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ESTIMATING THE REGIONAL MIGRATION PATTERNS OF THE FOREIGN-BORN POPULATION IN THE UNITED STATES: 1950–1990

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The regional distribution of the foreign-born population is determined by two principal migration processes: internal and external migration, modified, of course, by the impacts of mortality. (Since the fertility of the U.S. foreign-borns increases only the population of native-borns, it only needs to be included in studies of the regional distribution of the U.S. native-born population.) In this paper, we apply model schedules to graduate data on the internal and external regional migration patterns of the foreign-born population for the 1950–1990 period. Prior to the graduation we "cleanse" the observed foreign-born data of obvious inconsistencies and errors arising from a small sample size. No observed data are available for emigration, forcing us to draw on methods of indirect estimation to obtain it. To find estimates of the unrecorded migration flows in-between the four census-defined periods in our study (that is, for 1950–1955, 1960–1965, 1970–1975, and 1980–1985) we interpolate between the data of adjacent census time periods. Finally, we combine the estimated migration data with the corresponding mortality data to calculate and analyze the multiregional life tables and projections associated with each five-year time interval.

1. INTRODUCTION

The regional distribution of the foreign-born population is determined by two principal migration processes: the flows of immigrants and

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their initial region of arrival, and the subsequent redistribution of these immigrants *within* the United States as modified, of course, by the impacts of subsequent emigration and mortality. (Since the fertility of the U.S. foreign-borns increases only the population of native-borns, it only needs to be included in the projection of the U.S. native-born population.) Multiregional population projection models that seek to represent the dynamics of such migration processes generally need to keep track of enormous amounts of data. The disaggregations incorporated in such projections are introduced either because forecasts of the specified population subgroups, such as regional- and age-specific foreign-born totals, are important in their own right or because it is believed that simple and regular trends are more likely to be discovered at relatively higher levels of disaggregation.

High levels of disaggregation permit a greater flexibility in the use of the projections by a wide variety of users; they also often lead to a detection of greater consistency in patterns of behavior among more homogeneous population subgroups. But greater disaggregation requires the estimation of even greater numbers of data points, both those describing initial population stocks and those defining the future rates of events and flows that are expected to occur. The practical difficulties of obtaining and interpreting such data soon outstrip the benefits of disaggregation.

Mathematical descriptions of schedules of demographic rates, here called *model schedules*, offer a means for smoothing and condensing the amount of information to be specified as assumptions. They also express this condensed information in a language and in variables that are more readily understood by the users of the projections, and they provide a convenient way of associating the variables to one another, extrapolating them over time, and relating them to variables describing the socioeconomic environment that underlies the projections (Rogers, 1986).

In this paper, we apply model schedules to graduate data on the internal and external migration flows of foreign-born populations enumerated in four decadal censuses: 1960, 1970, 1980, and 1990. Prior to the graduation we "cleanse" the observed foreign-born data (that is, for 1955–1960, 1965–1970, 1975–1980, and 1985–1990) of obvious inconsistencies and errors arising from a small sample size. To obtain estimates of the unrecorded migration flows in between the four census-defined periods (that is, for 1950–1955, 1960–1965, 1970–1975, and 1980–1985) we interpolate between adjacent census time periods. To obtain data on emigration, we adopt model schedules and a simple model that relates emigration to immigration. Finally, we combine the migration data with the corresponding mortality data to calculate and analyze the multiregional life tables and projections associated with each of the original four five-year decadal census time intervals. Corresponding data for the native-born population are included for purposes of comparison.

2. PREPARING THE INTERNAL MIGRATION DATA

2.1. "Cleaning" the Foreign-Born Migration Data

The foreign-born population in the United States, though increasing, is nevertheless still a relatively small fraction of the national population – ranging from about 5 to about 9 percent of the national total during the four decades encompassed in this analysis. The same is true of the foreign-born share of the national migration total: ranging from 6 to 7 percent during the four decades (1950–1990) for *interstate* migration and about the same percentage for *interregional* migration. Since our data on foreign-born migration come largely from the decadal PUMS files, themselves a product of a very small sample of responses to the Census Bureau's long-form questionnaire, it is clear that small sample problems arise in any effort to obtain adequate data on interregional foreign-born migration. Thus a general "cleaning" of the data becomes necessary.

We begin the "cleaning" process by plotting all of the interregional conditional survivorships (Rogers, 1995) calculated using the PUMS data for 1965–1970, 1975–1980, and 1985–1990. Since the 1960 census microdata files included geographical codes only for the current place of residence and ignored the place of origin, migration stream data were not available from that source for the 1955–60 period and had to be obtained from published materials. With four time periods and four Census regions, a total of 48 age-specific migration schedules needed to be examined. Four such schedules of proportions surviving 5 years are illustrated in Figure 1A – all originating from the Northeast and destined for the South. To facilitate a comparison of age profiles, the areas under all curves have been scaled to unit area. Irregularities in the first two five-year age groups are partly a consequence of the very small numbers of migrants and of "at-risk" populations at those ages (Figure 1B).

Each age-specific conditional survivorship proportion illustrated in Figure 1A is the ratio of the number of surviving migrants resident in

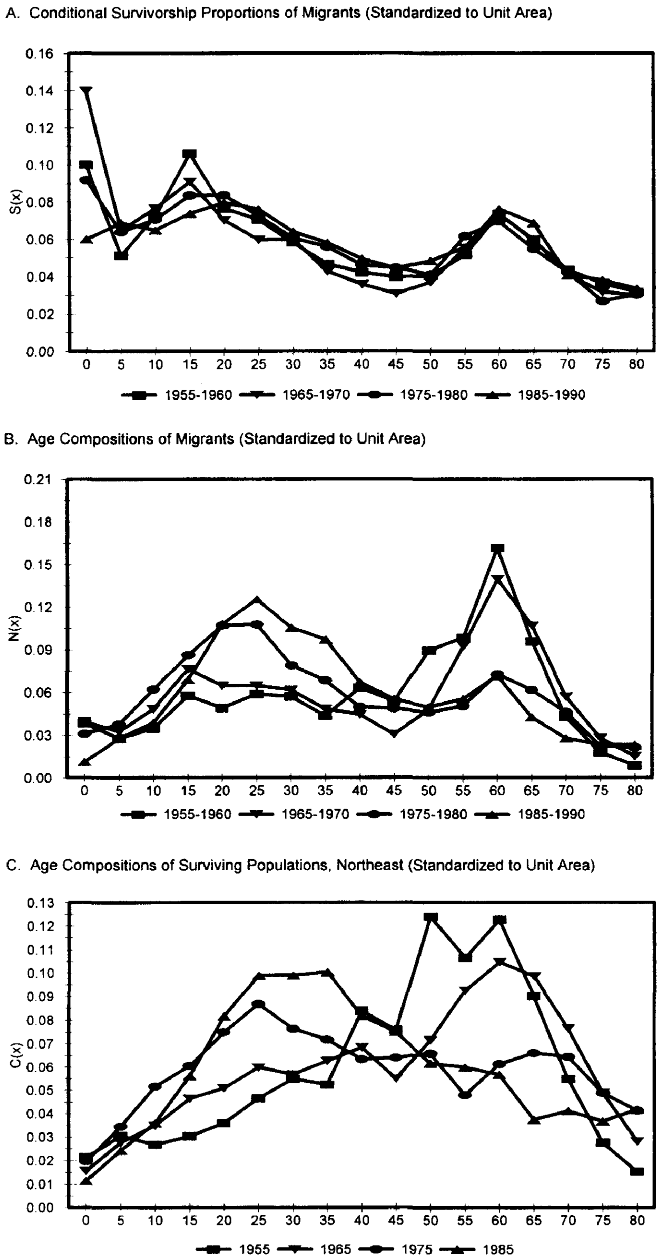

FIGURE 1 Observed U.S. foreign-born internal migration from Northeast to South: 1955–1960 to 1985–1990.

region j, say, at the end of the unit time interval of 5 years, who were residents of region i at the start of that same time interval $[K_{ij}(x)]$, divided by the "at-risk" population in region i at the start of the time interval $[K_{i\bullet}(x)]$, that is:

$$\bar{S}_{ij}(x) = \frac{K_{ij}(x)}{K_{i\bullet}(x)} \tag{1}$$

These survivorship fractions are said to be "conditional" because the census can only record as migrants those who survive to answer its questionnaire.

Both the numerator (migrants) and the denominator (at-risk population) exhibit particular age compositions, denoted by, say, $N_{ij}(x)$ and $C_{i\bullet}(x)$, respectively, and calculable as fractions of their respective totals for all ages:

$$N_{ij}(x) = \frac{K_{ij}(x)}{K_{ij}(\bullet)} \tag{2}$$

and

$$C_{i\bullet}(x) = \frac{K_{i\bullet}(x)}{K_{i\bullet}(\bullet)} \tag{3}$$

Substituting these expressions into Equation (1) gives us:

$$\begin{aligned} \bar{S}_{ij}(x) &= \frac{K_{ij}(\bullet)N_{ij}(x)}{K_{i\bullet}(\bullet)C_{i\bullet}(x)} \\ &= k_{ij}(\bullet)\frac{N_{ij}(x)}{C_{i\bullet}(\bullet)} \end{aligned} \tag{4}$$

an expression that defines each conditional survivorship as a function of three variables: the crude rate of survivorship from i to j (level of migration), the age composition of the migrants (age profile of migration), and the age composition of the surviving population at-risk of migrating (age profile of population). The second variable is illustrated in Figure 1B, whereas the third appears in Figure 1C. Their age-specific ratios, *scaled to unit area*, are set out in Figure 1A. The 1985–1990 values of $k_{ij}(\bullet)$ associated with the three curves in Figure 1 are set out in Table 1, along with the corresponding values for the other three

TABLE 1
Crude conditional survivorship proportions of internal migration in the United States, by nativity: 1955–1960 to 1985–1990

