The Migration Component in a Population Projections Model

Balkrishna Kale[1], David Egan-Robertson[1], Charles D. Palit[2], and Paul R. Voss [2]
Wisconsin Department of Administration [1]
University of Wisconsin-Madison [2]

Abstract

The future course of migration is probably more difficult to visualize than that of fertility and mortality in developing population projections. In this paper, we underscore the need to analyze past, current and emerging trends to determine the total amount of migration. We then present a procedure to set migration levels for males and females and two broad age bands and to derive migration rates for 5-year age groups that are consistent with the total levels set for the broad categories. This is based on the findings of researchers that migration rates generally change in the same direction and magnitude for most age-sex groups. The suggested method follows the net migration methodology that is employed by many demographers in their population projections. We use Wisconsin data for elucidation and evaluation of the proposed procedure.

Keywords: migration, population projections

1. Introduction

Future scenarios of fertility, mortality and migration form the crux of population projections based on the widely used cohort component model. It is critical that these scenarios are as reasonable as possible since population projections are often deemed as forecasts and used for planning, marketing and policymaking purposes. While all three components are important in this context, migration is probably the most difficult to handle. Fertility and mortality changes are small in populations with low fertility and high life expectancy, and any errors in projecting these components are minor. This is not necessarily the case with migration. We discuss here the difficulties in projecting migration and propose some solutions. Wisconsin data are used to illustrate the complexity in developing the overall future scenario and to evaluate the suggested procedure of disaggregating the projected overall migration levels by age and sex.

Some projection models adopt the gross migration approach by treating in- and out-migration flows separately. Other models follow the net migration path. Ten states out of 13 that responded to our survey in early 2005 had adopted the net migration procedure in their most recent population projections. (Most of the other states in the U.S. had not issued any population projections at the time, while a few did not use the cohort component method.) This paper is presented within a net migration framework.

2. Measurement of Migration

One way to estimate net migration by age and sex would be to restate the familiar demographic equation as follows:

$$m = p_2 - p_1 + d \qquad (1)$$

where p_1 is persons of age x at time 0 or the first census, p_2 is persons of age x+10 at time t+10 or the second census taken 10 years later, d is the number of resident deaths of persons who were of age x at the first census (this includes deaths of non-migrants as well as of in-migrants to the area during the decade), and m is net migration (in-migrants minus out-migrants) over the 10-year period among persons of age x at the first census.[1] For persons under 10 at the second census, p_1 represents the birth cohorts of the intercensal period and d would refer to deaths of children born in the respective years.

Stated differently,

$$m = p_2 - p_1 + d_{nm} + d_{im} \qquad (2)$$

where d_{nm} represents deaths among non-migrants and d_{im} is deaths among in-migrants to the area.

A slightly different estimate of net migration is given by the equation:

$$\hat{m} = p_2 - (e = s * p_1) \qquad (3)$$

where $\hat{m}$ represents (net) migrants, e is the expected population in the absence of any migration, and s is the intercensal survival rate applicable to p_1. The survival rates may be derived from an available life table that represents the average mortality over the 10-year period, e.g., the mid-decade life table, or can be calculated by means of an extension of the vital statistics method (Kale, et. al., 1993).

Viewing the expected population differently,

[1] In this equation and those that follow, lower-case notation signifies age cohorts and upper-case notation indicates totals.

$$e = p_1 - d_e \qquad (4)$$

where d_e represents expected intercensal deaths among persons who were residents of the area at the beginning of the period and thus includes deaths among non-migrants (d_{nm}) as well as deaths among out-migrants (d_{om}), i.e., deaths of persons who died after they left the area.

Thus,

$$\hat{m} = p_2 - p_1 + d_{nm} + d_{om} \qquad (5)$$

Now,

$$\begin{aligned} m - \hat{m} &= (p_2 - p_1 + d_{nm} + d_{im}) \\ &\quad - (p_2 - p_1 + d_{nm} + d_{om}) \\ &= d_{im} - d_{om} \qquad (6) \end{aligned}$$

Hence, the difference between the two estimates of net migration, m and $\hat{m}$, generally is small and attributable to the difference between the deaths among in-migrants and out-migrants. For Wisconsin, the estimate of $\hat{M}$ (i.e., sum of $\hat{m}$ across all age-sex groups) for the 1980-90 decade was -125,401 or 98.9 percent of M (i.e., sum of m), which we computed to be -126,739. For the 1990s, $\hat{M}$ was 224,028 or 98.5 percent of M, calculated to be 227,555.

