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 (1)	*1970* (2)	(3)	*1960* (4)	*1970* (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.