we noted that such research constituted one of four interrelated subtasks currently being carried out within the Migration and Settlement Study at IIASA. We shall now conclude the paper by briefly describing the broad outlines of the other three subtasks in order to more clearly identify the role of demometrics in the overall study. The three other subtasks are the dynamics, the policy, and the comparative study subtasks.

Dynamics

The unanticipated postwar baby boom had a salutary influence on demographic research. Extrapolations of past trends appropriately adjusted for expected changes in the age, sex, and marital composition of the population were very much wide of the mark. So long as trends were stable, demographic projections prospered; but when a "turning point" occurred, the projections floundered. The net result was increased pressure to consider the complex interrelationships between fertility behavior and socioeconomic variables.

But the poor predictive performance also had another important effect--it stimulated research in improved methods for measuring fertility and for understanding the dynamics by which it, together with mortality, determines the age composition of a population [12,66]. Inasmuch as attention was principally directed at national population growth, measurement of internal migration and the spatial dynamics through which it affects a national

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[3]Predetermined variables consist of exogenous variables and lagged (previously) endogenous variables.

settlement pattern were neglected. This neglect led Dudley Kirk [34] to conclude, in his 1960 Presidential address to the Population Association of America, that the study of migration was the stepchild of demography. Sixteen years later, Sidney Goldstein echoed the same theme in his Presidential address to the same body:

> ...the improvement in the quantity and quality of our information on population movement has not kept pace with the increasing significance of movement itself as a component of demographic change.... Redistribution has suffered far too long from neglect within the profession.... It behooves us to rectify this situation in this last quarter of the twentieth century, when redistribution in all its facets will undoubtedly constitute a major and increasingly important component of demographic change... [23, pp. 19-21].

Improved methods for measuring migration and understanding its important role in human population dynamics is a central research focus of the Migration and Settlement Study at IIASA. The search for improved methods for measuring migration has stimulated our research on the construction of multiregional life tables, and the need for a better understanding of spatial population processes has fostered a study of the fundamental "laws of motion" of spatial population growth and distribution.

Multiregional life tables are members of a special class of life tables known as increment-decrement life tables [61,67]. They view inmigration as a form of increment and treat outmigration and death as a form of decrement. Such life tables describe the evolution of several regional cohorts of babies, all born at a given moment and exposed to an unchanging multiregional age-specific schedule of mortality and migration. For each regional birth cohort, they provide various probabilities of dying, surviving, and migrating, while simultaneously deriving regional expectations of life at various ages. These expectations of life are disaggregated both by place of birth and by place of residence, and reflect, therefore, the influences both of mortality and of migration. Thus they may be used as indicators of levels of internal migration, in addition to carrying out their traditional role as indicators of levels of mortality.

Ordinary single-region life tables normally are computed using observed data on age-specific death rates. In countries lacking reliable data on death rates, however, recourse is often made to inferential methods that rely on model life tables such as those published by the United Nations [13]. These tables are entered with empirically determined survivorship proportions to obtain the particular expectation of life at birth (and corresponding life table) that best matches the levels of mortality implied by the observed proportions.

The inferential procedures of the single-region model may be extended to the multiregional case [59]. Such an extension requires the availability of model multiregional life tables and uses a set of initial estimates of survivorship and migration proportions to identify the particular combination of regional expectations of life, disaggregated by region of birth and region of residence, that best matches the levels of mortality and migration implied by these observed proportions.

Model multiregional life tables approximate the mortality and migration schedules of a particular multiregional population system by drawing on the regularities observed in the mortality and migration experiences of other comparable populations [60]. To construct such tables, we are currently summarizing the principal empirical regularities exhibited by observed age-specific patterns of migration in a number of IIASA member nations. These will be used to generate model tables that will provide demographers with a means for systematically approximating the migration schedules of populations lacking migration data. Our aim, in short, is to accomplish in the area of migration analysis what the United Nations model life tables contributed to the analysis of mortality.

The evolution of every spatial human population is governed by the interactions of birth, deaths, and migration. Individuals are born into a population, age with the passage of time, reproduce, and ultimately leave the population because of death or outmigration. These events and flows enter into an accounting relationship in which the growth of a regional population is determined by the combined effects of rates of natural increase (birth rates minus death rates) and rates of net migration (in-migration rates minus outmigration rates).