Components of population change provide net migration in terms of M. On the other hand, the migration component in population projections is calibrated by means of net migration rates that are based on $\hat{M}$. If future migration scenarios are stated in terms of M, the difference between M and $\hat{M}$ needs to be recognized and the value of $\hat{M}$ determined in order to make the projected numbers consistent with the assumed value of M for the projection horizon. Note that the difference between M and $\hat{M}$ is small and any error in the projected population on account of this difference may be regarded as insignificant.

3. The Overall Migration Levels

It is well known that projection errors are generally narrower for larger geographies than for smaller areas. This is true with respect to the projected total population as well as any of the three components of population change. Similarly, error rates are smaller in the projected overall migration level for an area than the projected migration for specific age-sex groups. Therefore, it is reasonable to develop the future migration scenario in terms of total net migration for the area first. The process may be discussed using Wisconsin data in this context.

Wisconsin showed a net loss of about 127,000 persons through migration (in terms of above defined M) in the 1980s. However, this picture based on the analysis of decennial census data is misleading. Annual population estimates tell a different story. The state evidenced net out-migration (M) of 159,000 persons in the 1980-1987 period as a result of serious economic problems experienced in the first years of the 1980s. Wisconsin's economy did much better, however, in the second half and even weathered the recession of the early 1990s fairly well. The state's unemployment rate remained discernibly below the national rate beginning in 1987. With a change in its economic climate, Wisconsin gained 32,000 persons through migration in the 1987-1990 time-span and 44,000 people in the two years between April 1, 1990 and April 1, 1992. In response to its economic turnaround beginning in the mid-1980s and indeed its robust economy thereafter, instead of losing people to the rest of the nation, the state was now attracting large number of migrants from elsewhere. Clearly the late 1980s data and the emerging trends of the early 1990s were quite different from what the analysis of data 10 years apart (between 1980 and 1990) were indicating. The 10-year picture was dominated by the pre-1987 losses. Even the gross migration data for the 1985-1990 period, based on the place of residence five years ago question in the 1990 census, showed a net gain of only 3,000 persons for the population of age five and above. These results were influenced by the losses of the early part of the second half of the decade. In short, neither the 10-year net migration analysis based on census data nor even the information based on place of residence five years ago would have provided a reasonable future migration scenario for Wisconsin.

Besides the vibrant economy, there was another equally important factor that favored migration toward areas of strong employment growth. The baby bust generation was beginning to enter the labor force around this time and the smaller numbers of new entrants to the labor force would have continued to dominate the entire 1990s. This demographic variable could not be ignored in developing the future scenario.

Finally, migration flows do not instantaneously stop or change when the economic circumstances change. There is a time lag between the onset of the up- or down-swing of the economy and its impact on the decisions that people make about going to or leaving from a certain area. There is a certain momentum built into the process.

In their population projections developed in 1992, Wisconsin's demographers quite appropriately disregarded the substantial loss through migration witnessed between 1980 and 1990 or the small gain indicated by the place of residence five years ago data and correctly determined that the state would gain about 100,000 persons through migration in the first half of the 1990s. However, they projected that, in a net migration framework, Wisconsin could not make equally large gains in the second half of the decade since the losing areas cannot sustain such losses as their base gets narrower, especially when the new entrants to the labor force were smaller in numbers everywhere. They projected that the net in-migration in the 1995-2000 period would be around 50,000, thus giving for the entire decade a total of about 150,000, which was about twice the net inflow between 1987 and 1992.

In fact, the 1990s showed a huge net gain for Wisconsin of 228,000 (in terms of M). Migration's role in the state's population growth in the 1990s was unprecedented, both in numerical and proportional terms (barring probably only the 1840s and the 1850s, the era when Wisconsin became a state). Sitting in 1992, Wisconsin's demographers did not foresee the massive net gains of the second half of the 1990s owing to a combination of several factors: (a) Wisconsin's strong economy, (b) a labor shortage at least partially caused by the baby bust generation entering the labor force, (c) a seemingly unlimited pool of immigrants from abroad making up for any labor shortage within the state and country, and (d) the momentum that results in significant gains for a while even when the economy slows. Clearly, demographers need to carefully study the emerging trends and the many variables impacting on future population change, particularly migration, when they are in the process of developing population projections.

