Projection Methods for Integrating Population Variables into Development Planning

Volume I
Methods for Comprehensive Planning

Module One
Conceptual issues and methods for preparing demographic projections

United Nations

ST/ESA/SER.R/90

Department of International Economic and Social Affairs

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EXPLANATORY NOTES

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The term "country" and "area" as used in the text of this report also refer, as appropriate, to territories, cities or areas.

The present study has been edited and consolidated in accordance with United Nations practice and requirements.

The following symbols have been used in the tables throughout the report:

A blank in a table indicates that the item is not applicable.

A minus sign (−) indicates a deficit or decrease, except as indicated.

A full stop (.) is used to indicate decimals.

Details and percentages in tables do not necessarily add to totals, because of rounding.

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PREFACE

The Population Division of the Department of International Economic and Social Affairs of the United Nations has published over the past 35 years a series of technical manuals, which have been widely used to prepare demographic inputs for policy making and planning. Some of these manuals have described methods of assessing the quality of demographic data, preparing estimates of demographic measures from incomplete data and measuring internal migration. Others have described methods of preparing projections of total population, urban and rural populations as well as the economically active population, households and families.

During this time, development planning has increasingly emphasized objectives such as employment generation, income equality and satisfaction of essential needs of the population. This expansion of the scope of development planning has occasioned greater awareness of the need for introducing demographic variables into the planning process. In connection with this, calls have been made in various international forums for increased recognition of demographic concerns in planning. In particular, the need to incorporate population factors was recognized in the recommendations adopted at the United Nations World Population Conference, 1974, at Bucharest and reaffirmed a decade later at the International Conference on Population, 1984, at Mexico City.

In response to those recommendations, the Population Division has been engaged in efforts to assist development planners in integrating population concerns into their work. Among those activities has been the preparation of a manual that could be used by development planners to prepare selected demographic and socio-economic projections useful in drafting overall or sectoral development plans. The proposed projection methods could be used in combination with techniques that have been part of a tool-kit of planners for some time to pursue planning objectives oriented towards economic growth, employment generation and provision of basic social services.

The orientation and the content of the manual were developed by the Population Division on the basis of wide-ranging consultations with academics, planners and other experts in the field of population and development planning. Among the research bodies consulted were the Population Council and the Research Triangle Institute; among the governmental institutions, were planning organizations in India, Kenya and the Republic of Korea. The international agencies consulted included the Food and Agriculture Organization of the United Nations; the International Labour Organisation; the United Nations Educational, Scientific and Cultural Organization; the United Nations Industrial Development Organization; and the World Health Organization.

In addition, as part of the consultative process, two expert group meetings were held at United Nations Headquarters during 2-3 September 1982 and 11-14 December 1984. An outcome of the second meeting was the working paper, "Proceedings of the United Nations Ad Hoc Expert Group Meeting on the Manual on Integrating Population Variables into Development Planning, New York, 11-14 December 1984" (ESA/P/WP/87). The paper included early versions of the chapters developed for the first volume of the manual; these were subsequently extensively revised and extended.

The manual will consist of two volumes, the first of which will be on methods relevant to comprehensive planning and the second on techniques for sectoral planning. Each volume will be composed of several modules, which will be published sequentially. The first volume will consist of three modules, of which this is the first.

This module deals with conceptual issues and methods for making demographic projections. The second module will include methods for making projections of school enrolment, labour force and employment. The third module will describe techniques of preparing projections of household and other incomes, household consumption and savings as well as projections of government consumption and investment. The methods presented in the first volume will enable planners to prepare a series of interrelated projections relevant to comprehensive planning that are capable of taking into account certain key linkages between demographic processes and socio-economic change.

The first volume is a result of a collaborative effort of the Population Division, two consultants and the Latin American Demographic Centre of the Economic Commission for Latin America and the Caribbean. The first module was prepared by the Population Division along with the materials on methods for making projections of school enrolment and labour force, developed for the second module. The materials describing methods for preparing projections of employment and incomes, which will be included in the second and the third modules respectively, were contributed by James C. Knowles, President of the Knowles Corporation, Chapel Hill, North Carolina (United States of America) and finalized by the Population Division. The descriptions of methods for making household consumption and saving projections, to be included in the third module, were originally prepared by Robert Kleinbaum, Societal Analysis, General Motors Research Laboratories, Warren, Michigan (United States of America) and further developed and completed by the Population Division. A description of the technique for preparing government consumption and investment projections was contributed by the Latin American Demographic Centre and finalized by the Population Division. The Division is grateful to Mr. Knowles and Mr. Kleinbaum and to the Latin American Demographic Centre for their respective contributions to this volume.

The Population Division also acknowledges with thanks the advice and comments received from participants of the two expert group meetings convened in connection with the work on the manual. The group that took part in the first meeting included: James C. Knowles; Ashok Mitra, former Registrar General and Census Commissioner and a former Member of the Planning Commission

of the Government of India; Warren Sanderson, Professor, Economics Department, State University of New York at Stony Brook; and George B. Simmons, Director and Professor, Department of Population Planning and International Health, University of Michigan, Ann Arbor.

The group of experts participating in the second meeting consisted of: Gustavo Cabrera, Vice President and Professor, El Colegio de Mexico, Mexico City; Scott R. Moreland, senior economist, Centre for Development Policy, Research Triangle Institute, Research Triangle Park, North Carolina; Joseph Olomajeye, chief planning officer, Social Service Division, Federal Ministry of National Planning, Lagos; George B. Simmons, Director and Professor, Department of Population Planning and International Health, University of Michigan, Ann Arbor; Tore Thonstad, Professor, Department of Economics, University of Oslo; and Andras Uthoff, regional adviser in population and employment, Programa Regional del Empleo para America Latina y el Caribe, Santiago.

The preparation of this manual was made possible by the generous support of the United Nations Population Fund. This support included financial assistance for a Population Division's project under which the manual is being prepared and assistance provided in connection with the consultations conducted with planners in developing countries. This assistance is gratefully acknowledged by the Population Division.

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INTRODUCTION

A. Origins, objectives and scope of the manual

1. Origins

After the Second World War, an increasing number of low-income countries turned to development planning as the means of promoting their economic and social development. As a result, the early 1950s saw the formulation of the first national development plans in those countries (Morawetz, 1977). The major objective of development at the time was to increase the standard of living of the population by attaining such secondary objectives as output growth, full employment (box 1)*, greater economic equality and the satisfaction of basic needs (Waterston, 1979; Morawetz, 1977). To meet those objectives, it was asserted that development planning must take population change into account as fully as possible. Thus, a United Nations document stated at the time that:

> "The primary needs of the people, which the development programmes aim to satisfy, cannot be gauged rationally without regard to the expected size and composition of the population, nor can the national resources be appraised adequately without considering labour, the supply of which depends primarily on population size and structure. If no estimates based on systematic analysis of population trends are available, the planners can only proceed with more or less vague assumptions or notions concerning the magnitude of needs and resources (United Nations, 1956).

In spite of the importance given to a variety of development objectives at the early stages of post-war planning, in many countries output growth became the dominant objective in much of the two decades after the mid-1950s. The basic assumption was that economic growth would help alleviate unemployment, income inequality and poverty, provided that it were fast enough (Morawetz, 1977). Partly as a result of this view, the interest of planners in population and related variables proved considerably weaker than had been anticipated in the early post-war years. In comprehensive national planning, this interest often did not transcend the size of population and its growth. These two variables were primarily used in this type of planning to calculate economic growth in per capita terms and to set overall output targets.

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* Terms defined in glossary boxes are underlined where they appear for the first time.

Box 1

Glossary

Full employment
A state of the economy where only frictional unemployment exists, and everyone else who wishes to work at the going wage rate for the given type of labour is employed. Frictional unemployment reflects the time needed to switch from one job to another.

Household consumption
The value of "final" goods and services consumed by households over a specified time period to meet their various consumption needs.

Household income
The flow of money or goods accruing to a household over a specified time period.

Poverty
A situation where a population or a section of a population is able to meet only its bare subsistence essentials of food, clothing and shelter in order to maintain minimum levels of living.

Unemployment
A situation which exists when members of the labour force wish to work but cannot find employment at the prevailing wage rate.

In sectoral planning, however, and especially in planning concerned with the provision of social services, population variables figured far more prominently. There, it proved important to consider not only population size and growth, but also its structure and distribution. In spite of this, population did not begin to emerge as one of the central variables of development planning in many countries prior to the mid-1970s.

Around this time it became increasingly clear that some of the development strategies adopted in the preceding two decades had been incapable of redressing the major economic and social problems of developing countries. Consequently, an interest in development objectives other than economic growth re-emerged in a number of countries. Employment generation, income equality and the satisfaction of basic needs began to figure as high on some planners' agendas as output growth itself. In order to achieve those objectives, it has been proposed that the scope of planning be extended by dealing directly with employment, household income and household consumption. It has been further suggesed that extending the scope of planning in this way would bring a variety of demographic variables into the planning process (Chenery and others, 1974).

The mid-1970s also witnessed a growing consensus among national Governments about the importance of population considerations in development planning. In particular, the World Population Plan of Action, adopted at the 1974 World Population Conference at Bucharest, reaffirmed the interdependence of demographic and development processes and called, inter alia, for development planning that would be more responsive to the needs of all the population (United Nations, 1975). Specifically, the Plan called for development planning that would meet national needs for specific goods and services, such as food and education, as well as satisfy the employment requirements of the labour force.

Following the Bucharest Conference, arguments in favour of incorporating demographic factors into development planning were advanced with increasing frequency. Those arguments, made in the context of a broader debate on integration of population and development planning, led the United Nations Economic and Social Council in the late 1970s to request the United Nations Secretariat to prepare guidelines for national planners on integration of population-related factors in the formulation and evaluation of development plans (United Nations, 1976). Upon reviewing the guidelines, the Council requested the Secretariat to prepare a technical manual on the methods of incorporating demographic factors into the development planning process. The present manual has been expressly prepared in response to that request with an objective of making this methodology more accessible to planners.

2. Objectives

Development planning may take a number of different forms. With respect to scope, it can be comprehensive or sectoral; in relation to geographic coverage, national or regional; and with respect to time horizon, short-, medium- or long-term. Organizationally, planning can be centralized or decentralized; and from the viewpoint of implementation, mandatory or indicative (Blitzer and others, 1975). Given this diversity, addressing a methodological manual to all types of planning would not be feasible. The present manual has been, therefore, designed to be applicable to a few specific types of planning, and in particular, to the national comprehensive and sectoral planning over the medium and long term. Furthermore, it has been designed to be used primarily by planners in countries with mixed or market economies practicing decentralized, indicative planning (box 2). In spite of this orientation, however, a substantial portion of the materials of this manual should be of considerable use to planners in socialist economies practicing central planning.

The two-way interactions between population and development manifest themselves fully only over the longer term. As a result, the methodology of the manual is bound to be more relevant to long-term than to medium-term and short-term planning. However, in a large number of developing countries, the former type of planning is less relevant to the policy-making process than the latter. In principle, this need not be so since medium-term planning could

Box 2

Glossary

Central planning
A type of development planning where government determines what shall be produced by various sectors of the economy, at what prices, and how factors of production shall be allocated among different users. The provisions of the plan, which is prepared at the centre, are mandated to the various sectors.

Comprehensive planning
A form of development planning, sometimes referred to as aggregative, global or overall planning which covers most or all sectors of the economy. This planning, unlike sectoral planning, is concerned with a full range of variables, including aggregate output, household and government consumption, savings and investment, imports and exports, employment and incomes.

Indicative planning
A type of development planning where government, in co-operation with the private sector, sets broad targets for the economy and defines policies to achieve those targets, including the allocation of public sector resources among the various users. The provisions of the plan are binding for the public sector but indicative for the private sector.

Labour force
Economically active persons, including armed forces and the unemployed, but excluding those not seeking employment, and conventionally, housewives and students.

Long-term planning
Preparation of a development plan for a time period that often ranges from 10 to 20 years.

Medium-term planning
Preparation of a development plan for a time period that typically ranges from 3 to 7 years.

Sectoral planning
A form of development planning, sometimes referred to as partial planning, which is concerned with individual sectors of the economy. Such planning is often conducted within the framework of a comprehensive plan.

frequently prove myopic unless a longer range view were also taken by the planner. This is particularly true where considerable population change is under way or will take place in the near future. In the countries where this point is appreciated by planners and where medium-term planning is cast within the framework of long-term planning, this manual may prove particularly useful. In such countries, the opportunities to incorporate demographic variables into development planning by means of the methodology described in the manual would be potentially greatest.

The manual is directed at planners working at the central planning offices and other governmental agencies involved in both comprehensive planning and sectoral planning. Other agencies could include the central statistical office and the planning departments of relevant sectoral ministries. In particular, the materials on the methodology of integrating demographic variables in comprehensive planning, which are included in the first volume, have been developed for use primarily by planning officials in central planning organizations. The materials on the methods relevant to integration of demographic factors in sectoral planning, to be presented in the second volume, will be useful to sectoral planners working at either central planning offices or sectoral ministries.

The manual has been designed as a "how to" publication presenting techniques for preparing various sorts of plan projections and addressing the issues of their application in planning. Hence, it consists of a number of methodological chapters describing various projection techniques. In addition, however, it includes materials providing the rationale and the conceptual basis for integrating demographic variables in planning. In the methodological chapters, the objective is to give initially overviews of the techniques along with their strengths and weaknesses, while spelling out the principles of the techniques. An additional objective is to discuss the types of inputs these techniques use and the way they could be prepared, and to illustrate the application of the techniques in making projections.

The methodological chapters are primarily aimed at planners entrusted with the development of the quantitative basis of national and sectoral plans. The materials on the rationale and conceptual underpinnings of integration are mainly addressed to planners charged with the co-ordination of the planning process and over-seeing of the technical work on the plans. These materials seek to sensitize planners to the potential benefits to be derived from taking population change into account. They also seek to describe major economic-demographic relationships that may need to be taken into account in planning as well as describe how some of those relationships can be dealt with in planning.

From the point of view of incorporating demographic factors in planning, it is useful, though somewhat arbitrary, to make a distinction between planning that is population-accommodating and planning that is population-influencing. The former takes demographic variables into account in order to accommodate prospective demographic change. The latter seeks to influence demographic processes to attain specific development objectives. The methodology of the manual is primarily suited to the former rather than

the latter type of planning. Specifically, the techniques discussed herein can be used, for example, in employment planning in order to meet the job requirements of the future labour force, consumption planning (and indirectly production planning) designed to satisfy the commodity requirements of the future population, and so on. The methodology of the manual is not designed to assist planners in formulating economic and social policies and programmes aimed at bringing about desired population change.

3. Scope

Preparing the quantitative basis of a national development plan or a sectoral plan normally involves making projections of selected economic, social and demographic variables over the plan horizon (box 3). In many developing countries those projections are made by means of partial techniques. In other countries, the number of which is still rather small, projections are being prepared by means of more or less comprehensive planning models. Because of the prevailing reliance on partial techniques and the likely continued use of those techniques in the future, the manual primarily deals with these techniques. In spite of this orientation, the materials of this manual could be also of considerable interest to planners working mainly with planning models. The reason for this is that a number of techniques described in the manual could be introduced into existing economic planning models as additional modules, thereby bringing demographic variables into those models and the planning process itself.

The methodological chapters of volume I deal with two groups of methods, for projecting demographic and socio-economic variables. The first group of techniques can be used to make projections of two key demographic variables--population and households. The second group of techniques can be used to make projections of school enrolment, labour force, employment, and incomes of households and other institutions (corporations and government). In addition, they can be used to make projections of household consumption and household savings as well as projections of selected components of government consumption and government investment.

The use of the former group of techniques is envisaged as a first step towards employing the methods of the latter group. This stepwise application of the methodology is conditioned by the fact that the projections of socio-economic variables depend directly or indirectly on the projections of demographic variables. It is through this sequential application of the methodology of volume I that at least a partial integration of demographic factors into comprehensive development planning can be achieved.

Some of the variables included in volume I can be projected by only one technique. This is the case of population, households, school enrolment, labour force, incomes, and selected components of government consumption and investment. The remaining variables can be projected using two or more alternative techniques. This is true of employment as well as of household consumption and savings. There are several reasons for having alternative techniques for projecting certain variables. First, alternative techniques enable projections under different data situations. Second, some techniques

Box 3

Glossary

Economic planning model
A mathematical representation of key economic variables and their relationships, normally used to prepare projections of output, use of productive factors, components of final demand etc.; it may be either sectoral or aggregate.

Government consumption
The amount of money that government spends on goods and services over a specified time period, other than that needed to replace and/or expand facilities.

Government investment
The amount of money that government spends on goods and services over a specified time period in order to replace and/or expand facilities.

Household
A single person living alone or a group voluntarily living together, having common housekeeping arrangements for supplying basic living needs, such as principal meals. The group may consist of related or unrelated persons.

Household savings
The portion of household disposable income that is not spent on consumption over a specified time period.

Plan horizon
A period of time to which a development plan refers.

School enrolment
The number of students who are enrolled and attend various educational institutions.

can be used in situations in which other techniques are inapplicable as a result of the assumptions employed. Finally, some techniques can produce types of projection results that could not be produced with other methods.

In most cases, the preparation of the manual did not involve the development of new methods. The materials largely reflect the state of the art relevant to integrating demographic variables in comprehensive and sectoral population-accommodating planning. Some of the projection techniques presented are rather advanced and data intensive and are at present applicable

in a relatively small number of developing countries. There are also simpler techniques, applicable in most countries. The less readily applicable methods are included on the assumption that they will become useful in an increasing number of countries as planners' expertise and data bases improve.

It has recently been argued that population-accommodating development planning, especially if focusing inter alia on the well-being of the poverty groups, should treat population as one of the central variables and allow for its disaggregation into socio-economic groups (See, for example, Pyatt and Thorbecke, 1976). The manual recognizes the importance of this disaggregation, but nevertheless does not include methods for projecting population and related variables for those groups, because at the present time an adequate methodology and requisite data for such projections are not yet available. Nevertheless, the manual presents a number of methods for making projections by urban and rural areas. To the extent that urban and rural populations could be viewed as the two principal socio-economic groups, the manual is applicable to disaggregated planning, albeit partially.

The rest of this introduction will first discuss the contents of this volume by giving, among other things, a preview of the methodology contained in it. Then, a possible use of the methodology in planning will be considered.

B. Contents of volume I

1. Structure of the volume

Volume I of the manual will consist of three modules. This, the first module, consists of three chapters. Chapter I presents a conceptual framework for planning which provides a theoretical basis for the type of projection exercises relevant to comprehensive planning. The remaining chapters of the module, which are methodological in nature present methods for making demographic projections. In particular, the cohort-component method for preparing population projections is presented in chapter II, and the headship-rate method of household projections is presented in chapter III.

The further chapters, to be included in the second and the third module, describe the methods for making socio-economic projections. Chapter IV presents the enrolment ratio method of school enrolment projections. Chapter V describes a method for projecting labour force utilizing labour force participation rates. Chapters VI through VIII present methods of employment projections based on two types of employment-value added relationships and on production functions (box 4). Chapter IX describes the income projections method based on the social accounting matrix. Chapters X and XI present methods of household consumption and savings projections based, respectively, on different per-household and per-capita specifications of demand systems. Lastly, chapter XII describes a method of projecting government consumption and investment.

Box 4

Glossary

Average labour productivity
The level of output per unit of labour input, usually measured as output per person-hour or person-year.

Enrolment ratio
The number of students attending a given school level, divided by the total number of persons of the age normally in school at that level.

Headship rate
The number of heads of households in a given age, sex and/or marital status category, divided by the corresponding number of persons in the same category.

Labour force participation rate
The number of persons in the labour force at a given age, sex and/or level of education, divided by the corresponding total number of persons of the same characteristics.

Production function
A mathematical representation of the technological relationship between the quantity of output of a firm, sector or the entire economy and the quantities of inputs required to make it.

Sex ratio
The number of males in a population or specific sub-population, divided by the corresponding number of females.

Social accounting matrix
The tabular presentation of the income and product flows in an economy during a specified time period. It consists of a set of accounts, such as those for factors of production (labour, capital) or institutions (households, corporations and government) along with the economy's input-output table.

Value added
For a firm or farm, the difference between its total revenue and the cost of raw materials, services and components used in production, over a specified time period. For the economy as a whole or any of its production sectors, the aggregate of value added of different firms or farms of which the economy or sector is composed.

2. Preview of the methodology

The methodological chapters of this volume present techniques which can be used to project two demographic and several socio-economic variables. Box 5 lists the variables along with the methods that can be used to project them.

(a) Methods for making demographic projections

Two techniques of demographic projections are indicated by the box: the cohort component technique of population projections and the headship rate method of household projections. The former technique projects population by tracing its age and sex structure over time. The results it generates include the age-sex structure of the population and a variety of summary indicators of population size, structure and change. Examples of these indicators are population size and population numbers in special, broad age groups; the sex ratio of the population; and rates of population change due to births and deaths.

The headship rate method projects households by applying headship rates to the population structures derived through a population projection. The headship rates, which are given by assumptions, reflect expectations regarding future changes in the formation and dissolution of households. The results of a household projection include the number of households, the rate at which this number changes over time and the average household size.

(b) Methods for making socio-economic projections

The first among the methods of socio-economic projections presented in the manual is the enrolment ratio technique of school enrolment projections. This method, which is a standard tool of educational planners, projects enrolment by applying enrolment ratios given by assumption to the school-age population suitably classified by age. The technique yields various results by academic level, which include the numbers of students, overall and by type of school (for example, public or private), as well as indicators of the size, composition and change in the numbers of students.

The labour force projection method applies labour force participation rates specified by assumptions to population structures. The results generated by the method include the size of the labour force and indicators of the growth and structure of labour force.

Among the techniques to project employment by production industry (or subindustry), two are based on different employment-value added relationships. The first of these methods employs average labour productivity that changes at a constant rate over time while the second uses employment-value added functions. These methods use projections of real value added as the key input to make projections of employment.

Box 5

Projection techniques for integrating population variables in comprehensive planning

Methods for making demographic projections

Variable	Technique
Population	1. Cohort component method
Households	1. Headship rate method

Methods for making socio-economic projections

Variable	Technique
Students	1. Enrolment ratio method
Labour force	1. Labour force participation rate method
Employment	1. Average labour productivity method 2. Employment-value added function method 3. Method based on Cobb-Douglas production functions
Household, corporate and government incomes	1. Method based on the social accounting matrix
Household consumption and savings	1. Method based on per-household specifications of demand systems 2. Method based on per-capita specifications of demand systems
Government consumption and investment (in education, health and housing)	1. Method based on the Long-range Planning Model 2

A third method for preparing employment projections by industry is based on the Cobb-Douglas production functions. The method makes a projection by means of rearranged and estimated production functions. It makes use of projections of real value added and the capital stock (box 6) by industry as principal inputs. These different methods of employment projections yield projected levels of employment by industry (or subindustry) as well as selected indicators of employment structure and growth.

The volume also describes a method for preparing projections of disposable incomes of households, corporations and government, based on the social accounting matrix. This method derives a projection of incomes by transforming value-added levels by industry into incomes of factors of production and, further, by converting factor incomes into incomes of institutions (households, corporations and government). The technique can also be used to project per capita and per household indicators of household disposable income.

Two techniques for projecting household consumption and savings are described. One method is patterned on the demand systems of the Kelley and the Bachue-Philippines models. The method postulates that household demand is primarily a function of income and demographic variables. The other technique draws on the Linear Expenditure System and the Extended Linear Expenditure System. These systems are based on the assumption that household consumption demand is primarily a function of income and prices and to a lesser extent of demographic variables. Each of the two methods is capable of generating the level and structure of household consumption by commodity groups as well as the level of household savings.

Lastly, this volume describes a technique, based on the methodology of the Long-range Planning Model 2, for preparing projections of government consumption and investment relating to education, health and housing (U.S. Bureau of the Census, 1972). The technique projects levels of government consumption and investment by calculating the resources needed to cover the operating costs along with investment costs of those sectors.

3. Structure of the methodological chapters

Each methodological chapter is devoted to one technique. The chapter provides an overview of the technique and discusses its strengths and weaknesses as a planning tool. Then, it describes the principles of the technique, stressing the various computational steps followed in applying it. The chapter further discusses the inputs used with the technique and suggests how they can be prepared. It concludes by presenting and describing one or more illustrative applications of the technique.

The emphasis in these chapters is on the technical description of the methods, the requisite inputs and the illustrative applications of the methods. Discussions on the preparation of inputs are less fully developed since the preparation of inputs, which include data collection and processing as well as estimation of various coefficients and parameters, is a broad area in its own right.

Box 6

Glossary

Capital stock
: The total amount of machines, equipment and buildings, as well as inventory existing at any one time in a firm, industry or economy.

Disposable income
: The income of a particular type of institution, such as household, corporation or government, after taxes or transfers, whichever is appropriate, which is available for consumption or savings.

Factor income
: The income accruing to a particular factor of production in return for services rendered by that factor. Examples of factor incomes are capital income and labour income.

Factors of production
: Resources or inputs required to produce a good or service. Basic categories of factors of production are land, labour, and capital.

Household consumption demand
: The amount of money that households are willing to spend on final goods and services over a specified time period to meet various consumption needs.

Investment costs
: Costs incurred in connection with accumulating inventory, installing new equipment or facilities and/or replacing the existing ones.

Operating costs
: Costs incurred in connection with production of goods or services, which vary with the level of output. Examples of this type of cost are costs of labour, raw materials and power.

To facilitate understanding, each chapter includes a list of indices, variables and special symbols along with their definitions. Also, each includes a list of equations used in describing the principles of the technique in the chapter. Moreover, definitions of the various technical terms used in the methodological chapters are presented in a unified glossary at the end of each module.

Each methodological chapter contains one or more illustrative examples of projections. The examples are presented in order to: (a) illustrate the types of inputs required to apply various methods; (b) show how the requisite projection calculations are actually performed; and (c) illustrate the results that the methods are capable of generating. Often, examples are presented that illustrate projections at both national and urban-rural levels.

The inputs needed to make specific projections, in turn, require projections made by other methods described in the volume. In view of this, illustrative inputs presented in various chapters include, among other things, the results of illustrative projections prepared with other methods. Thus, illustrative inputs relating to examples of projections of households, labour force or household consumption and savings include relevant results of illustrative population projections. Though the illustrative inputs and projection examples provided throughout the volume try to present a set of examples resembling projections that would be prepared in a concrete planning exercise, it was, however, not possible to fully integrate all the various examples in this fashion.

Since the proposed methods are expected to be useful in medium- and especially long-run planning, they have been described as tools for making quinquennial rather than annual projections. Consequently, the results that they can generate are for dates spaced five years apart and for the intervening time intervals. However, without any modification, a number of methods could be used in preparing annual projections if the inputs are provided on an annual basis. Alternatively, annual projections can be derived from the quinquennial projections through interpolation.

C. Using the methodology

1. Some general observations

The methodology of this volume would normally be used to sequentially project a number of variables, since the projection results obtained by some methods are inputs into projections prepared by other methods. Thus, for example, the use of the cohort component method would precede that of the enrolment ratio technique or the headship rate method, since population projections are needed as inputs for making school enrolment or household projections.

Most of the proposed techniques enable one to make urban-rural projections, which may be more useful in planning than projections made for the country as a whole. The principal reason for this is the urban-rural dualism, which is typical of both economies and populations of developing countries. In particular, in long-term planning exercises in countries undergoing rapid changes in the economic structure and population distribution, it would be impossible to capture the effects of this dualism adequately unless the projections allowed for the urban-rural breakdown.

In most applications of the proposed methodology, it will probably be necessary to use the techniques in an iterative fashion in order to reduce inconsistencies among projections. For example, iterations would be required where labour force and employment projections prepared for urban and rural areas indicate sizeable imbalances between labour supply and demand. In particular, if imbalances appear to be a consequence of unrealistic urban-rural migration assumptions underlying the population projection, these assumptions would have to be reformulated and new population and labour force projections made until the imbalances were removed.

The application of this methodology in comprehensive development planning may encounter a variety of constraints in developing countries. These constraints may derive from data limitations or lack of sufficient expertise to prepare requisite projection inputs. In addition, they may stem from a limited access to computing facilities or assumptions embodied in some techniques that may prove overly restrictive.

2. The role of the proposed methodology in planning

The role that the methodology of the present volume may play in planning could be visualized by considering: (a) socio-economic and demographic projections that are essential to comprehensive planning; (b) interdependences among socio-economic and demographic projections; and (c) how those projections can be used in planning. Among the projections in question are those of the groups of variables shown in box 7. The variables indicated by an asterisk enclosed in parentheses (*), can be projected fully, or in part, by the methodology of this volume.

As suggested by the number of variables marked by an asterisk, this methodology can contribute a great deal to planning. However, the techniques described in this volume represent only part of a broader planning methodology, which can yield projections that are very much interdependent. The interdependencies among those projections are essentially of two types. First, the projections of a number of variables could not be undertaken unless projections of other variables were already made. And second, a number of projections must be checked against each other for consistency. This applies to most variables involved in comprehensive planning, whether or not they can be projected with this methodology.

These two types of interdependencies are illustrated in figure I. The projections of the variables listed above are displayed in rectangles, which are interconnected using three different types of arrows. The projections represented by 'single-line' rectangles can be prepared with the methodology of this volume. Those represented by the 'double-line' rectangles cannot be made with this methodology and require other techniques, many of which are routinely used by planners.

The solid and dotted arrows indicate dependencies of projections of given variables on the projections of other variables. In particular, any solid arrow shows that a projection of a particular variable must use as one input

Box 7

Variables to be projected in comprehensive development planning

(1) Variables relating to supply or production of commodities:
- Value added
- Intermediate inputs
- Total production

(2) Variables relating to demand or use of commodities:
- Final demand (*)
- Intermediate demand
- Total demand

(3) Variables relating to supply or availability of services of factors of production:
- Capital stock
- Cultivable land
- Labour force (*)

(4) Variables relating to demand or use of services of factors of production:
- Capital use
- Land use
- Employment (*)

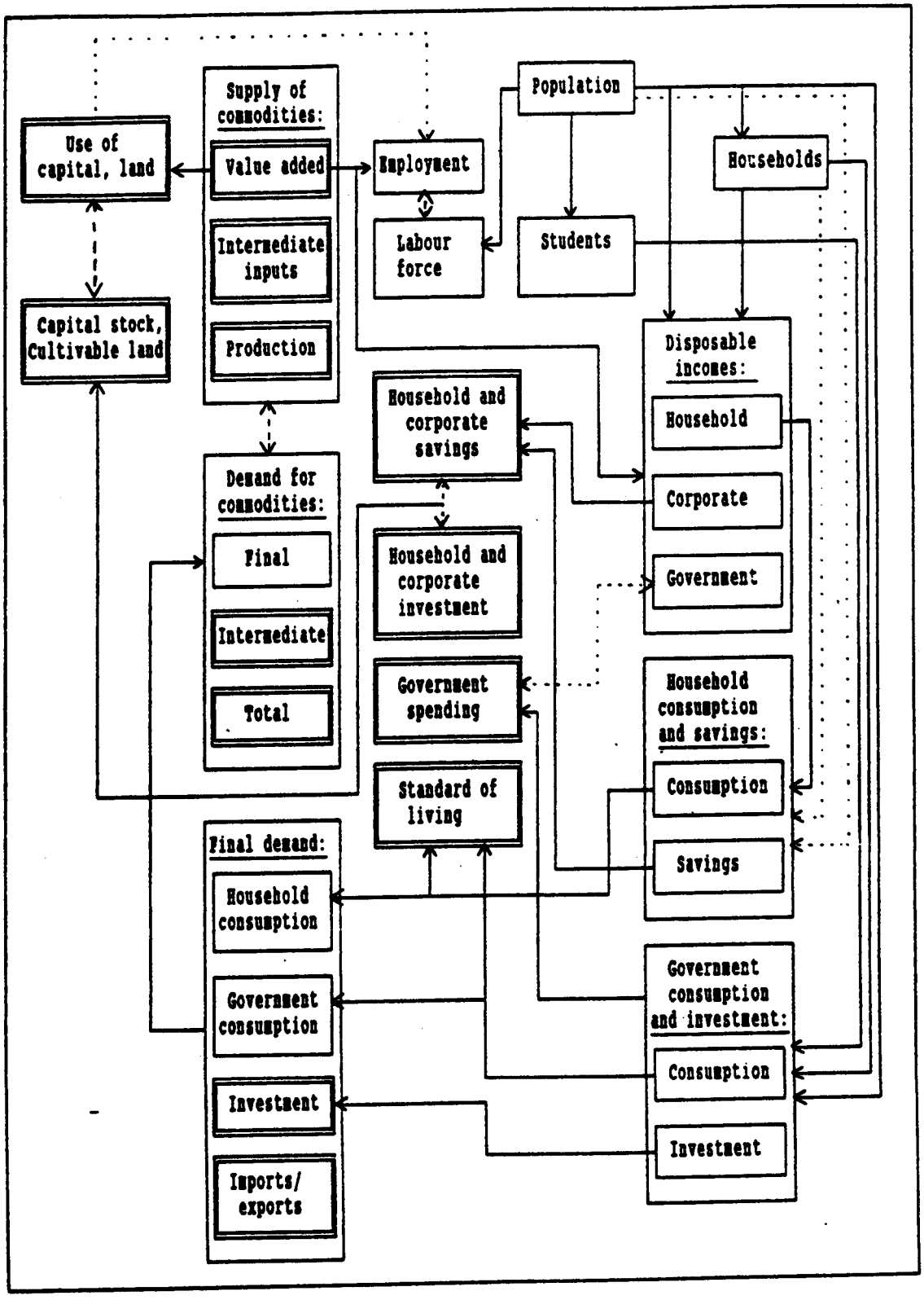
(5) Variables representing different types of disposable incomes of institutions:
- Household income (*)
- Corporate income (*)
- Government income (*)

(6) Variables relating to the disposition of disposable incomes:
- Household consumption and savings or investment (*)
- Government consumption and investment (*)
- Corporate investment

(7) Variables relating to population and its constituent functional groups:
- Total population (*)
- Young-age population (*)
- Working-age population (*)
- Old-age population (*)
- School-age population and students (*)
- Women of the childbearing period (*)

(8) Variables relating to households:
- Total number of households (*)
- Average household size (*)

Figure I. Projections of socio-economic and demographic variables in comprehensive development planning



the results of a projection of some other variable. Any dotted arrow indicates that a projection of a given variable may require the use of a projection of some other variable, but whether or not this is actually necessary depends on the type of technique used or inputs selected. Each dashed arrow indicates the need for consistency checks between projections of any given pair of variables.

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1. A CONCEPTUAL FRAMEWORK FOR DEVELOPMENT PLANNING

In order to place the methodology of this volume in a proper perspective, this chapter describes a conceptual framework for comprehensive development planning involving demographic variables. 1/ The framework is intended to show how the standard of living of different population groups can be determined by the working of the economic system and population dynamics, and their interactions under alternative strategy or policy scenarios. In particular, the chapter should provide a conceptual apparatus, or a "mental model" that can help the planner to better understand how different policies and structural reforms, operating through economic growth, population change or income re-distribution, can improve standards of living.

The chapter first presents an overview of the framework and then discusses the principal institutions distinguished in the framework. Further, major variables and interrelationships of the framework are examined, first from the static and then from the dynamic point of view. Finally, key economic-demographic interactions are considered.

A. Overview of the framework

The framework is based on the assumption that a primary objective of "social and economic development is the attainment of higher standards of living for all, but particularly the poor members of the society" (Pyatt and Thorbecke, 1976). In view of this, the framework brings together those economic and demographic variables that appear to have a crucial bearing on the well-being of various population groups. It is concerned with economic growth, population dynamics and income generation and distribution, as well as with the way these interact and impact on the standard of living of socio-economic groups.

The major elements of the framework include the supply of and the demand for both commodities and factors of production, plus the creation and distribution of incomes among population groups and other institutions (corporations and government). Other elements of the framework include the components of population change and the resultant demographic characteristics of population groups, as well as a variety of major economic-demographic interrelationships. Also, the framework embodies various policy instruments and structural reforms that planners and policy makers may utilize to influence economic performance, population dynamics and income generation and distribution.

In the framework, the standard of living of any particular group is visualized as a function of the average level of consumption enjoyed by the group. In this context, consumption consists of two major components, one of which is goods and services purchased or produced by the group for own consumption. The other consists of goods and services provided by government.

Policy instruments and structural reforms which the planner can use as part of a strategy include factor prices, taxes and transfers, or land and educational reforms. The policy instruments, such as family planning programmes or resettlement schemes may act on various components of population change. But, in order to formulate specific policies or strategies, the planner would have to operationalize the framework by performing numerical policy and strategy experiments.

A number of the variables of the framework need to be disaggregated for the framework to produce the most effective results. Thus, the population or the "household sector" ought to be subdivided into socio-economic groups. Further, in order to link the standards of living at the group level to the performance of the various segments of economy, other principle variables should be disaggregated. Thus, production as well as inputs to production should be disaggregated along dimensions such as economic sectors, location (urban/rural), and/or form of organization (modern/informal). Similarly, incomes and consumption should be subdivided by socio-economic group and, further, by source of income and commodity category, respectively.

B. Institutions

The framework distinguishes three categories of institutions: population groups, corporations and government. 2/ Each population group is treated as a separate institution. Corporations and government are each considered as one institution. These various institutions play distinct roles in the development process which in turn influences the performance of the economic system and, ultimately, the well-being of the population groups.

The number of socio-economic groups may vary from one country to another. In principle, the disaggregation of the population should yield groups that are susceptible to the effects of specific policies designed to influence their living standards. The groups, however, should consist of households having similar standards of living, similar levels of asset ownership and/or the same residential location. Where appropriate, they may consist of households having the same caste, ethnicity and/or religion. In view of this, defining socio-economic groups for a particular country may often necessitate disaggregating the national population by urban-rural location and within each location along one or two additional dimensions. For example, in the urban areas, it may be necessary to make a distinction between groups of households associated with modern and informal sectors. In the rural areas, a useful distinction could be between landless and small-farm households.

The use of the framework in planning requires that individual population groups be tracked over time. However, it is often difficult to formulate sound assumptions on the population transfers among the groups. Therefore, in many applications of the framework to medium-term and especially long-term planning, it will prove necessary to keep the number of groups small, although this would mean working with groups that are rather heterogeneous.

C. Principal variables

This section will first consider the statics (box 8) of the framework by stressing the accounting relationships of the system and the variables linked by them. Then, the dynamics of the system will be discussed by considering how it changes over time.

1. Statics

At any point in time, the system possesses internal consistency. Starting at any point in the system and moving through it, one returns to the same initial point. In this discussion, disposable incomes of various institutions, which are the end result of the process of income distribution among the institutions, are such a starting point. They begin a chain of linkages running from incomes to demand, from demand to production and all the way back to incomes.

(a) Disposable incomes

The disposable incomes of population groups consist of incomes (net of taxes) received from various sources. The groups typically spend portions of their disposable incomes on goods and services. This gives rise to household consumption demand which, in the aggregate, represents a major part of the total final demand. The rest of household disposable incomes are household savings which make possible investments of various sorts, such as those relating to housing and family businesses. These investment activities lead to household investment demand.

The corporate disposable income includes earnings retained by the corporations after making payments of dividends and taxes to population groups and government, respectively. This income, which represents gross business savings (box 9) of the corporations enables them to make investments into new facilities as well as to replace a part of the existing facilities. In the process of making those investments the corporations create corporate investment demand.

Government disposable income is comprised of revenues collected through direct and indirect taxes net of government transfer payments to population groups and corporations. A part of this income is earmarked for government's current operations. The rest, government savings, is used to build new public facilities and/or replace a part of the existing ones or augment and/or replace the physical capital of the government-owned businesses. As government seeks to purchase goods and services and engages in investment activities, it generates, respectively, government consumption demand and government investment demand.

Box 8

Glossary

Dynamics
That part of economics which is concerned with analysing the movement of economic systems through time. The "economic systems" concerned may be a market, a firm, the economy as a whole or even a whole set of interrelated economies.

Household investment demand
The amount of money that households are willing to spend on final goods and services over a specified time period that are used either as capital goods or as inputs in housing construction.

Investment
Expenditure incurred over a specified time period on capital goods with the view to replacing and/or augmenting the existing physical capital. In macro-economic terms, "gross" investment refers to the total expenditure on new capital goods, while "net" investment refers to the additional capital goods produced in excess of those that wear out and need to be replaced.

Statics
That part of economics which is concerned with analysing the economic system in equilibrium. The equilibrium is "timeless" or static in the sense that it does not change with time, it is fixed for all times, unless one of the underlying relationships in the system changes.

(b) Commodity markets

Household consumption demand is by far the most important of the components of final demand that are directly influenced by demographic variables. For each population group, consumption demand is influenced by its size as well as its age structure. Household consumption demand is also affected by non-demographic variables, notably the amount of disposable income. Population size helps to determine the group's per capita disposable income and, through it, the group's average propensity to consume (box 10) as well as the structure of the group's consumption demand by commodity category. Given differences in consumption requirements and preferences at different stages in one's life cycle, the group's age composition also affects the structure of consumption demand.

The level and pattern of household consumption demand varies considerably across population groups owing, among other things, to differences in preferences. Where inter-group differences are pronounced, aggregate household consumption demand can be significantly influenced by the distribution of the population among the various groups. That is, aggregate household consumption demand will be more heavily influenced by the preferences of those groups having larger weights in the total population.

Box 9

Glossary

Corporate investment demand
: The amount of money that corporations spend on capital goods over a specified time period in order to replace and/or augment their capital stock.

Government savings
: The portion of government disposable income not expended on current operations. It represents a measure of the amount available to government for investment.

Gross business savings
: The residual of net income accruing to corporations, after payments are made in various forms such as dividends and direct corporate taxes. It is usually kept by incorporated businesses as reserves and depreciation allowances or to finance new investment. It represents a measure of the amount available to corporations for investment.

Indirect taxes
: Taxes levied on goods and services purchased by consumers and exported by producers, for which the taxpayer's liability varies in proportion to the quantity of particular goods purchased or sold. Examples of indirect taxes are customs duties (tariffs), excise duties, sales taxes and export duties.

Physical capital
: The stock of goods used in production, which have themselves been produced. It consists of inventories and such durable goods as buildings, plants and machinery.

Government consumption and investment demand may also be significantly influenced by demographic variables, particularly in sectors seeking to provide services such as education, health care and housing. Since requirements for those services depend, among other things, on the group's demographic characteristics, the government demand is influenced by those demographic factors. Thus, a group having a large size and a larger proportion of their members within the school-age span would ceteris paribus have greater requirements for educational services and would increase government demand originating in the education sector.

Box 10

Glossary

Average propensity to consume
: For the economy, this is the proportion of national income devoted to consumption. Similarly, the average propensity to consume of an individual or a population group is the proportion of the individual's or group's income that is devoted to consumption.

Commodity markets
: Markets in which commodities are bought and sold through a process that determines prices and quantities of commodities traded.

Export demand
: The amount of money that foreign buyers spend over a specified time period on commodities of a particular economy.

Intermediate demand
: The amount of money that producers spend over a specified time period on goods and services that are used as inputs into production of other goods and services, rather than for final consumption.

Subsidy
: A special type of transfer payment to a corporation to prevent it from experiencing losses or to prevent an increase in its price.

However, since other factors influence the demand for services, different population groups having similar numbers of potential users of given services could have vastly different demands for those services. Where this is the case, the demographic effects on government consumption and investment demand could well transcend those arising from the demographic traits of the population groups. Under these conditions, the demands for the various services at the aggregate level would also be a function of the population distribution among the groups, and so would government consumption and investment demand.

Consumption, investment and government demand, together with export demand, comprise the total final demand. This, plus intermediate demand, make up the total demand for goods and services. To meet this demand, the various producers--corporations, unincorporated businesses and government--generate the economy's output, which together with imports yield the total supply of goods and services. Parts of the total demand and supply are exchanged in the nation's commodity markets. The remaining quantities of goods and services are used by their producers.

The transactions taking place in commodity markets determine the quantities and prices of commodities traded. As a rule, these market outcomes reflect, inter alia, the imperfections and rigidities characteristic of those markets. Those imperfections and rigidities are partly the consequence of government policy interventions operating through subsidies, indirect taxes and prices, and partly the result of institutional and structural rigidities.

One of the outcomes of the market clearing process is the acquisition of goods and services by population groups. These goods and services usually meet only a part of their consumption needs. Another part is satisfied by what the groups produce for their own consumption. And yet another part is met by the goods and services provided by the Government. The total consumption of goods and services determines the living standards of the various groups.

(c) Factor markets

In the course of generating the economy's output of goods and services, producers employ a range of production techniques. In some sectors, modern capital-intensive (box 11) methods are used along with traditional labour-intensive techniques to turn out similar products. In other sectors, competition among alternative production methods is largely absent as one class of techniques is universally preferred to the others. Through most of the economy, however, there is often substantial room for substitution between labour and capital.

To generate output, producers hire the services of productive factors--land, capital as well as labour of various skills. The quantities of various factors demanded will depend on the output levels being generated, the structure of output by sector, the technologies used in those sectors and prevailing prices of factor services.

Box 11

Glossary

Capital income
Income of different kinds, including profits, dividends and interest, accruing to physical capital and financial claims in return for services rendered by those forms of capital.

Capital-intensive
A process of production using proportionately more capital than other factors of production, such as labour.

Capital market
The market for long-term loanable funds as distinct from the money market, which deals in short-term funds. In principle, capital market loans are used by industry and commerce for fixed investment. The capital market is not one institution, but all those institutions that canalize the supply of long-term funds.

Factorial distribution
The distribution of income among various factors of production in return for services rendered by those factors.

Factor markets
Markets in which services of factors of production are bought and sold through a process that determines prices and quantities of those services traded. In aggregate terms, for instance, the labour market or the capital market.

Labour income
Income, primarily in the form of wages and salaries, accruing to labour in return for services rendered by it.

Labour-intensive
A process of production using proportionately more labour than other factors of production, such as capital.

Labour market
The market in which labour services are bought and sold through a process that determines the level of employment of labour as well as wages and salaries.

Rental income
Income accruing to a durable good, such as land or buildings, in return for services rendered by the good.

The owners of factors of production include all institutions--population groups, corporations and government. Labour services are exclusively supplied by population groups and in particular by those who participate in the labour force. The degree of their participation is a function of a number of factors: economic, social and demographic.

Depending on the distribution of land ownership, land services are provided by one or more population groups. Similarly, capital services are supplied by the institutions possessing assets in the form of physical and financial capital. These may include corporations or government, as well as all or only some population groups.

The transactions between buyers and sellers in factor markets determine the quantities of factor services hired as well as factor prices. Typically, only a part of the nation's demand for and supply of factor services appears in these markets as there are large segments of economy where the producers use factor services which they provide themselves. Like the commodity markets, factor markets are subject to imperfections and rigidities, which are partly the consequence of market fragmentation arising from less than perfect factor mobility and partly the result of the prevailing institutional arrangements. 3/

The operation of factor markets determines employment levels and prices of various factors, but also the levels of factor unemployment. Often, the most visible form of factor unemployment is unemployment of urban labour. The relative abundance of other categories of labour relative to natural and man-made resources manifests itself in underemployment, characterized by low productivity levels. 4/

(d) Income distribution

The employment of productive factors yields factor incomes and the factorial distribution of value added. Factor incomes accrue to the owners of factors of production--the institutions. Labour income is typically received by the households of various population groups. Capital income of different sorts--profits, dividends and interest income--accrues to institutions, including population groups, owning capital assets and financial claims. Similarly, rental income is received by property owners, and in particular by those owning land.

The process by which factor incomes are transformed into incomes of institutions is normally influenced by government. By means of the policy instruments at its disposal--particularly taxes and transfer payments--the government affects this process with the aim of raising the revenues needed to finance the provision of public goods and services and to modify incomes of other institutions. From the point of view of these other institutions, the taxes and transfers amount to net transfers. Once those net transfers are made, the distribution of income among the institutions is completed. The end result of this process is the disposable incomes of institutions (the point at which this description of the system started).

In summary, the standard of living of different population groups is a function of the quantities of goods and services these groups consume. These, in turn, largely depend on the disposable incomes these groups command, the prices they are charged, their wants as well as their demographic characteristics. In addition, they are a function of the goods and services that government makes available to the groups. The disposable incomes of population groups, in turn, depend, among other things, on a number of institutional and structural arrangements. Thus, they depend on the ownership of factors of production by the groups, the levels at which the factors are employed and the prices their services fetch, as well as on the government policy relating to taxes and transfers. Through employment levels and prices of factors of production, the disposable incomes of population groups are influenced by a number of the variables in this framework, among which is the commodity composition of private consumption demand, which in turn depends on the level and distribution of incomes.

2. Dynamics

The way in which the system changes over time is largely influenced by two major interrelated processes, which respectively set into motion two chains of events. One of the processes, asset formation (box 12), gives rise to a series of economic changes. The other consists of demographic events, which bring about population changes. These two processes and the resultant changes are discussed below.

(a) Asset formation

Central to the process of asset formation is capital formation--the process by which additions to the nation's stock of physical capital are made. This process is sustained by the savings and investment decisions taken, respectively, by institutions and producers. Each of the three types of institutions distinguished earlier can generate surplus funds over and above current consumption. These funds take the form of household savings, gross business savings, and government savings (the current government surplus), respectively, and together make the pool for investment. In a typical developing economy some of these savings and investment decisions are independent of one another while the others are made jointly and represent the two sides of the same process. This is the case when small unincorporated producers, mainly family businesses, rely on their own savings for investment.

Parallel to the increase in the stock of physical capital is a process of human capital formation. If human capital is defined to include a range of skills, this process can be visualized as one involving both additions to the labour force and the upgrading of its skills. The accumulation of human capital can, therefore, be visualized as a consequence of population change, educational processes--formal as well as informal--and the forces affecting the participation in the labour force.

Yet another form of asset formation consists of additions to as well as improvements in land and its products. This process is especially important

Box 12

Glossary

Asset formation
Additions to assets such as land, physical capital and human capital that households, corporations or government own.

