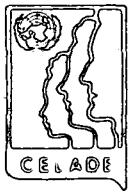
Ashraf K. Kayani

PREPARING SUBNATIONAL POPULATION PROJECTIONS: A MANUAL FOR SELECTED INDIRECT METHODS

CENTRO LATINOAMERICANO DE DEMOGRAFIA



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Santiago de Chile Serie B, N° 48 Marzo de 1980

I N D E X

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I. PURPOSE AND SCOPE OF THE STUDY

The study is designed to serve as a guide to persons interested in the methods of small area population projections. Since most of the existing methodologies of small area or sub-national population projections are developed for and applied to the populations of countries with reasonable historical data at subnational and national levels, the present study intends to explore the applicability of these methods for areas with limited and poor quality data. It may also serve as a source to those who are not well equipped with the technical aspects of preparing population projections for small areas.

Population projections for subnational populations are prepared either by direct methods or by indirect methods. Direct methods treat subnational populations as independent of or unrelated with their respective national population. Indirect methods are used when subnational population projections are interrelated with or dependent on the national ones. The focus of the present study is on indirect methods, that is, on the methods of subnational population projections when national projections are available. These are necessarily the methods that establish and project the relationships beween the parts (subnational populations) and the whole (national population).

The study is limited in many other ways. For example, no attempt is made:(a) to estimate the parameters through highly technical methods, (b) to correct the basic data and (c) to prepare any new models. Besides, the empirical data used in the computational examples are taken from only one Latin American country, namely Brazil. However, it is expected that the methods illustrated in the study can also be applied to other countries. The computations illustrated in the study are simple and are verifiable with the aid of a pocket-size calculator.

General Considerations

1. Concepts: In demographic literature three concepts are often confused and are sometimes used interchangeably. These are: population estimates, population projections and population forecasts. Population estimates differ from the other two in terms of time and generality while projections and forecasts differ from each methodologically and are more specific. An estimate is a measure of the existence of a population condition in the past or at present when it is difficult to measure the condition through direct means (for example surveys or census) because of the factors such as impracticality of data collection due to cost and resources. In other words, when direct measures are not possible the indirect measure of a population condition is known as population estimates (for example, intercensal estimates, estimates of migration, etc.).

Population projection and forecasts are measurements of a future condition. They differ from each other in terms of the degree of objectivity and the degree of the correctness of the measurements. Projections are purely analytical and they are always correct if the methodology with the given assumptions is correct (Keyfitz, 1977 and U.N., 1956). Contrary to the projections, forecasts are subjective in nature and are seldom correct since they are concerned with the expected measurement of a future condition. Forecasts are more like predictions and their accuracy depends on the accuracy of the assumptions.

2. Defining "Subnational". According to the United Nations (1975, p.8), a "subnational" population is any area smaller than the whole country of which it is a part typically a region, state or province, or a district or a village". For projection purposes, it is highly desireable that the geographic boundaries of the subnational population are clearly defined.

3. Data Requirements. Mostly, these depend on the type and the purpose of the subnational population projections. Selection of a particular method of projection depends on the purpose of the projection and data requirements vary from one method to another. For example, if the projection is

to be used for development planning there is a need to detect subnational differences in the levels and trends of demographic parameters as well as the distribution of basic characteristics such as age and sex (U.N., 1969, pp. 7-13).

Methods

Projections for Subnational areas are projected by means of: (a) mathematical methods, (b) economic models, (c) ratio methods, (d) component methods and (e) other methods such as vital statistics methods, density models, etc. These methods are discussed here briefly.

(a) Mathematical Methods. Use of mathematical techniques to project subnational and national populations is the oldest of all techniques in demography. Historically the countries of the world experienced high fertility and high mortality. Due to limited modes of transportation, migration was negligible in the past. International migration was mostly due to political reasons and not to economic reasons as is the case today. Wars of conquest is an example of such international migration in the past.

Due to high fertility and high mortality and almost no migration, national populations in the distant past were stable or semi stable. It was reasonable, therefore, to assume as a possibility of a uniform rate of growth and apply, mathematical methods to project the populations. The most common mathematical methods in population projections (Pollard, 1973; Croxton and Cowden, 1945; Cowden, 1947; and Arkin and Colton, 1970) are:

a) Graphic-extrapolation methods -for example, graphic, logarithmic scale and other such methods.

b) arithmetic change method of the form $Y = a+bx$

c) Geometric or exponential methods of the form $Y = a\, e^{rt}$

d) fitting polynomial curves of the form $Y = a + bx + cx^2 + mx^n$

e) Gompertz curve of the form $Y = Ka^{bx}$

f) Logistic curve or Pearl and Reed Method, e.g., $Y = \frac{K}{1+e^{a+bx}}$ or $Y = K_1 + \frac{K_2}{1+e^{a+bx}}$

g) other statistical techniques such as use of regression equations, e.g.

$$Y_{t+n} = a+bx_{t+n}$$

These techniques are used to project total population at national levels and they are not usually applied to subnational populations particularly when one wants to maintain the relationship between national and subnational populations. It has been observed that when the same mathematical method is applied to the nation and its regions, the total population of all regions is never equal to that obtained independently for the country (Zachariah, undated).

(b) Economic Models. In these models population projections are derived from economically related projections. Under these models, the relationship between population and economic variable is established. In countries where data quality is good and internal migration is mainly due to economic reasons, use of economic models in population projections is preferred. Most of these models establish the relationship between population and variables such as employment, housing stocks, labour force and school population (Greenberg, 1972; Erie and Niagra counties Regional Planning Board, 1972;Nikolaj, 1975; Stamberg, 1952).

(c) Ratio Methods. Comparatively, it is easier to prepare population projections for less developed countries at national level than at the subnational level. Usually national populations do not experience extreme fluctuations in at least their vital events while subnational populations are extrenely sensitive to seasonal changes in their demographic parameters. Secondly, the boundaries of the small areas are not well defined and/or not well perceived by people as compared with the national population where the people are more or less aware of the fact that their national boundaries act as a limit to their movements. Also, at national level one has to worry about the measurement of international migration only while measurements of internal migration for subnational populations pose serious problems for analysts interested in these projections (Zachariah, undated).

For Latin American countries where data at the national level are of poor quality, the most commonly used methods of subnational population projections are ratio methods. Ratio methods have also been used and tested in

most of the developed countries. Even at the present level of knowledge, these methods have a special use in the estimation of parameters for sub national population projections in the advanced countries. A variety of ratio methods have been developed. Most commonly mentioned mmethods are: (i) general ratio methods; (ii) apportionment method, (iii) analogy meth od, (iv) share method, (v) ratio correlation methods, (vi) ratio regression techniques, (vii) ratio dispersion method and (viii) ratio trend methods.

(i) Ratio Method: This method was developed and used by U.S. Bureau of the Census (1952) to prepare the population projections for subnational areas. First, national projections were prepared. The states were grouped according to their demographic similarities into divisions and the ratios of the divisions to the nation and the ratios of the states to the divisions were estimated. Initial rates of changes in the ratios on the basis of their changes during 1920-1950 were documented. An assumption was incorporated in the projections that the annual rate of change in the ratios would decline linearly to zero in 50 years. This method is more general in nature and assumptions may be changed as desired.

(ii) Apportionment Method: In this method, the future share of a small area to the large area is not projected. The share of a sub-area in the population change experienced by the larger area is projected. The method is based on the historical shares in the national population growth (Pittenger, 1976, pp. 98-100). Another form of apportionment method is to take the ratios of regions to national population and hold them constant by age groups. For example, ratio of the 0-14 age group to the national population is calculated. Within 0-14 age group, ratios of 0-4, 5-9 and 10-14 are established (Zachariah, undated).

(iii) Analogy Method: The assumption behind this method is that the population of a region is more or less parallel to the population of other regions (Zachariah, undated). In other words, within a national population, projection for small areas are prepared with respect to each other. The method is generally used to prepare population projections for cities. For example, to project the population of city x ratios of the population

size for city x to other surrounding cities are calculated and kept constant. Based on these ratios, projections for city x are derived from the projections of the surrounding cities. Because of the assumption of fixed ratios between the regions, the method is unrealistic and static.

(iv) Share method: In ratio methods, one of the major problems is to extrapolate the ratios of subnational areas to larger area over a long period of time. It is easy to perceive that when the ratios are unchecked, the extrapolation of ratios for fast growing regions in the past would exceed 1.00 while the ratios for the regions that lost population in the past might reach zero over a long period of time. To avoid this problem some checks are employed.

In the share method, the shares of the population of small areas in the national population are calculated on an historical basis (Pittenger, 1976. pp. 118-125; White, 1954; and Pichard, 1959). The trends in these shares are observed and the shares of all subnational populations are controlled to unity, usually by the formula $\left(A = \frac{1.0}{\sum_{i=1}^{n} S_i}\right)$ where A is an adjustment factor and S_i is the subnational unit share of area i and n is the total number of subnational populations in a national population.

(v) Ratio correlation methods. In these methods dependent variable is the share of the subnational population in the national population. Subnational shares of the attributes of a population are the independent variables (Isard, 1968). Data on attributes might concern labour force, growth rate, housing starts, per capita income, expenditure on education, etc. For example, Schmitt (1952 and 1954) used the multiple correlation method to determine the relationship between city growth and two factors: state growth and city density. Bogue (1950) suggested a method consisting of ratio of birth and death rates of subnational populations to those of the national or parent population. These ratios are projected by correlation methods.

(vi) Regression methods. These methods are similar to correlation methods. When there is only one independent variable simple regression analysis is conducted. With two independent variables the method of simple

regression analysis can be extended to get a multiple regression equation. If data permits time series analysis, a predictive equation is derived by the regression analysis. In such cases, time series analysis and the predictive equation are used to project the population.

Correlation and regression techniques are usually applied to estimate the population but due to certain advantages inherent in the methods they are also used for making projections by means of standard statistical packages for the use of computers. The major problem with these techniques is that the analyst has to project the independent variables themselves.

(vii) Ratio Trend Method (Method of Exponential Variation of Ratios) Conceptually ratio trend method is similar to the U.S. Bureau ratio method. The ratio trend method was developed to project metropolitan area populations (Picard, 1967). The method assumes that for short term projections a short historical trend is better than long term historical trends while for long term projections a long historical trend is superior to the short trend. The steps in the technique can be divided into the following:

1. Transform the shares of subnational populations into logarithms.
2. Calculate the rates of change in the shares expressed as differences of the logarithms.
3. Project the shares.
4. From the logarithmic form, transform projected shares back to percentages or in the form of $N(t) = N(o)e^{rt}$.

To calculate weights, Picard (1967) used ratios on the assumption that the recent trend would have greater impact than that of the distant past. The technicalities of the method will be demonstrated in chapter III.

In summary, ratio methods are subject to many pitfalls. While these methods are useful only to project population totals for the subnational populations, they do not provide insight into the determinants of the populations at subnational levels. Some of the ratio methods such as the analogy methods moreover are good only for cities. Besides this, all ratio methods face problems in extrapolating the ratios of the subnational units.

(d) Component methods of population projections. Other methods of population projections that are extensively used in national projections involve a variety of component methods. That is, within each component of population growth numerous methods have been developed and applied. Generally, these adopt one of the following two approaches: the cohort approach or the period approach. Each of the three components of population growth (fertility, mortality and migration) are assumed to be analytically different and are thus treated separately for projection purposes. For each of the population parameters past trends are observed and the evaluations are made about the future values of these parameters. Usually the projections are prepared by age and sex. These methods are discussed briefly below.