It should be noted here that immigration from abroad became a critical factor in the context of labor supply only in the late 1980s. The new entrants to the labor force comprised essentially the baby boom generation until then. An increasing female labor force participation rate also was in evidence at the same time. Immigration assumed significance after the baby bust generation started entering the labor force.

The above discussion points to the complexity in determining the overall future migration levels. We have underscored the need to understand the demographic as well as socio-economic dynamics in that context and then develop the most reasonable scenario. Even though the demographers will almost always miss the numeric target, their considered judgment adds useful information to the process.

Once the total migration levels are set, it is necessary to calibrate age-sex specific migration rates that are consistent with those totals. The next section describes our procedure to accomplish this task.

4. Projected Age-sex Specific Migration Rates

It is not enough to project the total (net) gain or loss through migration. It is also necessary to disaggregate that total by age and sex since population projections are generally needed by these attributes. The suggested procedure to do this is outlined below. We assume for this purpose that everything else is known except for the age-sex distribution of the migrants.

The observed data from the 1990s used in this exercise include:

(a) the age-sex specific 10-year survival probabilities of the 1990 population and the resulting expected population in 2000 in the absence of any migration;

(b) number of births of the inter-censal period and appropriate survival probabilities and then the expected number of 0-4 and 5-9 year-olds in 2000 in the absence of any migration; and

(c) the total number of inter-censal (net) migrants ($\hat{M}$) in 2000.

The known Wisconsin data for the base period include:

(a) the expected population by age and sex in 1990 in the absence of any migration; and

(b) inter-censal net migration between 1980 and 1990 and inter-censal net migration rates by age and sex.

Our focus here is not on the error in projecting total net migration. Rather, the objective is to evaluate the proposed procedure in deriving the age-sex decomposition of the projected total.

First, we divided the projected total amount of migration into total male and female net migrants based on the observed sex ratio of migrants in the 1980-1990 decade. Thus, the number of male (net) migrants of all ages was set at 118,289 (52.8 percent) and that for the females at 105,739. The actual 1990-2000 totals were 123,884 (55.3 percent) and 100,144. The larger than expected immigration from abroad (with a higher male:female ratio) was at least partially responsible for more males than females in the total net flow. Immigrants constituted about 40 percent of Wisconsin's total gain in the 1990s.

Next, the projected totals of male and female migrants were split into two broad age categories. Historically, net migration has been smaller from ages 55 and over, the late working and retirement years. Migration of the younger adults is more sensitive to economic opportunities, and children under 18 move along with their parents who essentially belong to the 18-54 age group. Our projection model assumes that the migration rates of the older adults do not change by the same amount as those of the under-55 age groups. We disaggregated the total into the two broad classes (under- and over-55) on the basis of the observed proportions in the 1980-1990 net migration pool. The 55-plus group constituted 12.05 percent among the male migrants and 12.25 percent among the females. Hence, for 1990-2000, the older adults were projected to account for 14,254 males and 12,961 females.[2]

After disaggregating the total by sex and by two broad age categories, the final step was to project net migrants by 5-year age groups. It may be noted in this context that although the amount and rate of total migration may change from one period to another, the overall pattern of age specific migration rates, especially within broad age bands, does not seem to change abruptly (Kale, et. al., 1994). The overall shape of the curve of age specific net migration rates remains generally the same with an upward or downward shift in the level of the entire curve. If the desired total migration is determined for some broad age categories, then it is possible to project the migration rates for 5-year age groups by changing a given set of rates from the preceding period by an additive amount *K* (within the broad categories). The following equation is used to calculate the additive constant:

$$K = (M! - \hat{M}\ ) / E \qquad (7)$$

where *K* is the constant to be added to the 5-year age specific migration rates (*nmr*) within a given broad category, *M!* is the desired total amount of migration for the broad category, $\hat{M}$ is total migration for that category given by using 5-year age specific rates (*nmr*) from the preceding period, and E is the total expected population in the absence of migration for the category. Thus,

$$n\hat{m}r = K + nmr \qquad (8)$$

where *nmr* is the original net migration rate and $n\hat{m}r$ is the adjusted rate.

