

A Sex- and Age-wise Estimation of Future Population in Small Open Areas

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I. Introduction

Recently we are in urgent need of planning regional development projects, for which estimates of population by region are required as the most important basic factor. The rural-urban migration has recently come to exert serious effect on population of local communities, not only decreasing the size of population, but also resulting in excess of death rate over birth rate in not a few towns and villages. The influence of the migration between regions, therefore, has become far more important for the estimation of regional population than that of death and birth rate. There are various methods in estimating population which have been proposed and subjected for experimentation and verification, but, if not widely modified, those methods are not applicable in the regions with high social migration rates.

The population estimates referred to in this paper are based on the complete tabulations by sex and age of the 1965 National Census of the Population and, as for the death and birth rates, on the assumption of future specific fertility and mortality rates by age which are concluded from their current trends. On the other hand, it is also an obvious fact that the forecasted population of open area does not conform to expectations, which are simply based on fertility and mortality rates; social, political and economic forces influence greatly over both in-migration and out-migration. Therefore, the method of estimating the future population in open area should require a social migration estimate.

The fertility and mortality rates, by the way, have been considerably stable in recent several years, and yet the migration rates are varied very much depending upon the region, age and sex. The in-migration and out-migration rates are extremely high especially at the time of graduation from the junior and senior high schools. The estimates of population by sex and age are required every year even for a small region in view of establishing the regional project, but it is practically not possible in such a small area to expect a stable birth and death rate.

In consideration of these points, it seems to be extremely difficult to make the legitimate estimates of future population for a small open area, by sex and age and every year. However, we are strongly encouraged to develop new prediction methods, taking the advantage of the computer systems as well as in compliance with strong demands which came from the administrative organizations and private companies; the new methods and estimates will appear later in this monograph. As a matter of course, it should be made clear that, whenever better data are available to us, we will revise the present estimates.

II. Methodological Note

1. Grouping: The development projects should be made ultimately for each city, town and village for practice, but the estimation of migration rates and of future population by each community unit can not be obtained at a single jump because the fertility, mortality and migration rates there have too large variances. Therefore, 97 local administrative units (cities, towns and villages) in Okayama Prefecture were grouped in 4 classes according to their recent demographic characteristics -- age composition of population, migration pattern and proportion of cultivated land. The following table shows the outline of these 4 regions:

| Region | No. of Units | Characteristics |
|--------|--------------|---|
| A | 28 | Urban or semi-urban region, increasing in population. |
| B | 20 | Semi-urban region, being stationary in population. |
| C | 23 | Rural region, decreasing in population. |
| D | 26 | Rural region, decreasing in population and seriously in young population. |

We first computed the future population estimates for Regions A, B, C, D, and whole the prefecture respectively and made adjustments finally.

2. Population to be estimated: The total population by sex and age as of October 1 is estimated for each year from 1966 to 1975.

3. Basic population: The figures used as the basic population are the total population by sex and age based on the final counts of the 1965 National Census of the Population.

4. Basic demographic statistics for the estimates:

1) Age-wise specific fertility rates: At first, 5-age group specific fertility rates are extrapolated to the future on basis of an modified exponential curve adapted with the recent several years' data. Putting an emphasis on prefectural estimates, these estimates are adjusted one after another. Next, agewise specific fertility rates are interpolated from 5-age group specific fertility rates in the following way in order:

$$\int_{r(t-1)}^{rt} \left(\sum_{i=0}^{r-1} a_i x^i \right) dx = F(t) \quad (t=i, i+1, \dots, i+r-1)$$

$F(t)$: Estimated average specific fertility rate of ages from $r(t-1)$ to $rt-1$ years.

r : 3 or 5

For the age-wise specific fertility rates in three 5-age groups, i.e. 15-19, 40-44, and 45-49, exponential curve is applied instead of the above polynomials.

2) Age-wise specific mortality rates: Age-wise specific mortality rates are estimated as almost similarly as the above mentioned fertility rates. In the estimation of age-wise specific mortality rates for -1, 0, 1, 2, 3, 4 and 85 years and over, however, many other demographic data are used.

3) Age-wise specific, net migration rates: If the migration survey by sex and age has been made every year, age-wise specific, net migration rates will be estimated as similarly as the above mentioned rates. However, if not or if the crude rates have a large deviation, we should compute some estimates based on several assumptions

following the equation shown below and adjust them:

$$P(x+5, t+5) = P(x, t) \prod_{i=t}^{t+4} (1 - d(x+j-t, j)) (1 + m(x+j-t, j))$$

$P(x, t)$: Population of age x as of Oct. 1 of the year t , based on the National Census.

$d(x, t)$: Mortality probability in the population of age x as of Oct. 1 of the year t , during one-year period starting on Oct. 1, t .

$m(x, t)$: Excess probability of in-migration of the age x as of Oct. 1 of the year t over out-migration of the same age during one-year period starting on Oct. 1, t .