Projection of mortality component: For national populations where mortality data are scanty, model life tables by the United Nations (1955 and 1968), Lederman (1969), Coale and Demeny (1966) or Carrier and Hobcraft, (1971), are used. The major assumption in model life tables is that there is an inter-relationship between the age-sex differentials of mortality. For the countries with reliable data on causes of death, mortality tables by cause of death are prepared (Preston, Keyfitz and Schoen, 1972).

For subnational population projections the use of model life tables is limited. Since the distribution of population in the subnational populations is usually distorted and is subject to drastic changes for example in sex ratios and age distribution, (not only due to the changes within an area but also due to the surrounding areas) it is extremely difficult for the analyst to justify the use of model life tables.

The most common method in mortality projections is the use of mortality trends. Trends in mortality are observed and extrapolated. If possible, trends in different mortality indicators are examined for the better understanding of mortality in the past. For example, Statistics Canada (1974) observed and used mortality trends in different indicators in their projections (Gnanasekaran, 1973; Gnanasekaran and Montigny, 1974). In Canadian projections, assumptions were made about the rates of change in the expectation of life at birth (e_o), excess of e_o for females over males,

ratio of male deaths due to the accidents to those for females and the ratios of males to females age-specific death rates. Once the values of the assumed indices of mortality are projected, survival ratios for the intervening years can be interpolated.

To derive mortality projections for subnational populations from the national projection, usually the ratio method is applied. This technique though commonly applied may produce erroneous results. If natural projections incorporate incorrect assumptions or the mortality conditions are not uniform in a nation, the systematic differences between subnational mortality patterns would remain throughout the projection period.

Projections of fertility component: There are various models to estimate and project the fertility component at micro and macro levels. Models by Henry (1953, 1957, 1961 and 1964), Brass (1958), Perrin and Sheps, (1964), Bourgeois-Pichat (1965), Romaniuk (1973) and Coale and Trusell (1974) are often cited in the literature. However, with the exception of Romaniuk's (1973) model, no other model so far has been used in fertility projections.

Romaniuk's (1973) model es specifically designed for the purpose of fertility projections. Based on Pearsonian curves, his model projects fertility by using total fertility rates and mean and modal ages of fertility. Statistics Canada Projections for Canada and its provinces (1974) are based on the model developed by Romaniuk.

Other methods to project fertility range from simple to complex ones. For subnational population projections the simplest method is that used by the U.S. Bureau of the Census (1966). First, the convergence of fertility rates for the states to the national pattern was observed. For short term projections, ratios of age specific fertility rates (ASFR) for states to the national ASFR were computed. For long term projections, the deviations of the ASFR ratios for states, to the national population were computed. On the basis of these ratios, general fertility rates (GFR) for the nation and the states were calculated and used for each projection period.

The resulting GFR for states were multiplied by the projected state female population age 15-44 to obtain trial birth projections. The projected births for the states were summed over for all states and this total number of births was divided by the independently projected national number of births. The ratio of the sum total of state birth to national births independently estimated was used to adjust birth values for the states to bring into agreement state and national projections.

Among the complex fertility projections methods, the target fertility method, fitting mathematical functions to fertility rates such as three parameter model (Romaniuk and Mitra, 1973) use of net-maternity function (Keyfitz, 1968) as well as other fertility component models are often used.

In the target fertility method, a set of targets in terms of total fertility (TFR) and ASFR are established. Mean age at child-bearing is also predetermined. The major assumption in this method is that after a complete replacement of females in child-bearing ages (usually after 30-35 years) of the initial cohort, the reproductive behaviour will mirror the target fertility patterns. This method, has, besides others, one major drawback for the small area projections. Since the subnational populations are sensitive to migration, the major assumption does not hold true because of the problem of "migration contamination".

The net-maternity function has been discussed and used by Keyfitz (1968). The net-maternity function is the product of the ASFR's and the proportion of a birth cohort of women to each child-bearing age group. This method has been used by Keyfitz to project national population but at the subnational level no attempt has been made to determine the utility of this method.

The use of fertility component methods for subnational projections is very recent. In these methods age specific fertility rates and cumulative fertility rates are reduced into their components. For example,one of the components is the progression of females from one parity status to the next. It has been observed that for countries where vital statistics data are not reliable or non-existent, census information on children ever-born

to females and children owned in the last year are reliable methods of estimating past fertility and also of preparing population projections. In the children ever-born method fertility is estimated through the comparison of the average number of children per woman at two successive censuses (Arretx, 1973).

Projecting Migration: The most difficult and crucial area in subnational population projections is the projection of migration. It is this component to which subnational populations are extremely sensitive. In most cases, particularly in countries where natural resources are not fully exploited, migration streams from one area to another are more predictable for a long period of time. Migration, being closely associated with economic development, is typically age, sex and occupation selective. Nevertheless, different methods have been suggested to measure and project migration for subnational populations. These methods are:

1. Cohort survival method or census survival method
2. Net migration rates method
3. Directional rates method
4. Migration ratios method
5. Proportional net migrants method
6. Linking migration to economic change.

The cohort survival method is used when one is interested in the combined effects of migration and mortality (Hamilton and Perry, 1962: 160-170). The method is simple and is based on census data concerning age distributions. Net effects of migration and mortality are projected by establishing the relationships between age groups of a cohort in two or more consecutive censuses. This relationship is held constant and the projections are prepared. Once the analyst knows the mortality parameters, he can separate the migration component from the mortality one.

The net migration method is used when past data on age specific migration rates are available or the rates can be estimated by other techniques (Krotki, 1979). For subnational populations, the preferred method of projecting the migration component is to observe the historical trends in internal migration and establish the correlates (e.g. economic variables)and

prospects of internal migration for subnational populations. Based on these trends and the correlates, assumptions about migration are derived (Statistics Canada, 1975, Ch. 7).

For countries and subnational populations which do not possess data on migration that warrants analysis, the use of migration ratios and proportional net migration methods is very common (Chevan, 1965 and Tarver and Black, 1966: 48-76).

Summary

In this Chapter we have attempted to review briefly the indirect methods of projecting subnational populations. Those reviewed are the ones most commonly cited in literature. Since mathematical methods cannot be usefully employed for small area projections, they are not discussed in detail.

Ratio Methods or Non-Component Methods, though frequently used in preparing small area projections, are not free of shortcomings such as problems associated with the extrapolation for fast growing areas, projection of independent variables and their failure to provide insight into the determinants of population since they are good only for projecting population totals.

Component Methods of population projections are preferred over other methods because of the obvious benefits the analyst and the user can obtain. In the following Chapters, using Brazil and its regions as an example, we attempt to show the mechanism used by these methods to project subnational populations when national projections are given.

II. EVALUATION OF BASIC DATA FOR SUBNATIONAL POPULATIONS

Population of Brazil and the regions

In this chapter background information on the demography of Brazil and its regions is provided. The population from the censuses of 1950, 1960 and 1970 are given in tables 2.1, 2.2 and 2.3. Population data for regions was estimated from the censuses. Before 1960, region 6 did not exist, therefore no population figures are given for 1950. From the basic data and the estimates derived from them by CELADE, a simple analysis is presented. It is important to examine the basic data before preparing the projections. For this purpose, the following exercises are presented.

Data:

Population by age and sex for Brazil and its regions is given in tables 2.1, 2.2 and 2.3 and the proportionate age distributions are given in tables 2.4, 2.4a and 2.4b.

Exercise 1

Calculate the ratio of regional population totals by sex to the Brazil total and the percentage changes in the ratios for the census years. What conclusions can be drawn?

Answer:

Table 2.5 shows the desired ratios and percentage changes in the ratios for the period 1950-1970. As both sexes are treated separately, the total in the first half of the table for each sex is approximately 100.00. From the table, we may deduce that: a) about 60 to 65 per cent of the total population of Brazil has been historically living in regions 3, 4 and 5; b) for over a twenty year period, regions 4 and 5 had proportionately been losing population either to other regions or to emigration and c) the proportionate increase is maximum for region 7 and second highest for region 3. The proportions for region 6, however are too small and are only for a ten year period, a typical problem of small areas where

changes are very sensitive due to the small size of the population. The proportions by sex are consistent and the pattern appears to be stable.

Exercise 2

Assuming that the census age distributions are correct, comment: a) on the changes in the age distributions of the regions and b) on the differences between the regional distributions and national distributions for the three censuses.

Answer:

There are a variety of methods to compare two or more age distributions. The simplest one is to compute the proportionate distribution of each population. After the proportionate distributions are computed, the percentage point differences for each age group are calculated. The percentage point difference in an age group of two or more distributions give the relative size of one distribution over the other with respect to that age group.

One of the drawbacks of this approach is that it does not show the relative change. If the proportions are large, the difference may also be large signifying a major change. And the difference between two small size proportions is more likely to be small giving the impression of little change (Bogue, 1969: 117-121). To overcome this problem an "index of relative composition" is suggested (Bogue, 1969 and Smith, 1966). The logic behind constructing the index is to relate percentage point differences to the percentages from which they have been derived.

Based on this idea other simple indices are constructed to measure unevenness, concentration, or the dissimilarities between two or more distributions. The most common index derived from the distributions is known as the "index of population concentration" (Duncan, 1957) or the "change ratio" or the "index of dissimilarity"(Δ).

For our problem we use the index of dissimilarity which has found frequent (Bogue, 1969, Keyfitz, 1968:47 and Mason, 1969). The index shows how different two or more distributions are. It is calculated by taking

two percentage distributions, subtracting one distribution from the other to get a distribution of percentage point differences. These percentage point differences have positive (+) and negative (-) signs. The sum of + signs always equals the sum of - signs. The sum of the categories of alike signs is termed index of dissimilarity (Δ). One can also take the total of all percentage point differences irrespective of the signs and divide the total by 2 to get Δ. Arithmetically:

$$\Delta = \frac{\sum_{x=1}^{n} |A_x - B_x|}{2}$$

where A and B are two proportionate distributions and x is any age category.

a) Table 2.6 and 2.6a show the changes in the proportions of regional and national age distributions. Table 2.6b demonstrates Δ calculated from table 2.6 and 2.6a. One may conclude from these tables that changes in the national age distributions were moderate for the two decades and the regional distributions changed disproportionately during the period. From 1950-1960, the distributions became younger for regions 1, 5 and 7 while the rest of the distributions became relatively older. Distributions by age and sex are distorted and no consistency is found in the aging process of the distributions. From 1960-1970, the proportions for 0-4 and 5-9 changed for the regions 1 and 7. The Δ pattern remained consistent for the period. The distortions in the trend by different age groups (excluding 0-4 and 5-9) show the effects of migration. Relative changes in the 0-9 age groups suggest changes in the fertility performance during the period.

b) Table 2.7 shows the differences between the regional distributions from the national distributions. Regions with larger shares of the national population had younger distributions than the national ones while regions 1 and 2 consistently had older distributions than the national ones. Region 2 became increasingly older than Brazil while regions 5 and 7 became increasingly younger than the national population. Region 6 shows neither young nor old age. It appears that the age distribution for region 6 was marked by larger labour force age groups.

Exercise 3

Estimated total fertility rates by different methods are given in table 2.8. Assuming that the proportions in the 0-4 age group is an indicator of fertility, what observations can be made about the TFR under different estimates? Use tables 2.6, 2.6a and 2.6b for reference.