[2] The observed number (11,180) for females was closer to the projected number than that for males (8,353). Perhaps the high immigration of the 1990s is a factor. Elderly persons form a much smaller percentage of immigrants and, as pointed out above, immigrants constituted a substantial proportion of the 1990s total migration flow, especially among males.

First, the 5-year age specific net migration rates (*nmr*) of the 1980-1990 period are applied to the expected population of the same 5-year age groups expected in 2000. Obviously, total net migration obtained by so doing would show a substantial net loss to the state. We then adjust the five-year age-sex migration rates within each of the four broad categories—using the above-described K technique—so that when the adjusted rates are multiplied by the 2000 expected population, total migration adds exactly to the desired amounts in each of those categories. For comparison purposes, we have also calculated projected numbers without making any distinction between under- and over-55 populations.

5. Evaluation of the Procedure

Table 1 presents, for Wisconsin males and females, the actual and projected age-specific net migrants and net migration rates as well as the expected population in 2000. It also gives the observed 1980-1990 net migration rates and net migrants for 1990-2000 if these rates were used. Figures 1a and 1b show the 1980-1990 observed migration rates, the projected rates derived in both ways (i.e., with and without consideration of the under- and over-55 age bands separately) and the 1990-2000 observed rates.

Differences between the observed and projected net migrants are more noticeable in some age groups than in others. We are focusing here on our preferred model that treats under- and over-55 age categories separately. First, the projected rate for children under 5 is too high compared to the actual. This is the result of the high rate for this age group in the past. Apparently, more mothers with young children came to Wisconsin in the past than those who left (although net out-migration was the general trend). This phenomenon seems to have abated especially in the late 1990s.

Secondly, Wisconsin generally shows some net loss through migration in the 25-29 age group, due to the out-migration of college graduates going to areas where they can find suitable work. Wisconsin's economic downturn in the 1980s exacerbated the situation. In view of the huge overall gains assumed for the 1990s for this exercise, one could have adjusted the rate for this age group using the rate for an earlier decade (and not that for the 1980s) as the base. The large immigrant group also comprised many migrants of this age and thus reduced the overall loss in this age group in the 1990s.

