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ACCOUNTING FOR MIGRATION IN COHORT-COMPONENT PROJECTIONS OF STATE AND LOCAL POPULATIONS

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The cohort-component method is the most widely used analytic method for making regional population projections in the United States (Shryock and Siegel 1973:796). It is used by the U.S. Bureau of the Census to make projections of national and state populations (e.g., U.S. Bureau of the Census 1983, 1984a), and is the method most frequently used by state demographic agencies to make state and county projections (Federal-State Cooperative Program 1984).

Under the cohort-component method, births, deaths, and migration are projected separately for each age group in the population. Of these three components of population growth, migration is the most difficult to forecast accurately for states and local areas (U.S. Bureau of the Census 1983:4). One difficulty is that migration is the most volatile component of population change; while death rates change slowly and predictably over time, and even birth rates follow fairly stable trends (at least in the short run), migration rates at the state and local level can change tremendously within a very short period of time. In Florida, for example, net inmigration averaged almost 400,000 per year during the first four years of the 1970s, but fell to only 160,000 per year during the next four years (Smith 1982:6). The possibility of large, abrupt changes is much greater for migration than for either births or deaths.

A second difficulty in forecasting migration stems from the methodological problem of choosing the appropriate population base (i.e., denominator) for migration rates. Theoretically, the appropriate base for any rate is the population at risk of the occurrence of the event under consideration (Shryock and Siegel 1973:7). For mortality and fertility rates, the choice is clear: for purposes of projection, the population at risk of dying or giving birth is the population of the state or local area being projected, adjusted for total person-years lived during the base period. For migration the choice is not so clear. If in- and outmigration are projected separately, the population at risk for outmigration is the population of the state or local area being projected. For inmigration, however, is the population at risk the rest of the world, the rest of the United States, or certain regions of the United States? If net migration data are used, the problem is even more difficult. Since net migration is the difference between the number of inmigrants and the number of outmigrants, it does not represent a real group of people; there is no such thing as a "net migrant." Consequently, there is *no* true population at risk for net migration.

If migration were a minor component of population growth, the methodological problem of choosing the appropriate population base would be strictly of academic interest; population projections would be little affected by alternate formulations of migration rates. In many states and local areas, however, migration is far from a minor component of population growth. In the four most rapidly growing states between 1970 and 1980, for example, migration accounted for 83 percent of population growth in Nevada, 76 percent in Arizona, 92 percent in Florida, and 70 percent in Wyoming (U.S. Bureau of the Census 1984d:14). For many local areas the proportion of growth attributable to migration is even higher.

Not only does migration account for a large proportion of population growth in many places but it is the factor primarily responsible for differences in growth rates among states and local areas (Shryock and Siegel 1973:793). The significance of migration has increased considerably in recent decades, because of declining birth rates and rising levels of foreign immigration, yet no study has considered how the choice of the population base for migration rates affects the outcome of population projections. This article develops three different models of migration for cohort-component projections, each using a different base (i.e., denominator) for migration rates. These models are used to produce three sets of population projections for a number of states, using identical data and assumptions for each, except for the different formulations of migration rates. The differences in the resulting projections are analyzed, and a number of conclusions are drawn regarding the construction of migration rates for use in cohort-component population projections.

DATA AND ASSUMPTIONS

Several studies have addressed the question of choosing the appropriate base for migration rates (e.g., Thomlinson 1962; Hamilton 1965). These studies, however, dealt primarily with whether the initial, terminal, or mid-point population should be used to calculate migration rates, and what adjustments for births, deaths, and migration during the base period should be made to estimate the total number of person-years lived. These studies considered the base population to be the population of the area being projected, regardless of whether the migration rates represented gross inmigration, gross outmigration, or net migration.

Such issues are certainly legitimate, but for purposes of projecting state and local populations they may not be as important as the more fundamental question of *which* area's population should be considered as the base for migration rates. This question is important not only from the standpoint of developing a theoretically sound model, but also because it can have a tremendous impact on the resulting projections. A number of different approaches can be taken when projecting migration in cohort-component projection models. The present study considers three.

Model I uses gross in- and outmigration data by age and constructs separate in- and outmigration rates for each age group. The outmigration rates are based on the population of the state being projected; the inmigration rates are based on the population of the rest of the United States. These are rates in a probabilistic sense, in that the frequency of in- and outmigration is related to the population at risk of in- and outmigration.