Region of origin	Migration period	Region of destination							
		Foreign-born				Native-born			
		Northeast	Midwest	South	West	Northeast	Midwest	South	West
Northeast	1955–1960	0.9715	0.0046	0.0152	0.0086	0.9550	0.0097	0.0235	0.0118
	1965–1970	0.9563	0.0071	0.0248	0.0119	0.9514	0.0112	0.0256	0.0118
	1975–1980	0.9326	0.0067	0.0426	0.0181	0.9349	0.0104	0.0386	0.0161
	1985–1990	0.9410	0.0049	0.0402	0.0139	0.9424	0.0079	0.0385	0.0112
Midwest	1955–1960	0.0076	0.9536	0.0182	0.0206	0.0069	0.9433	0.0244	0.0255
	1965–1970	0.0123	0.9302	0.0302	0.0273	0.0078	0.9469	0.0255	0.0198
	1975–1980	0.0104	0.9128	0.0387	0.0381	0.0062	0.9375	0.0336	0.0227
	1985–1990	0.0152	0.9071	0.0409	0.0368	0.0065	0.9441	0.0315	0.0179
South	1955–1960	0.0222	0.0224	0.9237	0.0318	0.0117	0.0204	0.9493	0.0186
	1965–1970	0.0312	0.0311	0.8870	0.0508	0.0117	0.0195	0.9527	0.0162
	1975–1980	0.0176	0.0164	0.9329	0.0331	0.0096	0.0154	0.9594	0.0156
	1985–1990	0.0197	0.0126	0.9361	0.0316	0.0107	0.0165	0.9570	0.0158
West	1955–1960	0.0068	0.0089	0.0137	0.9706	0.0072	0.0178	0.0241	0.9508
	1965–1970	0.0183	0.0128	0.0242	0.9447	0.0091	0.0211	0.0294	0.9403
	1975–1980	0.0063	0.0076	0.0185	0.9677	0.0074	0.0181	0.0292	0.9453
	1985–1990	0.0067	0.0058	0.0160	0.9715	0.0087	0.0167	0.0271	0.9475

Census Regions, the three earlier time periods, and for purposes of comparison, *all parallel values for the native-born* population.

The surviving migrant residents that appear in the numerator of the ratio in Equation (1) come from migration flow matrices, one for each age group, x to $x+4$, say, with entries denoted by $K_{ij}(x)$. These matrices of survivors from $t-5$ to the census year t may be constructed directly from the responses to the census question regarding place of residence 5 years ago; they represent the count at time t of persons by age (x), region of current residence (j), and region of residence 5 years ago (i). Each such matrix has row-sums, $K_{i\bullet}(x)$, which appear in the denominator of the ratio in Equation (1), that define regional numbers of persons at $t-5$ who survive to t, and column-sums, $K_{\bullet j}(x)$, that define the *surviving* regional populations at time t, a census year. These column-sums $K_{\bullet j}(x)$, $x = 5, 10, \ldots, 85+$, for a particular region define that region's age composition at census year, $C_{\bullet j}(x)$, whereas the $K_{i\bullet}(x)$, $x = 0, 5, \ldots, 80$ define the corresponding age composition, $C_{i\bullet}(x)$, 5 years prior to the census year.

The process of "cleaning" the foreign-born migration data was carried out as a two-step procedure applied first to the $C_{\bullet j}(x) = \sum C_{ij}(x)$ and then to its constituent elements the $C_{ij}(x)$, each case involving smoothing of the age composition data with cubic splines. The first step was to smooth each regional age composition $C_{\bullet j}(x)$, $x = 5, \ldots, 85+$, with a cubic-spline graduation, using the regional age composition of the corresponding census count for that census year as a guide. The second step was to allocate the newly-smoothed regional $C_{\bullet j}(x)$ back to their constituent elements, $C_{ij}(x)$, and then to graduate the entire set of these elements for each region with yet another cubic-spline. Before every graduation with a cubic-spline, we examined outliers and, when necessary, intervened by modifying or deleting those "errant" data points that exhibited unusual or unlikely patterns when viewed against the age compositions for the same origin-destination-specific migration stream in earlier or later census years.

At the end of this "cleaning" process we arrived at a final "repaired" set of values for $\bar{S}_{ij}(x)$, $N_{ij}(x)$, and $C_{i\bullet}(x)$. Four of these are illustrated in Figure 2, which is the "cleaned" counterpart to the earlier Figure 1.

2.2. Graduating the Internal Migration Data with Model Schedules

The most prominent regularity in age-specific schedules of migration is the high concentration of migration among young adults; rates of

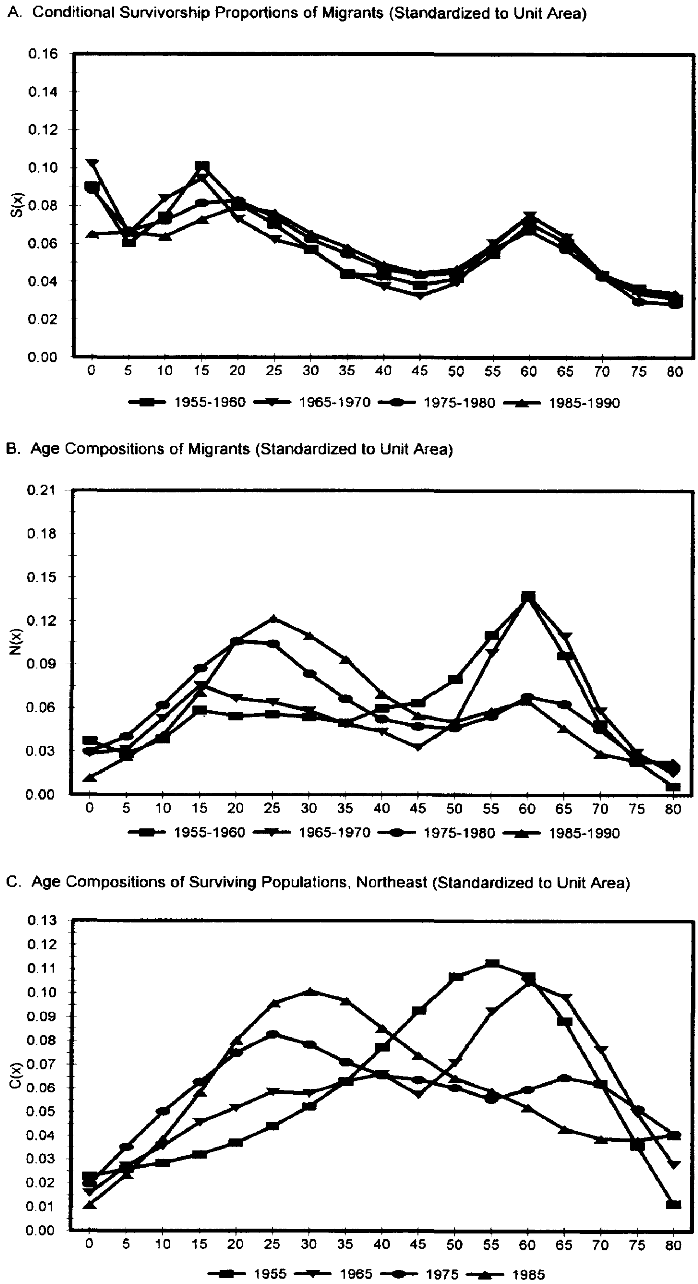

FIGURE 2 "Cleaned" U.S. foreign-born internal migration from Northeast to South: 1955–1960 to 1985–1990.

migration also are high among children, starting with a peak during the first year of life, dropping to a low point at about age 16, turning sharply upward to a peak near ages 20–22, and declining regularly thereafter, except for a possible slight hump or upward slope at the onset of the principal ages of retirement. (As, for example, in the case of the Northeast to South migration flows.)

Although the development of model mortality and fertility schedules has received a great deal of attention from demographers, the construction of model migration schedules has not, even though the techniques that have been successfully applied to the former can be readily extended to deal with the latter.

Past studies of age patterns in migration schedules (Rogers and Castro, 1981) have shown that such patterns exhibit an age profile that can be described by the mathematical expression appearing as Equation (5):

$$\begin{aligned} M(x) = {} & a_1 \exp(-\alpha_1 x) \\ & + a_2 \exp\{-\alpha_2(x-\mu_2) - \exp[-\lambda_2(x-\mu_2)]\} \\ & + a_3 \exp\{-\alpha_3(x-\mu_3) - \exp[-\lambda_3(x-\mu_3)]\} \\ & + a_4 \exp(\alpha_4) \\ & + a_0 \end{aligned} \tag{5}$$

The five terms in the equation represent childhood migration, labor force age migration, retirement migration, post-retirement migration, and a constant level of migration across all ages. The interpretation of the parameters in this model is straightforward and follows from a consideration of the parameters of its component parts: the single and double exponential functions.

The first term of the model, associated with the migration of children and adolescents, is a simple negative exponential that starts from an initial maximum level of a_1, during the first year of life, and decreases at a rate of α_1 thereafter. The second term, associated with mid-life mobility, is a double exponential with four parameters that (as in the case of fertility) describe the curve's level, shape, and position on the age axis. The height of the curve is reflected by a_2, the slope parameters associated with its rates of ascent and descent are λ_2 and α_2, respectively, and μ_2 is related to its mean age. The third term, the retirement component, may take on the value of zero or follow the profile of yet another four-parameter, double exponential. The fourth term, depicting post-retirement migration, may take on the value of zero or assume the form of an upwardly sloping two-parameter positive exponential. Finally, the fifth term, a_0, defines a constant level of migration across all ages. The migration rate $m(x)$, therefore, depends on values take on by anywhere from 7 to 13 parameters, all of which are strictly positive. We use only the 7, 9, and 11 parameter versions in this paper.