Answer:

As is evident from the table, the age distribution method shows an increase in fertility from 1950 to 1970, while the other two methods show a decline in the TFR for the same period. For regions with a relatively small population share (regions 1, 2 and 7), changes in the 0-4 age groups and changes in fertility for the same period are consistent. For regions 3, 4 and 5, changes in TFR's by the children ever-born method are consistent with the changes in the 0-4 age groups. This suggests that at the regional level the age distribution may not be as strong a tool of analysis as at the national level, or that methods of estimating fertility may not be applicable uniformally to all regions. Since the population base for regions 3, 4 and 5 is large, the children ever-born method appears to be reasonable. For regions having a small population base, the methods of estimating fertility may not be applicable owing to their special nature.

Table 2.1

CENSUS POPULATION OF BRAZIL AND REGIONS, 1970[a/]

(Resident Population)

Age	Country		Region 1	
	Males	Females	Males	Females
Total	*46 331 343*	*46 807 694*	*4 409 066*	*4 535 736*
0-4	6 969 945	6 841 861	532 774	519 179
5-9	6 799 972	6 659 536	562 706	548 928
10-14	5 934 189	5 924 930	519 228	520 309
15-19	4 995 432	5 257 851	457 150	494 983
20-24	4 037 135	4 248 670	399 772	422 860
25-29	3 173 285	3 330 784	322 164	344 979
30-34	2 800 657	2 864 283	304 835	316 985
35-39	2 502 123	2 587 189	285 237	299 642
40-49	4 083 291	3 998 986	468 509	479 760
50-59	2 646 519	2 582 213	291 987	311 338
60-69	1 508 003	1 499 634	167 294	190 313
70 and over	787 988	920 583	84 446	123 842
Ignored	92 804	91 174	12 964	12 618

(continued)

Table 2.1 (Continued)

CENSUS POPULATION OF BRAZIL AND REGIONS, 1970[a/]

(Resident Population)

Age	Region 2		Region 3	
	Males	Females	Males	Females
Total	8 931 360	8 840 583	8 331 430	8 165 063
0-4	1 101 684	1 072 676	1 243 853	1 213 163
5-9	1 146 229	1 116 658	1 237 724	1 203 185
10-14	1 046 436	1 033 344	1 088 225	1 069 400
15-19	921 658	947 742	918 377	932 259
20-24	841 970	834 503	730 527	737 527
25-29	694 169	684 496	575 330	569 823
30-34	624 358	608 076	507 871	487 861
35-39	563 184	554 567	456 351	445 047
40-49	908 219	875 836	717 846	673 796
50-59	563 743	562 526	458 674	432 931
60-69	330 767	337 610	253 855	242 569
70 and over	168 136	193 092	129 177	144 657
Ignored	20 807	19 462	13 620	12 845

(continued)

Table 2.1 (Continued)

CENSUS POPULATION OF BRAZIL AND REGIONS, 1970[a/]
(Resident Population)

Age	Region 4		Region 5	
	Males	Females	Males	Females
Total	*6 513 637*	*6 573 111*	*13 719 134*	*14 392 793*
0-4	979 085	961 392	2 367 991	2 345 547
5-9	987 459	966 416	2 181 791	2 159 907
10-14	897 061	889 342	1 805 852	1 837 648
15-19	745 840	777 376	1 472 150	1 609 312
20-24	554 529	585 008	1 123 591	1 286 403
25-29	416 596	445 490	848 305	982 497
30-34	368 400	382 474	725 566	824 638
35-39	341 791	357 017	622 951	717 310
40-49	543 859	535 880	1 091 829	1 132 941
50-59	361 506	349 632	757 049	743 597
60-69	204 475	197 885	444 504	435 180
70 and over	103 867	115 668	252 301	290 770
Ignored	9 169	9 531	25 254	27 043

(continued)

Table 2.2 (Concluded)

CENSUS POPULATION OF BRAZIL AND REGIONS, 1970[a/]
(Resident Population)

Age	Region 6		Region 7	
	Males	Females	Males	Females
Total	*170 389*	*267 103*	*4 156 327*	*3 983 300*
0-4	45 823	44 253	698 735	685 646
5-9	39 852	39 251	644 211	625 191
10-14	28 357	29 854	549 030	545 033
15-19	26 551	29 463	453 706	466 716
20-24	28 446	29 008	358 300	353 361
25-29	24 171	25 005	292 550	278 494
30-34	23 495	20 250	246 132	223 999
35-39	16 498	15 013	216 111	198 593
40-49	21 443	18 429	331 586	282 344
50-59	9 822	9 787	203 738	172 402
60-69	3 980	4 380	103 128	91 697
70 and over	1 369	1 889	48 692	50 665
Ignored	582	516	10 408	9 159

a/ Censo Demográfico Brasil. VIII Recenseamento Geral 1970. Serie Nacional, volume I.

Table 2.2

CENSUS POPULATION OF BRAZIL AND REGIONS, 1960

Age	Total		Region 1		Region 2	
	Males	Females	Males	Females	Males	Females
Total	*35 059 546*	*35 131 824*	*3 291 379*	*3 357 767*	*6 477 519*	*6 346 237*
0-4	5 687 512	5 505 877	468 387	450 607	934 478	902 313
5-9	5 170 579	4 987 844	432 206	417 371	848 467	815 507
10-14	4 297 589	4 263 367	353 798	353 649	702 256	695 962
15-19	3 452 198	3 722 613	286 343	312 952	585 286	619 950
20-24	2 993 680	3 244 240	284 474	306 295	581 421	597 096
25-29	2 545 283	2 700 565	273 866	290 157	545 567	536 457
30-39	4 228 185	4 258 193	476 555	483 624	907 693	869 231
40-49	3 051 078	2 899 610	328 671	323 481	616 299	582 227
50-59	1 933 852	1 819 115	213 075	210 989	407 373	379 438
60-69	1 120 329	1 070 309	118 451	129 220	228 619	217 252
70 and over	530 745	609 613	51 413	74 925	105 657	115 957
Ignored	48 516	50 478	4 640	4 497	14 403	14 897

(continued)

Region 1 : Río de Janeiro, Guanabara.

Region 2 : Sao Paulo.

Table 2.2 (Continued)

CENSUS POPULATION OF BRAZIL AND REGIONS, 1960

Age	Region 3		Region 4	
	Males	Females	Males	Females
Total	*5 982 418*	*5 799 214*	*5 639 912*	*5 610 553*
0-4	979 374	943 370	966 353	933 139
5-9	895 870	856 082	877 851	841 299
10-14	748 950	726 984	713 885	703 704
15-19	598 529	618 257	568 269	615 970
20-24	517 196	524 620	486 791	520 654
25-29	442 352	437 319	404 893	421 975
30-39	715 561	687 782	625 324	632 217
40-49	504 638	466 721	461 026	435 143
50-59	314 168	284 121	288 333	267 563
60-69	179 075	161 598	165 185	152 227
70 and over	80 588	86 364	76 609	80 882
Ignored	6 117	5 996	5 393	5 780

(continued)

Region 3 : Paraná, Santa Catarina, Río Grande do Sul.

Región 4 : Minas Gerais, Serra Dos Aimores, Espirito Santo.

Table 2.2 (Concluded)

CENSUS POPULATION OF BRAZIL AND REGIONS, 1960

Age	Region 5		Region 6		Region 7	
	Males	Females	Males	Females	Males	Females
Total	*10 816 473*	*11 340 417*	*37 236*	*52 510*	*2 764 059*	*2 625 076*
0-4	1 848 272	1 806 363	9 802	9 391	480 846	460 694
5-9	1 677 255	1 641 776	7 001	7 109	431 929	108 700
10-14	1 424 385	1 439 684	4 962	5 157	349 353	338 227
15-19	1 123 068	1 256 349	8 647	5 355	282 056	293 780
20-24	865 959	1 049 412	18 762	6 604	239 077	239 559
25-29	662 860	812 004	12 325	5 684	203 420	196 969
30-39	1 168 589	1 286 027	14 899	7 574	319 564	291 738
40-49	906 236	895 392	7 155	3 297	227 053	193 349
50-59	580 294	566 865	2 653	1 427	127 956	108 712
60-69	360 647	350 843	720	553	67 632	58 616
70 and over	184 721	219 761	166	274	31 591	31 450
Ignored	14 187	15 941	194	85	3 582	3 282

Region 5 : Maranhao, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Fernando de Mocomba, Sergipe, Bahia.

Region 6 : Distrito Federal.

Region 7 : Matto Grosso.

Table 2.3

CENSUS POPULATION OF BRAZIL AND REGIONS, 1950

Age	Total		Region 1		Region 2	
	Males	Females	Males	Females	Males	Females
Total	*25 885 001*	*26 059 396*	*2 323 227*	*2 351 418*	*4 643 606*	*4 485 817*
0-4	4 235 876	4 135 004	319 235	311 855	673 919	658 647
5-9	3 560 850	3 454 677	256 093	250 102	562 020	543 723
10-14	3 164 704	3 143 863	240 829	242 885	511 900	506 426
15-19	2 644 531	2 857 764	233 350	249 593	469 744	486 510
20-24	2 384 460	2 606 679	235 489	247 108	469 113	468 414
25-29	2 030 312	2 101 959	205 491	207 148	404 610	386 377
30-39	3 145 715	3 140 337	327 539	325 007	620 941	585 352
40-49	2 246 107	2 119 252	244 649	231 549	454 272	405 039
50-59	1 360 580	1 289 734	150 255	148 060	269 269	238 716
60-69	728 802	722 666	76 062	84 345	137 549	128 777
70-79	247 755	297 415	22 899	34 433	49 366	52 299
80 and over	81 432	127 271	5 822	12 912	14 793	19 261
Ignored	53 877	62 755	5 514	6 421	6 110	6 276

(continued)

Region 1 : Distrito Federal (Guanabara), Rio de Janeiro

Region 2 : Sao Paulo.

Table 2.3 (Continued)

CENSUS POPULATION OF BRAZIL AND REGIONS, 1950

Age	Region 3		Region 4	
	Males	Females	Males	Females
Total	3 961 792	3 879 078	4 356 036	4 383 420
0-4	675 609	674 225	741 235	718 851
5-9	546 264	525 295	634 027	605 996
10-14	482 474	469 942	563 430	555 477
15-19	414 024	434 054	465 884	513 381
20-24	363 377	382 869	393 985	434 862
25-29	309 525	307 698	323 628	340 027
30-39	473 748	454 910	496 760	506 337
40-49	329 248	301 130	357 941	338 278
50-59	200 810	184 763	211 956	199 118
60-69	110 588	101 246	111 437	106 376
70-79	38 602	40 235	37 862	41 012
80 and over	10 564	14 765	12 441	17 953
Ignored	6 959	8 119	5 420	5 752

(continued)

Region 3 : Paraná, Santa Catarina, Río Grande do Sul.

Region 4 : Minas Gerais, Serra dos Aimores, Espirito Santo.