Capital formation
Additions to the stock of physical capital. Two types of capital formation are distinguished--gross and net. The former includes replenishment of inventories, depreciation, repairs and maintenance expenditure, while the latter excludes them.

Human capital
Productive investments embodied in human persons. These include skills, abilities, ideals, health etc. that result from expenditures on education, on-the-job training and medical care.

Migratory movements
Geographic mobility defined as change of usual residence between defined political or statistical areas or between residence areas of different types.

Technical progress
Increased application of new scientific knowledge in form of inventions and innovations with regard to capital, both physical and human.

Vital events
Births, deaths, marriages and divorces.

in economies where agriculture and mining are the predominant sectors. In the case of agriculture, for example, additions to arable land may result from a number of different activities, ranging from the resettlement of population into new agricultural zones to the conversion of forested land into cultivable fields. Land improvements may result from irrigation, terracing, and so on.

Technical progress influences and is influenced by the pace of asset formation. A major factor in stimulating the long-term economic growth in both developed and developing countries, technical progress is affected by a number of factors, among which could be demographic trends.

(b) Economic change

Asset formation gives rise to new production activities and brings about structural change in the economy. These changes are typically multi-dimensional. Thus, they often involve shifts in the sectoral structure of output towards manufacturing and services and away from agriculture, typically favouring urban as opposed to rural areas. The structural changes manifest themselves in the growing importance of modern businesses as against traditional activities, especially in the urban economy, and in the adoption of capital-intensive in the place of labour-using technologies.

In addition to bringing about growth and structural change in the economy, asset formation also alters the distribution of the ownership of factors of production among different institutions, and more particularly among various population groups. These changes, typically, have multiple implications for the entire system. The most important among them, from the viewpoint of the standard of living, is the redistribution of factor incomes among households and other institutions altering the distribution of disposable incomes and ultimately the standards of living of population groups.

The Government may intervene in the process of asset formation with a view to bringing about changes in the distribution of asset ownership in favour of poverty groups. In doing so, it may resort to policy instruments and structural reforms that improve the access of those groups to credit, training, modern-sector employment and land. The objective of these interventions may be to increase household disposable incomes, household consumption and living standards for poverty groups and, by implication, to achieve greater economic equality among groups.

Revisions in disposable incomes of various groups, whether or not they occur partly as a result of government action would usually have further repercussions over time. They would first lead to changes in the output mix through altered household consumption demand, provided that constraints on the supply side did not prevent producers from responding to the new demand. The new output mix would imply changes in the demand for factor services and a new pattern of employment of productive factors. Ultimately, this may bring about changes in the factorial distribution of income and a new distribution of income among institutions, including population groups.

(c) Demographic processes

Demographic processes are shaped by vital events or migratory movements. Vital events include births, deaths, marriages and divorces. Migratory movements include various types of moves into and out of a population group. The migratory processes are broadly defined in this framework to include all types of movements affecting population groups, no matter whether they involve physical movements or not. A migratory movement could include a change in one's residence, a change in one's socio-economic status, or both.

(d) Population change

Demographic processes bring about changes in the size and composition of various population groups. Fertility and mortality levels vary among groups and result in different rates of natural increase. The rate of population growth is modified, sometimes drastically, by migration among groups and, where the country is open to international population movements, by international migration. Consequently, some groups may experience rapid increases in their numbers, far beyond those resulting from their births and deaths, while other groups may grow more slowly or even shrink in size in spite of their positive balance of births over deaths. The end result of demographic processes over time is the revised totals of individual population groups and, by the same token, the altered distribution of the total population among the groups.

In addition, demographic processes bring about changes in the composition of the various population groups by age, sex, and other characteristics. Of particular interest to the planner are shifts in the age structure of these groups. Where fertility and mortality conditions have remained roughly stable in the recent past, these shifts can arise primarily from inter-group population transfers and/or international migration. However, fertility and mortality decline have an impact on the age structure in their own right. The effects of a fertility decline are typically far greater than those arising from a mortality decline. Thus, a fertility decline causes the age structure to become progressively "older", while a comparably large mortality decline, distributed over all age groups has less effect on the age structure.

Migration is often highly selective by age (and often by sex). In general, a disproportionate share of migrants are persons in the working ages. Therefore, groups experiencing net gains due to migration mainly undergo increases in their numbers of working age persons. Similarly, groups experiencing net losses largely suffer a depletion of those same age groups. As a result, the former groups typically witness declines in their dependency burden (ratio of the young and old population combined, to the working age population) and the latter groups see their dependency burden rising.

Migration can be also highly selective with respect to education. This selectivity both derives from and reinforces inter-group differentials in educational attainment. The causes of these differentials are twofold. First, occupations in which members of various groups are predominantly engaged require types of skills that are normally acquired through schooling of varying duration (or no schooling at all). And second, educational attainment is often closely associated with personal income and wealth and is therefore bound to vary among the groups enjoying different income levels and standards of living. Where selectivity of migration by education is strong, migratory processes tend to perpetuate inter-group educational differentials, though they do not alter the educational distribution of the total population.

D. Economic-demographic interactions

Asset formation and demographic processes, and the economic and population changes emanating from them interact over time in a number of complex ways. Some of these interactions are well understood, others are not. These interactions have such an important impact on the dynamics of development and population change that planning exercises need to take them into account.

The description of relationships that follows is intended to be illustrative rather than prescriptive because the way any given relationship manifests itself in any particular country will depend on a wide range of unique local conditions. To effectively consider any such relationship in developing the planning framework for a particular country, a careful review of the local conditions is absolutely essential. Only in that way can the framework be fully adapted to the unique local conditions.

1. Effects of population change on socio-economic variables

Demographic variables operate on economic variables largely through two different channels. In one, population change influences the supply of goods and services, mainly indirectly through asset formation. In the other, population change impacts on the demand for goods and services directly. Each of the two groups of effects will be reviewed. The effect of population change on the distribution of disposable incomes will also be considered.

(a) Supply of goods and services

Population change may impact on the supply of goods and services *inter alia* through household savings. In each population group, these savings could be influenced over time by the increase in the group's size and the change in its age structure. In particular, the effect of population increase is transmitted through per capita income. All other things being equal, a reduction of the group's population growth from high to moderate levels would lead to a faster increase in its per capita income. This, in turn, could lead to a more rapid increase in both average saving ratio (box 13) and the total volume of household savings. This would be true whenever the income elasticity of savings is greater than unity, as is often the case in many developing countries. The effect of the change in the age structure on household savings may be positive if this change amounts to a decrease in the dependency burden. 5/

Population growth can also influence the way savings, especially government savings, are invested. A distinction is sometimes made between directly productive investments, such as those made into irrigation schemes or factories, and investment in social infrastructure, such as housing, education or water supply systems. It is argued that the former type contributes directly to output growth, while the contribution of the latter type is indirect and delayed in time. The latter directly improves the welfare of population groups, and its contribution to output growth is to eventually produce a better educated, healthier and presumably more motivated labour force.

A reduction of rate of population growth from high to moderate levels may favour investment allocation to directly productive investment and, therefore, earlier output growth. With a given volume of savings--including household, corporate and government savings--a slower population growth necessitates channelling a smaller share of those savings to social infrastructure investment in order to maintain a given per capita level of services. As a result, a larger proportion of savings is available for directly productive investment, enabling faster capital accumulation and output growth.

Population growth, over a period of time, leads to an increase in the working-age population (a prime determinant of the labour force) and, thus, has a positive effect on output. This effect, however, may be quite weak if unskilled labour is in excess supply. On the other hand, in those developing countries that have no labour surplus, population growth and the resultant labour force increase can act as the major stimuli to output expansion. Irrespective of the overall human resources situation, an increase in the educated labour force can be beneficial to economic expansion. Where educated labour is abundant, available managerial and technical skills may provide a strong stimulus to output growth.

Box 13

Glossary

Average savings ratio
: For the economy, this is the proportion of national income devoted to savings. Similarly, the average savings ratio of an individual or a population group is the proportion of the individual's or group's disposable income which is saved. The savings ratio is sometimes used synonymously with the average propensity to save.

Income elasticity of consumption
: The responsiveness of expenditure on a commodity or a group of commodities to changes in the consumer's income, measured by the proportionate change in expenditure divided by the proportionate change in income.

Income elasticity of demand
: The responsiveness of the quantity demanded of a commodity or a group of commodities to changes in the consumer's income, measured by the proportionate change in quantity demanded by the proportionate change in income.

Income elasticity of savings
: The responsiveness of the amount of money saved to changes in the consumer's income, measured by the proportionate change in savings divided by the proportionate change in income.

Other effects of population change on output growth are more subtle. Among them is the impact of population increase on agricultural output growth in densely populated countries with limited arable land. In such a setting, additions to the total population may cause a net loss of cultivable land for a number of reasons, including the growth of urban centres and the expansion of land-using infrastructure. More important, population growth can cause soil degradation due to overexploitation of land which in turn could result in a slower agricultural growth and even in a decline in the per-capita agricultural output. On the other hand, rising population pressure on land can trigger improvements in agricultural techniques, bringing about increases in land productivity and per capita agricultural output. 6/ It can promote the adoption of more productive labour-intensive agricultural techniques. Also, it can promote irrigation and cropping thereby increasing effective land areas and per capita agricultural output.

(b) Demand for goods and services

The effects of population change on the demand for goods and services, are particularly direct and strong in the case of household consumption, the largest component of final demand. The effects on government consumption and investment demand, are probably as significant but less direct. Lastly, the influences of population growth on household and corporate investment demand are more roundabout and delayed in time as they are transmitted through other demand components.

Like household savings, the household consumption demand of a population group is affected by a change in the population size as well as in its age structure. The increase in the size of any given population group affects its household consumption demand through per capita disposable income. Thus, a reduction of the rate of growth of a particular group from a high level would ceteris paribus lead to a more rapid increase in the group's per capita income. This, in turn, could cause a drop in the group's average propensity to consume. This would be true under the plausible assumption that the income elasticity of consumption is smaller than one.

Population growth can also affect the structure of household consumption demand by commodity categories, operating again through per capita income. Thus, all other things being equal, a substantial deceleration of the population increase would cause per capita income to grow faster, and this, in turn, would lead to a relative increase in the consumption of commodities having an income elasticity of demand greater than one. Such commodities are more likely to be considered luxury items.

The structure of household consumption demand of a population group could also change as a result of shifts in the group's age structure. Since consumption preferences vary among persons at different stages of the life cycle, the demand for various consumption goods and services would change as the proportions of a group's members at different years of age change.

The re-distribution of the total population among the groups may exert further influence on household consumption demand at the aggregate level. The levels and patterns of consumption demand may differ among the groups for a

variety of social and cultural reasons. Hence, aggregate household consumption demand may undergo changes in response to the shifts in the relative shares of the various groups. These changes take place as the preferences of the population groups gaining in size become increasingly felt relative to those of the groups shrinking in relative size. Thus, in a country experiencing rapid urbanization and modernization, the composition of aggregate household consumption demand would tend to become progressively "urban" and "modern" as population groups having these attributes tend to expand at the expense of other groups.

The influence of population change on government consumption and investment demand is typically strongest in those sectors providing social services. All other things being equal, an increase in the size of the relevant segments of the population or the total population of a group translates into an increased demand for specific services. Thus, for example, an increase in the school-age population ceteris paribus would lead to the growing demand for educational services.

In addition to this, a change in the age-sex structure of segments of the total population would tend to modify the demand for specialized services in fields such as education and health. Thus, given the increase in total school-age population, shifts in its age-sex structure can cause the demand for educational services at different levels of schooling to grow at different rates, and some to decline. This would happen, for example, in a group that had been recently experiencing a sharp reduction in fertility leading to the decreasing numbers of children eligible to enter elementary schools. Similarly, changes in the group's age structure can modify the demand for the specialized health services, such as those catering to children, women of childbearing age, and the elderly.

(c) Distribution of income

Demographic change may also have an impact on the disposable incomes of population groups. Thus, in the short to medium run, differences in population growth brought about, say, by differences in fertility declines experienced by different groups can increase or decrease inter-group differentials in per capita disposable income and the standard of living. For example, where population groups with higher standards of living experience more rapid fertility declines and slower population growth than groups with lower living standards, the inter-group differences in the standard of living might increase.

In the long run, a different kind of effect of population growth on inter-group income inequality and the standard of living may operate. Where overall population growth is rapid, a concomitant rapid increase in the supply of labour may reduce the rate of return to labour relative to the rate of return to other factors of production. Since the wealthier population groups generally possess a disproportionate share of non-labour factors of production, their disposable incomes are likely to increase relative to other population groups. As a result, rapid population growth may lead to a more unequal income distribution (Working Group on Population Growth and Economic Development, 1986).

2. Effects of socio-economic change on demographic variables

The effects of socio-economic change on demographic variables are complex and not fully understood. Some effects are largely direct whereas others operate indirectly through intermediate variables that can be social, cultural and biological.

These relationships are generally the result of the behaviour of numerous individuals, couples or families. The behaviour underlying these relationships is frequently moulded by cultural and institutional factors, which often do not lend themselves to rigorous quantitative analysis.

In spite of their elusive nature, these relationships are a part of the framework since they are of increasing interest to policy analysis and planning. These relationships are reveiwed below and suggestions are made on how social and economic change affects demographic processes through them.

(a) Fertility

Among the most important relationships between socio-economic and demographic variables are those by which the two principal determinants of fertility in a population are shaped (United Nations, 1987). One of the determinants is the extent to which women of various childbearing ages are married, which is generally an outcome of marriage formation and dissolution, and the other is the extent to which the married women give births.

(i) Marriage

The proportion of women who are currently married is primarily determined by the age of entry into first marriage and the extent to which women choose to remain single. Thus, where the mean age of first marriage is low and celibacy among women is rare, the proportions of women currently married rises swiftly with age and typically remains close to unity towards the upper end of the childbearing span. Whether or not women enter first marriage early and whether or not a small proportion of them remains single is largely a function of societal norms and customs. It is further a function of the alternatives to marriage, among the most important of which are secondary and higher education and employment outside the home. In addition, it is also a function of the availability of eligible males.

(ii) Marital fertility

Decisions by couples on the timing, spacing and the number of children are influenced by a variety of factors including group-level and/or societal norms, household incomes, benefits and costs of children, mortality conditions, and the preferences for children versus other sources of satisfaction. These decisions can be often influenced by government policy towards fertility.

Some of the effects of economic change on the reproductive decision of couples are direct while the others are roundabout. Some are immediate while others are delayed.

Socio-economic change also affects the costs and benefits of children to parents. In general and over the long term, such changes tend to increase the former and reduce the latter. The combined effect of rising costs and falling benefits is a decline in the number of children desired. These trends in costs and benefits most often are initially more intense in urban-based groups. As a result, fertility reduction usually originates in urban groups and later spreads to rural groups.

Direct costs of children, which are heavily influenced by the prevalence and duration of schooling, tend to increase with development as education becomes more universal and prolonged. Opportunity costs (box 14) also tend to grow as employment opportunities for women improve and their skills and educational attainment are upgraded. At the same time, both economic and old-age security benefits of children tend to decline. The former fall as a result of the process that transfers a growing proportion of children from the labour force to the educational system. The latter decline as institutionalized social security programmes gradually supersede the family as the major provider of old-age security.

Box 14

Glossary

Inter-birth interval
: Time elapsed between successive births.

Morbidity
: The extent of illness, injury or disability in a population.

Opportunity cost
: The value of the alternatives or other opportunities that have to be forgone in order to achieve a particular thing. It coincides with money expenditure or outlays necessary to achieve it, if and only if the prices with which the outlays are calculated correctly reflect the value of alternative uses of the resources.

Post-partum sterility
: The period of temporary sterility following a birth. The duration of this period is heavily influenced by duration and intensity of breast-feeding.

A fertility decline brought about by social and economic change is sometimes reinforced by mortality reduction, especially by mortality decline occurring in infancy and early childhood. Where fertility is uncontrolled, declining mortality would cause a fertility decline at least among some couples through a biological mechanism. Fewer deaths would mean longer post-partum sterility associated with lactation and, thereby, longer inter-birth intervals and lower fertility. Where fertility is subject to control, mortality reduction would lead to lower fertility because as fewer children die, a smaller number of births are required to achieve a desired number of surviving children.

The preferences of parents for children versus other sources of satisfaction undergo changes with development. Typically these shifts lead to a decline in the number of children that parents desire. In many situations, however, desired fertility is lower, sometimes considerably lower, than the fertility actually achieved by the couples. This is normally the consequence of the inability of couples to effectively control their fertility. It may derive from the fact that the knowledge of suitable and effective contraceptives is limited, that such contraceptives are not readily and widely available, or that available methods are unacceptable for cultural, religious or other reasons.

(b) Mortality

There are different routes by which socio-economic change influences mortality. One major channel through which these effects are felt is household income and consumption. Where these increase over time, morbidity and mortality are likely to decline. With rising incomes and consumption, the nutritional intake and balance is likely to improve, bringing about greater resistance to disease. Furthermore, growing incomes and consumption typically lead to improvements in household sanitation and reduced exposure to disease. Finally, rising household incomes may enable households to spend more on health care.

Economic change also operates on mortality through the resources used by communities or the Government to make environmental improvements. In particular, where economic expansion is rapid these resources may become more plentiful. If they are used to upgrade existing and build new facilities, such as water supply and waste disposal systems, the improvements in environmental sanitation will translate into lower morbidity and mortality.

The third channel by which economic change influences mortality is the health system, and particularly its public component. In general, rapid economic growth increases the share of the national product allocated to the public health sector, with the result that both preventive and curative health care becomes more readily available to the population.

(c) Migration

Migration is often particularly important for the planner because, unlike fertility and mortality, migration can respond quickly to social and economic change. This is true both of internal migration and of international migration. Hence, the planner may consider migration to be a component of population change over which he can exert substantial influence in the medium term and, sometimes, even in the short term.

Internal migration usually occurs as individuals and families respond to differences in economic and other opportunities in various locations. However, these decisions are normally taken under conditions of imperfect information and often under financial and other constraints. Those other constraints may include linguistic, ethnic, caste or institutional barriers to mobility.

Domestic economic expansion usually favours some population groups over others and, consequently, the economic opportunities open to various groups differ. This brings about mobility from groups having poorer to those enjoying better opportunities and access to assets, employment, services etc. This mobility may take on a number of different forms, such as migration of landless farmers to new arable land in another rural area. Another form would be a movement of underemployed farm labourers from depressed rural areas to the informal urban-based economy. Yet another form would be that involving a transfer of adolescents, after completing education, from families affiliated with the urban informal sectors to the groups attached to the modern urban economy.

As development favours some groups more than the others, per capita incomes in various groups are likely to grow at different rates, meaning that the members of different groups would not find mobility equally affordable. This is particularly true of moves that require the acquisition of assets, no matter whether these take the form of land purchases or the acquisition of new skills through formal schooling.

Responses to differential economic and social opportunities may also take the form of international migration. When this type of migration involves the movement of members of the domestic population groups towards foreign countries, emigration can be permanent, temporary or a combination of the two. Temporary emigration, which normally includes workers seeking or accepting employment abroad on a temporary basis, is accompanied by a movement of population in the opposite direction. This reverse movement represents the return migration of the original temporary emigrants.

E. Summary

To better understand how various policies or structural reforms can influence the standard of living of various population groups, it is necessary for a planner to have a conceptual famework or a mental model as a basis for comprehensive planning. This chapter outlines such a framework including demographic variables, which permit one to visualize how different socio-economic or demographic policy instruments and reforms, operating through

economic growth, population change or income re-distribution have an impact on standards of living. This framework is being described as a backdrop for projection exercises that can be prepared with the proposed methodology for comprehensive planning.

The framework, which makes a distinction between three categories of institutions--population groups, corporations and government, is considered from both the static and the dynamic point of view. The statics of the system is described by looking into the chain of linkages running from incomes of institutions to demands in commodity and factor markets, to incomes of factors of production, and back to institutions' incomes. The dynamics of the systems is examined by considering the asset formation process and economic changes emanating from it along with demographic processes and the resultant population change.

An important aspect of the framework are two-way interactions between socio-economic and demographic variables of the system. Therefore, the effects of population change on key socio-economic variables, the supply of and demand for goods and services and the distribution of incomes are described. The effects of socio-economic changes on demographic variables and especially those on the key components of population change--fertility, mortality and migration--are also discussed.

Notes

1/ The framework will draw ideas from the critical re-examination of growth-oriented planning, which initially sought to balance rapid economic growth with income redistribution. It will also borrow from the conceptual frameworks underlying recent Indian planning and Bachue-type economic-demographic modelling. The discussion will also make use of a recent review of the consequences of demographic trends for socio-economic change. For the relevant literature, see: Chenery and others, 1974; Pyatt and Thorbecke, 1976; Government of India, Planning Commission, 1981; Rodgers and others, 1978; and Working Group on Population Growth and Economic Development, 1986.

2/ Note that this three-way classification of institutions is similar to a three-way classification of economic agents in the standard economic analysis, which distinguishes among households, businesses and government.

3/ Thus, in the capital market, which often consists of two insulated segments serving respectively modern and informal sectors, they appear to be the result of the lack of an adequate network of financial intermediaries serving both segments simultaneously. In the labour market, which normally consists of two or more semi-independent markets, minimum wage legislation, trade unions and the employers' willingness to share the productivity gains with their workers may all contribute to less than perfectly competitive conditions, especially in the urban areas.

4/ Underemployment is particularly widespread and typical of much of economic activities in a developing country. It is normally seen as one of the most conspicuous signs of underdevelopment and as the root cause of poverty. As a result, development usually amounts to providing more productive employment to a large and often rapidly growing underemployed labour force with the concomitant increase in incomes and the standards of living of large segments of the population.

5/ The available evidence on this effect, however, is at best ambiguous. Its importance is likely to be far smaller than that of the population increase.

6/ For a recent summary of the literature on the effects of population growth and density on agricultural technology, see Working Group on Population Growth and Economic Development, 1986.

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II. THE COHORT COMPONENT METHOD FOR MAKING POPULATION PROJECTIONS

A. Introduction

Preparing population projections is a critical first step in incorporating population concerns into comprehensive planning. Many projections relevant to this type of planning, such as projections of employment, incomes and consumption directly or indirectly make use of population projections. For example, projections of employment are normally made in conjunction with projections of labour force, which are in turn often derived using population projections.

A variety of methods can be used to project a nation's population. Some methods directly project the total population given the initial size of the population and assumptions on future rates of population growth.1/ The cohort component method, however, can project population by age and sex employing the initial age and sex structure of the population together with assumptions on the future components of population change, such as fertility and mortality.

This chapter describes a variant of the cohort component method which can be used to make a projection either of the national population or of urban and rural populations. The method is capable of projecting the structure of the population by age and sex along with various indicators of population size, structure and change. The chapter will not describe methods which can only project the total population, since the projected population structures are a critical prerequisite for many planning exercises using population projections.

The population structures projected by the method can be used as inputs for projecting the number of households, school enrolment, and the size and composition of the labour force. Projections of the population size can be employed to project household incomes as well as household consumption and savings. Likewise, the results can be used as an input for projecting government consumption and investment in the health sector.

The major strength of this technique is its ability to project a population in a straightforward and unambiguous manner. The technique does not embody restrictive or arbitrary assumptions and generates results which faithfully reflect the initial population structure and the fertility, mortality and migration conditions specified by the user. It yields projection results which are indispensable to any planning exercise seeking to take the future population change into account. These features make this technique fundamental for integrating population factors into development planning.

It is important, however, not to confuse these strengths with the capacity to provide sound forecasts of future demographic change. A projection prepared by this technique may not necessarily be an accurate prediction of future population change. Given the initial population, the technique can only provide an indication of the future population, if the components of population change turn out to be as specified by the initial assumptions. The degree to which a specific projection will correspond to future demographic events will depend on the accuracy with which the initial population was specified and trends in the components of population change were forecast.

In general, the decision on whether to apply the technique at all, or whether to use it in order to project only the national population depends on whether it is possible to prepare sound inputs. Under most conditions, the preparation of those inputs would require a substantial amount of information, especially if projections of urban and rural populations are sought. National statistical or census offices and national research institutions, as well as offices within the United Nations system, often have prepared estimates of the major demographic parameters. These estimates can frequently serve as a guide or basis for peparation of demographic inputs into the projection process.

A population projection requires many computations in order to arrive at a projection, particularly at a projection of urban and rural populations. This apparent problem is compounded by the fact that, for many planning purposes, a single projection will not suffice. However, these tedious calculations are readily performed with the aid of an electronic computer and, fortunately, several computer programs have been developed for preparing population projections. Some of those programs are for use on mainframe computers and others for use on microcomputers (box 15). A computer program that will correspond to the description of the cohort component method contained herein will be developed in the future for microcomputers.

The remainder of this chapter initially sets forth the procedures which make up the cohort component method. Then, it describes the inputs required and discusses how these inputs can be prepared. Finally, the chapter presents examples showing how the technique is used to prepare projections.

B. The technique

1. Overview

As an introduction to the cohort component method, this overview indicates the types of inputs it requires along with the types of outputs it can generate. In addition, the overview outlines the computational steps involved.

(a) Inputs

In order to project the national population, the following types of inputs will be required:

Box 15

Computer programs for population projections

One of the first computer programs for making population projections was developed by the United Nations Population Division in 1973. a/ The program, which was designed for preparing national projections on a mainframe computer, was revised in 1982 and again in 1987. b/ The 1987 program is available in two versions, which can be respectively used on a mainframe computer and a microcomputer.

Another early mainframe-based program was developed by Shorter and Pasta, for preparing national projections and certain subnational projections, such as projections of the urban population. c/ This program was recently adapted for a microcomputer. d/

A few other microcomputer-based programs for making national population projections have been recently published. One of those programs, based on the United Nations projection methodology was prepared by The Futures Group. e/ Another program was recently published by the United Nations Economic and Social Commission for Asia and the Pacific. f/

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a/ "A computer program for population projections using the component method", Population Division working paper (ESA/P/WP.50, June 1973).

b/ United Nations, "A user's manual to the population projection computer program of the Population Division of the United Nations" (ESA/P/WP.77, 26 January 1982); "United Nations population projection computer program" (forthcoming).

c/ Frederic Shorter and David Pasta, Computational Methods for Population Projections: with Particular Reference to Development Planning (New York, The Population Council, 1974).

d/ Frederick C. Shorter, David Pasta and Robert Sendek, Computational Methods for Population Projections: With Particular Reference to Development Planning, 1st ed. with supplement added (New York, The Population Council, 1987).

e/ The Futures Group, A Demographic Projection Model for Development Planning for the IBM PC Micro-computer (Glastonbury, Connecticut, November 1986).

f/ Economic and Social Commission for Asia and the Pacific, "ESCAP/POP: a computer program for projecting populations by age and sex", Population Research Leads, No. 22 (Bangkok, 1986).

(i) Initial age and sex structure;
(ii) Assumptions on mortality;
(iii) Assumptions on fertility;
(iv) For an open population, assumptions on international migration.

If a projection of urban and rural populations is sought, the requisite inputs will include those listed under (i) through (iv) for each population -- urban and rural. In addition the inputs will include assumptions on internal (urban-rural) migration.

Box 16 lists the types of inputs required to make a population projection (national or urban-rural). Since the cohort component method is described in this chapter as a tool for preparing quinquennial population projections, assumptions on the components of population change would be for dates five years apart or for the intervening five-year time interval. As indicated in box 16, these assumptions can be expressed in terms of a variety of mortality, fertility and migration measures.

(b) Outputs

Where the cohort component method is used to project the national population, the types of results can include projections of the following:

(i) Age and sex structure of the population;
(ii) Various population aggregates, such as the population size, young- and old-age population, and the number of women in the childbearing ages;
(iii) Indicators of the population structure, such as the proportions of population in broad age groups (0-14, 15-64 and 65+) and the sex ratio of the population;
(iv) Rates of population change due to births, deaths and, where appropriate, international migration.

Where the technique is employed to project urban and rural populations, the results can include projections of the variables listed under (i) to (iv), both for the national population and for urban and rural populations. In addition, the results can include indicators of the population distribution, such as proportions of the national population, urban and rural, plus rates of population change due to internal (urban-rural) migration.

The types of results that can be obtained by the method, which are listed in box 17, would be for the dates five years apart or the intervening projection intervals.

(c) Computational steps

Projecting the population with the cohort component method involves a sequence of computational steps that are repeated for successive projection intervals, which in this description of the method are five-year time intervals. 2/ The steps use assumptions on future demographic conditions to modify the age and sex structure of the population as well as to derive

Box 16

Inputs for applying the cohort component method

1. Initial age and sex structure of the population (national or urban and rural)

2. Assumptions on mortality (national or urban and rural):

   Survival ratios by age and sex; or

   Expectations of life at birth by sex; or

   Infant mortality rates by sex and
   Expectations of life at age 5 by sex

3. Assumptions on fertility (national or urban and rural):

   Fertility rates by age; or

   Total fertility rates and
   Proportionate fertility rates by age

4. Assumptions on international migration (national or urban and rural; if population is open to international migration):

   Net international migration rates by age and sex; or

   Total net international migration rates by sex and
   Proportionate net inernational migration rates by age, by sex;
   or

   Net change to the population due to international migration by
   age and sex

5. Assumptions on internal migration (for urban or rural population; if urban and rural populations are being projected):

   Net internal (urban-rural) migration rates by age and sex; or

   Total net internal (urban-rural) migration rates by sex and
   Proportionate net internal (urban-rural) migration rates by age,
   by sex; or

   Net change to the population due to internal (urban-rural)
   migration by age and sex

Box 17

Outputs of the cohort component method

1. Age and sex structure of the population (national or urban, rural and national)

2. Population aggregates (national or urban, rural and national):

   Population size
   Population in selected broad age groups
   Mid-interval population size
   Number of person-years-lived
   Population growth
   Births
   Deaths
   Net change due to migration (international, internal and/or combined international and internal)

3. Indicators of the population structure (national or urban, rural and national):

   Proportions by broad age groups
   Dependency ratios
   Median age of the population
   Proportion of women in childbearing ages
   Sex ratio of the population

4. Indicators of the population distribution (national; if urban and rural populations are being projected):

   Proportion urban
   Proportion rural

5. Rates of population change (national or urban, rural and national):

   Crude birth rate
   Crude death rate
   Rate of natural increase
   Crude net migration rates (international, internal and/or combined international and internal)
   Rate of population growth

various indicators of the population size, structure and changes. They result in the projected age and sex structures for the end of the projection intervals along with different types of indicators pertaining to the same dates or the intervals themselves.

Typically, a projection of population prepared in connection with a development plan will be made for a 15- or 20-year time period. A projection over a period of this length will be made even when the planning exercise is limited to a medium term, such as a five-year period, and does not include any perspective planning. This is so since for a variety of purposes, a longer-term population perspective will be needed. In view of this, making a projection by the cohort component method will require repeating the sequence of steps for several five-year projection intervals.

2. National population

This section will initially elaborate the steps involved in deriving the age and sex structure along with other results that can be obtained in the course of projecting the national population closed to international migration. This section will then discuss additional steps needed to project a national population open to international migration. The steps used to derive rural and urban populations will be described in a later section.

(a) Closed population

The procedure involved in making a projection of the national population closed to international migration over a five-year projection interval (t to t+5) includes, among others, steps needed to derive the age and sex structure of the population at the end of that interval. These steps can be divided into two groups: (i) those which yield the segment of the population structure at age five and above; and (ii) steps to derive the segment of that structure below age five. The procedure also includes steps to calculate various population aggregates and indicators of population structure and change. The steps that make up this procedure are summarized in box 18, and a subset of them, used to calculate the age and sex structure of the population, are also depicted diagramatically in figure II.

(i) Segment of the population structure at age 5 and over

a. Survival ratios

The nature of the first step in deriving the age and sex structure will depend on whether the mortality assumptions are formulated in terms of survival ratios (box 19) or summary mortality measures, such as expectations of life at birth. 3/ If they are specified in terms of survival ratios, these can be used directly as inputs into the projection process as shown in equations (2), (3) and (8).

Alternatively, if mortality assumptions are formulated using, say, expectations of life at birth by sex, then survival ratios first need to be

Box 18

Computational steps to project a national population closed to international migration

The steps used to project a national population closed to international migration over a five-year projection interval are:

(1) Use mortality assumptions to derive survival ratios by age and sex for the interval.

(2) Apply the survival ratios to the age and sex structure of the population at the beginning of the interval to obtain the segment of the age and sex structure of the population at age 5 and above at the end of the interval.

(3) Use fertility assumptions to derive fertility rates by age for the interval.

(4) Use the fertility rates, the numbers of women in the childbearing ages at the beginning and the end of the interval, and the sex ratio at birth to calculate the numbers of births by sex occurring during the interval.

(5) Apply appropriate survival ratios to the numbers of births by sex to obtain the segment of the age and sex structure below age 5 at the end of the interval.

(6) Derive various population aggregates, such as the population size, population of broad age groups and the numbers of births and deaths.

(7) Calculate various indicators of the population structure, such as proportions of population in various broad age groups, dependency ratios and the sex ratio of the population.

(8) Compute various rates of population change such as the crude birth and death rates as well as rates of natural increase and population growth.

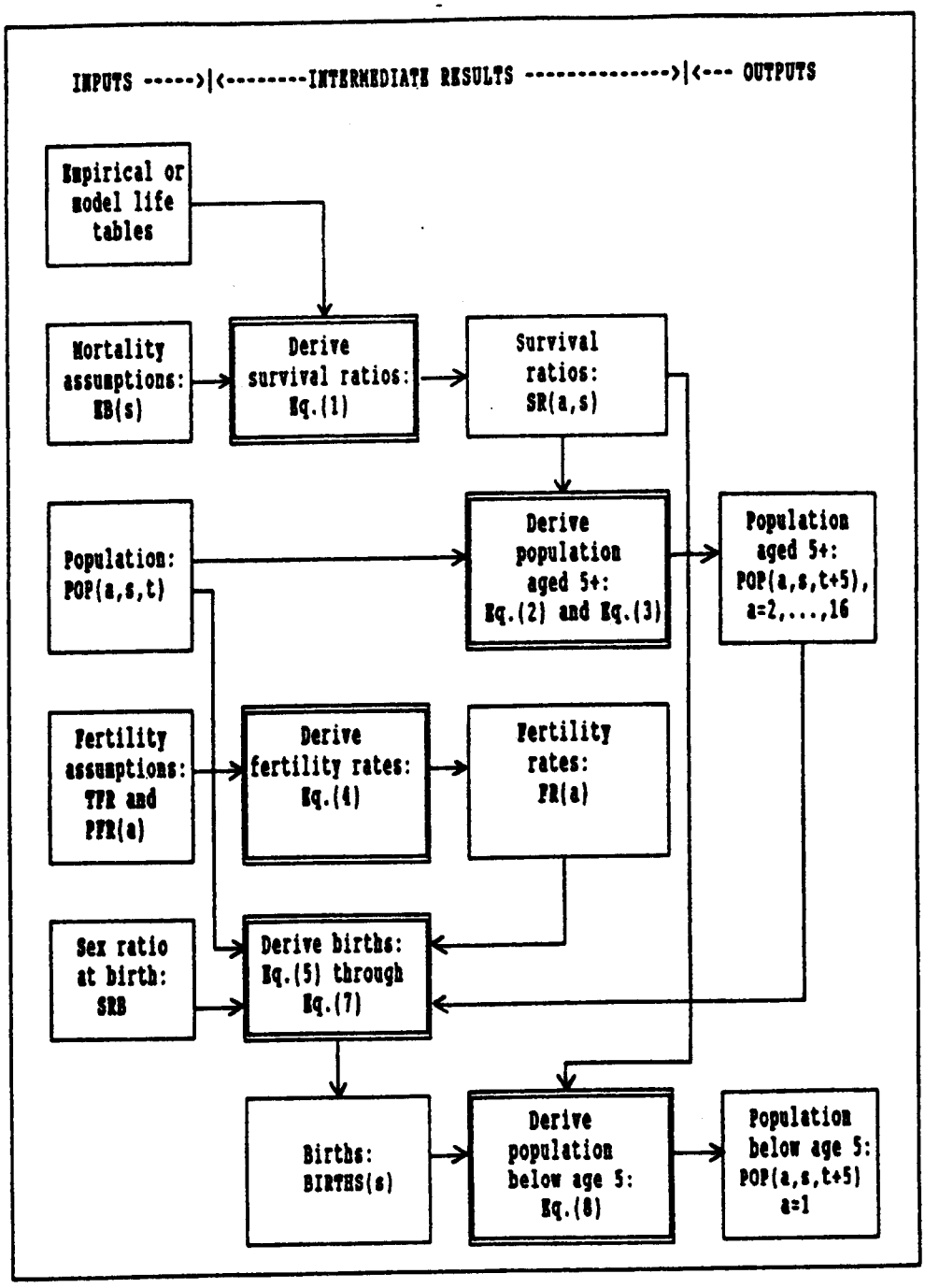
derived from those expectations. Written in general terms, the survival ratios would be calculated as follows:

$$SR(a,s) = T\,[EB(s)]; \qquad (1)$$

$$a = 1,\ldots,16;$$

$$s = 1,2,$$

Figure II. Steps to derive age and sex structure of the national population closed to international migration at the end of projection interval t to t+5



Box 19

Glossary

Expectation of life at birth
The average number of years a member of a cohort of births would be expected to live if the cohort were subject to the mortality conditions specified by a particular set of age-specific mortality rates. It is denoted by the symbol e_0 in the life table notation.

Life table
A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age-specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The tabulations commonly accompanying a life table include other features of the cohort's experience.

Model life table
An expression of typical mortality experience derived from a group of observed life tables.

Survival ratio
The probability of survival between one age or age group and another; when computed for age groups the ratios correspond to those of the person-years-lived function, ${}_nL_x$, of a life table.

where:

a = 1,...,16	are five-year age groups 0-4,...,75+, 4/
s = 1,2	are male and female sexes,
SR(a,s)	is the survival ratio representing the probability of survival over the interval among persons who belong to age group a and sex s at the end of the interval, 5/
EB(s)	is the expectation of life at birth of sex s specified for the interval, and
T	is the transformation of expectations of life at birth by sex into survival ratios using selected life tables. (See annex I to this chapter, Description of a life table.)

For either sex, the first survival ratio, obtained by means of a transformation indicated in equation (1) i.e., for a = 1, represents the probability of survival between birth occurring during the interval and age 0-4 at its end. The remaining ratios indicate the probabilities of survival between years of age 0-4, 5-9,..., 70+ at the beginning of the interval and the respective ages 5-9, 10-14, ..., 75+ at its end.

The transformation shown by equation (1), will typically amount to deriving survival ratios within the selected family of model life tables that correspond to expectations of life at birth given by assumptions. 6/ This derivation may involve an interpolation among survival ratios at appropriate levels of mortality in the model life tables employed. The computations involved in this transformation that use a linear interpolation are described in section C. Also, described in annex II to this chapter are calculations involved in a related transformation of infant mortality rates (box 20) and expectations of life at age 5 into survival ratios.

b. Population aged 5 and over

The numbers of survivors who belong to the various five-year age groups at age 5 and over at the end of the five-year projection interval (except those in the open age group) are calculated by applying the survival ratios to the numbers of persons belonging to corresponding five-year age groups at the beginning of the interval:

$$POP(a,s,t+5) = POP(a-1,s,t) \cdot SR(a,s); \qquad (2)$$

$$a = 2,\ldots,15;$$

$$s = 1,2,$$

where:

t is the year of the projection period,

POP(a,s,t+5) is the population (survivors) of age group a and sex s at the end of the interval, and

POP(a-1,s,t) is the population of age group (a-1) and sex s at the beginning of the interval.

The number of survivors in the open (eldest) age group at the end of the five-year projection interval is obtained by applying survival ratios to the numbers of persons who at the beginning of the interval belong either to the open age group or to the age group preceding it:

$$POP(16,s,t+5) = \left[\sum_{a=15}^{16} POP(a,s,t) \right] \cdot SR(16,s); \qquad (3)$$

$$s = 1,2.$$

Box 20

Glossary

Age-specific fertility rate
The number of births occurring during a specified period to women of a given age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the given age is usually divided by the mid-year population of women of that age.

Childbearing span
The age span within which women are capable of bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

Expectation of life at exact age x
The average number of years a person of exact age x would be expected to live if subjected to the mortality conditions specified by a particular set of age-specific mortality rates at age x and above. It is denoted by the symbol e_x in the life table notation.

Infant mortality rate
The ratio of the number of deaths of children under one year of age occurring in a given year to the number of births in the same year. Also used in a more rigorous sense to mean the number of deaths that would occur to children under one year of age in a life table with a radix of 1,000. In this sense, it is denoted by the symbol ${}_1q_0$.

Proportionate age-specific fertility rate
The rate calculated by dividing a particular age-specific fertility rate by the sum of age-specific fertility rates across the childbearing ages. The sum of all proportionate age-specific fertility rates equals one.

Sex ratio at birth
The number of male births for each female birth, conventionally multiplied by 100.

Total fertility rate
The average number of children that would be born per women if all women lived to the end of their childbearing years and bore children according to a given set of age-specific fertility rates. This rate can be computed as the sum of fertility rates by single year of age or the sum of fertility rates by five-year age group, multiplied by 5.

Taken together, the steps described by equations (2) and (3) yield the structure of the population at age 5 and over at the end of the interval.

(ii) Segment of the population structure below age 5

The numbers of persons below age 5 at the end of a five-year projection interval consist of survivors of children born during the interval. Therefore, in order to obtain those numbers, it is first necessary to compute the numbers of births by sex occurring during the interval and then multiply those numbers by suitable survival ratios. The numbers of births are calculated from fertility rates based on fertility assumptions, the numbers of women in the childbearing ages and the sex ratio at birth.

a. Fertility rates

Fertility assumptions can be specified using age-specific fertility rates or summary fertility measures, such as the total fertility rate along with proportionate age-specific fertility rates. If the assumptions are expressed in terms of age-specific fertility rates, those rates can be directly used in the projection, as shown in equation (6).

Where fertility assumptions are formulated using summary measures, the age specific fertility rates ought to be first computed from those measures. Thus, if the assumptions are given in terms of the total fertility rate and proportionate fertility rates by age, the derivation of age-specific fertility rates for a given five-year projection interval amounts to scaling the proportionate rates with a factor that equals the total fertility rate divided by the number of years in the projection interval, 5:

$$FR(a) = (TFR/5) \cdot PFR(a); \qquad (4)$$

$$a = 4,\ldots,10,$$

where:

FR(a) is the average annual fertility rate of age group a for the interval,

TFR is the total fertility rate specified for the interval, and

PFR(a) is the proportionate fertility rate of age group a for the interval.

b. Births

To calculate the number of births occurring during the interval using the age-specific fertility rates, it is first necessary to derive the numbers of women in the various five-year age groups of the childbearing span at the mid-point of the interval. For each age group, this is done by calculating

the geometric mean of the number of women at the beginning and at the end of the time interval: 7/

$$MIPOP(a,2) = [\ (POP(a,2,t) \cdot (POP(a,2,t+5)\ ]^{1/2}; \qquad (5)$$

$$a = 4,\ldots,10,$$

where:

MIPOP(a,2) is the mid-interval number of women of age group a.

Given the age-specific fertility rates and the mid-interval numbers of women of the childbearing span, the number of births taking place during the interval is:

$$BIRTHS = 5 \cdot [\ \sum_{a=4}^{10} FR(a) \cdot MIPOP(a,2)\ ], \qquad (6)$$

where:

BIRTHS is the number of births occurring during the interval.

As suggested by equation (6), the number of births for a given five-year projection interval equals the sum of the products of the age-specific fertility rates for the interval and the mid-interval numbers of women by age, multiplied by the length of the interval, five.

To calculate the numbers of children who survive to the end of this interval, it is necessary that the total number of births be disaggregated by sex. This can be done by using proportions of births by sex, derived from an assumed sex ratio at birth:

$$BIRTHS(s) = BIRTHS \cdot PBS(s); \qquad (7)$$

$$s = 1,2,$$

where:

$$PBS(s) = \begin{cases} SRB/(100 + SRB), \text{ when } s = 1 \\ 100/(100 + SRB), \text{ when } s = 2, \end{cases}$$

and where:

BIRTHS(s) is the number of births of sex s occurring during the interval,

PBS(s) is the proportion of births of sex s, and

SRB is the sex ratio at birth.

c. Population below age 5

For each sex, the population aged 0-4 at the end of the interval is obtained by applying survival ratios to the numbers of births:

$$POP(1,s,t+5) = BIRTHS(s) \cdot SR(1,s); \qquad (8)$$

$$s = 1,2.$$

This step completes the derivation of the age and sex structure of the closed population at the end of the five-year projection interval.

(iii) Other results

Once the age and sex structure of the population is derived for the end of a given five-year projection interval, it is possible to calculate many indicators that are useful for planning and policy making. Some of these indicators refer to population aggregates, some refer to the population structure and some refer to rates of population change.

a. Population aggregates

The age and sex structures can be used to calculate a number of different population aggregates, among which are the population size and the number of persons in special age intervals---the young-age population, the working-age population and the old-age population along with the school-age population and the number of women in the childbearing ages. All these aggregates refer to the end of the five-year projection interval. Among the other aggregates which can be calculated are the mid-interval population size and the total person-years-lived by the population during the interval. Yet another group of aggregates includes total births, deaths and the growth of the population.

i. Population size

The population size can be obtained by aggregating the numbers of persons projected for the end of the interval across the age groups and sexes: where:

$$POP(t+5) = \sum_{a=1}^{16} \sum_{s=1}^{2} POP(a,s,t+5), \qquad (9)$$

where:

$POP(t+5)$ is the size of the population at the end of the interval.

ii. Young-age population

The young-age population can be calculated as the sum of all persons below age 15:

$$YAP(t+5) = \sum_{a=1}^{3} \sum_{s=1}^{2} POP(a,s,t+5), \quad (10)$$

where:

YAP(t+5) is the young-age population at the end of the interval.

iii. Working-age population

The working-age population is normally defined as the population within the age interval 15-64 and can be calculated as:

$$WAP(t+5) = \sum_{a=4}^{13} \sum_{s=1}^{2} POP(a,s,t+5), \quad (11)$$

where:

WAP(t+5) is the working-age population at the end of the interval.

iv. Old-age population

The old-age population conventionally includes persons aged 65 and over and can be obtained as:

$$OAP(t+5) = \sum_{a=14}^{16} \sum_{s=1}^{2} POP(a,s,t+5), \quad (12)$$

where:

OAP(t+5) is the old-age population at the end of the interval.

v. School-age population

The school-age population is conventionally defined as population within the age range 5-24 and can, therefore, be obtained by adding up all persons within this age interval:

$$SAP(t+5) = \sum_{a=2}^{5} \sum_{s=1}^{2} POP(a,s,t+5), \quad (13)$$

where:

SAP(t+5) is the school-age population at the end of the interval.

vi. Women of the childbearing ages

The number of women of the childbearing ages, which is typically defined as the number of women between age 15 and age 49 is calculated as:

$$WCA(t+5) = \sum_{a=4}^{10} POP(a,2,t+5), \quad (14)$$

where:

WCA(t+5) is the number of women in the childbearing ages at the end of the interval.

vii. Mid-interval population size

The mid-interval population size is calculated as the geometric mean of the population sizes at the beginning and the end of the interval respectively:

$$MIPOP = [\, POP(t) \cdot POP(t+5) \,]^{1/2}, \quad (15)$$

where:

MIPOP is the mid-interval population size.

viii. Total number of person-years-lived

The total number of person-years-lived by the population, which is the number of years lived by all members of the population during the interval, can be obtained as the product of the mid-interval population size and the length of the interval, 5:

$$NPYL = MIPOP \cdot 5, \quad (16)$$

where:

NPYL is the total number of person-years-lived by the population during the interval.

ix. Population growth

The growth of the population over a specified interval equals the difference between the population sizes at the end and the beginning of the interval respectively:

$$POPGR = POP(t+5) - POP(t), \quad (17)$$

where:

POPGR is the population growth over the interval.

x. Births

The number of births occurring during the interval (BIRTHS) is calculated as shown earlier (equation (7)).

xi. Deaths

The number of deaths can be obtained as the difference between the number of births and the population growth:

$$DEATHS = BIRTHS - POPGR, \quad (18)$$

where:

DEATHS is the number of deaths occurring during the interval.

b. Indicators of the population structure

Indicators of the age and sex structure of the population can play an important role in planning and policy formulation. Among those indicators are the proportions of the population in broad age groups, such as 0-14, 15-64 and 65+ (which include young-age, working-age and old-age populations, respectively). Other important indicators of age structure include dependency ratios such as the young-age dependency ratio, the old-age dependency ratio and the total dependency ratio. Yet another indicator of the age structure is the median age of the population. These various age structure indicators can be supplemented by two more indicators. These are the proportion of women of the childbearing ages in the total population, an indicator of the age and sex structure, and the sex ratio of the population, an indicator of the sex structure.

i. Proportions by broad age groups

The proportions by broad age groups (0-14, 15-64 and 65+) are obtained by dividing the numbers of persons in these broad age groups by the population size:

the proportion at young age:

$$PYA(t+5) = YAP(t+5) / POP(t+5), \quad (19)$$

the proportion at working age:

$$PWA(t+5) = WAP(t+5) / POP(t+5), \quad (20)$$

and the proportion at old age:

$$POA(t+5) = OAP(t+5) / POP(t+5), \quad (21)$$

where:

PYA(t+5) is the proportion of the population at young age (age group 0-14) at the end of the interval,

PWA(t+5) is the proportion of the population at working age (age group 15-64) at the end of the interval, and

POA(t+5) is the proportion of the population at old age (age group 65+) at the end of the interval.

ii. Dependency ratios

Dependency ratios include the young-age dependency ratio, the old-age dependency ratio and the total dependency ratio. They are respectively calculated by dividing the young-age population, the old-age population and the sum of these two populations by the working-age population:

the young-age dependency ratio:

$$YADR(t+5) = YAP(t+5) / WAP(t+5), \quad (22)$$

the old-age dependency ratio:

$$OADR(t+5) = OAP(t+5) / WAP(t+5), \quad (23)$$

and the total dependency ratio:

$$TDR(t+5) = [\ YAP(t+5) + OAP(t+5)\ ] / WAP(t+5), \quad (24)$$

where:

YADR(t+5) is the young-age dependency ratio at the end of the interval,

OADR(t+5) is the old-age dependency ratio at the end of the interval, and

TDR(t+5) is the total dependency ratio at the end of the interval.

iii. Median age of the population

The median age of the population is computed using the standard formula for computing the median age from grouped data. 8/ If applied to the population age structure, this formula is:

$$MAPOP(t+5) = (a'-1) \cdot 5 + [(POP(t+5)/2 - \sum_{a=1}^{a'-1} \sum_{s=1}^{2} POP(a,s,t+5)) / \sum_{s=1}^{2} POP(a',s,t+5)] \cdot 5, \quad (25)$$

where:

MAPOP(t+5) is the median age of the population at the end of the interval, and

a' is the five-year age group containing the member of the population who is older than one half of the population and younger than the other half.

