Preparing Migration Data for Subnational Population Projections

United Nations

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Department of International Economic and Social Affairs

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United Nations New York, 1992

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The term "country" as used in the text of this publication also refers, as appropriate, to territories or areas.

The designations "more developed" and "less developed" regions are intended for statistical convenience and do not necessarily express a judgement about the stage reached by a particular country or area in the development process.

ST/ESA/SER.A/127

UNITED NATIONS PUBLICATION

Sales No. E.92.XIII.6

ISBN 92-1-151243-3

PREFACE

The present publication provides guidance for researchers preparing subnational population projections, that is, population projections for regions within countries. The most difficult issue in undertaking such projections is the preparation of baseline estimates and projection assumptions for interregional migrations. With particular emphasis on common data situations in developing countries, this publication overviews and suggests methods suited for preparing these migration data.

The publication reviews the different types of data generally available for estimating internal migration in developing countries, delineates the methods for transforming different types of data into the form necessary for subnational population projections, discusses the formulation of migration assumptions and compares the advantages and disadvantages of different data sources and methods for preparing migration input for subnational projections.

Grateful acknowledgement is due to Alden Speare of Brown University, who prepared this report on behalf of the United Nations Secretariat.

CONTENTS

Page

Preface iii
Explanatory notes vii

INTRODUCTION 1

Chapter

I. REVIEW OF SOURCES OF DATA FOR MIGRATION PROJECTIONS 3

A. Censuses 3
B. Surveys 4
C. Registration data 4

II. MEASUREMENT OF THE VOLUME OF MIGRATION 6

A. Migration data from a census or survey question on residence at a fixed prior time 6
B. Migration estimated from census questions on previous place of residence and duration of residence 10
C. Estimation of net migration by census survival-ratio method 14

III. ESTIMATION OF THE DISTRIBUTION OF MIGRANTS BY AGE AND SEX 19

A. Age and sex distributions from a census with a question on place of residence at a fixed prior date 19
B. Age distributions from census data on place of previous residence and duration of residence 21
C. Age distributions from surveys 24
D. Age distributions from registers 25
E. Use of model migration schedules 25

IV. PROJECTION OF BASELINE MIGRATION INTO THE FUTURE 29

A. Alternative strategies for projecting migration 29
B. Adjustment of separate regional projections for national consistency 31

V. RECOMMENDATIONS FOR DATA COLLECTION 34

ANNEXES

I. Example of modified multiregional projections 37

No. *Page*

II. Model migration age schedules 41

References. 45

TABLES

1. Interregional migration in five years before 1980 census, population aged 5 years or over, Indonesia 8
2. Numbers of in-migrants and out-migrants for provinces of Argentina based on place of residence in 1975 and 1980, according to 1980 census 9
3. Female migrants to the province of East Java, Indonesia, by province of previous residence and duration, 1971 11
4. Estimation of lifetime return migration for provinces and regions of Indonesia, 1971 13
5. Adjustment of migration based on last residence, Indonesia, 1966-1971 14
6. Estimation of net migration of females, Manila, 1960-1970 16
7. Estimated five-year net migration of females, Manila, 1965-1970 17
8. In-migrants and out-migrants, by age and sex, Buenos Aires, 1975-1980, according to census of Argentina 20
9. Use of model age migration schedule to divide broad age groups, male migration to Buenos Aires, 1980 20
10. Female migrants to the province of East Java, Indonesia, by age and duration of residence in 1971 21
11. In-migration with durations from zero to four years, by age and sex, for major destinations of migrants from East Java, according to 1971 census of Indonesia 22
12. Calculation of gross and net migration for females by age, East Java, Indonesia, 1971 23
13. Mobility by region and age, United States of America, 1980-1985 24
14. Estimates and projections of the population of the United States of America by region, 1988-2010 30
15. Interregional migration in five years before and after the 1980 census in Indonesia, population aged 5 or over 32
16. Adjustment of projected in-migrants and out-migrants; regions of Indonesia 33

ANNEX TABLES

A.1 Application of model migration schedules to Indonesian females 37
A.2 Multiregional projections for females in three regions of Indonesia, 1980-1985 38
A.3 Five-year model migration rates for males 42
A.4 Five-year model migration rates for females 43

FIGURE

Model migration rates by age, males 27

Explanatory notes

Symbols of United Nations documents are composed of capital letters combined with figures.

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

Two dots (..) indicate that the data are not available or are not separately reported.
An em dash (--) indicates that the amount is nil or negligible.
A hyphen (-) indicates that the item is not applicable.
A minus sign (-) before a number indicates a decrease.
A point (.) is used to indicate decimals.
A slash (/) indicates a crop year or financial year, e.g., 1988/89.
Use of a hyphen (-) between dates representing years (e.g., 1984-1985), signifies the full period involved, including the beginning and end years.

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

References to "dollars" ($) indicates United States dollars, unless otherwise stated.

The term "billion" signifies a thousand million.

INTRODUCTION

The smaller the geographical unit, the greater is the importance of migration in determining population change from one period to the next. Projections at the national level often do not require much attention to migration. In many countries, international migration is relatively small compared with natural increase and can either be ignored or be incorporated with a simple approach, into the process of preparing population projections. If, however, one is interested in projecting the population of regions or smaller divisions, migration becomes a much more significant component of change and its estimation is not a simple matter. For example, Frey and Speare (1988) found that variations in rates of migration accounted for about 93 per cent of the total variation in growth of metropolitan areas of the United States of America between 1970 and 1980.

This publication deals with population projections for regions of countries; urban versus rural areas or any grouping of geographical areas. It also deals both with the preparation of migration data for the projection of a single region and with the preparation of a set of consistent projections for all the regions of a country. Although it is not possible to provide a comprehensive discussion of all the available methods, considerable attention is given to those methods which are appropriate for countries with limited or deficient data on migration. The examples and problems discussed here are intended to represent some of the most common situations encountered, especially in developing countries. Each country, however, is likely to have some unique problems, relating either to specific types of migration or to the quality and availability of some of the data, which may require unique solutions.

When projections for all the regions of a country are desired and the appropriate data are available, a multiregional approach should be considered, as it is the only way to guarantee that the total migration flows between regions will sum to zero (or to the assumed level of international migration). Multiregional methods for projection have been developed by Rogers (1985) and Willekens and Rogers (1978) and have been used in several European countries. These methods have not been widely used in developing countries, however, because of the lack of adequate migration data and the difficulty of applying the methods. Multiregional methods require the estimation of separate age-specific migration rates between each region and every other region of the country, and such detailed data are rarely available. Although it is possible to estimate some of the missing data (see Willekens, Por and Raquillet, 1979), the task of preparing data can become overwhelming if there are many regions. For example, a country with 30 regions would require estimating migration rates by age and sex for 30 times 29, or 870 migration streams. If there are only a few streams, however, the multiregional method is the best method to use.

If multiregional methods are not used, because of either lack of data or the computational complexity involved, the next best approach is to estimate separate flows into and out of a region and to adjust these flows to be roughly consistent with the flows into and out of other regions. When this process is not possible, estimates of net migration can be used, although these are more likely to lead to internal contradictions among projections for different regions in future periods.

The task of preparing migration data for subnational projections can be divided into three major tasks: (*a*) the development of suitable baseline estimates of the total amount of migration between regions; (*b*) the determination of the age and sex distribution of migrants for each region; and (*c*) the use of these baseline estimates and other data or assumptions to prepare projections of future migration rates. All of these tasks are difficult.

Estimating the volume of migration can be difficult because few countries provide complete tabulations of migration flows between regions and many do not even provide the total number of in-migrants and out-migrants for each region over a fixed time interval. A variety of the methods to process the different types of migration data available in different countries are described below.

The second task, the determination of the age and sex distribution of migrants, is straightforward when in-migrants and out-migration for each region are tabulated by age and sex for a period of time corresponding to the desired projection interval (usually either one year or five years). When the data are incomplete or based on a different time interval, adjustments must be made. In making adjustments, the model age schedules developed by Rogers and Castro (1981) are very helpful. In fact, because of the regularity in age patterns of migration throughout the world, these model schedules can be used in cases where there is no information on the age distribution of migrants.

The third task is equally difficult because migration trends frequently change over time. Areas that receive unusually large numbers of migrants during the base period of observation may not continue to do so for the next 10-20 years, and areas that receive little migration during the base period may become growth areas in the future. This situation is particularly true of areas where there is extraction of natural resources, but migration patterns to urban areas may change due to shifting patterns of job opportunities, and migration to rural areas can be greatly affected by resettlement and agricultural development programmes. For these reasons, the simple projection forward of migration rates observed during the base period, although useful for purposes of comparison, may not provide the best forecast of the future. Various alternative methods for adjusting base- period rates in the future are described.

This report focuses entirely on cohort-component projections. Other methods of subnational projection are discussed by Rogers (1985) and Pittenger (1976), but those methods do not provide reliable age and sex distributions and are most useful for small areas for which little migration data are available. Cohort-component projections are preferred because the basic components of population change--births, deaths and migrants--are very sensitive to changes in the age distribution. It is essential that cohort projections be used so that the changes in the age structure and their impact on the total number of births, deaths and migrants can be properly modelled. Secondly, cohort-component projections result in age and sex distributions for each projection period, which are often needed for planning purposes. Computer programs for producing such projections are readily available, and it is also possible to compute projections using spreadsheet programs, such as EXCEL and LOTUS 1-2-3, if sufficient care is taken in constructing the formulas linking the cells of the spreadsheet.

Further disaggregation of projections by race, ethnicity or other characteristics is not discussed. To the extent that these characteristics are assigned at birth and do not change over a lifetime, such projections can be made separately for each subgroup of the population, following the procedures discussed herein, However, seemingly unchanging characteristics, such as race, can still present problems if there is intermarriage of persons of different characteristics and the children born to these couples do not automatically take the characteristic of the mother. For such characteristics as education and labour force participation which can change over time, it is better to apply age-specific ratios to the results of the population projection to obtain the population of each subgroup.

This report contains four major chapters. Chapter I provides a brief review of the various types of data that can be used for estimating migration for the base period. Chapter II describes with the estimation of the volume of interregional migration from available data and covers a variety of methods that can be used, depending upon the form of the data. Chapter III discusses alternative methods for determining the age and sex composition of migration streams, as well as model age schedules for migration rates and how they can be used when age data are unavailable or as a means of smoothing or adjusting existing migration data by age. Chapter IV discusses different approaches to projecting base migration rates into the future and the conversion of gross migration data into net migration data when the computer program being used requires net migration. A brief concluding chapter describes desired questions and tabulation plans for future censuses and surveys which would facilitate the preparation of subnational projections.

I. REVIEW OF SOURCES OF DATA FOR MIGRATION PROJECTIONS

The three tasks of preparing migration data for subnational projections require three different types of data: (*a*) base-period estimates of the level or rate of migration between regions; (*b*) estimates of the age and sex distribution of migrants in different streams; and (*c*) indicators of likely future trends in migration. Sources for the first two types of estimates are discussed in this section, while the third type of estimates is discussed in chapter IV.

The different sources of migration data are discussed in order of usual preference. In general, the best source of migration data for projections is a census with a question on place of residence at a fixed prior time. If such a question was not asked, the next best alternative is usually a census with a pair of questions on place of previous residence and duration of residence. If neither type of question was asked in a census, migration estimates may be obtained from a large-scale survey or, in a few instances, from population registers or other administrative records.

The types of data for migration estimation and their strengths and weaknesses are discussed extensively in the literature on demographic techniques (see Shryock and Siegel, 1973; United Nations, 1970; Arriaga, 1977; Bogue, Hinze and White, 1982) and are reviewed only briefly here.

A. CENSUSES

Censuses usually provide the most complete count of the population by current residence. The exact definition of place of residence used in the census is very important to migration. If the census is taken according to legal residence, many migrants who have not yet changed their legal residence to the place of destination are not counted as migrants. If, on the other hand, a strict de facto definition is used, many short-term visitors to an area will be counted as migrants. Most countries use the concept of "usual place of residence", which is intended to avoid the two extremes represented by legal and de facto definitions but which can still vary considerably the way it is applied to recent migrants.

The main advantages of censuses is that they provide both fairly complete counts of persons in all geographical areas and estimates with either no sampling error or minimal sampling error. The disadvantages are related to the large scale of the operation, which limits the number of questions that can be asked about migration, interferes with the quality of reporting, and makes it expensive both to code places of origin and to tabulate and publish all the desired information on migration.

As of 1970, most censuses collected some information on migration. According to a United Nations survey of 121 countries (United Nations, 1978), 107 collected data on place of birth, 91 on place of previous residence, 70 on residence, and 75 on place of residence on a particular date in the past. The last-named question, which is best suited for estimating base-period migration for regional population projections, was available for 60 per cent of the countries surveyed. Although results of a similar survey of migration questions are not yet available for the 1980 and 1990 rounds of censuses, it is expected that the percentage of countries using a fixed-period migration question will have increased.

Although questions on migration were asked in the majority of censuses, they may not have been coded or tabulated appropriately. Even in the United States of America, where there is a very large budget for census operations, budget restrictions, prevented the coding of more than one half of the migration data collected in 1980. In many countries where questions are coded, only simple frequency distributions are published, and the necessary cross-tabulations, such as migration by age, sex and regions of origin and destination, are not published. The lack of necessary tabulations should become less of a problem as more countries use computers for processing, because the cost of tabulating large data sets continues to decline.

B. SURVEYS

Surveys have the advantage that more questions can be asked about migration, and the costs of coding and tabulating the data are rarely a barrier to obtaining the results. In few surveys, however, is the geographical representation adequate for use as accurate measures of the volume of migration. Even when the surveys are taken in each of the regions of interest, the samples within the regions tend to be highly clustered and the clusters may not adequately represent the destination of migrants within the regions.

An analysis of the 1976 intercensal survey in Indonesia (Speare, 1979) shows significant underestimation of migration to areas of rural resettlement in the outer islands. Although 247,500 migrants had been recorded in the Government's programme and considerable numbers of unsponsored migrants had been observed in these areas, only 171,200 were estimated from the survey results. Speare attributes the difference to the fact that although the survey included over 60,000 households, they were clustered in some 770 villages and the chances of missing the main resettlement areas in a random sample were high. A similar result was observed in the 1985 intercensal survey (Mantra, 1986).

Another problem with survey samples is that they tend to be based on previous censuses or registers which do not include new areas of settlement within the region. Nevertheless, surveys can be useful in identifying some groups of migrants which may be missed in a census using a definition of residence that excludes these groups. In particular, surveys can provide information on sequences of moves and their timing which can be useful in correcting census data based on previous place of residence. Surveys can also provide age and sex distributions and distributions of other characteristics of migrants.

C. REGISTRATION DATA

Only a few countries have sufficiently complete household registers to be useful in the measurement of migration. Most of these countries are in Europe, although China, Japan and the Republic of Korea have registers that have been used for migration. Even when the registers are reasonably complete in terms of inclusion of the total population, they are not necessarily accurate in terms of current residence. In an evaluation of the household register at Taipei, Taiwan Province of China, Speare and associates (1975) found that 12 per cent of the people in a random sample of neighbourhoods were not registered in the neighbourhood and 14 per cent of those registered as living in these neighbourhoods were not actually living there. Much of the problem is due to a lag in the reporting of moves. Because the register serves as a proof of legal residence, however, people may sometimes prefer to maintain their registration at a place other than their usual place of residence. Some rural-urban migrants remained concerned about village politics and wanted to be able to continue to vote at their place of origin. Others who lived outside the city maintained their registration in the city to enable their children to attend city schools, to be able to own property in the city or for other legal reasons. Although there are penalties for failure to be registered at one's place of usual residence, these penalties are small and registration officials are too busy to seek out people who fail to report changes of address.

Despite these problems, household registers can provide annual data on migration for all geographical areas. They may also provide tabulations of migration by age and sex.