Table 2.3 (Concluded)

CENSUS POPULATION OF BRAZIL AND REGIONS, 1950

Age	Region 5		Region 7	
	Males	Females	Males	Females
Total	*8 766 551*	*9 206 862*	*1 828 819*	*1 752 801*
0-4	1 513 011	1 494 051	307 867	298 548
5-9	1 297 506	1 276 299	264 940	253 262
10-14	1 138 537	1 149 051	227 534	220 082
15-19	872 883	978 890	188 646	195 356
20-24	754 058	901 818	168 438	171 608
25-29	640 465	722 689	146 593	138 020
30-39	1 000 475	1 062 928	226 252	205 803
40-49	710 538	710 100	149 459	132 156
50-59	446 370	447 512	81 920	71 565
60-69	248 190	262 241	44 976	39 681
70-79	85 960	114 816	13 066	14 620
80 and over	33 589	56 006	4 223	6 374
Ignored	24 969	30 461	4 905	5 726

Region 5 : Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, F. de Moronha.

Region 6 : Did not exist.

Region 7 : Matto Grosso, Goias, Guaporé, Acre, Amazonas, Rio Branco, Pará, Amapá.

Table 2.4

AGE DISTRIBUTIONS BY REGIONS, 1950 CENSUS OF BRAZIL

Age	Total Brazil		Region					
			1		2		3	
	Males	Females	Males	Females	Males	Females	Males	Females
0-4	16.36	15.86	13.74	13.21	14.60	14.68	17.05	17.00
5-9	13.75	13.25	11.01	10.63	12.09	12.12	13.78	13.54
10-14	12.22	12.06	10.36	10.32	11.01	11.28	12.17	12.11
15-19	10.21	10.96	10.04	10.61	10.10	10.84	10.45	11.18
20-24	9.21	10.00	10.13	10.50	10.09	10.44	9.17	9.87
25-29	7.84	8.00	8.84	8.80	8.70	8.61	7.81	7.93
30-39	12.15	12.05	14.09	13.82	13.35	13.04	11.95	11.72
40-49	8.62	8.13	10.53	9.84	9.77	9.02	8.31	7.76
50-59	5.25	4.94	6.46	6.29	5.79	5.32	5.06	4.76
60-69	2.81	2.77	3.27	3.58	2.95	2.87	2.79	2.61
70-79	0.95	1.14	0.93	1.46	1.06	1.16	0.97	1.03
80 and over	0.31	0.48	0.25	0.54	0.31	0.42	0.26	0.38

(continued)

Table 2.4 (Concluded)

AGE DISTRIBUTION BY REGIONS, 1950 CENSUS OF BRAZIL

Age	Region					
	4		5		7	
	Males	Females	Males	Females	Males	Females
0-4	17.01	16.39	17.25	16.22	16.83	17.03
5-9	14.55	13.82	14.80	13.86	14.48	14.44
10-14	12.93	12.67	12.98	12.48	12.44	12.55
15-19	10.69	11.71	9.95	10.63	10.31	11.14
20-24	9.04	9.92	8.60	9.79	9.21	9.79
25-29	7.42	7.75	7.30	7.84	8.01	7.87
30-39	11.40	11.55	11.41	11.54	12.37	11.74
40-49	8.21	7.71	8.10	7.71	8.17	7.53
50-59	4.86	4.54	5.09	4.86	4.47	4.08
60-69	2.55	2.42	2.83	2.84	2.45	2.26
70-79	0.86	0.93	0.98	1.24	0.71	0.83
80 and over	0.28	0.40	0.38	0.60	0.23	0.36

Table 2.4a

AGE DISTRIBUTION BY REGIONS, 1960 CENSUS OF BRAZIL

Age	Total Brazil		Region					
			1		2		3	
	Males	Females	Males	Females	Males	Females	Males	Females
0	16.22	15.67	14.22	13.41	14.42	14.21	16.37	16.26
5	14.74	14.19	13.12	12.43	13.09	12.85	14.97	14.76
10	12.25	12.13	10.74	10.53	10.84	10.96	12.51	12.53
15	9.84	10.59	8.69	9.32	9.03	9.76	10.00	10.66
20	8.53	9.23	8.64	9.12	8.97	9.40	8.64	9.04
25	7.25	7.68	8.31	8.64	8.42	8.45	7.39	7.54
30	12.06	12.12	14.47	14.40	14.01	13.69	11.96	11.85
40	8.70	8.25	9.98	9.63	9.51	9.17	8.43	8.04
50	5.51	5.17	6.47	6.28	6.28	5.97	5.25	4.89
60	3.19	3.04	3.59	3.84	3.52	3.42	2.99	2.78
70 and over	1.51	1.73	0.14	2.23	1.63	1.82	1.34	1.48

(continued)

Table 2.4b (Concluded)

AGE DISTRIBUTIONS BY REGIONS, 1960 CENSUS OF BRAZIL

Age	Region							
	4		5		6		7	
	Males	Females	Males	Females	Males	Females	Males	Females
0	17.13	16.63	17.08	15.92	11.22	17.88	17.39	17.54
5	15.56	14.99	15.50	14.47	8.02	13.53	15.62	15.56
10	12.65	12.54	13.16	12.69	5.68	9.82	12.63	12.88
15	10.07	10.97	10.30	11.07	9.90	10.19	10.20	11.19
20	8.63	9.27	8.00	9.25	21.49	12.57	8.64	9.12
25	7.17	7.52	6.12	7.16	14.29	10.82	7.35	7.50
30	11.08	11.26	10.80	11.34	17.06	14.42	11.56	11.11
40	8.17	7.75	8.37	7.69	8.19	6.27	8.21	7.36
50	5.11	4.76	5.36	4.99	3.03	2.71	4.62	4.14
60	2.92	2.71	3.33	3.09	0.32	1.05	2.44	2.23
70 and over	1.35	1.44	1.70	1.93	0.19	0.52	1.14	1.19

Table 2.4b

PERCENTAGE AGE DISTRIBUTION OF POPULATION BY REGIONS, BRAZIL, 1970 (RESIDENT)

Age	Total Brazil		Region					
			1		2		3	
	Males	Females	Males	Females	Males	Females	Males	Females
0-4	15.04	14.61	12.08	11.32	12.33	12.13	14.92	14.85
5-9	14.67	14.22	12.76	11.97	12.83	12.63	14.85	14.73
10-14	12.80	12.65	11.77	11.34	11.71	11.68	13.06	13.09
15-19	10.78	11.23	10.31	10.79	10.31	10.72	11.02	11.41
10-14	8.71	9.07	9.06	9.22	9.42	9.43	8.76	9.03
25-29	6.84	7.11	7.30	7.52	7.77	7.74	6.90	6.97
30-39	11.44	11 63	13.37	13.44	13.29	13.14	11.56	11.42
40-49	8.80	8.54	10.62	10.46	10.16	9.90	8.61	8.25
50-59	5.70	5.51	6.62	6.78	6.31	6.36	5.50	5.30
60-69	3.24	3.19	3.79	4.15	3.70	3.81	3.04	2.50
70 and over	1.70	1.96	1.91	2.70	1.88	2.18	1.55	1.77

(continued)

Table 2.4b (Concluded)

PERCENTAGE AGE DISTRIBUTION OF POPULATION BY REGION, BRAZIL, 1970 (RESIDENT)

Age	Region							
	4		5		6		7	
	Males	Females	Males	Females	Males	Females	Males	Females
0-4	15.03	14.62	17.26	16.29	16.94	16.56	16.81	17.21
5-9	15.15	14.70	15.90	15.00	14.73	14.69	15.49	15.69
10-14	13.77	13.53	13.16	12.76	10.48	11.17	13.20	13.68
15-19	11.45	11.82	10.73	11.18	9.81	11.03	10.91	11.71
20-24	8.51	8.90	8.18	8.93	10.52	10.86	8.62	8.87
25-29	6.39	6.77	6.18	6.82	8.93	9.36	7.03	6.99
30-34	5.65	5.81	5.28	5.72	8.68	7.58	5.92	5.62
35-39	5.24	5.43	4.54	4.98	6.10	5.62	5.19	4.98
40-49	8.34	8.15	7.95	7.87	7.93	6.89	7.97	7.08
50-59	5.54	5.31	5.51	5.16	3.63	3.66	4.90	4.32
60-69	3.13	3.01	3.24	3.02	1.47	1.63	2.48	2.30
70 and over	1.59	1.75	1.83	2.02	0.50	0.70	1.17	1.27

Table 2.5

RATIO OF TOTAL POPULATION OF REGIONS TO TOTAL NATIONAL POPULATION BY SEX, BRAZIL AND REGIONS 1950-1970

Regions	Ratio to total population in percentage					
	1950		1960		1970	
	Male	Female	Male	Female	Male	Female
1	8.97	9.02	9.38	9.55	9.51	9.79
2	17.95	17.21	18.47	18.06	19.27	18.88
3	15.30	14.88	17.06	16.50	17.98	17.44
4	16.82	16.82	16.08	15.97	14.04	14.04
5	33.86	35.33	30.85	32.27	29.61	30.74
6	-	-	0.24	0.14	0.58	0.57
7	7.06	6.72	7.88	7.47	8.97	8.50
Total Brazil	99.96	99.98	99.96	99.96	99.96	99.96

Regions	Percentage change in the ratios					
	1950-1960		1960-1970		1950-1970	
	Male	Female	Male	Female	Male	Female
1	4.57	5.88	1.39	2.51	6.02	8.54
2	2.90	4.94	4.33	4.54	7.35	9.70
3	11.50	10.89	5.39	5.70	17.52	17.20
4	- 4.40	- 5.05	-12.69	-12.09	-16.53	-16.53
5	- 8.89	- 9.23	- 4.02	- 4.74	-12.55	-12.99
6	-	-	141.67	307.14	-	-
7	11.61	11.16	13.83	13.79	27.05	26.49
Total Brazil	-	-	-	-	-	-

Table 2.6

CHANGES IN PROPORTIONS OF REGIONAL AGE DISTRIBUTIONS, 1950-1960

(Changes between)

Age	Region					
	1		2		3	
	Male	Female	Male	Female	Male	Female
0	- 0.48	- 0.20	+ 0.18	+ 0.47	+ 0.68	+ 0.74
5	- 2.11	- 1.80	- 1.00	- 0.73	- 1.19	- 1.22
10	- 0.38	- 0.21	+ 0.17	+ 0.32	- 0.34	- 0.42
15	+ 1.35	+ 1.29	+ 2.07	+ 1.08	+ 0.45	+ 0.52
20	+ 1.49	+ 1.38	+ 1.12	+ 1.04	+ 0.53	+ 0.83
25	+ 0.53	+ 0.16	+ 0.28	+ 0.16	+ 0.42	+ 0.39
30	- 0.38	- 0.58	- 0.66	- 0.65	- 0.01	- 0.13
40	+ 0.55	+ 0.21	+ 0.26	- 0.15	- 0.12	- 0.28
50	- 0.01	+ 0.01	- 0.49	- 0.65	- 0.19	- 0.13
60	- 0.32	- 0.26	- 0.51	+ 0.61	- 0.20	- 0.17
70 and over	+ 1.09	- 0.23	- 1.32	- 1.40	- 0.11	- 0.07
Total	- 5.01	- 3.28	+ 3.98	+ 3.58	+ 2.16	+ 2.42

(Continued)

Table 2.6 (Concluded)

CHANGES IN PROPORTIONS OF REGIONAL AGE DISTRIBUTIONS, 1950-1960
(Changes between)