Some assumptions for m :

a. $m(x, t) = m(x)$, irrespective of the year.

b. $m(x+j-t, j) = p(j) m(x+j-t)$ ($p(j)$: absolute value of net total migration probability based on the Residence Registration Law; j : year)

4) Computation of population by sex and age as of October 1, each year from 1966 to 1975: We computed the population by sex and age as of October 1, each year from 1966 to 1975 as follows:

$$P(x+t, 65+t) = P(x, 65) \prod_{j=0}^{t-1} (1 - d(x+j, 65+j)) (1 + m(x+j, 65+j))$$

$$t = 1, 2, \dots, 10$$

$$x = 0, 1, \dots, 84$$

Newly-born infants are computed each year as follows and classified as male and female according to the recent masculinity of birth:

$$P(0, t+1) = \sum_{x=15}^{49} PF(x, t) f(x, t) (1 - d(-1, t))$$

$P(0, t+1)$: Population of age 0 as of October 1 of the year $t+1$.

$PF(x, t)$: Female population of age x as of October 1, t .

$f(x, t)$: Specific fertility probability in the female population of age x as of October 1 of the year t during one-year period starting on October 1, t .

$1-d(-1, t)$: Neo-natal probability, which means the survival rate of the babies born during the period between Oct. 1 of the year t and Sept. 30 of the year $t+1$, until October 1 of the year $t+1$.

5) Adjustment: Estimates by sex, age, and region for each year are finally adjusted as follows:

$$P'_A = kP_A, \quad P'_B = kP_B, \quad P'_C = kP_C, \quad P'_D = kP_D$$

$$k = P_P / (P_A + P_B + P_C + P_D).$$

P'_A : Adjusted population in Region A.

P_P : Estimated population in Okayama Prefecture.

III. Estimated Future Population as of Oct. 1, 1975

The next table shows the estimated future population by sex, 5-year age group, and region as of October 1, 1975. We estimated the future population by age but summarize

here by 5-age group only due to the space limit.

The political population means the future population estimated under the assumption that the out-migration rates at the graduation time of the junior and senior high schools can be reduced by 50%, by providing with an appropriate regional development project.

"Estimated Political Population by 5-Year Age Group, Sex and Region as of October 1, 1975."

| AGE G. | Male | | | | | Female | | | | |
|--------------|---------------|---------------|--------------|--------------|---------------|---------------|---------------|---------------|--------------|---------------|
| | A | B | C | D | KEN | A | B | C | D | KEN |
| 0 — 4 | 64649 | 14907 | 6520 | 4901 | 90377 | 60282 | 13930 | 6128 | 4569 | 84909 |
| 5 — 9 | 49459 | 12145 | 5933 | 4925 | 72352 | 45954 | 11309 | 5488 | 4611 | 67362 |
| 10 — 14 | 42166 | 11425 | 6593 | 5716 | 65900 | 39968 | 10750 | 6131 | 5571 | 62420 |
| 15 — 19 | 41979 | 12214 | 7687 | 6028 | 67908 | 43794 | 13520 | 7838 | 5774 | 70926 |
| 20 — 24 | 58275 | 12114 | 5396 | 4537 | 80812 | 49797 | 15181 | 8411 | 5743 | 79132 |
| 25 — 29 | 75606 | 11959 | 4128 | 3036 | 94729 | 69663 | 13412 | 5198 | 3828 | 92101 |
| 30 — 34 | 49085 | 7719 | 2716 | 2146 | 61665 | 53779 | 9077 | 3358 | 2695 | 68909 |
| 35 — 39 | 43780 | 8795 | 4404 | 3501 | 60480 | 43611 | 10057 | 5340 | 4274 | 63282 |
| 40 — 44 | 43742 | 11269 | 6847 | 5473 | 67331 | 42186 | 12069 | 7449 | 6012 | 67716 |
| 45 — 49 | 36986 | 11692 | 7670 | 6493 | 62841 | 35954 | 12568 | 8604 | 6839 | 63975 |
| 50 — 54 | 24739 | 8697 | 6113 | 5379 | 44928 | 30049 | 11178 | 7727 | 6441 | 55395 |
| 55 — 59 | 19509 | 7451 | 5159 | 4386 | 36505 | 24947 | 9701 | 6825 | 5461 | 46934 |
| 60 — 64 | 19316 | 7496 | 5280 | 4193 | 36285 | 23924 | 9591 | 6243 | 5136 | 44894 |
| 65 — 69 | 16282 | 6505 | 4655 | 3678 | 31120 | 20009 | 8118 | 5383 | 4265 | 37775 |
| 70 — 74 | 12292 | 5428 | 3766 | 3105 | 24591 | 15582 | 6799 | 4702 | 3560 | 30643 |
| 75 — 79 | 8105 | 3599 | 2774 | 2153 | 16631 | 10919 | 4720 | 3397 | 2596 | 21632 |
| 80 — 84 | 3380 | 1659 | 1425 | 1042 | 7506 | 5028 | 2349 | 1747 | 1377 | 10501 |
| 85 — | 1475 | 717 | 682 | 501 | 3375 | 2820 | 1329 | 985 | 747 | 5881 |
| TOTAL | 610825 | 155791 | 88233 | 70993 | 925847 | 618276 | 175658 | 100954 | 79499 | 974387 |

"Population (Oct. 1, 1965) and Estimated Population (Oct. 1, 1975) by 5-Year Age Group, Sex and Region."