In addition to household registers, the amount of information collected by Governments for other purposes may be useful in estimating migration. In the United States, base data on migration streams between states is obtained from tax records. Because a substantial majority of American households file tax forms each year and because they are required by law to enter their social security number and current address, computers are able to match records for adjacent years and count the number of movers (see Wetrogan and Long, 1990). However, because low-income persons are not required to file tax forms and because persons entering the labour force or entering the country may not have filed in the previous year, only about 80 per cent of the population are covered by matching tax records for adjacent years. Although migration rates are based only on matched records, when these rates are applied to the total population, it is assumed that the uncovered population moves at the same rate. Wetrogan and Long (1990) compared these rates with census and Current Population Survey rates for comparable periods and found that the differences were small.

II. MEASUREMENT OF THE VOLUME OF MIGRATION

In order to make reliable subnational projections, it is desirable to obtain separate estimates of in-migration and out-migration for each region. If the number of regions is small, one should try to obtain estimates of all migration streams among regions. This information will permit the use of the multiregional projection method; and even if this method is not used, it is helpful to know the volume of each stream when the separate regional projections are adjusted for national consistency.

Counts of in-migrants and out-migrants are referred to as "gross migration", whereas the difference between in-migration and out-migration is referred to as "net migration". Net migration can be either positive or negative. While some of the methods used to estimate migration provide only data for net migration, methods that can estimate gross migration are preferred.

Net migration is satisfactory only when the projections periods are very short and the rates of migration are small and can be assumed to remain the same from the base period to the projection period. If one wishes to assume an increase or decrease in the amount of migration, it may be difficult to adjust net migration figures, as they are often negative for some age groups and positive for others and a change in the level of migration might change the signs of some of these age-specific numbers. Furthermore, if migration is substantial, it will change the composition of the populations at origin and destination and these changes will result in different numbers of in-migrants and out-migrants. The effect of these changes on net migration is not always obvious until the separate effects on in- and out-migration have been calculated.

Information on the volume of internal migration is often obtained by direct questions on censuses, and tabulations of these questions are often the best source of migration estimates. Two types of questions are frequently asked in censuses or large surveys. The first is a question on place of residence at some fixed prior date, such as one year or five years prior to the census. The other is a combination of a question on duration of current residence and a question on the place of previous residence. Also, in countries without any direct data on migration, it is often possible to estimate net migration for each region by comparing two censuses. The methods appropriate for each of these forms of data are discussed in turn.

A. Migration data from a census or survey question on residence at a fixed prior time

1. General considerations with fixed interval data

There are several advantages to obtaining base-period migration data from a recent census, if questions about migration were asked. The use of a single census avoids problems with differences in definitions and procedures between censuses, and there is no need to be concerned with the changes in boundaries that may have occurred between censuses or with the relative completeness of coverage of different censuses.

The region of previous residence should be tabulated by region of residence at the census and by age group and sex. If only the total number of migrants or the total for each sex is available, alternative methods can be used to estimate the age distribution, as is discussed in chapter III.

The time interval over which migration is measured should be the same as the projection interval. For projections using a five-year projection interval, the best measure of migration would be based on a question on place of residence five years prior to the census. When the time interval for the migration question differs from that desired for projections, adjustments will need to be made (see Long and Boertlein, 1990). It is much easier to use base data for a shorter time interval than the projection interval than to use data for a longer interval. It is difficult to divide migrants within a time interval; such adjustments usually distort the data and should be avoided whenever possible.

Two examples are provided: the first includes estimates of all streams between different regions; and the second includes only estimates of in-migration and out-migration for each region. The first type of data is preferable because it allows for the possibility of using multiregional projection techniques. Even if projections are made one region at a time, knowledge of all of the streams can be useful in adjusting in- and out-migration in future periods so that these quantities remain equal across the entire population.

2. Example of migration streams: 1980 census of Indonesia

The total numbers of migrants between five major regions of Indonesia were obtained from one of the summary volumes of the 1980 census. Panel A (of table 1) shows the data as they appear in the census publication. The columns represent the region of residence five years prior to the census. The diagonal cells contain all the persons who reported that they resided in the same region and the off-diagonal cells represent the migrants.

This table also illustrates two of the common problems with census data based on place of residence at a fixed prior period. First, some of the people enumerated in the census were not living in the country at the previous date. Unfortunately, there is no count of persons who were living in the country at the previous date but who had emigrated before the census, so the data do not provide a complete picture of international migration. If international migration is significant and the international migrants are considered to be part of the population, they should be dealt with explicitly in the projections. In this example, it is be assumed that the immigrants are either treated as a separate population or that they are exactly balanced by an equal number of emigrants within each region. They have therefore been deleted from table 1 for purposes of estimating internal migration.

A second problem that is evident in table 1 is that some persons who were enumerated in the census did not report a previous place of residence. Although the number of such persons constituted only 0.5 to 1.0 per cent of the regional populations, it was large in relation to some of the migration streams between regions. Lacking any other information about these persons, it is usually best to assume that they have the same distribution of previous place of residence as those who reported a previous place within the country, as has been done in panel B of table 1. Each cell in panel A is multiplied by a ratio of the total excluding those abroad and the total excluding both those abroad and those with a previous place not stated.

Two other problems are not as obvious, but they deserve some attention. First, the census data exclude all persons, both migrants and non-migrants that die during the interval. This exclusion is not a problem if it can be assumed that age-specific death rates for migrants are similar to those for non-migrants; and if, in the projection process, deaths are subtracted from the population before migration rates are applied to estimate the number of migrants in each projection interval. Unfortunately, such computer programs as FIVFIV (Shorter, Pasta ad Sendek, 1987) and ABACUS (United Nations, 1989) apply mortality rates to migrants in the projection process. To adjust properly for this feature, it is necessary to apply reverse-survival rates to the number of migrants to estimate the total number that moved, including those dying after the move.

The other problem is that the population under age 5 is excluded from the census table because they were not alive five years before the census and thus could not have a previous place of residence. One way to calculate an approximate migration rate for children aged 0-4 years is to use one half of the average migration rate for married women in the reproductive years, on the assumption that children usually move with their mothers and that one half of the migrant women giving birth during the projection interval will move after the birth. Another approach would be to obtain the migration rate for age group 0-4 from the most similar model age schedule (see chapter IV).

Panel C of table 1 shows the computation of destination-specific out-migration rates for each region. The appropriate migration streams given in panel B are divided by the survivors of the population in the region five years prior to the census, shown in column (6) of panel B. The result is a five-year migration rate for the interval 1975-1980 for persons that survived the interval.

TABLE 1. INTERREGIONAL MIGRATION IN FIVE YEARS BEFORE THE 1980 CENSUS IN INDONESIA, POPULATION AGED 5 AND OVER

Region of residence in 1975	*Region of residence at census, 1980*					
	Sumatra (1)	*Java (2)*	*Kalimatan (3)*	*Sulawesi (4)*	*Other islands (5)*	*Total (6)*
	A. Region of residence, 1980 by region, 1975 (census tabulation)					
Sumatra	22 530 497	267 717	9 947	16 992	24 047	22 849 200
Java	835 743	78 224 144	143 024	57 070	39 178	79 299 159
Kalimantan	5 486	46 410	5 467 847	7 737	1 757	5 529 237
Sulawesi	7 932	41 357	43 603	8 726 380	51 272	8 870 544
Other	13 068	101 426	2 574	29 826	8 772 323	8 919 217
Abroad	2 146	8 392		1 455	487	12 480
Not Stated	57 417	134 939	16 718	21 803	14 087	244 964
TOTAL	23 452 289	78 824 385	5 683 713	8 861 263	8 903 151	125 724 801
TOTAL ABROAD	23 450 143	78 815 993	5 683 713	8 859 808	8 902 664	125 712 321
LESS NOT STATED	23 392 726	78 681 054	5 666 995	8 838 005	8 888 577	125 467 357
	B. Revised migration matrix with unknowns prorated and excluding those abroad					
Sumatra	22 585 798	268 176	9 976	17 034	24 085	22 905 069
Java	837 794	78 358 299	143 446	57 211	39 240	79 435 991
Kalimantan	5 499	46 490	5 483 978	7 756	1 760	5 545 482
Sulawesi	7 951	41 428	43 732	8 747 908	51 353	8 892 372
Other	13 100	101 600	2 582	29 900	8 786 226	8 933 407
TOTAL	23 450 143	78 815 993	5 683 713	8 859 808	8 902 664	125 712 321
	C. Migration rates as proportions of survivors of 1975 population					
Sumatra	-	0.0117	0.0004	0.0007	0.0011	0.0139
Java	0.0105	-	0.0018	0.0007	0.0005	0.0136
Kalimantan	0.0010	0.0084	-	0.0014	0.0003	0.0111
Sulawesi	0.0009	0.0047	0.0049	-	0.0058	0.0162
Other	0.0015	0.0114	0.0003	0.0033	-	0.0165

Source: Penduduck Indonesia 1980 (Census of Indonesia 1980), Series S, No. 1 (Jakarta, Biro Pusat Statistic, 1982).

3 . *Examples of in-migration and out-migration: 1980 census of Argentina*

Some countries tabulate only the total number of in-migrants and out-migrants for each region. The 1980 census of Argentina provides an example. Table 2 shows the number of in-migrants and out-migrants for each province between 1975 and 1980, as published in the census volumes.

As in the Indonesian example, table 2 also includes some people that were enumerated in the census but were not living in the country at the previous date. These persons should be counted as immigrants to the country, but, as with Indonesia, there is no corresponding estimate of emigrants from the country.

It is normally desirable to remove international migration from the estimates. This step is done in column (3) of table 2 by subtracting a prorated share of the immigrants from the number of in-migrants to each province, which assumes that immigrants are distributed among provinces in proportion to the in-migrants to each province. This assumption is often not very good and should be avoided if there is a separate count of the number of foreign immigrants in each place of destination.

TABLE 2. NUMBERS OF IN-MIGRANTS AND OUT-MIGRANTS FOR PROVINCES OF ARGENTINA BASED ON PLACE OF RESIDENCE IN 1975 AND 1980 ACCORDING TO 1980 CENSUS

Province	*Out-migrants* (1)	*In-migrants* (2)	*Adjusted number of in-migrants* (3)
Capital Federal	401 974	263 184	242 453
Buenos Aires	293 402	685 759	631 741
Catamarca	17 842	10 681	9 840
Chaco	53 154	32 100	29 571
Chubut	22 945	27 600	25 426
Córdoba	85 805	101 566	93 565
Corrientes	63 350	31 153	28 699
Entre Ríos	61 869	34 160	31 469
Formosa	21 494	12 312	11 342
Jujuy	28 510	20 461	18 849
La Pampa	10 323	16 072	14 806
La Rioja	13 851	8 256	7 606
Mendoza	49 803	50 226	46 270
Misiones	30 820	26 437	24 355
Neuquén	18 411	32 847	30 260
Río Negro	32 094	38 864	35 803
Salta	41 091	31 433	28 957
San Juan	28 603	12 414	11 436
San Luis	16 397	13 925	12 828
Santa Cruz	11 868	18 998	17 501
Santa Fé	78 164	93 864	86 470
Santiago del Estero	61 987	23 070	21 253
Tucuman	54 184	34 415	31 704
Tierra Del Fuego	3 395	9 914	9 133
SUBTOTAL	1 501 336	1 629 711	1 501 336
Foreign country	128 375	-	-
TOTAL	1 629 711	1 629 711	1 501 336

Source: Censo Nacional de Población y Vivienda, 1980, República Argentina (Buenos Aires, r.d.), table M.10.

NOTE: Column (3) is calculated by multiplying column (2) by the ratio of the subtotal in column (1) to the total in column (1).

As with the example for Indonesia, there are two other potential problems which deserve some attention: the relative timing of migration and death for those dying in the interval, and the estimation of migration rates for those under age 5. These problems are essentially the same as in the Indonesian example and similar solutions can be sought.

B. Migration estimated from census questions on previous place of residence and duration of residence

1. General approach

Many censuses do not have a question on place of residence at a fixed prior date but ask for previous place of residence and duration of residence in the current place. Although it has been argued that these two questions, when taken together, provide more useful information than place of residence at a fixed prior date, this is clearly not the case for the estimation of migration rates to use in projections. As Courgeau (1988) points out, these questions are only useful in estimating migration rates if it is assumed that each person made only one move during the period of interest or if some estimate of multiple moves can be used to adjust the data.

Obtaining an approximate measure of migration from these questions requires that the data be tabulated in a large three-way table (or in a series of component tables) showing place of current residence by place of previous residence by duration of residence. Alternatively, the total numbers of in-migrants and out-migrants for each province can be tabulated by duration of residence.

In preparing these data for projections, separate estimates of in-migration and out-migration are obtained for each region. These estimates are then checked to see that the total number of in-migrants equals the total number of out-migrants or that the difference equals the assumed level of net international migration. If they are not equal, adjustments need to be made, as is illustrated in table 2.

Projections require estimates of the movement of people between the beginning and the end of a projection interval. If, for example, the interval is five years, then one needs estimates of the movement of people from their place of residence at the beginning of the five-year period to their place of residence at the end of the period. Any intermediate moves are of no interest. If a person resided at place A five years prior to the census and later moved from place A to place B and then moved again to place C, that person should be counted as moving from place A to place C. Similarly, if persons moved from A to B and back to A, they should be considered to be non-migrants for purposes of projection.

Both of these cases create a problem when migration is estimated from a cross-tabulation of previous place of residence and duration of residence. Those that moved from A to B to C will be recorded as having moved from B to C, and those that moved from A to B to A will be recorded as having moved from B to A. In both cases, however, they were actually at place A at the beginning of the projection period. If no adjustment is made for repeated movement during the five-year period, these two cases would be erroneously subtracted from the population at place B and not from place A. If there were many such persons, the population at place A would be projected to be larger and that at place B smaller than should be the case.

Another problem arises when the question of duration of residence either does not specify the level of geography or specifies a different level than is desired for regional projections. If, for example, projections are desired at the provincial level, but previous place of residence and duration of residence apply to the village level, then many interprovincial moves will be missed because they are followed by a move between villages within the province of destination. Unless further questions are asked about prior residences, only the last move will be recorded and there will be no information on which province the person lived in five years (or whatever the projection interval is) prior to the census. Only the place of residence for those that did not move within the five-year period is certain.

2. *Example of data on previous place of residence data from Indonesia*

An example of data on previous place of residence and duration of residence is given in table 3 for the province of East Java in Indonesia in 1971. Similar tables were published for each of the 26 provinces and together provide a complete set of data on migration streams from previous place of residence. These data also illustrate the problem with data based on these questions. In the period prior to the census there had been considerable movement from the island of Java to Sumatra; this movement was mostly for settlement of unoccupied rural land. Migrants had moved both with government sponsorship under the transmigration programme and spontaneously with their own resources. However, there were many news accounts of the return migration of persons that had been unsuccessful at the destination. When the census results were released, they showed that the migration from some provinces of Sumatra to Java had been almost as high as the number moving from Java to Sumatra, which led some to conclude erroneously that almost all of the settlers had returned.