Model II uses the same gross in- and outmigration data as Model I, but combines them to form net migration data. Age-specific net migration rates are made by dividing the net migration numbers by the state population in each age group. These are not rates in a probabilistic sense because they do not represent the frequency of an event in relation to the population at risk of its occurrence. They are rather "rates of growth due to net migration." Model II represents the approach taken in virtually all projections using net migration data (e.g., Shryock and Siegel 1973, chapter 24; Pittenger 1976, chapter 8; U.S. Bureau of the Census 1983).

Model III also uses net migration data by age, but calculates age-specific net migration rates by using the United States population as a base, rather than the population of the state being projected. This relates projected net migration to the growth of the United States population, rather than to the growth of the state being projected. For states that are growing considerably more rapidly or slowly than the United States, the projections from Model III will differ considerably from those from Model II.

All three models are identical except for the formulation of migration rates. Projections for each were made in five year intervals, starting with the 1980 population broken into five-year age groups. Survival rates by age were based on life tables for the United States (U.S. Department of Health and Human Services 1984). Migration rates were constructed by dividing the number of migrants between 1975 and 1980 for each age group (U.S. Bureau of the Census 1984c) by the population of each age group in 1975.[1] The application of survival and migration rates provided projections of the population age five and older. The population less than age five was projected by multiplying the 1980 child/adult ratio for each state (i.e., population less than age 5 divided by population age 15–44) by the population age 15–44 in the projection year. Each five-year projection served as the base for the following five-year projection. The projections of the United States population were taken from the middle series of the most recent Census Bureau projections (U.S. Bureau of the Census 1984a).

In terms of the current state of the art of population projection methodology, these techniques are somewhat simplistic. Numerous refinements could be made, such as dividing each age group by sex and race, applying state-specific survival rates, or using age-specific fertility rates instead of child/adult ratios.[2] For present purposes, however, such refinements are unnecessary. The goal of this study is not to produce the "best" set of projections possible, but rather to show the differences that emerge when applying each of the three formulations of migration rates, while holding everything else constant. For this purpose, a simplified methodology is satisfactory.

Models I, II, and III were used to make population projections for ten states. Four were high-growth states. Nevada, Wyoming, and Arizona were the three fastest growing states between 1975 and 1980, and Florida was the most rapidly growing large state (U.S. Bureau of the Census 1984b). Three (New York, Massachusetts, Pennsylvania) were low-growth states. These were the only three states to lose population between 1975 and 1980. Three (Arkansas, Kentucky, Montana) were moderate-growth states. They grew at about the same rate as the United States between 1975 and 1980, and their growth rates placed them at the median when compared to the growth rates of other states.

The models were tested, then, in three different types of states. For rapidly growing states, it is expected that the three models will produce vastly different projections. Both Models II and III are expected to produce higher projections than Model I because they do not account for the faster increase in the source of outmigrants (i.e., the population of the state) than the source of inmigrants (i.e., the population of the rest of the nation). Model II projections are expected to be higher than Model III projections because net inmigration in Model II is based on the rapidly growing state population, rather than the more slowly growing national population.

For slowly growing states, the projections from the three models will also be quite dissimilar. Models II and III are expected to produce lower projections than Model I because they do not account for the faster increase in the source of inmigrants than in the source of outmigrants. Model III is expected to be particularly low because net outmigration rates are based on the U.S. population, which will be growing more rapidly than the population of these slowly growing states.

For moderately growing states, it is expected that all three models will produce similar projections because the bases of the migration rates will be growing at similar rates, regardless of whether the state or national population is used.