Age	Region					
	4		5		7	
	Male	Female	Male	Female	Male	Female
0	+ 0.79	- 0.24	+ 0.17	+ 0.30	- 0.56	- 0.51
5	- 0.19	- 1.17	- 0.70	- 0.61	- 1.14	- 1.12
10	+ 0.68	+ 0.13	- 0.18	- 0.21	- 0.19	- 0.33
15	+ 0.85	+ 0.74	- 0.43	- 0.40	+ 0.11	- 0.08
20	+ 0.51	+ 0.65	+ 0.60	+ 0.54	+ 0.57	+ 0.67
25	+ 0.17	+ 0.23	+ 1.18	+ 0.68	+ 0.66	+ 0.37
30	- 0.66	+ 0.29	+ 0.61	+ 0.20	+ 0.81	+ 0.63
40	- 0.49	- 0.04	- 0.27	- 0.18	- 0.04	+ 0.17
50	- 0.65	- 0.22	- 0.27	- 0.13	- 0.15	- 0.06
60	- 0.64	- 0.29	- 0.50	- 0.25	+ 0.01	- 0.03
70 and over	- 0.47	- 0.11	- 0.34	- 0.09	- 0.20	0.00
Total	+ 3.10	2.07	2.56	1.72	2.28	2.13

Table 2.6a

CHANGES IN THE PROPORTIONS OF REGIONAL AGE DISTRIBUTIONS FOR BRAZIL, 1960-1970

Age	Region 1		2		3		4	
	Male	Female	Male	Female	Male	Female	Male	Female
0	+2.14	+2.09	+2.09	+2.08	+1.45	+1.41	+2.10	+2.01
5	+0.36	+0.46	+0.26	-2.00	+0.24	+0.03	+0.41	+0.29
10	-1.03	-0.81	-0.87	-0.72	-0.055	-0.056	-1.12	-0.99
15	-1.62	-1.47	-1.28	-0.96	-1.02	-0.75	-1.38	-0.85
20	-0.37	-0.10	-0.30	-0.03	-0.12	+0.01	+0.12	+0.37
25	+1.01	+1.12	+0.87	+0.71	+0.49	+0.57	+0.78	+0.75
30	+1.10	+0.96	+1.11	+0.55	+0.40	+0.43	+0.19	+0.02
40	-0.64	-0.48	-0.53	-0.39	-0.18	-0.21	-0.17	-0.40
50	-0.15	-0.50	-0.03	-0.39	-0.25	-0.41	-0.43	-0.55
60	-0.20	-0.31	+0.14	-0.39	-0.05	+0.28	-0.21	-0.30
70 and over	-1.77	-0.47	+0.35	-0.36	-0.21	-0.29	-0.24	-0.31
Δ	5.78	4.14	4.82	3.34	2.58	2.73	3.60	3.44

Age	Region 5		6		7	
	Male	Female	Male	Female	Male	Female
0	-0.18	-0.37	- 5.72	+1.32	+0.58	+0.33
5	-0.40	-0.53	- 6.71	-1.16	+0.13	-0.13
10	0.00	-0.07	- 4.80	-1.35	-0.57	-0.80
15	-0.35	-0.11	+ 0.09	-0.84	-0.71	-0.52
20	-0.18	+0.32	+10.97	+1.71	+0.02	+0.25
25	-0.06	+0.34	+ 5.36	+1.46	+0.36	+0.51
30	+0.98	+0.64	+ 2.28	+1.22	+0.45	+0.51
40	+0.42	+0.02	+ 0.26	-0.62	+0.24	+0.28
50	-0.15	-0.17	- 0.60	-0.95	-0.28	-0.18
60	+0.09	+0.07	- 0.65	-0.58	-0.04	+0.07
70 and over	-0.13	-0.09	- 0.31	-0.18	-0.03	-0.08
Δ	1.49	1.39	18.96	5.71	1.78	1.95

Table 2.6b

INDEX OF DISSIMILARITY BETWEEN THE AGE DISTRIBUTIONS OF THE REGIONS AND BRAZIL, 1950-1970

Regions	1950-1960		1960-1970	
	Males	Females	Males	Females
Brazil	1.99	1.81	2.31	2.68
Region 1	5.01	3.28	5.78	4.14
Region 2	3.98	3.58	4.82	3.34
Region 3	2.16	2.42	2.58	2.73
Region 4	3.10	2.07	3.60	3.44
Region 5	2.56	1.72	1.49	1.39
Region 6	-	-	18.96	5.71
Region 7	2.28	2.13	1.78	1.95

Table 2.7

AGING AND INDEX OF DISSIMILARITY FROM THE NATIONAL DISTRIBUTION BY SEX AND BY REGIONS, 1950-1970

Regions	Years					
	1950		1960		1970	
	Males	Females	Males	Females	Males	Females
1	+ 7.49	+ 7.36	+ 6.88	+ 7.00	+ 6.37	+ 7.29
2	+ 4.74	+ 3.27	+ 5.67	+ 4.80	+ 6.11	+ 5.55
3	- 0.96	- 1.70	- 1.05	- 1.63	- 0.91	- 1.14
4	- 2.64	- 1.96	- 2.46	- 2.59	- 1.92	- 1.96
5	- 2.08	- 1.22	- 3.50	- 1.84	- 3.91	- 2.63
6	-	-	±24.93	±10.99	± 8.23	± 8.03
7	- 1.91	- 2.53	- 3.00	- 4.59	- 3.12	- 5.58

\+ Older than National Distribution.
\- Younger than National Distribution.
± Distributions differ at middle ages.

III. NON-COMPONENT METHODS OF PROJECTIONS

In this chapter, selected non component of population projections are used to derive population projections for the regions of Brazil. Due to data limitations, complicated methods are excluded and where calculations were too lengthy to handle, examples from one region or few are only given.

Exercise 1

Using the arithmetic projection technique, project the female population of regions from 1970 to 1980 and compare the projections with the projected population of Brazil 1980 (63 368 128).

Solution:

Population is projected by the formula:

$$Pn = Po + \frac{n(Po - Pm)}{m}$$

where Pn is projected population over n years, Po is the population in the most recent census and Pm is the population in the past at time m. Table 3.1 gives the details of the projections.

Total populations of Brazil through arithmetic method = 59 500 314

Projected population of Brazil (national projections) = 63 368 128

It appears that the arithmetic method under projects the population by about 7 per cent. One convenient way to adjust for the under projections is to raise the regional projections by 7 per cent so that the national projected total equals the sum total of regional projections.

Table 3.1

PROJECTED FEMALE POPULATION FOR REGIONS, 1980

Regions	Pm 1960	Po 1970	n(Po-Pm) / m	Population in 1980
1	3 406 736	4 661 840	1 255 104	5 916 944
2	6 442 477	8 990 351	2 547 874	11 538 225
3	5 885 984	8 304 647	2 418 663	10 723 310
4	5 696 919	6 685 621	988 702	7 674 323
5	11 551 559	14 637 892	3 086 333	17 724 225
6	49 942	271 425	221 483	492 908
7	2 664 745	4 047 562	1 382 817	5 430 379
total	35 698 362	47 599338		59 500314

Exercise 2

Using national projection for Brazil (variant 3), prepare regional projections for males by U.S. Census Bureau Ratio Method of 1952.

Answer:

The ratio method is basically based on two factors:

1. Extrapolation of the ratios of the regions to the national population, and
2. Application of the extrapolated ratios to the population projections for the nation.

Step 1: Group together the regions based on ratio data for two or more census. If the data are not available for more than two decades, interpolate the ratios for mid censal years. The regions should be grouped in not more than three groups by the following criteria:

Group 1: Regions with constant direction of change over the period.

Group 2: Regions with constant direction of change for the latest two decades but with a different direction of change in the first decades.

Group 3: Regions with different direction of change in the recent decade than the other decades.

Step 2: All of the regions of Brazil fall in group 1. For group 1 regions, assign a rate of change in their ratios as the average annual rate of change for the period in which the rate of change is the lowest or close to zero. For example, from 1950 to 1970, if the rate of change (annual) for 1960-1965 is the least, select 1960-1965 annual rate of change (tables 3.2 and 3.2a). For group 2 regions assign the lesser of the annual rates of change for one of the most recent decades. For group 3, assign rates equal to one half of the average annual rate for the most recent period.

Step 3: Assume and trend all rates so that the annual rate of change would linearly decline to zero in 50 years. Values between the initial and the terminal rates are linearly interpolated.

Table 3.2b gives the share change ratios for males based on five year average rates and ten year average rates. These rates are used only for interpolation.

Step 4: Calculate annual share change ratios from table 3.2b by using the formula: $R = \left| \sqrt[t]{(P1/Po)} - 1 \right|$ where t is the number of years between populations P1 and Po. Annualized share change ratios are given in table 3.2c. Select the lowest ratios based on both time intervals (10 years and 5 years).

Step 5: Trend the ratios that are selected in table 3.2c for each year of decade of the projections under the assumption that annual share change ratios would linearly converge to zero in 50 years. Add 1.0 to each of the trended ratios and cumulatively multiply over the desired number of years of projection.

Table 3.2d demonstrates step 5. The two time periods (5 years and 10 years) show the differences between the ratios when different time intervals are used.

Step 6: Check the inconsistencies in table 3.2d. The ratios for regions 4 and 5 were negative showing the losses in population over the period. Therefore these ratios must be changed to values of less than unity. This is done to correct the use of absolute annual ratios. Hence, the corrected ratios for regions 4 and 5 are:

	Region 4	Region 5
Based on 5 years	0.947639	0.976437
Based on 10 years	0.907294	0.958715

Step 7: Apply the cumulatively multiplied ratios to the ratios for males given in table 3.2. The results are given in table 3.2e. These ratios are corrected so that the projected shares sum up to unity by the formula: $A = 1.0/\sum_{i=1}^{n} S_i$, (table 3.2f). For convenience we use the following terminology:

5 year projections based on 5 year interval ratios = method 2
10 year projections based on 5 year interval ratios = method 2a
5 year projections based on 10 year interval ratios = method 1
10 year projections based on 10 year interval ratios = method 1a

Step 8: Population projections for Brazil are prepared by CELADE. Total population of males in Brazil was projected as 54 767 665 for 1975 and 63 021 083 for 1980 according to the third set of the projections. The corrected and the projected shares of the regions are applied to the projected male population of Brazil to prepare two sets of projections for 1975 and 1980 in table 3.2g.

Table 3.2

INTERPOLATION* OF RATIOS FOR MID CENSUS YEARS

Regions	1950		1955		1960		1965		1970	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
1	8.97	9.02	9.18	9.29	9.38	9.55	9.45	9.67	9.51	9.79
2	17.95	17.21	18.21	17.64	18.47	18.06	18.87	18.47	19.27	28.88
3	15.30	14.88	16.18	15.69	17.06	16.50	17.52	16.97	17.98	17.44
4	16.82	16.82	16.45	16.40	16.08	15.97	15.06	15.01	14.04	14.04
5	33.86	35.33	32.36	33.80	30.85	32.27	30.23	31.51	29.61	30.74
6					0.24	0.14	0.41	0.35	0.58	0.57
7	7.06	6.72	7.47	7.10	7.88	7.47	8.43	7.99	8.97	8.50

* Interpolation is done by taking the average of the ratios between 1950 and 1960 and between 1960 and 1970.