A change in any one of these component rates affects the dynamics of the spatial demographic system, but it occasionally does so in ways that are not immediately self-evident. Our studies of such sensitivity analyses have led us to develop sensitivity functions that relate a change in a particular component rate to the corresponding changes in various spatial demographic statistics [84]. In this analysis we have used matrix differentiation techniques to derive analytical expressions that establish the impacts of changing rates on multiregional life table statistics, population projections, and stable population characteristics. These sensitivity functions reveal how each spatial demographic characteristic depends on age-specific rates and how it reacts to changes in those rates.

Increasing concern about the sizes and growth rates of national populations has generated a vast literature dealing with a particular form of sensitivity analysis, namely the demographic consequences of a reduction of fertility to replacement levels and the consequent evolution of national populations to a zero growth condition [22,65]. But where people choose to live in the future presents issues and problems that are potentially as serious as those posed by the number of children they choose to have.

Yet the spatial implications of reduced fertility have received relatively little attention and we are, in consequence, ill-equipped to develop adequate responses to questions about the ways in which stabilization of a national population is likely to affect migration and local growth[4].

We have considered some of the redistributional consequences of an immediate reduction of fertility to bare replacement levels and have found that stabilization of a multiregional population system will alter the relative contributions of natural increase and migration to regional population growth [63]. The redistributional effects of stabilization will depend in a very direct way on the redistributional pattern of total births that is occasioned by fertility reduction. Regional age compositions will also be affected, and in ways that are strongly influenced by the age patterns of migration. Retirement havens, for example, will receive proportionately higher flows of inmigrants as a national population increases in average age, whereas destinations that previously attracted mostly younger migrants will receive proportionately fewer inmigrants.

Finally, as demographers have come to model dynamic socioeconomic systems of growing size and complexity they have been forced to rely on ever more sophisticated high-speed digital computers. However, their capacity for handling large-scale systems has not kept pace with the growing demands for more detailed information. Consequently, it is becoming especially important to identify those aspects of a system which permit one to deal with parts of it independently from the rest or to treat relationships among particular subsystems as though they were independent of the relationships within those subsystems. These questions are those of aggregation and decomposition, respectively, and their application toward "shrinking" large-scale population projection models is an important element of our spatial population dynamics subtask [57].

We have adopted a shrinking procedure for large-scale population projection models that combines aggregation and decomposition in a particularly appealing way. One begins by partitioning the large multiregional system projection model into smaller submodels in a way that effectively exploits any weak interdependencies revealed by indices such as migration levels. The growth of the original multiregional system then is projected by appropriately combining (1) the results of disaggregated intra-subsystem projections, in which within subsystem interactions are represented at a relatively fine level of detail, with (2) the results of aggregated inter-subsystem projections, in which the between subsystem interactions are modeled at a relatively coarse level of detail. In the short-run, the within subsystem interactions dominate the behavior of the

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[4] A notable exception is the work of Peter Morrison [48].

system; in the long-run, the between subsystem interactions become increasingly important and ultimately determine the behavior of the entire system. In this manner a large-scale population projection process can be modeled with a considerable saving in computer time and storage space.

Policy

If the principal purpose of the dynamics subtask is to understand the fundamental "demographic processes" that govern the evolution of human settlement patterns and that of the demometrics subtask is to explain the causal determinants of past and future patterns, then the major goal of the policy subtask is to develop a deeper appreciation of the impact of policy variables on population processes and of population processes on human welfare.

Social concern with population processes arises when the demographic acts of individuals affect the welfare of others and combine in ways that produce a sharp divergence between the sum of individual (private) preferences and the social well-being. In such instances, population processes properly become the subject of public debate and the object of public policy.

Populations policies are actions undertaken by public bodies with the aim of affecting processes of demographic growth and change. Family planning programs, investments in health-care facilities and services, and government assisted migration are examples of public-actions taken, respectively, to reduce fertility levels, to promote health and longevity, and to foster personal betterment through geographical mobility.

Among national population policies, the problem of fertility reduction has been of paramount importance. The negative consequences of rapid population growth for socioeconomic development are becoming widely recognized and this has led many countries to undertake serious efforts to control fertility. Since manipulating mortality levels is obviously not a feasible policy, the concern with rapid national population growth necessarily has been a concern about high levels of fertility.

Spatial population policies, on the other hand, tend to focus primarily on internal migration and its contribution to human settlement growth and structure. The perceived negative consequences of rapid rates of urban growth on socioeconomic development have let the adoption of policies to curtail growth in certain localities, while at the same time stimulating it in others. Generally, such national urbanization or human settlement policies have been defended on the grounds either of national efficiency or of regional equity, and their principal arguments often have been framed in terms of an underlying conceptual framework known as "growth-center theory" [50].