TABLE 3. FEMALE MIGRANTS TO THE PROVINCE OF EAST JAVA, INDONESIA BY PROVINCE OF PREVIOUS RESIDENCE AND DURATION, 1971

Province of previous residence	*Duration of residence in previous province (years)*												*Total*
	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10 +*	*Not stated*	
Aceh	66	109	102	39	101	6	101	4	2	9	482	624	1 645
North Sumatra	254	389	474	333	150	321	324	286	211	151	2 848	523	6 264
West Sumatra	32	240	82	155	64	144	282	113	29	91	1 139	2 133	4 504
Riau	15	108	327	315	10	336	184	510	122	262	995	181	3 365
Jambi	0	168	61	20	69	60	10	0	12	1	495	567	1 463
South Sumatra	58	544	687	407	202	166	764	419	176	79	2 790	334	6 626
Bengkulu	0	48	5	0	1	0	0	21	26	0	176	420	697
Lampung	5	222	284	72	250	64	92	0	80	0	659	262	1 990
Jakarta	532	1 839	1 234	1 105	792	931	604	253	332	427	3 266	675	11 990
West Java	792	1 890	2 419	1 497	2 063	1 065	982	473	982	765	5 901	576	19 405
Central Java	1 267	3 577	3 084	2 801	2 643	2 626	2 301	1 576	1 877	1 428	31 102	4 018	58 300
Yoyakarta	138	975	754	489	343	804	756	403	274	246	4 624	939	10 475
East Java	0	0	0	0	0	0	0	0	0	0	0	0	0
Bali	183	517	274	611	476	484	514	531	104	121	1 452	147	5 414
West Nusa Tenggara .	62	67	128	42	415	267	97	99	31	20	591	98	1 917
East Nusa Tenggara .	104	156	459	188	125	51	192	15	44	31	770	100	2 235
West Kalimantan . . .	162	177	108	256	21	24	221	3	22	126	988	82	2 190
Central Kalimatan . .	21	42	96	73	21	21	182	52	41	0	336	97	982
South Kalimantan. . .	191	423	357	514	289	340	476	99	261	228	3 059	227	6 464
East Kalimantan. . . .	258	469	335	298	277	141	195	110	263	122	1 669	140	4 277
North Sulawesi	84	542	462	226	183	92	113	159	114	192	1 832	52	4 051
Central Sulawesi . . .	0	21	150	50	27	144	95	135	82	8	955	68	1 735
South Sulawesi	342	409	493	546	336	251	438	354	301	481	3 532	152	7 635
Southeast Sulawesi . .	21	5	53	401	4	0	13	0	4	54	455	76	1 086
Maluku	145	242	247	326	49	111	202	57	43	64	1 238	322	3 046
West Irian	72	63	48	67	42	26	82	20	5	0	118	2	545
Abroad	113	53	21	42	52	21	10	92	47	42	7 644	1 503	9 640
TOTAL	4 917	13 295	12 744	10 873	9 005	8 496	9 230	5 784	5 485	4 948	79 116	14 318	178 211

Source: Based on Sensus Penduduk Indonesia, 1971 (1971 Population Census), Series E, No. 13 (Jakarta, Biro Pusat Statistic, 1974), table 25.

The problem is that during whatever period one chooses to sum migration, be it 1, 5 or 10 years, all persons both moving to the resettlement area and returning during that same period will be counted only as return movers. Thus, if 100 moved and 50 returned, the census would show 50 movers in each direction. Although it would appear that all had returned, actually only half would have returned.

Speare (1975) made adjustments to the 1971 Indonesian migration data by using separate data on place of birth to estimate the percentage of lifetime return migrants for each province and making rough estimates of the likely percentage of those returning within the same five-year period as their move. These adjustments are shown in table 4. Columns (1) and (2), respectively, show the total number of in-migrants for each province based on previous place of residence and the total number based on place of birth. For every province, the number of in-migrants exceeds the number born in other provinces; the difference is assumed to be the number of return migrants, that is, persons born in the province that had lived at some time in another province but had returned to the province of birth by the time of the census. These figures are given in the column (3). Column (4) shows this number as a percentage of the total number of in-migrants based on previous place of residence.

In preparing migration data for regional projections in Indonesia, Speare (1976) arbitrarily assumed that one half of the return migrants made their return within the same five-year period as their move from their province of birth and that the other half returned after a longer interval. Thus, in estimating the number of in-migrants for the five years preceding the census from those with durations of zero to four years, one half of the percentage shown in table 4 was subtracted from the number of in-migrants with zero to four years of duration.

This calculation is given in table 5. The first line of this table shows that there were 662,800 in-migrants to Sumatra with durations of residence of zero to four years in 1971. Using the estimate from table 4, 13 per cent of these are assumed to be return migrants and one half are assumed to be returning from moves made within the five years prior to the census. Removing this proportion from the number of in-migrants results in an adjusted estimate of 619,700 in-migrants.

A similar procedure can be followed for out-migrants. The number of lifetime out-migrants (persons born in one province but living in another province) can be calculated for each province and compared with the total number reporting that province as their previous place of residence while living in another province. The extent to which the total number reporting a province as their previous residence exceeds those reporting the province as their place of birth is taken as an estimate of the total return or repeat migration from that province. One half of this movement can then be arbitrarily assumed to have occurred during the five years prior to the census.

Speare (1976) also made a further adjustment to all of the migration numbers for underreporting of migration and misreporting of duration of residence in the census. The 1971 census treated people as residents of a place only if they had lived there for six months or longer. Migrants within the preceding six months were considered to be temporary and were counted in their place of origin. The effect of this can clearly be seen in table 3 by the relatively small number of migrants with zero years of duration. It is common (although not necessary) to see the largest number of migrants within the first year of duration of residence and a decline in numbers of migrants with increasing duration. In addition, there appears to be some heaping on particular digits which is similar to the age- heaping observed in the same census. By fitting a regression line to the sum of all migration for provinces in Java and Bali for single years of duration from one to five years and extrapolating to zero years, it was estimated that these two errors resulted in observed migration rates for the sum of durations zero to four years which were about 87 per cent of what they should be. Thus, an adjustment was made by multiplying the number of migrants with durations of 0 to 4 years by 1/0.87 or by 1.15.

TABLE 4. ESTIMATION OF LIFETIME RETURN MIGRATION FOR PROVINCES AND REGIONS OF INDONESIA, 1971
(Thousands)

Province and region	*Total in-migrants (a/)*	*Born in other provinces*	*Return migrants*	*Percentage of in-migrants who are return migrants*
Sumatra				
Aceh	89.8	61.0	28.8	32.1
North Sumatra	586.9	530.0	56.9	9.7
West Sumatra	262.5	87.9	174.6	66.5
Riau		220.9	203.7	17.8
Jambi	165.1	155.9	9.2	5.6
South Sumatra	373.9	327.3	46.6	12.5
Bengkulu	44.3	36.1	8.2	18.5
Lampung	1 018.8	1 000.2	18.6	1.8
TOTAL	2 762.2	2 402.1	360.1	13.0
Java/Bali				
Jakarta	1 837.6	1 791.6	46.0	2.5
West Java	680.6	371.5	309.1	45.4
Central Java	594.9	253.5	341.4	57.4
Yogyakarta	144.2	99.8	44.4	30.8
East Java	406.5	273.3	133.2	32.8
Bali	45.2	22.1	23.1	51.1
TOTAL	3 709.0	2 811.8	897.2	24.2
Kalimantan				
West Kalimantan	26.6	20.8	5.8	21.8
Central Kalimantan	58.4	50.1	8.3	14.2
South Kalimantan	95.4	66.1	29.3	30.7
East Kalimantan	42.5	39.6	2.9	6.8
TOTAL	222.9	176.6	46.3	20.8
Sulawesi				
North Sulawesi	119.4	48.7	70.7	59.2
Central Sulawesi	62.9	51.0	11.9	18.9
South Sulawesi	143.0	67.0	76.0	53.1
Southeast Sulawesi	38.6	25.9	12.7	32.9
TOTAL	363.9	192.6	171.3	47.1
Other				
West Nusa Tenggara . . .	44.6	33.6	11.0	24.7
East Nusa Tenggara	25.1	10.3	14.8	59.0
Maluku	55.2	42.2	13.0	23.6
West Irian	36.7	33.5	3.2	8.7
TOTAL	161.6	119.6	42.0	26.0
All provinces	7 219.6	5 702.7	1 516.9	21.0

Source: Adapted from Alden Speare, Jr., "Interpreting the migration data from the 1971 census", *Majalah Demografi Indonesia* (Jakarta), No. 3 (1975), p. 77.

(a/) Based on place of last residence.

TABLE 5. ADJUSTMENT OF MIGRATION BASED ON LAST RESIDENCE, INDONESIA, 1966-1971
(Thousands)

Region	*Total number of in-migrants during past 5 years* (1)	*Percentage of lifetime return migrants* (2)	*Estimated percentage returning migrants during past 5 years* (3)	*Adjusted number of in-migrants* (4)
Sumatra	662.8	13.0	6.5	619.7
Java/Bali	1 201.3	24.2	12.1	1 055.9
Kalimantan	72.2	20.8	10.4	64.7
Sulawesi	118.8	47.1	23.6	90.8
Other	52.7	26.0	13.0	45.8
All provinces	2 107.8	21.0	10.5	1 877.0

Source: Adapted from Alden Speare, Jr. "Interpreting the migration data from the 1971 census", *Majalah Demografi Indonesia* (Jakarta), No. 3 (1975), p. 77.

NOTE: Column (3) = 1/2 column (2); column (4) = column (1).[1-column(3)/100].

In other countries, a similar procedure might be followed to check for errors of digit preference or omission of short-duration migrants. Although a linear form of the relation between migration and duration was assumed in Indonesia, an exponential form might fit the data better. This form could be fitted with regression by taking the natural logarithm of the number of migrants for each year of duration and regressing them against the year.

C. ESTIMATION OF NET MIGRATION BY CENSUS SURVIVAL RATIO METHOD

1. General approach

Where no tabulations of migration are available in a census but there is a previous census, data from the two censuses can be used to prepare residual estimates of net migration. This technique is fully discussed in United Nations (1970) and in Shryock and Siegel (1973), and only a brief description is provided here. There are two basic methods. The first method involves the comparisons of age distributions at two points in time and results in net migration estimates by age. The second method uses only the total regional population at two points in time and independent estimates of births and deaths in the region (usually from vital statistics) to estimate the total number of net migrants for the region. The second method is rarely used in developing countries because of lack of data on regional births and deaths.

The census survival-ratio method is the most commonly used of the net migration methods because it can be applied when there are two censuses with data on population by age for the region of interest and for the country as a whole. The census survival ratio method makes the following assumptions: (*a*) the boundaries of the regions are the same in both censuses (or sufficient data are available to reconstruct the regions so that the boundaries are the same); (*b*) the survival rates by age and sex are the same in all regions as in the country as a whole; (*c*) errors of enumeration and age misstatement are the same in all regions as in the country as a whole; and (*d*) international migration is distributed to each region in proportion to its population. If these assumptions are met, the method yields rates of internal net migration which are free from effects of age misstatement, enumeration errors and international migration. If the last assumption is not fully met, then the differential distribution of international migrants (that part which is higher or lower than the national average) is included in the net migration estimate.

The method involves two basic steps. First, the national survival ratios are computed from the national age and sex distributions of the two censuses. Secondly, these ratios are used with the age and sex distributions of the region at both censuses to produce estimated net migration by age and sex.

When the time interval between censuses is 10 years, the equations for the computations are:

$$ {}_nS_{x \text{ to } x+10} = {}_nP_{2,\, x+10} \,/\, {}_nP_{1,\, x}, $$

where x = lowest age in group;
n = number of years in age group;
${}_nS_x$ = survival rate from age group x to $x + n$ to age group $x + 10$ to $x + 10 + n$, 10 years later;
${}_nP_{2,\, x+10}$ = population between ages $x + 10$ and $x + 10 + n$ at the second census.
${}_nP_{1,\, x}$ = population between ages x and $x + n$ at the first census;

$$ \text{and } {}_nM_{i,\, x \text{ to } x+10} = {}_nP_{2,\, i,\, x+10} - {}_nS_{x \text{ to } x+10} \cdot {}_nP_{1,\, i,\, x}, $$

where ${}_nM_{i,\, x \text{ to } x+10}$ = net migration over 10 years for region i for persons at first between ages x and $x + n$ to ages between $x + 10$ and $x + 10 + n$, 10 years later;
${}_nP2,{}_{i,\, x+10}$ = population in region i between ages $x + 10$ and $x + 10 + n$ at second census;
${}_nP1,{}_{i,\, x}$ = population in region i between ages x and $x + n$ at first census.

This procedure is commonly referred to as the "forward method" of migration estimation because the population is survived forward from the first census. There is a similar method, called the" reverse method", in which the population by age and sex at the second census is divided by age-specific and sex-specific survival ratios to reverse survive that population back to the first census. The methods differ in the way in which deaths of migrants are treated. In the forward method, all deaths of migrants are not counted as migrants, which is equivalent to assuming that they all died at the place of origin. In the reverse method, the opposite is assumed. All migrants that die are counted as migrants, as are as those that would have moved had they survived the interval. If one wishes to count as migrants only those that died after moving, then an approximate estimate can be obtained by averaging the two methods (Bogue, Hinze and White, 1982).

Two additional steps are required to complete the estimation of net migrants by the census survival-ratio method. First, estimates of migrants aged 0-10 years must be made. These migrants were born between censuses and cannot be estimated by using census survival ratios. If the exact number of births by year is known from vital registration, these numbers can be used in place of the population at the first census. Otherwise, Shryock and Siegel (1973) recommend using a child/woman ratio and basing the migration rates of children under age 10 on those for women in the reproductive years. In either case, it is necessary to assume that there is no relationship between migration and fertility.

The second step involves the computation of five-year migration rates from the 10-year rates for use in projections involving five-year intervals. The common method of doing this computation is to take one half of the average of the rates for adjacent cohorts. However, this method distorts the age distribution in a way similar to the effect of using moving averages to smooth the data. The result is a flattening of the peaks and dips in the age distribution of migration rates, as Irwin (1977) illustrates. A way around this problem would be to use model age schedules, as is explained in chapter III.

2. *Example for the Philippines, 1960-1970*

Table 6 shows how the census survival-ratio method is used to estimate female net migration for Manila for the period between the 1960 and 1970 censuses. Columns (1) and (2) give the national population by age in 1960 and 1970, respectively. In column (3), the 10-year survival ratio is computed by taking the ratio of the population in 1970 to that for persons 10 years younger in 1960. For example, there were 2,478,426 females aged 10-14 in 1970. This number is divided by the 2,218,377 females aged 0-4 in 1960 to provide a survival ratio of 1.1172. Since errors in enumeration, age-reporting and international migration are included in these numbers, it is possible for the survival ratio to exceed 1.0, as is the case in this example. The assumption is that these errors equally affect the population statistics of Manila. Note that there are no survival ratios for the first two age groups because these persons were not alive at the first census.

TABLE 6. ESTIMATES OF NET MIGRATION OF FEMALES FOR MANILA, 1960-1970

Age group	*Population of the Philippines*		*Ten-year Survival*	*Population of Manila*		*Survivors from 1960*	*Net migration*
	1960	*1970*		*1960*	*1970*		
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
0-4	2 218 377	2 871 594	1.1172	80 275	85 870	-	-236
5-9	2 114 832	2 893 681	0.9915	70 875	83 054	-	-8 938
10-14	1 669 435	2 478 426	0.9729	63 250	79 489	89 685	-10 196
15-19	1 429 547	2 096 954	0.8893	85 618	101 410	70 276	31 134
20-24	1 264 441	1 624 113	0.8413	75 793	90 410	61 533	28 877
25-29	1 000 981	1 271 238	0.9571	60 037	56 055	76 137	-20 082
30-34	791 473	1 063 783	0.9513	34 813	44 648	63 765	-19 117
35-39	725 906	958 013	0.9042	31 927	36 963	57 460	-20 497
40-44	552 585	752 922	0.9295	24 297	28 873	33 117	-4 244
45-49	508 045	656 332	0.7966	20 207	23 678	28 867	-5 189
50-54	344 745	513 635	0.8770	13 714	19 063	22 584	-3 521
55-59	235 536	404 713	0.8352	9 366	14 484	16 097	-1 613
60-64	199 118	302 336	0.7116	7 921	10 205	12 027	-1 822
65-69	369 795	196 716	0.5624	11 114	6 405	7 822	-1 417
70-74		141 689			3 746	5 636	-1 890
75+		207 990			4 779	6 251	-1 472
All ages	13 424 816	18 434 135	-	589 207	689 132	551 258	-40 224

NOTES: Column (3) = population 1970, age x divided by population 1960, age x-10; column (6) = column (4) (age - 10) times survival rate in column (3); column (7) = column (5) minus column (6)

For ages under 10, net-migration estimates are derived as follows: for age 0-4: 1/4 (ratio of population 0-4 to female population aged 15-44) times net migration for females aged 15-44; for age 5-9: 3/4 (ratio of population 5-9 to female population aged 20-49) times net migration for females aged 20-49.