Table 3.2a

ASSIGNING THE LEAST RATE OF CHANGE TO REGIONS

Regions	Rates of change	
	1 Based on 5 year average	2 Based on 10 year average
	Males	Males
1	1.01	1.014
2	1.01	1.029
3	1.03	1.054
4	-1.02	-1.044
5	-1.02	-1.040
6	1.41	2.416
7	1.06	1.116

Table 3.2b

SHARE CHANGE RATIOS FOR MALES BY REGIONS

Time period	Ratios based on five years						
	Regions						
	1	2	3	4	5	6	7
1970/1950	0.060201	0.073538	0.175163	-0.165279	-0.125517	-	0.270538
1970/1955	0.035948	0.058210	0.111248	-0.146505	-0.084981	-	0.200803
1970/1960	0.013859	0.043313	0.053927	-0.126866	-0.040194	1.41667	0.138325
1970/1965	0.006349	0.021198	0.026256	-0.067729	-0.020509	0.414634	0.064057
	Ratios based on ten years						
1970/1950	0.060201	0.073538	0.175163	-0.165279	-0.125517	-	0.270538
1970/1960	0.013859	0.043313	0.053927	-0.126866	-0.040194	1.41667	0.138325

Table 3.2c

ANNUAL SHARE CHANGE RATIOS FOR MALES, BY REGIONS

Regions	Time frame			
	Based on 10 and 5 years (together)			
	1970/1950	1970/1955	1970/1960	1970/1965
1	0.002927	0.002357	0.001377	0.001267
2	0.003554	0.003779	0.004249	0.004204
3	0.008103	0.007057	0.005266	0.005197
4	-0.008992	-0.010505	-0.013475	-0.013928
5	-0.006684	-0.005903	-0.004094	-0.004136
6	-	-	0.092249	0.071837
7	0.012044	0.012274	0.013040	0.012498

	Selected ratios based on:	
	10 years	5 years
1	0.001377	0.001267
2	0.003554	0.003554
3	0.005266	0.005197
4	-0.008992	-0.008992
5	-0.004094	-0.004094
6	0.092249	0.071837
7	0.012044	0.012044

Table 3.2d

TRENDING FOR EACH YEAR OF DECADE UNDER THE ASSUMPTION OF LINEAR CONVERGENCY TO ZERO OVER 50 YEARS

Years	Multi-pliers	Regions				
		1		2	3	
		10 years Basic Selected Ratios 0.001377	5 years 0.001267	10 years-5 years 0.003554	10 years 0.005266	5 years 0.005197
1	0.98	0.001349	0.001242	0.003483	0.005161	0.005093
2	0.96	0.001322	0.001216	0.003412	0.005055	0.004989
3	0.94	0.001294	0.001191	0.003341	0.004950	0.004885
4	0.92	0.001267	0.001166	0.003270	0.004845	0.004781
5	0.90	0.001239	0.001140	0.003199	0.004739	0.004677
6	0.88	0.001212	0.001115	0.003128	0.004634	0.004573
7	0.86	0.001184	0.001090	0.003056	0.004529	0.004469
8	0.84	0.001157	0.001064	0.002985	0.004423	0.004365
9	0.82	0.001129	0.001039	0.002914	0.004318	0.004262
10	0.80	0.001102	0.001014	0.002843	0.004213	0.004158

Add 1.0 to each of the basic and trended ratios and cumulatively multiplying over all years we get:

5 years	1.019099	1.007244	1.020431	1.030394	1.029990
10 years	1.025007	1.012616	1.035753	1.053380	1.052669

(continued)

Table 3.2d (Concluded)

TRENDING FOR EACH YEAR OF DECADE UNDER THE ASSUMPTION OF LINEAR CONVERGENCY TO ZERO OVER 50 YEARS

Years	Multi-pliers	Regions							
		4		5		6		7	
		10 years	5 years	10 years	5 years	10 years	5 years	10 years	5 years
		0.008992		0.004094		0.092249	0.071837	0.012044	
1	0.98	0.008812		0.004012		0.090404	0.070400	0.011803	
2	0.96	0.008632		0.003930		0.088559	0.068964	0.011562	
3	0.94	0.008452		0.003848		0.086714	0.067527	0.011321	
4	0.92	0.008273		0.003766		0.084869	0.066090	0.011080	
5	0.90	0.008093		0.003685		0.083024	0.064653	0.010840	
6	0.88	0.007913		0.003603		0.081179	0.063217	0.010599	
7	0.86	0.007733		0.003521		0.079334	0.061780	0.010358	
8	0.84	0.007553		0.003439		0.077489	0.060343	0.010117	
9	0.82	0.007373		0.003357		0.075644	0.058906	0.009876	
10	0.80	0.007194		0.003275		0.073799	0.057470	0.009635	
Add 1.0 to each of the basic and trended ratios and cumulatively multiplying over all years we get:									
5 years		1.052361		1.023563		1.655357	1.486000	1.070643	
10 years		1.092706		1.041285		2.404084	1.991806	1.125909	

Table 3.2e

PROJECTED SHARES OF REGIONS TO BRAZIL

Regions	Projections for 5 years		Projections for 10 years	
	Based on 10 year data	Based on 5 year data	Based on 10 year interval	Based on 5 year interval
1	0.096916	0.095789	0.097478	0.096300
2	0.196637	0.196637	0.199590	0.199590
3	0.185265	0.185192	0.189398	0.189270
4	0.133049	0.133049	0.127384	0.127384
5	0.289123	0.289123	0.283876	0.283876
6	0.009601	0.008619	0.013944	0.011552
7	0.096037	0.096037	0.100994	0.100994

Table 3.2f

CORRECTED PROJECTED SHARE OF THE REGIONS

Method	Regions						
	1	2	3	4	5	6	7
1	0.09628	0.19535	0.18405	0.13218	0.28723	0.00954	0.09541
1a	0.09626	0.19709	0.18703	0.12579	0.28033	0.01377	0.09973
2	0.09536	0.19577	0.28437	0.13246	0.28784	0.00858	0.09562
2a	0.09544	0.19782	0.18759	0.12625	0.28135	0.01145	0.10010

Table 3.2g

POPULATION PROJECTIONS FOR MALES BY REGIONS OF BRAZIL
USING U.S. CENSUS BUREAU METHOD OF 1952

Regions	Method 1	Method 1a	Method 2	Method 2a
	1975	1980	1975	1980
1	5 255 729	5 989 719	5 205 507	5 938 696
2	10 562 770	12 263 805	10 686 685	12 309 229
3	10 046 914	11 637 827	10 064 382	11 672 674
4	7 215 436	7 827 206	7 230 721	7 855 829
5	15 679 300	17 443 363	15 712 599	17 506 832
6	529 769	856 830	468 364	712 469
7	5 208 237	6 205 638	5 219 155	6 228 661

Exercise 3

Given the following data, prepare the projections for the female population of regions 2 and 5 by means of the apportionment method.

Table 3.3

FEMALE POPULATION OF BRAZIL AND REGIONS 2 AND 5*

Year	Brazil	Region 2	Region 5
1950	26 216 780	4 511 908	9 262 388
1960	35 672 634	6 442 478	11 511 559
1970	47 618 388	8 990 352	14 637 892

* Figures for Brazil are taken from Population Projections Variant 3 of CELADE. Actual ratios of regions to Brazil for 1950-1970 are applied to the 'projected population of Brazil' assuming as if the populations in this table are actual ones.

Solution:

The method assumes that the distance into the future that is being projected should be based on the historical period of equal lengths as its model. For example, projections from 1970 to year 2000 has a 30 year distance so the projections should be based 30 year historical period, that is, trend of 1940-1970. The following steps are taken:

Calculate the change in the female population from 1950-1970 as in table 3.3a.

Table 3.3a

FEMALE POPULATION CHANGE

Period	Region 2	Region 5	Brazil	Ratio	
				Region 2	Region 5
1960-1970	2 547 874	3 126 333	11 945 754	0.21329	0.26171
1950-1970	4 478 444	5 375 504	21 401 608	0.20926	0.25117

The projections are prepared as in table 3.3b

Table 3.3b

Year	Brazil	Ratios		Change		Projected population	
		Region 1	Region 2	Region 1	Region 2	Region 1	Region 2
1970	47 618 388						
1980	62 587 756	0.21329	0.26171	3 192 816	3 917 633	12 183 168	18 555 525
1990	79 351 309	0.20926	0.25117	6 640 431	7 970 357	15 630 783	22 608 249

Exercise 4

Using the ratios (by five year interval) of the regions to Brazil from 1950 to 1970, prepare projections for males in region 1 for 1975, 1980 and 1990 by means of the ratio trend method.

Ratio (as percentage) of region 1 population to Brazil

Year	Ratio
1950	8.97
1955	9.18
1960	9.38
1965	9.45
1970	9.51

Solution:

As stated earlier, this method is similar to U.S. Bureau of Census 1952 method except that it can project the population partner into the future than U.S. method. In this method, short historical trend is used for short term projection and long historical trend is used for long term projection.

Step 1: Calculate log (100R) and Δ log R or transform the shares into logarithms as in table 3.4.

Table 3.4.

Year	Region 1 Log (100 R)	Δ Log R
1950	0.95279	-
1955	0.96284	0.01005
1960	0.97220	0.00936
1965	0.97543	0.00323
1970	0.97818	0.00275

Step 2: Define the mid points of 1950-1955 as D_1, 1955-1960 as D_2, 1960-1965 as D_3, 1965-1970 as D_4, 1970-1975 as D_5, 1975-1980 as D_6, 1980-1985 as D_7 and 1985-1990 as D_8.

Step 3: Use table 3.4 and calculate D_5, D_6 and $D_7 + D_8$ as:

$$D_5 = \frac{[2(D_4) + (D_3)]}{3} = [2(0.00275) + (0.00323)]/3$$

$$= 0.00873/3 = 0.00291$$

$$D_6 = [6(D_4) + 4(D_3) + 3(D_2) + 2(D_1)]/15$$

$$= \frac{[6(0.00275) + 4(0.00323) + 3(0.00936) + 2(0.01005)]}{15}$$

$$= (0.01650 + 0.01292 + 0.02808 + 0.01105)/15$$

$$= \frac{0.06855}{15} = 0.00457$$

$$(D_7+D_8) = [6(D_5+D_6) + 3(D_3+D_4) + 2(D_1+D_2)]/11$$

$$= [6(0.00291+0.00457)+3(0.00323+0.00275)+2(0.01005+0.00936)]/11$$

$$= \frac{0.10164}{11} = 0.00924$$

Step 4: Calculate projected shares of region 1 in logarithms as in table 3.4a.

Table 3.4a

1975 = 0.97818 + 0.00291 = 0.98109	
1980 = 0.98109 + 0.00457 = 0.98566	
1990 = 0.98566 + 0.00924 = 0.99490	

Step 5: Transform the projected shares in logarithms into the projected percentages for region 1, we get:

1975	9.57392
1980	9.67520
1990	9.88325

Note that these percentage shares of region 1 may be combined with similarly calculated shares of all other regions of Brazil and adjusted (as we did in U.S. Census Bureau Method of 1952) so that the sum total equals 100.00. The projections for the regions by using national projections can be computed for 1975, 1980 and 1990. Table 3.4b gives the population projections for males for region 1.

Table 3.4b

PROJECTED NUMBER OF MALES IN REGION 1

Projection year	Projected number of males in Brazil	Region 1
1975	54 767 665	5 243 412
1980	63 021 083	6 097 416
1990	82 581 442	8 161 730

IV. COMPONENT METHODS OF PROJECTIONS

As mentioned earlier, a variety of component methods are discussed in the literature on population projections. As data restrictions are severe in the case of Latin American countries, only those methods that can be based on the available data are presented here.