A number of studies have adopted this model to describe national and regional age patterns of migration. Bates and Bracken (1982), for example, fitted the model to migration flows out of 108 local authorities in England and Wales as part of an effort to streamline subnational population projection methods there. Drewe and Rosenboom (1983) applied the model to data on intercommunal migration in the Netherlands, and Potrykowska (1988) applied it in an extensive study of age patterns of migration in Poland. Despite differences in estimation methods, sizes of areal units, and widths of migration-defining time intervals, the profile parameters that were obtained are remarkably similar, generally falling inside the ranges identified by Rogers and Castro (1981), in a study of more than 500 observed interregional migration schedules.

The multiexponential model migration schedule defined in Equation (5) can be fitted to observed data, using a Windows-based program produced by Jandel Scientific called *TableCurve 2D*. The program can be customized to fit a particular model specification under its option entitled *User Defined Functions*, which allows up to 10 parameters to be estimated by means of a nonlinear regression routine.

An example of a model schedule fit is presented in Figure 3, along with the associated 11 parameter values. The schedule is for the 1975–80 interval and refers to age-specific migration of foreign-borns leaving the Northeast to locate in the South. (Since the *TableCurve 2D* program can estimate at most 10 parameters, the 11th parameter, a_0, was fixed at 0.0025 for all 11 parameter schedules that were estimated.)

The Northeast-to-South model schedule of Figure 3 appears once again in Figure 4, along with the corresponding schedules for each five-year period from 1950 to 1990. Four of the eight model schedules were fitted to the "cleaned" survivorship proportions for the 1955–1960, 1965–1970, 1975–1980, and 1985–1990 periods. Initial estimates for the others were obtained by linear interpolation, and backward linear extrapolation in the case of the 1950–1955 schedule.

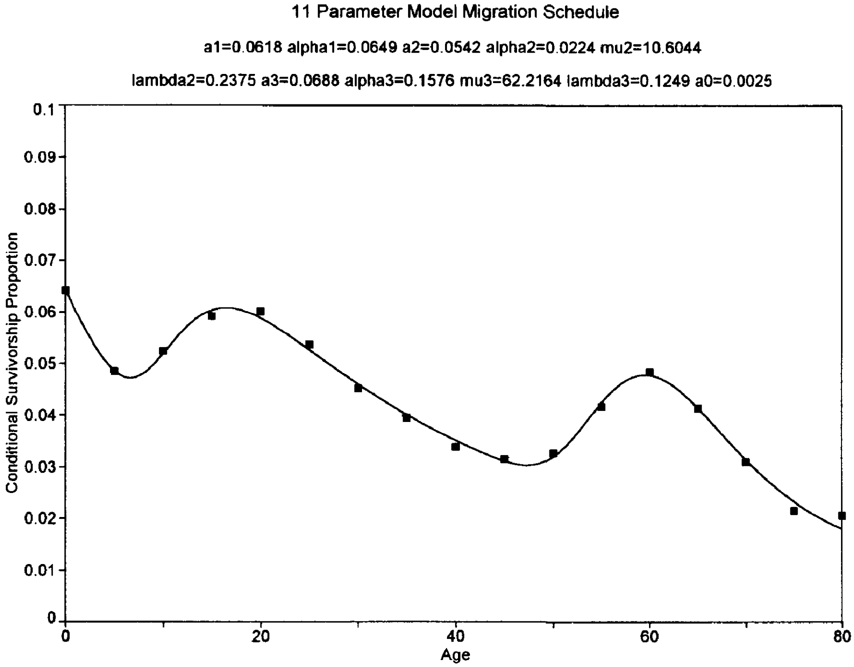

FIGURE 3 U.S. foreign-born internal migration from Northeast to South: 1975–1980.

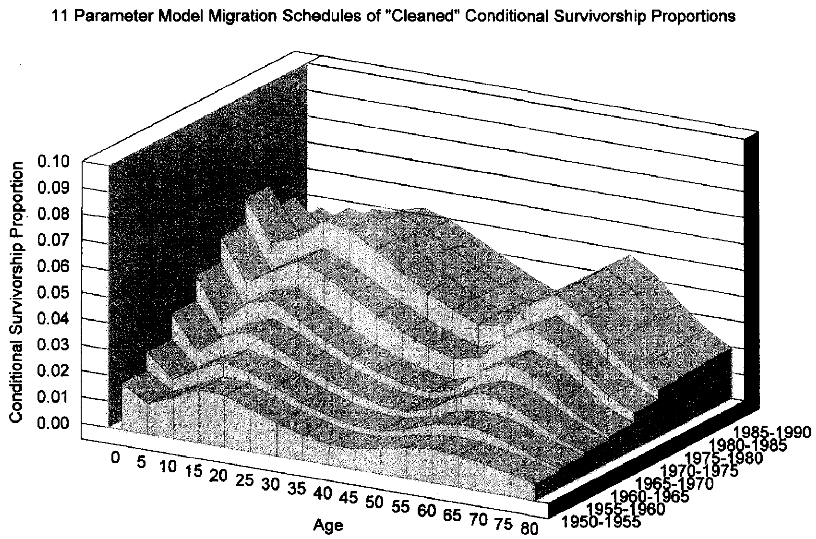

FIGURE 4 U.S. foreign-born internal migration from Northeast to South: 1950–1990.

3. ESTIMATING EMIGRATION AS A FUNCTION OF IMMIGRATION

The public debate over immigration policy in the United States has largely ignored the impacts of emigration. Yet, historically, emigration levels have been significant. For example, in 1960 the U.S. Bureau of the Census (1960) estimated that about 30 percent of the roughly 16 million immigrants who entered the U.S. between 1908 and 1957 returned to their country of origin. Warren and Peck (1980) calculated that 1.1 million foreign-born emigrants left the U.S. between 1960 and 1970. Warren and Kraly (1985) estimated that the ratio of immigrants to emigrants has been 3-to-1 since the start of the century. More recently, Reyes (1997) examined data on adult immigrants to the U.S., collected in 31 Mexican communities in six states of Western Mexico between 1982 and 1993, and found that 48 percent of those immigrants returned to their place of origin after only two years, with less than a third of the sample staying longer than 10 years.

If most immigrants stay only a short time in the United States, then the usual emigration rates used by cohort-component projection models obviously significantly under-represent the true level of emigration. Nevertheless, estimates of emigration are important for making population estimates and projections, and also for assessing the completeness of decennial censuses (Woodrow-Lafield, 1996). Typically, such efforts employ 1-year age-specific emigration rates that have been estimated *indirectly*. Direct measurement of emigration was discontinued by the U.S. Immigration and Naturalization Service (INS) in 1957.

Indirect measurements of emigration typically use some form of a residual calculation in which all other components of the standard demographic accounting equation are estimated first and then the difference between expected and observed population totals is decomposed into immigration and emigration components. However, as Woodrow-Lafield (1996) points out, this method based on intercensal comparisons is increasingly inappropriate today, because the residual also includes the unknown contribution of net undocumented migration.

About a decade ago Warren and Passel (1987) produced a careful assessment of emigration and net undocumented migration as of 1980, using the time series of INS Alien Address Registration data for 1965–1980. Their findings suggested that the official estimates of 36,000 emigrants a year was too low, and this induced the U.S. Bureau of the

Census to increase their annual allowance to 160,000 emigrants (and 200,000 net undocumented migrants) in constructing postcensal level population estimates and projections.

More recently, Ahmed and Robinson (1994) developed more refined estimates of annual *foreign-born* emigration, based on the 1980 and 1990 censuses, arguing that the total level of such emigration should be increased to 195,000 – nearly 50 percent higher than the currently used estimate of 133,000 per year. The Ahmed and Robinson (1994) estimates of emigration *rates* are the most authoritative data that are available. Yet they have not been evaluated in a rigorous projection of the demographic consequences that they imply.

3.1. Developing Counter-Flow Estimates of Emigration

There have been several published attempts to quantify the amount of emigration from the United States. The most common approach uses some form of the residual technique mentioned above; where, emigration equals the amount "left-over" after combining some or all of the demographic components in the standard demographic accounting equation. Our efforts to apply this method were totally unsuccessful, producing unrealistic estimates of emigration (However, we ended up using the residually estimated *net* immigration *totals* – see Section 3.1.3) (Rogers and Raymer, 1998). Two alternative approaches worth mentioning include cohort (Ahmed and Robinson, 1994; Jasso and Rosenzweig, 1982) and survey (Woodrow, 1988; Woodrow-Lafield, 1994) methods of indirect estimation. The *cohort* method tracks an immigrant population from one census to the next by identifying the survivors. The difference between the original cohort population and the survivors reflects the impacts of mortality and emigration. Mortality is then estimated, and the remainder gives emigration. The *survey* technique samples populations outside the United States for the purpose of identifying persons who have resided in the United States and who are now considered emigrants. Both techniques are useful as indirect estimation procedures, but are costly and often inadequate, especially, when examining longer time intervals.

Unable to discover a usable method for indirectly estimating emigration from 1950 to 1990 by age and region, we set out to formulate our own procedure. To estimate emigration for the U.S. foreign-born regional population by age from 1950 to 1990, we combined three approaches: (1) multiregional demographic methods, (2) model migration schedules, and (3) emigration linkages with immigration. First, a multiregional demographic model (Rogers, 1995) allowed us to project regional populations by age (subjected to mortality rates, internal migration, and international migration) in five year intervals. Second, age compositions of emigrants were specified to agree with the *standard* migration curve (Rogers and Castro, 1981). For smoothing our estimates of migration rates, we adopted a seven parameter model schedule. Finally, the levels of immigration and emigration should be related to each other. A positive association between rates of inmigration and outmigration has been a "law" of mobility since Ravenstein (1885, 1889), who first posited that each main current of migration produces a compensating counter-current (Mueser and White, 1989). For this study, we therefore assumed that areas of high immigration were also areas of high emigration.