To illustrate, net migration for ages 0-4 = 1/4 (85870/358359) x (-3934) = -236;
net migration for ages 5-9 = 3/4 (83054/280627) x (-40261) = -8,938.

The national survival ratios are then applied to the regional population of interest. For example, the survival ratio of 1.1172 from ages 0-4 to ages 10-14 is multiplied by the 1960 population of Manila aged 0-4 (80,275) to yield the expected population aged 10-14 in 1970, in the absence of internal migration. This estimate (92,857) is then subtracted from the reported population aged 10-14 in 1970 (79,489) to yield the estimated net migration of (-10,196), shown in column (6). Because this figure is negative, it implies that there was net out-migration.

The calculation of the number of net migrants aged 0-4 and 5-9 at the second census requires additional data and assumptions about fertility because these persons were born after the first census. The equations given below are taken from Shryock and Siegel (1973, p. 632):

$$_5M_{i,0} = 1/4 \cdot CWR_0 \cdot {}_{30}M^f_{i,15},$$
$$_5M_{i,5} = 3/4 \cdot CWR_5 \cdot {}_{30}M^f_{i,20},$$

where: CWR_0 = ratio of children aged 0-4 to women aged 15-44 at the second census.
CWR_5 = ratio of children aged 5-9 to women aged 20-29 at the second census.
$_{30}M^f_{i,x}$ = net migration for women between ages x and $x + 30$.

The derivation of five-year migration numbers from the 10-year numbers is shown in table 7. The logic for the computation can be understood if one observes that migration over a five-year period for any group, such as persons aged 20-24 who are aged 25-29 five years later, is part of two 10-year numbers, the number from ages 15-19 to ages 25-29 and from ages 20-24 to ages 30-34. Thus, the five-year migration is estimated by taking one half of the average of these two 10-year numbers, on the assumption that migration is uniform throughout the 10-year period. In this case, the estimate for females aged 25-29 in 1970 is 0.25(-20,082 - 19,117) = -9,800, as is shown in column (2) of table 7. The multiplier of 0.25 represents the product to the 0.5 needed for taking an average of the two age groups and .5 for the assumed one half of migration occurring during a five-year period.

TABLE 7. ESTIMATED FIVE-YEAR NET MIGRATION OF FEMALES FOR MANILA, 1965-1970

Age group, 1970	*Ten-year net migration (1)*	*5-year net migration, 1965-1970 (2)*	*Reconstructed 10-year migration (3)*
0-4	-236	-2 353	-2 353
5-9	-8 938	-4 784	-7 136
10-14	-10 196	5 234	451
15-19	31 134	15 003	20 237
20-24	28 877	2 199	17 202
25-29	-20 082	-9 800	-7 601
30-34	-19 117	-9 904	-19 703
35-39	-20 497	-6 185	-16 089
40-44	-4 244	-2 358	-8 544
45-49	-5 189	-2 178	-4 536
50-54	-3 521	-1 284	-3 461
55-59	-1 613	-859	-2 142
60-64	-1 822	-810	-1 669
65-69	-1 417	-827	-1 637
70-74	-1 890	-841	-1 668
75 + ...	-1 472	-368	-1 577
All ages	-40 674	-20 112	-40 224

NOTES: Five-year migrants = 0.25 * (10 year migrants in same age group + 10 year migrants in next age group).

For age group 0-4, the formula is modified to: 0.5 * migrants 0-4 + 0.25 * migrants 5-9.

Although the five-year net migration numbers obtained in this manner sum to one half of the 10-year numbers, they do not yield exactly the same numbers when applied to two consecutive five-year periods as the 10-year numbers. This discrepancy is apparent if column (3) of table 7 is compared with column (1). This problem is discussed by Irwin (1977). What happens is equivalent to a smoothing of the data and it has the greatest effect on the numbers when they change rapidly, such as those between ages 10 and 30.

III. ESTIMATION OF THE DISTRIBUTION OF MIGRANTS BY AGE AND SEX

As with estimates of the volume of migration, estimates of the age distribution of migrants can be obtained from direct census questions, from indirect census-based measures and from large surveys and registers. In addition, model migration age schedules can be used when data on age distributions are lacking or where data are incomplete or distorted by errors. These methods are discussed below in turn.

A. AGE AND SEX DISTRIBUTIONS FROM A CENSUS WITH A QUESTION ON PLACE OF RESIDENCE AT A FIXED PRIOR DATE

1. General considerations

When base rates are prepared from a census that has a question on place of residence at a fixed prior date (such as five years prior the census), the region of previous residence should be tabulated by region of residence at the census and by age group and sex. If there are many regions, this tabulation will require a large number of age and sex distributions. For example, if there were 30 provinces in a country, there would be 30 * 29 = 870 streams, each tabulated by age and sex. Although such tabulations may not be feasible in countries with limited computer capacity, at a minimum there should be tables of the numbers of in-migrants and out-migrants for each region by age and sex (only 60 tables in the case of 30 provinces). The age groups should correspond to those to be used in the projection. Thus, if the projection is by five-year age groups, then migration should be tabulated by the same age groups. It is also necessary to have the total population of each region by the same age and sex categories so that rates can be calculated.

When the base period or the age groups do not correspond to those used in the projection, adjustments need to be made. Although there is no single solution to the problem of adjusting migration observed over one-time interval to a different time interval, there are methods which give reasonable approximations in many situations (see Long and Boertlein, 1990). When the problem relates to differences in the divisions of age groups, either model age schedules of migrants (Rogers and Castro, 1981) or age distributions from another similar population can be used.

When the time interval used in the census and that used in the projection differ, there is also a problem of the relationship of the age at the time of the move to the age at the census. When the time intervals correspond, the age at the census identifies a cohort and one need only be careful to apply the migration rates to the corresponding cohort in the projection. For example, those aged 20-24 at the time of the census were aged 15-19 five years prior to the census and their mobility rate should be applied to those aged 15-19 at the beginning of a five-year projection interval. However, if the time interval in the base data is either shorter or longer than that used in the projections, there is a risk of assigning the observed mobility to the wrong age group.

2. Example for Argentina

Table 8 shows the number of in-migrants and out-migrants for Buenos Aires by age and sex. However, migrants are only divided into 10- or 20-year age groups and these groups need to be divided into five-year age groups for purposes of projection. Because rates of migration are known to vary significantly by age, it is not sufficient simply to prorate the migrants according to the distribution of the total population within the broad age groups.

TABLE 8. IN-MIGRANTS AND OUT-MIGRANTS BY AGE AND SEX, BUENOS AIRES, 1975-1980, ACCORDING TO 1980 CENSUS OF ARGENTINA

Age group	In-migrants Males	In-migrants Females	Out-migrants Males	Out-migrants Females
5-14	63 485	64 283	25 203	24 958
15-24	92 493	79 762	31 737	31 415
25-44	140 976	123 266	61 945	55 436
45-64	40 936	42 347	23 031	22 208
65 + ...	14 498	23 713	6 519	10 930
TOTAL	352 388	333 371	148 435	144 947

Source: *Censo Nacional de Población y Vivienda, 1980, República Argentina* (Buenos Aires, n.d.), table M.10.

The best approach is to find another age distribution of migrants for a similar area or to choose the model age distribution that best fits the available age distribution and to use it to divide the broad age groups into five-year age groups. The model age distribution is that which fitted rural-urban migrants in the Union of Soviet Socialist Republics (Rogers and Castro, 1981). This model was chosen because it was a published distribution for rural-urban migration and is suited for illustrating the method. Because only the distributions within each age range are used from the model, the choice of the model is not too critical. If one were preparing an actual projection for Argentina, however, one might try to find other evidence to determine whether this model was the best one available.

This method is shown in table 9 for the in-migrants to Buenos Aires. Within each of the broad age groups, the model migration rates for each five-year age group are multiplied by the population in that age group to obtain the number of expected migrants if those migration rates held. The ratio of each of these estimated number of migrants to the total migrants in the broad age group is then computed and this figure is multiplied by the actual number of migrants to obtain the numbers in each five-year age group.

TABLE 9. USE OF MODEL AGE MIGRATION SCHEDULE TO DIVIDE BROAD AGE GROUPS MALE MIGRATION TO BUENOS AIRES, 1980

Age group	Total population	Model migration distribution	1980 census: Age groups in-migrants	1980 census: Reported in-migrants	Adjusted in-migrants
0-4 [a]	394 528	0.0225			46 804
5-9	342 124	0.0190	5-14	63 485	34 331
10-14	295 779	0.0187			29 154
15-19	276 244	0.1301	15-24	92 493	25 632
20-24	276 427	0.3391			66 861
25-29	265 069	0.1938			85 118
30-34	251 569	0.0809	25-44	140 976	33 709
35-39	221 029	0.0384			14 060
40-44	197 569	0.0247			8 088
45-49	191 059	0.0205			13 018
50-54	180 559	0.0192	45-64	40 936	11 520
55-59	155 232	0.0188			9 698
60-64	107 935	0.0186			6 700
65-69	87 384	0.0186			5 949
70-74	60 414	0.0186	65+	14 498	4 110
75+	65 262	0.0186			4 439
TOTAL	3 368 183	1.00		352 388	399 192

Source: For model migration schedule, the urban-rural migration in the Union of Soviet Socialist Republics from Andrei Rogers and Luis J. Castro, *Model Migration Schedules*. Research Report 81-30. (Laxemburg, Austria, International Institute of Applied Systems Analysis, 1981). Ages 0-4 derived from model in proportion to observed migration ages 5-14.

[a] Derived from model in proportion to observed migration of ages 5-14.

B. Age distributions from census data on place of previous residence and duration of residence

1. *General considerations*

If place of previous residence and duration of residence were obtained instead of place of residence at a fixed prior date, it is necessary to have a tabulation of migrants with fewer than five years duration by place of current residence, place of previous residence, age and sex. Such a table is usually not found among published data. If the entire census or a substantial sample of the census is available on a computer file, however, it should be possible to make the tabulation. In making this tabulation, the duration could be fixed to five years or under; the format of the tables would then be the same as those from data obtained from a question on place of residence at a fixed prior time, although the interpretation would be somewhat different.

If flows between regions are not tabulated, but in- and out-migration for each region are tabulated, these data can be used in a way similar to that described in the previous section, although additional adjustments may be needed for the problems peculiar to data on previous place of residence, as discussed earlier.

If only in-migrants by age and duration have been tabulated and one is willing to make the additional assumption that migrants from different origins have the same age distribution, then these can be used to estimate the age distribution of migrants. This procedure does not, however, provide any direct data on the age distribution of out-migrants. In this case, the age distribution of out-migrants has to be set equal to the distribution of in-migrants to the major destination of migrants from each region.

2. *Example from the 1971 census of Indonesia*

The provincial volumes of the 1971 Indonesian census included a tabulation of migrants by age, sex and duration of residence. The data for female migrants to East Java are shown in table 10. By summing the numbers of migrants with durations of zero to four years within each age group, one obtains an approximate

TABLE 10. FEMALE MIGRANTS TO THE PROVINCE OF EAST JAVA, INDONESIA, BY AGE AND DURATION OF RESIDENCE IN 1971

Duration of residence in current province	*Age group* 0-4 (1)	5-9 (2)	10-14 (3)	15-19 (4)	20-24 (5)	25-29 (6)	30-34 (7)	35-39 (8)	40-44 (9)
Under 1 year	777	436	520	928	824	482	261	244	107
1 year	1 396	1 453	1 245	2 074	2 927	1 690	846	502	297
2 years	1 497	1 688	1 447	1 947	2 071	1 474	817	692	177
3 years	653	1 510	1 134	1 509	1 623	1 950	645	741	420
4 years	200	964	1 047	1 356	1 637	1 317	727	698	211
5 years	0	951	888	877	1 455	1 426	751	734	371
6 years	0	1 119	1 300	1 200	1 109	1 469	860	859	554
7 years	0	474	635	576	608	1 339	762	627	244
8 years	0	211	458	479	684	1 358	785	558	263
9 years	0	183	664	760	366	804	605	488	338
10 years +	0	0	3 022	4 751	4 904	6 760	8 608	10 676	9 622
Not stated	519	831	694	876	939	879	1 050	619	633
TOTAL	5 042	9 820	13 054	17 333	19 147	20 948	16 717	17 438	13 237

Source: Based on *Sensus Penduduk Indonesia, 1971* (1971 Population Census), Series E, No. 13. (Jakarta, Biro Pusat Statistic, 1974), table 24.

distribution of in-migrants by age for a five-year period. The distribution is approximate because return migrants that both moved from the province and returned during the five-year period are included in the distribution, whereas they should be excluded when the base data for projections is prepared. If these return migrants differ significantly from other migrants in age, they will distort the age distribution.

The Indonesian data also show that for approximately 7 per cent of the migrants the duration of residence was indicated as "not stated". These responses should be prorated according to the duration of residence distribution within each age group, unless there is other information to indicate that they have a different distribution by duration.

The Indonesian data are typical of those from many countries in that they provide only the age distribution of in-migrants. Since the provinces of destination are known from the tabulations of previous place of residence by duration of residence for migrants to each province, it is possible to determine the major destination of migrants from East Java by the combining data from each of the other provincial volumes. In this way it was determined that the major destinations were Jakarta, Central Java and South Sumatra. If one is willing to assume that migrants from East Java to these destinations were similar to other in-migrants to these destinations, then it is possible to estimate the age distribution of out-migrants from East Java by averaging the distributions of in-migrants to the major destinations. In the example given in table 11, unweighted average are calculated, ignoring the different sizes of each migration stream. This is a reasonable approach when the major migration streams are of similar sizes and the age data are subject to inaccuracy. In many cases, it may be preferable to calculate weighted averages of the percentage distributions, giving greater weight to the larger streams.

TABLE 11. IN-MIGRATION WITH DURATIONS FROM ZERO TO FOUR YEARS, BY AGE AND SEX, FOR MAJOR DESTINATIONS OF MIGRANTS FROM EAST JAVA, ACCORDING TO 1971 CENSUS OF INDONESIA
(Percentage distributions)

Age group	*Males*			*Females*		
	To Jakarta	*To Lampung*	*Average*	*To Jakarta*	*To Lampung*	*Average*
0-4	9.95	14.20	12.08	10.75	15.36	13.06
5-9	7.72	12.68	10.20	8.34	13.76	11.05
10-14	11.29	9.50	10.40	14.80	11.71	13.26
15-19	21.80	10.16	15.98	23.79	13.93	18.86
20-24	20.33	14.28	17.31	15.63	12.50	14.07
25-29	12.72	13.04	12.88	9.73	10.60	10.17
30-34	5.95	9.79	7.87	5.41	7.63	6.52
35-39	4.35	5.03	4.69	3.36	5.17	4.27
40-44	2.33	4.19	3.26	2.59	2.56	2.58
45-49	1.33	2.95	2.14	1.90	1.90	1.90
50-54	0.96	1.68	1.32	1.26	1.77	1.52
55-59	0.56	1.27	0.92	0.88	1.43	1.16
60-64	0.30	0.67	0.49	0.69	0.76	0.73
65-69	0.17	0.39	0.28	0.46	0.55	0.51
70-74	0.12	0.09	0.11	0.21	0.18	0.20
75+	0.13	0.08	0.11	0.21	0.19	0.20
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

Source: Calculated from *Sensus Penduduk Indonesia*, 1971 (1971 Population Census). (Jakarta, Biro Pusat Statistic, 1974).