1. Mortality projections

Projection of life expectancy at birth.

Since life expectancy at birth (e_o) is an outcome of the overall mortality experience, the projection of e_o's is the most convenient method for areas where historical mortality data are either not available or are of poor quality. Even if data on mortality are available, the projections of e_o are generally examined in the light of other mortality statistics, as was the case in Statistics Canada Projections. For countries with scanty mortality data, once e_o's are projected the survival ratios can be estimated, usually through the selection of appropriate model life tables.

Exercise

Given the following e_o's for females for Brazil and regions at two points of time, project e_o's and survival ratios for females for the years 1975/1980 and 1980/1985:

e_o for females

	1955	1974/1975
Brazil	50.97	64.44
Region 1	53.83	69.83
Region 2	54.57	68.26
Region 3	56.49	67.61
Region 4	51.26	65.57
Region 5	41.63	52.65
Region 6	50.97	69.60
Region 7	52.29	66.57

Solution

Take the ratio of regional e_o's to national e_o's and observe the trend as follows:

Table 4.1

RATIO OF REGIONAL e_o's TO NATIONAL e_o's

Region	1955	1974/1975
1	1.056	1.083
2	1.071	1.059
3	1.108	1.049
4	1.006	1.017
5	0.817	0.817
6	1.000	1.080
7	1.026	1.033

As is evident from table 4.1, the recent ratios of regional e_o's do not conform with those in 1955. The ratios for region 5 are well below the ratios for other regions. In fact, all regions except region 5 had higher e_o values than the nation. Only region 5 had a life expectancy at birth lower than average.

Since there is no clear trend in the e_o values, it is reasonable to assume that the recent ratios (1974/1975) would remain constant in the future. Under this assumption, the projected e_o values for regions of Brazil are given in table 4.2. These projected e_o values for regions are based on the projected e_o values for Brazil, prepared by CELADE.

For most population projections by component methods, survival probabilities are used. Therefore, the survival probabilities that correspond to these life expectancy values can be obtained with reference to the projected national life tables. Using the life table for 1974/1975 for region 1 and the projected tables, for brazil the survival ratios (i.e. S_x values) are calculated for region 1 by linear interpolation for 1975-1980

as in table 4.3. For example, calculate the increase in S_x for Brazil from 1970-1975 to 1975-1980 from the projections and multiply the S_x for females of region 1 from the life table of 1974-1975.

Table 4.2

PROJECTED FEMALE LIFE EXPECTANCY AT BIRTH
FOR REGIONS OF BRAZIL

	1970-1975	1975-1980	1980-1985
Brazil	64.44	66.71	68.77
Region 1	69.83	72.25	74.48
Region 2	68.26	70.65	72.83
Region 3	67.61	69.98	72.14
Region 4	65.57	67.84	69.94
Region 5	52.65	54.50	56.19
Region 6	69.60	72.05	74.27
Region 7	66.57	68.91	71.04

Table 4.3

PROJECTED FEMALE SURVIVAL RATIOS FOR REGION 1 FOR 1975-1980

Age x	$_5S_{x,x+4}$	Age x	$_5S_{x,x+4}$	Age x	$_5S_{x,x+4}$
0	0.99337	30	0.98708	60	0.93835
5	0.99825	35	0.98707	65	0.91238
10	0.99460	40	0.98345	70	0.87112
15	0.99153	45	0.97739	75	0.73024
20	0.98664	50	0.96791	{75 and over 80 and over}	0.45410
25	0.99022	55	0.95523		

2. *Fertility projections*

As in mortality projections, fertility projections can be prepared through the use of different models. The choice of model depends upon the availability of data suitable for the models being used. In case of regions or countries where historical data are not reliable, models such as Romaniuk's (1973) can not be used. Under these circumstances projections of fertility are usually prepared by extrapolating total fertility rates and age specific fertility rates by the method demonstrated in this section.

Exercise

Age-specific fertility rates for Brazil and the regions are given in tables 4.4 and 4.5. Project the total fertility rates for the regions for 1970/1975, 1975/1980 and 1980/1985. Using these projected total fertility rates, compute the age specific fertility rates for region 1 for the projection years.

Table 4.4.

AGE SPECIFIC FERTILITY RATES, BRAZIL AND REGIONS, 1950-1960

Age	Region						
	1	2	3	4	5	7	Total
15-19	0.0654	0.0717	0.0839	0.0797	0.0881	0.1072	0.0830
20-24	0.1905	0.2077	0.2473	0.2635	0.2784	0.2799	0.2478
25-29	0.1914	0.2057	0.2620	0.2935	0.3307	0.2916	0.2672
30-34	0.1483	0.1638	0.2284	0.2567	0.2950	0.2511	0.2303
35-39	0.0992	0.1076	0.1703	0.1819	0.2020	0.1818	0.1600
40-44	0.0412	0.0371	0.0806	0.0864	0.0932	0.0929	0.0675
45-49	0.0016	-0.0040	0.0050	-0.0032	-0.0008	0.0032	-0.0028
TFR	3.6713	3.9476	5.3870	5.7923	6.4321	6.0387	5.2649

Table 4.5

AGE SPECIFIC FERTILITY RATES, BRAZIL AND REGIONS, 1960-1970

Age	Region							
	1	2	3	4	5	6	7	Total
15-19	0.0584	0.0610	0.0813	0.0659	0.0872	0.0839	0.1085	0.0773
20-24	0.1917	0.2033	0.2533	0.2531	0.2935	0.2284	0.2988	0.2511
25-29	0.2104	0.2152	0.2807	0.3059	0.3521	0.2399	0.3267	0.2848
30-34	0.1741	0.1732	0.2370	0.2701	0.3415	0.2112	0.2847	0.2422
35-39	0.1263	0.1238	0.1779	0.1991	0.2189	0.2125	0.2095	0.1737
40-44	0.0712	0.0648	0.0919	0.1003	0.1003	0.1365	0.1068	0.0811
45-49	0.0233	0.0212	0.0170	0.0097	0.0038	0.0931	0.0144	0.0090
TFR	4.2765	4.3140	5.6951	6.0202	6.8354	6.0275	6.7473	5.5960

Table 4.6

RATIO OF REGIONAL AGE SPECIFIC RATES (ASFR) TO THOSE FOR BRAZIL, 1950-1960 AND 1960-1970*

Age	Region													
	1		2		3		4		5		6		7	
	1955	1965	1955	1965	1955	1965	1955	1965	1955	1965	1955	1965	1955	1965
15-19	0.70	0.65	0.76	0.67	0.89	0.90	0.85	0.73	0.94	0.96	-	0.93	1.14	0.86
20-24	0.77	0.79	0.85	0.83	1.01	1.04	1.07	1.04	1.13	1.20	-	0.94	1.01	1.23
25-29	0.69	0.77	0.74	0.78	0.95	1.02	1.06	1.11	1.20	1.28	-	0.87	1.05	1.19
30-34	0.63	0.77	0.70	0.77	0.97	1.05	1.09	1.19	1.25	1.51	-	0.93	1.07	1.21
35-39	0.61	0.85	0.66	0.83	1.04	1.20	1.12	1.34	1.24	1.48	-	1.43	1.11	1.41
40-44	0.48	0.98	0.43	0.90	0.93	1.27	1.00	1.39	1.07	1.39	-	1.89	1.07	1.48
45-49	0.06	1.01	a/	0.92	0.20	0.74	a/	0.42	a/	0.16	-	4.03	0.13	0.62

* Age specific fertility rates for 1950-1960 and 1960-1970 are treated as those for 1955 and 1965 respectively. Fertility rates for Brazil are taken from Arretx (1973).

a/ Estimated rates for these age groups are negative because of estimation procedures.

Solution

Since we have to compute age specific fertility rates it is essential to establish a link between the age specific rates for the region and those for the nation. The most common method is to take the ratios of the regional age specific rates to the national ones. These ratios are given in table 4.6. They are based on fertility rates for Brazil given by Arretx (1973). The total fertility rates for Brazil were 5 643 in 1955 and 5 382 in 1965.

By examining the tables 4.4 and 4.5, the fertility is estimated to be increasing for the regions. But the national projections for Brazil used declining fertility. As we ought to project regional fertility in relation with national fertility, a correction factor has been introduced for standardized TFR's. This correction factor is defined as the ratio of the TFR for Brazil used in projections to the TFR for Brazil computed from regional fertility in 1965. Thus:

$$\text{Correction factor} = \frac{5.382}{5.996} = 0.96$$

Applying the correction factor to the regional total fertility rates, we get adjusted regional TFR's for 1965-1970. Using this as a base, the TFR's are projected for the regions from TFR's of Brazil as in table 4.7.

Table 4.7

CORRECTED AND PROJECTED TFR's FOR REGIONS

Period	Brazil	Regions						
		1	2	3	4	5	6	7
1965-1970	5382	4081	4133	5425	5786	6561	5786	6458
1970-1975	5150	3914	3955	5191	5537	6278	5537	6180
1975-1980	4890	3716	3755	4929	5257	5961	5257	5868
1980-1985	4615	3507	3544	4651	4962	5626	4962	5538

Age specific fertility rates for region 1 are projected by using the distribution of the ASFR's for 1965 and the corrected TFR's. The results are given in table 4.8.

Table 4.8

PROJECTED AGE SPECIFIC FERTILITY RATES FOR REGION 1
USING 1960-1970 DISTRIBUTION OF ASFR RATES
AND CONNECTED TFR's

Age	1965-1970	1970-1975	1975-1980	1980-1985
15-19	0.0557	0.0534	0.0507	0.0479
20-24	0.1829	0.1754	0.1666	0.1572
25-29	0.2008	0.1925	0.1828	0.1725
30-34	0.1661	0.1593	0.1513	0.1428
35-39	0.1205	0.1156	0.1097	0.1036
40-44	0.0679	0.0651	0.0618	0.0584
45-49	0.0222	0.0213	0.0202	0.0191
TFR	4081	3914	3716	3507

3. *Migration projections*

There are two types of methodologies that are used in migration projections: a) analytical and b) models. Analytical methods are based on historical data and their extrapolation. These methods are usually not adequate and are subjective. In the second method the projections are developed on the basis of models (e.g. regression models). Another simple way of projecting migration is to assume net migration as a rate of total population and keep these rates constant over the period of projection.

In the present section, two simple methods (analytical) of migration projections are demonstrated: the cohort survival and the cohort ratio method:

a) Cohort survival method

The method combines the effects of mortality and net migration (Hamilton and Perry, 1960). Cohort survival rates for each age group are obtained by the following formula:

$$P_x^{t+n} = (P_x^t \; / \; P_{x-n}^{t-n}) \quad xP_{x-n}^t$$

where x is age, p is the population at time t and n is the time interval between the two populations.

Exercise

Using the cohort survival ratio method and applying life table survival ratios, project the female net migration for region 1 for age groups 10-29 for the year 1980.