PROJECTION RESULTS

Projections were made from 1980 to 2030 for each of the ten states covered; results are summarized in Table 1. For rapidly growing states, large differences among the three migration models are apparent. Model I produced the lowest population projections in all four states and Model II produced the highest. The differences were

Table 1.—Population projections, 1990–2030 (in thousands)

State	1980	1990	2000	2010	2020	2030
Rapid growth						
Nevada						
Model I	800	1,073	1,282	1,433	1,528	1,573
Model II	800	1,275	1,965	2,939	4,299	6,092
Model III	800	1,159	1,526	1,881	2,201	2,462
Wyoming						
Model I	470	612	721	798	848	875
Model II	470	708	1,060	1,574	2,320	3,383
Model III	470	661	872	1,096	1,325	1,547
Arizona						
Model I	2,718	3,427	4,005	4,470	4,812	5,017
Model II	2,718	3,728	4,990	6,572	8,515	10,757
Model III	2,718	3,586	4,476	5,372	6,225	6,966
Florida						
Model I	9,746	11,696	13,398	14,903	16,095	16,842
Model II	9,746	12,266	15,133	18,427	21,985	25,373
Model III	9,746	11,966	14,152	16,278	18,154	19,552
Slow growth						
New York						
Model I	17,558	16,896	16,374	15,873	15,328	14,717
Model II	17,558	16,635	15,549	14,254	12,754	11,130
Model III	17,558	16,486	15,046	13,204	10,992	8,538
Massachusetts						
Model I	5,737	5,702	5,680	5,660	5,590	5,461
Model II	5,737	5,639	5,444	5,144	4,721	4,195
Model III	5,737	5,625	5,403	5,061	4,577	3,979
Pennsylvania						
Model I	11,864	11,769	11,684	11,561	11,335	10,986
Model II	11,864	11,660	11,312	10,792	10,061	9,136
Model III	11,864	11,643	11,237	10,606	9,724	8,616
Moderate growth						
Arkansas						
Model I	2,286	2,548	2,801	3,016	3,180	3,277
Model II	2,286	2,562	2,856	3,146	3,408	3,623
Model III	2,286	2,562	2,852	3,127	3,365	3,547
Kentucky						
Model I	3,661	3,992	4,293	4,537	4,703	4,783
Model II	3,661	4,009	4,339	4,625	4,840	4,967
Model III	3,661	4,006	4,332	4,610	4,813	4,928
Montana						
Model I	787	863	931	982	1,016	1,032
Model II	787	868	943	1,007	1,055	1,083
Model III	787	867	942	1,003	1,050	1,076

huge. For the two most rapidly growing states (Nevada and Wyoming) the Model II projections were twice as large as the Model I projections by 2010, and four times as large by 2030. For Arizona, the Model II projections were almost 50 percent larger by 2010, more than twice as large by 2030. Even for Florida, a large state with a considerably lower growth rate than the other three, the Model II projection was more than 50 percent larger than the Model I projection by 2030. Model III projections were also uniformly higher than Model I projections, but not nearly as high as Model II projections. For the four rapidly growing states, projections using net migration were clearly much closer to projections using gross migration if net migration rates were based on the national population rather than the state population.

Large differences among the migration models can also be found for the slowly growing states. For all three states Model I produced the highest projections and Model III the lowest. The differences were not as large as those for rapidly growing states, but they were substantial, especially for the longer projection horizons. In the year 2030, Model I projections exceeded Model III projections by 72 percent for New York, 37 percent for Massachusetts, and 28 percent for Pennsylvania.

For the three moderately growing states Model I uniformly produced the lowest projections and Model II the highest, but the differences were very small. For the year 2030 the differences between Models I and II were only 11 percent for Arkansas, 4 percent for Kentucky, and 5 percent for Montana. For the year 2000 the differences were only 2 percent, 1 percent, and 1 percent, respectively. It is clear that for moderately growing states the choice of migration model had little effect on the resulting projections.

Differences among the three migration models are even more striking when the focus is on projected net migration rather than on total population. Table 2 shows net migration during the base period 1975–1980, and projected net migration during the second half of each of the following five decades.

For the rapidly growing states Model I produced projections of net migration that declined over time for Nevada, Wyoming, and Arizona (even becoming negative for Wyoming). For Florida, Model I produced levels of net migration that declined during the 1980s but increased during the following decades. The different pattern for Florida was most likely due to its much larger population than the other three states' and its lower growth rate between 1975 and 1980. The age structure of Florida's migration stream may also have had an effect on projected net migration. For Model II, levels of net migration in the rapidly growing states increased steadily over the fifty-year projection horizon, by ever-increasing amounts. Between 2025 and 2030, the level of net inmigration was 7.5 times larger than it was between 1975 and 1980 for Nevada, 7.2 times larger for Wyoming, 4.2 times larger for Arizona, and 3.0 times larger for Florida. These steadily increasing net migration numbers were caused by the geometric nature of Model II. For Model III levels of net migration in the rapidly growing states also increased over time, but by relatively small amounts. Between 2025 and 2030, the level of net inmigration was only 26 percent larger than it was between 1975 and 1980 for Nevada, 4 percent larger for Wyoming, 39 percent larger for Arizona, and 55 percent larger for Florida.