Because many computer programs deal only with the number of migrants, the final step is to scale the age distributions by the numbers of in-migrants and out-migrants estimated earlier to determine the number in each age group. The number of net migrants is also calculated. Although working only with net migrants can create inconsistencies in projections, some computer programs are designed to accept only estimates of net migrants. The steps in the calculation are illustrated in table 12. The first column is taken from table 11. These percentages are then multiplied by the estimated total number of female migrants, which was obtained by summing the number of female migrants to each of the other provinces as recorded in each of the provincial volumes of the census.

TABLE 12. CALCULATION OF GROSS AND NET MIGRATION FOR FEMALES BY AGE, EAST JAVA, INDONESIA, 1971

		Number of				
Age group	*Out-migrants (percentage) (1)*	*Out-migrants (numbers) (2)*	*Adjusted out-migrants (3)*	*In-migrants (numbers) (4)*	*Adjusted In-migrants (5)*	*Net migrants (6)*
0-4	13.06	14 208	13 668	4 523	3 781	-9 886
5-9	11.05	12 026	11 569	6 051	5 059	-6 510
10-14	13.26	14 425	13 877	5 393	4 509	-9 368
15-19	18.86	20 525	19 745	7 814	6 533	-13 213
20-24	14.07	15 307	14 725	9 082	7 593	-7 133
25-29	10.17	11 062	10 642	6 913	5 779	-4 863
30-34	6.52	7 096	6 826	3 296	2 755	-4 071
35-39	4.27	4 642	4 465	2 877	2 405	-2 060
40-44	2.58	2 802	2 696	1 212	1 013	-1 683
45-49	1.90	2 068	1 989	993	830	-1 159
50-54	1.52	1 649	1 586	900	752	-834
55-59	1.16	1 257	1 209	481	402	-807
60-64	0.73	789	759	371	310	-449
65-69	0.51	550	529	433	362	-167
70-74	0.20	212	204	246	206	2
75 + ...	0.20	218	209	249	208	-1
TOTAL	100.00	108 834	104 698	50 834	42 497	-62 201

Sources: Column (1) was taken from table 11.

Column (2) was obtained by multiplying the percentages in column (1) by the total number of out-migrants obtained by summing the in-migrants from East Java in each of the other provinces.

Column (3) equals column (2) multiplied by (1-0.5 · proportion return migrants), or 0.962.

Column (4) was obtained by adding the migrants with durations 0-4 in table 10.

Column (5) equals column (4) multiplied by (1-0.5 · proportion of return migrants given in table 4), or 0.836.

Column (6) is column (3) minus column (2).

The number of in-migrants is obtained by summing the numbers with durations from zero to four years given in table 8. Because these data were obtained from questions on place of previous residence and duration of residence, an adjustment was made for return migration, as described in chapter II. Although the proportion of return migrants may differ by age, the necessary data to determine that aspect are not available for Indonesia and the rate for all migrants in the stream has been used.

The number of net migrants is then estimated by subtracting column (2) from column (3). In estimating the number of net migrants for each future projection period, it is important first to estimate the numbers of in-migrants and out-migrants; and then to take the difference, as it is not easy to adjust net migration numbers by age unless they are always of the same sign. This matter is discussed further in chapter IV.

C. Age distributions from surveys

Although surveys may not provide accurate estimates of the number of interregional migrants, they may provide adequate information on the age and sex distribution of migrants. Even if the numbers of migrants in each age group are not sufficient to provide reliable estimates of age-specific rates, the survey data should be able to locate the age at which migration rates peak and the relative rate of decline from that peak. With this information, an appropriate model age distribution can be found.

Table 13 shows the age and sex distribution of interregional migrants in the United States based on the Current Population Survey. Columns (8)-(11) of table 13 show the numbers of migrants from each of the regions. Although these data refer to the five-year period 1980-1985, this is an annual survey and for each year similar tables are available for migration over the past year.

TABLE 13. MOBILITY BY REGION AND AGE, UNITED STATES OF AMERICA, 1980-1985

Region and age group, 1985	*Total*	*Same house (non-movers)*	*Different house in the United States (movers)*									*Movers from abroad*
			Total	*Same county*	*Total*	*Same state*	*Different state*					
							Total	*North-east*	*Mid-west*	*South*	*West*	
United States												
Total	216 108	125 982	86 269	47 858	38 411	19 629	18 782	3 423	4 952	6 148	4 259	3 857
5-9	16 566	7 927	8 287	4 945	3 342	1 587	1 755	246	485	568	457	352
10-14	17 226	9 961	6 977	4 119	2 858	1 418	1 440	226	384	509	322	288
15-19	18 325	11 803	6 124	3 518	2 606	1 354	1 253	213	329	401	310	398
20-24	20 466	7 996	11 878	6 303	5 575	3 018	2 557	455	753	854	494	593
25-29	21 106	5 587	14 850	7 954	6 896	3 516	3 380	650	880	1 088	763	669
30-34	19 752	8 085	11 159	6 283	4 876	2 516	2 361	404	621	760	576	508
35-44	31 299	18 405	12 329	6 804	5 525	2 684	2 841	532	751	936	621	566
45-54	22 398	16 330	5 859	3 155	2 704	1 397	1 308	261	304	458	285	209
55-64	22 151	17 489	4 474	2 308	2 166	1 161	1 004	225	231	322	226	189
65+	26 818	22 400	4 332	2 470	1 862	979	883	211	213	252	206	86
Median age	33.6	41.3	28.3	28.2	28.5	28.5	28.5	29.4	28.0	28.4	28.6	27.2
North-east												
Total	46 058	30 814	14 412	8 667	5 745	3 343	2 402	1 184	328	651	238	832
5-9	3 130	1 747	1 287	837	450	249	202	90	37	61	13	96
10-14	3 398	2 275	1 065	717	348	200	149	86	15	40	7	58
15-19	4 060	2 978	1 002	644	358	222	136	70	23	33	9	80
20-24	4 286	2 276	1 899	1 056	843	541	302	165	29	83	24	111
25-29	4 097	1 404	2 556	1 455	1 101	622	478	238	53	136	52	136
30-34	3 921	1 780	2 030	1 214	815	458	357	155	54	102	46	111
35-44	6 796	4 531	2 131	1 256	875	465	410	203	74	95	38	134
45-54	5 028	4 040	936	532	404	227	178	86	22	44	25	51
55-64	5 114	4 340	735	452	283	172	111	60	10	27	13	39
65+	6 220	5 442	771	504	267	187	80	30	9	30	10	16
Median age	35.2	41.5	28.8	28.7	29.0	28.7	29.3	28.8	30.5	29.0	31.5	27.6
Midwest												
Total	54 214	33 015	20 742	12 391	8 352	4 924	3 428	378	1 526	854	669	457
5-9	4 272	2 155	2 087	1 298	789	416	373	37	164	75	98	30
10-14	4 552	2 781	1 743	1 084	658	386	272	27	127	69	49	29
15-19	4 680	3 187	1 442	895	547	310	237	27	92	63	56	51
20-24	5 162	2 016	3 086	1 718	1 369	916	453	59	225	127	43	60
25-29	5 250	1 400	3 723	2 152	1 571	945	625	80	259	158	129	127
30-34	5 045	2 276	2 721	1 689	1 032	584	448	49	207	95	96	48
35-44	7 666	4 842	2 751	1 668	1 083	566	517	58	242	112	106	73
45-54	5 310	4 092	1 201	717	484	292	192	18	81	58	35	17
55-64	5 605	4 602	988	537	450	297	153	18	63	52	21	16
65+	6 672	5 665	1 000	633	367	212	155	6	67	46	36	7
Median age	33.2	40.6	27.7	27.8	27.6	27.3	28.0	27.5	28.0	28.0	28.4	27.3

TABLE 13 *(continued)*

Region and age group, 1985	Total	Same house (non-movers)	*Different house in the United States (movers)*										Movers from abroad
			Total	Same county	Total	Same state	*Different state*						
							Total	North-east	Mid-west	South	West		
South													
Total	73 167	40 999	30 988	15 758	15 229	7 184	8 045	1 389	1 954	3 617	1 085	1 180	
5-9	5 699	2 601	2 992	1 679	1 313	594	719	94	187	322	117	105	
10-14	5 839	3 168	2 578	1 431	1 147	485	662	96	177	311	77	93	
15-19	6 096	3 710	2 276	1 201	1 075	545	530	91	126	231	82	110	
20-24	6 885	2 439	4 263	2 100	2 163	1 012	1 151	167	304	530	149	182	
25-29	7 192	1 870	5 144	2 576	2 568	1 191	1 377	238	329	591	219	177	
30-34	6 591	2 642	3 772	1 911	1 861	935	926	116	217	444	149	177	
35-44	10 391	5 829	4 376	2 156	2 219	1 041	1 178	210	272	562	135	187	
45-54	7 767	5 422	2 275	1 105	1 170	591	578	97	133	279	69	70	
55-64	7 391	5 695	1 650	737	914	448	465	127	97	202	39	45	
65+	9 317	7 622	1 661	862	799	342	457	151	112	145	49	34	
Median age	33.7	42.0	28.3	27.8	28.7	29.0	28.5	30.3	27.8	28.5	27.7	27.8	
West													
Total	42 669	21 154	20 127	11 042	9 086	4 178	4 908	472	1 144	1 025	2 267	1 388	
5-9	3 465	1 423	1 921	1 132	789	329	461	25	98	110	228	121	
10-14	3 438	1 738	1 592	887	705	347	358	17	65	88	188	109	
15-19	3 489	1 927	1 404	777	626	276	350	24	88	74	163	158	
20-24	4 133	1 265	2 629	1 429	1 200	549	651	64	195	114	278	239	
25-29	4 568	912	3 427	1 770	1 656	757	899	95	239	203	363	228	
30-34	4 194	1 387	2 636	1 468	1 168	538	630	83	143	119	284	172	
35-44	6 446	3 202	3 072	1 724	1 348	613	735	62	163	167	343	171	
45-54	4 294	2 776	1 447	801	646	287	360	60	67	77	156	71	
55-64	4 042	2 852	1 101	582	519	244	275	19	61	41	153	89	
65+	4 600	3 672	900	472	428	238	190	24	25	31	110	29	
Median age	32.7	41.0	28.7	28.7	28.7	28.9	28.5	30.7	27.7	28.1	28.8	26.5	

Source: United States of America, Bureau of the Census, *Geographical Mobility: 1985*, Current Population Reports, P-20, No. 420 (Washington, D.C., Government Printing Office, 1987), table 12.

D. AGE DISTRIBUTIONS FROM REGISTERS

Age distributions of migrants can sometimes be obtained from population registers. However, they may not be accurate because registers tend to correspond to changes of legal residence. There is generally more incentive for property owners to register and others who must have legal proof of registration. Temporary workers are less likely to appear in registration records. In general, it may be difficult to assume that the migrants registering have the same age and sex composition as those who failing to register.

E. USE OF MODEL MIGRATION SCHEDULES

Model migration schedules provide a means of estimating the age distribution of migrants when there is no information or only limited information about their age distribution. Rogers and Castro (1981) have shown that most migration streams have an age distribution that peaks in the early adult years, usually between 20 and 30, and then declines. Migration of children under the age of entry into the labour force tends to decline with age, paralleling the rates of their parents. The relative magnitude of pre-labour force migration depends upon the extent to which entire families move, compared with single workers. Where a significant proportion of migration to or from a place is related to marriage, schooling, military service or other non-labour force reasons, age distributions may become distorted from those represented in the model schedules. In most countries, however, most migration streams appear to correspond to the model schedules.

Rogers and Castro (1981) show that these model schedules can be expressed in terms of equations of the form:

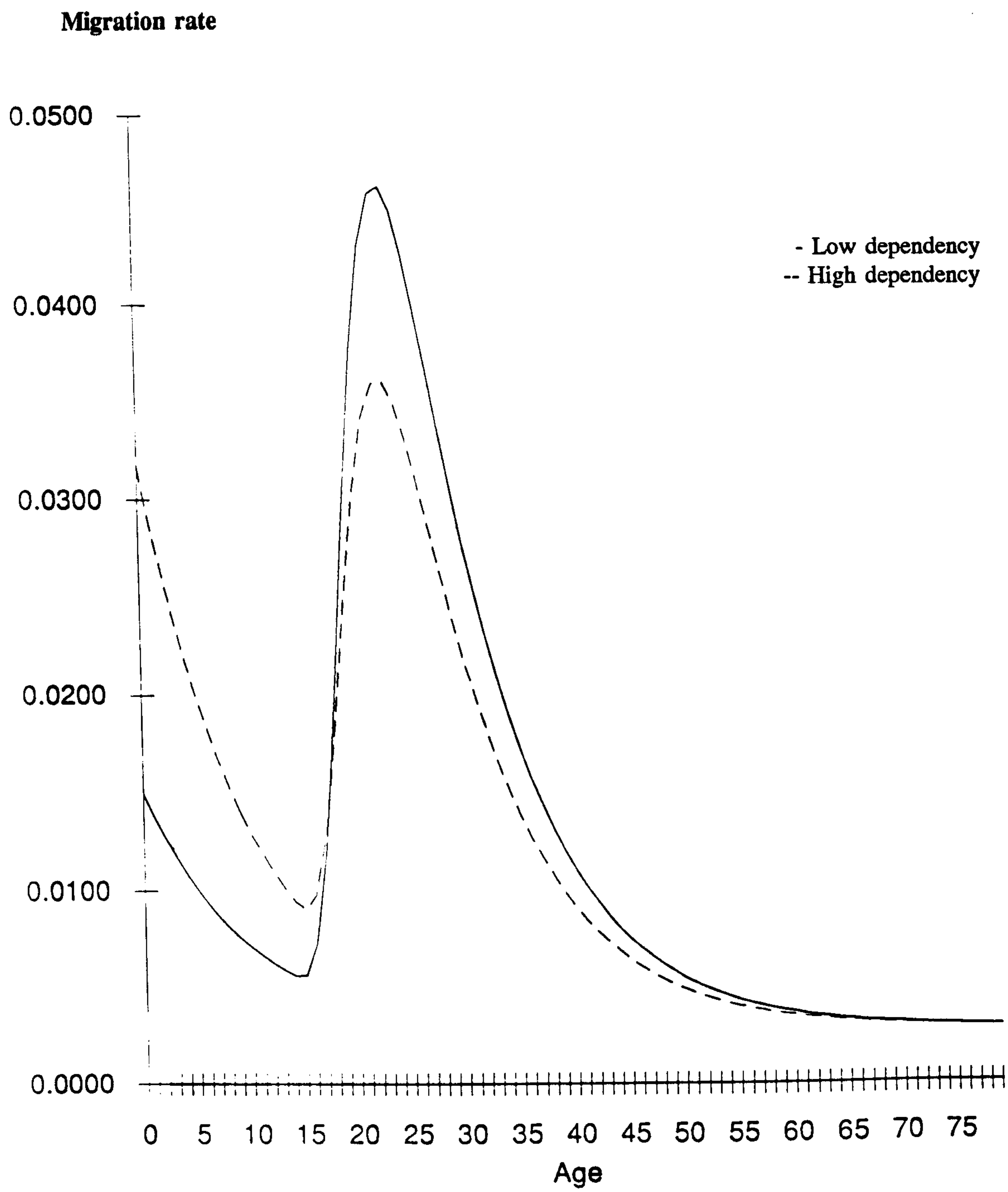
$$M(x) = a_1 \exp(-\alpha_1 x) + a_2 \exp\{-\alpha_2(x - \mu) - \exp(-\lambda(x - \mu))\} + c,$$

where $M(x)$ = migration rate at age x, and a_1, α_1, a_2, α_2, μ, λ and c are constants.