In developing indirect estimates of regional emigration, we first estimated *national* rates in five-year intervals by age from 1950 to 1990. Then the national emigration rates were disaggregated into *regional* rates. Sections 3.1.1 and 3.1.2 outline our procedure and the results of our estimations of national and regional emigration rates, respectively.

3.1.1. National Rates

We began our indirect estimation process by borrowing the only two published inferred age profiles of U.S. emigrants that we could find (Figure 5A). The first, for the decade of 1960–1970, appears in an article by Keely and Kraly (1978); the second, for the decade of 1980–1990, was developed by the U.S. Census Bureau's Ahmed and Robinson (1994). Since the former ended its age profile with the open-ended age group of 65 and over, we disaggregated that percentage total, using the five-year proportions of the latter age profile. A seven parameter model migration schedule was then fitted to both age profiles and five-year age group percentage values were obtained from it (Figure 5B). (The data point for the 5–9 age group in the 1980–1990 profile was deemed to be an outlier and was removed prior to the calculation of model schedule parameters.) The 1960–1970 age composition was adopted for the 1965–1970 time interval and the 1980–1990 for the 1985–1990 time interval; linear interpolation and extrapolation then produced the needed eight five-year emigrant age compositions for the 1950–1990 period.

To develop emigration *rates* from our emigrant age composition (and the populations at risk) we needed estimates of aggregate emigration *levels*. To obtain these we assumed that levels of total emigration were tied to levels of observed immigration and began with a somewhat arbitrarily assumed base level of 200,000 foreign-born emigrants for the 1950–1955 period. This level was selected because it matched previously published estimates (e.g., Warren and Kraly, 1985), and

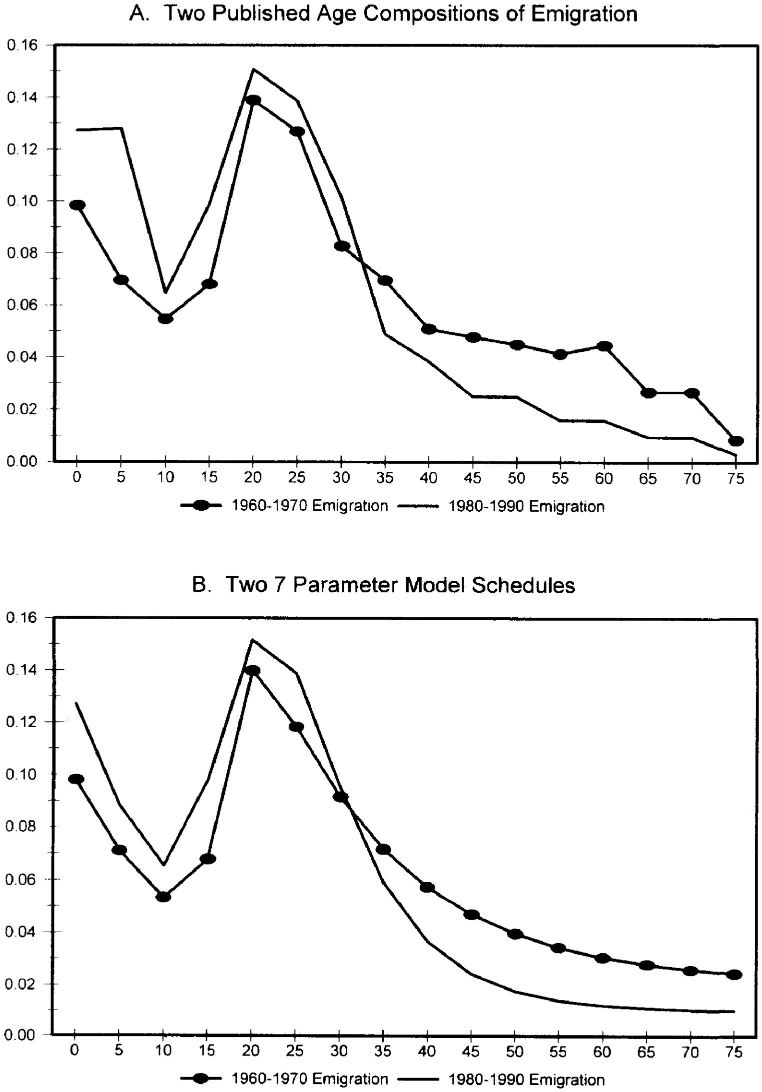

FIGURE 5 Age compositions of U.S. foreign-born emigration: 1960–1970 and 1980–1990.

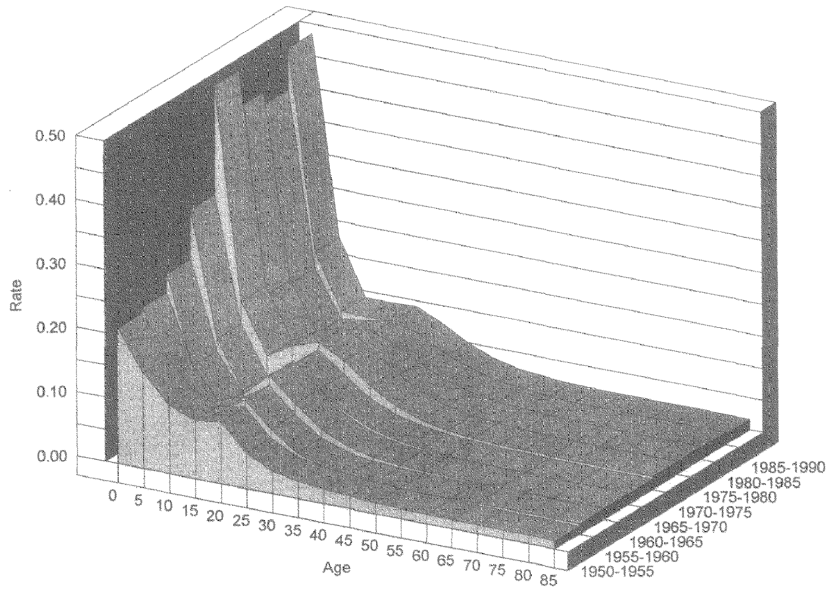

FIGURE 6 U.S. foreign-born 5-year emigration rates (smoothed): 1950–1990.

because it, together with the rest of the estimated demographic regime, produced projected foreign-born population stocks that closely resembled the corresponding observed stocks over the 40-year regional demographic history of the U.S. population. Incrementing that total every five years with the rate of increase of observed *immigration*, and dividing the resulting age patterns of emigration *numbers* by the populations at risk, we obtained the desired age-specific emigration rates and graduated them with a seven-parameter model schedule. These appear in Figure 6.

3.1.2. Regional Rates

Regional disaggregations of the national emigration rates were obtained by means of a simple model that once again linked emigration to immigration. Given a region's share of the observed national immigration rate, we simply assumed that it exhibited the same share of the national emigration rate. The resulting regional emigration rate schedules were then graduated with the seven-parameter model migration schedule. These smoothed schedules appear in Figure 7. The regional levels of emigration that they imply are presented in Figure 8.

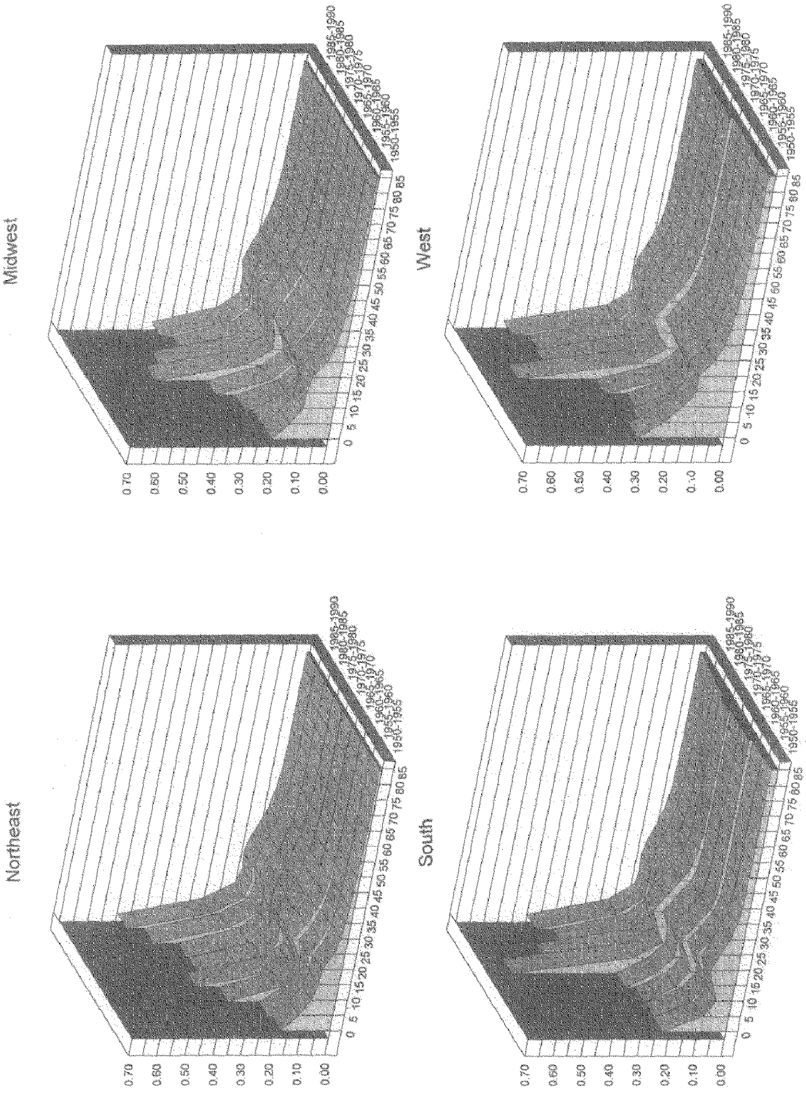

FIGURE 7 U.S. foreign-born 5-year emigration rates by region (smoothed): 1950–1990.