The results are given in table 4.9

Table 4.9

MIGRATION PROJECTIONS FOR REGION 1, AGE 10-29

Age group	Female population in region 1			Projected population by:		Net migration projections
	1970	1960	1950	Cohort survival method 1980	Using life table 1980 (without migration)	
0-4	519 179	450 607	311 855			
5-9	548 928	417 370	250 102			
10-14	520 309	353 649	242 885	599 489	514 834	84 655
15-19	494 983	312 952	249 553	651 003	545 008	105 995
20-24	422 860	306 295	247 108	622 136	513 116	109 020
25-29	344 979	290 157	107 148	545 636	484 233	61 406

b) *Cohort ratio method*

This method is devised as a means of projecting net migration by age and sex. To apply this method, it is important to have census data for at least two consecutive censuses as well as birth data by sex. The following steps are involved:

i) Compute the ratio of the subarea population at age x to the population of the nation at age x = ${}^5A^t_x$

ii) Calculate ratio of cohort change R by the formula:

$$R_x = ({}^5A^{t+10}_{x+10}) \; / \; {}^5A^t_x$$

Exercise

Project the net migration by age for females of region 1 to 1980 (using the cohort ratio method) for ages 10 to 29.

Solution

The ratios by age and the cohort change ratios are computed for region 1 as in table 4.10.

Table 4.10

MIGRATION PROJECTION FOR REGION 1 USING COHORT RATIO METHOD

Age groups	A_x 1960	A_{x+10} 1970	R_{x+10}	Projected population in 1980
0-4	0.0818			
5-9	0.0837			
10-14	0.0830	0.0878	1.0736	598291
15-19	0.0841	0.0941	1.1243	606006
20-24		0.0995	1.1988	607910
25-29		0.1036	1.2319	583155

After applying life table survival ratios and calculating the difference between the projected population in table 4.10 and the projected closed population, the net migration from 1970-1980 is projected as:

Age	Projected net migration for females 1970-1980
10-14	83 457
15-19	60 998
20-24	94 794
25-29	98 922

V. SUMMARY AND CONCLUSIONS

In the present document we have briefly reviewed the literature on the subject of small area population projections with particular emphasis on indirect methods. Where appropriate, concepts that are relevant to the subject matter have been defined for the purpose of clarity (Chapter I).

In Chapter II, we have presented a few exercises on the basic data that are important for a non-technical person who is interested in small area projections. The main objective of Chapter II is to show that if one does not have a feel for the basic data to be used in the projections, the ultimate projection results may not be trustworthy, particularly when the projections are treated as forecasts for planning purposes.

Chapters III and IV deal with the non-component and component methods of small area projections respectively. They are intented to show how a method is actually applied in preparing projections. Due to the limitations of the basic data on regions of Brazil, most of the methods had to be discarded (this will be the case generally for most developing countries). In non-component methods, the impact of the time interval on the projected figures have been shown, where appropriate. For example, from table 3.2 it is evident that if we use ratios based on five years, the projected figures are different from the use of ratios based on ten years. Ideally, the time interval for the computation of ratios should be associated with the rate of change in other socio-economic variables if one is to use the projected figures for planning purposes. It is very possible that for one region ratios based on a shorter period yield better results than those based on a longer period, and vice versa.

In case of the regions of Brazil, use of component methods presented numerous problems. Due to the non-availability of data on components of population growth by regions for a long period of time in the past, no sophisticated method could be presented. However, an attempt has been made to show that some methods, though crudely, can be applied within given circumstances.

Assuming that Brazil and its regions are representative of other Latin American countries and their regions, in terms of data quality and availability, the question arises as to which method is superior. The answer depends on:

a) The purpose of preparing projections. If the purpose is analytical, component methods should be preferred. This is also true when one is interested in the future estimates of one or more components of the regions. If one is interested in population totals in the future, ratio methods are preferred.

b) Population projections for subnational areas used as forecasts for planning in social, economic and health fields. Under these circumstances, one is interested in the future parameters of the three components of population growth as well as in the age and sex distribution.

The recommended methods for small area projections are a combination of the ratio and component methods. This combination of the two approaches has been applied to the projections of Canada's population, (1979) both nationally and by province (by the direct method) and by Torres in projecting the rural and urban populations of Paraguay (by the indirect methods) and have been found to be useful.

REFERENCES

Arkin, H. and R. Colton (1970), Statistical Methods. New York: Barnes and Noble.

Arretx, Carmen (1973), "Estimación de la Fecundidad a Base de Información sobre Hijos Nacidos Vivos,recogida en Censos Sucesivos", Notas de Población, Año I, Vol. 3, Santiago, Chile.

Bogue, Donald (1950), "A Technique for Making Extensive Population Estimates", Journal of the American Statistical Association, 45 (250): 149-163.

Bogue, Donald (1969), Principles of Demography, New York, John Wiley and Sons.

Bourgeois-Pichat, Jean, (1965), "Les Facteurs de la Fecondité non dirigeé", Population, 20: 383-424.

Brass, William (1958), "The Distribution of Births in Human Population". Population Studies, 12:51-72.

Carrier, N. and J. Hobcraft(1971), Demographic Estimation for Developing Societies, Winchester, England: Wykeham Press.

Chevan, Albert (1965) "Population Projection System", Technical Report, N° 3, Philadelphia: Pen Jersey Transportation Study.

Coale, Ansley and Paul Demeny, (1966), Regional Model Life Tables and Stable Populations, Princeton, New Jersey, Princeton University Press.

Coale, Ansley and J. Trussell, (1974) "Model Fertility Schedules: Variations in the Age Structure of Childbearing in Human Populations" , Population Index, 40(2), April: 185-257.

Cowden, D.J. (1947), "Simplified Methods of Fitting Certain Types of Growth Curves",Journal of the American Statistical Association, 42 (240): 585-90.

Croxton, F. and D.J. Cowden (1945), Applied General Statistics, New York, Prentice Hall.

Duncan, Otis D., (1957),"Measurement of Population Distribution", Population Studies, 11(27).

Erie and Niagra Counties Regional Planning Board (1972), Regional Population Projections, Erie and Niagra Counties, Grand Island, New York.

Gnanasekaran, K.S. (1973), Mortality Trends and Projections by Causes of Death in Canada, 1950-1990, Harvard Actuarial Conference, Boston.

Gnanasekaran, K.S. and G. Montigny, (1974), On Period Verses Cohort Approach to Mortality Projections. Paper presented at the Population Association of America Meetings, New York.

Greenberg, Michael (1972)"A Test of Combinations of Models for Projecting the Populations of Minor Civil Divisions",Economic Geography 48 (2): 179-88.

Hamilton, C. and J. Perry (1962),"A Short Method for Projecting Population by Age from one Decennial Census to another", Social Forces , 41(2): 160-70.

Henry, Louis,(1953)"Fondements Theoriques des Mesures de la Fecondité Naturelle", Revue de L'Institut International de Statistique,21, N° 3: 135-31.

Henry, Louis (1957), Fecondité et Famille. Modeles Mathematiques (I), Population, 12(3): 413-44.

Henry, Louis (1961), Fecondité et Famille, Modeles Mathematiques (II), Population, 16(1): 27-48.

Henry, Louis (1964),"Mesure du Temps Mort en Fecondité Naturelle".Population, 19(3): 485-514.

Isard, Waller (1960), Methods of Regional Analysis: An Introduction to Regional Science, Cambridge, Mass.: The M.I.T. Press.

Keyfitz, Nathan (1968), Introduction to Mathematics of Population, Don Mills, Ontario: Addison and Wesley Publishing Co.

Keyfitz, Nathan (1972),"On Future Population",Journal of the American Statistical Association, 67:338-353.

Krôtki, Karol (1969), The Treatment of Age Errors in Population Data in the U.N. Proposed Application of Stable Population Methods. Paper presented at the Annual Meeting of Population Association of America. Atlantic City, New Jersey.

Ledermann, Sully (1969), Nouvelles Tables -Types de Mortalité. Paris: Institut National d'Etudes Demographiques, Travaux et Documents, Cahier 53.

Mason, William (1969), "The Impact of Military Service on the Subsequent Civilian Attainment of Post World War II American Veterans" . Proceedings of the Social Statistics Section of the American Statistical Association. 420-27.

Nikolaj, Mice (1975), Method of Forecasting Population by Territorial Units. Problemi Na Geografijata (Sofia) 1(4):3-13.

Perrim, Edward and M.C. Sheps (1964)," Human Reproduction: A Stochastic Process ", Biometrics, 20: 28-245.

Pichard, J. (1967),"Dimensions of Metropolitanism",Research Monograph, 14 A, Washington D.C., Urban Land Institute.

(1959)," Metropolitanization of the United States",Research Mcnograph, 2, Washington D.C., Urban Land Institute.

Pittenger, Donald (1976), Projecting State and Local Populations, Cambridge, Mass. Ballinger Publishing Company.

Pollard, J.H. (1973), Mathematical Models for the Growth of Human Populations. Cambridge: Cambridge University Press.

Preston, Keyfitz and Schoen (1972), Causes of Death: Life Tables for National Populations. New York: Seminar Press.

Romaniuk, A. (1973),"A Three Parameter Model for Birth Projections", Population Studies, Vol. XXVII, N°3, Nov.: 467-78.

Romaniuk, A. and Mitra S.(1972), Pearsonian Type I Curve and its Fertility Projection Potentials. Paper presented at the Annual Meeting of of the American Statistical Association, Montreal.

Schmitt, Robert (1953),"A New Method of Forecasting City Population", Journal of the American Institute of Planners 19(1):40-42.

Schmitt, Robert((1954),"A Method of Projecting the Population of Census Tracts", Journal of the American Institute of Planners 20(2): 102.

Smith, T.M.F. (1966),"Ratio of Ratios and their Applications". Journal of the Royal Statistical Society, Series A, N°129: 531-33.

Stanberg, Henry V.B. (1952),"Better Population Forecasting for Areas and Communities", Domestic Commerce, Series N°32, U.S. Department of Commerce, Washington D.C.

Statistics Canada (1974),"Population Projections for Canada and the Provinces. 1972-2001", Information Canada, Ottawa.

Tarver, J.D. and T.R. Black (1966),"Making County Population Projections...", Bulletin 459, Logan Utah: Utah Agricultural Experiment Station.

United Nations (1955),"Age and Sex Patterns of Mortality. Model Life Tables for Under-Developed Countries", U.N. Population Studies 22, New York.

United Nations (1956),"Methods for Population Projections by Age and Sex, Manual III",Population Studies N° 25, New York.

United Nations (1968)"The Concept of a Stable Population. Application to the Study of Population of Countries with Incomplete Demographic Statistics", U. N. Population Studies 39, New York.

United Nations (1969), Projection of Population of Subnational Areas. Economic Commission for Asia and the Far East, Bangkok, Thailand.

United Nations, (1975),"Guidelines for Preparing Sub-National Population Projections", Asian Population Studies Series N°32, Bangkok, Thailand.

U.S. Bureau of the Census (1952), Current Population Reports, Series P-25, N° 56.

U.S. Bureau of the Census (1966), Methods of Population Estimation. Current Population Reports, Series P-25, N°339, Washington D.C.

White, Helen (1964), Empirical Study of the Accuracy of Selected Methods of Projecting State Populations. Journal of the American Statistical Association 29, 267:480-98.

Zachariah, K.C. (undated), Notes on Population Projections(Mimeographed), Demographic Training and Research Centre, Chembur, Bombay, India.

CENTRO LATINOAMERICANO DE DEMOGRAFIA
CELADE
Edificio Naciones Unidas
Avenida Dag Hammarskjöld
Casilla 91, Santiago, CHILE

Apartado Postal 5249
San José, COSTA RICA