Table 1: PROJECTED AGE-SEX DISTRIBUTION OF NET MIGRATION: 1990-2000

Age Group	1980-90 Observed NMRs	2000 Expected Population	1990-2000 Migrants Based on '80-90 NMRs	1990-2000 Adjusted NMRs (1980-90 NMR+k)*	*1990-2000 Observed NMRs*	1990-2000 Adjusted Migrants	*1990-2000 Observed Migrants*
MALES							
0-4	0.027852	170,945	4,761	0.103926	*0.023961*	17,766	*4,096*
5-9	0.032430	178,558	5,791	0.108504	*0.089316*	19,374	*15,948*
10-14	0.023047	186,731	4,304	0.099121	*0.106752*	18,509	*19,934*
15-19	0.008836	191,350	1,691	0.084910	*0.091116*	16,248	*17,435*
20-24	-0.082089	179,977	-14,774	-0.006015	*0.013307*	-1,083	*2,395*
25-29	-0.142500	175,490	-25,007	-0.066426	*-0.031221*	-11,657	*-5,479*
30-34	-0.054145	180,258	-9,760	0.021929	*0.045246*	3,953	*8,156*
35-39	-0.025990	196,480	-5,107	0.050084	*0.107813*	9,841	*21,183*
40-44	-0.018617	205,827	-3,832	0.057457	*0.075777*	11,826	*15,597*
45-49	-0.023310	189,827	-4,425	0.052764	*0.056862*	10,016	*10,794*
50-54	-0.019239	162,614	-3,129	0.056835	*0.033650*	9,242	*5,472*
55-59	-0.016307	121,242	-1,977	0.028258	*0.025742*	3,426	*3,121*
60-64	-0.018667	97,819	-1,826	0.025898	*0.018003*	2,533	*1,761*
65-69	-0.022466	84,935	-1,908	0.022099	*0.009843*	1,877	*836*
70-74	-0.022873	78,250	-1,790	0.021692	*0.004601*	1,697	*360*
75plus	-0.006755	124,854	-843	0.037810	*0.018221*	4,721	*2,275*
Total		**2,525,157**	**-57,832**			**118,289**	***123,884***
FEMALES							
0-4	0.027506	163,955	4,510	0.097185	*0.020396*	15,934	*3,344*
5-9	0.028324	170,110	4,818	0.098003	*0.087402*	16,671	*14,868*
10-14	0.017633	178,031	3,139	0.087312	*0.103229*	15,544	*18,378*
15-19	0.021132	182,829	3,864	0.090811	*0.085222*	16,603	*15,581*
20-24	-0.048865	170,762	-8,344	0.020814	*0.024350*	3,554	*4,158*
25-29	-0.122451	170,358	-20,861	-0.052772	*-0.037897*	-8,990	*-6,456*
30-34	-0.059357	180,713	-10,727	0.010322	*0.017309*	1,865	*3,128*
35-39	-0.026921	200,448	-5,396	0.042758	*0.085528*	8,571	*17,144*
40-44	-0.028629	209,468	-5,997	0.041050	*0.044756*	8,599	*9,375*
45-49	-0.032696	190,511	-6,229	0.036983	*0.034439*	7,046	*6,561*
50-54	-0.024578	163,644	-4,022	0.045101	*0.017618*	7,381	*2,883*
55-59	-0.021044	125,924	-2,650	0.010530	*0.019496*	1,326	*2,455*
60-64	-0.021733	104,230	-2,265	0.009841	*0.011407*	1,026	*1,189*
65-69	-0.021523	95,395	-2,053	0.010051	*0.009990*	959	*953*
70-74	-0.015770	93,804	-1,479	0.015804	*0.008251*	1,482	*774*
75plus	0.006539	214,308	1,401	0.038113	*0.027106*	8,168	*5,809*
Total		**2,614,490**	**-52,291**			**105,738**	***100,144***

***COMPUTATION OF K FACTORS**

Desired Total Net Migrants (NMs), 1990-2000	224,028	
	Males	Females
Proportions Male & Female (based on '80-90)	0.52801	0.47199
Desired Total NMs by Sex, 1990-2000	118,289	105,739
Proportions Age 55 and over (based on '80-90)	0.120505	0.122576
Desired NMs, Age 55+, 1990-2000 (M!)	14,254	12,961
Desired NMs, Under 55, 1990-2000 (M!)	104,035	92,778
NMs, Age 55+, based on '80-90 rates	-8,344	-7,046
NMs, Under 55, based on '80-90 rates	-49,487	-45,245
Expected Population, 2000, Ages 55+	507,100	633,661
Expected Population, 2000, Ages Under 55	2,018,057	1,980,829
K for Age Groups 55 and over	0.044564	0.031574
K for Age Groups Under 55	0.076074	0.069679