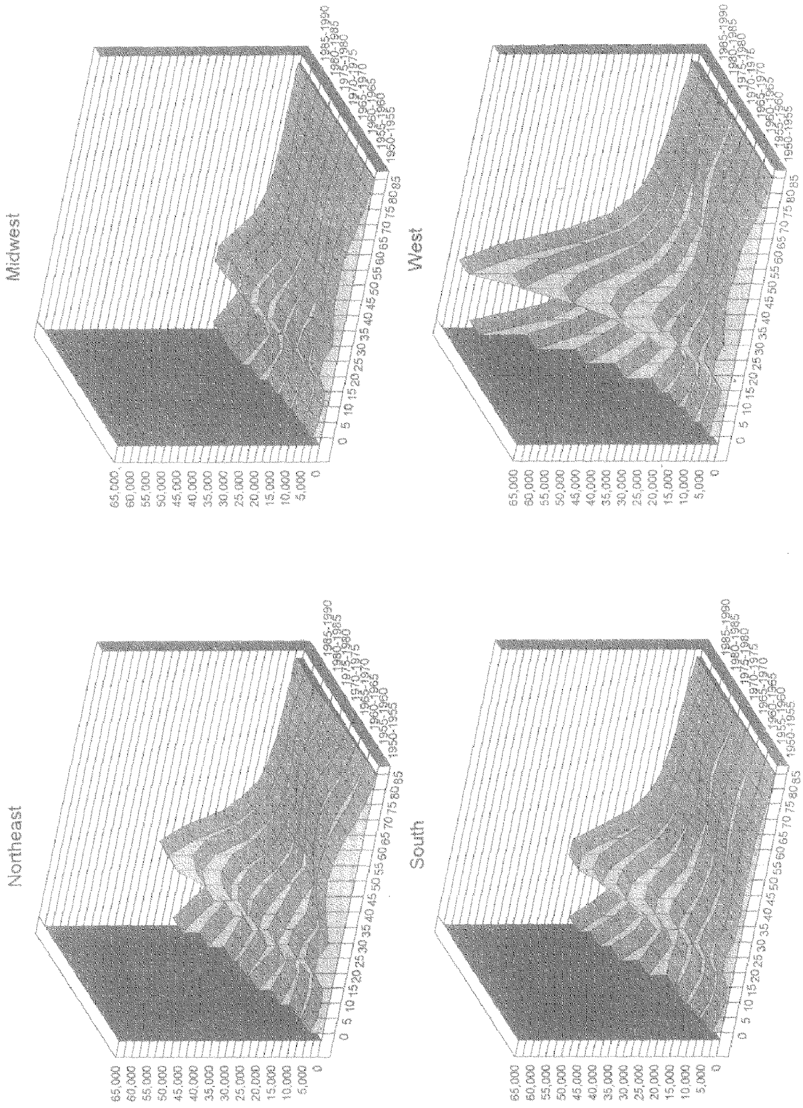

FIGURE 8 U.S. foreign-born 5-year emigration levels by region: 1950–1990.

For foreign-born emigration from the United States, we find that the greatest amount of increase occurred in the West and the least amount in the Midwest (Figure 8). The regional patterns of emigration, by definition in our model, are similar to observed patterns of immigration (see Figure 9 below). One difference, however, is a double-hump in the age structure of emigrants. This double-hump only appears in earlier emigration periods, that is, before 1970. We attribute this characteristic to the age structure of the foreign-born population (Figure 1), which during that time was significantly older.

3.1.3. Immigration

The census-reported levels of age-specific foreign-born in-flows from abroad in 1955–1960, 1965–1970, 1975–1980, and 1985–1990 were our starting point for developing regional immigration totals. These *numbers* of immigrants by age were then graduated with a model migration schedule, and are set out in Figure 9. Data for the missing four intervals were obtained by linear interpolation. (In estimating our national and regional *emigration* rates, we assumed that these immigration data adequately approximated the numbers observed during those particular periods.)

Once regional emigration rates were established, they were included in the multiregional cohort-component model along with all other demographic variables, *except immigration*, and projected forward in five-year increments. The aggregate differences between the projected and observed regional populations defined the regional immigration component. The regional age-specific (model schedule) levels of immigration were then adjusted proportionately, to accord with net immigration totals obtained with the residual method carried out earlier over the eight time intervals. This final adjustment completed the regional evolution of the estimated foreign-born external migration components from 1950 to 1990.

We adjusted our immigration numbers after first estimating emigration because previous experiments with the standard residual method of estimating net immigration yielded satisfactory results (Rogers and Raymer, 1998). But, when the census-reported gross immigration totals were inserted into the multiregional demographic model, the standard demographic accounting equation produced unrealistic emigration residuals. At this point, we decided to first estimate emigration rates and then to adjust the smoothed age-compositions of observed immigration numbers, such that when combined our immigration and

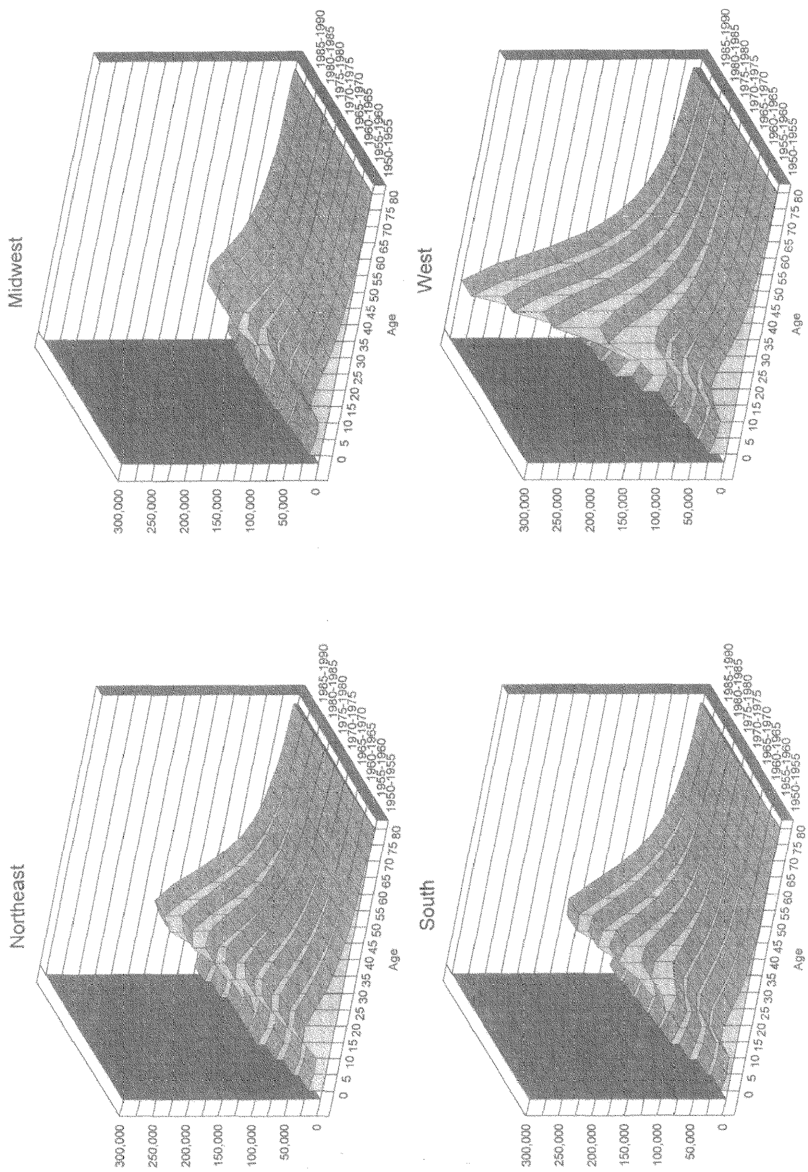

FIGURE 9 U.S. foreign-born 5-year immigration by region (smoothed): 1950–1990.

emigration estimates were consistent with the residually estimated net immigration totals. The results of our procedure changed the census-reported gross immigration levels for the 1955–1960, 1965–1970, 1975–1980, and 1985–1990 periods. (For the record, these changes of immigration totals at the national level were 13.0, –5.4, 29.6, and 16.8 percent, respectively. At the regional level, the differences between published immigration estimates and our own varied somewhat more, attaining a maximum numerical difference of 536,000 for the 1985–1990 immigration flows to the West, and a maximum *percentage* difference of 32.2 percent for the 1975–1980 immigration flows to the South.)

3.2. Assessing the Quality of the Emigration Rates

How reasonably do our indirect estimates measure the components of international migration for the foreign-born population? And, what do these rates imply? Because emigration is an "unmeasurable" component, our estimates cannot be entirely verified, but they can be analyzed effectively in several ways. For our emigration estimates, we (1) compared our results against published estimates, (2) looked for consistency with national and regional trends, (3) examined the impact of the estimates on immigration, and (4) compared our projected populations with observed regional trends in the foreign-born population. In assessing the quality of the emigration rates, we first analyzed the emigration rates, and then examined the subsequent emigration levels. In both cases, we compared emigration patterns to immigration patterns.