In equation (25), the first term on the right-hand size, $(a'-1) \cdot 5$, represents the lower limit of the five-year age group containing the middle member of the population. The term, $\sum_{a=1,a'-1}\sum_{s=1,2}POP(a,s,t+5)$, stands for the number of persons in all five-year age groups preceding the age group containing the middle member, and the term, $\sum_{s=1,2}POP(a',s,t+5)$ is the number of persons in that latter age group.

iv. Proportion of women in the childbearing ages

The proportion of women who are in the childbearing period is obtained as a ratio of the number of women in childbearing ages to the population size:

$$PWCA(t+5) = WCA(t+5) / POP(t+5), \quad (26)$$

where:

PWCA(t+5) is the proportion of women in the childbearing ages at the end of the interval.

v. Sex ratio of the population

The sex ratio of the population (box 21) is calculated as the ratio of the number of males in the population to the number of females:

$$SRP(t+5) = [(\sum_{a=1}^{16} POP(a,1,t+5)) / (\sum_{a=1}^{16} POP(a,2,t+5))] \cdot 100, \quad (27)$$

where:

SRP(t+5) is the sex ratio of the population at the end of the interval.

Box 21

Glossary

Crude birth rate
The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per 1,000 population.

Crude death rate
The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per 1,000 population.

Rate of natural increase
The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is equal to the difference between the crude birth rate and the crude death rate.

Rate of population growth
The increase or decrease of a population in a specified period divided by the number of person-years-lived by the population during the same period. The increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants.

Sex ratio of the population
The number of males in the population for each female, conventionally multiplied by 100.

c. Rates of population change

The projections made thus far make it possible to derive the following average annual rates of population change: the crude birth rate, the crude death rate, the rate of natural increase and the rate of population growth.

i. Crude birth rate

The crude birth rate for a five-year projection interval (t to t+5) is obtained by dividing the average annual number of births by the mid-interval population and multiplying by 1,000:

$$CBR = [\ (BIRTHS/5) \ / \ MIPOP\ ] \cdot 1{,}000, \tag{28}$$

where:

CBR is the crude birth rate for the interval.

ii. Crude death rate

The crude death rate for an interval is obtained by dividing the average annual number of deaths by the mid-interval population and multiplying by 1,000:

$$CDR = [\ (DEATHS/5) \ / \ MIPOP\ ] \cdot 1{,}000, \tag{29}$$

where:

CDR is the crude death rate for the interval.

iii. Rate of natural increase

The average annual rate of natural increase, which expresses the change in the population size resulting from births and deaths, is calculated as the difference between the crude birth rate and the crude death rate:

$$RNI = CBR - CDR, \tag{30}$$

where:

RNI is the rate of natural increase for the interval.

iv. Rate of population growth

The average annual rate of population growth, is calculated for the five-year projection interval as follows:

$$GRP = [\ \ln(\ POP(t+5)/POP(t)\ )\ /\ 5\ ] \cdot 1{,}000, \tag{31}$$

where:

GRP is the average annual growth rate of the population for the interval, and

ln is the natural logarithm.

In a closed population, the growth rate of the population equals the rate of natural increase.

(b) Open population

The procedure used to project an open national population over a five-year projection interval (t to t+5) utilizes all the steps described above along with additional steps relating to international migration (box 22). The steps used in this type of projection are summarized in box 23, while a subset of steps employed to derive the age and sex structure are also depicted diagramatically in figure III. The discussion that follows will focus on those steps related to international migration.

International migration can be measured in a variety of ways from the perspective of a country which is being affected by it. Thus, the measurement may seek to quantify both gains and losses to the country's population due to international migration or assess net changes to the population (gains minus losses) caused by it. The measurement, which should be typically for a fixed time interval, may concern the numbers of persons gained and lost or the net change due to migration during the interval. Alternatively, it may focus on the gains and losses or net changes to the population at the end of the time interval caused by migration occurring during the interval.

There are many different measures of international migration, which is partly a consequence of a variety of ways of measuring this type of population mobility. Those measures include, for example, gross and net international migration rates which, respectively, measure gains and losses and net changes due to migration. Depending on the types of data at hand, the rates that are derived from them may measure gains and losses or net changes to the population caused by migration over a given time interval. Alternatively, they may measure gains and losses or net changes to the population at the end of the time interval in question resulting from migration occurring during the interval.

This discussion of the cohort component method will make use of international migration measures which quantify net changes to the surviving population at the end of a given time interval due to international migration occurring over the interval. Such measures, which will be used here in connection with international migration assumptions, include age-specific net international migration rates. They may also include selected summary international migration measures, such as the total net international migration rate and proportionate age-specific net international migration rates, both of which are specific by sex. Furthermore, they may include the numbers of survivors by age and sex at the end of the time interval that the population lost and/or gained on balance due to international migration that took place during the interval.

Box 22

Glossary

Age-specific net international migration rate
The net gain or loss to the survivors of a given age or age group at the end of a specified period due to international migration occurring during that period divided by the number of survivors of that age or age group.

Crude net international migration rate
The net change (loss or gain) to the population due to international migration during a specified period, divided by the number of person-years-lived by the population during the same period. It is frequently expressed as net change due to international migration per 1,000 population.

International migration
Movements of population across national boundaries. It is designated as emigration from the standpoint of the nation from which the movement occurs and as immigration from that of the receiving nation.

Proportionate age-specific net international migration rate
The rate calculated by dividing a particular age-specific net international migration rate by the sum of age-specific net international migration rates across all ages or age groups. The sum of proportionate age-specific net international migration rates across all ages equals one.

Reverse survival
A procedure to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It can be used to estimate the number of births occurring over a specified time interval from the observed number of survivors of those births at the end of the interval. Similarly, the procedure can be employed to calculate net changes to the population due to migration occurring during a given time interval from the observed changes in the numbers of survivors in the population at the end of the interval resulting from migration.

Total net international migration rate
The sum of age-specific net international migration rates across all ages or age groups.

Box 23

Computational steps to project a national population open to international migration

The steps used to project a national population open to international migration over a five-year projection interval are:

(1) Use mortality assumptions to derive survival ratios by age and sex for the interval.

(2) Apply the survival ratios to the age and sex structure of the population at the beginning of the interval to obtain the numbers of survivors by age and sex at age 5 and over at the end of the interval.

(3) Use international migration assumptions to derive net international migration rates by age and sex for the end of the interval.

(4) Use net international migration rates to modify the numbers of survivors at age 5 and over and thus derive the segment of the age and sex structure of the population over that age range at the end of the interval.

(5) Use fertility assumptions to derive fertility rates by age for the projection interval.

(6) Use the fertility rates, the average numbers of women in the childbearing ages at the beginning and the end of the interval and the sex ratio at birth to obtain the numbers of births by sex occurring during the interval.

(7) Apply appropriate survival ratios to the numbers of births by sex to obtain the numbers of survivors by sex below age 5 at the end of the interval.

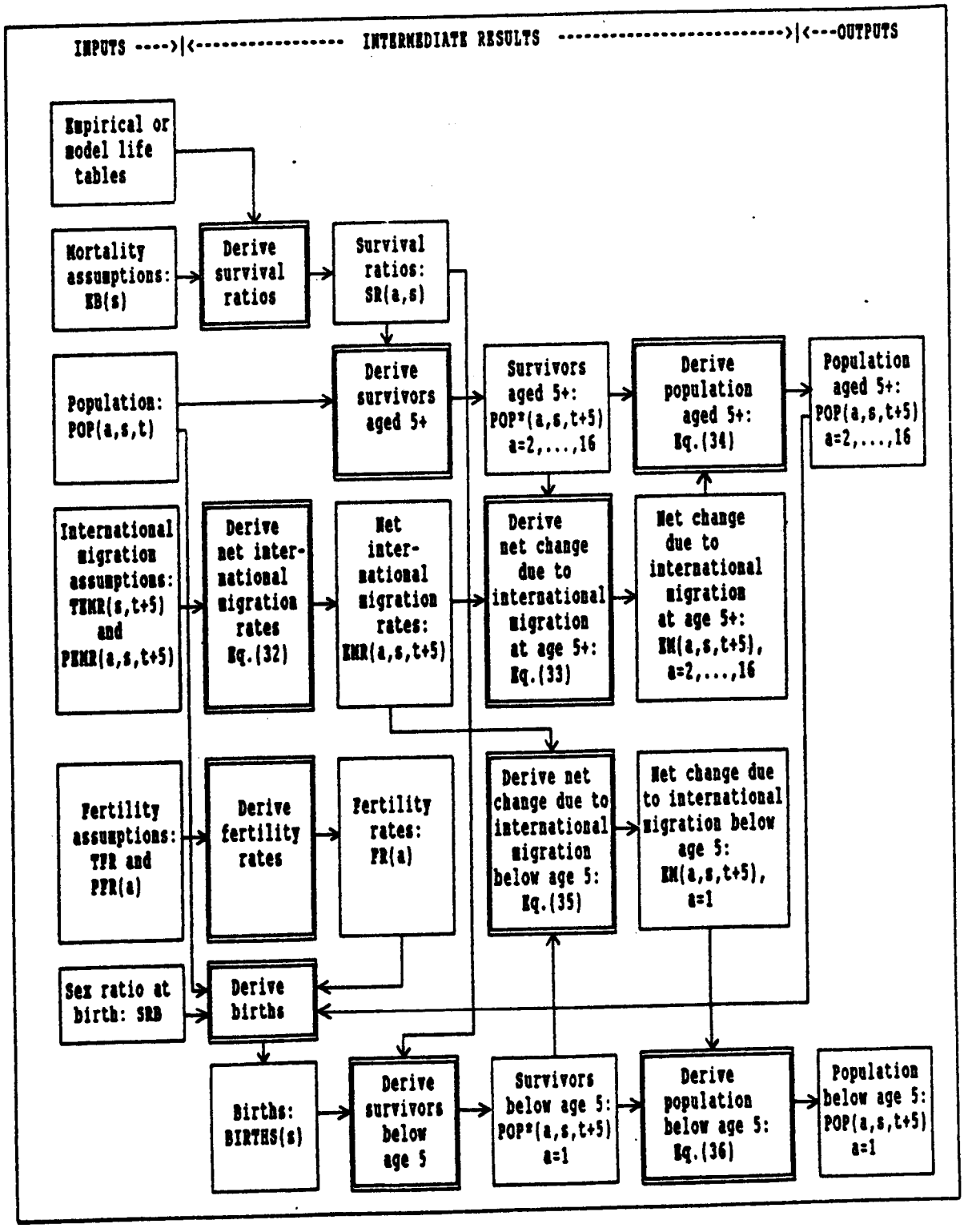
(8) Use appropriate net international migration rates to modify those survivors and in the process obtain the segment of the age and sex structure of the population below age 5 at the end of the interval.

(9) Derive various population aggregates, such as the population size, population of broad age groups and the numbers of births and deaths along with the net change due to international migration.

(10) Calculate various indicators of the population structure, such as proportions of population in various broad age groups, dependency ratios and the sex ratio of the population.

(11) Compute various rates of population change, including the crude birth, death and international migration rates as well as rates of natural increase and population growth.

Figure III. Steps to derive age and sex structure of the national population open to international migration at the end of projection interval t to t+5



(i) Segment of the population structure at age 5 and over

a. Survival ratios and survivors aged 5 and over

The first steps in computing the age and sex structure of an open population at the end of a five year projection interval involve calculating survival ratios for the projection interval and the number of survivors aged 5 and over at the end of the interval. These steps are identical to those described by equation (1) and equations (2) and (3), respectively. The numbers of survivors aged 5 and over should, however, be further modified using net international migration rates.

b. Net international migration rates

If international migration assumptions are formulated using age-specific net international migration rates, the rates can be used as a direct input into the projection, as indicated in equations (33) and (35). Where those assumptions are specified in terms of the numbers of survivors lost and/or gained at the end of the projection interval, the numbers can be used directly as shown in equations (34) and (36). Alternatively, if the assumptions are specified in terms of the summary measures, such as those mentioned above, age specific net international migration rates ought to be first derived from those measures.

Among the summary measures used here, the total net international migration rate for a given sex is a sum of age-specific net international migration rates of that sex. This rate is a measure of the extent to which survivors of a given sex at the end of the five-year time interval are affected by international migration. (The total net international migration rate is not affected by the age structure of the population.) Proportionate age-specific net international migration rates for a specific sex represent the age patterns of net international migration rates for that sex.

Using these migration measures, age-specific net international migration rates are obtained by multiplying the proportionate age-specific rates by the total net internal migration rates:

$$EMR(a,s,t+5) = TEMR(s,t+5) \cdot PEMR(a,s,t+5); \qquad (32)$$

$$a = 1,\ldots,16;$$

$$s = 1,2,$$

where:

EMR(a,s,t+5) is the net international (external) migration rate applying to survivors of age group a and sex s at the end of the interval,

TEMR(s,t+5) is the total net international (external) migration rate applying to survivors of sex s at the end of the interval, and

PEMR(a,s,t+5) is the proportionate net international (external) migration rate applying to survivors of age group a and sex s at the end of the interval.

c. Population aged 5 and over

To derive the segment of the age and sex structure at age 5 and over, it is first necessary to calculate the net changes among the survivors due to international migration. These changes are obtained by multiplying the numbers of survivors by the net international migration rates:

$$EM(a,s,t+5) = POP^{*}(a,s,t+5) \cdot EMR(a,s,t+5); \quad (33)$$

$$a = 2,\ldots,16;$$

$$s = 1,2,$$

where:

EM(a,s,t+5) is the net change due to international (external) migration among survivors of age group a and sex s at the end of the interval, and

POP*(a,s,t+5) is the number of survivors of age group a and sex s at the end of the interval. 9/

Following this, the numbers of survivors are modified by these net changes:

$$POP(a,s,t+5) = POP^{*}(a,s,t+5) + EM(a,s,t+5); \quad (34)$$

$$a = 2,\ldots,16;$$

$$s = 1,2,$$

This yields the age and sex structure of the open population at age 5 and above at the end of the interval.

(ii) Segment of population structure below age 5

a. Fertility rates, births and survivors below age 5

In order to obtain the segment of the population structure below age 5, it is first necessary to calculate fertility rates and the numbers of births along with the numbers of survivors below that age. The calculations can be performed using the steps indicated by equations (4) through (8).

b. Population below age 5

To complete the derivation of the segment of the population structure below age 5, the net international migration rates are initially used to compute net changes due to migration among survivors below age 5:

$$EM(1,s,t+5) = POP^{*}(1,s,t+5) \cdot EMR(1,s,t+5); \qquad (35)$$

$$s = 1,2.$$

Then, population below age 5 is obtained by modifying the numbers of survivors by those net changes:

$$POP(1,s,t+5) = POP^{*}(1,s,t+5) + EM(1,s,t+5); \qquad (36)$$

$$s = 1,2.$$

This completes the derivation of the age-sex structure of the open national population at the end of the interval.

(iii) Other results

After the age and sex structure of the population is derived for the end of a given five year projection interval, indicators of the population size, structure and change can be calculated. The indicators include all those that are obtained in the course of projecting a closed population, plus a few additional ones.

a. Population aggregates

With but two exceptions, the population aggregates obtained in this type of projection can be calculated as in the closed population, using steps indicated by equations (9) through (17). The total number of deaths cannot be obtained using equation (18), and is calculated in a different way. Furthermore, one additional aggregate is obtained in the course of this projection, which is the net change in the population due to international migration. This net change needs to be calculated before calculating the number of deaths.

i. Change due to international migration

The net change to the population resulting from international migration during a projection interval can be obtained by a procedure which involves a reverse survival of the net gains or losses due to migration among the survivors at the end of the interval. The reverse survival is carried out over two and a half years, until the mid-point of the projection interval. The results, which represent net gains or losses to the population classified by age and sex due to international migration, are then aggregated across ages and sexes:

$$NCDEM = \sum_{a=1}^{16} \sum_{s=1}^{2} EM(a,s,t+5) \;/\; SRF(a,s) \qquad (37)$$

where for each s:

$$SRF(a,s) = \begin{cases} 0.67 + 0.33 \cdot SR(1,s), & \text{when } a = 1 \\ (1 + SR(a,s)) \;/\; 2, & \text{when } 1 < a \leq 16, \underline{10/} \end{cases}$$

and where:

NCDEM is the net change in the population due to international (external) migration during the interval, and

SRF(a,s) is the survival ratio factor used to reverse survive the net change due to international migration among the survivors of age group a and sex s.

ii. Deaths

The number of deaths occurring in an open population during a five-year projection interval is obtained in a way to ensure that this number will reflect the fact that the population gains or loses numbers owing to international migration. The number of deaths can be obtained as the difference between the number of births and the population growth plus the net change due to international migration:

$$DEATHS = BIRTHS - POPGR + NCDEM \qquad (38)$$

b. Indicators of the population structure

The indicators of the age and sex structure of the population calculated as part of a projection of an open population are identical to those that can be obtained in the course of projecting a closed population. The steps used to calculate the indicators are described by equations (19) through (27).

c. Rates of population change

The rates computed in the course of projecting an open population include those obtained as part of a projection of a closed population as described by equations (28) through (31). In addition, this type of projection makes it possible to calculate the crude net international migration rate.

i. Crude net international migration rate

The average annual crude net international migration rate for a given projection interval is computed as the average annual net change due to international migration divided by the mid-interval population and multiplied by 1,000:

$$CEMR = [\ (NCDEM/5)\ /\ MIPOP\ ]\ \cdot\ 1{,}000, \qquad (39)$$

where:

CEMR is the crude net international (external) migration rate referring to the interval.

For an open population, the crude net international migration rate must equal the difference between the rate of growth of population and the rate of natural increase.

3. Urban and rural populations

If the projections are needed for two or more subnational populations, one may utilize a projection of the national population along with projected ratios of subnational populations to the national population. 11/ Alternatively, one can use a variant of the cohort component method. 12/

For many planning exercises, projections of population totals at the national or subnational level without projecting age and sex composition are not sufficient. Hence, this section describes a variant of the cohort component method which can be used to project the age and sex structures of the national population or of urban and rural populations separately.

The procedure described here is similar to that employed to project the national population, except that additional steps are needed in order to introduce internal migration (box 24) into the projection process. In this description of the cohort component method, internal migration denotes migration between urban and rural areas. As in the case of the national population, the steps involved in making a projection of urban and rural populations depend on whether international migration is assumed to be among the components of population change.

(a) Closed populations

The procedure to project urban and rural populations closed to international migration consists of steps that yield segments of age and sex structures of the populations at age 5 and over and below age 5. Those steps are shown schematically in figure IV. The procedure also includes steps to compute population aggregates and indicators of population structure and change. The discussion of the procedure will emphasize the steps related to internal migration.

Box 24

Glossary

Age-specific net internal migration rate
: The net gain or loss to the survivors of a given age or age group within a given location, such as urban or rural areas at the end of a specified period due to internal migration occurring during that period, divided by the number of survivors of that age or age group within that location.

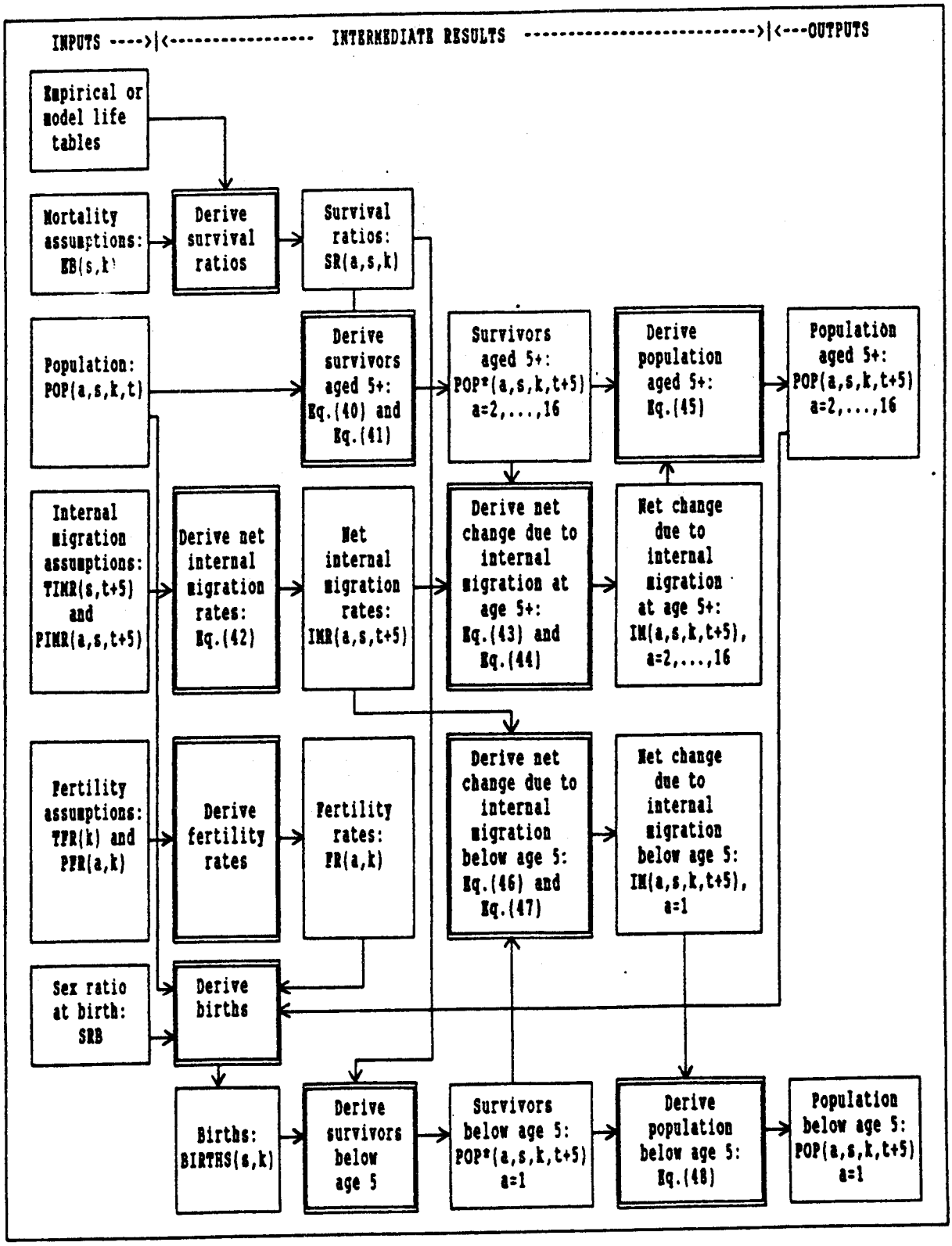
Crude net internal migration rate
: The net change (loss or gain) to the population residing within a given geographical or residential location due to internal migration during a specified period, divided by the number of person-years-lived by th population of that location during the same period. It is frequently expr sed as net change due to internal migration per 1,000 population.

Internal migration
: Movements of population within the national boundaries involving relatively permanent changes in residence. It is designated as out-migration from the standpoint of the location from which the movement occurs and as in-migration from that of the receiving nation.

Proportionate age-specific net internal migration rate
: The rate calculated by dividing a particular age-specific net internal migration rate by the sum of age-specific net internal migration rates across all ages or age groups. The sum of proportionate age-specific net internal migration rates across all ages equals one.

Total net internal migration rate
: The sum of age-specific net internal migration rates across all ages or age groups.

Figure IV. Steps to derive age and sex structures of urban and rural populations closed to international migration at the end of projection interval t to t+5



Internal migration can be measured in a variety of ways from the perspective of geographical or residential locations within a given country. For any specific location, the measurement may seek to quantify both gains and losses to the population of the location concerned due to internal migration. Alternatively, it may seek to assess net changes to the population (gains minus losses) caused by internal migration. The measurement, which should normally be for a given time interval, may concern the numbers of persons gained and lost or the net change due to migration during the interval. Alternatively, it may concentrate on the gains and losses or net changes to the survivors in the given population at the end of the time interval caused by migration occurring during the interval.

Among the various measures of internal migration are gross and net internal migration rates. Depending on the types of data available, these rates may measure, say losses to the population in each given location (vis-à-vis those in other locations) or net changes to the population of each location caused by migration over a given time interval. Alternatively, these rates may measure losses or net changes to the populations of various locations at the end of a given time interval caused by migration occurring during the interval.

This discussion will employ internal migration measures that quantify changes to the survivors in the population of a given residential location at the end of a time interval which are caused by internal migration occurring over that interval. Such measures, which will be used in relation to the internal migration assumptions, include age-specific net internal migration rates by sex which apply to one of the two locational populations, for example the rural population. They can include selected summary internal migration measures, such as the total net internal migration rate and proportionate age-specific net internal migration rates, both of which are specific by sex. These measures can be also defined with respect to the rural population. Also, the measures may include the numbers of survivors by age and sex at the end of the interval that the rural population loses and/or gains on balance through internal migration.

(i) Segments of population structures at age 5 and over

a. Survival ratios

If mortality assumptions are expressed in selected summary measures of mortality such as expectations of life at birth, a projection of urban and rural populations for a given projection interval begins with the derivation of survival ratios for that interval. The survival ratios are derived separately for urban and rural areas by means of an urban-rural counterpart of the transformation described in equation (1).

b. Survivors aged 5 and over

In each population the numbers of survivors at age 5 and over at the end of the interval are calculated by means of urban-rural counterparts of steps described by equations (2) and (3). In particular, the numbers of survivors over this age span, except those at the open age group, are obtained as:

$$POP^{*}(a,s,k,t+5) = POP(a-1,s,k,t) \cdot SR(a,s,k); \qquad (40)$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2,$$

where:

$k = 1,2$ are urban and rural locations,

$POP^{*}(a,s,k,t+5)$ is the population (survivors) of age group a and sex s in location k at the end of interval,

$POP(a-1,s,k,t)$ is the population of age group (a-1) and sex s in location k at the beginning of the interval, and

$SR(a,s,k)$ is the survival ratio representing the probability of survival over the interval among persons who belong to age group a and sex s in location k at the end of the interval.

The numbers of survivors in the open age group is obtained as:

$$POP^{*}(16,s,k,t+5) = \left[\sum_{a=15}^{16} POP(a,s,k,t)\right] \cdot SR(16,s,k); \qquad (41)$$

$$s = 1,2;$$

$$k = 1,2.$$

After deriving the numbers of survivors at age 5 and over in each location, these numbers must be modified using net internal migration rates.

c. Net internal migration rates

Where internal migration assumptions are specified in terms of age-specific net internal migration rates, they can be used directly in the projection, as shown in equations (43) and (46). Where the assumptions are formulated using the summary internal migration rates, examples of which are introduced above and used in this description, those measures need to be transformed into age-specific net internal migration rates.

The summary internal migration measures used here refer to the rural population. The total net internal migration rate for a given sex is the sum of the age specific net internal migration rates of that sex. It measures the extent to which rural survivors of a given sex are affected by internal

migration. Proportionate age specific net internal migration rates for a specific sex represent the age pattern of net internal migration rates for that sex.

Using these measures, age specific net internal migration rates are obtained through multiplication of the proportionate rates by age by the total net internal migration rate:

$$IMR(a,s,t+5) = TIMR(s,t+s) \cdot PIMR(a,s,t+5); \quad (42)$$

$$a = 1,\ldots,16;$$

$$s = 1,2,$$

where:

IMR(a,s,t+5) is the net internal migration rate applying to rural survivors of age group a and sex s at the end of the interval,

TIMR(s,t+5) is the total net internal migration rate applying to rural survivors of sex s at the end of the interval, and

PIMR(a,s,t+5) is the proportionate net internal migration rate applying to rural survivors of age group a and sex s at the end of the interval.

d. Population aged 5 and over

To derive the numbers of persons aged 5 and over at the end of the projection interval, it is first necessary to calculate net changes to urban and rural survivors at age 5 and above due to internal migration. In particular, net changes among the rural survivors are obtained by multiplying the numbers of rural (k=2) survivors by the net internal migration rates as follows:

$$IM(a,s,2,t+5) = POP^{*}(a,s,2,t+5) \cdot IMR(a,s,t+5); \quad (43)$$

$$a = 2,\ldots,16;$$

$$s = 1,2,$$

where:

IM(a,s,k,t+5) is the net change due to internal migration among survivors of age group a, sex s and location k at the end of the interval.

Net changes among urban survivors due to internal migration equal those among rural survivors, but with an opposite sign. This is so since any gain (loss) to urban survivors arising from internal migration equals the loss (gain) to rural survivors. Therefore:

$$IM(a,s,1,t+5) = - IM(a,s,2,t+5); \quad (44)$$

$$a = 2,\ldots,16;$$

$$s = 1,2.$$

Following this, the numbers of urban and rural survivors are modified by these net changes:

$$POP(a,s,k,t+5) = POP^{*}(a,s,k,t+5) + IM(a,s,k,t+5); \quad (45)$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2.$$

This yields the age and sex structures of urban and rural populations aged 5 and over at the end of the interval.

(ii) Segments of population structures below age 5

a. Fertility rates, births and survivors below age 5

Deriving the segments of age and sex structures below age 5 for the populations of the two locations initially involves the same steps as those described in the projection of the national population closed to international migration. For each location, these steps include deriving age-specific fertility rates, the numbers of births by sex, and the numbers of survivors below age 5. The steps involved are the urban-rural counterparts of the steps described by equations (4) through (8).

b. Population below age 5

To allow for the effect of internal migration the numbers of survivors below age 5, net changes resulting from internal migration among these survivors must be calculated. Net changes among the rural survivors are obtained as follows:

$$IM(1,s,2,t+5) = POP^{*}(1,s,2,t+5) \cdot IMR(1,s,t+5); \quad (46)$$

$$s = 1,2,$$

and those for urban survivors are:

$$IM(1,s,1,t+5) = - IM(1,s,2,t+5); \qquad (47)$$

$$s = 1,2.$$

Lastly, for each sex within each location the numbers of survivors below age 5 are modified by these net changes:

$$POP(1,s,k,t+5) = POP^{*}(1,s,k,t+5) + IM(1,s,k,t+5); \qquad (48)$$

$$s = 1,2;$$

$$k = 1,2.$$

This completes the derivation of the age and sex structures of urban and rural populations closed to international migration at the end of a five-year projection interval.

(iii) Other results

The urban-rural projection can yield other results for those two populations as well as for the national population. Those other results include:

a. Population aggregates;
b. Indicators of population structures;
c. Indicators of population distribution;
d. Rates of population change.

Most of the results obtained under these four categories are similar to those discussed earlier in connection with the projection of the national population. Most of them are, however, calculated for the urban and rural, as well as for the national population.

a. Population aggregates

The population aggregates obtained in the course of a projection of urban and rural populations include all those listed earlier, which in the case of this projection are for the urban, rural and the national population. Those aggregates, except the numbers of deaths, are calculated using steps similar to those indicated by equations (9) through (17). The numbers of deaths in urban and rural populations are calculated by means of a step which is similar to that described by equation (35), while the number of deaths in the national population equals the sum of urban and rural deaths. In addition, the population aggregates include net changes in urban and rural populations due to internal migration.

i. Change due to internal migration

For a given interval, the net change to the rural population due to internal migration is derived in a way similar to that of calculating net change to the national population due to international migration. In particular, the change due to internal migration can be obtained by a reverse survival of net changes due to internal migration among rural (k=2) survivors at the end of the interval, followed by aggregation:

$$NCDIM(2) = \sum_{a=1}^{16} \sum_{s=1}^{2} IM(a,s,2,t+5) \; / \; SRF(a,2,s), \tag{49}$$

where for each s:

$$SRF(a,2,s) = \begin{cases} 0.67 + 0.33 \cdot SR(1,2,s), & \text{when } a = 1 \\ (1 + SR(a,2,s)) \; / \; 2, & \text{when } 1 < a \leq 16, \end{cases}$$

and where:

NCDIM(k) is the net change to the population of location k due to internal migration occurring during the interval, and

SRF(a,2,s) is the survival ratio factor used to reverse survive the net change due to internal migration among the rural survivors of age group a and sex s.

As the gain (loss) to the rural population due to internal migration equals the loss (gain) to the urban population, net change to the urban population due to internal migration equals the net change to the rural population with an opposite sign:

$$NCDIM(1) = - \; NCDIM(2). \tag{50}$$

ii. Deaths

The number of deaths in each population are calculated in a way similar to that used to obtain the number of deaths in an open national population. The number of deaths in either population equals the difference between the number of births and the population growth plus the net change in the population due to internal migration:

$$DEATHS(k) = BIRTHS(k) - POPGR(k) + NCDIM(k); \tag{51}$$

$$k = 1,2,$$

where:

DEATHS(k) is the number of deaths occurring in location k during the interval,

BIRTHS(k) is the number of births occurring in location k during the interval,

POPGR(k) is the population growth in location k over the interval.

b. Indicators of the population structure

The indicators of population structure calculated for the urban and rural populations are the same as those obtained for the national population. However, those indicators are calculated separately for the urban, rural and national populations, using steps similar to those indicated by equations (19) through (27).

c. Indicators of the population distribution

In addition to other indicators, a projection of urban and rural populations makes it possible to compute the proportions of the national population urban and rural, indicators of the population distribution.

i. Proportions urban and rural

The proportion urban (k=1) is obtained as a ratio of the urban population size to the national population size:

$$PURB(t+5) = POP(1,t+5) / POP(t+5), \quad (52)$$

where:

PURB(t+5) is the proportion of the national population urban at the end of the interval, and

POP(k,t+5) is the size of the population of location k at the end of the interval.

The proportion rural can be calculated as a complement of the proportion urban:

$$PRUR(t+5) = 1 - PURB(t+5), \quad (53)$$

where:

PRUR(t+5) is the proportion of the national population rural at the end of the interval.

d. Rates of population change

In the course of a projection of urban and rural populations closed to international migration, it is possible to derive for the urban, rural and the national populations, all those rates of population change that can be computed as part of projecting the national population closed to international migration. In addition, the crude net internal migration rate can be computed for urban and rural populations.

i. Crude net internal migration rate

For each population, the average annual crude net internal migration rate over a given projection interval is computed by dividing the average annual net change due to internal migration by the mid-interval population and multiplying by 1,000:

$$CIMR(k) = [\ (NCDIM(k) / 5) / MIPOP(k)\ ] \cdot 1{,}000; \qquad (54)$$

$$k = 1,2,$$

where:

CIMR(k) is the crude net internal migration rate of the population of location k for the interval, and

MIPOP(k) is the mid-interval population size of the population of location k.

(b) Open populations

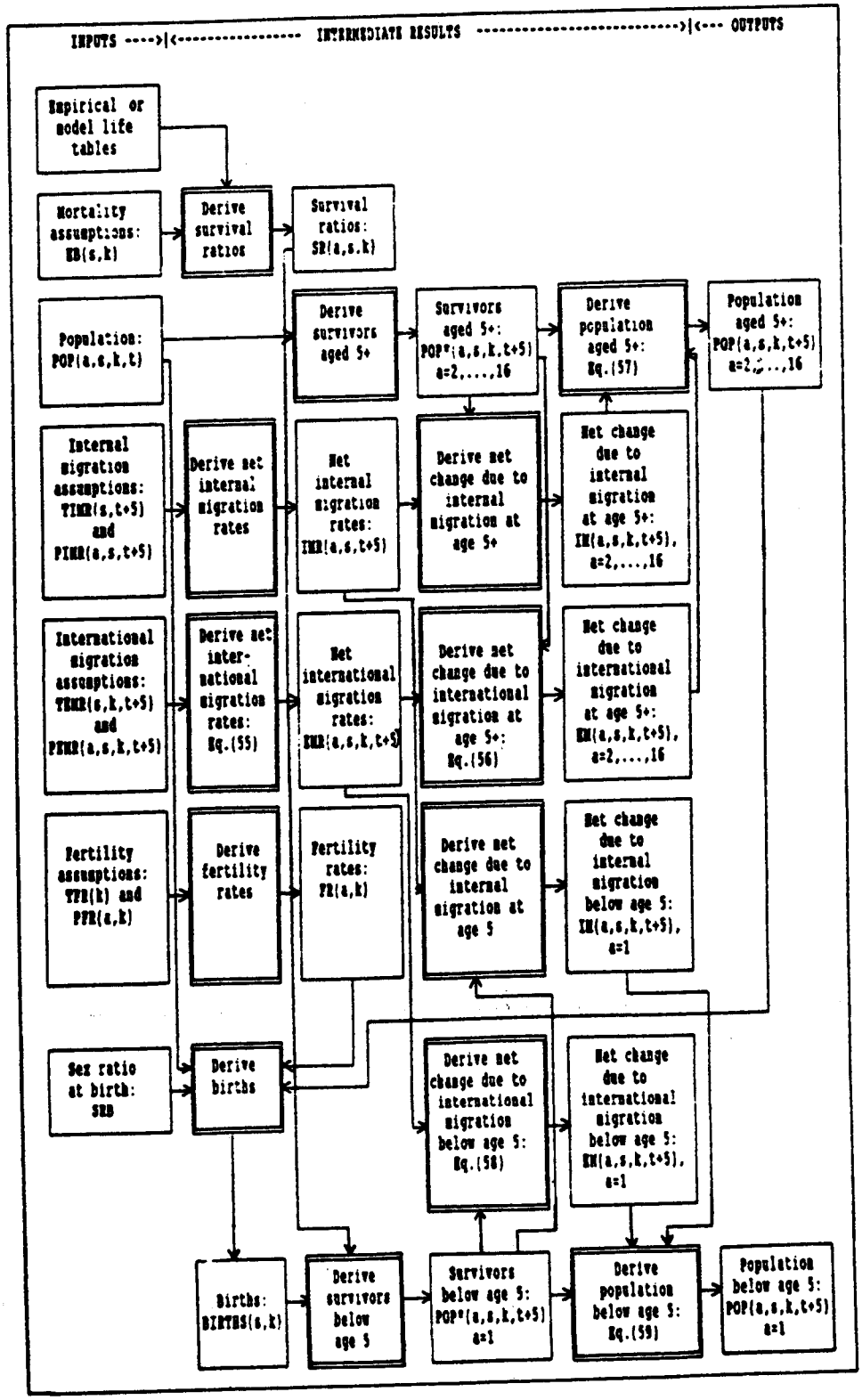
The procedure employed to project urban and rural populations open to international migration over a five-year projection interval makes use of all the steps described above and additional steps relating to international migration. Those steps, which are used to derive age and sex structures of urban and rural populations at the end of the interval, are depicted diagramatically in figure V.

(i) Segments of population structures at age 5 and over

a. Survival ratios, survivors aged 5 and over, and net internal migration rates

Steps involved in computing age and sex structures of urban and rural populations open to international migration initially include those required to compute survival ratios for both locations--urban and rural. In addition, they include steps to compute the numbers of survivors aged 5 and over (equations (40) and (41)) and net internal migration rates (equation (42)). If the international migration assumptions are formulated using relevant summary measures, further steps include the calculation of net international migration rates.

Figure V. Steps to derive age and sex structures of urban and rural populations open to international migration at the end of projection interval t to t+5



b. Net international migration rates

If the international migration assumptions for urban and rural populations are specified in terms of total net international migration rates and age specific proportionate net international migration rates, the international migration rates are obtained using an urban-rural counterpart of the step indicated by equation (32). In particular, the rates are computed as:

$$EMR(a,s,k,t+5) = TEMR(s,k,t+5) \cdot PEMR(a,s,k,t+5); \quad (55)$$

$$a = 1,\ldots,16;$$

$$s = 1,2,$$

$$k = 1,2,$$

where:

EMR(a,s,k,t+5) is the net international (external) migration rate applying to survivors of age group a and sex s in location k at the end of the interval,

TEMR(s,k,t+5) is the total net international (external) migration rate applying to survivors of sex s in location k at the end of the interval, and

PEMR(a,s,k,t+5) is the proportionate net international (external) migration rate applying to survivors of age group a and sex s in location k at the end of the interval.

c. Population aged 5 and over

To derive the numbers of persons aged 5 and over at the end of the projection interval, it is necessary to calculate net changes due to internal migration among urban and rural survivors at age 5 and over. Those net changes are obtained as indicated by equations (43) and (44). It is also necessary to derive net changes due to international migration among the survivors at age 5 and over using urban-rural counterparts of steps described by equation (33). In particular:

$$EM(a,s,k,t+5) = POP^{*}(a,s,k,t+5) \cdot EMR(a,s,k,t+5); \quad (56)$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2,$$

where:

EM(a,s,k,t+5) is the net change due to international (external) migration among survivors of age group a and sex s in location k at the end of the interval.

Then, the numbers of urban and rural survivors at age 5 and above are modified using net changes due to both internal and international migration:

$$POP(a,s,k,t+5) = POP^{*}(a,s,k,t+5) + IM(a,s,k,t+5) + EM(a,s,k,t+5); \quad (57)$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2,$$

where:

IM(a,s,k,t+5) is the net change due to internal migration among survivors of age group a and sex s in location k at the end of the interval.

This step completes the derivation of segments of the population structures at age 5 and above.

(ii) Segments of population structures below age 5

a. Fertility rates, births and survivors below age 5

The derivation of the segments of population structures below age 5 begins with calculations of fertility rates, numbers of births and the numbers of survivors below age 5 in urban and rural populations, respectively. The steps involved are identical to those used to project urban and rural populations closed to international migration.

b. Population below age 5

The numbers of survivors below age 5 are next used along with net internal migration rates to compute net changes due to internal migration among those survivors. The computations are described by equations (46) and (47). Also, the numbers of survivors are used along with net international migration rates to compute net changes among the survivors due to this type of migration:

$$EM(1,s,k,t+5) = POP^{*}(1,s,k,t+5) \cdot EMR(1,s,k,t+5); \quad (58)$$

$$s = 1,2.$$

$$k = 1,2.$$

The numbers of urban and rural survivors below age 5 are then modified using net changes due to both internal and international migration:

$$POP(1,s,k,t+5) = POP^*(1,s,k,t+5) + IM(1,s,k,t+5) + EM(1,s,k,t+5); \quad (59)$$

$$s = 1,2;$$

$$k = 1,2.$$

This completes the derivation of age and sex structures of urban and rural populations open to international migration at the end of a five-year projection interval. The step is followed by aggregation of those structures across locations to obtain the age and sex structure of the national population.

(iii) Other results

This type of projection yields population aggregates, indicators of the population structure and distribution as well as rates of population change. As in the case of an urban-rural projection closed to international migration, most of those other results obtained in the current type of projection are for the urban, rural and the national populations.

a. Population aggregates

Population aggregates include all those obtained in an urban-rural projection closed to international migration. In addition, they include two additional aggregates, which are net changes to population due to international migration and net changes to population resulting from combined internal and international migration. The two indicators are respectively calculated for the urban, rural and the national population and for the urban and rural populations.

Net changes to urban and rural populations due to international migration are obtained using urban-rural counterparts of the steps described by equation (37). The net change to the national population is the sum of the net changes to the urban and rural populations. On the other hand, net changes to those two populations resulting from internal migration are obtained using steps indicated by equations (49) and (50). Lastly, net changes due to combined migration for the two populations are obtained as sums of net changes resulting from international and internal migration.

Only after net changes due to migration are calculated, is it possible to derive the numbers of births in the urban, rural and the national populations. In the two former populations, those numbers are derived by taking into account net changes due to both internal and international migration. The number of deaths in the national population equals the sum of the numbers of deaths in urban and rural populations.

i. Deaths

The number of deaths in urban or rural population equals the difference between the number of births and the population growth, plus net changes due to internal and international migration:

$$DEATHS(k) = BIRTHS(k) - POPGR(k) + NCDIM(k) + NCDEM(k); \quad (60)$$

$$k = 1,2,$$

where:

NCDEM(k) is the net change in the population of location k due to international (external) migration during the interval.

b. Indicators of the population structure

These indicators include all those that can be calculated in the course of a projection of urban and rural populations closed to international migration.

c. Rates of population change

Two rates, in addition to those computed in the course of a projection of urban and rural populations closed to international migration can be calculated. They are crude net international migration rates and crude net combined migration rates. The former rates are derived for the urban, rural and the national population. The latter rates are computed for the urban and rural population.

Crude net international migration rates are obtained using an urban-rural equivalent of the step indicated by equation (40). To obtain crude net combined migration rates, it is first necessary to compute crude net internal migration rates, using the steps described by equation (51).

i. Crude net combined migration rate

For the population of either location, this rate is derived as a sum of crude net international and internal migration rates:

$$CCMR(k) = CEMR(k) + CIMR(k); \quad (61)$$

$$k = 1,2,$$

where:

CCMR(k) is the crude net combined migration rate of the population of location k for the interval, and

CEMR(k) is the crude net international (external) migration rate of the population of location k for the interval.

C. The inputs

This section will discuss issues relating to the inputs used with the cohort component method. In particular, it will list the types of inputs required to make a projection with the method and describe how those inputs can be prepared.

1. Types of inputs required

The inputs required to apply the cohort component technique depend on the type of projection that one wishes to make. As indicated in the preceding section, the projection can be that of the national population, which can be either closed or open to international migration. Alternatively, the projection can be that of urban and rural populations, which can also be either affected or unaffected by international migration.

(a) National projection

To project the national population closed to international migration, the inputs must include:

(i) The initial age and sex structure;
(ii) Assumptions on mortality;
(iii) Assumptions on fertility.

To project an open national population, the inputs should also include:

(iv) Assumptions on international migration.

The initial population structure should pertain to the mid-point of the initial year of the plan, denoted below as year 0. The population shall be disaggregated into the standard five-year age groups, 0-4, 5-9, ..., 75+.

Assumptions on mortality and fertility should refer to the consecutive five-year projection intervals, 0-5, 5-10,... Where the measures used to formulate international migration assumptions are of the type used in section B (see equation (32)), those assumptions ought to refer to the end of the consecutive five-year projection intervals although they represent migration conditions during the intervals.

(b) Urban-rural projections

In order to project urban and rural populations which are closed to international migration, the following inputs would be needed for each population:

(i) The initial age and sex structure;
(ii) Assumptions on mortality;
(iii) Assumptions on fertility.

Also, the inputs should include:

(iv) Assumptions on internal migration, for, say, rural population.

If urban and rural populations open to international migration are to be projected, the inputs would need also to include for each population:

(v) International migration assumptions.

The urban and rural age and sex structures should refer to the initial year of the plan. Similarly, mortality and fertility assumptions ought to refer to the five-year time intervals of the plan horizon. Where the internal and international migration assumptions are specified in terms of the measures used in section B (equations (42) and (55)), the assumptions ought to refer to the end of the five-year intervals.

(c) Measures used in assumptions

One may formulate assumptions on the future trends in the components of population change using different demographic measures as long as those measures can be used to derive the basic inputs for the projection--survival ratios and fertility and migration rates. The measures chosen in this presentation enable one to specify both the level as well as the pattern of the relevant rates.

Thus, the total fertility rate and proportionate age-specific fertility rates make it possible to specify the level of fertility as well as its pattern by age. The use of expectations of life at birth by sex enables one to specify both the level and sex pattern of mortality. Alternatively, the use of infant mortality rates and expectations of life at exact age 5 by sex makes it possible to choose both the level and the age-sex pattern of mortality. Where infant mortality rates and expectations of life at age 5 are used, they are employed, respectively, as indicators of mortality below 5 and mortality at age 5 and above. 13/ The use of total net migration rates along with proportionate age-specific net migration rates by sex allow the user to specify both the level and age-sex pattern of migration over time. This is true for both international and internal migration.

The choice of mortality measures would normally be based on an analysis involving the observed life tables for the population concerned and the model life tables of different families. The appropriate mortality measure to use in any given application of the method will depend on whether or not the family of model life tables selected for the projection closely approximates the observed mortality experience by age in the population concerned. Where the observed age pattern of mortality is well approximated by the selected family of life tables over the entire age range, it will be appropriate to use expectations of life at birth. However, where the observed pattern is closely approximated only within age groups 0-4 and 5+, which may often be the case in developing countries, the use of infant mortality rates and expectations of life at age 5 would be preferable. In this instance, these two mortality measures can be used as representations of mortality conditions below age 5 and at age 5 and above.

2. Preparation of the inputs

The preparation of inputs for a projection would include the preparation of the age and sex structure of the population for the initial year of the plan. Also, it would involve formulating assumptions on the components of population change during the plan horizon.

(a) Initial age and sex structure(s)

If a population projection is to be used in a development plan, it will usually be convenient to start that projection in the initial year of the plan. Since at the time of plan preparation this initial year will lie in the future, it will be necessary to make a preliminary projection of the age and sex structure(s) for the initial year of the plan by using the age and sex structure(s) of the most recent population census or survey.

In rare circumstances, where the census or survey precedes the initial year of the plan by a multiple of five (say, five or ten) years, the initial age and sex structure(s) could be derived directly from the preliminary projection, by carrying this projection forward until the initial year. Where the time difference between the initial year of the plan and the year of the most recent census or survey is not a multiple of five, the preliminary projection can be carried out beyond the initial year of the plan and the age and sex structure(s) for the initial year can be derived by interpolation.