Figure 1a: OBSERVED AND PROJECTED NET MIGRATION RATES, MALES

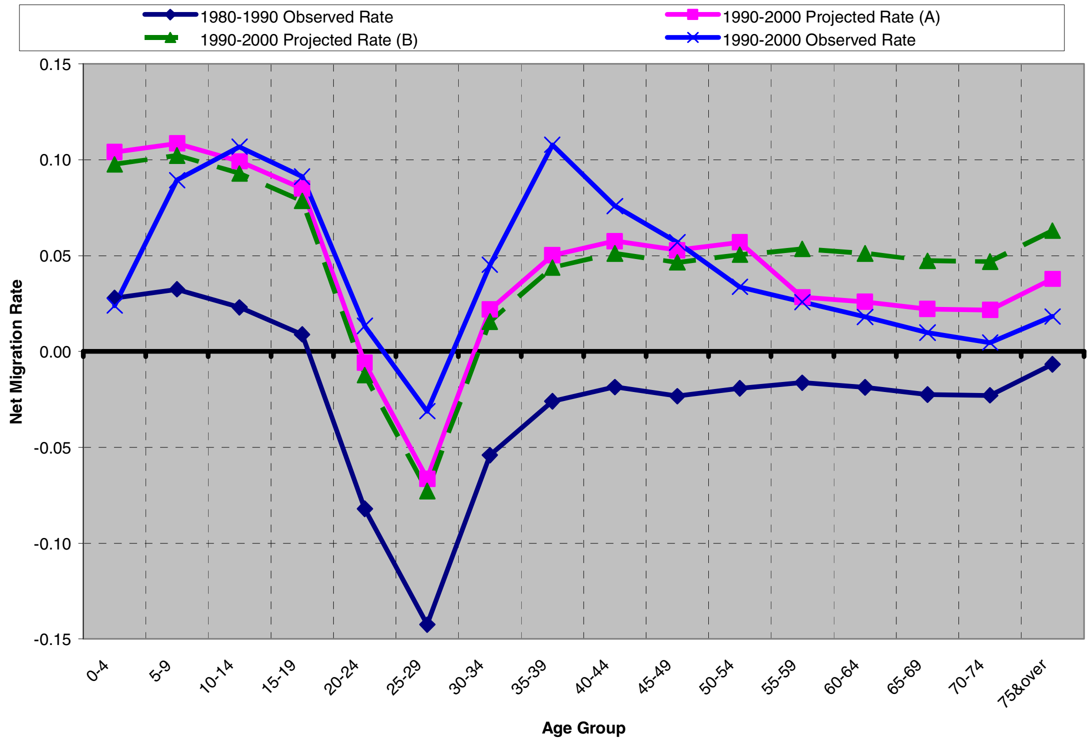
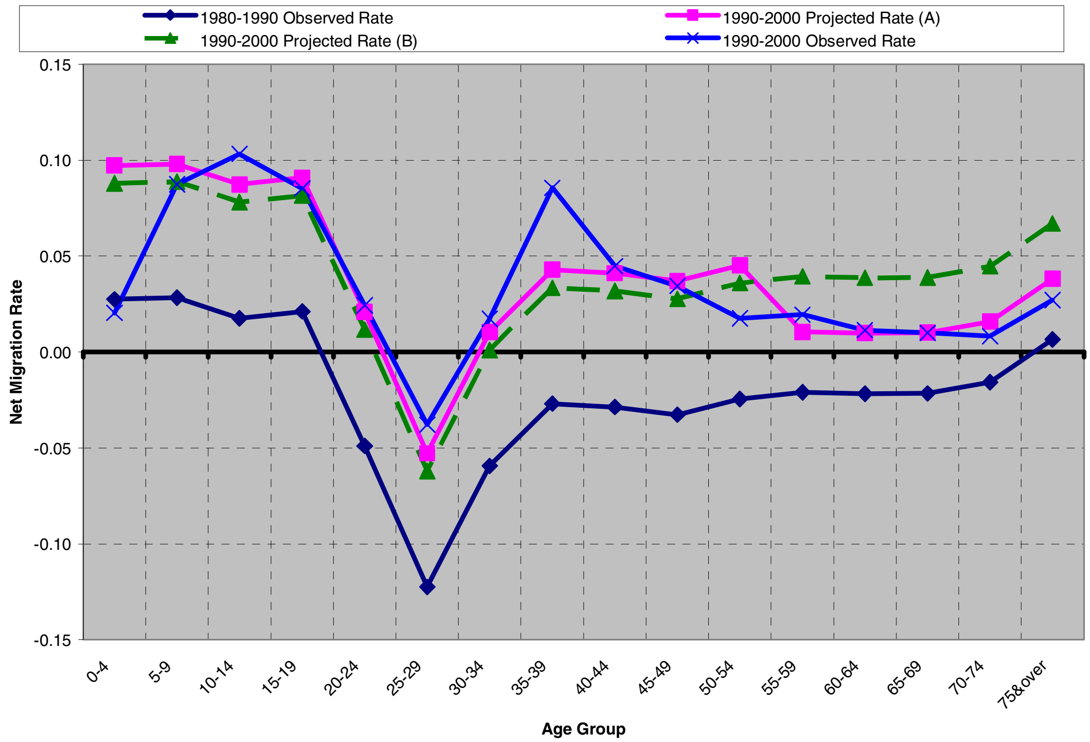


Figure 1b: OBSERVED AND PROJECTED NET MIGRATION RATES, FEMALES



NOTE: Projected Rate (A): Separate K factors applied to the 0-54 and 55-and-over age groups.
Projected Rate (B): Single K factor applied to all age groups.