The emigration rates set out in Figures 6 and 7 can be summarized by gross migraproduction rates (GMRs). GMRs are similar to gross reproduction rates used in fertility analysis in that they both represent the area under the curve of age-specific rates (Rogers, 1995). The GMRs were calculated for both immigration and emigration in Table 2. Because emigration was linked with immigration in the estimation process, the regional and national *patterns* of the GMRs are similar. The principal difference between the GMRs of immigrants and emigrants is the much higher GMR of immigrants. Over the past forty years, the GMRs for emigrants have ranged from 0.9 (1955–1960) to 1.5 (1970–1975), whereas those of immigrants have varied from 4.6 (1985–1990) to 6.3 (1970–1975). Curiously, the ratios of the GMRs of immigrants to emigrants, for both the nation and the four regions, have decreased since 1950, dropping from appoximately 6.0 to 3.6. This is most likely a result of the compositional change in the age

TABLE 2
Gross Migraproduction Rates for U.S. foreign-born immigration and emigration: 1950–1990

	Period	Northeast	Midwest	South	West	Total
Immigration	1950–1955	4.38	5.54	5.08	8.46	5.51
	1955–1960	4.25	4.45	5.40	6.12	4.90
	1960–1965	4.82	4.04	6.04	5.23	4.86
	1965–1970	4.91	4.24	6.39	4.81	4.93
	1970–1975	4.75	5.69	8.57	7.56	6.34
	1975–1980	4.44	4.99	6.08	6.11	5.39
	1980–1985	4.63	3.77	4.81	5.31	4.73
	1985–1990	4.70	3.73	4.51	4.84	4.55
Emigration	1950–1955	0.73	0.91	0.96	1.48	0.93
	1955–1960	0.77	0.79	1.01	1.19	0.90
	1960–1965	0.97	0.81	1.28	1.12	1.00
	1965–1970	1.09	0.91	1.40	1.12	1.10
	1970–1975	1.08	1.29	2.08	1.81	1.47
	1975–1980	1.06	1.18	1.51	1.53	1.30
	1980–1985	1.20	0.95	1.25	1.41	1.22
	1985–1990	1.30	1.01	1.25	1.37	1.27
Ratio	1950–1955	6.01	6.09	5.30	5.70	5.92
	1955–1960	5.55	5.63	5.33	5.15	5.43
	1960–1965	4.95	4.99	4.70	4.68	4.86
	1965–1970	4.49	4.65	4.58	4.31	4.48
	1970–1975	4.40	4.42	4.11	4.17	4.31
	1975–1980	4.20	4.22	4.03	4.00	4.13
	1980–1985	3.87	3.96	3.85	3.77	3.87
	1985–1990	3.61	3.70	3.60	3.53	3.60

structure of the foreign-born population – one that has shifted from an older population to a younger one. Except for the Northeast, similar GMR patterns were found for regional populations. Unlike the other three regions (and the nation as a whole), the Northeast did not experience a peak GMR during the 1970–1975 migration period.

The aggregate U.S. foreign-born external migration components for ten-year periods are shown in Table 3. Comparing the ten-year migration periods of 1950–1960 and 1980–1990, our estimates show that national immigration and emigration levels have increased from 2.3 and 0.4 million to 9.2 and 1.4 million, respectively. Regional emigration levels for the 1980–1990 period varied from region to region, with estimates of 364, 150, 333, and 591 (in thousands) persons for the Northeast, Midwest, South, and West, respectively. These estimates

TABLE 3
External migration components of the U.S. foreign-born population: 1950–1990

	Migration period	Northeast	Midwest	South	West	Total
Immigration	1950–1960	903,330	471,969	294,061	658,469	2,327,829
	1960–1970	1,141,596	413,052	518,636	863,842	2,937,126
	1970–1980	1,957,448	978,475	1,819,779	2,891,260	7,646,962
	1980–1990	2,188,536	707,521	2,120,272	4,158,315	9,174,644
Emigration	1950–1960	157,004	87,810	58,716	132,270	435,800
	1960–1970	220,518	90,357	112,539	159,824	583,238
	1970–1980	273,116	132,741	230,494	362,947	999,298
	1980–1990	364,490	150,226	333,345	591,427	1,439,488
Net Immigration	1950–1960	746,326	384,159	235,345	526,199	1,892,029
	1960–1970	921,078	322,695	406,097	704,018	2,353,888
	1970–1980	1,684,332	845,734	1,589,285	2,528,313	6,647,664
	1980–1990	1,824,046	557,295	1,786,927	3,566,888	7,735,156
Ratio of Immigration to Emigration	1950–1960	5.75	5.37	5.01	4.98	5.34
	1960–1970	5.18	4.57	4.61	5.40	5.04
	1970–1980	7.17	7.37	7.90	7.97	7.65
	1980–1990	6.00	4.71	6.36	7.03	6.37

differ significantly from those estimated for the 1950–1960 period, when 157, 88, 59, and 132 (in thousands) persons emigrated from the Northeast, Midwest, South, and West, respectively.

The ratios of immigration to emigration *levels* are presented in Table 3. Here, the highest ratios were observed between 1970 and 1980 for all regions, whereas the lowest ratios occurred during the 1960–1970 period. The range of the ratios spanned from 4.57 (1960–1970 Midwest) to 7.97 (1970–1980 West).

As a final assessment of our emigration rates, we consider their patterns over time. Figure 10 depicts national and regional emigration levels, from 1950 to 1990 in five-year migration intervals. For national emigration, a steady increase from around 200,000 in 1950–1955 to nearly 800,000 in 1985–1990 is observed. Regional emigration levels also increased, but at varying rates. The 1950–1955 period shows the Northeast region with the highest amount of emigration and the South with the lowest. By the 1985–1990 period, the West clearly dominates the emigration of foreign-born, and the South reaches the same level as does the Northeast. The Midwest region, however, shows little change in emigration levels over the entire forty-year period.

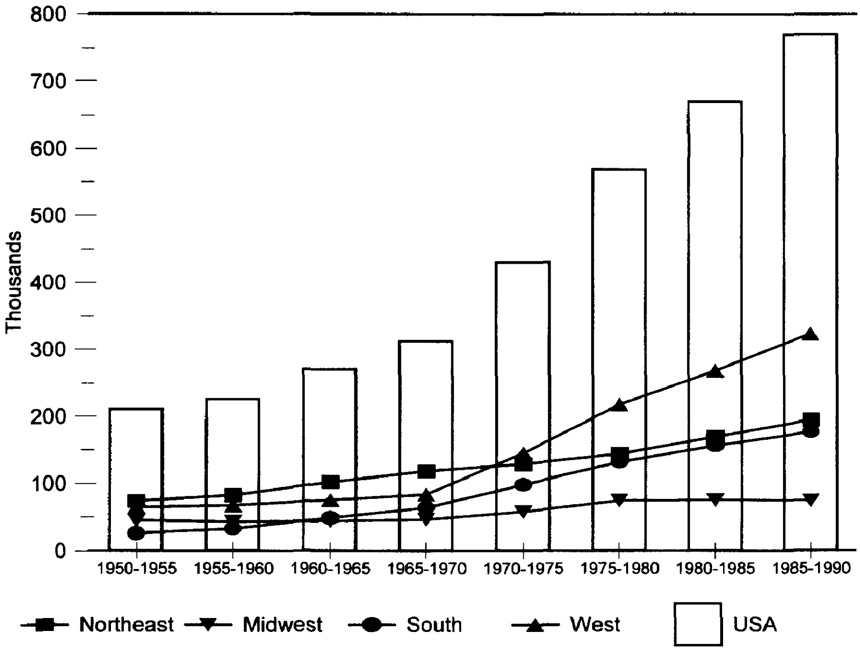

FIGURE 10 U.S. foreign-born emigration levels, by region: 1950–1990.

Regional percentages of total emigration reveal that over the forty-year period from 1950 to 1990, the regional emigration apportionments become reversed, shifting from the dominant Northeast and Midwest in 1950–1955 to the South and West by 1985–1990. During the 1950–1955 period, the Northeast and Midwest sent out nearly 60 percent of all emigrants. By the 1985–1990 migration period, however, just over 60 percent of the total emigrants departed from the South and West. It is important to note that these patterns are consistent with corresponding observed foreign-born population changes over the same forty-year period.

Finally, how do our national estimates of emigration compare with previous estimates? Our national estimates of foreign-born emigrants (Table 3), rounded to the nearest thousand, show 436,000 for 1950–1960, 583,000 for 1960–1970, 999,000 for 1960–1970, and 1,440,000 for 1980–1990. Previously published estimates of foreign-born emigration are 425,000 for 1950–1960 (Warren and Kraly, 1985), 900,000 for 1960–1970 (Warren and Kraly, 1985), 1,176,000 for 1970–1980 (Warren and Kraly, 1985), and 1,950,000 for 1980–1990 (Ahmed and Robinson, 1994). In comparison, our emigration estimates for 1950 to 1990 are approximately 1 million less than the combined totals of the published estimates (3.46 million vs. 4.45 million, respectively).

After assessing the quality of our estimates of foreign-born emigration, we conclude that our simple model produced usable and accurate results for the time periods and regions specified. Our estimates follow the general foreign-born population patterns over the same period, and they match up with conservative immigration estimates to produce what we believe are reasonable net immigration totals.

4. ANALYZING THE ESTIMATED MIGRATION DATA WITH LIFE TABLES AND PROJECTIONS

No demographer would accept a schedule of indirectly estimated mortality rates without first calculating the life expectancies that they imply; nor should a schedule of indirectly estimated migration rates be accepted without some analogous verification procedure. We suggest one below. The procedure involves the calculation of multiregional life tables. Although we also report the results of multiregional projections of the populations, these are of limited use in the verification process because they are guaranteed to reproduce perfectly the observed regional populations at every 5 years from 1955 to 1990. This is because our regional immigration levels were derived as residuals and were rescaled to ensure perfect fits. Nevertheless, the decomposition of the average annual growth rates into the separate contributions of mortality, immigration, emigration, inmigration, and outmigration provides us with an overview of the historical evolution of the fundamental components of regional population change. And if these appear to take on reasonable values, our confidence in our estimates should increase.