In many developing countries population censuses are defective due to under-enumeration, over-enumeration, and/or age misreporting. Where these defects are believed to be quantitatively important, it is essential to adjust the census population structure(s) before using it (them) to prepare the preliminary projection. Various procedures have been expressly designed to address these problems (See, for example, Ewbank, 1981; and United Nations, 1983, pp. 241-249).

Where the preliminary projection is made for urban and rural populations, the original census or survey structures of population for the two areas should be based on a de jure (or place of permanent residence) enumeration. Furthermore, where appropriate, they may be based on definitions of urban and rural populations utilizing the community population size as the classification criterion.

(b) Estimates and assumptions for the preliminary projection

Available observations on the relevant demographic measures will never refer to a time period that comes all the way up to the initial year of the plan. Therefore, it is necessary first to make a preliminary projection covering the period from the most recent census or survey to the initial year of the plan period. The following comments describe data needs related to the formulation of assumptions to be used with such a preliminary projection.

In order to formulate reliable assumptions for making the preliminary population projection, it is necessary to have the most accurate available information on recent levels and trends of fertility and mortality. In some countries, reliable information on recent fertility and mortality will be available from vital statistics collected through a vital registration system or a sample survey registration scheme. Where reliable information is lacking and no estimates of recent fertility and mortality are available, an indirect estimation of their levels and trends may prove necessary. Fortunately, a number of techniques are available for indirect estimation of the fertility and mortality measures used in this chapter (United Nations, 1967 and 1983).

Where the population to be projected is open to international migration, it will be necessary to have information or estimates on the relevant measures of international migration for recent years. The international migration measures used in this chapter could be derived from census or survey information on immigration and emigration for the country concerned. The data should refer to survivors among immigrants and emigrants, make it possible to classify them by age and sex at the time of census or survey, and include information on the date of international migration. In addition, if one needs international migration measures for urban and rural areas, the data should also contain information on the previous location of residence of emigrants and the current location of residence of immigrants.

International migration data are often the weakest among population statistics in developing countries, especially where international migration is quantitatively unimportant or where the Government lacks the means to or interest in collecting those data. In view of this, it may often prove necessary to estimate international migration measures by indirect means. The measures used in this chapter can be obtained using one of the standard methods of indirect migration estimation--the survival ratio method of migration estimation (United Nations, 1970). However, the method can only yield estimates for the national population, but not for urban and rural populations. To apply the method, age and sex structures of the population must be available from two censuses, preferably taken a multiple of five years apart. Intercensal mortality estimates must also be available.

If projections of urban and rural populations are sought, inputs for the preliminary projections would also need to make use of observations or estimates of recent internal (urban-rural) migration. Where retrospective internal migration data are available from population censuses or surveys, observations on internal migration measures used in the chapter can be readily obtained. Along with standard information on age, sex and residence at the time of census or survey, the data should include the following information relating to persons who have moved prior to the census or survey: the date of the move (or whether the change of residence occurred in the five years before the census or survey) along with residence (rural or urban) before migration.

Where this type of data is unavailable, it will be necessary to estimate internal migration indirectly. The measures used in the chapter could be obtained by the survival-ratio method of migration estimation. This method requires age and sex structures of the rural population based on adjacent

censuses, along with an estimate of intercensal mortality for the rural areas. These measures can only be estimated if the country remained closed to any significant international migration during the intercensal period.

The data required to prepare a preliminary projection might be difficult to obtain, especially if an urban-rural projection is sought. This may be particularly true where the population to be projected is open to international migration. In such situations, the planner may need to adopt a pragmatic approach to filling data gaps even if there is not a very solid basis for doing so. For example, national estimates of mortality may be used in place of missing urban and rural estimates in order to make an urban-rural projection. Using national estimates would be justified if there is some evidence that urban-rural mortality differentials are relatively small.

(c) Assumptions for the plan projection

(i) National projection

To formulate assumptions for the national projection over the plan period, it is normally necessary to consider expected socio-economic trends as well as social, economic and population policies to be implemented over the plan horizon. Where feasible, the likely impact of these trends and policies on the components of population change should be assessed on the basis of research findings concerning the determinants of fertility, mortality and international migration. In doing so, it will be necessary to allow for the fact that the effects of various factors on the components of change will be felt after a delay, the length of which may vary from one factor to another.

a. Mortality

In order to formulate mortality assumptions it will often be necessary to assess the effect on mortality of likely changes in such factors as female education, availability of and access to health services, household incomes and environmental conditions. Thus, if the proportion of females receiving formal education is expected to rise over the plan horizon, the mortality assumptions should normally allow for rising survival ratios or increases in expectations of life at birth, but only after a time lag. This is so since higher maternal education is generally associated with improvements in household sanitary conditions, better child nutrition and a greater demand for health services catering to children.

b. Fertility

Fertility assumptions could be formulated by identifying likely developments in educational attainment, health status, and labour force participation among women, as well as by considering likely changes in child education, infant and childhood mortality, urbanization and family planning. If, for example, educational attainment and labour force participation among women, as well as school enrolment among children, are expected to rise during

the plan period, the fertility assumptions could allow for a falling total fertility rate. Similarly, if rapid urbanization is envisaged, assumptions would generally allow for falling fertility. An assumption of falling fertility could also be made if the Government and/or non-governmental organizations were expected to pursue an effective family planning programme. The effects of these various factors may be subject to lags of different duration.

Some of the factors considered here as direct determinants of fertility may also influence fertility indirectly, through their effect on the age of marriage. In particular, increases in female labour force participation and urbanization may both influence age of marriage among females, leading to lower proportions married at early childbearing ages and to lower fertility rates at those ages. The same effect could occur as a result of increases in school attendance among females and the resultant increases in their educational attainment. Some of these effects can be felt however, after considerable delays.

Improvements in infant and child survivorship could also directly contribute to a fertility reduction. Where fertility is uncontrolled and breast-feeding is widespread and lengthy, fewer deaths in infancy and early childhood, as a rule, may lead to fewer births, for biological reasons. Even if fertility is subject to control, lower infant and early childhood mortality may bring about lower fertility. Under such conditions, the improved survivorship would enable parents to achieve the desired number of surviving children through fewer births. However, child survivorship often improves hand-in-hand with maternal health, in which case, these health improvements would tend to increase fertility through increased fecundity (the biological capacity to conceive and bear children) (United Nations, 1987).

c. International migration

International migration assumptions, especially for small- to medium-size countries experiencing considerable international migration, may have to be rather speculative. For countries that are net importers of labour, the assumptions might be formulated by taking into account expected trends in the domestic labour requirements as well as domestic labour force trends. For labour exporting countries, domestic unemployment and labour earnings as well as likely economic trends in the countries that are net importers of workers ought to be considered. Where international migration is subject to considerable governmental control, these assumptions should reflect expected government policies towards population movements across its national boundaries.

(ii) Urban-rural projections

a. Fertility, mortality and international migration

Where the inputs are prepared for the projection of urban and rural populations, mortality, fertility and international migration assumptions can

be formulated as for the national population. However, in this case, they should reflect likely changes in the relevant factors and policies and their impact in rural and urban areas separately.

b. Internal migration

To formulate internal (urban-rural) migration assumptions, it would be necessary to identify likely changes in the factors that bear upon decisions to migrate between urban and rural areas. In most circumstances, it will prove necessary to take into account expected trends in employment, underemployment and open unemployment in both urban and rural areas. Also, it would be desirable to consider household incomes and the cost of living as well as the availability of educational, health, and housing services in those areas. For example, where urban-rural disparities in employment and earning opportunities as well as differentials in the availability of services are large and expected to remain so, internal migration assumptions would have to allow for a sizeable net outmigration from rural areas.

Also, it would often be important to consider the relative size of the urban population and the concomitant absorptive capacity of the urban centres. Where the urban population is relatively small, the assumptions might need to provide for a relatively small net outflow from the rural areas in view of the limited absorptive capacity of the urban areas. Normally, these assumptions should not imply rates of growth of the urban population that surpass, say, the highest rates on record in the country concerned or those in similar countries.

In addition, where they are present, the effects of active government policies that directly impact on urban-rural migration would need to be taken into account. Such policies might include the repatriation of the residents of urban squatter settlements to the rural areas from which they came or the resettling of populations among geographical regions that may involve the crossing of urban-rural boundaries.

(d) Revising assumptions for the plan projection

In most planning exercises population projections will be prepared prior to making projections of the socio-economic variables. As a result, before formulating assumptions for the population projection it will normally be necessary to informally predict the future changes in socio-economic variables which are likely to have a demographic impact, including those to be subsequently projected. Furthermore, it would be necessary to infer the likely effects of those changes on the components of population change. In view of this, at least initially, the demographic assumptions may lead to population projections which appear implausible in the context of subsequent socio-economic projections.

Once the formal projections of the socio-economic variables are made, it may prove useful to re-examine the assumptions underlying the population projection, and if necessary, to revise them and to project population again. This iterative approach would allow each new set of demographic assumptions to reflect the changes in the socio-economic projections. Repeating population and socio-economic projections in an iterative fashion is also likely to lead to a greater consistency among the various projection outcomes as well as assumptions.

D. Illustrative examples of projections

Three examples are presented in this section to illustrate the preparation of different types of population projections using the cohort component method. The first example will show how to project a closed national population. The second will project an open national population. The third example will illustrate the projection of urban and rural populations which are closed to international migration.

Each example will describe the required calculations for the first five-year projection interval, 0-5. Projection results for a 20-year projection period will also be presented since planners will often find it useful to project population over a 20-year period even in planning exercises that focus exclusively on the medium term.

1. National population

This section will first illustrate a projection of the national population which is closed to international migration. Then it will describe a projection of such a population open to international migration.

(a) Closed population

This example will first show how to derive the segment of the age and sex structure at age 5 and over at the end of the projection interval 0-5. Next, it will illustrate how to obtain the segment of the population structure below age 5. Lastly, other results obtained for the interval 0-5 will be calculated. The example will be based on the inputs contained in table 1, which include the initial age and sex structure of the population and assumptions on mortality and fertility.

The initial population structure and the assumptions selected for this example portray an age and sex structure and trends in mortality and fertility representative of a country that has already experienced substantial mortality decline along with a limited fertility reduction. As indicated in figure VI, the lower end of the age pyramid suggests some recent fertility reduction. Figure VII shows a continuation of the mortality decline associated with some deceleration in that decline. And figure VIII indicates a further decline in fertility, which accelerates over the projection period.

Table 1. Inputs for making a projection of the national population closed to international migration

(a) Initial population by age and sex (thousands):

Age group	Male	Female
0-4	784.5	750 7
5-9	740.0	694.8
10-14	624.0	580.5
15-19	486.6	448 3
20-24	402.2	359.8
25-29	361.5	348.3
30-34	358.7	352 2
35-39	312.4	300.9
40-44	223.6	206.7
45-49	152.1	158.5
50-54	192.5	174.6
55-59	157.0	164.0
60-64	128.1	126.1
65-69	90.1	105.6
70-74	44.2	63.5
75+	38.6	69.4

(b) Mortality assumptions:

Time interval	Expectations of life at birth (years)	
	Male	Female
0-5	51.63	53 01
5-10	55.65	57 06
10-15	59.19	60 47
15-20	62.16	63 13

(c) Fertility assumptions:

Time interval	Total fertility rates	Proportionate age-specific fertility rates by age						
		15-19	20-24	25-29	30-34	35-39	40-44	45-49
0-5	5.57	0.081	0.251	0.245	0.195	0.143	0 059	0.026
5-10	5.16	0.087	0.259	0.248	0.190	0.139	0 058	0 022
10-15	4.54	0.092	0.268	0.249	0.183	0.133	0.056	0.019
15-20	3.79	0.097	0.277	0.254	0.177	0.124	0.054	0.016

Figure VI. Initial age and sex structure of the population

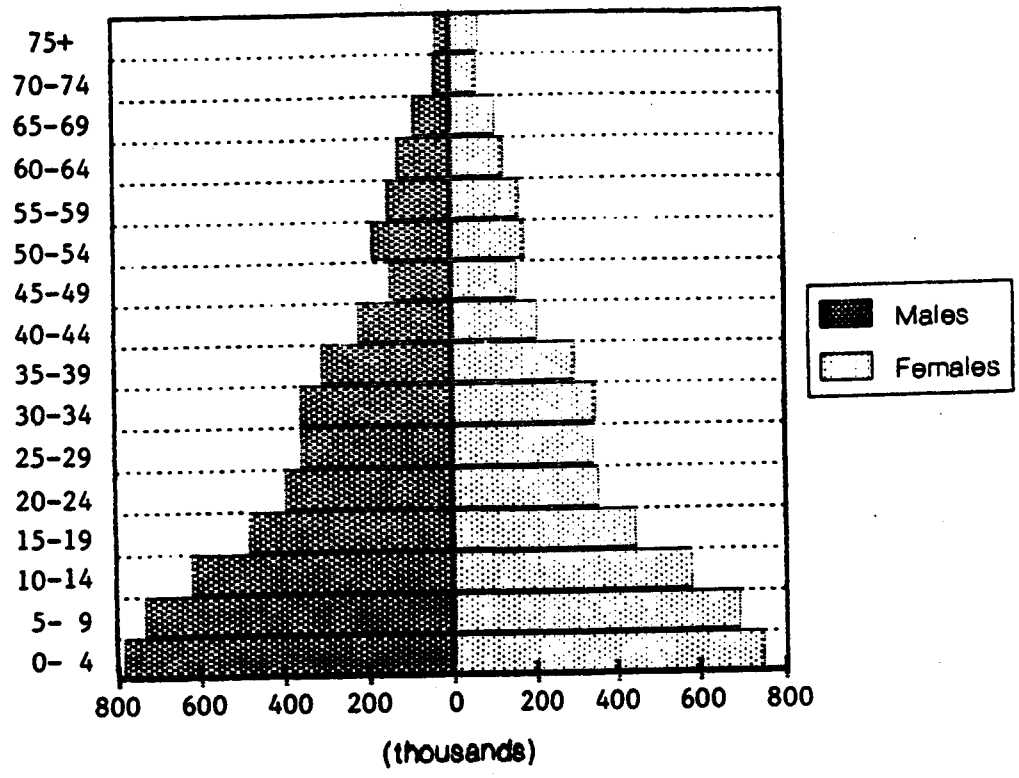


Figure VII. Expectations of life at birth

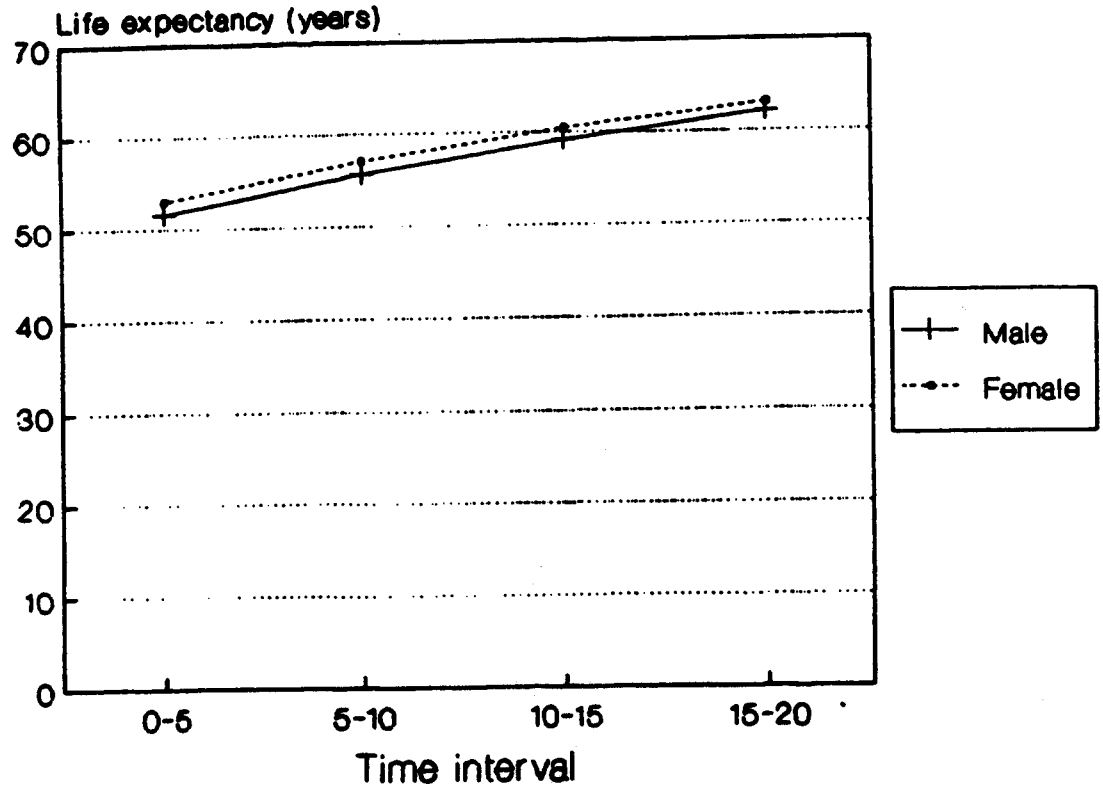
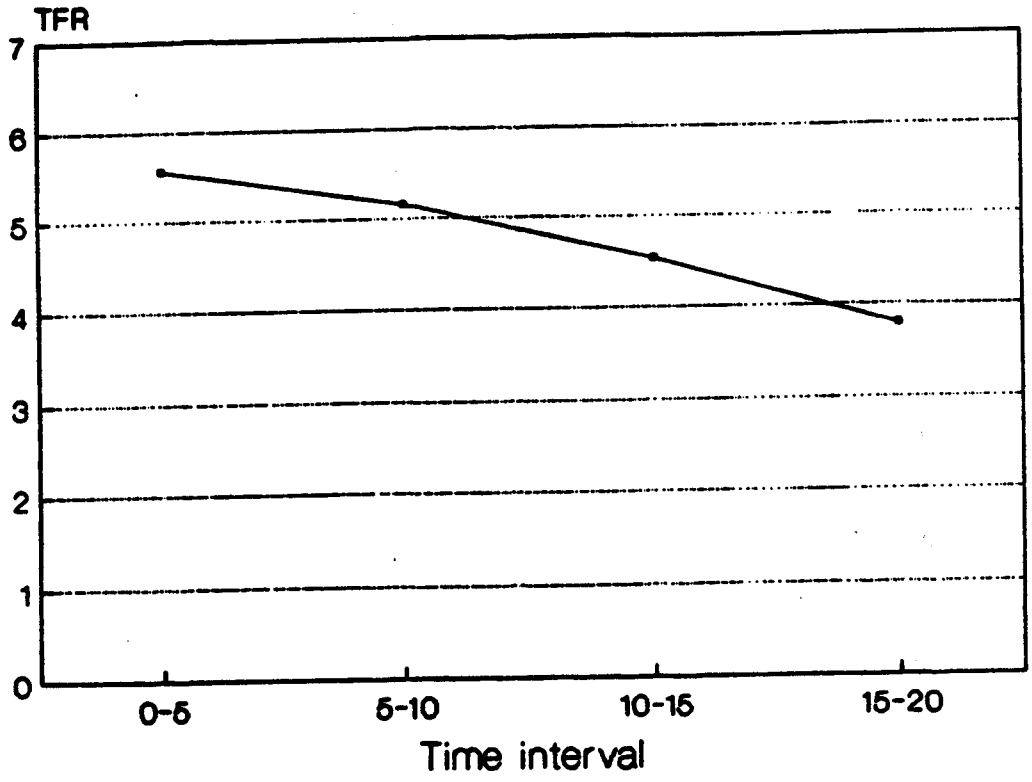


Figure VIII. Total fertility rate



(i) Segment of the population structure at age 5 and over

To derive the segment of the population structure at age 5 and above, it is initially necessary to obtain survival ratios from mortality assumptions. These survival ratios are then multiplied by the appropriate populations to determine the number of survivors.

a. Survival ratios

The procedure to calculate survival ratios from expectations of life at birth using a selected family of model life tables is the same for each sex. Its application will be illustrated using the expectation for males, 51.63 years (table 1), and the United Nations family of South Asian model life tables (United nations, 1981). 14/ Since the use of a suitable family of model life tables in a population projection may be fairly important, box 25 describes a procedure to select the most suitable family.

Table 2 illustrates the way male survival ratios are calculated using an expectation of life at birth and a family of model life tables. Columns 2 and 3 show relevant male survival ratios (panel A) and selected numbers of person-years-lived (panel B) in the South Asian family that correspond to male expectations of life at birth 51.0 and 52.0. It is noted that all survival ratios shown in the two columns, except those in the last row (70+ to 75+), along with the numbers of person-years-lived come directly from the model life tables in question.

The survival ratios shown in the last row are not available in the model life tables and, therefore, must be calculated using the numbers of person-years-lived at ages 70 and 75 (panel B). At each level of expectation of life at birth, this ratio is obtained as the ratio of the number of person-years-lived at age 75 and over to the number of person-years-lived at age 70 and above. Thus, at the expectation of life at birth 51.0 (column 2), the ratio in question, 0.5485, is obtained as 176,292 divided by 321,294, where 321,394 is the number of person-years-lived at age 70 and over and 176,292 is the number of person-years-lived at age 75 and above.

Survival ratios that correspond to male expectation of life at birth 51.63 (column 4) can be obtained by linear interpolation of survival ratios at expectations of life 51.0 and 52.0. The interpolation factor is 0.37, which is obtained as (52.0 - 51.63)/(52.0 - 51.0). Using this factor, the first survival ratio 0.83874, shown in column 4, is calculated as:

$$0.83874 = (0.37)\,(0.8342) + (1 - 0.37)\,(0.8414), \qquad (1)$$

where 0.8342 and 0.8414 are the survival ratios at expectations of life 51.0 and 52.0, respectively. The remaining survival ratios for the expectation of life 51.63 are obtained in the same way.

Box 25

Selecting a family of model life tables

There are a number of alternative ways of selecting a family of model life tables that best represents the age pattern of mortality in a given population. These different ways are variants of the same procedure which utilizes an empirical life table, such as the national life table for a given sex. They also make use of model life tables for the same sex that belong to different families of model life tables, such as the United Nations or the Coale-Demeny model life tables. a/

One way to select a family of model life tables was recently described by the United Nations. b/ The procedure utilizes age-specific central death rates ($_nm_x$ values) or age-specific probabilities of dying ($_nq_x$ values) to compute indices of similarity between empirical and model age patterns of death rates or probabilities of dying.

An index of similarity, which is computed for each of the families considered can be obtained for the entire age span or selected portions of it. An index for the entire span can be computed as follows:

$$I = \sum_{x=0}^{w} | e_0 (x,x+n) - M | / N$$

where:

I	is the index of similarity for a given family of model life tables,
$x = 0,1,5,\ldots,w$	are the lower limits of age groups used in a life table 0, 1-4, 5-9, ..., w+ , where w is the lower limit of the open age group,
$e_0 (x,x+n)$	is the expectation of life at birth in the family of model life tables used which corresponds to the empirical death rate or probability of dying in age group x to x+n,
M	is the median of all different $e_0(x,x+n)$ values, and
N	is the number of age groups within the entire age span.

(continued)

Box 25 (continued)

Once the values of the index of similarity are computed using different families of model life tables, one has a basis for selecting the most representative of the families. The family that yields the lowest value of the index is the one that best fits the empirical age pattern of mortality.

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a/ See Model Life Tables for Developing Countries (United Nations publication, Sales No. E.81.XIII.7). Also, Ansley J. Coale, Paul Demeny and Barbara Vaughan, Regional Model Life Tables and Stable Populations, 2nd ed. (New York, Academy Press, 1983).

b/ MORTPAK-LITE: The United Nations Software Package for Mortality Measurement; Interactive Software for the IBM-PC and Compatibles (United Nations publication, Sales No. E.88.XIII.2).

b. Population aged 5 and over

When the survival ratios are applied to the population at the beginning of a given projection interval, the result is population aged 5 and over at the end of the interval. In particular, when the relevant survival ratios (table 3, column 4) are applied to the population in year 0 (column 3), one obtains the age and sex structure of the population at age 5 and over in year 5 (column 5). 15/

For example, the number of males aged 5-9 in year 5, 737.0 (column 5), is calculated as the product of the number of males aged 0-4 in year 0, 784.5 (column 3) and the survival ratio among males aged 5-9, 0.93949 (column 4):

$$737.0 = (784.5)\ (0.93949). \qquad (2)$$

The number of males aged 75+ in year 5, 45.6, is the product of the number of males aged 70+ in year 0, 82.8 (obtained as 44.2 + 38.6) and the appropriate survival ratio, 0.55073:

$$45.6 = (82.8)\ (0.55073). \qquad (3)$$

Table 2. Calculating survival ratios: results for males; projection interval 0-5

	Age	Expectations of life at birth		
		51.0 a/	52.0 a/	51.63 b/
	(1)	(2)	(3)	(4)
PANEL A: Survival ratios	Birth to 0-4	0.8342	0.8414	0.83874
	0-4 to 5-9	0.9371	0.9409	0.93949
	5-9 to 10-14	0.9858	0.9867	0.98637
	10-14 to 15-19	0.9909	0.9914	0.99122
	15-19 to 20-24	0.9891	0.9897	0.98948
	20-24 to 25-29	0.9870	0.9876	0.98738
	25-29 to 30-34	0.9840	0.9848	0.98450
	30-34 to 35-39	0.9793	0.9803	0.97993
	35-39 to 40-44	0.9710	0.9723	0.97182
	40-44 to 45-49	0.9582	0.9599	0.95927
	45-49 to 50-54	0.9378	0.9399	0.93912
	50-54 to 55-59	0.9089	0.9115	0.91054
	55-59 to 60-64	0.8665	0.8696	0.86845
	60-64 to 65-69	0.8064	0.8102	0.80879
	65-69 to 70-74	0.7290	0.7334	0.73177
	70+ to 75+	0.5485	0.5520	0.55073
PANEL B: Person-years lived at indicated age and above	70	321394	336971	
	75	176292	185997	

a/ From South Asian model life tables.
b/ Calculated by interpolation.

Table 3. Deriving the segment of age and sex structure of the national population closed to international migration at age 5 and over; end of projection interval 0-5

Sex	Age group	Population in year 0 a/ (thousands)	Survival ratios b/	Population in year 5 c/ (thousands)
(1)	(2)	(3)	(4)	(5)
Male	0-4	784.5		
	5-9	740.0	0.93949	737.0
	10-14	624.0	0.98637	729.9
	15-19	486.6	0.99121	618.5
	20-24	402.2	0.98948	481.5
	25-29	361.5	0.98738	397.1
	30-34	358.7	0.98450	355.9
	35-39	312.4	0.97993	351.5
	40-44	223.6	0.97182	303.6
	45-49	152.1	0.95927	214.5
	50-54	192.5	0.93912	142.8
	55-59	157.0	0.91054	175.3
	60-64	128.1	0.86845	136.3
	65-69	90.1	0.80879	103.6
	70-74	44.2	0.73177	65.9
	75+	38.6	0.55073	45.6
Female	0-4	750.7		
	5-9	694.8	0.93874	704.7
	10-14	580.5	0.98621	685.2
	15-19	448.3	0.99031	574.9
	20-24	359.8	0.98701	442.5
	25-29	348.3	0.98521	354.5
	30-34	352.2	0.98311	342.4
	35-39	300.9	0.97981	345.1
	40-44	206.7	0.97541	293.5
	45-49	158.5	0.96831	200.2
	50-54	174.6	0.95422	151.2
	55-59	164.0	0.92892	162.2
	60-64	126.1	0.88943	145.9
	65-69	105.6	0.83374	105.1
	70-74	63.5	0.75775	80.0
	75+	69.4	0.54846	72.9

a/ From table 1.
b/ From table 2, col. 4.
c/ For age groups:
5-9 through 70-74:
(Entry in a preceding row of col. 3) . (Entry in the given row of col. 4).

75+:
(The sum of entries corresponding to age groups 70-74 and 75+ in col. 3) . (Entry corresponding to the latter of age groups in col. 4).

(ii) Segment of the population structure below age 5

To obtain the segment of the population structure below age five at the end of a given five year projection interval, it is necessary first to calculate the total number of births for the interval using, among other things, fertility rates for the interval. It will then be necessary to calculate the number of survivors among these births.

a. Fertility rates

In this example, the fertility assumptions are specified in terms of the total fertility rate and proportionate age specific fertility rates. Using these measures, age specific fertility rates can be calculated as shown in table 4. In particular, any age specific fertility rates (column 3) can be obtained as a product of the given total fertility rate divided by 5 and the corresponding proportionate age specific fertility rate (column 2).

For example, the fertility rate for the age group 20-24, 0.2796, is obtained as:

$$0.2796 = (5.57/5)\ (0.251), \tag{4}$$

where 5.57 is the total fertility rate, shown in table 1, and 0.251 is the proportionate fertility rate for the age group 20-24.

b. Births

Before the number of births can be calculated, it is necessary to derive the mid-interval numbers of women of the childbearing period. These numbers can be obtained as geometric means of the numbers of women in various five-year age groups at the beginning and the end of the interval (table 5).

For example, the number of women for age group 15-19, 507.7, shown in column 4 is calculated as:

$$507.7 = [(448.3)\ (574.9)]^{1/2}, \tag{5}$$

where 448.3 is the number of women aged 15-19 at the beginning of the interval (column 2) and 574.9 is the corresponding number at the end of the interval (column 3).

The number of births is calculated from the fertility rates and the mid-interval numbers of women as illustrated in table 6. The number is obtained as five times the sum of the products of the age-specific fertility rates (column 2) and the mid-interval numbers of women by age (column 3). The sum of the products (column 4) stands for the average annual number of births which is multiplied by 5 to calculate the total number of births for the interval:

Table 4. Calculating age-specific fertility rates; projection interval 0-5

Age group	Proportionate age-specific fertility rates a/	Age-specific fertility rates b/
(1)	(2)	(3)
15-19	0.081	0.0902
20-24	0.251	0.2796
25-29	0.245	0.2729
30-34	0.195	0.2172
35-39	0.143	0 1593
40-44	0.059	0 0657
45-49	0.026	0.0290

a/ From table 1.
b/ (Total fertility rate/5) . (Col. 2).

Table 5. Calculating mid-interval numbers of women of childbearing ages; projection interval 0-5

(Thousands)

Age group	Women of childbearing age		
	In year 0 a/	In year 5 b/	At mid-point of time interval 0-5 c/
(1)	(2)	(3)	(4)
15-19	448.3	574.9	507.7
20-24	359.8	442.5	399.0
25-29	348.3	354.5	351.4
30-34	352.2	342.4	347.3
35-39	300.9	345.1	322.2
40-44	206.7	293.5	246.3
45-49	158.5	200.2	178.1

a/ From table 1.
b/ From table 3, col. 5.
c/ $\{ (\text{Col. 2}) \cdot (\text{Col. 3}) \}^{1/2}$.

Table 6. Calculating the average annual number of births: projection interval 0-5

Age group	Age-specific fertility rates a/	Mid-interval number of women b/ (thousands)	Numbers of births c/ (thousands)
(1)	(2)	(3)	(4)
15-19	0.0902	507.7	45.8
20-24	0.2796	399.0	111.6
25-29	0.2729	351.4	95.9
30-34	0.2172	347.3	75.4
35-39	0.1593	322.2	51.3
40-44	0.0657	246.3	16.2
45-49	0.0290	178.1	5.2
Total			401.4

a/ From table 4, col. 3.
b/ From table 5, col. 4.
c/ (Col. 2) . (Col. 3).

$$2{,}007.0 = (5)\ (401.4), \qquad (6)$$

where 401.4 is the average annual number of births (total in column 4).

In order to calculate the numbers of survivors aged 0-4 by sex, the total number of births by sex should be subdivided by sex. The total number of births is disaggregated using proportions of births by sex, derived from the assumed value of the sex ratio at birth (105). The proportion male based on this sex ratio at birth is:

$$0.5122 = 105 / (\ 100 + 105\ ),$$

and the proportion female is:

$$0.4878 = 100 / (\ 100 + 105\ ).$$

The number of males born during the interval is therefore:

$$1{,}028.0 = (0.5122)\ (2{,}007.0), \qquad (7)$$

and the number of females born is:

$$979.0 = (0.4878)\ (2{,}007.0). \qquad (7)$$

c. Population below age 5

To derive the population below age 5 by sex at the end of a five-year time interval, it is necessary to multiply the numbers of births by sex by the appropriate survival ratios. This is so since in a closed population the number of persons aged 0-4 at the end of a five-year time interval consists of the survivors of children born during the interval.

Thus, the number of male children aged 0-4 at the end of the interval, 862.2 (column 4 of table 7), is obtained as:

$$862.2 = (1{,}028.0)\ (0.83874), \qquad (8)$$

where 1,028.0 (column 2) is the number of male births and 0.83874 (column 3) is survival ratio for males.

The number of female children aged 0-4 at the end of the interval is calculated in the same manner:

$$828.9 = (979.0)\ (0.84666). \qquad (8)$$

This completes the projection of the age and sex structure of the closed population for the end of the projection interval 0-5.

When repeated over subsequent time intervals, the calculations illustrated above for the interval 0-5 produce projected population structures for the end of intervals 5-10, 10-15, and so on. Thus, a projection over a 20-year time

Table 7. Deriving the segment of age and sex structure of the national population closed to international migration below age 5: end of projection interval 0-5

Sex	Births for interval 0-5 a/ (thousands)	Survival ratios b/	Population aged 0-4 in year 5 c/ (thousands)
(1)	(2)	(3)	(4)
Male	1028.0	0.83874	862.2
Female	979.0	0.84666	828.9

a/ Derivation illustrated in text.
b/ From table 2, col. 4.
c/ (Col. 3) . (Col. 4).

period produces the age and sex structures presented in table 8. The age and sex structure at the end of the 20-year interval is depicted in figure IX.

(iii) Other results

A variety of indicators may be calculated along with population structures, which include:

a. Population aggregates;
b. Indicators of population structure;
c. Rates of population change.

The calculation of those indicators will be illustrated below for the projection interval 0-5 and the results will be presented in table 9 along with indicators for the subsequent projection intervals.

a. Population aggregates

A number of population aggregates can be obtained by adding up the numbers of persons in designated age and sex groups.

i. Population size

The population size at the end of the interval 0-5--that is, in year 5, 11,210.4 (table 9)--is the result of adding up the numbers of persons of both sexes and the various age groups at that date. The growth of the population over the projection period is illustrated in figure X.

ii. Young-age population

The young-age population for the end of the interval, 4,547.9, is obtained by summing up the numbers of persons of both sexes in age groups 0-4 through 10-14.

iii. Working-age population

The working-age population, 6,189.4, is found by adding up the numbers of persons of both sexes in age groups 15-19 through 60-64.

iv. Old-age population

The old-age population, 473.1, is obtained by summing up the numbers of both sexes in age groups 65-69 through 75+. The growth of the young age, working age and old age populations over the projection period is illustrated in figure XI.

Table 8. Projected national population closed to international migration, by age and sex

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	0-4	784.5	862.2	957.3	1022.5	1012.7
	5-9	740.0	737.0	822.2	923.3	994.4
	10-14	624.0	729.9	729.3	815.6	917.5
	15-19	486.6	618.5	724.9	725.4	812.0
	20-24	402.2	481.5	613.4	720.1	721.5
	25-29	361.5	397.1	476.7	608.5	715.5
	30-34	358.7	355.9	392.2	472.0	603.6
	35-39	312.4	351.5	350.2	387.1	466.9
	40-44	223.6	303.6	343.4	343.5	381.0
	45-49	152.1	214.5	293.2	333.5	335.1
	50-54	192.5	142.8	203.2	279.9	320.3
	55-59	157.0	175.3	131.5	189.0	262.4
	60-64	128.1	136.3	154.4	117.4	170.5
	65-69	90.1	103.6	112.4	129.5	99.9
	70-74	44.2	65.9	77.7	86.2	101.4
	75+	38.6	45.6	63.0	81.4	99.1
Female	0-4	750.7	828.9	916.3	974.5	961.3
	5-9	694.8	704.7	789.6	882.6	945.8
	10-14	580.5	685.2	697.4	783.3	877.0
	15-19	448.3	574.9	680.2	693.5	779.9
	20-24	359.8	442.5	569.3	675.3	689.6
	25-29	348.3	354.5	437.5	564.5	670.7
	30-34	352.2	342.4	349.9	433.2	560.0
	35-39	300.9	345.1	337.0	345.5	428.7
	40-44	206.7	293.5	338.2	331.6	340.8
	45-49	158.5	200.2	285.7	330.7	325.2
	50-54	174.6	151.2	192.3	276.1	320.9
	55-59	164.0	162.2	141.9	181.9	262.8
	60-64	126.1	145.9	146.3	129.5	167.6
	65-69	105.6	105.1	124.0	126.4	113.4
	70-74	63.5	80.0	81.7	98.5	102.3
	75+	69.4	72.9	86.4	97.5	116.1

Figure IX. Terminal age and sex structure of the population

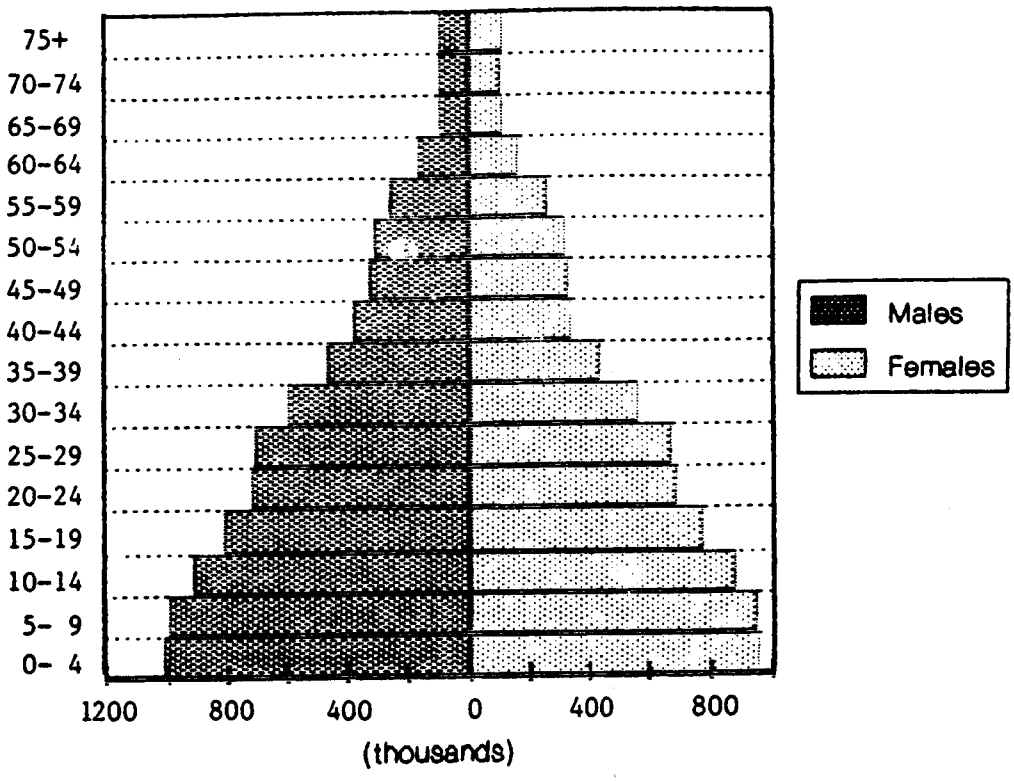


Table 9. Population aggregates, indicators of the population structure and rates of population change of the national population closed to international migration

Indicators	Year 0	5	10	15	20
Population aggregates (thousands)					
Population size	10000.0	11210.4	12619.0	14159.4	15675.6
Young-age	4174.5	4547.9	4912.1	5401.8	5708.7
Working-age	5414.1	6189.4	7161.4	8138.2	9335.0
Old-age	411.4	473.1	545.2	619.5	632.2
School-age	4336.2	4974.2	5626.3	6219.1	6737.7
Women of childbearing age	2174.7	2553.1	2997.8	3374.3	3794.9
Mid-interval population size	10587.9	11893.9	13367.0	14898.2	
Number of person-years lived	52939.6	59469.3	66835.1	74491.1	
Population growth	1210.4	1408.6	1540.4	1516.2	
Births	2007.0	2157.0	2244.0	2179.0	
Deaths	796.6	748.4	703.6	662.8	
Indicators of the population structure					
Proportions by broad age groups					
At young age (0-14)	0.42	0.41	0.39	0.38	0.36
At working age (15-64)	0.54	0.55	0.57	0.57	0.60
At old age (65+)	0.04	0.04	0.04	0.04	0.04
Dependency ratios					
Young-age	0.77	0.73	0.69	0.66	0.61
Old-age	0.08	0.08	0.08	0.08	0.07
Total	0.85	0.81	0.76	0.74	0.68
Median age of population	19.4	19.4	20.0	20.9	21.9
Proportion of women of childbearing age	0.22	0.23	0.24	0.24	0.24
Sex ratio of the population	104	104	104	104	105
Rates of population change (per thousand)					
Birth rate	37.9	36.3	33.6	29.3	
Death rate	15.0	12.6	10.5	8.9	
Natural increase	22.9	23.7	23.0	20.4	
Population growth	22.9	23.7	23.0	20.3	

Figure X. Population size, school-age population and number of women of childbearing ages

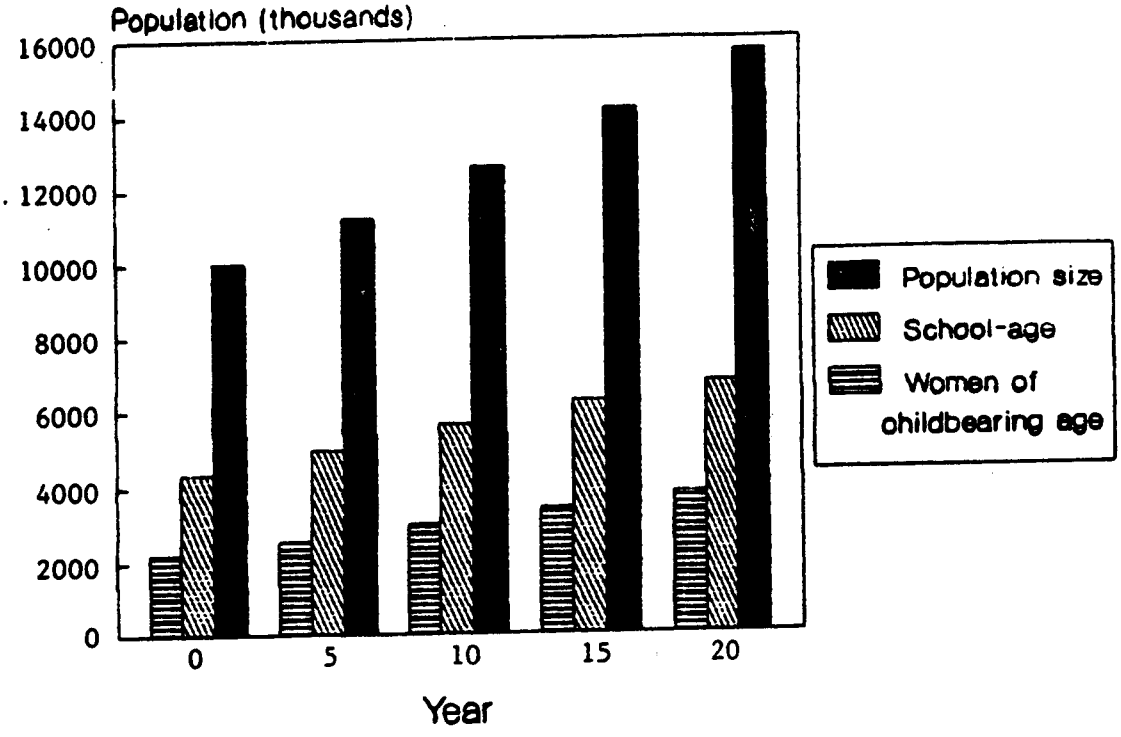
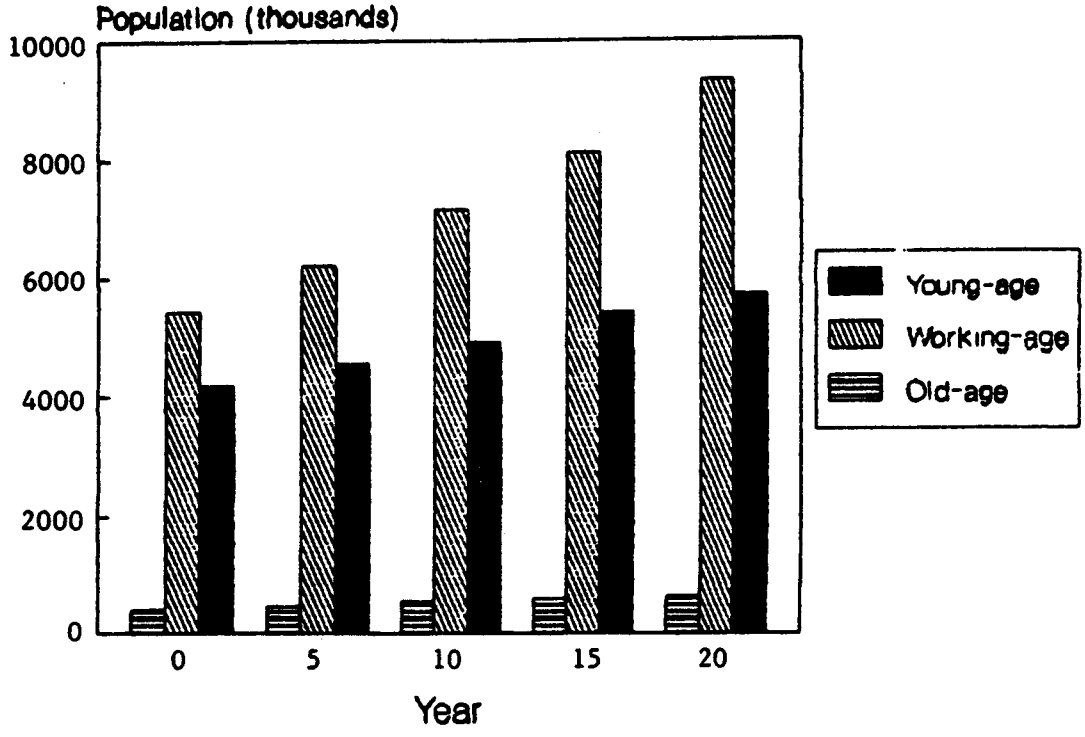


Figure XI. Young-age population, working-age population and old-age population



v. School-age population

The school-age population at the end of the interval, 4,974.2, is derived by adding up the numbers of persons of both sexes in age groups 5-9 through 20-24.

vi. Women of the childbearing ages

The number of women of the childbearing ages, 2,553.1, is the sum of the numbers of women in age groups 15-19 through 45-49. The growth of the school-age population and women of the childbearing ages is illustrated in figure X.

vii. Mid-interval population size

The mid-interval population size for the interval 0-5, 10,587.9, is calculated as the geometric mean of the population sizes at the beginning and the end of the interval--10,000.0 and 11,210.4, respectively:

$$10{,}587.9 = [(10{,}000.0)\ (11{,}210.4)]^{1/2}. \qquad (15)$$

viii. Total number of person-years-lived

The number of person-years-lived by the population during the interval, 52.939.6, is calculated as 5 times the mid-interval population size:

$$52{,}939.6 = (10{,}587.9)\ (5). \qquad (16)$$

ix. Population growth

Among the aggregates indicating changes in the population size, the population growth, 1,210.4, is obtained as the difference between the population size at the end of the interval--11,210.4--and the population size at the beginning--10,000.0:

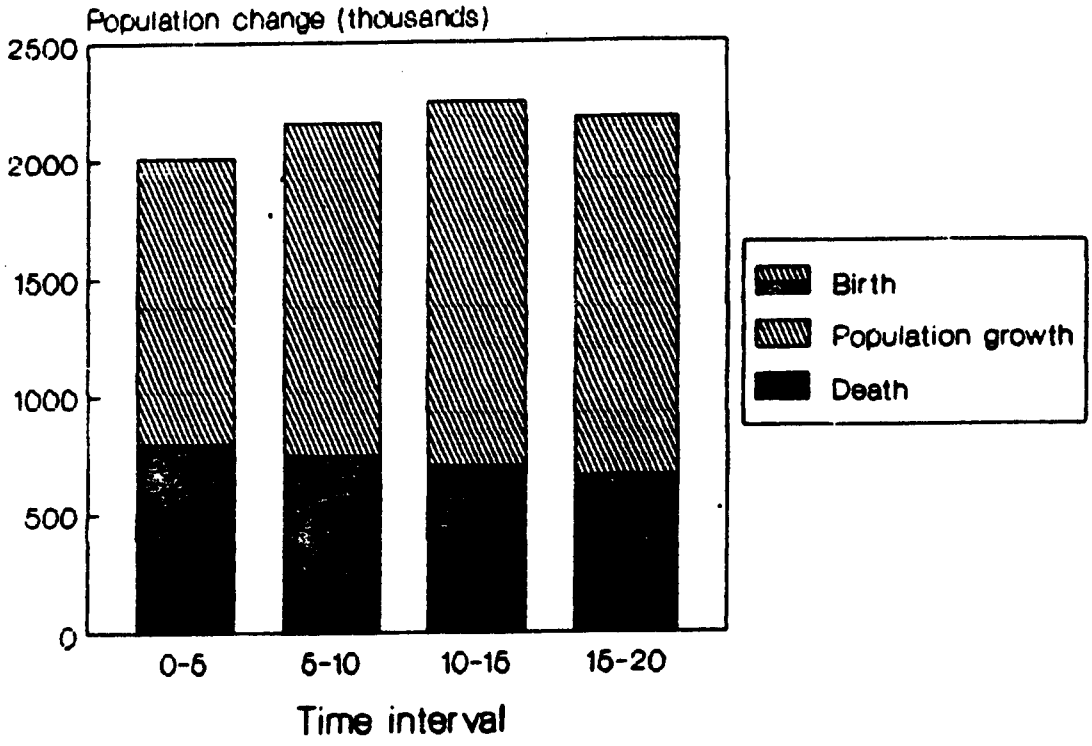
$$1{,}210.4 = 11{,}210.4 - 10{,}000.0. \qquad (17)$$

Population growth during each five-year interval of the projection period is illustrated in figure XII as the difference between births and deaths during the interval.

x. Births

The number of births, 2,007.0, is calculated in the course of deriving the age and sex structure of the population.