Growth centers, it is commonly argued, generate, intercept, and attract migrants. They may encourage some underemployed people in the center's hinterland to migrate and to shift to more productive occupations. They can be used to divert migrants away from major overcrowded metropolitan areas. And they make it possible for an economically depressed region to attract the skilled and professional manpower that it needs for its growth and development.

But migration has both individual and societal consequences. The experience of migration in general affects favorably the personal wellbeing and satisfaction of the migrant [35,47]. However, the societal consequences of migration often fall unequally on different groups.

Migration, as a mechanism for transferring labor from labor surplus areas to areas with a labor deficit, moves the national economy toward greater efficiency. But this adjustment of the national labor market has local consequences with regard to equity. And it is these negative consequences that often fall on those "left behind", since it is the most productive members of the labor force that are the ones who move away, leaving behind localities increasingly unattractive for industrial investment [47].

The various individual and societal consequences of internal migration have broad implications for national policies dealing with migration and settlement. The build-in conflict between the goals of national efficiency and regional equity is a fundamental aspect of such policies, one that ultimately can only be resolved in the political arena. A potentially useful tool for illuminating some of the trade-offs that arise is offered by the formal theory of economic policy, first proposed by Jan Tinbergen [74] in the field of economic planning.

The Tinbergen paradigm focuses on the problem of using available means to achieve desired ends in an optimal manner. It begins by adopting a quantitative empirical (econometric) model and divides variables into endogenous variables, i.e., those determined within the model, and predetermined variables, i.e., those determined outside of the model and lagged previous endogenous variables. A further distinction is introduced within these two categories of variables. Endogenous variables are disaggregated into target variables, which are of direct interest to policymakers, and irrelevant variables, which are not. Exogenous variables are composed of instrument variables, which are subject to direct control by policy bodies, and data variables which are beyond their control. The latter include exogenously predetermined variables, uncontrollable variables such as the weather, and lagged endogenous variables.

The policy problem, as formulated by Tinbergen, is to choose an appropriate set of values for the instrumental variables so as to render the values of the target values equal to desired values previously established by an objective function called a welfare function. Thus the basic ingredients of the Tinbergen paradigm

are a welfare function that is a function of various target variables and instrument variables; a quantitative empirical model that links target variables to instrument variables; and a set of boundary conditions or constraints which restrict the range of values that can be assumed by the different variables in the model [21].

It is important to keep in mind the fundamental difference between the manner in which the variables are related to one another in the models of the dynamics and demometrics subtasks and the way in which they are interconnected in the models of the policy subtask. In the former, the values of instrumental variables are specified and the analysis seeks to determine their effects. In the latter, the desired effects are given and the analysis is instead directed toward establishing the values that have to be assumed by the instrumental variables in order for the specified effects to be attained [83].

Despite their fundamentally different perspectives, both kinds of models are necessary in the formulation of enlightened population policies. For as Paul Demeny recently observed

> ...a proper formulation of population policies can be said to require the following essential elements: (a) an understanding of demographic processes in a descriptive sense; (b) an understanding of the antecedents of demographic behavior...; (c) an understanding of the impact of population processes ...on...welfare; (d) an evaluation of the welfare significance...of conceivable policy interventions... [18, p. 153].

Demeny's first two essential elements are being examined in the dynamics and demometrics subtasks of the Migration and Settlement Study; the other two will be receiving considerable attention in the future work of the policy subtask. National case studies dealing with all four elements currently form the focus of the comparative study subtask.

Comparative Study

The World Population Conference held in Bucharest in 1974 recognized the importance of the migration and settlement component of national population policies, called for a better coordination of migration policies and the absorptive capacities of major urban centers, and argued for the proper integration of these policies into plans and programs aimed at social and economic development [85]. But demographic and developmental processes are manifested in diverse ways in different national settings, and a meaningful analysis of their interaction must take into account important national differences. Yet certain regularities persist, and there are grounds for expecting a comparative study of migration and settlement to contribute to the state of our knowledge about the causal interrelationships between migration, urbanization, and development:

> ...in order to advance on both the theoretical and the applied levels, we must have comparative research on population movement, especially in relation to urbanization in preindustrial, industrial, and post-industrial settings. Only through such comparisons can we come to understand the varied forms which movement takes,... [23, pp. 15-16].

The comparative study of migration and settlement at IIASA aims to contribute to our understanding of the relationships between geographical mobility, urbanization, and national development by assembling, summarizing, and analyzing data on migration and spatial population growth in a number of developed and developing countries. For this activity, it has adopted the general framework of two recently published studies that have been carried out in a closely related area. Specifically, the comparative study of human migration and redistribution is being carried out in a manner that is analogous to the procedures used by two studies of human mortality-fertility and reproduction, namely, the book by Keyfitz and Flieger [33] entitled Population: Facts and Methods of Demography and the book edited by Berelson [6] entitled Population Policy in Developed Countries.