4.1. Multiregional Life Tables

Changes in the age profiles and levels of the directional model migration schedules that were fitted for this study are difficult to summarize. A convenient mechanism for such summarization is offered by life tables. Just as a normal *uniregional* life table summarizes the mortality regime of a single population, so too the *multiregional* life table summarizes the mortality and migration regimes of a system of multiple populations that interact with each other by exchanging members (Rogers, 1995). To calculate such life tables we assembled the age-specific mortality data that are associated with the migration data developed in this study, drawing on data published by the National Center for Health Statistics. For each 5-year interval from 1950–1955 to 1985–1990, we computed mid-interval age-specific death rates by interpolating between the published death rates of the interval's starting and ending years. Of the many life table measures produced by our calculations, only two are presented in Table 4: (1) gross migraproduction rates with their percentage allocations across the regions of destination, and (2) the corresponding mobility expectancies. These two measures were computed both for the foreign-born and for the *native-born* populations.

Studies of changing mortality levels tend to focus on life expectancies, those of changing fertility levels on total fertility rates, or gross reproduction rates. Because migrations can be viewed from either perspective: a mortality-like "life expectancy lived in a particular region," or a fertility-like "area under the age-specific schedule of rates," we present in Table 4 two sets of measures: the area under the schedule outmigration of rates – the gross migraproduction rate emanating from region i, GMR_i, and the percentage of lifetime spent residing in region j by an individual born in region i, ${}_i\theta_j$.

An examination of the gross migraproduction rates reveals that, except for the West in 3 of the 4 periods and the Northeast in 1955–1960, the propensities of foreign-borns to leave their current region of residence were higher than were the corresponding propensities for the native-born population. In addition, variations in the period regional outmigration levels for all time periods were wider for foreign-borns than for native-borns. The values of the GMR for the foreign-born population ranged from a low of 0.42 in 1985–1990 to a high of 2.01 in 1965–1970, whereas the corresponding values for the native-born population ranged from 0.58 in 1975–1980 to 1.00 also in 1975–1980. Also, except for the first interval, native-borns were least prone to leave the South, while foreign-borns were least prone to leave the Northeast in the first two intervals and the West thereafter. Except for the native-borns leaving the South, foreign-borns and native-borns tended overwhelmingly to select destinations in the South or West in all four time periods.

Focusing on the dimension of space in the analysis of the allocation of the gross migraproduction rates, one can see that the South was the dominant migration magnet for native-born and foreign-born populations living in the Northeast. Over a half of the total GMR was allocated to this destination. The attractiveness of this particular region increased over time, while the percentage allocations to the other two regions necessarily decreased.

Because migration, like fertility, is a potentially repeatable occurrence, its level can be measured by a count of such occurrences, as in the case of the GMR. But because migration also leads to changes in residential location, its level also can be measured in terms of expected durations of residence in different regions, as indicated by the fraction of the expected lifetime of a person born in region i that is expected to be lived in region j:

$$ {}_i\theta_j = \frac{{}_ie_j(0)}{{}_ie_{\bullet}(0)} \tag{6} $$

We call such fractions *retention expectancies* if $j = i$ and *mobility expectancies* otherwise. Note that the full set of mobility expectancies reflects not only the level but also the spatial structure of a particular multiregional migration regime.

In the normal uniregional life table, the standard measure of a longevity is the expectancy of life at age 0, $e(0)$ say. With the introduction of regions and a multiregional life table perspective, one must introduce locations of initial and subsequent residence. Thus, ${}_ie_j(0)$ exhibits two subscripts: one on the left to designate i as the region of initial residence at age 0 and another on the right, j, to identify a region of subsequent residence. But complications arise when the first subscript refers to the region of birth in a foreign country. In such instances the lifetable measures are calculated on the assumption that the newlyborn locate in a region on the day of birth and are immediately exposed to that region's mortality and migration regime. In Table 4, as before, emigration is not taken into account, and each regional mortality regime is that of the total regional population. (When emigration was taken into account, its impact was similar to that of an increase in the death rate: life expectancies at birth (to be lived in the United States) decreased by roughly 30 to 38 years in the 1950s and 1960s and by about 40 to 47 years in the 1970s and 1980s.)

Comparing the *retention* life expectancies by nativity set out in Table 4 one finds that native-born persons were more likely to spend a larger fraction of their lifetime in their original region of residence than were their foreign-born counterparts. This finding remained true for all time periods and all regions, with four exceptions: the West for all periods except 1965–1970 and the Northeast in 1955–1960. It seems that the

TABLE 4

Multiregional indicators of internal migration patterns for foreign-born and native-born total populations in the United States: 1955–1960 to 1985–1990

Migration period	Residence at age 0	Foreign-born				Native-born			
		NE	MW	S	W	NE	MW	S	W
A. Gross Migraproduction Rates (in Parentheses) and Their Percentage Allocations									
1955–1960	Northeast	(0.5657)	19.02	50.88	30.10	(0.7333)	19.16	57.45	23.39
	Midwest	17.61	(0.9601)	38.16	44.22	11.36	(0.8754)	44.10	44.54
	South	29.42	29.95	(1.3335)	40.63	23.50	40.97	(0.7328)	35.53
	West	21.48	29.87	48.64	(0.6417)	14.01	37.86	48.13	(0.7292)
1965–1970	Northeast	(0.8590)	18.32	54.54	27.14	(0.7582)	20.58	56.62	22.80
	Midwest	17.45	(1.5446)	43.50	39.06	13.27	(0.8198)	49.02	37.71
	South	27.36	28.73	(2.0070)	43.91	24.92	41.72	(0.6772)	33.36
	West	32.10	22.81	45.09	(1.0481)	14.60	36.92	48.48	(0.8553)
1975–1980	Northeast	(1.1920)	9.61	65.31	25.09	(1.0024)	14.23	62.51	23.27
	Midwest	11.28	(1.4974)	44.80	43.92	9.06	(0.9363)	54.97	35.97
	South	28.06	25.93	(1.0544)	46.01	24.42	38.38	(0.5830)	37.20
	West	19.39	24.49	56.13	(0.4725)	13.03	34.56	52.40	(0.7625)
1985–1990	Northeast	(1.0169)	7.77	70.48	21.75	(0.9127)	12.26	69.62	18.12
	Midwest	15.61	(1.6472)	45.24	39.15	10.50	(0.8562)	57.79	31.71
	South	31.12	20.55	(0.9942)	48.33	25.13	39.00	(0.6330)	35.87
	West	22.17	20.29	57.54	(0.4207)	15.71	32.60	51.69	(0.7686)

B. Mobility Expectancies									
1955–1960	Northeast	77.18	5.41	8.73	8.68	71.65	6.61	13.83	7.92
	Midwest	8.27	64.34	11.14	16.25	4.72	67.64	13.71	13.92
	South	12.36	12.27	55.92	19.45	6.80	11.05	70.99	11.16
	West	7.28	8.03	11.19	73.51	4.80	9.90	13.75	71.54
1965–1970	Northeast	68.35	7.32	11.75	12.57	70.35	7.63	14.49	7.52
	Midwest	13.01	49.86	15.65	21.48	5.16	69.63	14.45	10.77
	South	16.43	13.68	44.74	25.14	6.83	11.12	72.57	9.49
	West	14.77	9.10	13.58	62.55	5.63	11.50	16.14	66.73
1975–1980	Northeast	59.27	4.89	20.74	15.10	63.89	6.64	19.93	9.53
	Midwest	6.16	50.33	18.04	25.46	3.83	65.94	18.33	11.89
	South	7.82	7.47	64.67	20.04	5.15	8.61	76.78	9.46
	West	3.85	3.98	10.73	81.45	4.15	9.39	16.60	69.86
1985–1990	Northeast	65.37	3.27	19.49	11.87	66.92	5.75	20.12	7.22
	Midwest	9.31	46.20	20.40	24.09	4.28	68.05	17.56	10.12
	South	9.58	5.40	64.67	20.35	5.94	9.29	75.31	9.45
	West	4.05	2.90	9.09	83.96	5.03	9.13	15.92	69.92

foreign-born population has become more "attached" to the West than has been the native-born population.

The redistributional impacts of a particular set of period migration levels and directional propensities are reflected in a cohort's *mobility* expectancies. Apparently the patterns of relocation did not change much. In 1975–1980 and in 1985–1990, foreign-borns seemed to prefer to live in the West and not in the Midwest. But in 1955–1960 and 1965–1970 their most preferred region was the Northeast. This undoubtedly was a consequence of the changing composition of the foreign-born population. Native-borns seemed to prefer the South beginning in 1965–1970. Also, the directional mobility expectancies indicated a definite preference for "correcting" one's initial region of residence, if it was the Northeast or the Midwest, by migrating and living a relatively large fraction of one's remaining lifetime in the South or the West. Native-borns tended to leave the Northeast and the Midwest for the South. Foreign-borns tended to leave the Northeast for the South as well, but preferred to live in the West if they originated in the Midwest. However, no such corrections occurred in the reverse direction. Indeed, among those starting out their life in the South or the West, it usually was the other region that was the preferred location over the Northeast or the Midwest.

In conclusion, the different indicators used thus far point to the following common set of findings. First, at the national level, foreign-borns were more likely to migrate interregionally than native-borns. Second, the variations in the period *regional* outmigration propensities were generally wider for the foreign-born population than for the native-born population. Third, the South appeared to be the principal destination for migrating populations. Fourth, the life expectancies mirrored the tendencies identified earlier. The retention life expectancies of the foreign-borns living in the Northeast were the highest during the first two periods and then were superseded by those for the West, as the foreign-born population became increasingly Asian and Latino in composition, indicating that the foreign-borns apparently tended to stay in this particular region. Native-borns, on the other hand, seemed to be more attached to the South after the 1955–1960 period.