Figure XII. Population growth, number of births and number of deaths



xi. Deaths

The number of deaths, 796.6, is obtained as the difference between the number of births, 2,007.0, and the population growth, 1,210.4:

$$796.6 = 2{,}007.0 - 1{,}210.4. \quad (18)$$

Births and deaths are illustrated in figure XII.

b. Indicators of the population structure

i. Proportions by broad age groups

The first group of indicators of the population structure--proportions by broad age groups (0-14, 15-64 and 65+)--is obtained by dividing the young-age population, the working-age population and the old-age population, respectively, by the population size. In the course of the illustrative projection, those proportions are calculated for the end of the interval 0-5 as follows:

The proportion at young age:

$$0.41 = 4{,}547.9 / 11{,}210.4, \quad (19)$$

where 4,547.9 is the size of the young-age population;

The proportion at working age:

$$0.55 = 6{,}189.4 / 11{,}210.4, \quad (20)$$

where 6,189.4 is the size of the working-age population; and

The proportion at old age:

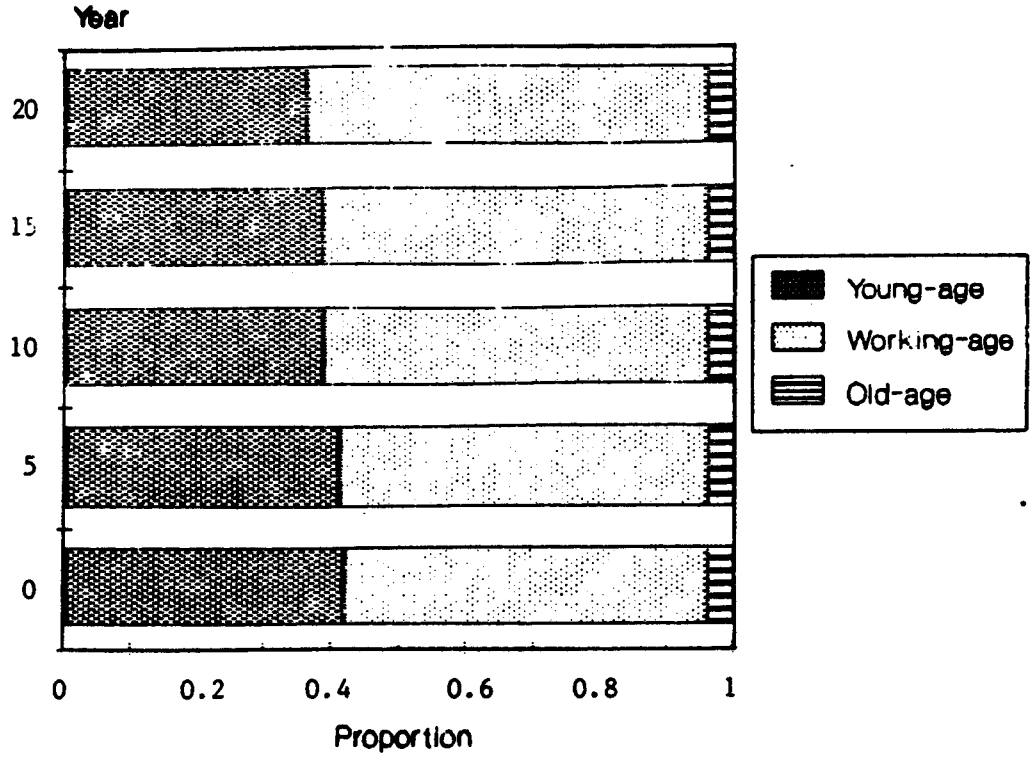
$$0.04 = 473.1 / 11{,}210.4, \quad (21)$$

where 473.1 is the size of the old-age population. The total population size is 11,210.4. These proportions at five-year intervals are shown in table 9 and illustrated in figure XIII.

ii. Dependency ratios

Dependency ratios are obtained in a similar manner. Thus, the three dependency ratios--the young-age dependency ratio, the old-age dependency ratio and the total dependency ratio--for the end of the interval 0-5 are calculated as:

Figure XIII. Proportions of the population in broad age groups (0-14, 15-64 and 65+)



The young-age dependency ratio:

$$0.73 = 4,547.9 / 6.189.4, \quad (22)$$

where 4,547.9 is the young age population;

The old-age dependency ratio:

$$0.08 = 473.1 / 6,189.4, \quad (23)$$

where 473.1 is the old-age population; and

The total dependency ratio:

$$0.81 = (4,547.9 + 473.1) / 6,189.4, \quad (24)$$

and where in each expression 6,189.4 is the working-age population.

The three dependency ratios are shown for dates five years apart in table 9 and figure XIV.

iii. Median age of the population

The median age of the population is computed using the formula for calculating the median age from the grouped data. For the end of the 0-5 interval, the median age of the population, 19.4, is computed as follows:

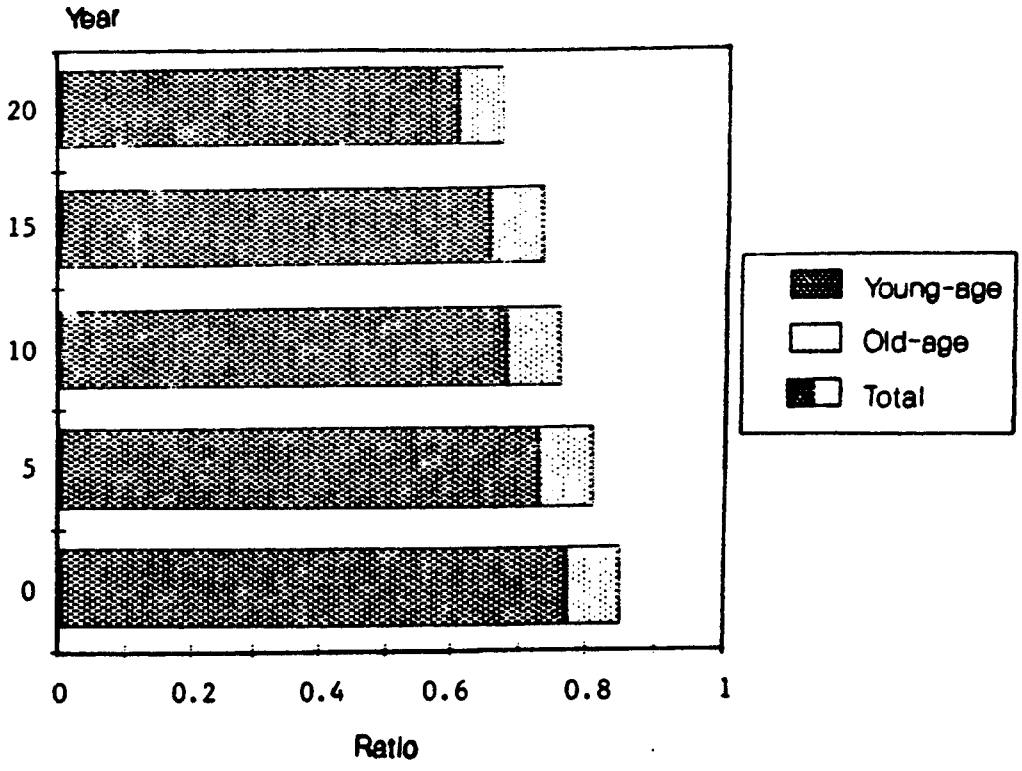
$$19.4 = (4 - 1) (5) + [(11,210.4 / 2 - 4,547.9) / 1,193.4] (5). \quad (25)$$

Among the numbers used in the expression, the 4 in the first parenthesis stands for the fourth five-year age group, 15-19, which contains the middle member of the population; this term is multiplied by 5, the length of the five-year age group. The result, 15, is the lower limit of the five-year age group containing the middle number. The population size at the end of the interval 0-5 is 11,210.4. The number of persons in the population below age 15 (prior to the fourth age group) is 4,547.9, and 1,193.4 is the number of persons in the 15-19 age group. These two numbers are obtained by adding up the numbers of persons of both sexes in age groups 0-4 through 10-14 and within the age group 15-19, respectively. Again, the term is multiplied by 5, the length of the five-year age group.

iv. Proportion of women in the childbearing ages

The proportion of women in the childbearing ages is obtained as the number of women of that age divided by the population size. For the end of the 0-5 interval, this proportion is:

Figure XIV. Dependency ratios



$$0.23 = 2{,}553.1 \;/\; 11{,}210.4, \qquad (26)$$

where 2.553.1 is the number of women in childbearing years and 11,210.4 is the population size.

v. Sex ratio of the population

The sex ratio is a ratio of the number of males in the population to the number of females. The sex ratio at the end of the 0-5 interval is:

$$104 = (5{,}711.3 \;/\; 5{,}489.1) \cdot 100, \qquad (27)$$

where 5,721.3 and 5,489.1 are, respectively, the numbers of males and females in the population at that date.

c. Rates of population change

In the case of a projection of the national population closed to international migration, these rates include the crude birth rate and the crude death rate along with the rate of natural increase and the rate of population growth.

i. Crude birth rate

The average annual crude birth rate for the interval 0-5 is calculated as follows :

$$37.9 = [\,(\,2{,}007.0 \;/\; 5\,) \;/\; 10{,}587.9\,] \cdot 1{,}000, \qquad (28)$$

where 2,007.0 is the number of births for the interval, 5 is the length of the interval, and 10,587.9 is the mid-interval population size.

ii. Crude death rate

The average annual crude death rate for the same interval is calculated as:

$$15.0 = [\,(\,796.6 \;/\; 5\,) \;/\; 10{,}587.9\,] \cdot 1{,}000, \qquad (29)$$

where 796.6 is the total number of deaths for the interval, 5 is the length of the interval, and 10,587.9 is the mid-interval population size.

iii. Rate of natural increase

The rate of natural increase, which equals the difference between the crude birth rate and the crude death rate, is:

$$22.9 = 37.9 - 15.0, \quad (30)$$

where 37.9 and 15.0 are crude birth and death rates.

iv. Rate of population growth

Lastly, the rate of population growth is obtained from the population sizes at the beginning and the end of the interval, using the exponential growth-rate formula. For the period 0-5, this rate is obtained as:

$$22.9 = [\ \ln (\ 11{,}210.4 \ / \ 10{,}000.0\ )\ /\ 5\ ] \cdot 1{,}000, \quad (31)$$

where 11,210.4 and 10,000.0 are the population sizes in year 5 and 0, respectively, and 5 is the length of the interval. This rate, along with crude birth and death rates and the rate of natural increase is shown in table 9. As can be observed, in a closed population, the rate of natural increase is equal to the rate of population growth.

The crude birth rate, the crude death rate, the rate of natural increase and the rate of population growth are shown in table 9 and are illustrated in figure XV.

(b) Open population

A number of steps used to project an open national population are the same as those used to project a closed population. Therefore, this example will not illustrate those steps, but emphasize the steps relating to international migration. The example will make use of the inputs of table 1 along with those of table 10, in which assumptions on international migration are given for a 20-year time interval.

(i) Segment of the population structure at age 5 and over

a. Survival ratios and survivors aged 5 and over

The survival ratios are computed exactly as described for the closed population. The steps used to derive survivors aged 5 and over at the interval's end are identical to those employed to obtain population aged 5 and over in the closed population. As this example uses the same initial population structure and mortality assumptions as the previous one, the numbers of survivors aged 5 and over (table 11, column 3) are identical to the numbers obtained earlier (table 3, column 5). In a projection of an open population those numbers of survivors have to be modified using net international migration rates.

Figure XV. Rates of population change

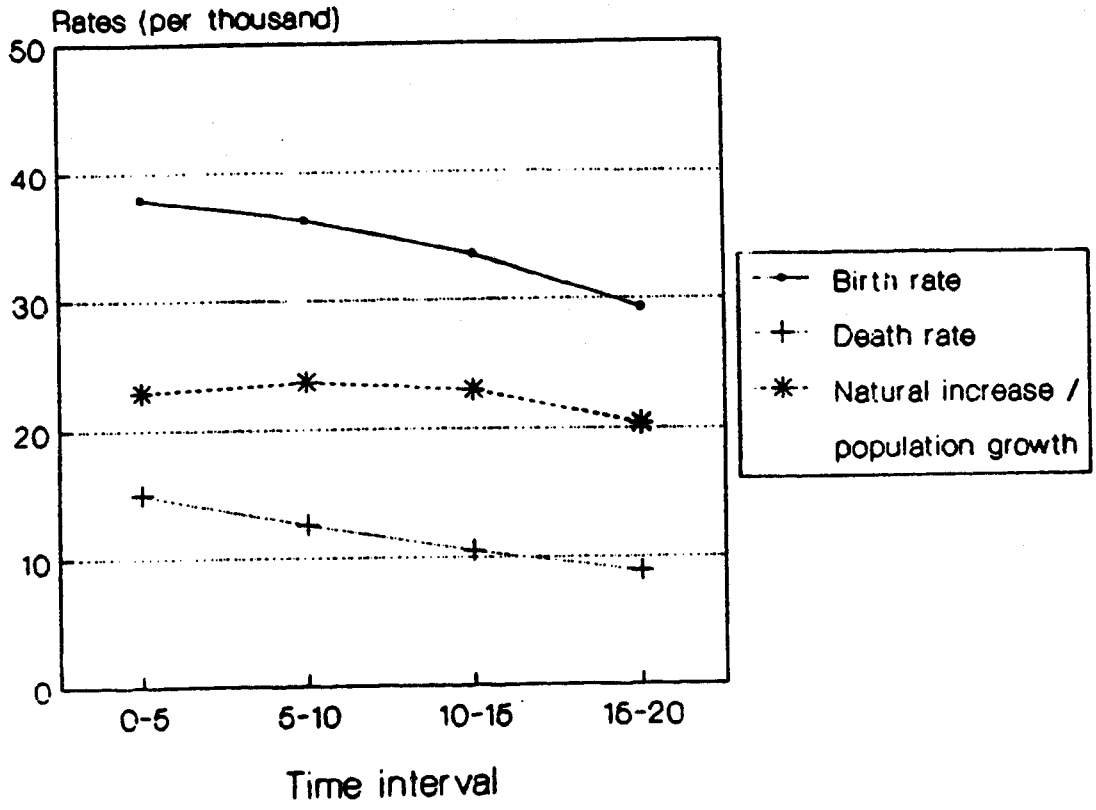


Table 10. International migration assumptions for making a projection of the national population

Year	Total net international migration rates	Proportionate age-specific net international migration rates															
		0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
								Male									
5	-0.1949	0.023	0.024	0.027	0.009	0.040	0.228	0.296	0.190	0.125	0.074	-0.005	-0.008	-0.008	-0.006	-0.005	-0.003
10	-0.2252	0.022	0.023	0.027	0.009	0.039	0.231	0.290	0.195	0.127	0.074	-0.004	-0.008	-0.008	-0.006	-0.005	-0.002
15	-0.2061	0.022	0.024	0.028	0.009	0.038	0.228	0.288	0.196	0.128	0.074	-0.004	-0.008	-0.008	-0.006	-0.005	-0.002
20	-0.1842	0.022	0.023	0.027	0.009	0.038	0.221	0.294	0.201	0.129	0.074	-0.003	-0.008	-0.009	-0.006	-0.006	-0.005
								Female									
5	-0.0712	0.050	0.050	0.041	0.028	0.177	0.220	0.208	0.158	0.114	0.057	-0.015	-0.024	-0.019	-0.016	-0.014	-0.013
10	-0.1049	0.050	0.050	0.042	0.028	0.177	0.219	0.210	0.160	0.110	0.056	-0.015	-0.024	-0.019	-0.016	-0.015	-0.015
15	-0.1149	0.049	0.049	0.041	0.027	0.168	0.215	0.214	0.166	0.112	0.056	-0.014	-0.023	-0.018	-0.016	-0.014	-0.014
20	-0.1155	0.046	0.046	0.038	0.024	0.152	0.208	0.222	0.176	0.118	0.059	-0.013	-0.021	-0.017	-0.014	-0.013	-0.013

Table 11. Deriving the segment of age and sex structure of the national population open to international migration at age 5 and over; end of projection interval 0-5

Sex	Age group	Survivors in year 5 a/ (thousands)	Net international migration rates b/	Net change due to international migration among survivors c/ (thousands)	Population in year 5 d/ (thousands)
(1)	(2)	(3)	(4)	(5)	(6)
Male	5-9	737.0	-0.0047	-3.44	733.6
	10-14	729.9	-0.0053	-3.83	726.1
	15-19	618.5	-0.0018	-1.08	617.4
	20-24	481.5	-0.0078	-3.75	477.7
	25-29	397.1	-0.0445	-17.68	379.4
	30-34	355.9	-0.0576	-20.49	335.4
	35-39	351.5	-0.0369	-12.99	338.5
	40-44	303.6	-0.0243	-7.38	296.2
	45-49	214.5	-0.0144	-3.09	211.4
	50-54	142.8	0.0010	0.14	143.0
	55-59	175.3	0.0016	0.27	175.6
	60-64	136.3	0.0016	0.21	136.6
	65-69	103.6	0.0012	0.12	103.7
	70-74	65.9	0.0010	0.06	66.0
	75+	45.6	0.0008	0.03	45.6
Female	5-9	704.7	-0.0036	-2.51	702.2
	10-14	685.2	-0.0029	-2.00	683.2
	15-19	574.9	-0.0020	-1.15	573.7
	20-24	442.5	-0.0126	-5.57	436.9
	25-29	354.5	-0.0157	-5.55	348.9
	30-34	342.4	-0.0147	-5.02	337.4
	35-39	345.1	-0.0112	-3.88	341.2
	40-44	293.5	-0.0081	-2.38	291.1
	45-49	200.2	-0.0041	-0.81	199.3
	50-54	151.2	0.0011	0.16	151.4
	55-59	162.2	0.0017	0.28	162.5
	60-64	145.9	0.0014	0.20	146.1
	65-69	105.1	0.0011	0.12	105.3
	70-74	80.0	0.0010	0.08	80.1
	75+	72.9	0.0009	0.07	73.0

a/ Calculations not illustrated.
b/ From table 12, col. 3.
c/ (Col. 3) . (Col. 4).
d/ (Col. 3) + (Col. 5).

b. Net international migration rates

In this example, the international migration assumptions are formulated using total net international migration rates and proportionate age specific net international migration rates. These measures need first to be used to derive age specific net international migration rates, the calculation of which is illustrated for males in table 12. Each rate (column 3) is obtained by multiplying a corresponding proportionate age specific rate (column 2) by the given total net international migration rate.

For example, the net international migration rate for males in the age group 0-4 at the end of the 0-5 projection interval, -0.0045, is obtained as:

$$-0.0045 = (-0.1949)\ (0.023), \qquad (32)$$

where -0.1949 is the total net international migration rate for males for year 5, shown in table 10, while 0.023 is the proportionate rate for males aged 0-4 for that date.

c. Population aged 5 and over

To modify the numbers of survivors aged 5 and over for international migration, it is necessary to apply these rates to the numbers of survivors and derive net changes due to international migration among those survivors. The numbers of survivors are then modified by the net changes. In this example, in table 11, net international migration rates (column 4) are applied to the numbers of survivors (column 3) to obtain net changes due to international migration among the survivors (column 5).

Hence, for age group 5-9, the number of male survivors, 737.0, is multiplied by the net international migration rate, -0.0047, to get the net change due to international migration, -3.44:

$$-3.44 = (737.0)\ (-0.0047). \qquad (33)$$

These net changes are further used to modify the numbers of survivors and the result is population aged 5 and over at the end of the interval (column 6). Thus, the number of males aged 5-9, 733.6, would equal the sum of the male survivors, 737.0, and the net change due to international migration among males, -3.44:

$$733.6 = 737.0 + (-3.44). \qquad (34)$$

This completes the projection of the structure of the population age 5 and over for the end of the interval 0-5.

(ii) Segment of the population structure below age 5

a. Fertility rates, births and survivors below age 5

In order to derive the population below age 5, age-specific fertility rates are first calculated from the fertility assumptions as in the case of

Table 12. Calculating age-specific net international migration rates; results for males; end of projection interval 0-5

Age group	Proportionate net international migration rates a/	Net international migration rates b/
(1)	(2)	(3)
0-4	0.023	-0.0045
5-9	0.024	-0.0047
10-14	0.027	-0.0053
15-19	0.009	-0.0018
20-24	0.040	-0.0078
25-29	0.229	-0.0445
30-34	0.296	-0.0576
35-39	0.190	-0.0369
40-44	0.125	-0.0243
45-49	0.074	-0.0144
50-54	-0.005	0.0010
55-59	-0.008	0.0016
60-64	-0.008	0.0016
65-69	-0.006	0.0012
70-74	-0.005	0.0010
75+	-0.003	0.0006

a/ From table 10.
b/ (Total net international migration rate) . (Col. 2).

the closed population. Then, the number of births is derived as in the preceding example, except that in this example the mid-interval numbers of women reflect the impact of international migration occurring during the interval. This number is further disaggregated by sex, using the assumed sex ratio at birth. The resultant numbers of births by sex differ somewhat from those obtained for the closed population owing to the difference in the numbers of women in the childbearing period.

To obtain the numbers of survivors age 0-4 by sex at the end of the interval (table 13, column 2), the survival ratios are applied to the numbers of births classified by sex. The numbers of survivors obtained in the current example are somewhat smaller than in the preceding example (see table 7, column 4) owing to the net emigration of women in the childbearing ages.

b. Population below age 5

To obtain the numbers of persons aged 0-4 by sex at the end of the interval in an open population, the numbers of survivors must be modified for international migration. This is done in the same way as for the numbers of survivors aged 5 and over, as illustrated in table 11. In particular, net international migration rates for the age group 0-4 by sex (table 13, column 3) are first applied to the numbers of survivors age 0-4 by sex (column 2) to calculate the net changes among those survivors due to international migration (column 4).

Thus, for males aged 0-4, the net change due to international migration, -3.83, equals the number of survivors, 857.0, times the net international migration rate, -0.0045:

$$-3.83 = (857.0)\ (-0.0045). \qquad (35)$$

These changes are then used to modify the numbers of survivors. Thus, males aged 0-4, 853.1, equals the number of survivors, 857.0, plus net change due to international migration, -3.83:

$$853.1 = 857.0 + (-3.83). \qquad (36)$$

This completes the derivation of the age and sex structure of an open national population at the end of the 0-5 projection interval. When the steps described above are applied to the following five-year time intervals, 5-10, 10-15,..., the result is age and sex structures at the end of those intervals. The age and sex structures obtained as part of this illustrative projection are displayed in table 14.

(iii) Other results

It is possible to compute a variety of other results in the course of a projection of an open national population. Those other results, which are shown in table 15, include all those types of results obtained as part of a projection of the closed national population (table 9), plus some additional

Table 13. Deriving the segment of age and sex structure of the national population open to international migration below age 5: end of projection interval 0-5

Sex	Survivors aged 0-4 in year 5 a/ (thousands)	Net international migration rates b/	Net changes due to international migration among survivors c/ (thousands)	Population aged 0-4 in year 5 d/ (thousands)
(1)	(2)	(3)	(4)	(5)
Male	857.0	-0.0045	-3.83	853.1
Female	823.9	-0.0036	-2.93	821.0

a/ Calculations not illustrated.
b/ From table 12, col. 3.
c/ (Col. 2) : (Col. 3).
d/ (Col. 2) + (Col. 4).

Table 14. Projected national population open to international migration, by age and sex

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	0-4	784.5	853.1	934.6	986.0	967.2
	5-9	740.0	733.6	809.4	897.0	954.9
	10-14	624.0	726.1	721.5	798.2	886.9
	15-19	486.6	617.4	719.6	716.3	793.4
	20-24	402.2	477.7	606.9	709.3	707.5
	25-29	361.5	379.4	448.4	573.9	676.0
	30-34	358.7	335.4	350.4	417.8	538.5
	35-39	312.4	338.5	315.6	331.8	398.0
	40-44	223.6	296.2	321.3	301.4	318.7
	45-49	152.1	211.4	281.3	307.3	290.1
	50-54	192.5	143.0	200.5	268.8	295.3
	55-59	157.0	175.6	131.9	186.7	252.4
	60-64	128.1	136.6	154.9	117.9	168.7
	65-69	90.1	103.7	112.7	130.1	100.4
	70-74	44.2	66.0	77.9	86.6	101.9
	75+	38.6	45.6	63.1	81.6	99.5
Female	0-4	750.7	821.0	894.3	938.7	917.0
	5-9	694.8	702.2	777.9	856.5	906.2
	10-14	580.5	683.2	691.9	768.1	847.3
	15-19	448.3	573.7	676.3	685.9	762.6
	20-24	359.8	436.9	557.6	658.3	669.9
	25-29	348.3	348.9	422.1	539.2	638.1
	30-34	352.2	337.4	336.8	407.6	521.1
	35-39	300.9	341.2	326.5	326.2	395.2
	40-44	206.7	291.1	330.6	317.1	317.4
	45-49	158.5	199.3	281.8	321.1	308.9
	50-54	174.6	151.4	191.8	272.7	312.1
	55-59	164.0	162.5	142.4	181.9	260.2
	60-64	126.1	146.1	146.9	130.3	167.9
	65-69	105.6	105.3	124.4	127.1	114.2
	70-74	63.5	80.1	81.9	99.0	103.0
	75+	69.4	73.0	86.6	97.9	116.8

Table 15. Population aggregates, indicators of the population structure and rates of population change of the national population open to international migration

Indicators	Year				
	0	5	10	15	20
Population aggregates (thousands)					
Population size	10000.0	11092.6	12319.7	13638.2	14907.2
Young-age	4174.5	4519.2	4829.6	5244.5	5479.5
Working-age	5414.1	6099.7	6943.6	7771.5	8792.0
Old-age	411.4	473.7	546.6	622.3	635.8
School-age	4336.2	4950.8	5561.1	6089.6	6528.7
Women of childbearing age	2174.7	2528.5	2931.7	3255.4	3613.2
Mid-interval population size		10532.1	11690.1	12962.2	14258.6
Number of person-years lived		52660.7	58450.3	64811.0	71292.9
Population growth		1092.6	1227.1	1318.5	1269.0
Births		1994.8	2116.0	2174.1	2089.6
Deaths		793.3	739.2	689.8	645.5
Net change due to international migrtion		-108.9	-149.7	-165.8	-175.1
Indicators of the population structure					
Proportions by broad age groups					
At young age (0-14)	0.42	0.41	0.39	0.38	0.37
At working age (15-64)	0.54	0.55	0.56	0.57	0.59
At old age (65+)	0.04	0.04	0.04	0.05	0.04
Dependency ratios					
Young-age	0.77	0.74	0.70	0.67	0.62
Old-age	0.08	0.08	0.08	0.08	0.07
Total	0.85	0.82	0.77	0.75	0.70
Median age of population	19.4	19.3	19.8	20.6	21.5
Proportion of women of childbearing age	0.22	0.23	0.24	0.24	0.24
Sex ratio of the population	104	103	103	103	103
Rates of population change (per thousand)					
Birth rate		37.9	36.2	33.5	29.3
Death rate		15.1	12.6	10.6	9.1
Natural increase		22.8	23.6	22.9	20.3
International migration		-2.1	-2.6	-2.6	-2.5
Population growth		20.7	21.0	20.3	17.8

ones. The discussion below will explain how the number of deaths and the net change due to international migration are calculated. The calculation of the crude net rate of international migration will also be illustrated.

a. Population aggregates

i. Change due to international migration

The change due to international migration is derived by reverse surviving net changes due to international migration by age and sex, followed by adding up the results. The reverse survival is carried out over a two-and-a-half-year period, up to the mid-point of the five year interval, using the survival ratios by age and sex.

Table 16 illustrates the way the change to the national population due to international migration is computed. Net changes due to international migration among the survivors by age and sex are shown in column 3. The survival ratios for the interval are shown in column 4. These are used to produce by reverse survival net changes due to migration among various age and sex groups (column 5). The total net change, -108.9, is calculated as the sum of the net changes for each age group (total in column 5).

The way individual net changes are calculated by reverse survival can be illustrated in relation to males as follows. For males aged 0-4, the net change due to international migration, -4.05, is:

$$-4.05 = (-3.83) \,/\, [\ 0.67 + (0.33)\ (0.83874)\ ], \qquad (37)$$

where -3.83 is the net change due to international migration among male survivors age 0-4 and 0.83874 is the survival ratio relating to males of that age at the end of the interval.

For males aged 5-9, the net change due to international migration, -3.55, is:

$$-3.55 = (-3.44) \,/\, [\ (1 + 0.93949) \,/\, 2\ ], \qquad (37)$$

where -3.44 is the relevant net change due to international migration among survivors and 0.93949 is the survival ratio, respectively. The results for age groups 10-14 and beyond are obtained in a way similar to that for the age group 5-9.

ii. Deaths

The number of deaths in an open population is calculated by taking into account the fact that the population loses or gains numbers through migration. The number of deaths for the period 0-5, 793.3, can be obtained as:

$$793.3 = 1{,}994.8 - 1{,}092.6 + (-108.9), \qquad (38)$$

Table 16. Computing net change due to international migration; projection interval 0-5

Sex	Age group	Net change to the survivors due to international migration a/ (thousands)	Survival ratios b/	Net change to the population due to international migration c/ (thousands)
(1)	(2)	(3)	(4)	(5)
Male	0-4	-3.83	0.83874	-4.05
	5-9	-3.44	0.93949	-3.55
	10-14	-3.83	0.98637	-3.86
	15-19	-1.08	0.99121	-1.09
	20-24	-3.75	0.98948	-3.76
	25-29	-17.68	0.98738	-17.80
	30-34	-20.49	0.98450	-20.65
	35-39	-12.99	0.97993	-13.12
	40-44	-7.38	0.97182	-7.49
	45-49	-3.09	0.95927	-3.15
	50-54	0.14	0.93912	0.14
	55-59	0.27	0.91054	0.29
	60-64	0.21	0.86845	0.23
	65-69	0.12	0.80879	0.13
	70-74	0.06	0.73177	0.07
	75+	0.03	0.55073	0.03
Female	0-4	-2.93	0.84666	-3.09
	5-9	-2.51	0.93874	-2.59
	10-14	-2.00	0.98621	-2.01
	15-19	-1.15	0.99031	-1.15
	20-24	-5.57	0.98701	-5.61
	25-29	-5.55	0.98521	-5.59
	30-34	-5.02	0.98311	-5.06
	35-39	-3.88	0.97981	-3.92
	40-44	-2.38	0.97541	-2.41
	45-49	-0.81	0.96831	-0.82
	50-54	0.16	0.95422	0.17
	55-59	0.28	0.92892	0.29
	60-64	0.20	0.88943	0.21
	65-69	0.12	0.83374	0.13
	70-74	0.08	0.75775	0.09
	75+	0.07	0.54846	0.09
	Total			-108.90

a/ From table 11, col. 5 and table 13, col. 4.
b/ Calculations not illustrated.
c/ (Col. 3)/(0.67 + (0.33) . (Col. 4)), when age group is 0-4, and (Col. 3)/((1 + (Col. 4))/2), when age group is 5-9 or over.

where 1,994.8 is the number of births, 1,092.6 is the population growth and and -108.9 is the net change due to international migration during the period.

b. Rates of population change

i. Crude net international migration rate

This rate is calculated from the net change due to international migration and the mid-interval population size. For the interval 0-5, the crude net international migration rate, -2.1, is obtained as:

$$-2.1 = [\ (\ -108.9/5\ )\ /\ \ 10{,}532.1\ ]\ \cdot\ 1{,}000, \qquad (39)$$

where -108.9 is the net change to the national population due to international migration, 5 is the length of the projection interval, and 10,532.1 is the mid-interval population size.

2. Urban and rural populations

This section will describe a projection of urban and rural populations closed to international migration. A companion projection of urban and rural populations open to international migration will not be illustrated since it would introduce few new principles. Furthermore, such a projection would only rarely be prepared, partly due to excessive data requirements relating to migration inputs.

(a) Closed populations

The example given to illustrate this type of projection will use the illustrative inputs shown in tables 17 through 19. It will draw on the two preceding illustrative projections as appropriate, but will not deal in detail with all the steps which are urban-rural counterparts of calculations described as part of those projections. The focus of this example will be on internal migration and how this component of population change is introduced into the projection process. For the sake of brevity, the example will present only calculations that refer to females. As in the previous examples, the illustrative calculations will be presented for the interval 0-5. Complete projection results will be, however, given for the entire 20-year period.

(i) Segments of population structures at age 5 and over

a. Survival ratios and survivors aged 5 and over

The first steps performed in the course of making a projection of urban and rural populations closed to international migration are similar to those made in order to project a closed national population. They include the derivation of survival ratios from mortality assumptions and the use of these

Table 17. Inputs for making a projection of urban and rural populations closed to international migration: inputs for urban areas

(a) Initial population by age and sex (thousands):

Age group	Male	Female
0-4	184.8	175.6
5-9	181.7	173.1
10-14	170.0	154.8
15-19	181.7	137.4
20-24	201.3	110.9
25-29	134.5	103.2
30-34	126.2	102.4
35-39	109.9	96.7
40-44	77.7	63.0
45-49	51.6	50.0
50-54	59.6	49.2
55-59	47.1	52.4
60-64	31.6	33.3
65-69	26.1	32.6
70-74	12.8	19.6
75+	11.2	21.4

(b) Mortality assumptions:

Time interval	Expectations of life at birth (years)	
	Male	Female
0-5	56.19	57.54
5-10	58.76	60.12
10-15	60.93	62.28
15-20	63.31	64.26

(c) Fertility assumptions:

Time interval	Total fertility rates	Proportionate age-specific fertility rates by age						
		15-19	20-24	25-29	30-34	35-39	40-44	45-49
0-5	4.00	0.096	0.251	0.245	0.186	0.149	0.063	0.010
5-10	3.80	0.100	0.255	0.248	0.184	0.143	0.061	0.009
10-15	3.50	0.104	0.258	0.252	0.182	0.137	0.059	0.008
15-20	3.10	0.107	0.262	0.257	0.179	0.130	0.057	0.008

Table 18 Inputs for making a projection of urban and rural populations closed to international migration: inputs for rural areas

(a) Initial population by age and sex (thousands):

Age group	Male	Female
0-4	599.7	575.1
5-9	558.3	521.7
10-14	454.0	425.7
15-19	304.9	310.9
20-24	200.9	248.9
25-29	227.0	245.1
30-34	232.5	249.8
35-39	202.5	204.2
40-44	145.9	143.7
45-49	100.5	108.5
50-54	132.9	125.4
55-59	109.9	111.6
60-64	96.5	92.8
65-69	64.0	73.0
70-74	31.4	43.9
75+	27.4	48.0

(b) Mortality assumptions:

Time interval	Expectations of life at birth (years)	
	Male	Female
0-5	49.78	51.32
5-10	53.87	55.48
10-15	57.84	59.25
15-20	61.08	62.20

(c) Fertility assumptions:

Time interval	Total fertility rates	Proportionate age-specific fertility rates by age						
		15-19	20-24	25-29	30-34	35-39	40-44	45-49
0-5	6.40	0.076	0.253	0.245	0.197	0.141	0.057	0.031
5-10	6.20	0.079	0.263	0.249	0.192	0.135	0.055	0.027
10-15	5.60	0.082	0.273	0.253	0.187	0.129	0.053	0.023
15-20	4.80	0.085	0.282	0.257	0.182	0.122	0.052	0.020

Table 19. Inputs for asking a projection of urban and rural populations closed to international migration: internal migration assumptions

Year	Total net internal migration rates	Proportionate age-specific net internal migration rates by age															
		0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
								Male									
5	-1.5604	0.020	0.028	0.108	0.158	0.140	0.094	0.085	0.072	0.056	0.046	0.039	0.035	0.038	0.031	0.029	0.021
10	-1.5013	0.020	0.028	0.108	0.158	0.140	0.094	0.085	0.072	0.056	0.046	0.039	0.035	0.038	0.031	0.029	0.021
15	-1.4492	0.020	0.028	0.108	0.158	0.140	0.094	0.085	0.072	0.056	0.046	0.039	0.035	0.038	0.031	0.029	0.021
20	-1.4412	0.020	0.028	0.108	0.158	0.140	0.094	0.085	0.072	0.056	0.046	0.039	0.035	0.038	0.031	0.029	0.021
								Female									
5	-1.2431	0.015	0.018	0.069	0.103	0.129	0.117	0.097	0.079	0.067	0.059	0.049	0.045	0.049	0.040	0.037	0.027
10	-1.3704	0.015	0.018	0.069	0.103	0.129	0.117	0.097	0.079	0.067	0.059	0.049	0.045	0.049	0.040	0.037	0.027
15	-1.2255	0.015	0.018	0.069	0.103	0.129	0.117	0.097	0.079	0.067	0.059	0.049	0.045	0.049	0.040	0.037	0.027
20	-1.2115	0.015	0.018	0.069	0.103	0.129	0.117	0.097	0.079	0.067	0.059	0.049	0.045	0.049	0.040	0.037	0.027

ratios to calculate the numbers of survivors aged 5 and over at the end of the interval. Each step is carried out for both urban and rural populations. When these steps are performed using the inputs of tables 17 through 19, the results obtained for females are those shown in table 20.

In particular, the table shows for both rural and urban areas the survival ratios applying to women (column 4) and the numbers of female survivors aged 5 and over (column 5). These results along with those obtained for males, but not shown in table 20, can be derived using the steps similar to those illustrated earlier with respect to the closed national population. The numbers of survivors need to be further modified using net internal migration rates.

b. Net internal migration rates

The derivation of net internal migration rates is in principle identical with that used to obtain net international migration rates. Net internal migration rates are calculated for each sex by multiplying the age specific proportionate net internal migration rates by age of each sex by the total net internal migration rate for that sex. Table 21 illustrates how age specific net internal migration rates for females are calculated for the projection interval 0-5.

In particular, the proportionate rates (column 2) are all multiplied by the given total net internal migration rate to obtain age-specific net internal migration rates (column 3). Thus, the rate for the age group 0-4, -0.019, is obtained as:

$$-0.019 = (-1.2431)\ (0.015), \qquad (42)$$

where -1.2431 is the total net internal migration rate, shown in table 19, and 0.015 is the proportionate migration rate for age group 0-4.

c. Population aged 5 and over

To derive population aged 5 and over in urban and rural areas, net changes among rural survivors aged 5 and over due to internal migration are first calculated. They are obtained by applying net internal migration rates to the numbers of rural survivors aged 5 and above. In particular, for rural female survivors, net changes at age 5 and over (table 22, column 5) are obtained as the products of the numbers of survivors (column 3) and appropriate net internal migration rates (column 4).

For example, the net change among rural female survivors aged 5-9, -11.81, is obtained as:

$$-11.81 = (536.2)\ (-0.022), \qquad (43)$$

Table 20. Deriving the numbers of survivors in urban and rural populations closed to international migration at age 5 and over; results for females; end of projection interval 0-5

Location	Age group	Population in year 0 a/ (thousands)	Survival ratios b/	Survivors in year 5 c/ (thousands)
(1)	(2)	(3)	(4)	(5)
Urban	0-4	175.6		
	5-9	173.1	0.95413	167.5
	10-14	154.8	0.99003	171.4
	15-19	137.4	0.99297	153.7
	20-24	110.9	0.99068	136.1
	25-29	103.2	0.98923	109.7
	30-34	102.4	0.98749	101.9
	35-39	96.7	0.98474	100.8
	40-44	63.0	0.98069	94.8
	45-49	50.0	0.97415	61.4
	50-54	49.2	0.96166	48.1
	55-59	52.4	0.93929	46.2
	60-64	33.3	0.90357	47.3
	65-69	32.6	0.85191	28.4
	70-74	19.6	0.77970	25.4
	75+	21.4	0.56701	23.2
Rural	0-4	575.1		
	5-9	521.7	0.93235	536.2
	10-14	425.7	0.98462	513.7
	15-19	310.9	0.98912	421.1
	20-24	248.9	0.98542	306.4
	25-29	245.1	0.98345	244.8
	30-34	249.8	0.98125	240.5
	35-39	204.2	0.97778	244.3
	40-44	143.7	0.97328	198.7
	45-49	108.5	0.96595	138.8
	50-54	125.4	0.95134	103.2
	55-59	111.6	0.92504	116.0
	60-64	92.8	0.88409	98.7
	65-69	73.0	0.82705	76.8
	70-74	43.9	0.74980	54.7
	75+	48.0	0.54193	49.8

a/ From tables 17 and 18.
b/ Derivation not illustrated.
c/ For age groups:
5-9 through 70-74:
(Entry in a preceding row of col. 3) . (Entry in the given row of col. 4).

75+:
(The sum of entries corresponding to age groups 70-74 and 75+ in col. 3) . (Entry corresponding to the latter of age groups in col. 4).

Table 21. Computing net internal migration rates; results for females; end of projection interval 0-5

Age group (1)	Proportionate net internal migration rates a/ (2)	Net internal migration rates b/ (3)
0-4	0.015	-0.019
5-9	0.018	-0.022
10-14	0.069	-0.086
15-19	0.103	-0.128
20-24	0.129	-0.160
25-29	0.117	-0.145
30-34	0.097	-0.120
35-39	0.079	-0.098
40-44	0.067	-0.083
45-49	0.059	-0.073
50-54	0.049	-0.061
55-59	0.045	-0.056
60-64	0.049	-0.061
65-69	0.040	-0.050
70-74	0.037	-0.046
75+	0.027	-0.034

a/ From table 19.
b/ (Total net internal migration rate) . (Col. 2).

Table 22. Deriving age and sex structures of urban and rural populations closed to international migration at age 5 and over; results for females; end of projection interval 0-5

Location	Age group	Survivors in year 5 a/ (thousands)	Net internal migration rates b/	Net change due to internal migration among survivors c/ (thousands)	Population in year 5 d/ (thousands)
(1)	(2)	(3)	(4)	(5)	(6)
Urban	5-9	167.5		11.81	179.4
	10-14	171.4		44.21	215.6
	15-19	153.7		53.94	207.7
	20-24	136.1		49.06	185.2
	25-29	109.7		35.52	145.2
	30-34	101.9		28.88	130.8
	35-39	100.8		23.96	124.8
	40-44	94.8		16.51	111.3
	45-49	61.4		10.14	71.5
	50-54	48.1		6.30	54.4
	55-59	46.2		6.50	52.7
	60-64	47.3		6.02	53.4
	65-69	28.4		3.84	32.2
	70-74	25.4		2.52	27.9
	75+	23.2		1.69	24.9
Rural	5-9	536.2	-0.022	-11.81	524.4
	10-14	513.7	-0.086	-44.21	469.5
	15-19	421.1	-0.128	-53.94	367.1
	20-24	306.4	-0.160	-49.06	257.3
	25-29	244.8	-0.145	-35.52	209.3
	30-34	240.5	-0.120	-28.88	211.6
	35-39	244.3	-0.098	-23.96	220.3
	40-44	198.7	-0.083	-16.51	182.2
	45-49	138.8	-0.073	-10.14	128.7
	50-54	103.2	-0.061	-6.30	96.9
	55-59	116.0	-0.056	-6.50	109.5
	60-64	98.7	-0.061	-6.02	92.6
	65-69	76.8	-0.050	-3.84	72.9
	70-74	54.7	-0.046	-2.52	52.2
	75+	49.8	-0.034	-1.69	48.1

a/ Table 20, col. 5.
b/ Table 21, col. 3.
c/ For rural: (Col. 3) . (Col. 4); for urban: (-1) . (Col. 5 under 'rural').
d/ (Col. 3) + (Col. 5).

where 536.2 is the number of female survivors aged 5-9 and -0.022 is the net internal migration rate applying to these survivors.

Further, net changes due to internal migration among urban survivors are obtained as those among rural survivors. However, they will have the opposite sign since any loss (gain) to rural survivors resulting from internal migration equals the gain (loss) to urban survivors. Therefore, net changes among urban female survivors (table 22, column 5) equal those among rural female survivors, with an opposite sign.

For example, net change among urban female survivors aged 5-9, 11.81, equals that among rural female survivors of the same age, -11.81, with an opposite sign:

$$11.81 = - (11.81). \qquad (44)$$

The net changes due to internal migration are next added to the survivors aged 5 and over in each population. Thus, the rural female population aged 5-9, 524.4, is obtained as the sum of the number of survivors, 536.2, and the net change due to internal migration, -11.81:

$$524.4 = 536.2 + (-11.81). \qquad (45)$$

The result is the age and sex structures of the two populations at age 5 and over at the end of the five-year projection interval. The age structures of females in urban and rural populations obtained through this process for the end of the interval 0-5 are shown in column 6 of table 22.

(ii) Segments of population structures below age 5

a. Fertility rates, births and survivors below age 5

To obtain the segments of the population structures below age 5 in urban and rural areas it is necessary to calculate fertility rates, the numbers of births by sex and the numbers of survivors aged 0-4 by sex. The calculations for each location are performed as in the projection of the national population. The numbers of female survivors aged 0-4 for urban and rural areas obtained by those steps are shown in table 23, column 2.

b. Population below age 5

These numbers of survivors are further used to compute net changes due to internal migration. The net changes are in turn employed to modify the numbers of survivors and thus take into account the impact of this type of migration. In table 23, the results of these calculations are illustrated for urban and rural females.

Table 23. Deriving age and sex structures of urban and rural populations closed to international migration below age 5; results for females: end of projection interval 0-5

Location	Survivors aged 0-4 in year 5 a/ (thousands)	Net internal migration rates b/	Net change due to internal migration c/ (thousands)	Population aged 0-4 in year 5 d/ (thousands)
(1)	(2)	(3)	(4)	(5)
Urban	214.7		11.58	226.3
Rural	609.0	-0.019	-11.58	597.4

a/ Calculations not illustrated.
b/ From table 21, col. 3.
c/ For rural: (Col. 2) . (Col. 3); for urban: (-1) . (Col. 4 under 'rural').
d/ (Col.2) + (Col. 4).

The net change in the number of rural female survivors aged 0-4 due to internal migration, -11.58 (column 4), is equal to the number of rural female survivors of that age, 609.0 (column 2), multiplied by the net internal migration rate, -0.019 (column 3):

$$-11.58 = (609.0)\ (-0.019). \tag{46}$$

The net change in the number of urban female survivors aged 0-4 due to internal migration would, therefore, equal 11.58 (column 4):

$$11.58 = -\ (-11.58). \tag{47}$$

The numbers of females aged 0-4 in urban and rural areas are then obtained by adding the net changes to the numbers of survivors. Thus, the number of rural females aged 0-4, 597.4 (column 5), is found as follows:

$$597.4 = 609.0 + (-11.58), \tag{48}$$

where 609.0 is the number of survivors and -11.58 is the net change due to internal migration.

The calculations illustrated above yield the age and sex structures of the urban and rural populations at the end of the interval 0-5. When repeated over subsequent time intervals, they project the population structures for each area in years 10, 15 and beyond. A projection of age and sex structures of urban and rural populations for a 20-year time interval is presented in tables 24 and 25. Table 26 shows age and sex structures of the national population, which are obtained by aggregating urban and rural structures.

(iii) Other results

A variety of results in addition to the population structures can be derived as part of a projection of urban and rural populations. Most of these results are of the same type as those obtained in the course of projecting a national population and can be obtained as illustrated in the two preceding examples. Those results are shown in tables 27 through 29, for the urban, rural and the national population.

a. Population aggregates

Most population aggregates can be found using the same steps as in the case of the national population closed to international migration. The calculation of an additional aggregate obtained in this type of projection will be shown here - net changes to urban and rural populations due to internal migration. The way the numbers of deaths are calculated in these populations will also be illustrated.