Large differences among the three models can also be seen for the slowly growing states. For Model I, net outmigration became smaller as the projection horizon became longer, and actually reversed its direction and became net inmigration for Massachusetts and Pennsylvania by around the year 2000. The primary cause for this result is that the base from which inmigrants were drawn was growing considerably more rapidly than the base from which outmigrants were drawn. For Model II, net outmigration also became smaller as the projection horizon increased, but did not reverse its sign in any of the three states. For Model III, net outmigration continued for all three states and became a larger negative number as the projection horizon lengthened. This was the result of net migration rates' being based on the United States population, which was projected to keep increasing in size.

For the three moderately growing states, differences in projections of net

Table 2.—Net migration 1975–1980 and projected net migration, 1985–1990 through 2025–2030 (in thousands)

State	1975-1980	1985-1990	1995-2000	2005-2010	2015-2020	2025-2030
Rapid growth						
Nevada						
Model I	133.2	99.4	79.4	67.4	58.6	54.6
Model II	133.2	217.6	325.4	489.1	711.1	992.9
Model III	133.2	147.1	154.7	163.1	166.6	167.4
Wyoming						
Model I	52.4	31.0	13.5	1.2	-5.7	-9.6
Model II	52.4	82.8	122.0	178.2	259.1	377.1
Model III	52.4	56.5	56.3	56.0	55.2	54.7
Arizona						
Model I	297.4	239.6	208.3	194.0	190.0	184.6
Model II	297.4	411.7	551.6	749.4	995.6	1254.8
Model III	297.4	325.1	349.1	378.7	402.0	412.1
Florida						
Model I	1062.1	1035.7	1082.8	1167.8	1256.8	1299.2
Model II	1062.1	1370.1	1731.4	2221.1	2746.1	3163.1
Model III	1062.1	1179.5	1309.0	1462.9	1590.6	1650.3
Slow growth						
New York						
Model I	-648.7	-452.5	-291.3	-181.8	-92.7	-9.7
Model II	-648.7	-612.4	-569.4	-535.6	-496.0	-439.0
Model III	-648.7	-712.5	-772.5	-839.7	-904.3	-944.0
Massachusetts						
Model I	-72.2	-36.0	11.3	47.9	72.4	96.5
Model II	-72.2	-78.4	-78.0	-75.5	-72.3	-64.2
Model III	-72.2	-87.3	-94.4	-101.7	-110.5	-112.2
Pennsylvania						
Model I	-177.8	-97.1	-15.6	32.0	80.5	123.6
Model II	-177.8	-169.0	-149.8	-150.0	-142.3	-127.9
Model III	-177.8	-181.4	-183.5	-209.4	-218.9	-224.3
Moderate growth						
Arkansas						
Model I	69.7	73.7	78.1	77.9	81.7	81.9
Model II	69.7	79.6	93.0	105.2	115.7	121.4
Model III	69.7	79.8	91.3	97.4	104.1	105.4
Kentucky						
Model I	48.2	45.2	47.6	46.0	45.6	47.3
Model II	48.2	50.8	55.5	57.4	57.5	57.8
Model III	48.2	49.6	54.2	54.6	53.6	53.9
Montana						
Model I	8.2	9.8	8.1	5.9	6.7	6.5
Model II	8.2	10.8	10.3	9.9	10.3	9.8
Model III	8.2	10.4	10.2	8.9	9.3	8.6

migration among the three models were very small. Model II produced the largest projections of net migration in all three states and Model I the smallest, but the differences were insignificant. The specific formulation of migration rates has little impact on projected levels of net migration in moderately growing states.