The first term represents the pre-labour force migration and the second term, the labour force age migration. In countries where there is substantial migration at retirement ages, a third term representing the increase in migration around retirement may be needed. For most developing countries, however, this aspect may be neglected.

The figure given below shows the simplified model age distribution obtained by Rogers and Castro on the basis of observing several European populations. The sharp peak around age 25 and the following decline is typical of most migration distributions.

Model migration rates by age, males



Model schedules can be used when there are no adequate data on the age distribution of migration, when data in broad age groups need to be divided into smaller groups or when age distributions from sample data need to be smoothed to remove sampling error. The latter two uses require the fitting of aa model distribution to the observed data, which can be a difficult task involving iterative non-linear procedures.

Castro (1985) attempts to simplify the process of fitting a model schedule to data by relating the age peak to the age of entry into the labour force. This method also provides a potential means of selecting an appropriate age schedule when there are no data on the age of migrants, but age-specific labour force participation rates are available.

Tables A.3 and A.4 in annex II provide a small set of model schedules based on the work of Rogers and Castro with European data. These model schedules vary by two factors (*a*) the age of the labour force peak; and (*b*) the relative proportion of pre-labour force migration. The standard model represents the average derived by Rogers and Castro from over 100 model schedules for each sex from Europe and Japan. The variants for low and high labour force peaks correspond to the value of m, approximately one standard deviation above and below the standard;, while the high and low dependency rates correspond to values of $a_{1,}$ which are one standard deviation above and below the average.

In selecting models for developing countries, the low labour force peak may be appropriate because the age at entry into the labour force is younger in these countries than in the European countries and Japan. For migration streams involving rural resettlement, however, the migrants tend to be older and also to have a high proportion of dependents. For those streams, either the average or high labour force peak and the high dependency would be appropriate.

IV. PROJECTION OF BASELINE MIGRATION INTO THE FUTURE

There are two problems in projecting future migration. The first and major problem is to make reasonable assumptions about future migration trends for each region. The second and more minor problem with migration projections is a technical one. Even if it is assumed that past trends will continue, the populations in regions are likely to change at different rates so that when the same rates are applied to these regions over time, the sum of the number of net migrants across all regions, which was zero for the base period, will not be zero in the future periods. The various solutions to these problems are discussed below.

A. Alternative strategies for projecting migration

Because migration can change dramatically from one period to the next, past rates of migration may be poor predictors of future rates. It is often advisable to prepare two or more alternative sets of subnational projections: one is based on the assumption that past trends will continue; the other assumes a particular change in migration. Sometimes, it is also helpful to prepare subnational projections that assume no migration so that the effect of alternate migration assumptions can be seen. There are four conflicting objectives which can be fulfilled in projecting future migration (United States of America, 1990). These objectives are:

(*a*) To use a long time period so that random or abnormal fluctuations will be averaged out;
(*b*) To use the most recent data available to take account of shifts in migration patterns;
(*c*) To continue recent changes so that emergent trends will be projected, provided one is satisfied that these changes are not random or unusual fluctuations;
(*d*) To ensure convergence of migration rates towards equilibrium at some point in the future.

No one set of regional projections is likely to satisfy all of these objectives. Objectives (*a*) and (*c*) appear to be in direct contradiction. The first would tend to ignore divergent changes in the last year or two of a data series while objective (*c*) would take these changes as suggesting continued divergence and would project them to continue. By carefully studying the factors responsible for recent changes in migration patterns for different regions, it may be possible to make a judgement as to which changes are likely to continue and which are due to unusual events or factors that are unlikely to reoccur.

An example of the use of alternative migration assumptions is the set of state projections prepared by the United States Bureau of the Census (1990). This publication includes four different projection series based on different assumptions about migration. Three of these series vary in the amount and recency of the past migration data used, while the fourth assumes no migration and is useful as a basis of comparison. The assumptions of these series and the regional summaries of the results are shown in table 14. Series A used regression on annual migration data from 1975 to 1988 to extract the trend for each migration stream; and these trends were used, with some modification of extreme values, to project migration into the future. This series attempts to satisfy all four objectives to some degree. Series B used the mean value of the migration rates for each stream over the period 1975-1988 which satisfies the first objective of using a long time period. Series B meets objective (*b*) by using only the most recent three years to compute a mean for each state-by-state migration rate. The fourth series assumed no internal migration and provided a base to compare the effects of migration on the future distribution of the population. Although other assumptions could have been made, the approach taken by the Bureau of the Census illustrates the importance of using alternative migration assumptions.

Another approach is to begin with rates from the base period but to adjust them towards zero so that they become zero at some specified future time-point, such as 25 or 30 years from the base period. This approach satisfies objective (*d*) of projecting a trend towards equilibrium and reduces errors caused by assuming that some unusual movements during the base period will continue indefinitely. The scaling of the rates can be done in a linear way.

For example, if equilibrium is assumed within 25 years, the rates for the first period are 80 per cent of those in the base period, the rates in the second period are 60 per cent, etc.

TABLE 14. ESTIMATES AND PROJECTIONS OF THE POPULATION OF THE UNITED STATES OF AMERICA BY REGION, 1988-2010
(Thousands)

Series and region	*1988 estimate*	*Projections*			*Percentage of total population*				*Average annual percentage change*		
		1990	*2000*	*2010*	*1988*	*1990*	*2000*	*2010*	*1988-1990*	*1990-2000*	*2000-2010*
Series A											
United States	245 807	249 891	267 748	282 056	100.0	100.0	100.0	100.0	0.8	0.7	0.5
North East	50 595	50 850	52 419	53 801	20.6	20.3	19.6	19.1	0.3	0.3	0.3
Midwest	59 878	60 288	60 528	59 696	24.4	24.1	22.6	21.2	0.3	-	-0.1
South	84 655	86 517	95 575	103 529	34.4	34.6	35.7	36.7	1.1	1.0	0.8
West	50 679	52 237	59 226	65 030	20.6	20.9	22.1	23.1	1.5	1.3	0.9
Series B											
United States	245 807	249 891	267 748	282 056	100.0	100.0	100.0	100.0	0.8	0.7	0.5
North East	50 595	50 707	51 005	50 763	20.6	20.3	19.0	18.0	0.1	0.1	-
Midwest	59 878	60 205	61 342	61 997	24.4	24.1	22.9	22.0	0.3	0.2	0.1
South	84 655	86 644	95 382	102 577	34.4	34.6	35.6	36.4	1.2	1.0	0.7
West	50 679	52 336	60 019	66 719	20.6	20.9	22.4	23.7	1.6	1.4	1.1
Series C											
United States	245 807	249 891	267 748	282 056	100.0	100.0	100.0	100.0	0.8	0.7	0.5
Northeast	50 595	50 814	51 662	51 961	20.6	20.3	19.3	18.4	0.2	0.2	0.1
Midwest	59 878	60 296	61 815	62 744	24.4	24.1	23.1	22.2	0.3	0.2	0.1
South	84 655	86 489	94 483	101 008	34.4	34.6	35.3	35.8	1.1	0.9	0.7
West	50 679	52 292	59 778	66 344	20.6	20.9	22.3	23.5	1.6	1.3	1.0
Series D											
United States	245 807	249 801	267 748	282 056	100.0	100.0	100.0	100.0	0.8	0.7	0.5
Northeast	50 595	51 179	53 583	55 028	20.6	20.5	20.0	19.5	0.6	0.5	0.3
Midwest	59 878	60 723	64 231	66 824	24.4	24.3	24.0	23.7	0.7	0.6	0.4
South	84 655	85 998	91 750	96 318	34.4	34.4	34.3	34.1	0.8	0.6	0.5
West	50 679	51 990	58 186	63 886	20.6	20.8	21.7	22.7	1.3	1.1	0.9

Source: United States of America, Bureau of the Census, *Projections of the Population of States by Age, Sex and Race: 1989 to 2010*, Current Population Reports, P-25, No. 1053 (Washington, D.C., Government Printing Office, 1990), table A.

NOTES: As of 1 July. Series A, B, C and D reflect different interstate migration assumptions. The percentage change is based on total beginning population.

Series A is a modified linear trend of the patterns of state-to-state migration observed from 1975 to 1988.

Series B is the average of the state-to-state migration rates observed from 1975 to 1988.

Series C is the average of the state-to-state migration rates observed from 1985 to 1988.

Series D assumes zero net internal migration.

B. ADJUSTMENT SEPARATE REGIONAL PROJECTIONS FOR NATIONAL CONSISTENCY

Unless a full multiregional projection method is used which includes migration rates for each migration stream, it is likely that the projected number of internal migrants will not sum to zero. To provide consistent results, some adjustment will be necessary. Three methods are discussed here: (*a*) the projection of numbers of migrants rather than rates; (*b*) the use of data on the destinations of out-migrants to adjust in-migration; and (*c*) the scaling of in-migration to equal out-migration.

1. Projection of number of migrants

Projection of the number of migrants is the approach most commonly used when the only available data on migration for the base period cover net migration for each region by age and sex. One can assume that the numbers of observed net migrants in each age and sex group remains the same. Since these summed to zero in the base period, they will sum to zero in each future period. It is unlikely, however, that the numbers will remain constant for very many years. Even if the factors that give rise to interregional migration do not change, the populations within the different regions are likely to change at different rates. If migration rates remain constant, which is somewhat more likely to be the case, the numbers of migrants will change as the population of the regions change.

2. Use of data on destination of out-migrants to adjust in-migrants

In many cases, the total migration in each stream is known, but a full multiregional method is not used in projections because the age and sex details for each stream are lacking or the volume of computations is considered to be too cumbersome to be worth the effort. In such cases, the base data on the total migrants in each stream can be used to adjust the in-migration. For each projection period and each region, the migration from each of the other regions to the region under consideration is summed to get the number of in-migrants. The projected numbers of in-migrants for each region are then scaled to equal these numbers. Alternatively, the rates of in-migration by age and sex can be scaled so that the total number of projected migrants equals this number.

Table 15 illustrates the method for the five regions of Indonesia. Although these data could have been used with a multiregional projection programme, it is assumed that separate projections are made for each region using in migration and out-migration rates. Only the totals are shown here, but one would usually apply separate rates for each age and sex group.

Panel A of table 15 shows the total number of migrants in each of the streams among the five regions. The second panel shows the calculation of the in-migration and out-migration rates. The number of in-migrants to a region is the number in the "total" column of panel A minus the number who were in the region in 1975. The number of out-migrants is the number in the "total" column minus those in the region in 1980. The numbers of in-migrants and out-migrants are divided by the population tabulated by previous place of residence (column (6) of panel A) and the result is multiplied by 1,000 to compute rates. Lastly, the net migration rate is computed as the difference between the in-migration and out-migration rates.

Panel C of table 15 shows the percentages of out-migrants from each region who move to every other region. These percentages are needed for the final calculation given in panel D.

Panel D shows how the in-migration and out-migration rates are applied to the 1980 population to project the number of migrants between 1980 and 1985. As expected, the number of projected in-migrants does not equal the number of projected out-migrants, illustrating the problem with independent projection of in-migration and out-migration. The correct number of in-migrants is obtained by using the proportions given in panel C to allocate the projected out-migrants to each of the other regions, which forces the number of in-migrants to equal the number of out-migrants.

TABLE 15. INTERREGIONAL MIGRATION IN FIVE YEARS BEFORE AND AFTER THE 1980 CENSUS IN INDONESIA, POPULATION AGED 5 OR OVER

Region of residence in 1975	*Region of residence at census in 1980*					
	Sumatra (1)	*Java* (2)	*Kalimantan* (3)	*Sulawesi* (4)	*Other Islands* (5)	*Total* (6)
			A. Total number of migrants			
Sumatra	22 530 497	267 717	9 947	16 992	24 047	22 849 200
Java	835 743	78 224 144	143 024	57 070	39 178	79 299 159
Kalimatan	5 486	46 410	5 467 847	7 737	1 757	5 529 237
Sulawesi	7 932	41 357	43 603	8 726 380	51 272	8 870 544
Other	13 068	101 426	2 574	29 826	8 772 323	8 919 217
Total	23 392 726	78 681 054	5 666 995	8 838 005	8 888 577	125 467 357
			B. Computation of in-migration and out-migration rates for base period			
Previous population	22 489 200	79 299 159	5 529 237	8 870 544	8 919 217	125 467 357
Out-migrants*	318 703	1 075 015	61 390	144 164	146 894	1 746 166
Out-migration rate (per 1,000)	13.9	13.6	11.1	16.3	16.5	13.9
In-migrants	862 229	456 910	199 148	111 625	116 254	1 746 166
In-migration rate (per 1,000)	37.7	5.8	36.0	12.6	13.0	-3.7
Net migration rate (per 1,000)	23.8	-7.8	24.9	-3.7	-3.4	0
			C. Percentage distribution of out-migrants			
Sumatra	0.0	84.0	3.1	5.3	7.5	100.0
Java	77.7	0.0	13.3	5.3	3.6	100.0
Kalimatan	8.9	75.6	0.0	12.6	2.9	100.0
Sulawesi	5.5	28.7	30.2	0.0	35.6	100.0
Other	8.9	69.0	1.8	20.3	0.0	100.0
			D. Projected number of in-migrants and out-migrants using base period rates			
Population at census	28 016 160	91 269 528	6 723 086	10 409 533	11 071 991	147 490 298
Out-migration rate	13.9	13.6	11.1	16.3	16.5	-
Projected out-migrants	390 772	1 237 291	74 645	169 176	182 349	2 054 233
In-migration rate	37.7	5.8	36.0	12.6	13.0	-
Projected in-migrants	1 057 208	525 881	242 147	130 991	144 313	2 100 541
Calculated in-migrants	994 101	559 126	231 173	132 952	136 881	2 054 233

Source: For panel A, table 1, excluding persons with previous place abroad or unknown.

NOTES: Calculated in-migrants were obtained by multiplying the percentages in panel C by the projected out-migrants in panel D.

Total 1980 population given in line 1 of panel D is larger than given in panel A because it includes persons aged 0-4 and those living abroad in 1975.

Although this example deals only with the total population, the same procedure can be applied to each age and sex group if the data are available. If migration streams are not available by age and sex, the ratio of the corrected in-migrants to the originally projected in-migrants can be applied to each age and sex group to adjust the number of in-migrants. This assumes that the age and sex composition of each of the migration streams is the same and should be avoided whenever more detailed data are available.

3. Adjustment of total number of in-migrants to equal total out-migrants

In many cases, the destinations of the out-migrants are unknown, so that it is not possible to use the method outlined above, but an acceptable solution to this problem can often be obtained by simply scaling the projected number of migrants so that the in-migrants are equal to the out-migrants. This is illustrated with the Indonesian data given in table 16. Each of the projected regional totals of in-migrants is multiplied by the ratio of the total number of in-migrants to the total number of out-migrants (2,054,233/2,100,541, or 0.978 in this case). This must be done for each projection period before proceeding to the next projection period. Note that the numbers given in table 16 are not the same as those shown in the last line of panel D of table 15, and the difference can be taken as a measure of the error in this procedure.