Table 24. Projected urban population closed to international migration, by age and sex

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	0-4	184.8	244.1	332.7	413.3	458.2
	5-9	181.7	201.1	259.5	346.9	426.7
	10-14	170.0	272.6	285.2	343.5	432.8
	15-19	181.7	279.7	378.8	384.6	447.3
	20-24	201.3	246.1	348.4	446.3	450.7
	25-29	134.5	228.4	277.0	381.7	480.5
	30-34	126.2	162.5	247.3	298.9	406.5
	35-39	109.9	149.9	180.9	259.4	313.8
	40-44	77.7	124.7	163.5	191.3	265.8
	45-49	51.6	85.1	132.9	170.9	196.7
	50-54	59.6	54.7	88.3	136.1	173.3
	55-59	47.1	61.6	55.0	87.9	134.8
	60-64	31.6	47.2	60.5	53.1	84.7
	65-69	26.1	29.8	42.8	54.7	47.9
	70-74	12.8	21.7	25.2	35.5	45.6
	75+	11.2	14.7	22.3	29.4	40 5
Female	0-4	175.6	226.3	311.4	387.0	428.6
	5-9	173.1	179.4	232.0	314.2	389.2
	10-14	154.8	215.6	226.8	276.4	359.1
	15-19	137.4	207.7	280.3	284.6	337.4
	20-24	110.9	185.2	270.3	341.3	346.4
	25-29	103.2	145.2	224.4	310.7	386.0
	30-34	102.4	130.8	171.1	247.6	338.0
	35-39	96.7	124.8	151.7	186.3	262.8
	40-44	63.0	111.3	142.4	164.4	196.7
	45-49	50.0	71.5	123.2	153.3	173.2
	50-54	49.2	54.4	77.4	128.8	159.3
	55-59	52.4	52.7	56.9	79.5	130.6
	60-64	33.3	53.4	54.7	56.9	79.1
	65-69	32.6	32.2	50.3	51.5	53.2
	70-74	19.6	27.9	28.4	43.1	44.7
	75+	21.4	24.9	32.7	37.9	50.7

Table 25. Projected rural population closed to international migration, by age and sex

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	0-4	599.7	611.6	617.8	608.3	553.0
	5-9	558.3	534.6	555.2	569.0	566.4
	10-14	454.0	457.1	442.4	464.4	477.1
	15-19	304.9	338.8	345.8	339.1	357.0
	20-24	200.9	235.5	265.0	273.6	269.1
	25-29	227.0	169.1	200.0	226.9	234.8
	30-34	232.5	193.5	145.5	173.5	197.3
	35-39	202.5	201.7	169.5	128.5	153.7
	40-44	145.9	179.1	180.1	152.6	116.1
	45-49	100.5	129.5	160.5	162.8	138.8
	50-54	132.9	88.3	115.1	144.1	147.4
	55-59	109.9	113.8	76.7	101.2	127.8
	60-64	96.5	89.2	93.9	64.3	85.9
	65-69	64.0	73.7	69.6	74.7	52.0
	70-74	31.4	44.2	52.3	50.7	55.6
	75+	27.4	31.0	40.7	51.7	58.3
Female	0-4	575.1	597.4	599.5	587.6	531.8
	5-9	521.7	524.4	551.8	562.5	556.4
	10-14	425.7	469.5	469.4	500.9	512.0
	15-19	310.9	367.1	399.7	407.6	436.5
	20-24	248.9	257.3	299.0	333.7	341.7
	25-29	245.1	209.3	213.3	253.7	284.4
	30-34	249.8	211.6	178.9	185.8	222.0
	35-39	204.2	220.3	185.4	159.3	166.2
	40-44	143.7	182.2	195.8	167.2	144.3
	45-49	108.5	128.7	162.6	177.4	152.0
	50-54	125.4	96.9	115.0	147.4	161.6
	55-59	111.6	109.5	85.0	102.5	132.3
	60-64	92.8	92.6	91.6	72.6	88.5
	65-69	73.0	72.9	73.8	74.8	60.2
	70-74	43.9	52.2	53.3	55.6	57.5
	75+	48.0	48.1	53.9	59.6	65.5

Table 26. Projected national population closed to international migration, by age and sex, obtained in the course of projecting urban and rural populations

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	0-4	784.5	855.7	950.5	1021.6	1011.2
	5-9	740.0	735.7	814.7	915.9	993.1
	10-14	624.0	729.6	727.7	807.9	910.0
	15-19	486.6	618.5	724.6	723.6	804.3
	20-24	402.2	481.6	613.4	719.9	719.8
	25-29	361.5	397.5	477.0	608.6	715.3
	30-34	358.7	356.0	392.8	472.4	603.8
	35-39	312.4	351.6	350.4	387.9	467.5
	40-44	223.6	303.7	343.6	343.8	381.9
	45-49	152.1	214.6	293.4	333.8	335.5
	50-54	192.5	142.9	203.4	280.2	320.6
	55-59	157.0	175.3	131.7	189.1	262.7
	60-64	128.1	136.4	154.4	117.5	170.6
	65-69	90.1	103.5	112.4	129.4	99.9
	70-74	44.2	66.0	77.5	86.2	101.2
	75+	38.6	45.6	63.0	81.1	98.7
Female	0-4	750.7	823.7	910.9	974.6	960.4
	5-9	694.8	703.7	783.7	876.7	945.6
	10-14	580.5	685.1	696.2	777.3	871.1
	15-19	448.3	574.8	680.0	692.2	773.8
	20-24	359.8	442.5	569.2	675.0	688.2
	25-29	348.3	354.5	437.7	564.4	670.4
	30-34	352.2	342.4	350.0	433.4	559.9
	35-39	300.9	345.1	337.1	345.7	429.0
	40-44	206.7	293.6	338.2	331.6	341.0
	45-49	158.5	200.2	285.9	330.7	325.3
	50-54	174.6	151.3	192.4	276.3	321.0
	55-59	164.0	162.2	142.0	181.9	262.9
	60-64	126.1	146.0	146.3	129.6	167.6
	65-69	105.6	105.1	124.2	126.3	113.4
	70-74	63.5	80.2	81.6	98.7	102.1
	75+	69.4	73.1	86.6	97.5	116.1

Table 27. Population aggregates, indicators of the population structure and rates of population change for the urban population closed to international migration

Indicators	Year				
	0	5	10	15	20
Population aggregates (thousands)					
Population size	2983.4	4067.0	5334.3	6697.3	8140.9
Young-age	1040.0	1339.1	1647.6	2081.3	2494.6
Working-age	1819.7	2576.9	3485.0	4363.6	5363.6
Old-age	123.7	151.2	201.7	252.1	282.6
School-age	1310.9	1787.4	2281.3	2737.8	3189.6
Women of childbearing age	663.6	976.5	1363.4	1688.2	2040.5
Mid-interval population size	3483.3	4657.7	5977.1	7383.9	
Number of person-years lived	17416.6	23288.7	29885.4	36919.5	
Population growth	1083.6	1267.3	1363.0	1443.6	
Births	503.8	690.3	857.1	943.5	
Deaths	194.6	228.7	259.9	281.9	
Net change due to internal migration	774.4	805.7	765.8	782.0	
Indicators of the population structure					
Proportions by broad age groups					
At young age (0-14)	0.35	0.33	0.31	0.31	0.31
At working age (15-64)	0.61	0.63	0.65	0.65	0.66
At old age (65+)	0.04	0.04	0.04	0.04	0.03
Dependency ratios					
Young-age	0.57	0.52	0.47	0.48	0.47
Old-age	0.07	0.06	0.06	0.06	0.05
Total	0.64	0.58	0.53	0.53	0.52
Median age of population	22.1	22.4	22.9	23.8	25.0
Proportion of women of childbearing age	0.22	0.24	0.26	0.25	0.25
Sex ratio of the population	117	121	119	119	118
Rates of population change (per thousand)					
Birth rate	28.9	29.6	28.7	25.6	
Death rate	11.2	9.8	8.7	7.6	
Natural increase	17.8	19.8	20.0	17.9	
Internal migration	44.5	34.6	25.6	21.2	
Population growth	62.0	54.3	45.5	39.0	

Table 28. Population aggregates, indicators of the population structure and rates of population change for the rural population closed to international migration

Indicators	Year				
	0	5	10	15	20
Population aggregates (thousands)					
Population size	7016.6	7130.6	7258.0	7433.5	7503.1
Young-age	3134.5	3194.6	3236.1	3292.7	3196.7
Working-age	3594.4	3614.0	3678.4	3773.8	3957.4
Old-age	287.7	322.1	343.6	367.1	349.1
School-age	3025.3	3184.3	3328.3	3450.8	3516.2
Women of childbearing age	1511.1	1576.5	1634.7	1684.7	1747.1
Mid-interval population size	7073.4	7194.0	7345.2	7468.2	
Number of person-years lived	35366.9	35970.1	36726.1	37341.1	
Population growth	114.0	127.4	175.5	69.6	
Births	1493.0	1455.4	1388.4	1234.1	
Deaths	604.6	522.3	447.1	382.5	
Net change due to internal migration	-774.4	-805.7	-765.8	-782.0	
Indicators of the population structure					
Proportions by broad age groups					
At young age (0-14)	0.45	0.45	0.45	0.44	0.43
At working age (15-64)	0.51	0.51	0.51	0.51	0.53
At old age (65+)	0.04	0.05	0.05	0.05	0.05
Dependency ratios					
Young-age	0.87	0.88	0.88	0.87	0.81
Old-age	0.08	0.09	0.09	0.10	0.09
Total	0.95	0.97	0.97	0.97	0.90
Median age of population	18.0	17.6	17.6	17.8	18.5
Proportion of women of childbearing age	0.22	0.22	0.23	0.23	0.23
Sex ratio of the population	99	96	95	93	92
Rates of population change (per thousand)					
Birth rate	42.2	40.5	37.8	33.0	
Death rate	17.1	14.5	12.2	10.2	
Natural increase	25.1	25.9	25.6	22.8	
Internal migration	-21.9	-22.4	-20.9	-20.9	
Population growth	3.2	3.5	4.8	1.9	

Table 29. Population aggregates, indicators of the population structure and distribution, and rates of population change for the national population closed to international migration, obtained in the course of projecting urban and rural populations

Indicators	Year 0	5	10	15	20
Population aggregates (thousands)					
Population size	10000.0	11197.5	12592.3	14130.8	15644.0
Young-age	4174.5	4533.5	4883.7	5374.0	5691.4
Working-age	5414.1	6190.7	7163.5	8137.6	9321.1
Old-age	411.4	473.5	545.3	619.2	631.4
School-age	4336.2	4971.5	5609.5	6188.5	6705.9
Women of childbearing age	2174.7	2553.1	2998.1	3373.0	3787.6
Mid-interval population size		10581.8	11874.4	13339.4	14868.2
Number of person-years lived		52909.1	59372.2	66696.9	74340.8
Population growth		1197.5	1394.8	1538.5	1513.2
Births		1996.7	2145.7	2245.5	2177.6
Deaths		799.2	750.9	707.0	664.4
Indicators of the population structure					
Proportions by broad age groups					
At young age (0-14)	0.42	0.40	0.39	0.38	0.36
At working age (15-64)	0.54	0.55	0.57	0.58	0.60
At old age (65+)	0.04	0.04	0.04	0.04	0.04
Dependency ratios					
Young-age	0.77	0.73	0.68	0.66	0.61
Old-age	0.08	0.08	0.08	0.08	0.07
Total	0.85	0.81	0.76	0.74	0.68
Median age of population	19.4	19.5	20.0	21.0	22.0
Proportion of women of childbearing age	0.22	0.23	0.24	0.24	0.24
Sex ratio of the population	104	104	104	104	105
Indicators of the population distribution					
Proportions of the national population					
Urban	0.30	0.36	0.42	0.47	0.52
Rural	0.70	0.64	0.58	0.53	0.48
Rates of population change (per thousand)					
Birth rate		37.7	36.1	33.7	29.3
Death rate		15.1	12.6	10.6	8.9
Natural increase		22.6	23.5	23.1	20.4
Population growth		22.6	23.5	23.1	20.3

i. Change due to internal migration

The net change to the rural population is computed by reverse surviving net changes to rural survivors over a two-and-a-half-year interval and by aggregating the results. Table 30 illustrates how net changes to female rural survivors are calculated by reverse survival.

Thus, the net change to the rural female population aged 0-4 due to internal migration, -12.24 (column 4), is obtained as:

$$-12.24 = (-11.58) / [\ 0.67 + (0.33)\ (0.83618)\ ], \quad (49)$$

where -11.58 (column 2) is the net change due to internal migration among survivors and 0.83618 (column 3) is the survival ratio.

The net change to the rural female population aged 5-9 due to internal migration, -12.22, is obtained as:

$$-12.22 = (-11.81) / [\ (1 + 0.93235) / 2\ ], \quad (49)$$

where -11.81 and 0.93235 are, respectively, net change among the survivors and the survival ratio. Net changes due to internal migration relating to other age groups are computed in a way identical to that for the age group 5-9.

The net change to female rural population due to internal migration is -317.8 (total in column 4). A similarly calculated net change to male rural population amounts to -456.6. As a result, the net change to the rural population equals -774.4. The net change to the urban population is, therefore, 774.4:

$$774.4 = -(-774.4). \quad (50)$$

ii. Deaths

The number of deaths in the urban population for the interval 0-5, 194.6, is obtained as:

$$194.6 = 503.8 - 1{,}083.6 + 774.4, \quad (51)$$

where 503.8 is the number of births, 1,083.6 is the population growth, and 774.4 is the net change due to internal migration in the urban population during that interval.

The number of deaths in the rural population, 604.5, is obtained in the same way:

$$604.5 = 1{,}493.0 - 114.0 - (-774.4), \quad (51)$$

where 1,493.0, 114.0 and -774.4 are the number of births, the population growth and the net change due to internal migration in the rural population.

Table 30. Computing net change due to internal migration: results for rural females; projection interval 0-5

Age group	Net changes to the survivors due to internal migration a/ (thousands)	Survival ratios b/	Net change to the population due to internal migration c/ (thousands)
(1)	(2)	(3)	(4)
0-4	-11.58	0.83618	-12.24
5-9	-11.81	0.93235	-12.22
10-14	-44.21	0.98462	-44.56
15-19	-53.94	0.98912	-54.24
20-24	-49.06	0.98542	-49.42
25-29	-35.52	0.98345	-35.82
30-34	-28.88	0.98125	-29.16
35-39	-23.96	0.97778	-24.23
40-44	-16.51	0.97328	-16.73
45-49	-10.14	0.96595	-10.32
50-54	-6.30	0.95134	-6.46
55-59	-6.50	0.92504	-6.75
60-64	-6.02	0.88409	-6.39
65-69	-3.84	0.82705	-4.20
70-74	-2.52	0.74980	-2.88
75+	-1.69	0.54193	-2.20
Total			-317.82

a/ From table 22, col. 5 and table 23, col. 4.
b/ From table 20, col. 4, for all age groups except the first.
c/ (Col. 2)/(0.67 + (0.33) . (Col.3)), when age group is 0-4, and (Col.2)/((1 + (Col. 3))/2), when age group is 5-9 or over.

b. Indicator of the population distribution

i. Proportions urban and rural

The proportion urban of the national population is calculated by dividing the urban population size by the total population size. This proportion is obtained as:

$$0.36 = 4{,}067.0 \;/\; 11{,}197.5, \tag{52}$$

where 4,067.0 and 11,197.5 are, respectively, the urban and total population sizes at the end of the interval 0-5.

The proportion rural equals the complement of the proportion urban:

$$0.64 = 1 - 0.36. \tag{53}$$

c. Rates of population change

i. Crude net internal migration rates

The crude net internal migration rate for the urban population is calculated as follows:

$$44.5 = [\; (774.4 \;/\; 5) \;/\; 3{,}483.3 \;] \cdot 1{,}000, \tag{54}$$

and the crude net internal migration rate for the rural population is calculated as:

$$-21.9 = [\; (-774.4 \;/\; 5) \;/\; 7{,}073.4 \;] \cdot 1{,}000. \tag{54}$$

In these calculations, 774.4 and -774.4 are net changes to urban and rural populations due to internal migration during the interval 0-5, and 5 is the length of the interval; 3,483.3 and 7,073.4 are mid-interval urban and rural population sizes, respectively.

E. Summary

This chapter has described the cohort component method for making population projections. Such projections are a basic pre-requisite for integrating population considerations into comprehensive planning. The method can be used to make a projection of a national population or of urban and rural populations. These populations could be either closed or open to international migration. The method can be employed to make a projection over one or several consecutive five-year projection intervals and thus generate projection results for dates five years apart and the intervening projection intervals. A list of projection results that can be obtained by the method as described in this chapter is presented in box 26.

Box 26

Outputs of the cohort component method

1. Age and sex structure of the population (national or urban, rural and national)

2. Population aggregates (national or urban, rural and national):

Population size:

- Young-age population
- Working-age population
- Old-age population

- School-age population
- Women of childbearing ages

Mid-interval population size
Number of person-years-lived

Population growth
Births
Deaths
Net change due to international migration (if population open to international migration)
Net change due to internal migration (if urban and rural populations are being projected; urban and rural only)
Net change due to combined international and internal migration (if urban and rural populations open to international migration are being projected; urban and rural only)

3. Indicators of the population structure (national or urban, rural and national)

Proportions by broad age groups:

- Proportion at young age (0-14)
- Proportion at working age (15-64)
- Proportion at old age (65 +)

(continued)

Box 26 (continued)

Dependency ratios:

- Young-age dependency ratio
- Old-age dependency ratio
- Total dependency ratio

- Median age of the population
- Proportion of women in childbearing ages
- Sex ratio of the population

4. Indicators of the population distribution (national; if urban and rural populations are being projected)

   - Proportion urban
   - Proportion rural

5. Rates of population change (national or urban, rural and national, except where stated otherwise)

   - Crude birth rate
   - Crude death rate
   - Rate of natural increase
   - Crude net international migration rate (if population open to international migration)
   - Crude net internal migration rate (urban and rural only; if urban and rural populations are being projected)
   - Crude net combined international and internal migration rate (urban and rural only; if urban and rural populations open to international migrations are being projected)
   - Rate of population growth

Procedures used to make national or urban-rural projections, closed or open to international migration have been presented. Also, the types of inputs used with the method have been discussed along with issues relating to the preparation of the inputs. Lastly, these projection examples have been introduced and described with a view to illustrating the use of the method to project population. The examples were those of making projections of the national population closed and open to international migration, and of a projection of urban and rural populations closed to international migration.

F. Notation and equations

1. Indices, variables and special symbols

(a) List of indices

a = 1,...,16	are five-year age groups 0-4,...,75+
k = 1,2	are urban and rural locations
s = 1,2	are male and female sexes
t	is the year of the projection period

(b) List of variables

BIRTHS	is the number of births occurring during the interval
BIRTHS(s)	is the number of births of sex s occurring during the interval
BIRTHS(k)	is the number of births occurring in location k during the interval
CBR	is the crude birth rate for the interval
CCMR(k)	is the crude net combined migration rate of the population of location k for the interval
CDR	is the crude death rate for the interval
CEMR	is the crude net international (external) migration rate for the interval
CEMR(k)	is the crude net international (external) migration rate of the population of location k for the interval
CIMR(k)	is the crude net internal migration rate of the population of location k for the interval
DEATHS	is the number of deaths occurring during the interval
DEATHS(k)	is the number of deaths occurring in location k during the interval
EB(s)	is the expectation of life at birth of sex s specified for the interval

EM(a,s,k,t+5)	is the net change due to international (external) migration among survivors of age group a and sex s in location k at the end of the interval
EM(a,s,t+5)	is the net change due to international (external) migration among survivors of age group a and sex s at the end of the interval
EMR(a,s,k,t+5)	is the net international (external) migration rate applying to survivors of age group a and sex s in location k at the end of the interval
EMR(a,s,t+5)	is the net international (external) migration rate applying to survivors of age group a and sex s at the end of the interval
FR(a)	is the average annual fertility rate of age group a for the interval
GRP	is the average annual growth rate of the population for the interval
IM(a,s,k,t+5)	is the net change due to internal migration among survivors of age group a and sex s in location k at the end of the interval
IMR(a,s,t+5)	is the net internal migration rate applying to rural survivors of age group a and sex s at the end of the interval
MAPOP(t+5)	is the median age of the population at the end of the interval
MIPOP	is the mid-interval population size
MIPOP(a,2)	is the mid-interval number of women of age group a
MIPOP(k)	is the mid-interval size of the population of location k
NCDEM	is the net change in the population due to international (external) migration during the interval
NCDEM(k)	is the net change in the population of location k due to international (external) migration during the interval
NCDIM(k)	is the net change to the population of location k due to internal migration occurring during the interval

NPYL	is the total number of person-years-lived by the population during the interval
OADR(t+5)	is the old-age dependency ratio at the end of the interval
OAP(t+5)	is the old-age population at the end of the interval
PBS(s)	is the proportion of births of sex s
PEMR(a,s,k,t+5)	is the proportionate net international (external) migration rate applying to survivors of age group a and sex s in location k at the end of the interval
PEMR(a,s,t+5)	is the proportionate net international (external) migration rate applying to survivors of age group a and sex s at the end of the interval
PFR(a)	is the proportionate fertility rate of age group a pertaining to the interval
PIMR(a,s,t+5)	is the proportionate net internal migration rate applying to rural survivors of age group a and sex s at the end of the interval
POA(t+5)	is the proportion of the population at old age (age group 65+) at the end of the interval
POP(a,s,k,t+5)	is the population (survivors) of age group a and sex s in location k at the end of interval
POP(a,s,t+5)	is the population (survivors) of age group a and sex s at the end of the interval
POP(a-1,s,k,t)	is the population of age group (a-1) and sex s in location k at the beginning of the interval
POP(a-1,s,t)	is the population of age group (a-1) and sex s at the beginning of the interval
POP(k,t+5)	is the size of the population of location k at the end of the interval
POP(t+5)	is the size of the population at the end of the interval
POPGR	is the population growth over the interval
POPGR(k)	is the population growth in location k over the interval

PRUR(t+5)	is the proportion of the national population rural at the end of the interval
PURB(t+5)	is the proportion of the national population urban at the end of the interval
PWA(t+5)	is the proportion of the population at working age (age group 15-64) at the end of the interval
PWCA(t+5)	is the proportion of women in the childbearing ages at the end of the interval.
PYA(t+5)	is the proportion of the population at young age (age group 0-14) at the end of the interval
RNT	is the rate of natural increase for the interval
SAP(t+5)	is the school-age population at the end of the interval
SR(a,s)	is the survival ratio representing the probability of survival over the interval among persons who belong to age group a and sex s at the end of the interval
SR(a,s,k)	is the survival ratio representing the probability of survival over the interval among persons who belong to age group a and sex s in location k at the end of the interval
SRB	is the sex ratio at birth
SRF(a,s)	is the survival ratio factor used to reverse survive the net change due to international migration among survivors of age group a and sex s at the end of the interval
SRF(a,2,s)	is the survival ratio factor used to reverse survive the net change due to internal migration among the rural survivors of age group a and sex s at the end of the interval
SRP(t+5)	is the sex ratio of the population at the end of the interval
TDR(t+5)	is the total dependency ratio at the end of the interval
TEMR(s,k,t+5)	is the total net international (external) migration rate applying to survivors of sex s in location k at the end of the interval

TEMR(s,t+5)	is the total net international (external) migration rate applying to survivors of sex s at the end of the interval
TFR	is the total fertility rate specified for the interval
TIMR(s,t+5)	is the total net internal migration rate applying to rural survivors of sex s at the end of the interval
WAP(t+5)	is the working-age population at the end of the interval
WCA(t+5)	is the number of women in the childbearing ages at the end of the interval
YADR(t+5)	is the young-age dependency ratio at the end of the interval
YAP(t+5)	is the young-age population at the end of the interval

(c) List of special symbols

ln	is the natural logarithm
T	is the transformation of expectations of life at birth by sex into survival ratios using selected life tables
a'	is the five-year age group containing the member of the population who is older than one half of the population and younger than the other half

2. Equations

National population

(a) Closed population

(i) Segment of the population structure at age 5 and over

a. Survival ratios

$$SR(a,s) = T\,[EB(s)]; \qquad (1)$$

$$a = 1,\ldots,16;$$

$$s = 1,2$$

b. Population aged 5 and over

$$POP(a,s,t+5) = POP(a-1,s,t) \cdot SR(a,s); \quad (2)$$

$$a = 2,\ldots,15;$$

$$s = 1,2$$

$$POP(16,s,t+5) = \left[\sum_{a=15}^{16} POP(a,s,t) \right] \cdot SR(16,s); \quad (3)$$

$$s = 1,2$$

(ii) Segment of the population structure below age 5

a. Fertility rates

$$FR(a) = (TFR/5) \cdot PFR(a); \quad (4)$$

$$a = 4,\ldots,10$$

b. Births

$$MIPOP(a,2) = [\ (POP(a,2,t) \cdot (POP(a,2,t+5)\ ]^{1/2}; \quad (5)$$

$$a = 4,\ldots,10$$

$$BIRTHS = 5 \cdot \left[\sum_{a=4}^{10} FR(a) \cdot MIPOP(a,2) \right] \quad (6)$$

$$BIRTHS(s) = BIRTHS \cdot PBS(s); \quad (7)$$

$$s = 1,2,$$

where:

$$PBS(s) = \begin{cases} SRB/(100 + SRB), & \text{when } s = 1 \\ 100/(100 + SRB), & \text{when } s = 2 \end{cases}$$

c. Population below age 5

$$POP(1,s,t+5) = BIRTHS(s) \cdot SR(1,s); \quad s = 1,2 \tag{8}$$

(iii) Other results

a. Population aggregates

i. Population size

$$POP(t+5) = \sum_{a=1}^{16} \sum_{s=1}^{2} POP(a,s,t+5) \tag{9}$$

ii. Young-age population

$$YAP(t+5) = \sum_{a=1}^{3} \sum_{s=1}^{2} POP(a,s,t+5) \tag{10}$$

iii. Working-age population

$$WAP(t+5) = \sum_{a=4}^{13} \sum_{s=1}^{2} POP(a,s,t+5) \tag{11}$$

iv. Old-age population

$$OAP(t+5) = \sum_{a=14}^{16} \sum_{s=1}^{2} POP(a,s,t+5) \tag{12}$$

v. School-age population

$$SAP(t+5) = \sum_{a=2}^{5} \sum_{s=1}^{2} POP(a,s,t+5) \tag{13}$$

vi. Women of the childbearing ages

$$WCA(t+5) = \sum_{a=4}^{10} POP(a,2,t+5) \tag{14}$$

vii. Mid-interval population size

$$MIPOP = [\ POP(t) \cdot POP(t+5)\ ]^{1/2} \quad (15)$$

viii. Total number of person-years-lived

$$NPYL = MIPOP \cdot 5 \quad (16)$$

ix. Population growth

$$POPGR = POP(t+5) - POP(t) \quad (17)$$

x. Births

xi. Deaths

$$DEATHS = BIRTHS - POPGR \quad (18)$$

b. Indicators of the population structure

i. Proportions by broad age groups

the proportion at young age:

$$PYA(t+5) = YAP(t+5) / POP(t+5) \quad (19)$$

the proportion at working age:

$$PWA(t+5) = WAP(t+5) / POP(t+5) \quad (20)$$

and the proportion at old age:

$$POA(t+5) = OAP(t+5) / POP(t+5) \quad (21)$$

ii. Dependency ratios

the young-age dependency ratio:

$$YADR(t+5) = YAP(t+5) / WAP(t+5) \quad (22)$$

the old-age dependency ratio:

$$OADR(t+5) = OAP(t+5) \;/\; WAP(t+5) \tag{23}$$

and the total dependency ratio:

$$TDR(t+5) = [\, YAP(t+5) + OAP(t+5) \,] \;/\; WAP(t+5) \tag{24}$$

iii. Median age of the population

$$MAPOP(t+5) = (a' - 1) \cdot 5 + [\, (POP(t+5)/2 - \sum_{a=1}^{a'-1} \sum_{s=1}^{2} POP(a,s,t+5) \,) \;/\; \sum_{s=1}^{2} POP(a',s,t+5) \,] \cdot 5 \tag{25}$$

iv. Proportion of women in the childbearing ages

$$PWCA(t+5) = WCA(t+5) \;/\; POP(t+5) \tag{26}$$

v. Sex ratio of the population

$$SRP(t+5) = [\, \sum_{a=1}^{16} POP(a,1,t+5) \,] \;/\; [\, \sum_{a=1}^{16} POP(a,2,t+5) \,] \tag{27}$$

c. Rates of population change

i. Crude birth rate

$$CBR = [\, (BIRTHS/5) \;/\; MIPOP \,] \cdot 1{,}000 \tag{28}$$

ii. Crude death rate

$$CDR = [\, (DEATHS/5) \;/\; MIPOP) \,] \cdot 1{,}000 \tag{29}$$

iii. Rate of natural increase

$$RNI = CBR - CDR \tag{30}$$

iv. Rate of population growth

$$GRP = [\ \ln(\ POP(t+5)/POP(t)\ )\ /\ 5\ ] \cdot 1{,}000 \tag{31}$$

(b) Open population

(i) Segment of the population structure at age 5 and over

a. Survival ratios and survivors aged 5 and over

b. Net international migration rates

$$EMR(a,s,t+5) = TEMR(s,t+5) \cdot PEMR(a,s,t+5); \tag{32}$$

$$a = 1,\ldots,16;$$

$$s = 1,2$$

c. Population aged 5 and over

$$EM(a,s,t+5) = POP^{*}(a,s,t+5) \cdot EMR(a,s,t+5); \tag{33}$$

$$a = 2,\ldots,16;$$

$$s = 1,2$$

$$POP(a,s,t+5) = POP^{*}(a,s,t+5) + EM(a,s,t+5); \tag{34}$$

$$a = 2,\ldots,16;$$

$$s = 1,2$$

(ii) Segment of population structure below age 5

a. Fertility rates, births and survivors below age 5

b. Population below age 5

$$EM(1,s,t+5) = POP^{*}(1,s,t+5) \cdot EMR(1,s,t+5); \tag{35}$$

$$s = 1,2$$

$$POP(1,s,t+5) = POP^{*}(1,s,t+5) + EM(1,s,t+5); \tag{36}$$

$$s = 1,2$$

(iii) Other results

a. Population aggregates

i. Change due to international migration

$$NCDEM = \sum_{a=1}^{16} \sum_{s=1}^{2} EM(a,s,t+5) \;/\; SRF(a,s), \tag{37}$$

where for each s:

$$SRF(a,s) = \begin{cases} 0.67 + 0.33 \cdot SR(1,s), & \text{when } a = 1 \\ (1 + SR(a,s)) \;/\; 2, & \text{when } 1 < a \leq 16 \end{cases}$$

ii. Deaths

$$DEATHS = BIRTHS - POPGR + NCDEM \tag{38}$$

b. Indicators of the population structure

c. Rates of population change

i. Crude net international migration rate

$$CEMR = [\ (NCDEM/5) \;/\; MIPOP\ ] \cdot 1{,}000 \tag{39}$$

Urban and rural populations

(a) Closed populations

(i) Segments of population structures at age 5 and over

a. Survival ratios

b. Survivors aged 5 and over

$$POP^{*}(a,s,k,t+5) = POP(a-1,s,k,t) \cdot SR(a,s,k); \tag{40}$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2$$

$$POP^{*}(16,s,k,t+5) = \left[\sum_{a=15}^{16} POP(a,s,k,t) \right] \cdot SR(16,s,k); \quad (41)$$

$$s = 1,2;$$

$$k = 1,2$$

c. Net internal migration rates

$$IMR(a,s,t+5) = TIMR(s,t+s) \cdot PIMR(a,s,t+5); \quad (42)$$

$$a = 1,\ldots,16;$$

$$s = 1,2$$

d. Population aged 5 and over

$$IM(a,s,2,t+5) = POP^{*}(a,s,2,t+5) \cdot IMR(a,s,t+5); \quad (43)$$

$$a = 2,\ldots,16;$$

$$s = 1,2$$

$$IM(a,s,1,t+5) = - IM(a,s,2,t+5); \quad (44)$$

$$a = 2,\ldots,16;$$

$$s = 1,2$$

$$POP(a,s,k,t+5) = POP^{*}(a,s,k,t+5) + IM(a,s,k,t+5); \quad (45)$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2$$

(ii) Segments of population structures below age 5

a. Fertility rates, births and survivors below age 5

b. Population below age 5

$$IM(1,s,2,t+5) = POP^{*}(1,s,2,t+5) \cdot IMR(1,s,t+5); \quad (46)$$

$$s = 1,2$$

$$IM(1,s,1,t+5) = - IM(1,s,2,t+5); \qquad (47)$$

$$s = 1,2$$

$$POP(1,s,k,t+5) = POP^{*}(1,s,k,t+5) + IM(1,s,k,t+5); \qquad (48)$$

$$s = 1,2;$$

$$k = 1,2$$

(iii) Other results

a. Population aggregates

i. Change due to internal migration

$$NCDIM(2) = \sum_{a=1}^{16} \sum_{s=1}^{2} IM(a,s,2,t+5) \,/\, SRF(a,2,s), \qquad (49)$$

where for each s:

$$SRF(a,2,s) = \begin{cases} 0.67 + 0.33 \cdot SR(1,2,s), & \text{when } a = 1 \\ (1 + SR(a,2,s)) / 2, & \text{when } 1 < a \leq 16 \end{cases}$$

$$NCDIM(1) = - NCDIM(2) \qquad (50)$$

ii. Deaths

$$DEATHS(k) = BIRTHS(k) - POPGR(k) + NCDIM(k); \qquad (51)$$

$$k = 1,2$$

b. Indicators of the population structure

c. Indicators of the population distribution

i. Proportions urban and rural

$$PURB(t+5) = POP(1,t+5) \,/\, POP(t+5) \qquad (52)$$

$$PRUR(t+5) = 1 - PURB(t+5) \qquad (53)$$

d. Rates of population change

i. Crude net internal migration rate

$$CIMR(k) = [\ (NCDIM(k) / 5) / MIPOP(k)\ ] \cdot 1{,}000; \qquad (54)$$

$$k = 1,2$$

(b) Open populations

(i) Segments of population structures at age 5 and over

a. Survival ratios, survivors aged 5 and over, and net internal migration rates

b. Net international migration rates

$$EMR(a,s,k,t+5) = TEMR\ (s,k,t+5) \cdot PEMR(a,s,k,t+5); \qquad (55)$$

$$a = 1,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2$$

c. Population aged 5 and over

$$EM(a,s,k,t+5) = POP^{*}(a,s,k,t+5) \cdot EMR(a,s,k,t+5); \qquad (56)$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2$$

$$POP(a,s,k,t+5) = POP^{*}(a,s,k,t+5) + IM(a,s,k,t+5) + EM(a,s,k,t+5); \qquad (57)$$

$$a = 2,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2$$

(ii) Segments of population structures below age 5

a. Fertility rates, births and survivors below age 5

b. Population below age 5

$$EM(1,s,k,t+5) = POP^{*}(1,s,k,t+5) \cdot EMR(1,s,k,t+5); \quad (58)$$

$$s = 1,2;$$

$$k = 1,2$$

$$POP(1,s,k,t+5) = POP^{*}(1,s,k,t+5) + IM(1,s,k,t+5) + EM(1,s,k,t+5); \quad (59)$$

$$s = 1,2;$$

$$k = 1,2$$

(iii) Other results

a. Population aggregates

i. Deaths

$$DEATHS(k) = BIRTHS(k) - POPGR(k) + NCDIM(k) + NCDEM(k); \quad (60)$$

$$k = 1,2$$

b. Indicators of the population structure

c. Rates of population change

i. Crude net combined migration rate

$$CCMR(k) = CEMR(k) + CIMR(k); \quad (61)$$

$$k = 1,2$$

Notes

1/ For alternative methods of population projections see, for example, Henry S. Shryock, Siegel and Associates, 1973.

2/ An alternative description of the cohort component method would use a one-year time period as a projection interval.

3/ Several definitions found in the glossary boxes throughout this chapter were adapted from Shorter and Macura, 1982.

4/ In the present description, the age structure of the population is that involving five-year age groups ending with the open age group, 75+ . In the application of the cohort component method the open age group may actually be 65+, 70+ or 80+, instead of 75+.

5/ In equation (1), as well as in the remainder of the chapter, the notation used differs from the standard demographic notation. A uniform notation is being used throughout the manual, which is primarily designed to describe methods to project socio-economic variables rather than demographic variables.

6/ An alternative would be the use of an empirical life table, such as a national life table to derive survival ratios from given expectation of life at birth.

7/ The geometric mean is used in this and similar computations, since this type of mean rather than some others, such as the arithmetic mean, is compatible with the assumption of exponential growth of the population. In particular, if population grows at a constant exponential rate, the geometric mean of the population at the beginning and the end of the interval, represents the mid-interval population.

8/ For a discussion of the calculation of the median age from grouped data, see: Shryock, Siegel and Associates, 1973.

9/ The intermediate results obtained in calculating a particular variable in the course of a projection are marked with an asterisk, *. In this particular instance, the numbers of survivors obtained for the end of a five-year projection interval represent the intermediate result of projecting an open population and are, therefore, marked with an asterisk.

10/ These two expressions, applying to the five-year groups below age 5 and at age 5 and above, have been adopted from Shorter and others, 1987.

11/ An example of this category of methods is the so-called urban-rural growth differential method which derives proportions of the national population in urban and rural areas and then applies those proportions to the national population projection in order to calculate projected urban and rural populations. For the urban-rural growth differential method along with alternative techniques for making urban and rural population projections, see United Nations, 1974.

12/ An example of such a variant of the cohort component method is the multiregional population projection model elaborated in Rogers, 1975.

13/ For the use of infant mortality rates and expectations of life at five as measures of mortality below 5 and at age 5 and over, see Shorter and others, op. cit.

14/ In preparing a population projection using, among other things, model life tables, the planner can choose from among several families of model life tables. The United Nations model life tables include five such families, which are referred to as Latin American, Chilean, South Asian, Far Eastern and General. Another set of model life tables, developed by Coale and Demeny, consists of four families, called West, North, East and South. In connection with this set see, Ansley J. Coale, Paul Demeny and Barbara Vaughan, Regional Model Life Tables and Stable Populations, 2nd ed., (New York, Academic Press, 1983).

15/ The initial age and sex structure of the population, shown in table 1, is expressed in units of one thousand. In view of this, the numbers of persons in this illustrative example will be given in thousands.

Annex I

DESCRIPTION OF A LIFE TABLE

A life table is a table showing a listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort (box 27), typically of one sex. It represents an experience of a cohort subject from birth to a particular set of age-specific mortality rates, which are usually those observed in a given population during a particular time period. A life table also presents other aspects of the cohort's experience, such as probabilities of dying and the numbers of person-years-lived between specific years of age. The following is a typical life table:a/

Age	$_nm_x$	$_nq_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x
0	0.18522	0.16532	100000	16532	89254	4300001	43.000
1	0.04080	0.14733	83468	12297	301421	4210746	50.447
5	0.00710	0.03486	71171	2481	349653	3909326	54.929
10	0.00300	0.01488	68690	1022	340895	3559673	51.822
15	0.00437	0.02161	67668	1462	334845	3218778	47.567
20	0.00532	0.02626	66206	1739	326754	2883933	43.560
25	0.00564	0.02782	64467	1794	317904	2557179	39.667
30	0.00652	0.03207	62673	2010	308421	2239275	35.730
35	0.00731	0.03592	60663	2179	297956	1930854	31.829
40	0.00854	0.04183	58484	2446	286458	1632898	27.921
45	0.01080	0.05266	56037	2951	273132	1346440	24.028
50	0.01609	0.07751	53086	4115	255709	1073308	20.218
55	0.02449	0.11574	48972	5668	231407	817599	16.695
60	0.03773	0.17294	43304	7489	198476	586192	13.537
65	0.05517	0.24297	35815	8702	157737	387715	10.825
70	0.08240	0.34149	27113	9259	112366	229978	8.482
75	0.12232	0.46362	17854	8278	67672	117613	6.587
80	0.16561	0.57223	9577	5480	33089	49941	5.215
85	0.24310		4097	4097	16851	16851	4.113

The various functions or columns in a life table are defined as follows:

Age is the age interval (x to x + n) where x is the initial age of the interval and n is its length; the length equals five years with the exception of the first interval (one year), second interval (four years) and the last interval (open-ended),

$_nm_x$ is the death rate (number of deaths per person-years-lived) between age x and x + n,

$_nq_x$ is the probability of surviving between age x and x + n,

l_x is the number of survivors at age x out of an original cohort of 100,000 (or the radix of a different value),

Box 27

Glossary

Age-specific mortality rate
: The number of deaths occurring during a specified period to persons (usually specified by sex) of a specified age or age group, divided by the number of person-years-lived during that period by the persons of that age or age group. When an age-specific mortality rate is calculated for a calendar year, the number of deaths to persons of the specified age is usually divided by the mid-year population of persons of that age.

Cohort
: A group of individuals who experienced the same class of events in the same period. Thus, a birth or age cohort is a group of people born during a particular time period.

Person-years-lived
: The number of years lived by a group of people, such as the national population or the urban population, during a specified period of time. When used in relation to a life table it represents the number of years lived by a hypothetical cohort between any two exact ages, and it is denoted by the symbol $_nL_x$.

Radix
: The hypothetical birth cohort of a life table. Its common values are 1, 1,000 or 100,000.

$_nd_x$ is the number of deaths between age x and x + n,

$_nL_x$ is the number of person-years-lived between age x and x + n,

T_x is the total number of person-years-lived from age x onward,

e_x is the expectation of life at age x.

In addition to the columns shown in the above table, a typical life table would either include or be accompanied by a column showing survival ratios, defined as follows:

$_nP_x$ is the proportion of persons between ages x and x + n surviving until ages x + 5 to x + n + 5.

A column of survival ratios accompanying the above life table is:

Age	$_nP_x$
Birth to 0-4	0.7813
0-4 to 5-9	0.8950
5-9 to 10-14	0.9750
10-14 to 15-19	0.9823
15-19 to 20-24	0.9758
20-24 to 25-29	0.9729
25-29 to 30-34	0.9702
30-34 to 35-39	0.9661
35-39 to 40-44	0.9614
40-44 to 45-49	0.9535
45-49 to 50-54	0.9362
50-54 to 55-59	0.9050
55-59 to 60-64	0.8577
60-64 to 65-69	0.7947
65-69 to 70-74	0.7124
70-74 to 75-79	0.6022
75-79 to 80-84	0.4890
80+ to 85+	0.3374

The various life table functions are interrelated, which makes it possible to derive an entire life table from one particular function, such as $_nm_x$ or $_nq_x$. The relationships among the functions may often be useful where one wishes, on the basis of an existing life table, to derive entries that are not available in it. An example of such an entry, which is unavailable in the illustrative life table used above, is the death rate for the age interval 0-4, $_5m_0$. The relationships among various life table are as follows:

$$_nq_x = (n \cdot {}_nm_x) / [\, 1 + (n - {}_na_x \cdot {}_nm_x) \,],$$

$$l_{x+n} = l_x \cdot (1 - {}_nq_x),$$

$$_nd_x = l_x - l_{x+n},$$

$$_nL_x = {}_na_x \cdot l_x + (n - {}_na_x) \cdot l_{x+n},$$

$$T_x = \sum_{a=x}^{w} {}_nL_x, \text{ and}$$

$$e_x = T_x / l_x,$$

where $_na_x$'s are constants and w is the lower end of the open age interval.b/

Notes

a/ This illustrative life table was published in *Model Life Tables for Developing Countries* (United Nations publication, Sales No. E.81.XIII.7).

b/ *Ibid.*, p. 31.

Annex II

DERIVING SURVIVAL RATIOS FROM INFANT MORTALITY RATES AND EXPECTATIONS OF LIFE AT AGE 5

This annex will show, using an illustrative example, how to derive survival ratios from infant mortality rates and expectations of life at age 5 employing a family of model life tables. The example, which will illustrate calculations for males, will use the male infant mortality rate, 156.7, and the male expectation of life at age 5, 63.6, along with the South Asian family of United Nations model life tables for males. a/

Where infant mortality rates and expectations of life at age 5 are used as measures to formulate mortality assumptions, the two measures can be used as representations of mortality below age 5 and at age 5 and above, respectively. Therefore, the use of these measures to derive survival ratios would involve locating segments of model life tables below age 5 and at age 5 and above that correspond to those measures. It would also involve making additional calculations using the two segments.

This annex will initially show how to derive survival ratios below age 5 and at age 5 and above. Then, it will illustrate how to obtain a survival ratio that bridges the two age segments.

A. Survival ratio below age 5

The survival ratio below age 5, which indicates the probability of survival between a birth during a five-year interval and the population age 0-4 at the end of the interval, is obtained using the given infant mortality rate specified for the interval. Also derived along with this survival ratio are selected model life table entries needed to later calculate the survival ratio bridging the two age spans--below age 5 and at age 5 and above. Those entries include the number of survivors at age 5 and the numbers of person-years-lived at exact ages 0-1 and 1-5.

The derivation of the survival ratio below age 5 and the relevant life table entries that correspond to the male infant mortality rate 156.7 is illustrated in table 31. The derivation is based on a linear interpolation between entries in columns 2 and 3, which were taken from the male model life tables of the United Nations South Asian family at expectations of life at birth, 46 and 47. Note that the model life tables in question are those embodying infant mortality rates (161.43 and 155.91) which bracket the infant mortality rate selected for this illustration (156.7). The factor of interpolation used, 0.8569, is computed as:

$$0.8569 = (161.43 - 156.7) / (161.43 - 155.91),$$

Table 31 Deriving the segment of a model life table below age 5, using infant mortality rate, results for males

	Age	Selected model life table entries at adjacent expectations of life at birth, 46 and 47		Various entries corresponding to infant mortality rate, 156 7
	(1)	(2)	(3)	(4)
Expectation of life at birth		46 0	47 0	
Infant mortality rate		161.43	155.91	156 7
Survival ratios	Birth to 0-4	0.7960	0 8046	0 8035
Survivors	5	73974	75001	74854
Person-years lived	0-1	89184	89554	89501
	1-5	309256	312724	312228
	0-5			401729

where 161.43 and 155.91 are male model infant mortality rates embodied in the model life tables at expectations of life at birth, 46 and 47; 156.7 is the male infant mortality rate selected for this illustration.

With this factor of interpolation, the survival ratio sought, 0.8035, which is shown in column 4, is obtained as:

$$0.8035 = (0.8569)\ (0.8046) + (1 - 0.8569)\ (0.7969),$$

where 0.7969 and 0.8046 are, respectively, model survival ratios between birth and age 0-4 in male model life tables at expectations of life at birth, 46 and 47 years. Among the remaining entries sought--the number of survivors at age 5 (74,854) and the numbers of person-years-lived at exact years of age 0-1 and 1-5 (89,501 and 312,228), shown in column 4--are obtained in the same way.

The last result obtained, which is the number of person-years-lived at ages 0-5, 401,729, shown in column 4, is derived as follows:

$$401{,}729 = 89{,}501 + 312{,}228,$$

where 89,501 and 312,228 are the numbers of person-years-lived at ages 0-1 and 1-5.

B. Survival ratios at ages 5 and above

The survival ratios at age 5 and over are obtained using the given expectation of life at age 5 specified for the five-year times interval in question. Also derived with those ratios are selected entries, some of which are required to calculate the survival ratio at the border of the two age spans.

The calculations of those survival ratios and life table entries are illustrated in table 32. Those calculations are made by means of a linear interpolation between entries in columns 2 and 3, which contain values taken from the male model life tables used in this example at expectations of life at birth, 59 and 60. Note that the expectations at age 5 embodied in these life tables (63.355 and 63.873) bracket the expectation of life at age 5 selected for this example (63.6). The factor of interpolation used is computed as follows:

$$0.5270 = (63.873 - 63.6) \,/\, (63.873 - 63.355),$$

where 63.355 and 63.873 are male model expectations of life at birth in the model life tables at expectations of life at birth, 59 and 60 (columns 2 and 3); 63.6 is the expectation of life at age 5 selected for this example.

This interpolation factor is used to obtain survival ratios ranging from the one for "5-9 to 10-14" through that for "65-69 to 70-74". Thus, for example, the first of these ratios, 0.9921, is obtained as:

$$0.9921 = (0.5270)\ (0.9918) + (1 - 0.5270)\ (0.9924),$$

Table 32. Deriving the segment of a model life table at age 5 and over using expectation of life at age 5; results for males

	Age	Selected model life table entries at adjacent expectations of life at birth, 59 and 60		Various entries corresponding to expectation of life at age 5, 63.6
	(1)	(2)	(3)	(4)
Expectation of life at birth		59.0	60.0	
Expectation of life at age 5		63.355	63.873	63.600
Survival ratios	5-9 to 10-14	0.9918	0.9924	0.9921
	10-14 to 15-19	0.9945	0.9949	0.9947
	15-19 to 20-24	0.9933	0.9938	0.9935
	20-24 to 25-29	0.9919	0.9924	0.9921
	25-29 to 30-34	0.9900	0.9907	0.9903
	30-34 to 35-39	0.9868	0.9877	0.9872
	35-39 to 40-44	0.9808	0.9819	0.9813
	40-44 to 45-49	0.9710	0.9724	0.9717
	45-49 to 50-54	0.9543	0.9563	0.9552
	50-54 to 55-59	0.9294	0.9320	0.9306
	55-59 to 60-64	0.8917	0.8950	0.8933
	60-64 to 65-69	0.8377	0.8418	0.8396
	65-69 to 70-74	0.7665	0.7716	0.7689
	70+ to 75+	0.5779	0.5819	0.5798
Survivors	5	86116	86934	86503
Person-years lived	5-10	428143	432401	430157
	70+	465675	487387	
	75+	269089	283592	

where 0.9918 and 0.9924 (columns 2 and 3) are the relevant model survival ratios.

To calculate the last of the survival ratios, which is one for "70+ to 75+", it is necessary first to calculate corresponding model survival ratios in the model life tables used. These survival ratios can be obtained from the numbers of person-years-lived at ages 70 and above and 75 and over. Thus, the survival ratio for "70+ to 75+" in the model life table at the expectation of life at birth 59, 0.5779, shown in column 2, is obtained as:

0.5779 = 269,689 / 465,675,

where 465,675 and 269,089 (column 2) are the numbers of person-years-lived at age 70 and above and 75 and over.

Given survival ratios for "70+ to 75+" in the two adjacent model life tables at expectations of life at birth, 59 and 60, the survival ratio that corresponds to the expectation of life at age 5, 63.6, is obtained in a similar way. This ratio, 0.5798, is obtained as:

0.5798 = (0.5270) (0.5779) + (1 - 0.5270) (0.5819).

This completes the calculation of survival ratios at age 5 and over.

In order to enable the calculation of the survival ratio spanning the age intervals below age 5 and at age 5 and above, it is also necessary to perform further calculations involving the model numbers of survivors at age 5 and the model numbers of person-years-lived at ages 5-10 (columns 2 and 3). These calculations yield the number of survivors at age 5, 86,503, and the number of person-years-lived at age 5-10, 430,157, shown in column 4, which correspond to the expectation of life at age 5, 63.6 (column 4). They are performed by means of a linear interpolation using the same interpolation factor, 0.5270.

C. Survival ratio spanning age intervals below age 5 and age 5 and above

The survival ratio for "0-5 to 5-10" is obtained using the numbers of person-years-lived aged 0-5 and 5-10 which are respectively derived from the given infant mortality rate (156.7) and the expectation of life at age 5 (63.6). Also used in the calculation are the numbers of survivors at age 5 obtained using these two mortality measures.

The survival ratio sought, 0.9266, is calculated as follows:

0.9266 = [(430,157) (74,854/86,503)] / 401,729,

where 401,729 and 430,157 are the numbers of person-years-lived at ages 0-5 and 5-10, derived from the given infant mortality rate and the expectation of life at age 5. 74,854 and 86,503 are the numbers of survivors at age 5 derived from those two measures, respectively.