The third age group that stands out is that of the 35-39 year-olds. This age group witnessed a substantial amount of net gain that was not shown by the projected numbers. Some of the people who had left the state in their late 20s in bad times of the 1980s may have returned when the state's economy turned robust in the 1990s.

Finally, net gains among the elderly males were more modest than among the females in the 1990s. The projected migration among the elderly females turned out closer to the actual number than for the males.

Despite these differences, the overall projected pattern based on our proposed procedure appears reasonable. The R-square between the projected and actual net migrants by age is 0.62 for males and 0.66 for females. The R-square between the projected and actual population is 0.99 for both males and females. These results compare the actual and projected values obtained when the desired migration totals are based on the 1990-2000 observed total migration and on the 1980-1990 observed male/female and under- and over-55 shares. It is assumed that everything except 5-year age-specific net migration is known regarding the 1990-2000 decade. The R-square between the actual and projected net migration when no distinction is made between under- and over-55 age categories is much smaller, 0.51 for males as well as females.

6. Conclusion

These results indicate that, given a good projection of total net migration, we can indeed disaggregate the total into small age-sex groups with reasonable accuracy and, in turn, produce population projections close to the truth. We think that the main wild card is in the production of the total net migration figure. It is in forecasting the total net migration number that the art of the demographer is really tested. Getting it right is dependent on one's ability not only to identify but also to quantify the future trends as precisely as possible. This requires careful analysis as well as some luck.

The main objective of this paper was to present a procedure that would simply change the level of age specific migration rates of the preceding period by an additive amount in such a way that total migrants given by these rates would equal total migration projected independently. However, someone actually doing the projections needs to have additional steps in the process. The same Wisconsin example may be used to illustrate these details. Before proceeding to the 1990s, the 5-year age specific rates of the 1980s ought to be adjusted (within each of the four broad age-sex categories) so that, when the adjusted rates are multiplied by the 1990 expected population, total migration adds exactly to the projected total for the 1990s. While doing so, it would be necessary to keep the male/female proportions and the under- and over-55 shares the same as observed in 1990. The adjusted migration rates of age groups 10-14 and over would then be applied to the expected population in 2000 of the respective ages. A preliminary projection of the population 10 and over is now obtained by adding the expected population and net migrants. The female population of the reproductive ages is also thereby known, thus enabling the calculation of the weighted average of the reproductive female population at the midpoint of the first and second half of the decade. The 1990 population and the preliminary projected population would be used for this purpose. Projected fertility rates for the respective periods are then used to derive the projected intercensal births and the expected population of age under 10 that, in turn, would be multiplied by the appropriate migration rates. Total migration numbers for the four broad categories obtained in this process would be different from the desired targets based on the 1980-1990 sex ratio and under- and over-55 shares. The difference in the totals for the four categories as well as the state as a whole (despite the rate adjustment) is due to the difference between the 1990 and the 2000 expected populations. The migration rates need to be adjusted a second time within each of the four broad categories. The K adjustment this time uses the desired migration totals, the preliminarily projected net migration totals given by the migration rates adjusted earlier, and the 2000 expected population. This iterative process would ensure that the projected migration totals are the same as the desired numbers determined in the beginning.

Population projection is a complex undertaking. Careful analysis of the past and emerging trends, development of future fertility, mortality and especially migration scenarios, and the step-by-step and sometimes iterative calibration of the numbers makes the process intricate but interesting.

References

Kale, Balkrishna, John Besl, Charles Palit, Paul Voss, Frederick Krantz and Henry Krebs, "An Extension of the Vital Statistics Method to Derive Survival Rates," 1993 Proceedings of the Social Statistics Section, American Statistical Association, pp. 791-796.

Kale, Balkrishna, John Besl, Charles Palit and Paul Voss, "Updating Age-Sex-Specific Net Migration Rates with Limited Data," 1994 Proceedings of the Social Statistics Section, American Statistical Association, pp. 116-121.