TABLE 16. ADJUSTMENT OF PROJECTED IN-MIGRANTS AND OUT-MIGRANTS, REGIONS OF INDONESIA

Region	*Previous population*	*Out-migrants*	*Out-migration rate (per 1,000)*	*In-migrants*	*In-migration rate (per 1,000)*
	A. Computation of in-migration and out-migration rates for base period, 1975-1980				
Sumatra	22 849 200	318 703	13.9	862 229	37.7
Java	79 299 159	1 075 015	13.6	456 910	5.8
Kalimantan	5 529 237	61 390	11.1	199 148	36.0
Sulawesi	8 870 544	144 164	16.3	111 625	12.6
Other	8 919 217	146 894	16.5	116 254	13.0
TOTAL	125 467 357	1 746 166	13.9	1 746 166	13.9

B. Projected in-migrants and out-migrants using base period rates

	Population at census	*Out-migration rate*	*Projected out-migration*	*In-migration rate*	*Trial projected in-migration*	*Adjusted in-migration*
Sumatra	28 016 160	13.9	390 772	37.7	1 057 208	1 033 900
Java	91 269 528	13.6	1 237 291	5.8	525 881	514 288
Kalimantan	6 723 086	11.1	74 645	36.0	242 147	236 809
Sulawesi	10 409 533	16.3	169 176	12.6	130 991	128 103
Other	11 071 991	16.5	182 349	13.0	144 313	141 132
TOTAL	147 490 298	-	2 054 233	-	2 100 541	2 054 233

Source: For base data, *Penduduk Indonesia 1980* (Population of Indonesia, 1980), (Jakarta, Biro Pusat Statistic, 1982).

NOTES: Excluding persons from abroad or with unknown previous residence from in-migrants and from previous population. Projected in-migrants = trial in-migrants times (total projected out-migrants/total trial in-migrants).

V. RECOMMENDATIONS FOR DATA COLLECTION

Censuses are usually the best source of base data for internal migration for use in projections. Large surveys are only useful if they have broad geographical coverage including several areas within each region. Even then, because migrants are often concentrated in particular small areas at the place of destination, it is easy to miss them in surveys.

The best census question is one that asks about place of residence at a fixed prior time preceding the census by the time interval of interest for projections. Although five-year projections by five-year age group have commonly been used in the past, there is likely to be an increased demand for single year projections. A great deal of planning is short-range planning, which requires annual projections of population. Often, there is a demand for current population estimates by age and sex which can best be met by making single-year projections forward from the most recent census.

This situation suggests that a question on place of residence one year prior to the census, which is tabulated by single year of age, would be the most useful question for obtaining migration data for use in projections. The question on place of residence one year before the census is also likely to yield more complete and more accurate responses than the question on place of residence five years prior to the census.

There are, however, three potential problems with the one-year question. First, if the concept place of residence used to define where people live at the time of the census requires some minimum duration of residence, then some of the most recent migrants will not be counted and the effective period of measurement will be less than one year. Secondly, the year before the census may be atypical in terms of migration patterns. Thirdly, reporting of age in single years may be highly erroneous. In these cases, a longer period of time would provide a better measurement.

Where it can be afforded, two questions should be asked, one on place of residence one year prior to the census and another on place of residence five years before the census. Although asking for the place of previous residence and the duration of residence would appear to offer a good compromise which leaves the choice of time interval up to the analyst after the census, it has been shown that this approach can produce misleading data because of the possibility of multiple moves during whatever time period is chosen for analysis. The results are also affected by the level of geographical area used in asking the question. If place of residence is defined at the town or village level, then many moves across major boundaries, such as provinces, may be missed because they were followed by shorter moves within the major boundaries and only the last move is obtained. This is not a problem with the question on place of residence at a fixed prior time because it can be classified by whatever boundaries are desired for projections.

Lastly, it is important that the question on place of residence one or five years prior to the census be tabulated by current region of residence and age and sex. If a separate volume is produced for each state or province, one may include in each of these volumes a table on state or province of residence at the fixed prior time by age and sex. By combining data from all of these tables, it is possible to obtain the complete set of migration streams between states or provinces by age and sex, which is the best form of data for subnational projections.

ANNEXES

ANNEX I

Example of modified multiregional projection

The purpose of annex I is to provide a simple example of the use of multiregional methods for regional projections in a developing country. The multiregional method of projection has been developed by Rogers (1985) and also by Rees and Wilson (1977). The presentation usually begins with formal demography and uses matrix algebra to express the equations. A computer program written by Willekens and Rogers (1978) is available to carry out the projections. However, it is also possible to perform the projection using standard spreadsheet programs which are available for most personal computers.

In this example, the female population of Indonesia is divided into three regions (Sumatra, Java and the other islands) and a five-year projection is made for each region. The procedure could easily be modified for a larger number of regions and the process could be repeated for more time intervals and for males. However, three regions for one sex and time period are sufficient to illustrate the method. Using a spreadsheet program, it is easy to repeat a procedure by simply copying the spreadsheet and changing the input data.

The input data needed for the projection and their sources for this example are:

(a) *Age distribution for each region.* The age distributions were obtained from the 1980 census. The regional age distributions included some age ranges broader than five years, which were divided into conventional age groups by using the distribution of the national population within the broad age ranges;

(b) *Survival rates for each region.* Because age-specific mortality data were not available for the regions of Indonesia, United Nations model life-tables were used (United Nations, 1982). The South Asian models were selected as most appropriate for Indonesia and survey estimates of infant mortality by region published by Dasvarma (1984) were used to select the specific tables. The selected tables for the three regions were identified by the following life expectancies: Sumatra, 61 years; Java, 60 years; and the other islands, 57 years;

(c) *Age specific fertility rates by region.* Survey estimates of age-specific fertility rates by region were obtained from the Indonesian Central Bureau of Statistics (1982) and refer to the period 1974-1978;

(d) *Migration rates by age, origin and destination.* The total migration rates between regions published in the 1980 census are given in table 1 of this publication. These rates were combined into the three regions used in this example. Model age schedules were used to estimate migration rates by age. This procedure is described in the next section. The selected schedules are:

(i) Sumatra to Java: Young labour force entry, low dependency;
(ii) Sumatra to other: Average labour force entry, low dependency;
(iii) Java to Sumatra: Average labour force entry, high dependency;
(iv) Java to other: Average labour force entry, high dependency;
(v) Other islands to Sumatra: Average labour force entry, low dependency;
(vi) Other islands to Java: Young labour force entry, low dependency.

The rationale for these choices is that migration into Java from Sumatra and the other islands tends to be movement towards major cities, which is dominated by young people with few dependants. The movement from Java to Sumatra and other islands contains a large fraction of rural settlers that tend to be older families with children. Movement between Sumatra and other islands is mostly employment-related and is assumed to have average age but lower than average dependency.

A. Using model age schedules for migration streams

It is often possible to estimate the overall migration rate for migrants from each region to every other region, but age specific rates are lacking, as is the case in this example. An appropriate model schedule can be chosen for each stream and the rates from this schedule can be scaled so that the total is equal to the overall migration rate. This method is illustrated in annex table A.1.

TABLE A.1 APPLICATION OF MODEL MIGRATION SCHEDULES TO INDONESIAN FEMALES

Age in 1980	Population in 1980 (1)	Migrants from Sumatra to Java: Model migration rates (2)	Estimated migrants (3)	Scaled model rates (4)	Migrants from Sumatra to other islands: Model migration rates (5)	Estimated migrants (6)	Scaled model rates (7)
Births after 1980 . . .	-	0.0418	-	0.0056	0.0418	-	0.0011
0-4	2 167.2	0.0649	140.6	0.0088	0.0649	140.6	0.0018
5-9	2 107.2	0.0460	96.9	0.0062	0.0454	95.7	0.0012
10-14	1 770.4	0.0957	169.4	0.0129	0.0386	68.4	0.0011
15-19	1 533.3	0.2199	337.1	0.0297	0.1365	209.3	0.0037
20-24	1 364.6	0.1729	236.0	0.0233	0.2182	297.7	0.0060
25-29	970.2	0.0997	96.7	0.0135	0.1464	142.0	0.0040
30-34	707.5	0.0585	41.4	0.0079	0.0835	59.0	0.0023
35-39	743.6	0.0379	28.2	0.0051	0.0502	37.4	0.0014
40-44	642.0	0.0278	17.8	0.0037	0.0338	21.7	0.0009
45-49	540.2	0.0228	12.3	0.0031	0.0257	13.9	0.0007
50-54	408.3	0.0203	8.3	0.0027	0.0218	8.9	0.0006
55-59	252.4	0.0191	4.8	0.0026	0.0198	5.0	0.0005
60-64	256.1	0.0185	4.7	0.0025	0.0188	4.8	0.0005
65-69	137.4	0.0182	2.5	0.0025	0.0184	2.5	0.0005
70-74	131.4	0.0181	2.4	0.0024	0.0181	2.4	0.0005
75+	128.7	0.0180	2.3	0.0024	0.0180	2.3	0.0005
TOTAL	13 860.5	1.0000	1 201.5	-	-	1 111.7	-
Calculated total rate	-	-	0.087	-	-	0.080	-
Desired total rate	-	-	0.0117	-	-	0.0022	-

Column (1) shows the age distribution of the population, which is needed to calculate the number of migrants implied by the model rates. Column (2) contains the model migration rates given in the tables A.3 and A.4 in annex II. Column (3) is obtained by multiplying the model migration rate in column (2) by the population in column (1). These estimated numbers of migrants are summed and the sum is divided by the total population to give the "calculated total rate". This calculation is compared with the desired rate, which in this case was based on the 1980 census, as shown in panel C of table 1. By taking the ratio of the desired total rate to the calculated rate, a scale factor is obtained (0.0117/0.087= 0.134 in this example) which is then multiplied by the rates in column (2) to yield the scaled rates given in column (4). This procedure is repeated in columns (5), (6) and (7) for migrants from Sumatra to the other islands. The scaled rates are used in the population projection.

B. STEPS IN THE POPULATION PROJECTION

The calculation of a multiregional projection is illustrated for Indonesia in annex table A.2. The steps followed in this example are a simplification of the multiregional approach of Rogers (1985) in that survival, migration and births are calculated independently. The numbers shown in this example do not always sum exactly to the numbers shown in the table because the numbers in the table are rounded whereas the calculations actually used by the spreadsheet program involved more digits than are shown.

Step 1. Computation of survivors by region. Whereas the projection for a single region involves multiplying the population at the first time-point in each age group by a survival rate to obtain the survivors to the next age group at the second time-point, multiregional projection involves a compound survival rate which specifies the probability of surviving and being in a particular region at the second time-point. In this example, the compound survival rate for survival to one of the two other regions is simply the product of the survival rate and the out-migration rate to that region. For survival in the same region, the compound rate is the survival rate times one minus the sum of the out-migration rates to the other regions. For example, the number of females aged 0-4 in Sumatra in 1980 is 2,167.2 (column (2)). The number of those surviving and remaining in Sumatra is 2,167.2 · 0.9647 · (1 - 0.0088 - 0.0018) = 2,068.7. These persons are shown in column (6) at ages 5-9 in 1985. This procedure is repeated for each of the age groups in each of the regions;

TABLE A2. MULTIREGIONAL PROJECTIONS FOR FEMALES IN THREE REGIONS OF INDONESIA, 1980-1985

Age group	*Population in 1980*	*Survival rate*	*Age-specific fertility*	*Out-migration rate*		*Survivors to region*				*Population*
				To Java	*To other*	*Sumatra*	*Java*	*other*	*In-migrants*	*in 1985*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
A. Region 1: Sumatra										
	-	-	-	0.0056	0.0011	-	-	-	-	-
0-4	2 167.2	0.9647	-	0.0088	0.0018	2515.7	14.3	2.9	71.7	2 587.4
5-9	2 107.2	0.9924	-	0.0062	0.0012	2068.7	18.3	3.7	85.3	2 153.9
10-14	1 770.4	0.9947	-	0.0129	0.0011	2075.6	13.0	2.6	59.8	2 135.4
15-19	1 533.3	0.9930	0.101	0.0297	0.0037	1736.4	22.7	1.9	39.1	1 775.5
20-24	1 364.6	0.9919	0.270	0.0233	0.0060	1471.7	45.2	5.7	80.6	1 552.3
25-29	970.2	0.9904	0.249	0.0135	0.0040	1313.9	31.6	8.1	92.1	1 406.0
30-34	707.5	0.9880	0.210	0.0079	0.0023	944.1	12.9	3.9	50.5	994.7
35-39	743.6	0.9843	0.118	0.0051	0.0014	691.9	5.5	1.6	21.8	713.6
40-44	642.0	0.9784	0.060	0.0037	0.0009	727.1	3.7	1.0	14.6	741.7
45-49	540.2	0.9671	-	0.0031	0.0007	625.1	2.4	0.6	9.0	634.1
50-54	408.3	0.9470	-	0.0027	0.0006	520.4	1.6	0.4	6.0	526.4
55-59	252.4	0.9144	-	0.0026	0.0005	385.4	1.1	0.2	4.3	389.7
60-64	256.1	0.8662	-	0.0025	0.0005	230.1	0.6	0.1	2.4	232.5
65-69	137.4	0.7975	-	0.0025	0.0005	221.2	0.6	0.1	2.2	223.4
70-74	131.4	0.7024	-	0.0024	0.0005	109.3	0.3	0.1	1.1	110.4
75+	128.7	0.5008	-	0.0024	0.0005	156.3	0.2	0.0	0.9	157.2
TOTAL	13 860.5	-	-	-	-	15 792.9	174.0	32.9	541.5	16 334.3

Steps in computing population aged 0-4:

1. Computed births, 1980 1,039.7;
2. Computed births, 1985 1,286.1;
3. Estimated births, 1980-1985 5,814.7;
4. Female births, 1980-1985 2,836.4;
5. Survival rate, birth to ages 0-4 0.893;
6. Population 0-4 in 1985 2,532.9.

Age group	*Population in 1980*	*Survival rate*	*Age-specific fertility*	*Out-migration rate*		*Survivors to region*				*Population*
				To Java	*To other*	*Sumatra*	*Java*	*other*	*In-migrants*	*in 1985*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
B. Region 2: Java										
	-	-	0.0098	0.0028	-	-	-	-	-	-
0-4	5 929.5	0.9618	-	0.0146	0.0042	7 077.8	70.3	20.1	24.8	7 102.6
5-9	6 217.7	0.9918	-	0.0095	0.0027	5 595.6	83.5	23.9	31.2	5 626.8
10-14	5 325.7	0.9942	-	0.0072	0.0021	6 091.4	58.5	16.7	22.4	6 113.9
15-19	4 942.7	0.9924	0.121	0.0159	0.0045	5 245.6	38.2	10.9	29.2	5 274.8
20-24	4 398.9	0.9912	0.228	0.0202	0.0058	4 804.9	77.9	22.3	65.3	4 870.2
25-29	3 714.4	0.9896	0.205	0.0132	0.0038	4 246.8	88.2	25.2	60.1	4 306.9
30-34	2 708.4	0.9871	0.153	0.0078	0.0022	3 613.6	48.4	13.8	28.6	3 642.2
35-39	2 846.6	0.9833	0.084	0.0050	0.0014	2 646.7	20.9	6.0	12.0	2 658.7
40-44	2 457.6	0.9772	0.037	0.0036	0.0010	2 781.1	14.0	4.0	7.9	2 788.9
45-49	2 067.9	0.9656	-	0.0029	0.0008	2 390.4	8.7	2.5	4.7	2 395.2
50-54	1 738.7	0.9448	-	0.0026	0.0007	1 989.3	5.8	1.7	3.1	1 992.4
55-59	1 074.8	0.9113	-	0.0024	0.0007	1 637.3	4.2	1.2	2.0	1 639.3

TABLE A.2. *(continued)*

Age group	*Population in 1980 (1)*	*Survival rate (2)*	*Age-specific fertility (3)*	*Out-migration rate To Java (4)*	*Out-migration rate To other (5)*	*Survivors to region Sumatra (6)*	*Survivors to region Java (7)*	*Survivors to region Other (8)*	*In-migrants (9)*	*Population in 1985 (10)*
60-64	1 090.7	0.8620	-	0.0023	0.0007	976.4	2.3	0.7	1.1	977.5
65-69	585.3	0.7923	-	0.0023	0.0006	937.4	2.2	0.6	1.0	938.4
70-74	559.4	0.6960	-	0.0022	0.0006	462.3	1.0	0.3	0.5	462.8
75+	548.2	0.4895	-	0.0022	0.0006	655.8	0.9	0.2	0.4	656.2
TOTAL	46 206.6	-	-	-	-	51 152.6	525.1	150.0	294.3	51 446.9

Steps in computing population aged 0-4:
1. Computed births, 1980 — 3,106.9;
2. Computed births, 1985 — 3,515.4;
3. Estimated births, 1980-1985 — 16,555.7;
4. Female births, 1980-1985 — 8,075.9;
5. Survival rate, birth to age 0-4 — 0.8876;
6. Population aged 0-4 in 1985 — 7,168.2.