This completes the derivation of the survival ratios from infant mortality rates and the expectation of life at age 5.

Note

a/ Model Life Tables for Developing Countries (United Nations publication, Sales No. E. 81. XII1.7).

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III. THE HEADSHIP RATE METHOD FOR MAKING HOUSEHOLD PROJECTIONS

A. Introduction

Household projections can be extremely useful for planning. Thus, the total number of households and the average household size (box 28), obtained as part of a projection, may be used as inputs for projections of household income or household consumption and savings. Those results may be employed as inputs into projections of government consumption and investment in the housing sector. They can also be used in a variety of other planning exercises.

Household projections can be prepared by the headship rate method, which is available in several versions. The simplest version derives a projection by applying assumed age- and sex-specific headship rates to the projected age and sex structures of the population (United Nations, 1973). A more complex version applies age-, sex- and marriage-specific headship rates to the projected population disaggregated by age, sex and marital status. 1/ Another version employs assumptions on age- and sex-specific headship rates along with assumptions on the proportionate size distributions of households classified by the age group of the household head (See, for example, Kono, 1981 and 1987). Yet another version of the method employs assumptions on headship rates by age, sex and household category. Among the categories are one-person households and households headed by males with the spouse present (Mason, 1986).

This chapter describes the simplest version of the headship rate method, which is least demanding in terms of both data and assumptions and, therefore, most readily applicable in planning. The method can be used to make a national projection or a projection for urban and rural areas, given requisite age and sex structures of the population along with assumptions on future trends in age- and sex-specific headship rates. The method yields the projected numbers of households by age and sex of household head, average household size and other relevant indicators.

The version of the headship-rate method described here requires limited data and simple calculations. The data include the numbers of household heads and their age, sex and location of residence along with information on the population classified by the same characteristics. Though the data requirements are not great, until recently the lack of requisite census or survey information relating to households made the method inapplicable in many developing countries. As these data are becoming more readily available, the method is likely to be increasingly used by planners in those countries.

A major limitation of the headship rate method (in all its versions) is that it generates the number of households in a mechanical way. This is so

Box 28

Glossary

Average household size
The mean number of members per household.

Family
A group of two or more persons related by birth, marriage or adoption and residing together.

Household head
A member of the household in whose name the housing unit occupied by the household is owned, rented or maintained. If there is no such person, the household head can be any other adult member of the household.

since it is not capable of approximating the process of formation and dissolution of households in the course of a household projection. In particular, the method does not trace individual households as they are formed, undergo change in size and composition and ultimately dissolve (Kono, 1987).

A particular disadvantage of the method for planning purposes is that it cannot yield projections of the average household size disaggregated by age and sex of the head of household. In addition, the version described here cannot project the distribution of households by the number of household members or by the category of households. Such projections would be useful for planning services to meet the needs of households headed by youth or the elderly or the requirements of particular categories of households. Furthermore, the method cannot be used to prepare projections of families.

Preparing assumptions on future trends in age- and sex-specific headship rates might not be straightforward since our understanding of the demographic and socio-economic determinants of those rates is still very limited. Consequently, even the projections generated with this simplest version of the method should be treated with caution, especially when they are prepared for countries undergoing major socio-economic and demographic change.

This chapter will first describe the procedure for projecting households. It will then describe inputs required and discuss how assumptions on headship rates can be formulated. Lastly, the chapter will present two illustrative household projections, one for a country as a whole and the other for urban and rural areas.

B. The technique

1. Overview

This overview will first indicate the types of inputs required by the headship rate method and list the types of outputs that it can generate. Also, the overview will outline computational steps involved in preparing a household projection with this method.

(a) Inputs

The inputs required to project households will include:

(i) projected age and sex structures of the population at age 10 and over;
(ii) projected size of the population;
(iii) assumptions on headship rates.

For a national projection the inputs would refer to the national population. For a rural-urban projection, they would be for rural and urban populations, respectively. The inputs are listed in box 29.

Since the method is described as a procedure for making quinquennial household projections, the inputs would be for dates five years apart, starting with the initial year of the plan.

(b) Outputs

The outputs that the headship rate method can generate would partly depend on the type of projection being made. In the case of a national projection, the method would yield:

(i) the structure of households by age and sex of household head;
(ii) various household aggregates, such as the total number of households and the growth in this number;
(iii) average household size;
(iv) indicators of the structure of households by age and sex of household head;
(v) rates of change in the numbers of households, including that of the total number of households.

If the technique is used to make an urban-rural projection, the results would include all those listed under (i) through (v), which would be for urban and rural areas as well as the country as a whole. In additon, the results would include indicators of the rural-urban distribution of households. The types of inputs that the method can generate as part of the national or urban-rural projection are shown in box 30.

The results obtained by the method would be for the dates five years apart or the intervening projection intervals.

Box 29

Inputs for applying the headship rate method

1. Age and sex structures of the population at age 10 and over (national or urban and rural)

2. Population sizes (national or urban and rural)

3. Assumptions on headship rates (national or urban and rural)

   Headship rates by age and sex

(c) Computational steps

The first step of the procedure to project households for a given projection date involves the calculation of the structure of households by age and sex of the household head. This structure is obtained from the age and sex structure of the population at age 10 and over and age- and sex-specific headship rates. The procedure also entails deriving for each projection date the total number of households and the average household size along with other date-specific indicators. In addition, the projection involves calculating growth rates in the numbers of households for the intervening intervals.

2. National level

The description of the technique will initially introduce steps to compute the structure of households along with other results for a given projection date or interval at the national level. A summary of those steps is presented in box 31. The steps used to derive urban and rural household structures together with the related results will be described in a later section.

(a) Household structure

The first step of the procedure is to calculate the numbers of households headed by persons of different age groups and sexes at a given date--say, at the end of a given five-year projection interval (t to t+5). Assuming that

Box 30

Types of outputs of the headship rate method

1. Structures of households by age and sex of household head (national or urban, rural and national)

2. Households aggregates (national or urban, rural and national)

   Numbers of households headed by persons of different age and sex categories

   Growth in the number of households headed by persons of different age and sex categories

3. Average household sizes (national or urban, rural and national)

4. Indicators of the structure of households (national or urban, rural and national)

   Proportions of households headed by persons of different age and sex categories

5. Indicators of the rural-urban distribution of households (national only; if urban and rural households are being projected)

   Proportions of households in different residential locations

6. Rates of growth in the numbers of households (national or urban, rural and national)

   Rates of growth in the numbers of households headed by persons of different age and sex categories

there are no household heads below age 10, the numbers of households in each age and sex group are obtained by multiplying the relevant numbers of persons at age 10 and over by the corresponding headship rates:

Box 31

Computational steps to project households at the national level

The steps used to project households at the national level over a five-year projection interval are:

(1) Apply age- and sex-specific headship rates to the age and sex structure of the population at age 10 and over at the end of the projection interval to compute the structure of households by the age and sex of the household head at that date;

(2) Derive various household aggregates, such as the total number of household and the numbers of households by broad age group and sex, by aggregating the numbers of households having heads at different age and sex groups. Also, calculate other household aggregates, such as the growth in the total number of households and the numbers of households by broad age group and sex, using the relevant numbers of households at the beginning and the end of the projection interval;

(3) Use the population size and the total number of households to derive the average household size;

(4) Derive indicators of the structure of households by age and sex of head of household, using the household aggregates;

(5) Compute rates of growth in the total numbers of households and in the numbers of households by broad age groups and sex over the projection interval from the relevant numbers of households referring to the beginning and the end of the interval.

$$NH(a,s,t+5) = POP(a,s,t+5) \cdot HR(a,s,t+5); \qquad (1)$$

$$a = 3,\ldots,16;$$

$$s = 1,2,$$

where:

$a = 3,\ldots,16$	are five-year age groups 10-14,...,75+,
$s = 1,2$	are male and female sexes,
t	is the year of the projection period,
$NH(a,s,t+5)$	is the number of households headed by persons of age group a and sex s at the end of the interval,
$POP(a,s,t+5)$	is the population of age group a and sex s at the end of the interval, and
$HR(a,s,t+5)$	is the headship rate among persons of age group a and sex s at the end of the interval. 2/

(b) Other results

Once the structure of households by age and sex of the household head is derived for the end of a given projection interval, several useful indicators can be calculated. Among these indicators are household aggregates, average household size, indicators of the household structure as well as the rate of change in the numbers of households.

(i) Household aggregates

A key aggregate that can be calculated from the household structure is the total number of households. Also, it is possible to obtain from this structure the numbers of households headed by persons belonging to different broad age groups and the number of households headed by males and the number headed by females. Once these numbers are obtained for different dates five years apart, one can further calculate the increases in those numbers over the intervening five-year projection intervals.

a. The total number of households

The total number of households can be obtained by aggregating the numbers of households across age groups and sexes. For the end of a projection interval (t to t+5) this number is:

$$NH(t+5) = \sum_{a=3}^{16} \sum_{s=1}^{2} NH(a,s,t+5), \qquad (2)$$

where:

NH(t+5) is the total number of households at the end of the interval.

b. Numbers of households headed by persons in broad age groups

The age span 10 and over may be subdivided into broad age groups, e.g., 10-24, 25-65 and 65 and over. The first group might include younger household heads, who still are of school-age, less than 25. The second group could consist of household heads in their prime working years, 25-65 which overlaps with much of the working age span, 15-64. And the third group would include elderly household heads, 65 and over.

i. The number of households headed by younger persons

This number of households can be obtained by aggregating the numbers of households headed by men and women who belong to age groups 10-14 through 20-24:

$$NHY(t+5) = \sum_{a=3}^{5} \sum_{s=1}^{2} NH(a,s,t+5), \qquad (3)$$

where:

NHY(t+5) is the number of households headed by younger persons at the end of the interval.

ii. The number of households headed by prime-working-age persons

This number of households can be derived by summing the numbers of households headed by persons of either sex at age groups 25-29 through 60-64:

$$NHP(t+5) = \sum_{a=6}^{13} \sum_{s=1}^{2} NH(a,s,t+5), \qquad (4)$$

where:

NHP(t+5) is the number of households headed by prime-working-age persons at the end of the interval.

iii. The number of households headed by old-age persons

The number of households headed by old-age persons can be derived by adding up the numbers of households headed by persons at age group 65-69 and above:

$$NHO(t+5) = \sum_{a=14}^{16} \sum_{s=1}^{2} NH(a,s,t+5), \qquad (5)$$

where:

NHO(t+5) is the number of households headed by old-age persons at the end of the interval.

c. Numbers of households headed by males and females

In addition to the numbers of households headed by persons at different broad age groups, it is also possible to compute the numbers of households headed by males and females.

i. The number of households headed by males

This number of households can be calculated by summing up households headed by males at different age groups:

$$NHM(t+5) = \sum_{a=3}^{16} NH(a,1,t+5), \qquad (6)$$

where:

NHM(t+5) is the number of households headed by males at the end of the interval.

ii. The number of households headed by females

The number of households headed by females can be obtained as the difference between the total number of households and the number of households headed by males:

$$NHF(t+5) = NH(t+5) - NHM(t+5), \qquad (7)$$

where:

NHF(t+5) is the number of households headed by females at the end of the interval.

d. Growth in the total number of households

The growth in the total number of households for the projection interval (t to t+5) equals the difference between the total numbers of household at the end and the beginning of the interval:

$$HHGR = NH(t+5) - NH(t), \quad (8)$$

where:

HHGR is the growth in the number of households during the interval.

e. Growth in the numbers of households headed by persons in broad age groups

The increase in the numbers of households headed by younger, prime-working-age and old-age persons over the projection interval are respectively obtained as follows:

The growth in the number of households headed by young persons is:

$$HYGR = NHY(t+5) - NHY(t), \quad (9)$$

The growth in the number of households headed by prime-working-age persons is:

$$HPGR = NHP(t+5) - NHP(t), \quad (10)$$

The growth in the number of households headed by old-age persons is:

$$HOGR = NHO(t+5) - NHO(t), \quad (11)$$

where:

HYGR is the growth in the number of households headed by younger persons during the interval,

HPGR is the growth in the number of households headed by prime-working-age persons during the interval, and

HOGR is the growth in the number of households headed by old-age persons during the interval.

f. Growth in the numbers of households headed by males and females

The increase in the numbers of households headed by males and females can be obtained as:

The growth in the number of households headed by males is:

$$HMGR = NHM(t+5) - NHM(t), \quad (12)$$

The growth in the number of households headed by females is:

$$HFGR = NHF(t+5) - NHF(t), \quad (13)$$

where:

HMGR is the growth in the number of households headed by males over the interval, and

HFGR is the growth in the number of households headed by females over the interval.

(ii) Average household size

The average household size is computed by dividing the population size by the total number of households:

$$AHS(t+5) = POP(t+5) / NH(t+5), \quad (14)$$

where:

AHS(t+5) is the average household size at the end of the interval, and

POP(t+5) is the population size at the end of the interval.

(iii) Indicators of the structure of households

Once the various household aggregates are obtained, it is possible to derive proportions of households headed by persons in different broad age groups and of different sexes.

a. Proportions by broad age groups

Proportions of households headed by persons who belong to the broad age groups identified above can be obtained as follows:

The proportion headed by younger persons is:

$$PHY(t+5) = NHY(t+5) / NH(t+5), \quad (15)$$

The proportion headed by prime-working-age persons is:

$$PHP(t+5) = NHP(t+5) / NH(t+5), \quad (16)$$

The proportion headed by old-age persons is:

$$PHO(t+5) = NHO(t+5) / NH(t+5), \quad (17)$$

where:

PHY(t+5) is the proportion of households headed by younger persons at the end of the interval,

PHP(t+5) is the proportion of households headed by prime working-age persons at the end of the interval, and

PHO(t+5) is the proportion of households headed by old-age persons at the end of the interval.

b. Proportions by sex

The proportions of households headed by males and by females respectively can be computed as follows:

The proportion headed by males is:

$$PHM(t+5) = NHM(t+5) / NH(t+5), \quad (18)$$

The proportion headed by females is:

$$PHF(t+5) = 1 - PHM(t+5), \quad (19)$$

where:

PHM(t+5) is the proportion of households headed by males at the end of the interval, and

PHF(t+5) is the proportion of households headed by females at the end of the interval.

(iv) Rates of growth in the numbers of households

As part of a household projection, it is possible to compute average annual rates of growth in the total number of households and the numbers of households headed by persons of different broad age groups or sexes.

a. Rate of growth in the total number of households

The average annual growth rate in the total number of households for a given projection interval can be computed from the total numbers of households at the beginning and the end of the interval. The percentage growth rate can be obtained using the formula for calculating an exponential growth rate:

$$GRHH = [\ \ln(\ NH(t+5)/NH(t)\ )\ /\ 5\ ]\ \cdot\ 100, \quad (20)$$

where:

GRHH is the growth rate of the total number of households for the interval, and

ln is the natural logarithm.

b. Rates of growth in the numbers of households headed by persons in broad age groups

The percentage rates of growth for the numbers of households headed by persons in broad age groups for the interval can be obtained as follows:

The growth rate of the number of households headed by younger persons is:

$$GRHY = [\ \ln(NHY(t+5)/NHY(t)) / 5\ ] \cdot 100, \quad (21)$$

The growth rate of the number of households headed by prime-working-age persons is:

$$GRHP = [\ \ln(NHP(t+5)/NHP(t)) / 5\ ] \cdot 100, \quad (22)$$

The growth rate of the number of households headed by old-age persons is:

$$GRHO = [\ \ln(NHO(t+5)/NHO(t)) / 5\ ] \cdot 100, \quad (23)$$

where:

GRHY	is the growth rate of the number of households headed by younger persons for the interval,
GRHP	is the growth rate of the number of households headed by prime-working-age persons for the interval, and
GRHO	is the growth rate of the number of households headed by old-age persons for the interval.

c. Rates of growth in the numbers of households headed by males and females

The growth rates in the numbers of households headed by persons of different sexes can be obtained as:

The growth rate in the number of households headed by males is:

$$GRHM = [\ \ln(NHM(t+5)/NHM(t)) / 5\ ] \cdot 100, \quad (24)$$

The growth rate in the number of households headed by females is:

$$GRHF = [\ \ln(NHF(t+5)/NHF(t)) / 5\ ] \cdot 100, \quad (25)$$

where:

GRHM	is the growth rate in the number of households headed by males for the interval, and
GRHF	is the growth rate in the number of households headed by females for the interval.

3. Urban-rural level

This section will describe a procedure needed to calculate an urban-rural projection of households which is similar to that employed in the national projection. The procedure consists of steps used to project the structures of households by age and sex along with those needed to derive a variety of other results.

(a) Household structures

Household structures for urban and rural areas for the end of a given projection interval (t to t+5) are calculated using an urban-rural equivalent of the step described by equation (1):

$$NH(a,s,k,t+5) = POP(a,s,k,t+5) \cdot HR(a,s,k,t+5), \qquad (26)$$

$$a = 3,\ldots,16;$$

$$s = 1,2;$$

$$k = 1,2,$$

where:

$k = 1,2$	are urban and rural areas,
$NH(a,s,k,t+5)$	is the number of households headed by persons of age group a and sex s in location k at the end of the interval,
$POP(a,s,k,t+5)$	is the population of age group a and sex s in location k at the end of the interval, and
$HR(a,s,k,t+5)$	is the headship rate among persons of age group a and sex s in location k at the end of the interval.

(b) Other results

The indicators discussed in connection with the national projection can also be computed as part of an urban-rural projection. Those indicators are, however, calculated for urban and rural areas and for the entire country, using steps analogous to those indicated by equations (2) through (25). In addition, indicators of the distribution of households by residential location--proportions urban and rural--can be calculated.

(i) Proportions urban and rural

The proportion of households urban at the end of a projection interval is computed by dividing the number of urban (k=1) households by the total number of households:

$$HURB(t+5) = NH(1,t+5) / NH(t+5), \quad (27)$$

where:

HURB(t+5) is the proportion of the total number of households in urban areas at the end of the interval, and

NH(k,t+5) is the number of households in location k at the end of the interval.

The proportion of households rural can be found as a complement of the proportion urban:

$$HRUR(t+5) = 1 - HURB(t+5), \quad (28)$$

where:

HRUR(t+5) is the the proportion of the total number of households in rural areas at the end of the interval.

This completes the discussion of the technique for making household projections.

C. The inputs

This section will consider issues concerning the inputs used by the headship rate method. Specifically, it will list those inputs and then describe how they can be prepared.

1. Types of inputs required

The following inputs are required to apply the headship rate method:

(a) Projected age and sex structure of the population at age 10 and over;
(b) The projected population size;
(c) Assumptions on headship rates by age and sex.

Depending on whether one wishes to make a national projection or a projection for urban and rural areas, those inputs will be required for the country as a whole or for urban and rural areas.

2. Preparation of the inputs

The projected population structures and population sizes required for the headship rate method can be prepared by making a population projection with the cohort component method (chapter II).

(a) Observed headship rates

Assumptions on headship rates can be formulated using headship rates pertaining to the recent past and by considering the effect of future demographic and socio-economic change on household formation. In particular, to formulate assumptions on headship rates for the initial year of the plan, it will typically be necessary to use observations on headship rates for a recent date or preferably for a few such dates. If these rates are not readily available, they will have to be derived from data on household heads and population, classified by age, sex and, if necessary, location.

No matter whether headship rates are available or need to be calculated from appropriate data, the definition of household on which they are based may differ from the one used in this chapter (box 28). The population census or the large scale demographic survey, which is the source of the household data used may have a definition of household that is more suited to the local conditions. Where this is the case, the headship rate method can still be employed as described in the previous section. The projection results, however, need to be interpreted taking into account the definition of household used in the census or survey.

The planner preparing the household projection may have access to two or more sources of data that permit calculation of headship rates referring to different dates. Using such sources would make it possible to identify recent trends, if any, in headship rates over time, which would facilitate the formulation of assumptions on those rates for the initial year of the projection. However, the data from different sources would need to be used with caution. In particular, where the definition of the household varies from one source to another, adjustments must be made in order to remove effects of the definitional differences.

(b) Assumptions on future headship rates

As a rule, assumptions on headship rates for the initial year of the plan are formulated by extrapolating past rates. The objective of this exercise is to approximate trends in the rates between the most recent date for which they are available and the initial year of the projection.

To formulate assumptions on headship rates for dates beyond the initial year, it will normally be necessary to assess the impact of likely changes in marriage patterns, household income, housing, and possibly urbanization, on these rates. This may have to be done on the basis of *ad hoc* considerations, primarily because the determinants of household formation are not well understood.

If the age at first marriage is expected to increase over the plan horizon, the planner may wish to assume a decline in headship rates among adolescent and young adult males, especially where newly-wedded couples tend to set up their own households. On the other hand, if the proportions of females currently married by age are likely to decline, say, as a result of a growing incidence of celibacy and/or divorce, the headship rates among women in the prime working years of age and beyond could be assumed to increase.

Similarly, headship rates, especially among younger persons, could be assumed to increase over time if household income and the availability of housing are expected to improve (United Nations, 1973). Both trends are likely to enable an increasing number of young adults to live apart from their parents. Where there are sizeable urban-rural differentials in headship rates, it will often be warranted to take into account possible future trends in urbanization when preparing assumptions for a national projection. 3/

D. Illustrative examples of projections

The examples presented below will illustrate the use of the headship rate method to prepare a national projection and an urban-rural projection, respectively. These examples will indicate how the relevant calculations are made by focusing on the projection interval 0-5. In addition, they will provide complete projection results for the 20-year period.

1. National projection

The calculations presented in this example will be based on the inputs contained in tables 33 and 34, which respectively show population structures and sizes and assumptions on headship rates. The inputs are specified for dates five years apart, starting with the initial year of the plan, which is denoted as year 0. The age and sex structures are those at age 10 and over, and the headship rates are for various age and sex groups over the same age range.

(a) Household structure

For any given date, the numbers of households headed by persons who belong to different age and sex groups are calculated as products of the numbers of persons in those groups and the corresponding headship rates. These calculations are illustrated in table 35 for the end of the projection interval 0-5. The numbers of households by age and sex of household head (column 4) are obtained by multiplying the numbers of persons by age and sex (column 2) by the corresponding headship rates (column 3). 4/

For example, the number of households headed by males aged 10-14 at the end of the interval 0-5, 29.6, is obtained as:

$$29.6 = (729.9)\ (0.0405), \qquad (1)$$

Table 33. Inputs for projecting households at the national level: population structures at age 10 and over and population sizes

(Thousands)

	Sex	Age group	Year 0	5	10	15	20
(a) Population at age 10 and over, by age and sex							
	Male	10-14	624.0	729.9	729.3	815.6	917.5
		15-19	486.6	618.5	724.9	725.4	812.0
		20-24	402.2	481.5	613.4	720.1	721.5
		25-29	361.5	397.1	476.7	608.5	715.5
		30-34	358.7	355.9	392.2	472.0	603.6
		35-39	312.4	351.5	350.2	387.1	466.9
		40-44	223.6	303.6	343.4	343.5	381.0
		45-49	152.1	214.5	293.2	333.5	335.1
		50-54	192.5	142.8	203.2	279.9	320.3
		55-59	157.0	175.3	131.5	189.0	262.4
		60-64	128.1	136.3	154.4	117.4	170.5
		65-69	90.1	103.6	112.4	129.5	99.9
		70-74	44.2	65.9	77.7	86.2	101.4
		75+	38.6	45.6	63.0	81.4	99.1
	Female	10-14	580.5	685.2	697.4	783.3	877.0
		15-19	448.3	574.9	680.2	693.5	779.9
		20-24	359.8	442.5	569.3	675.3	689.6
		25-29	348.3	354.5	437.5	564.5	670.7
		30-34	352.2	342.4	349.9	433.2	560.0
		35-39	300.9	345.1	337.0	345.5	428.7
		40-44	206.7	293.5	338.2	331.6	340.8
		45-49	158.5	200.2	285.7	330.7	325.2
		50-54	174.6	151.2	192.3	276.1	320.9
		55-59	164.0	162.2	141.9	181.9	262.8
		60-64	126.1	145.9	146.3	129.5	167.6
		65-69	105.6	105.1	124.0	126.4	113.4
		70-74	63.5	80.0	81.7	98.5	102.3
		75+	69.4	72.9	86.4	97.5	116.1
(b) Population size			10000.0	11210.4	12618.7	14159.5	15675.9

Table 34. Inputs for projecting households at the national level: assumptions on headship rates

Sex	Age group	Headship rates: year 0	5	10	15	20
Male	10-14	0.0419	0.0405	0.0338	0.0334	0.0262
	15-19	0.0688	0.0683	0.0613	0.0613	0.0546
	20-24	0.1036	0.1034	0.0962	0.0955	0.0889
	25-29	0.4980	0.4935	0.4933	0.4923	0.4913
	30-34	0.5393	0.5356	0.5358	0.5357	0.5407
	35-39	0.5675	0.5653	0.5691	0.5646	0.5710
	40-44	0.5763	0.5749	0.5799	0.5780	0.5812
	45-49	0.5895	0.5882	0.5933	0.5920	0.5967
	50-54	0.5922	0.5910	0.5966	0.5957	0.6013
	55-59	0.5813	0.5808	0.5866	0.5861	0.5921
	60-64	0.5608	0.5592	0.5649	0.5639	0.5696
	65-69	0.5415	0.5416	0.5448	0.5433	0.5477
	70-74	0.4999	0.5011	0.5077	0.5089	0.5150
	75+	0.4767	0.4821	0.4874	0.4936	0.4984
Female	10-14	0.0013	0.0015	0.0013	0.0013	0.0012
	15-19	0.0042	0.0044	0.0037	0.0037	0.0028
	20-24	0.0080	0.0088	0.0082	0.0084	0.0075
	25-29	0.0149	0.0156	0.0098	0.0100	0.0051
	30-34	0.0213	0.0219	0.0161	0.0166	0.0104
	35-39	0.0516	0.0523	0.0540	0.0557	0.0571
	40-44	0.0837	0.0851	0.0923	0.0937	0.1017
	45-49	0.1163	0.1170	0.1249	0.1255	0.1333
	50-54	0.1804	0.1819	0.1891	0.1903	0.1973
	55-59	0.2180	0.2180	0.2254	0.2258	0.2329
	60-64	0.2449	0.2468	0.2534	0.2545	0.2616
	65-69	0.2652	0.2651	0.2734	0.2734	0.2810
	70-74	0.2781	0.2788	0.2853	0.2869	0.2934
	75+	0.2956	0.2959	0.3028	0.3030	0.3100

Table 35. Calculating the structure of households, by age and sex of head of household; end of projection interval 0-5

Sex	Age group	Population at age 10 and over in year 5 a/ (thousands)	Headship rates in year 5 b/	Households in year 5 c/ (thousands)
(1)	(2)	(3)	(4)	(5)
Male	10-14	729.9	0.0405	29.6
	15-19	618.5	0.0683	42.2
	20-24	481.5	0.1034	49.8
	25-29	397.1	0.4935	196.0
	30-34	355.9	0.5356	190.6
	35-39	351.5	0.5653	198.7
	40-44	303.6	0.5749	174.5
	45-49	214.5	0.5882	126.2
	50-54	142.8	0.5910	84.4
	55-59	175.3	0.5808	101.8
	60-64	136.3	0.5592	76.2
	65-69	103.6	0.5416	56.1
	70-74	65.9	0.5011	33.0
	75+	45.6	0.4821	22.0
Female	10-14	685.2	0.0015	1.0
	15-19	574.9	0.0044	2.5
	20-24	442.5	0.0088	3.9
	25-29	354.5	0.0156	5.5
	30-34	342.4	0.0219	7.5
	35-39	345.1	0.0523	18.0
	40-44	293.5	0.0851	25.0
	45-49	200.2	0.1170	23.4
	50-54	151.2	0.1819	27.5
	55-59	162.2	0.2180	35.4
	60-64	145.9	0.2468	36.0
	65-69	105.1	0.2651	27.9
	70-74	80.0	0.2788	22.3
	75+	72.9	0.2959	21.6

a/ From table 33.
b/ From table 34.
c/ (Col. 3) . (Col. 4).

where 729.9 is the number of males aged 10-14 and 0.0405 is the male headship rate for age group 10-14 at that date.

Performing the calculations illustrated for the end of the interval 0-5 for each five-year interval of the entire projection period produces the household structures for the entire period. The household structures for the 20-year projection interval are shown in table 36.

(b) Other results

Other results that can be obtained as part of a projection at the national level include various household aggregates, a measure of average household size, indicators of the structure of households and the rates of growth in the numbers of households.

(i) Household aggregates

Household aggregates include the numbers of households at dates five years apart and the increases in those numbers over the intervening projection intervals. The numbers of households involved include the total number of households and the numbers of households headed by persons of different broad age groups or sexes. The increases in the numbers of households are those for the total number of households and the numbers of households headed by persons in different age and sex categories.

a. Total number of households

The total number of households at the end of a given projection interval is obtained as the sum of the numbers of households headed by persons of different age and sex groups. At the end of interval 0-5, the total number of households, 1,638.7, is computed by adding the numbers of households across ages and sexes of household heads at that date. This number is shown in table 37 (in the column corresponding to year 5) along with other results derived for the entire 20-year projection period. The increase in the total number of households over this period is indicated in figure XVI.

b. Numbers of households headed by persons in broad age groups

The numbers of households headed by younger, prime-working-age and old-age persons are obtained by aggregating the numbers of households within the age groups 10-24, 25-64 and 65+, respectively.

Table 36. Projected numbers of households, by age and sex of household head

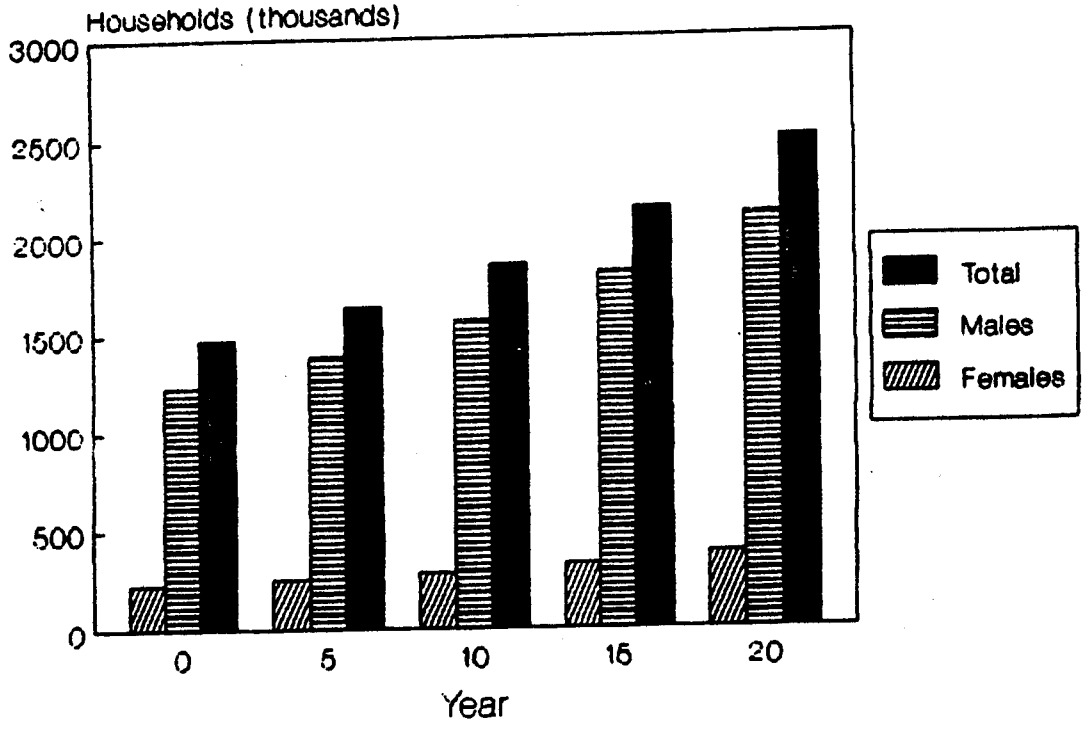
(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	10-14	26.1	29.6	24.7	27.2	24.0
	15-14	33.5	42.2	44.4	44.5	44.3
	20-25	41.7	49.8	59.0	68.8	64.1
	25-26	180.0	196.0	235.2	299.6	351.5
	30-37	193.4	190.6	210.1	252.9	326.4
	35-38	177.3	198.7	199.3	218.6	266.6
	40-49	128.9	174.5	199.1	198.5	221.4
	45-40	89.7	126.2	174.0	197.4	200.0
	50-51	114.0	84.4	121.2	166.7	192.6
	55-52	91.3	101.8	77.1	110.8	155.4
	60-63	71.8	76.2	87.2	66.2	97.1
	65-64	48.8	56.1	61.2	70.4	54.7
	70-75	22.1	33.0	39.4	43.9	52.2
	75+	18.4	22.0	30.7	40.2	49.4
Female	10-14	0.8	1.0	0.9	1.0	1.1
	15-19	1.9	2.5	2.5	2.6	2.2
	20-24	2.9	3.9	4.7	5.7	5.2
	25-29	5.2	5.5	4.3	5.6	3.4
	30-34	7.5	7.5	5.6	7.2	5.8
	35-39	15.5	18.0	18.2	19.2	24.5
	40-44	17.3	25.0	31.2	31.1	34.7
	45-49	18.4	23.4	35.7	41.5	43.3
	50-54	31.5	27.5	36.4	52.5	63.3
	55-59	35.8	35.4	32.0	41.1	61.2
	60-64	30.9	36.0	37.1	33.0	43.8
	65-69	28.0	27.9	33.9	34.6	31.9
	70-74	17.7	22.3	23.3	28.3	30.0
	75+	20.5	21.6	26.2	29.5	36.0

Table 37. Household aggregates, indicators of the structure of households and rates of change in the number of households

Indicators	Year 0	5	10	15	20
Household aggregates (thousands)					
Numbers of households headed by:					
(Totals)	1470.7	1638.7	1854.7	2138.4	2486.2
Younger persons	106.8	129.0	136.2	149.7	140.9
Prime-working-age persons	1208.5	1326.8	1503.7	1741.9	2091.1
Old-age persons	155.5	182.9	214.8	246.8	254.2
Males	1237.0	1381.1	1562.8	1805.5	2099.8
Females	233.8	257.5	291.9	332.8	386.4
Growth in numbers of households headed by:					
(Totals)		167.9	216.0	283.7	347.8
Younger persons		22.2	7.2	13.5	-8.8
Prime-working-age persons		118.3	176.9	238.2	349.2
Old-age persons		27.4	31.9	32.0	7.4
Males		144.1	181.7	242.7	294.3
Females		23.7	34.4	40.9	53.6
Average household size	6.80	6.84	6.80	6.62	6.31
Proportions of households headed by:					
Younger persons	0.07	0.08	0.07	0.07	0.06
Prime-working-age persons	0.82	0.81	0.81	0.81	0.84
Old-age persons	0.11	0.11	0.12	0.12	0.10
Males	0.84	0.84	0.84	0.84	0.84
Females	0.16	0.16	0.16	0.16	0.16
Rates of growth in numbers of households headed by:					
(Totals)		2.16	2.48	2.85	3.01
Younger persons		3.78	1.09	1.89	-1.21
Prime-working-age persons		1.87	2.50	2.94	3.65
Old-age persons		3.25	3.22	2.78	0.59
Males		2.20	2.47	2.89	3.02
Females		1.93	2.51	2.62	2.99

Figure XVI. Total households and numbers of households headed by males and females



i. The number of households headed by younger persons

The number of households headed by younger persons at the end of the first five years (interval 0-5), 129.0, is obtained by aggregating the numbers of households headed by males and females at age groups 10-14 through 20-24. The number is shown in table 37 (column corresponding to year 5).

ii. The number of households headed by prime-working-age persons

The number of households headed by prime working-age persons, 1,326.8, is found by summing the numbers of households headed by persons of both sexes at age groups 25-29 through 60-64.

iii. The number of households headed by old-age persons

The number of households headed by the elderly, 182.9, is the sum of all those households headed by men and women aged 65 and over.

The numbers of households headed by persons in different broad age groups over the projection period are shown in figure XVII.

c. Numbers of households headed by males and females

These numbers of households headed by a person of a given sex are derived by adding up households headed by all males and females, respectively.

i. The number of households headed by males

The number of households headed by males at the end of the interval 0-5, 1,381.1, is obtained as the sum of the numbers of households headed by males of different age groups from 10-14 onward. The number is shown in table 37.

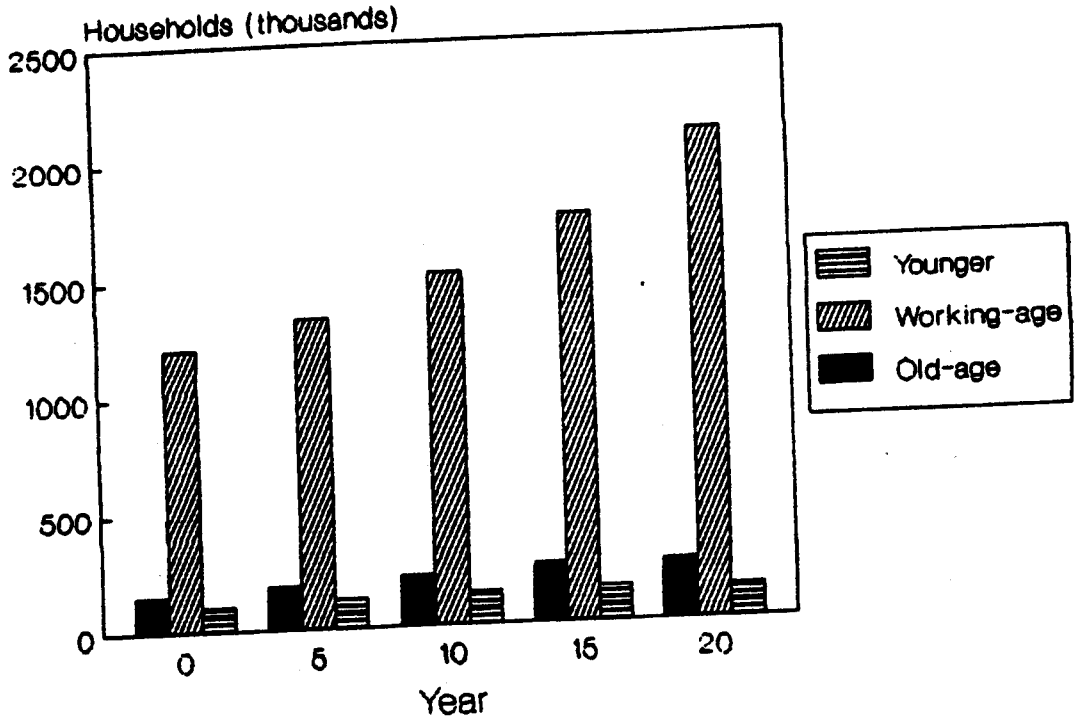
ii. The number of households headed by females

The number of households headed by females, 257.5, can be calculated by subtracting the number of households headed by males, 1,381.1, from the total number of households, 1,638.7.

$$257.5 = 1{,}638.7 - 1{,}381.1, \qquad (7)$$

The numbers of household headed by males and females at different dates during the projection period are indicated in figure XVI.

Figure XVII. Numbers of households headed by younger persons, prime-working-age persons and old-age persons



d. Growth in the total number of households

The total number of households that are added over a given projection interval equals the difference between the total numbers of households at the end and the beginning of the interval. For the interval 0-5, the growth in the total number of households, 167.9, is obtained as:

$$167.9 = 1,638.7 - 1,470.7, \quad (8)$$

where 1,470.7 and 1,638.7 are, respectively, the total numbers of households at the beginning and the end of the interval (shown in columns corresponding to years 0 and 5, respectively).

e. Growth in the numbers of households headed by persons in broad age groups

The increase in the numbers of households over the interval 0-5 that are headed by persons at different broad age groups are obtained as follows:

The growth in the number of households headed by younger persons is:

$$22.2 = 129.0 - 106.8, \quad (9)$$

where 106.8 and 129.0 are the numbers of households headed by younger persons in years 0 and 5;

The growth in the number of households headed by prime-working-age persons is:

$$118.3 = 1,326.8 - 1,208.5, \quad (10)$$

where 1,208.5 and 1,326.8 are the numbers of households headed by prime-working-age persons in years 0 and 5; and

The growth in the number of households headed by old-age persons is:

$$27.4 = 182.9 - 155.5, \quad (11)$$

where 155.5 and 182.9 are the numbers of households headed by old-age persons in years 0 and 5.

f. Growth in the numbers of households headed by males and females

The increase in the numbers of households over the interval 0-5 headed by males and females are calculated as:

The growth in the number of households headed by males is:

$$144.1 = 1,381.1 - 1,237.0, \quad (12)$$

where 1,237.8 and 1,381.1 are the numbers of households headed by males in years 0 and 5; and

The growth in the number of households headed by females is:

$$23.7 = 257.5 - 233.8, \quad (13)$$

where 233.8 and 257.5 are the numbers of households headed by females in years 0 and 5.

(ii) Average household size

The average household size at the end of a given interval is obtained by dividing the population size by the total number of households. For the end of the interval 0-5, the average number of persons in a household, 6.84, is obtained as:

$$6.84 = 11,210.4 / 1,638.7, \quad (14)$$

where 11,210.4 is the population size in year 5, shown in table 33, and 1,638.7 is the total number of households in the same year, displayed in table 37.

The change in the average household size over the 20-year projection period is shown in figure XVIII.

(iii) Indicators of the structure of households

Indicators of the structure of households that can be calculated as part of a household projection include proportions of households headed by persons in broad age groups and proportions of households headed by males and females.

a. Proportions by broad age groups

These indicators include proportions in the total number of households headed by younger, prime-working-age and old-age persons. For the end of the interval 0-5, these proportions are obtained as follows:

The proportion headed by younger persons is:

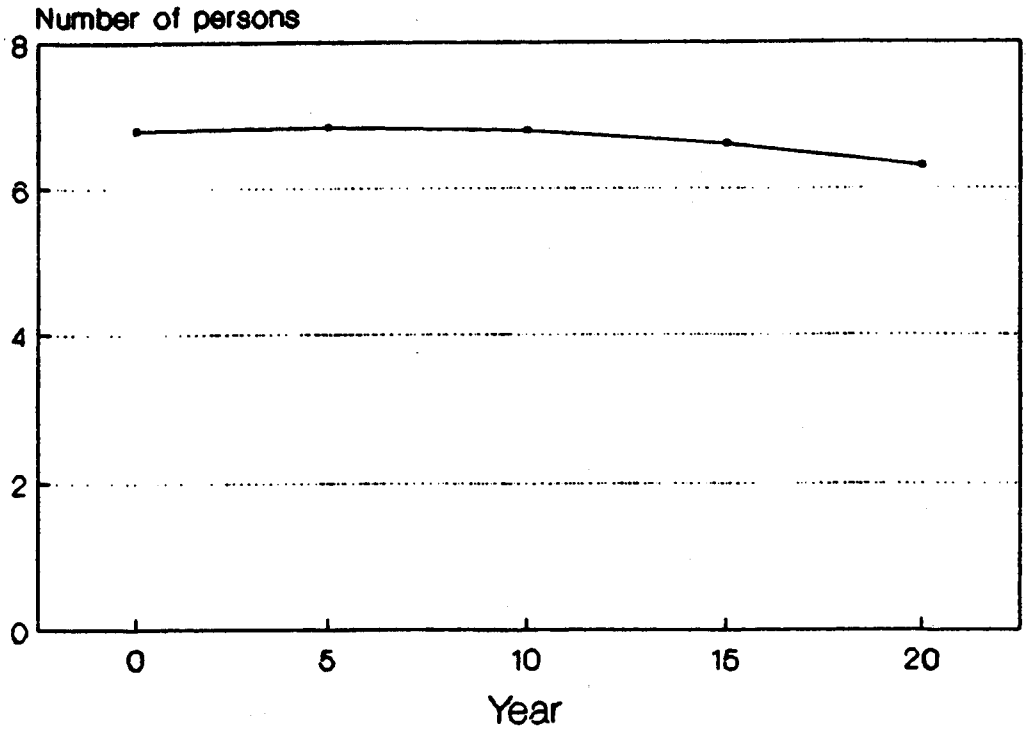
$$0.08 = 129.0 / 1,638.7, \quad (15)$$

where 129.0 and 1,638.7 are, respectively, the number of households headed by younger persons and the total number of households;

The proportion headed by prime-working-age persons is:

$$0.81 = 1,326.8 / 1,638.7, \quad (16)$$

Figure XVIII. Average household size



where 1,326.8 is the number of households headed by prime-working-age persons; and

The proportion headed by old-age persons is:

$$0.11 = 182.9 / 1{,}638.7, \quad (17)$$

where 182.9 is the number of households headed by old-age persons.

b. Proportions by sex

These indicators include proportions of households headed by males and females, respectively. For the end of the interval 0-5, these proportions are as follows:

The proportion headed by males is:

$$0.84 = 1{,}381.1 / 1{,}638.7, \quad (18)$$

where 1,381.1 is the number of households headed by males and 1,638.7 is the total number of households.

The proportion headed by females is:

$$0.16 = 1 - 0.84, \quad (19)$$

where 0.84 is the proportion of households headed by males.

(iv) Rates of growth in the number of households

The rates of growth of the numbers of households are calculated for the total number of households and the numbers of households headed by persons of different broad age groups and sexes.

a. Rate of growth in the total number of households

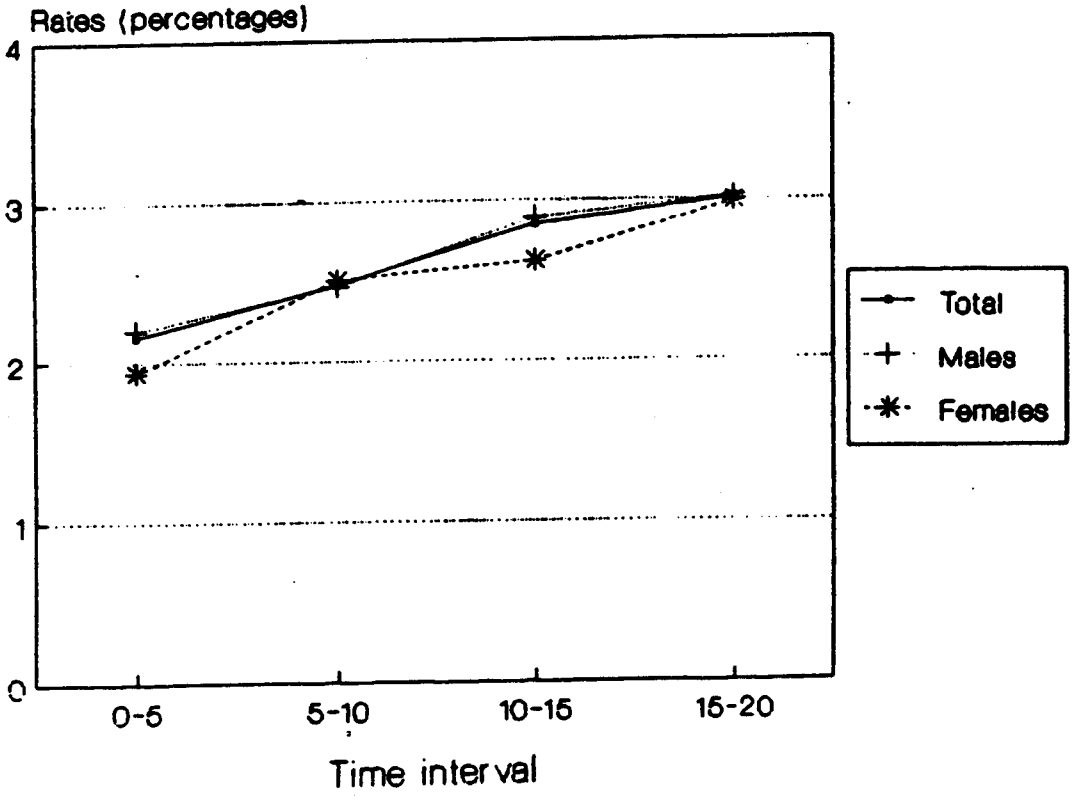
The average annual growth rate of the number of households for a given interval is obtained by the exponential growth rate formula. For the projection interval 0-5, this growth rate, which equals 2.16 (table 37), is obtained as follows:

$$2.16 = [\ \ln (1{,}638.7 / 1{,}470.7) / 5\ ] \cdot 100, \quad (20)$$

where 1,470.7 and 1,638.7 are the total numbers of households in years 0 and 5, respectively, and 5 is the length of the interval.

Rates of growth in the total number of households over the 20-year projection period are shown in figure XIX.

Figure XIX. Rates of growth in the total number of households and in numbers of households headed by males and females



b. Rates of growth in the numbers of households headed by persons in broad age groups

The percentage rates of increase in the numbers of households headed by persons in broad age groups for the interval 0-5 are calculated as follows:

The rate of growth in the number of households headed by younger persons:

$$3.78 = [\ \ln(129.0 / 106.8) / 5\ ] \cdot 100, \qquad (21)$$

where 106.8 and 129.0 are the numbers of households headed by younger persons in years 0-5;

The rate of growth in the number of households headed by prime-working-age persons is:

$$1.87 = [\ \ln(1,326.8 / 1,208.5) / 5\ ] \cdot 100, \qquad (22)$$

where 1,208.5 and 1,326.8 are the numbers of households headed by prime-working-age persons in years 0 and 5; and

The rate of growth in the number of households headed by old-age persons is:

$$3.25 = [\ \ln(182.9 / 155.5)\ ) / 5\ ] \cdot 100, \qquad (23)$$

where 155.5 and 182.9 are the numbers of households headed by old-age persons in years 0 and 5.