DISCUSSION

Which of the three models discussed in this article provides the most realistic migration projections? While this question cannot be answered definitively, several observations can be made. Models using gross migration data are generally considered to be better than models using net migration data (e.g., Shryock and Siegel 1973:801; Irwin 1977:22; Morrison 1977:10; U.S. Bureau of the Census 1983:6). There are a number of reasons for this. First, gross migration is closer to the real migration process than is net migration. People either move into an area or they move out; they do not "net migrate." Second, gross migration data can be related to the size of the source population from which migrants come, providing migration rates that theoretically represent the probability of migrating. Since net migration is the difference between in- and outmigration, it has no definable source population, and net migration "rates" do not represent the probability of migrating. Third, and perhaps most important, gross migration models can account for differences in growth rates between origin and destination populations. If the population at risk of outmigration is growing more rapidly than the population at risk of inmigration, for example, gross migration models can project increasing numbers of outmigrants relative to the number of inmigrants. This is a realistic feature that net migration models cannot incorporate. For all these reasons, projections based on gross migration models will generally be superior to projections based on net migration models.

Of the two net migration models covered by this study, Model III appears to be a better model for rapidly growing areas and Model II for slowly growing or declining areas. Model II bases net migration rates on the population of the state being projected, while Model III bases net migration rates on the national population. If a state has net inmigration, more people are moving in than out. The nation—not the state—thus represents the source population of the majority of the migrants. For states with net outmigration, the opposite is true: the state, rather then the nation, represents the source population of the majority of the migrants. On conceptual grounds, then, Model III more nearly reflects the migration process for rapidly growing areas and Model II for slowly growing or declining areas.

There are also empirical reasons for favoring Model III for rapidly growing areas and Model II for slowly growing or declining areas. Model II leads to higher and higher levels of net inmigration over time for rapidly growing states, as constant migration rates are applied to a constantly expanding population base. If carried too far into the future, this can produce absurd results. Similarly, Model III leads to higher and higher levels of net outmigration for slowly growing or declining states, in spite of a constantly declining population from which outmigrants can be drawn. This, too, is an unreasonable outcome.

Table 1 showed that, for rapidly growing states, Model III projections are much closer to Model I projections than is the case for Model II. For slowly growing states, Model II projections are closer to Model I. If it is accepted that Model I is superior to either Model II or Model III, this provides additional evidence that Model III provides more realistic projections for rapidly growing areas than Model II, while for slowly growing areas the opposite is true.

CONCLUSIONS

Two critical decisions must be made when projecting migration in cohort-component projection models. First is the choice of the base period from which migration data are taken. The importance of this choice has long been recognized by demographers. Which base period provides the migration patterns most likely to be repeated in the future? Did any unusual events occur which are not likely to be repeated? Should any modifications or adjustments be made? If migration patterns were considerably different in one potential base period than in another, the choice of the base period will have a large impact on the resulting population projections.

The second critical decision is the choice of the model used to project migration rates. Which of the assumptions embodied in Models I, II, and III is most likely to be valid for a given state or local area, at a particular point in time? Would other models, based on other assumptions, provide even more realistic representations of the migration process? The importance of this choice has generally not been noted by demographers but, as shown in this study, can have a tremendous impact on population projections for states and local areas that are growing very rapidly or very slowly.

Population projections are frequently used as forecasts. That is, they are used not simply as the hypothetical outcomes of a given set of assumptions, but rather as trusted predictions of future events. Consequently, it is important that demographers base their projections on the data and assumptions that are most likely to provide accurate forecasts of future population change. It is not the purpose of this article to contend that one particular model of migration is superior to all others for every place and every time period. Rather, the purpose is to illustrate how the choice of the migration model in itself can have a major impact on population projections, independently of all other assumptions made in applying the cohort-component method. If demographers are to provide population projections that can reasonably be used as forecasts, they must carefully consider not only which base period provides the migration patterns most likely to be repeated in the future, but also which formulation of migration rates provides the most realistic model of future migration flows.

NOTES

[1] Estimates of the United States population by age in 1975 were taken from U.S. Bureau of the Census (1982). Estimates of the total population for states in 1975 were taken from U.S. Bureau of the Census (1984b). Estimates of state populations by age in 1975 were made by interpolating between the age distributions in 1970 and 1980 and applying the resulting proportions to the 1975 estimates of total population.

[2] A particularly useful refinement to Model I would be to distinguish among regions of the United States. Regions could be defined as particular states or groups of states. Inmigration rates could then be related to specific sources of inmigrants rather than to the United States population as a whole, allowing for the effects of different rates of population growth among regions.

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