C. Region 3: Other islands

Age group	*Population in 1980 (1)*	*Survival rate (2)*	*Age-specific fertility (3)*	*Out-migration rate To Java (4)*	*Out-migration rate To other (5)*	*Survivors to region Sumatra (6)*	*Survivors to region Java (7)*	*Survivors to region Other (8)*	*In-migrants (9)*	*Population in 1985 (10)*
			0.0006	0.0042	-	-	-	-	-	-
0-4	2 067.3	0.9524	-	0.0009	0.0065	2 465.4	1.4	10.4	23.0	2488.4
5-9	2 085.5	0.9896	-	0.0006	0.0046	1 954.3	1.7	12.9	27.6	1981.9
10-14	1 668.9	0.9927	-	0.0005	0.0039	2 053.1	1.3	9.4	19.3	2072.4
15-19	1 475.4	0.9903	0.086	0.0019	0.0138	1 649.4	0.9	6.5	12.8	1662.2
20-24	1 313.1	0.9888	0.254	0.0030	0.0220	1 438.3	2.7	20.1	28.0	1466.2
25-29	1 079.7	0.9870	0.254	0.0020	0.0148	1 266.0	3.9	28.5	33.3	1299.3
30-34	787.3	0.9842	0.217	0.0011	0.0084	1 047.8	2.1	15.7	17.7	1065.5
35-39	827.4	0.9801	0.143	0.0007	0.0051	767.4	0.9	6.5	7.6	775.0
40-44	714.4	0.9735	0.080	0.0005	0.0034	806.3	0.6	4.1	5.0	811.3
45-49	601.1	0.9608	-	0.0004	0.0026	692.7	0.3	2.4	3.1	695.8
50-54	437.9	0.9381	-	0.0003	0.0022	575.8	0.2	1.5	2.0	577.9
55-59	270.7	0.9019	-	0.0003	0.0020	409.8	0.1	0.9	1.4	411.2
60-64	274.7	0.8497	-	0.0003	0.0019	243.6	0.1	0.5	0.8	244.4
65-69	147.4	0.7770	-	0.0003	0.0019	232.9	0.1	0.4	0.7	233.7
70-74	140.9	0.6774	-	0.0002	0.0018	114.3	0.0	0.2	0.4	114.6
75+	138.1	0.4739	-	0.0002	0.0018	160.5	0.0	0.2	0.3	160.8
TOTAL	14 029.8	-	-	-	-	15 877.7	16.3	120.3	182.9	16 060.6

Steps in computing population aged 0-4:
1. Computed births, 1980 — 1,081.0;
2. Computed births, 1985 — 1,252.3;
3. Estimated births, 1980-1985 — 5,833.2;
4. Female births, 1980-1985 — 2,845.5;
5. Survival rate, birth to age 0-4 — 0.8706;
6. Population aged 0-4 in 1985 — 2,477.3.

Step 2: calculation of in-migrants. The numbers of in-migrants, shown in column (9), are obtained by summing the out-migrants from other regions to this region. For example, the number of in-migrants to Sumatra that were aged 5-9 in 1985 is the sum of the number of out-migrants aged 5-9 from Java (column 6 of panel B) and the number of out-migrants aged 5-9 from the other islands (column (7) of panel C) or 83.5 + 1.7 = 85.2;

Step 3: summming of survivors and in-migrants to obtain population aged 5 or over. The projected population in each group aged 5 or over, shown in column (10), is simply the sum of the survivors to the same region, column (6), and the number of in-migrants, column (9). For females aged 5-9 in Sumatra, this is 2,068.7 + 85.3 = 2,153.9;

Step 4: calculation of births and survivors to ages 0-4 by region. Annual births are estimated by applying the age-specific birth rates assumed for each region to the number of women in each of the reproductive age groups. This step is done separately for 1980 and 1985, and the results are averaged and then multiplied by five to get the total number of births in that region for the five-year projection interval. In this example, the same age-specific rates are used for 1980 and 1985, although different rates could have been assumed.

Since this projection is only for females, the number of births is multiplied by the assumed proportion female, or 0.488 in this example. This number is then multiplied by the survival rate from birth to ages 0-4, which in this case was obtained from the model life-table. Lastly, the out-migration rates for migration from birth to ages 0-4 are applied to the number of survivors to obtain the migrants to each of the regions and one minus the sum of the migration rates is multiplied by the survivors to get the number that remain in the same region. These numbers are shown for age group 0-4 in columns (6), (7) and (8). The in-migrants born during the period are obtained by summing the out-migrants from the other regions to this region as described above in step 2 and these are added to the births surviving in the same region to get the projected population aged 0-4 in each region.

This projection process can be repeated for further time intervals, and the assumed levels of mortality, fertility and migration can be altered for each projection period, if desired.

ANNEX II

Model migration age schedules

Annex II provides a few model schedules of migration rates by age which may be of use when data on migration by age are unavailable or incomplete for regions of a country. The use of these models is similar to the use of model schedules of mortality and fertility. However, the equation which describes the migration schedules is more complex because migration rates typically decline from birth to some minimum, usually in the teenage years, then rise to a peak, usually in the twenties, and then fall again. In some countries, there is a secondary peak around the time of retirement. However, this peak is rarely observed in developing countries and will be ignored.

The basic model age equation contains seven parameters. As developed by Rogers and Castro (1981), the equation without a post-labour force peak or rise is as follows:

$$M(x) = a_1 \exp(-\alpha_1 x) + a_2 \exp\{-\alpha_2(x-\mu) - \exp(-\lambda(x-\mu))\} + c$$

where M(x) = migration rate at age x, and a_1, α_1, a_2, α_2, μ, λ and c are constants.

While it is helpful to know that most distributions of migration rates by age fit this general form, it may be difficult to select appropriate model parameters in countries where there are little reliable data on migration by age. It may be more helpful to draw from their experience with a large number of age schedules to try to specify some specific alternatives which can be used especially for regional projections.

Using single-year migration rates for single years of age, Rogers and Castro (1981) compiled 164 schedules for males and 172 for females from Japan, Sweden and the United Kingdom of Great Britain and Northern Ireland. These schedules provide a range of estimates for the seven parameters given above in the equation. Using their results, a few combinations have been selected. The first, which is identified as the "Western standard", is based on the average of each of the parameters. Two of the major sources of variation among schedules have then been used to produce variants. These main sources of variation are (*a*) the ratio of pre-labour force "dependants" to labour force migrants and; (*b*) the average age of entry into the labour force or marriage, which relates to the peak in the distribution. In choosing the variants, the standard deviations calculated by Rogers and Castro for key parameters were used.

Six alternatives are presented for each sex:

(*a*) The average Western model;

(*b*) Low dependency: a_1 approximately one standard deviation below average, a_2 adjusted upward to keep sum = 1;

(*c*) High dependency: a_1 approximately one standard deviation above average, a_2 adjusted downward to keep sum = 1.

(*d*) Young labour force entry: μ approximately one standard deviation below average;

(*e*) Old labour force entry: μ approximately one standard deviation above average;

(*f*) Low dependency and young labour force entry.

These alternatives are based on the range of experience observed by Rogers and Castro in three highly developed countries and may not represent the range for other countries. Schedules tested for Brazil, Indonesia and the Philippines appear to fall within this range, which suggests that they may apply to many developing countries.

Following Rogers and Castro, the model schedules are expressed in terms of migration rates which sum to 1.0. This is somewhat analogous to total fertility, although it is more sensitive to the upper age-limit of the distribution because migration rates do not fall to zero above some age the way fertility does. Nevertheless, the use of schedules based on rates and summing to 1.0 is useful because the schedules are independent of the actual age distribution and can be scaled to match any observed level of migration.

Although Rogers and Castro work with single-year data, projections are often made with five-year age data and five-year time intervals. Even if single- year age data were available for migrants by region in a developing country, it might be very difficult to use because of problems of age-heaping. Thus, there is a need for model schedules that cover five-year age groups and five-year time periods.

Over a five-year time period, any five-year age cohort will pass through a total of nine single age groups. For example, those aged 10 at the beginning of the period will pass through ages 10, 11, 12, 13 and 14 and enter age 15 by the end of the period. Those aged 14 will be 19 at the end of the period. Thus, a total of nine different single-year migration rates will be experienced by the age cohort during the projection period. These rates, however, will not be experienced in equal amounts. The rate for those aged 10-11 will be experienced only once by one of the five single year cohorts within the five-year cohort. The same is true for the migration rate from 18 to 19. However, each of the five cohorts will experience the rate for ages 14-15. The five-year rate for any five-year cohort is the following sum of single-year rates:

$$ {}_5M_x = {}_1M_x + 2\ {}_1M_{x+1} + 3\ {}_1M_{x+2} + 4\ {}_1M_{x+3} + 5\ {}_1M_{x+4} $$

$$ + 4\ {}_1M_{x+5} + 3\ {}_1M_{x+6} + 2\ {}_1M_{x+7} + {}_1M_{x+8} $$

where ${}_5M_x$ = five-year migration rate for five-year age group beginning with age x;

${}_1M_x$ = single year migration rate for one-year age group aged x.

Using this formula, five-year migration rates have been computed from the single-year rates derived from the equation for model schedules using the combination of parameters described above. Minor adjustments had to be made for those born during the interval and for those that were already in the highest age group but survived the interval.

The results are shown in annex tables A.3 and A.4 along with the model age parameters used to derive the single-year rates which they are based. In using these models, it is important to be clear about whether a particular cohort is referred to by the age at the beginning of the period or the age at the end of the period. Projections often work with the age at the beginning of the interval. However, censuses usually tabulate migrants by age at the time of the census, which would be equivalent to the age at the end of the period. Thus, the age of peak migration may appear to be older in census measures of migration than in the corresponding single-year model.

TABLE A.3 FIVE-YEAR MODEL MIGRATION RATES FOR MALES

From ages	*To ages*	*Western standard*	*Low dependency*	*High dependency*	*Young labour force entry*	*Old labour force entry*	*Low dependency low labour force entry*
Birth	0-4	0.0547	0.0353	0.0741	0.0547	0.0547	0.0354
0-4	5-9	0.0824	0.0546	0.1104	0.0826	0.0826	0.0547
5-9	10-14	0.0544	0.0379	0.0710	0.0566	0.0545	0.0405
10-14	15-19	0.0443	0.0356	0.0532	0.1107	0.0379	0.1124
15-19	20-24	0.1293	0.1394	0.1188	0.1946	0.0438	0.2152
20-24	25-29	0.1894	0.2123	0.1659	0.1526	0.1496	0.1698
25-29	30-34	0.1375	0.1541	0.1204	0.0971	0.1796	0.1074
30-34	35-39	0.0868	0.0966	0.0768	0.0619	0.1233	0.0678
35-39	40-44	0.0557	0.0613	0.0501	0.0414	0.0778	0.0447
40-44	45-49	0.0378	0.0410	0.0346	0.0296	0.0506	0.0316
45-49	50-54	0.0275	0.0293	0.0258	0.0229	0.0349	0.0240
50-54	55-59	0.0216	0.0226	0.0207	0.0191	0.0259	0.0197
55-59	60-64	0.0183	0.0188	0.0178	0.0169	0.0208	0.0172
60-64	65-69	0.0163	0.0167	0.0161	0.0156	0.0178	0.0158
65-69	70-74	0.0152	0.0154	0.0152	0.0149	0.0162	0.0150
70-74	75+	0.0146	0.0147	0.0147	0.0145	0.0152	0.0145
75+	-	0.0143	0.0143	0.0144	0.0143	0.0147	0.0143
	TOTAL	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Parameters							
a_1		0.0215	0.0128	0.0303	0.0215	0.0215	0.0128
α_1		0.1050	0.1050	0.1050	0.1050	0.1050	0.1050
a_2		0.0694	0.0804	0.0582	0.0691	0.0691	0.0800
α_2		0.1120	0.1120	0.1120	0.1120	0.1120	0.1120
μ		20.0400	20.0400	20.0400	16.0900	23.9900	16.0900
λ		0.3910	0.3910	0.3910	0.3910	0.3910	0.3910
c		0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
Age at minimum		15	14	15	11	18.5	11
Age at maximum		23	23	23	19	27	19
Ratio of pre-labour force to labour force		0.298	0.154	0.477	0.254	0.328	0.138
Labour assymetry		0.443	0.431	0.467	0.454	0.443	0.427

TABLE A.4 FIVE-YEAR MODEL MIGRATION RATES FOR FEMALES

From ages	*To ages*	*Western standard*	*Low dependency*	*High dependency*	*Young labour force entry*	*Old labour force entry*	*Low dependency low labour force entry*
Birth	0-4	0.0605	0.0418	0.0792	0.0605	0.0605	0.0418
0-4	5-9	0.0916	0.0649	0.1183	0.0916	0.0916	0.0649
5-9	10-14	0.0611	0.0454	0.0767	0.0615	0.0611	0.0460
10-14	15-19	0.0471	0.0386	0.0584	0.0957	0.0432	0.0957
15-19	20-24	0.1256	0.1365	0.1283	0.1966	0.0485	0.2199
20-24	25-29	0.1923	0.2182	0.1635	0.1538	0.1591	0.1729
25-29	30-34	0.1296	0.1464	0.1064	0.0898	0.1765	0.0997
30-34	35-39	0.0751	0.0835	0.0631	0.0538	0.1087	0.0585
35-39	40-44	0.0462	0.0502	0.0404	0.0357	0.0635	0.0379
40-44	45-49	0.0319	0.0338	0.0291	0.0268	0.0404	0.0278
45-49	50-54	0.0248	0.0257	0.0235	0.0223	0.0290	0.0228
50-54	55-59	0.0213	0.0218	0.0207	0.0201	0.0234	0.0203
55-59	60-64	0.0196	0.0198	0.0193	0.0190	0.0206	0.0191
60-64	65-69	0.0188	0.0188	0.0186	0.0185	0.0192	0.0185
65-69	70-74	0.0183	0.0184	0.0183	0.0182	0.0186	0.0182
70-74	75+	0.0181	0.0181	0.0181	0.0181	0.0182	0.0181
75+		0.0180	0.0180	0.0180	0.0180	0.0181	0.0180
	TOTAL	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Parameters							
a_1		0.0233	0.0149	0.0318	0.0233	0.0233	0.0149
α_1		0.1070	0.1070	0.1070	0.1070	0.1070	0.1070
a_2		0.0766	0.0900	0.0632	0.0766	0.0766	0.0900
α_2		0.1436	0.1436	0.1436	0.1436	0.1436	0.1436
μ		20.6320	20.6320	20.0400	17.1320	24.1320	17.1320
λ		0.4003	0.4003	0.4003	0.4003	0.4003	0.4003
c		0.0036	0.0036	0.0036	0.0036	0.0036	0.0036
Age at minimum		15	15	15	11	19	12
Age at maximum		23	23	22	19	26	19
Ratio of pre-labour force to labour force		0.368	0.208	0.576	0.311	0.408	0.188
Labour assymetry		0.503	0.482	0.455	0.449	0.405	0.408

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Printed In U.S.A.
91-41312—February 1992—5,035
ISBN 92-1-151243-3

United Nations publication
Sales No. E.92.XIII.6
ST/ESA/SER.A/127