The rates of growth in the numbers of households headed by persons in broad age groups are shown in figure XX.

c. Rates of growth in the numbers of households headed by males and females

The percentage rates of increase in the numbers of households headed by persons of different sexes for the interval 0-5 are obtained as:

The rate of growth in the number of households headed by males is:

$$2.20 = [\ \ln(1,381.1 / 1,237.0) / 5\ ] \cdot 100, \qquad (24)$$

where 1,237.0 and 1,381.1 are the numbers of households headed by males in years 0 and 5; and

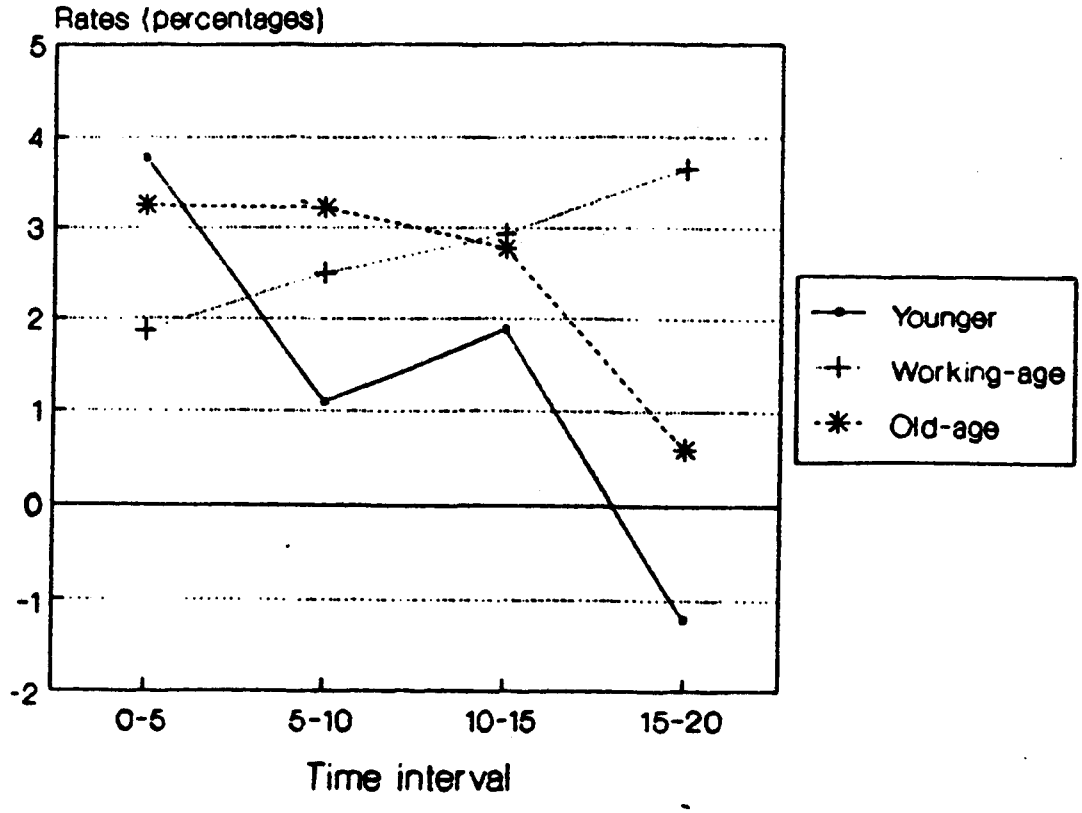
The rate of growth in the number of households headed by females is:

$$1.93 = [\ \ln(257.5 / 233.8) / 5\ ] \cdot 100, \qquad (25)$$

where 233.8 and 257.5 are the numbers of households headed by females in years 0 and 5.

The rates of growth in the numbers of households headed by males and females are indicated in figure XIX.

Figure XX. Rates of growth in numbers of households headed by younger persons, prime-working-age persons and old-age persons



2. Projection for urban and rural areas

The technique for projecting households for urban and rural areas is similar to that for making a household projection for the country as a whole. This example will show how such a projection can be prepared by utilizing the inputs shown in tables 38 through 41. Tables 38 and 39 show the population structures and sizes for urban and rural areas respectively. Tables 40 and 41 present assumptions on headship rates for urban and rural areas respectively.

The example will emphasize calculations which are unique to an urban-rural projection of households.

(a) Household structures

For any given date, such as the end of the projection interval, the structures of households for urban and rural areas are obtained by means of calculations identical to those used as part of the national projection. In the urban-rural projection, however, those calculations are performed for either area. The results referring to males obtained for the end of the 0-5 interval are shown in table 42.

Urban and rural structures of households at dates five years apart can be found by performing those calculations for all relevant dates over a projection period starting with the initial date of the projection. Those structures can be further aggregated across the two locations to obtain the national structures of households. Tables 43, 44 and 45 display urban, rural and national structures, respectively.

(b) Other results

Urban-rural household projections can be used to calculate all those additional results that can be obtained as part of the national projection. Those results. which refer to urban and rural areas as well as the entire country can be calculated by means of steps illustrated above. In addition, in the course of this projection, it is also possible to calculate proportions of households in urban and rural areas, respectively. This section will illustrate how those proportions can be obtained.

(i) Proportions urban and rural

The proportion urban is calculated for the end of a given projection interval as a ratio of the number of households in the urban areas to the total number of households calculated for that date. For the end of the interval 0-5, the proportion urban, 0.41, is obtained as:

$$0.41 = 671.3 / 1,639.5, \qquad (27)$$

where 671.3 is the number of households in urban areas and 1,639.5 is the total number of households at that date.

Table 38. Inputs for projecting households for urban and rural areas; population structures at age 10 and over and population sizes for urban areas

(Thousands)

	Sex	Age group	Year 0	5	10	15	20
(a) Population at age 10 and over, by age and sex							
	Male	10-14	170.0	272.6	285.2	343.5	432.8
		15-19	181.7	279.7	378.8	384.6	447.3
		20-24	201.3	246.1	348.4	446.3	450.7
		25-29	134.5	228.4	277.0	381.7	480.5
		30-34	126.2	162.5	247.3	298.9	406.5
		35-39	109.9	149.9	180.9	259.4	313.8
		40-44	77.7	124.7	163.5	191.3	265.8
		45-49	51.6	85.1	132.9	170.9	196.7
		50-54	59.6	54.7	88.3	136.1	173.3
		55-59	47.1	61.6	55.0	87.9	134.8
		60-64	31.6	47.2	60.5	53.1	84.7
		65-69	26.1	29.8	42.8	54.7	47.9
		70-74	12.8	21.7	25.2	35.5	45.6
		75+	11.2	14.7	22.3	29.4	40.5
	Female	10-14	154.8	215.6	226.8	276.4	359.1
		15-19	137.4	207.7	280.3	284.6	337.4
		20-24	110.9	185.2	270.3	341.3	346.4
		25-29	103.2	145.2	224.4	310.7	386.0
		30-34	102.4	130.8	171.1	247.6	338.0
		35-39	96.7	124.8	151.7	186.3	262.8
		40-44	63.0	111.3	142.4	164.4	196.7
		45-49	50.0	71.5	123.2	153.3	173.2
		50-54	49.2	54.4	77.4	128.8	159.3
		55-59	52.4	52.7	56.9	79.5	130.6
		60-64	33.3	53.4	54.7	56.9	79.1
		65-69	32.6	32.2	50.3	51.5	53.2
		70-74	19.6	27.9	28.4	43.1	44.7
		75+	21.4	24.9	32.7	37.9	50.7
(b) Population size			2983.4	4067.2	5334.3	6697.0	8140.8

Table 39. Inputs for projecting households for urban and rural areas: population structures at age 10 and over and population sizes for rural areas

(Thousands)

	Sex	Age group	Year 0	5	10	15	20
(a) Population at age 10 and over by age and sex							
	Male	10-14	454.0	457.1	442.4	464.4	477.1
		15-19	304.9	338.8	345.8	339.1	357.0
		20-24	200.9	235.5	265.0	273.6	269.1
		25-29	227.0	169.1	200.0	226.9	234.8
		30-34	232.5	193.5	145.5	173.5	197.3
		35-39	202.5	201.7	169.5	128.5	153.7
		40-44	145.9	179.1	180.1	152.6	116.1
		45-49	100.5	129.5	160.5	162.8	138.8
		50-54	132.9	88.3	115.1	144.1	147.4
		55-59	109.9	113.8	76.7	101.2	127.8
		60-64	96.5	89.2	93.9	64.3	85.9
		65-69	64.0	73.7	69.6	74.7	52.0
		70-74	31.4	44.2	52.3	50.7	55.6
		75+	27.4	31.0	40.7	51.7	58.3
	Female	10-14	425.7	469.5	469.4	500.9	512.0
		15-19	310.9	367.1	399.7	407.6	436.5
		20-24	248.9	257.3	299.0	333.7	341.7
		25-29	245.1	209.3	213.3	253.7	284.4
		30-34	249.8	211.6	178.9	185.8	222.0
		35-39	204.2	220.3	185.4	159.3	166.2
		40-44	143.7	182.2	195.8	167.2	144.3
		45-49	106.5	128.7	162.6	177.4	152.0
		50-54	125.4	96.9	115.0	147.4	161.6
		55-59	111.6	109.5	85.0	102.5	132.3
		60-64	92.8	92.6	91.6	72.6	88.5
		65-69	73.0	72.9	73.8	74.8	60.2
		70-74	43.9	52.2	53.3	55.6	57.5
		75+	48.0	48.1	53.9	59.6	65.5
(b) Population size			7016.6	7130.7	7258.1	7433.6	7503.2

Table 40. Inputs for projecting households for urban and rural areas; assumptions on headship rates for urban areas

Sex	Age group	Headship rates: year 0	5	10	15	20
Male	10-14	0.0323	0.0323	0.0258	0.0258	0.0194
	15-19	0.0645	0.0645	0.0581	0.0581	0.0516
	20-24	0.0968	0.0968	0.0903	0.0903	0.0839
	25-29	0.4839	0.4839	0.4839	0.4839	0.4839
	30-34	0.5161	0.5161	0.5226	0.5226	0.5290
	35-39	0.5484	0.5484	0.5548	0.5548	0.5613
	40-44	0.5613	0.5613	0.5677	0.5677	0.5742
	45-49	0.5742	0.5742	0.5806	0.5806	0.5871
	50-54	0.5806	0.5806	0.5871	0.5871	0.5935
	55-59	0.5742	0.5742	0.5806	0.5806	0.5871
	60-64	0.5484	0.5484	0.5548	0.5548	0.5613
	65-69	0.5161	0.5161	0.5226	0.5226	0.5290
	70-74	0.4839	0.4903	0.4968	0.5032	0.5097
	75+	0.4516	0.4581	0.4645	0.4710	0.4774
Female	10-14	0.0032	0.0032	0.0026	0.0026	0.0019
	15-19	0.0065	0.0065	0.0052	0.0052	0.0039
	20-24	0.0129	0.0129	0.0116	0.0116	0.0103
	25-29	0.0194	0.0194	0.0129	0.0129	0.0065
	30-34	0.0258	0.0258	0.0194	0.0194	0.0129
	35-39	0.0645	0.0645	0.0645	0.0645	0.0645
	40-44	0.0968	0.0968	0.1032	0.1032	0.1097
	45-49	0.1290	0.1290	0.1355	0.1355	0.1419
	50-54	0.1935	0.1935	0.2000	0.2000	0.2065
	55-59	0.2258	0.2258	0.2323	0.2323	0.2387
	60-64	0.2581	0.2581	0.2645	0.2645	0.2710
	65-69	0.2774	0.2774	0.2839	0.2839	0.2903
	70-74	0.2903	0.2903	0.2968	0.2968	0.3032
	75+	0.3032	0.3032	0.3097	0.3097	0.3161

Table 41. Inputs for projecting households for urban and rural areas: assumptions on headship rates for rural areas

Sex	Age group	Headship rates: year 0	5	10	15	20
Male	10-14	0.0455	0.0455	0.0390	0.0390	0.0325
	15-19	0.0714	0.0714	0.0649	0.0649	0.0584
	20-24	0.1104	0.1104	0.1039	0.1039	0.0974
	25-29	0.5065	0.5065	0.5065	0.5065	0.5065
	30-34	0.5519	0.5519	0.5584	0.5584	0.5649
	35-39	0.5779	0.5779	0.5844	0.5844	0.5909
	40-44	0.5844	0.5844	0.5909	0.5909	0.5974
	45-49	0.5974	0.5974	0.6038	0.6038	0.6103
	50-54	0.5974	0.5974	0.6038	0.6038	0.6103
	55-59	0.5844	0.5844	0.5909	0.5909	0.5974
	60-64	0.5649	0.5649	0.5714	0.5714	0.5779
	65-69	0.5519	0.5519	0.5584	0.5584	0.5649
	70-74	0.5065	0.5065	0.5129	0.5129	0.5194
	75+	0.4870	0.4935	0.5000	0.5065	0.5129
Female	10-14	0.0006	0.0006	0.0006	0.0006	0.0006
	15-19	0.0032	0.0032	0.0026	0.0026	0.0019
	20-24	0.0058	0.0058	0.0052	0.0052	0.0045
	25-29	0.0130	0.0130	0.0065	0.0065	0.0032
	30-34	0.0195	0.0195	0.0130	0.0130	0.0065
	35-39	0.0455	0.0455	0.0455	0.0455	0.0455
	40-44	0.0779	0.0779	0.0844	0.0844	0.0909
	45-49	0.1104	0.1104	0.1169	0.1169	0.1234
	50-54	0.1753	0.1753	0.1818	0.1818	0.1883
	55-59	0.2143	0.2143	0.2208	0.2208	0.2273
	60-64	0.2402	0.2402	0.2467	0.2467	0.2532
	65-69	0.2597	0.2597	0.2662	0.2662	0.2727
	70-74	0.2727	0.2727	0.2792	0.2792	0.2857
	75+	0.2922	0.2922	0.2987	0.2987	0.3052

Table 42. Computing structures of households headed by males, by age of household head; results for urban and rural areas; end of projection interval 0-5

Location	Age group	Population at age 10 and over in year 5 a/ (thousands)	Headship rates in year 5 b/	Households in year 5 c/ (thousands)
(1)	(2)	(3)	(4)	(5)
Urban	10-14	272.6	0.0323	8.8
	15-19	279.7	0.0645	18.0
	20-24	246.1	0.0968	23.8
	25-29	228.4	0.4839	110.5
	30-34	162.5	0.5161	83.9
	35-39	149.9	0.5484	82.2
	40-44	124.7	0.5613	70.0
	45-49	85.1	0.5742	48.9
	50-54	54.7	0.5806	31.8
	55-59	61.6	0.5742	35.4
	60-64	47.2	0.5484	25.9
	65-69	29.8	0.5161	15.4
	70-74	21.7	0.4903	10.6
	75+	14.7	0.4581	6.7
Rural	10-14	457.1	0.0455	20.8
	15-19	338.8	0.0714	24.2
	20-24	235.5	0.1104	26.0
	25-29	169.1	0.5065	85.6
	30-34	193.5	0.5519	106.8
	35-39	201.7	0.5779	116.6
	40-44	179.1	0.5844	104.7
	45-49	129.5	0.5974	77.4
	50-54	88.3	0.5974	52.7
	55-59	113.8	0.5844	66.5
	60-64	89.2	0.5649	50.4
	65-69	73.7	0.5519	40.7
	70-74	44.2	0.5065	22.4
	75+	31.0	0.4935	15.3

a/ From tables 38 and 39.
b/ From tables 40 and 41.
c/ (Col. 3) . (Col. 4).

Table 43. Projected numbers of households, by age and sex of household head in urban areas

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	10-14	5.5	8.8	7.4	8.9	8.4
	15-19	11.7	18.0	22.0	22.3	23.1
	20-24	19.5	23.8	31.5	40.3	37.8
	25-29	65.1	110.5	134.0	184.7	232.5
	30-34	65.1	83.9	129.2	156.2	215.1
	35-39	60.3	82.2	100.4	143.9	176.1
	40-44	43.6	70.0	92.8	108.6	152.6
	45-49	29.6	48.9	77.2	99.2	115.5
	50-54	34.6	31.8	51.8	79.9	102.9
	55-59	27.0	35.4	31.9	51.0	79.1
	60-64	17.3	25.9	33.6	29.5	47.5
	65-69	13.5	15.4	22.4	28.6	25.3
	70-74	6.2	10.6	12.5	17.9	23.2
	75+	5.1	6.7	10.4	13.8	19.3
Female	10-14	0.5	0.7	0.6	0.7	0.7
	15-19	0.9	1.3	1.4	1.5	1.3
	20-24	1.4	2.4	3.1	4.0	3.6
	25-29	2.0	2.8	2.9	4.0	2.5
	30-34	2.6	3.4	3.3	4.8	4.4
	35-39	6.2	8.1	9.8	12.0	17.0
	40-44	6.1	10.8	14.7	17.0	21.6
	45-49	6.5	9.2	16.7	20.8	24.6
	50-54	9.5	10.5	15.5	25.8	32.9
	55-59	11.8	11.9	13.2	18.5	31.2
	60-64	8.6	13.8	14.5	15.1	21.4
	65-69	9.0	8.9	14.3	14.6	15.4
	70-74	5.7	8.1	8.4	12.8	13.6
	75+	6.5	7.6	10.1	11.7	16.0

Table 44. Projected numbers of households, by age and sex of household head in rural areas

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	10-14	20.6	20.8	17.2	18.1	15.5
	15-19	21.8	24.2	22.5	22.0	20.9
	20-24	22.2	26.0	27.5	28.4	26.2
	25-29	115.0	85.6	101.3	114.9	118.9
	30-34	128.3	106.8	81.2	96.9	111.5
	35-39	117.0	116.6	99.1	75.1	90.8
	40-44	85.3	104.7	106.4	90.2	69.4
	45-49	60.0	77.4	96.9	98.3	84.7
	50-54	79.4	52.7	69.5	87.0	90.0
	55-59	64.2	66.5	45.3	59.8	76.3
	60-64	54.5	50.4	53.7	36.7	49.6
	65-69	35.3	40.7	38.9	41.7	29.4
	70-74	15.9	22.4	26.8	26.0	28.9
	75+	13.3	15.3	20.3	26.2	29.9
Female	10-14	0.3	0.3	0.3	0.3	0.3
	15-19	1.0	1.2	1:0	1.1	0.9
	20-24	1.5	1.5	1.6	1.7	1.6
	25-29	3.2	2.7	1.4	1.6	0.9
	30-34	4.9	4.1	2.3	2.4	1.4
	35-39	9.3	10.0	8.4	7.2	7.6
	40-44	11.2	14.2	16.5	14.1	13.1
	45-49	12.0	14.2	19.0	20.7	18.8
	50-54	22.0	17.0	20.9	26.8	30.4
	55-59	23.9	23.5	18.8	22.6	30.1
	60-64	22.3	22.2	22.6	17.9	22.4
	65-69	19.0	18.9	19.6	19.9	16.4
	70-74	12.0	14.2	14.9	15.5	16.4
	75+	14.0	14.1	16.1	17.8	20.0

Table 45. Projected numbers of households, by age and sex for the entire country, obtained in the course of projecting households for urban and rural areas

(Thousands)

Sex	Age group	Year				
		0	5	10	15	20
Male	10-14	26.1	29.6	24.6	27.0	23.9
	15-19	33.5	42.2	44.4	44.3	43.9
	20-24	41.7	49.8	59.0	68.7	64.0
	25-29	180.0	196.2	235.3	299.6	351.4
	30-34	193.5	190.7	210.5	253.1	326.5
	35-39	177.3	198.8	199.4	219.0	266.9
	40-44	128.9	174.7	199.2	198.8	222.0
	45-49	89.7	126.2	174.1	197.5	200.2
	50-54	114.0	84.5	121.3	166.9	192.8
	55-59	91.3	101.9	77.3	110.8	155.5
	60-64	71.8	76.3	87.2	66.2	97.2
	65-69	48.8	56.1	61.2	70.3	54.7
	70-74	22.1	33.0	39.3	43.9	52.1
	75+	18.4	22.0	30.7	40.0	49.2
Female	10-14	0.8	1.0	0.9	1.0	1.0
	15-19	1.9	2.5	2.5	2.5	2.2
	20-24	2.9	3.9	4.7	5.7	5.1
	25-29	5.2	5.5	4.3	5.7	3.4
	30-34	7.5	7.5	5.6	7.2	5.8
	35-39	15.5	18.1	18.2	19.3	24.5
	40-44	17.3	25.0	31.2	31.1	34.7
	45-49	18.4	23.4	35.7	41.5	43.3
	50-54	31.5	27.5	36.4	52.6	63.3
	55-59	35.7	35.4	32.0	41.1	61.2
	60-64	30.9	36.0	37.1	33.0	43.8
	65-69	28.0	27.9	33.9	34.5	31.9
	70-74	17.7	22.3	23.3	28.3	30.0
	75+	20.5	21.6	26.2	29.5	36.0

The proportion rural, 0.59, is calculated as a complement of the proportion urban:

$$0.59 = 1 - 0.41, \tag{28}$$

where 0.41 is the proportion urban.

These proportions along with all other results for the entire projection interval are shown in tables 46, 47 and 48, which respectively refer to the urban and rural areas and the entire country.

E. Summary

This chapter has discussed the utility of projections of households and described the headship rate method for preparing such projections at the national or urban-rural level. As part of the description of the method, the procedures used in making national and urban-rural projections have been presented. In addition, the types of inputs required by the method have been described along with a discussion relating to the preparation of the inputs. Lastly, two examples of projections--national and urban-rural--have been discussed. A complete listing of the outputs that can be generated by the method is shown in box 32.

Table 46. Households aggregates, indicators of the structure of households and rates of growth in the numbers of households in urban areas

Indicators	Year 0	5	10	15	20
Household aggregates (thousands)					
Numbers of households headed by:					
(Totals)	481.5	671.3	885.6	1148.0	1464.6
Younger-persons	39.5	55.1	66.0	77.7	74.8
Prime-working-age persons	396.1	558.9	741.5	970.9	1276.6
Old-age persons	45.9	57.3	78.1	99.4	112.9
Males	404.1	571.9	757.0	984.9	1258.5
Females	77.4	99.5	128.6	163.1	206.1
Growth in numbers of households headed by:					
(Totals)	189.8	214.3	262.4	316.6	
Younger-persons	15.6	10.9	11.7	-2.9	
Prime-working-age persons	162.8	182.6	229.4	305.7	
Old-age persons	11.4	20.8	21.3	13.5	
Males	167.8	185.1	227.9	273.6	
Females	22.1	29.1	34.5	43.0	
Average household size	6.20	6.06	6.02	5.83	5.56
Proportions of households headed by:					
Younger persons	0.08	0.08	0.07	0.07	0.05
Prime-working-age persons	0.82	0.83	0.84	0.85	0.87
Old-age	0.10	0.09	0.09	0.09	0.08
Males	0.84	0.85	0.85	0.86	0.86
Females	0.16	0.15	0.15	0.14	0.14
Rates of growth in numbers of households headed by:					
(Totals)	6.65	5.54	5.19	4.87	
Younger persons	6.66	3.61	3.26	-0.76	
Prime-working-age persons	6.89	5.65	5.39	5.47	
Old-age	4.44	6.19	4.82	2.55	
Males	6.95	5.61	5.26	4.90	
Females	5.02	5.13	4.75	4.68	

Table 47. Households aggregates, indicators of the structure of households and rates of growth in the numbers of households in rural areas

Indicators	Year				
	0	5	10	15	20
Household aggregates (in thousands)					
Numbers of households headed by:					
(Totals)	989.3	968.1	970.1	991.2	1022.2
Younger persons	67.3	74.0	70.1	71.7	65.3
Prime-working-age persons	812.4	768.6	763.3	772.4	815.9
Old-age persons	109.5	125.6	136.7	147.1	141.0
Males	832.9	810.0	806.6	821.3	841.9
Females	156.4	158.2	163.5	169.8	180.3
Growth in numbers of households headed by:					
(Totals)		-21.1	2.0	21.1	31.0
Younger persons		6.7	-3.9	1.6	-6.4
Prime-working-age persons		-43.8	-5.3	9.1	43.5
Old-age persons		16.1	11.1	10.4	-6.1
Males		-22.9	-3.4	14.7	20.6
Females		1.8	5.3	6.3	10.5
Average household size	7.09	7.37	7.48	7.50	7.34
Proportions of households headed by:					
Younger persons	0.07	0.08	0.07	0.07	0.06
Prime-working-age persons	0.82	0.79	0.79	0.78	0.80
Old-age persons	0.11	0.13	0.14	0.15	0.14
Males	0.84	0.84	0.83	0.83	0.82
Females	0.16	0.16	0.17	0.17	0.18
Rates of growth in numbers of households headed by:					
(Totals)		-0.43	0.04	0.43	0.62
Younger persons		1.90	-1.08	0.45	-1.87
Prime-working-age persons		-1.11	-0.14	0.24	1.10
Old-age persons		2.74	1.69	1.47	-0.85
Males		-0.56	-0.08	0.36	0.50
Females		0.23	0.66	0.76	1.20

Table 48. Households aggregates, indicators of the structure and distribution of households, and rates of growth in the numbers of households for the entire country, obtained in the course of projecting households for urban and rural areas

Indicators	Year				
	0	5	10	15	20
Household aggregates (thousands)					
Numbers of households headed by:					
(Totals)	1470.8	1639.4	1855.7	2139.2	2486.7
Younger persons	106.8	129.0	136.1	149.3	140.1
Prime-working-age persons	1208.5	1327.5	1504.9	1743.3	2092.7
Old-age persons	155.5	182.9	214.7	246.6	253.9
Males	1237.0	1381.8	1563.7	1806.2	2100 4
Females	233.8	257.6	292.0	333.0	386.3
Growth in numbers of households headed by:					
(Totals)		168.7	216.2	283.5	347.6
Younger persons		22.2	7.1	13.2	-9.2
Prime-working-age persons		119.0	177.4	238.4	349.4
Old-age persons		27.4	31.8	31.9	7.3
Males		144.8	181.9	242.5	294.2
Females		23.8	34.4	41.0	53.3
Average household size	6.80	6.83	6.79	6.61	6.29
Proportions of households headed by:					
Younger persons	0.07	0.08	0.07	0.07	0.06
Prime-working-age persons	0.82	0.81	0.81	0.81	0.84
Old-age persons	0.11	0.11	0.12	0.12	0.10
Males	0.84	0.84	0.84	0.84	0.84
Females	0.16	0.16	0.16	0.16	0.16
Proportions of households					
Urban	0.33	0.41	0.48	0.54	0.59
Rural	0.67	0.59	0.52	0.46	0.41
Rates of growth in numbers of households headed by:					
(Totals)		2.17	2.48	2.84	3.01
Younger persons		3.78	1.07	1.85	-1.27
Prime-working-age persons		1.88	2.51	2.94	3.65
Old-age persons		3.25	3.21	2.77	0.58
Males		2.21	2.47	2.88	3.02
Females		1.94	2.51	2.63	2.97

Box 32

Outputs of the headship rate method

1. Structure of households by age and sex of household head (national or urban, rural and national)

2. Households aggregates (national or urban, rural and national)

Total number of households

Numbers of households headed by:
- Younger persons
- Prime-working-age persons
- Old-age persons

Numbers of households headed by:
- Males
- Females

Growth in the total number of households

Growth in the numbers of households headed by:
- Younger persons
- Prime-working-age persons
- Old-age persons

Growth in the numbers of households headed by:
- Males
- Females

3. Average household sizes (national or urban, rural and national)

4. Indicators of the structure of households (national or urban, rural and national)

Proportions of households headed by:
- Younger persons
- Prime-working-age persons
- Old-age persons

(continued)

Box 32 (continued)

Proportions of households headed by:
- Males
- Females

5. Indicators of the rural-urban distribution of households (national only, if urban and rural households are being projected)

Proportions of households:
- Urban
- Rural

6. Rates of change in the numbers of households (national or urban, rural and national)

Rate of growth in the total numbers of households

Rates of growth in the numbers of households headed by:
- Younger persons
- Prime-working-age persons
- Old-age persons

Rates of growth in the numbers of households headed by:
- Males
- Females

F. Notation and equations

1. Indices, variables and special symbols

(a) List of indices

a = 3,...,16	are five-year age groups 10-14,...,75+
k = 1,2	are urban and rural areas
s = 1,2	are male and female sexes
t	is the year of the projection period

(b) List of variables

AHS(t+5)	is the average household size at the end of the interval
GRHF	is the growth rate of the number of households headed by females for the interval
GRHH	is the growth rate of the number of households for the interval
GRHM	is the growth rate of the number of households headed by males for the interval
GRHO	is the growth rate of the number of households headed by old-age persons for the interval
GRHP	is the growth rate of the number of households headed by prime-working-age persons for the interval
GRHY	is the growth rate of the number of households headed by younger persons for the interval
HFGR	is the growth in the number of households headed by females over the interval
HHGR	is the growth in the number of households during the interval
HMGR	is the growth in the number of households headed by males over the interval
HOGR	is the growth in the number of households headed by old-age persons during the interval

HPGR	is the growth in the number of households headed by prime-working-age persons during the interval
HR(a,s,k,t+5)	is the headship rate among persons of age group a and sex s in location k at the end of the interval
HR(a,s,t+5)	is the headship rate among persons of age group a and sex s at the end of the interval
HRUR(t+5)	is the the proportion of the total number of households in rural areas at the end of the interval
HURB(t+5)	is the proportion of the total number of households in urban areas at the end of the interval
HYGR	is the growth in the number of households headed by younger persons during the interval
NH(a,s,k,t+5)	is the number of households headed by persons of age group a and sex s in location k at the end of the interval
NH(a,s,t+5)	is the number of households headed by persons of age group a and sex s at the end of the interval
NH(k,t+5)	is the number of households in location k at the end of the interval
NH(t+5)	is the total number of households at the end of the interval
NHF(t+5)	is the number of households headed by females at the end of the interval
NHM(t+5)	is the number of households headed by males at the end of the interval
NHO(t+5)	is the number of households headed by old-age persons at the end of the interval
NHP(t+5)	is the number of households headed by prime-working-age persons at the end of the interval
NHY(t+5)	is the number of households headed by younger persons at the end of the interval
PHF(t+5)	is the proportion of households headed by females at the end of the interval
PHM(t+5)	is the proportion of households headed by males at the end of the interval

PHO(t+5)	is the proportion of households headed by old-age persons at the end of the interval
PHP(t+5)	is the proportion of households headed by prime-working-age persons at the end of the interval
PHY(t+5)	is the proportion of households headed by younger persons at the end of the interval
POP(a,s,k,t+5)	is the population of age group a and sex s in location k at the end of the interval
POP(a,s,t+5)	is the population of age group a and sex s at the end of the interval
POP(t+5)	is the population size at the end of the interval

(c) Special symbols

ln	is the natural logarithm

2. Equations

National level

(a) Household structure

$$NH(a,s,t+5) = POP(a,s,t+5) \cdot HR(a,s,t+5); \quad (1)$$

$$a = 3,\ldots,16;$$

$$s = 1,2$$

(b) Other results

(i) Household aggregates

a. The total number of households

$$NH(t+5) = \sum_{a=3}^{16} \sum_{s=1}^{2} NH(a,s,t+5) \quad (2)$$

b. Numbers of households headed by persons in broad age groups

i. The number of households headed by younger persons

$$NHY(t+5) = \sum_{a=3}^{5} \sum_{s=1}^{2} NH(a,s,t+5) \quad (3)$$

ii. The number of households headed by prime-working-age persons

$$NHP(t+5) = \sum_{a=6}^{13} \sum_{s=1}^{2} NH(a,s,t+5) \quad (4)$$

iii. The number of households headed by old-age persons

$$NHO(t+5) = \sum_{a=14}^{16} \sum_{s=1}^{2} NH(a,s,t+5) \quad (5)$$

c. Numbers of households headed by males and females

i. The number of households headed by males

$$NHM(t+5) = \sum_{a=3}^{16} NH(a,1,t+5) \quad (6)$$

ii. The number of households headed by females

$$NHF(t+5) = NH(t+5) - NHM(t+5) \quad (7)$$

d. Growth in the total number of households

$$HHGR = NH(t+5) - NH(t) \quad (8)$$

e. Growth in the numbers of households headed by persons in broad age groups

$$HYGR = NHY(t+5) - NHY(t) \quad (9)$$

$$HPGR = NHP(t+5) - NHP(t) \quad (10)$$

$$HOGR = NHO(t+5) - NHO(t) \quad (11)$$

f. Growth in the numbers of households headed by males and females

$$HMGR = NHM(t+5) - NHM(t) \quad (12)$$

$$HFGR = NHF(t+5) - NHF(t) \quad (13)$$

(ii) Average household size

$$AHS(t+5) = POP(t+5) / NH(t+5) \quad (14)$$

(iii) Indicators of the structure of households

a. Proportions by broad age groups

$$PHY(t+5) = NHY(t+5) / NH(t+5) \quad (15)$$

$$PHP(t+5) = NHP(t+5) / NH(t+5) \quad (16)$$

$$PHO(t+5) = NHO(t+5) / NH(t+5) \quad (17)$$

b. Proportions by sex

$$PHM(t+5) = NHM(t+5) / NH(t+5) \quad (18)$$

$$PHF(t+5) = 1 - PNM(t+5) \quad (19)$$

(iv) Rates of growth of the numbers of households

a. Rate of growth in the total number of households

$$GRHH = [\ \ln(\ NH(t+5)/NH(t)\ )\ /\ 5\ ]\ \cdot\ 100 \quad (20)$$

b. The rates of growth in the numbers of households headed by persons in broad age groups

$$GRHY = [\ \ln(\ NHY(t+5)/NHY(t)\ )\ /\ 5\ ]\ \cdot\ 100 \quad (21)$$

$$GRHP = [\ \ln(\ NHP(t+5)/NHP(t)\ )\ /\ 5\ ]\ \cdot\ 100 \quad (22)$$

$$GRHO = [\ \ln(\ NHO(t+5)/NHO(t)\ )\ /\ 5\ ]\ \cdot\ 100 \quad (23)$$

c. Rates of growth in the numbers of households headed by males and females

$$GRHM = [\ \ln (NHM(t+5) / NHM(t)) / 5] \cdot 100 \quad (24)$$

$$GRHF = [\ \ln (NHF(t+5) / NHF(t)) / 5] \cdot 100 \quad (25)$$

Urban-rural level

(a) Household structures

$$NH(a,s,k,t+5) = POP(a,s,k,t+5) \cdot HR(a,s,k,t+5); \quad (26)$$

$a = 3,\ldots,16;$

$s = 1,2,$

$k = 1,2$

(b) Other results

(i) Proportions urban and rural

$$HURB(t+5) = NH(1,t+5) / NH(t+5) \quad (27)$$

$$HRUR(t+5) = 1 - HURB(t+5) \quad (28)$$

Notes

1/ An example of this version is the one used by the United States Bureau of the Census, which is described in United States Bureau of the Census, "Projections of the number of households and families: 1986 and 2000", Population Estimates and Projections, Series p-25, No. 986 (Washington, D.C., 1986).

2/ This description of the headship rate method assumes that the numbers of persons living in institutions rather than households are relatively small and can be ignored in projections. This assumption, which is representative of the conditions that exist in many developing countries, is used in order to avoid dealing separetely with projections of "private" and "institutional" households. Such a projection would require separate projections of non-institutional and institutional populations along with assumptions on headship rates for the private and institutional households.

3/ Recent studies seeking to explain variations in headship rates using socio-economic variables, such as household income and urbanization, indicate the importance of these variables for household formation. Several of these studies are cited in Shigemi Kono, loc.cit., p.288.

4/ The age and sex structures of the population along with the population sizes used in this example are expressed in units of one thousand. Therefore, the projected numbers of households are also given in thousands.

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GLOSSARY

Age-specific fertility rate
The number of births occurring during a specified period to women of a given age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the given age is usually divided by the mid-year population of women of that age.

Age-specific mortality rate
The number of deaths occurring during a specified period to persons (usually specified by sex) of a specified age or age group, divided by the number of person-years-lived during that period by the persons of that age or age group. When an age-specific mortality rate is calculated for a calendar year, the number of deaths to persons of the specified age is usually divided by the mid-year population of persons of that age.

Age-specific net international migration rate
The net gain or loss to the survivors of a given age or age group at the end of a specified period due to international migration occurring during that period divided by the number of survivors of that age or age group.

Age-specific net internal migration rate
The net gain or loss to the survivors of a given age or age group within a given location, such as urban or rural areas at the end of a specified period due to internal migration occurring during that period, divided by the number of survivors of that age or age group within that location.

Asset formation
Additions to assets such as land, physical capital and human capital that households, corporations or government own.

Average household size
The mean number of members per household.

Average labour productivity
The level of output per unit of labour input, usually measured as output per person-hour or person-year.

Average propensity to consume
For the economy, this is the proportion of national income devoted to consumption. Similarly, the average propensity to consume of an individual or a population group is the proportion of the individual's or group's income which is devoted to consumption.

Average savings ratio
For the economy, this is the proportion of national income devoted to savings. Similarly, the average savings ratio of an individual or a population group is the proportion of the individual's or group's disposable income which is saved. The savings ratio is sometimes used synonymously with the average propensity to save.

Capital formation
Additions to the stock of physical capital. Two types of capital formation are distinguished--gross and net. The former includes replenishment of inventories, depreciation, repairs and maintenance expenditure while the latter excludes them.

Capital income
Income of different kinds, including profits, dividends and interest, accruing to physical capital and financial claims in return for services rendered by those forms of capital.

Capital market
The market for long-term loanable funds as distinct from the money market, which deals in short-term funds. In principle, capital market loans are used by industry and commerce for fixed investment. The capital market is not one institution, but all those institutions that canalize the supply of long-term funds.

Capital stock
The total amount of machines, equipment and buildings, as well as inventory existing at any one time, in a firm, industry or economy.

Capital-intensive
A process of production using proportionately more capital than other factors of production, such as labour.

Central planning
A type of development planning where government determines what shall be produced by various sectors of the economy, at which prices, and how factors of production shall be allocated among different users. The provisions of the plan, which is prepared at the centre, are mandated to the various sectors.

Childbearing span
The age span within which women are capable of bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

Cohort
A group of individuals who experienced the same class of events in the same period. Thus a birth or age cohort is a group of people born during a particular time period.

Commodity markets
Markets in which commodities are bought and sold through a process that determines prices and quantities of commodities traded.

Comprehensive planning
A form of development planning, sometimes referred to as aggregative, global or overall planning which covers most or all sectors of the economy. This planning, unlike sectoral planning, is concerned with a full range of variables, including aggregate output, household and government consumption, savings and investment, imports and exports, employment and incomes.

Corporate investment demand
The amount of money which corporations spend on capital goods over a specified time period in order to replace and/or augment their capital stock.

Crude birth rate
The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per 1,000 population.

Crude death rate
The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per 1,000 population.

Crude net internal migration rate
The net change (loss or gain) to the population residing within a given geographical or residential location due to internal migration during a specified period, divided by the number of person-years-lived by the population of that location during the same period. It is frequently expressed as net change due to internal migration per 1,000 population.

Crude net international migration rate
The net change (loss or gain) to the population due to international migration during a specified period, divided by the number of person-years-lived by the population during the same period. It is frequently expressed as net change due to international migration per 1,000 population.

Disposable income
The income of a particular type of institution, such as household, corporation or government, after taxes or transfers, whichever is appropriate, which is available for consumption or savings.

Dynamics
That part of economics which is concerned with analysing the movement of economic systems through time. The "economic systems" concerned may be a market, a firm, the economy as a whole or even a whole set of interrelated economies.

Economic planning model
A mathematical representation of key economic variables and their relationships, normally used to prepare projections of output, use of productive factors, components of final demand etc.; it may be either sectoral or aggregate.

Enrolment ratio
The number of students attending a given school level, divided by the total number of persons of the age normally in school at that level.

Expectation of life at birth
The average number of years a member of a cohort of births would be expected to live if the cohort were subject to the mortality conditions specified by a particular set of age specific mortality rates. It is denoted by the symbol e_0 in the life table notation.

Expectation of life at exact age x
The average number of years a person of exact age x would be expected to live if subjected to the mortality conditions specified by a particular set of age-specific mortality rates at age x and above. It is denoted by the symbol e_x in the life table notation.

Export demand
The amount of money that foreign buyers spend over a specified time period on commodities of a particular economy.

Factor income
The income accruing to a particular factor of production in return for services rendered by that factor. Examples of factor incomes are capital income and labour income.

Factor markets
Markets in which services of factors of production are bought and sold through a process that determines prices and quantities of those services traded. In aggregate terms, for instance, the labour market or the capital market.

Factorial distribution
The distribution of income among various factors of production in return for services rendered by those factors.

Factors of production
Resources or inputs required to produce a good or service. Basic categories of factors of production are land, labor, and capital.

Family
A group of two or more persons related by birth, marriage or adoption and residing together.

Full employment
A state of the economy where only frictional unemployment exists, and everyone else who wishes to work at the going wage rate for the given type of labour is employed. Frictional unemployment reflects the time needed to switch from one job to another.

Government consumption
The amount of money that government spends on goods and services over a specified time period, other than that needed to replace and/or expand facilities.

Government investment
The amount of money that government spends on goods and services over a specified time period in order to replace and/or expand facilities.

Government savings
The portion of government disposable income not expended on current operations. It represents a measure of the amount available to the government for investment.

Gross business savings
The residual of net income accruing to corporations, after payments are made in various forms such as dividends and direct corporate taxes. It is usually kept by incorporated businesses as reserves and depreciation allowance or to finance new investment. It represents a measure of the amount available to corporations for investment.

Headship rate
The number of heads of households in a given age, sex and/or marital status category, divided by the corresponding number of persons within the same category.

Household
A single person living alone or a group voluntarily living together, having common housekeeping arrangements for supplying basic living needs, such as principal meals. The group may consist of related or unrelated persons.

Household consumption
The value of "final" goods and services consumed by households over a specified time period to meet their various consumption needs.

Household consumption demand
The amount of money that households are willing to spend on final goods and services over a specified time period to meet various consumption needs.

Household head
A member of the household in whose name the housing unit occupied by the household is owned, rented or maintained. If there is no such person, the household head can be any other adult member of the household.

Household income
The flow of money or goods accruing to a household over a specified time period.

Household investment demand

The amount of money that households are willing to spend on final goods and services over a specified time period that are used either as capital goods or as inputs in housing construction.

Household savings

The portion of household disposable income that is not spent on consumption over a specified time period.

Human capital

Productive investments embodied in human persons. These include skills, abilities, ideals, health etc. that result from expenditures on education, on-the-job training and medical care.

Income elasticity of consumption

The responsiveness of expenditure on a commodity or a group of commodities to changes in the consumer's income, measured by the proportionate change in expenditure divided by the proportionate change in income.

Income elasticity of demand

The responsiveness of the quantity demanded of a commodity or a group of commodities to changes in the consumer's income, measured by the proportionate change in quantity demanded by the proportionate change in income.

Income elasticity of savings

The responsiveness of the amount of money saved to changes in the consumer's income, measured by the proportionate change in savings divided by the proportionate change in income.

Indicative planning

A type of development planning where the government, in co-operation with the private sector, sets broad targets for the economy and defines policies to achieve those targets, including the allocation of public sector resources among the various users. The provisions of the plan are binding for the public sector but indicative for the private sector.

Indirect taxes

Taxes levied on goods and services purchased by consumers and exported by producers, for which the taxpayer's liability varies in proportion to the quantity of particular goods purchased or sold. Examples of indirect taxes are customs duties (tariffs), excise duties, sales taxes and export duties.

Infant mortality rate

The ratio of the number of deaths under one year of age occurring in a given year to the number of births in the same year. Also used in a more rigorous sense to mean the number of deaths that would occur under one year of age in a life table with a radix of 1,000, in which sense it is denoted by the symbol $_1q_0$.

Inter-birth interval
Time elapsed between successive births.

Intermediate demand
The amount of money that producers spend over a specified time period on goods and services that are used as inputs into production of other goods and services, rather than for final consumption.

Internal migration
Movements of population within the national boundaries involving relatively permanent changes in residence. It is designated as out-migration from the standpoint of the location from which the movement occurs and as in-migration from that of the receiving nation.

International migration
Movements of population across national boundaries. It is designated as emigration from the standpoint of the nation from which the movement occurs and as immigration from that of the receiving nation.

Investment
Expenditure incurred over a specified time period on capital goods with the view to replacing and/or augmenting the existing physical capital. In macro-economic terms, "gross" investment refers to the total expenditure on new capital goods, while "net" investment refers to the additional capital goods produced in excess of those that wear out and need to be replaced.

Investment costs
Costs incurred in connection with accumulating inventory, installing new equipment or facilities and/or replacing the existing ones.

Labour force
Economically active persons, including armed forces and the unemployed, but excluding those not seeking employment, and conventionally housewives and students.

Labour force participation rate
The number of persons in the labour force at a given age, sex and/or level of education, divided by the corresponding total number of persons of the same characteristics.

Labour income
Income, primarily in the form of wages and salaries, accruing to labour in return for services rendered by it.

Labour market
The market in which labour services are bought and sold through a process that determines the level of employment of labour as well as wages and salaries.

Labour-intensive
A process of production using proportionately more labour than other factors of production, such as capital.

Life table
A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The tabulations commonly accompanying a life table include other features of the cohort's experience.

Long-term planning
Preparation of a development plan for a time period that often ranges from 10 to 20 years.

Medium-term planning
Preparation of a development plan for a time period that typically ranges from 3 to 7 years.

Migratory movements
Geographic mobility defined as change of usual residence between defined political or statistical areas or between residence areas of different types.

Model life table
An expression of typical mortality experience derived from a group of observed life tables.

Morbidity
The extent of illness, injury or disability in a population.

Operating costs
Costs incurred in connection with production of goods or services, which vary with the level of output. Examples of this type of cost are costs of labour, raw materials and power.

Opportunity cost
The value of the alternatives or other opportunities that have to be forgone in order to achieve a particular thing. It coincides with money expenditure or outlays necessary to achieve it, if and only if the prices with which the outlays are calculated correctly reflect the value of alternative uses of the resources.

Person-years-lived
The number of years lived by a group of people, such as the national population or the urban population during a specified period of time. When used in relation to a life table it represents the number of years lived by hypothetical cohort between any two exact ages, and it is denoted by the symbol ${}_nL_x$.

Physical capital
The stock of goods used in production, which have themselves been produced. It consists of inventories and such durable goods as buildings, plants and machinery.

Plan horizon
A period of time to which a development plan refers.

Post-partum sterility
The period of temporary sterility following a birth. The duration of this period is heavily influenced by duration and intensity of breast-feeding.

Poverty
A situation where a population or a section of a population is able to meet only its bare subsistence essentials of food, clothing and shelter in order to maintain minimum levels of living.

Production function
A mathematical representation of the technological relationship between the quantity of output of a firm, sector or the entire economy and the quantities of inputs required to make it.

Proportionate age specific fertility rate
The rate calculated by dividing a particular age-specific fertility rate by the sum of age specific fertility rates across the childbearing ages. The sum of all proportionate age-specific fertility rates equals one.

Proportionate age specific net international migration rate
The rate calculated by dividing a particular age-specific net international migration rate by the sum of age-specific net international migration rates across all ages or age groups. The sum of proportionate age-specific net international migration rates across all ages equals one.

Proportionate age-specific net internal migration rate
The rate calculated by dividing a particular age specific net internal migration rate by the sum of age-specific net internal migration rates across all ages or age groups. The sum of proportionate age-specific net internal migration rates across all ages equals one.

Radix
The hypothetical birth cohort of a life table. Its common values are 1, 1,000 or 100,000.

Rate of natural increase
The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is equal to the difference between the crude birth rate and the crude death rate.

Rate of population growth
The increase or decrease of a population in a specified period divided by the number of person-years lived by the population during the same period. The increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants.

Rental income
Income accruing to a durable good, such as land or buildings, in return for services rendered by the good.

Reverse survival
A procedure to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It can be used to estimate the number of births occurring over a specified time interval from the observed number of survivors of those births at the end of the interval. Similarly, the procedure can be employed to calculate net changes to the population due to migration occurring during a given time interval from the observed changes in the numbers of survivors in the population at the end of the interval resulting from migration.

School enrolment
The number of students who are enrolled and attend various educational institutions.

Sectoral planning
A form of development planning, sometimes referred to as partial planning, which is concerned with individual sectors of the economy. Such planning is often conducted within the framework of a comprehensive plan.

Sex ratio
The number of males in a population or specific sub-population, divided by the corresponding number of females.

Sex ratio at birth
The number of male births for each female birth, conventionally multiplied by 100.

Sex ratio of the population
The number of males in the population for each female, conventionally multiplied by 100.

Social accounting matrix
The tabular presentation of the income and product flows in an economy during a specified time period. It consists of a set of accounts, such as those for factors of production (labour, capital) or institutions (households, corporations and government) along with the economy's input-output table.

Statics
That part of economics which is concerned with analysing the economic system in equilibrium. The equilibrium is "timeless" or static in the sense that it does not change with time, it is fixed for all times, unless one of the underlying relationships in the system changes.

Subsidy
A special type of transfer payment to a corporation to prevent it from experiencing losses or to prevent an increase in its price.

Survival ratio
The probability of survival between one age or age group and another; when computed for age groups the ratios correspond to those of the person-years-lived function, ${}_nL_x$, of a life table.

Technical progress
Increased application of new scientific knowledge in form of inventions and innovations with regard to capital, both physical and human.

Total fertility rate
The average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to a given set of age specific fertility rates. This rate can be computed as the sum of fertility rates by single year of age or the sum of fertility rates by five-year age group, multiplied by 5.

Total net internal migration rate
The sum of age-specific net internal migration rates across all ages or age groups.

Total net international migration rate
The sum of age-specific net international migration rates across all ages or age groups.

Unemployment
A situation which exists when members of the labour force wish to work but cannot find employment at the prevailing wage rate.

Value added
For a firm or farm, the difference between its total revenue and the cost of raw materials, services and components used in production, over a specified time period. For the economy as a whole or any of its production sectors, the aggregate of value added of different firms or farms of which the economy or sector is composed.

Vital events
Births, deaths, marriages and divorces.

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