4.2. Multiregional Population Projections

In addition to reviewing the life table measures that the indirect estimates of migration generate, one also can examine the historical population projections that such estimates produce. Starting with the 1950 base-year population stocks, disaggregated by age and by region of residence, a multiregional demographic projection model can be used to project the 1950 regional populations forward to 1990, using the estimated migration patterns, together with the corresponding mortality data. In the case of the *native-born* regional populations, it is of course, also necessary to include the estimated fertility rates in the projection model (Rogers and Raymer, 1999). The summary results of such a historical reconstruction are summarized in Figures 11 and 12

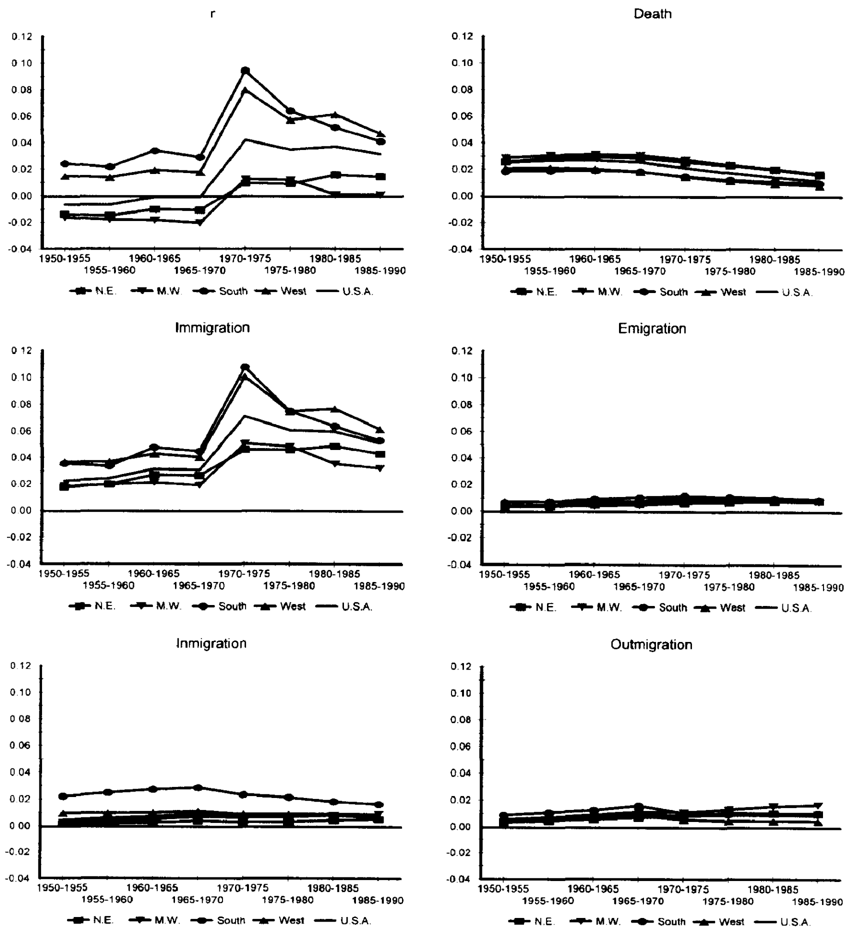

FIGURE 11 Annualized rates for the U.S. foreign-born population: 1950–1990.

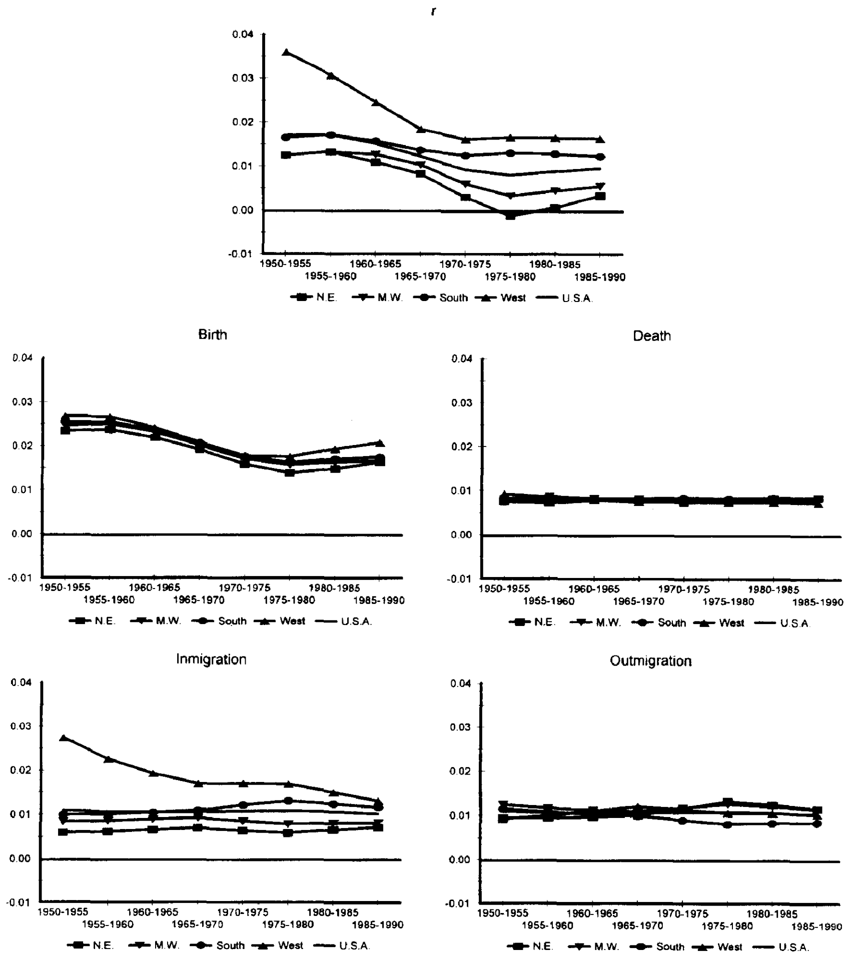

FIGURE 12 Annualized rates for the U.S. native-born population: 1950–1990.

below: first for the foreign-born regional populations, and then for the corresponding native-born populations.

The historical evolution of the annual rate of growth of the foreign-born population in the United States since 1950 exhibits a sudden upsurge after 1965 that is the result of changes in immigration laws brought about by the legislation enacted in that year. Starting with *negative* growth rates for the first 15 years, the national rate takes on positive values soon after 1965, reaches a high of 4.2 percent during the 1970–1975 period, and then declines to 3.1 percent during the

1985–1990 period. Regionally, the annual rate varies from consistently higher than national values for the West and South to correspondingly lower values for the Northeast and Midwest.

A decomposition of the annual rate for foreign-borns into its principal sources of growth and change (also set out in Figure 11) reveals that by far the most important component determining its value has been immigration. By way of illustration, consider the accounting identity for the 1970–1975 period for the national foreign-born population's annual growth rate of 4.2 percent:

$$\begin{aligned} r &= -d + IM - EM + i - o \\ &= -0.0210 + 0.0707 - 0.0080 + 0.0084 - 0.0084 \\ &= 0.0417 \end{aligned}$$

where d is the death rate, and IM, EM, i and o are the immigration, emigration, inmigration, and outmigration rates, respectively.

It is of interest to contrast this particular decomposition with the corresponding one for the native-born population, which is set out in Figure 12. Two differences are immediately apparent. First, there now is a birth rate, which is the sum of the native-born and foreign-born contributions, with the latter rate calculated using the "wrong" denominator, i.e., with the native-born population as the one "at risk" of childbearing. Thus it acts much in the same way as do inmigration and immigration rates, which also have a "wrong" denominator, i.e., the destination population instead of the origin population. The second difference is the absence of immigration and emigration components. Since these flows have occurred at relatively insignificant levels in the case of the native-born population, we didn't bother to estimate them. For the same 1970–1975 period, the national native-born population's annual growth rate was 0.92 percent, and its components took on the following values:

$$\begin{aligned} r &= b_{(NB)} + b_{(FB)} - d + i - o \\ &= 0.0163 + 0.0008 - 0.0079 + 0.0107 - 0.0107 \\ &= 0.0092 \end{aligned}$$

Notice the dramatic difference in the crude death rates. This difference is totally a consequence of different age compositions, inasmuch as the same mortality schedules were used for both the foreign-born and native-born populations.

5. CONCLUSION

The large waves of largely Asian and Latino immigration that have followed the passage of the Immigration and Nationality Act of 1965 have induced a surge of growth of the foreign-born population in the United States. Although this growth has led to a corresponding increase in research directed at immigration streams and the socioeconomic conditions of the foreign-born, only recently has it stimulated much attention at the *internal* migration patterns of the foreign-born and on their particular geography (e.g., Belanger and Rogers, 1992; Henning, 1997; Newbold, 1996; Nogle, 1996; Rogers and Henning, 1999).

The national geography of the U.S. foreign-born population is largely determined by two principal migration processes: the flows of immigrants into and out of regions in the United States, and the subsequent redistribution of these immigrants between these same regions. Severe data limitations have hindered serious study of such processes. Emigration data have not been collected since 1957, and internal migration data are available only for the second half of each census decade. Moreover, small sample problems plague what data are available, and illegal or undocumented immigration levels can only be estimated with very crude methods.

In this paper we have outlined straightforward procedures for inferring or repairing missing or inadequate migration data, illustrating our efforts with internal and external migration data drawn from four consecutive decadal censuses. First, foreign-born interregional migration flows and proportions, between four Census regions, were examined and ultimately graduated with model schedules for each of the four five-year census intervals. Second, the emigration patterns of foreign-borns were indirectly estimated by associating emigration patterns with immigration patterns and adopting a series of model migration schedules. Third, multiregional life tables and population projections using these migration data were calculated and their measures analyzed (and contrasted with the corresponding measures for the native-born population). The results point to significant differences and shifts in the patterns of migration that have shaped the population geography of the United States during the 40-year period: 1950–1990.

Finally, in the entire paper we have ignored the contribution of "illegal", or undocumented migration, mainly because we have not come up with a satisfactory method of inferring and incorporating their impacts. However, this work is currently underway and will be examined in a future paper.

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