The Keyfitz and Flieger book focuses on observed age- and sex-specific mortality and fertility schedules and projects the evolution of the populations exposed to these schedules. In order to examine the population trends of the present day, the authors collect together a data bank of population statistics from more than 90 countries and subject these data to a standardized analytical process.

If national population growth is the primary focus of the Keyfitz and Flieger study, its principal approach for examining such growth is embodied in a collection of computer programs that provide the means for analyzing population growth in a consistent and uniform manner. These programs and the mathematical models that underlie them, are also included in the published study findings.

Finally, the major contribution of the Keyfitz and Flieger study is the uniform application of a consistent methodology to a vast amount of data in order to trace population growth trends in a large number of countries.

The focus, approach, and contribution of the Keyfitz and Flieger book have much in common with those of the comparative study of migration and settlement. The focus of the latter also in population growth, but spatial population growth. The approach also relies on a uniform set of computer programs, but these embody the models of multiregional mathematical demography [59]. And the expected contribution also is that of linking data with theory, but the data and theory that are linked are spatial in character.

There are several important differences between the two study formats, however.

1. A primary concern of the Keyfitz and Flieger study is population reproduction and the demographic transition from high to low birth and death rates. An important focus of the comparative migration and settlement study is population redistribution and the mobility transition from low to high migration rates.
2. The Keyfitz and Flieger study is the product of two authors; the comparative migration and settlement study is combining the collaborative efforts of an international team of scholars residing in various member and non-member nations.
3. The Keyfitz and Flieger study identifies trends and the numerical consequences of the continuation of such trends into the future; the comparative migration and settlement study is, in addition, striving to link national trends with explanatory variables.
4. Although Chapter 4 of their book is entitled "Policy Dilemmas and the Future," the Keyfitz and Flieger study does not deal with national policies. (Their Chapter 4 is only three pages long.) The comparative migration and settlement study, however, is explicitly considering the national migration and settlement policies of each country represented. In this respect the study resembles more the study of population policies coordinated by Bernard Berelson.

The book edited by Bernard Berelson is a review of population policies in 24 developed countries. The individual chapters were written by collaborating scholars residing in the particular countries. Thus, for example, Professor Charles Westoff of Princeton's Office of Population Research wrote the chapter on population policy in the USA, and Professor Dimitri Valentei of Moscow State University's Population Center authored the chapter on population policy in the USSR.

According to Berelson, "the collaborators were given a common outline as a guide to the topics to be addressed, but each author was free to prepare his report in his own manner". It is therefore not surprising that different authors elected to emphasize different aspects of population policy and drew on different kinds of demographic data to develop their presentations. Thus the book is somewhat uneven in its exposition and in the data and indicators that are put forward by the various authors.

The migration and settlement study aims to marry the Berelson approach with the Keyfitz-Flieger approach in order to capture the best features of each. Every national analysis in the comparative study of migration and settlement is, as in the Berelson study, being carried out in collaboration with scholars residing in the countries being studied. However, most of the data, projections,

and indicators which form the foundation of the analysis, are being processed, as in the Keyfitz-Flieger study, by a common set of computer programs. These data and programs will be published together with the study's findings.

CONCLUSION

Internal migration and human settlement patterns are increasingly becoming subjects of governmental concern, both in developed countries and in the developing nations of the Third World. Whether the problem is that of ensuring an adequate supply of labor in Siberia or one of stemming the vast flood of migrants to the overcrowded major cities of Latin America, the need for a well-developed understanding of the relationships between spatial population dynamics and socioeconomic development is clear. A key to such understanding is a convincing theory of population and development.

Recent efforts at theory-building in the social sciences suggest that theoretical advances often follow along a path that might be called the theoretical transition. Demography seems to be entering the metrics stage of its theoretical development and should profit from the insights and conclusions that demometrics research is likely to generate.

Progress in research on the demometrics of migration and settlement would be furthered by the availability of improved methods for measuring migration and for gauging its redistributional impacts in spatial population dynamics. The practical utility of demometrics research would be enhanced by an improved understanding of the various individual and social costs and benefits of different patterns of migration behavior and settlement processes. Finally, our knowledge about the determinants and consequences of demographic change could be much improved and broadened through a careful assessment of the population dynamics, demometrics, and policies that prevail in various countries of the world today.

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