Male

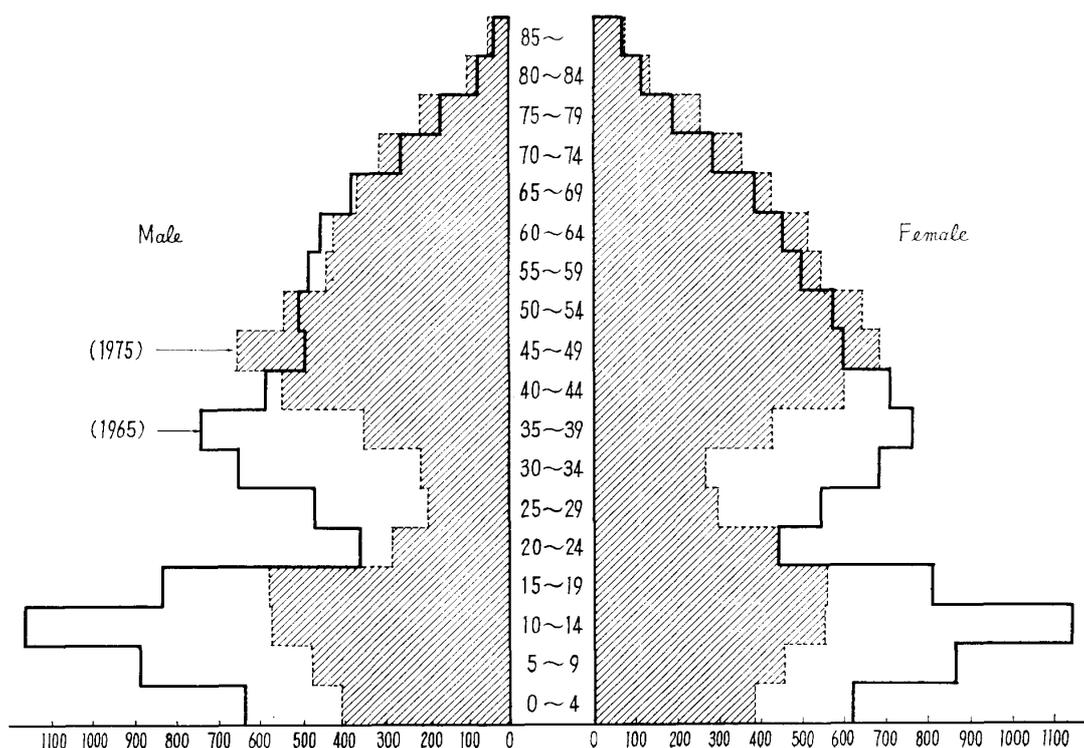
| AGE G. | Population as of Oct. 1, 1965 | | | | | Estimated Population as of Oct. 1, 1975 | | | | |
|--------------|-------------------------------|---------------|---------------|--------------|---------------|---|---------------|--------------|--------------|---------------|
| | A | B | C | D | KEN | A | B | C | D | KEN |
| 0 — 4 | 35953 | 11648 | 6814 | 6367 | 60782 | 60364 | 13864 | 5765 | 4044 | 84037 |
| 5 — 9 | 33630 | 13392 | 9273 | 8860 | 65155 | 48936 | 12018 | 5827 | 4730 | 71511 |
| 10 — 14 | 33003 | 15845 | 12066 | 11665 | 75579 | 42166 | 11425 | 6593 | 5716 | 65900 |
| 15 — 19 | 47627 | 17000 | 10264 | 8312 | 83203 | 39565 | 11877 | 7486 | 5745 | 64673 |
| 20 — 24 | 36162 | 9120 | 4284 | 3578 | 53144 | 46049 | 10676 | 4648 | 2829 | 64202 |
| 25 — 29 | 34533 | 9563 | 5316 | 4674 | 54086 | 62288 | 10703 | 3291 | 1946 | 78228 |
| 30 — 34 | 37415 | 12145 | 7429 | 6502 | 63491 | 49085 | 7719 | 2716 | 2146 | 61666 |
| 35 — 39 | 33978 | 12659 | 8317 | 7395 | 62349 | 43780 | 8795 | 4404 | 3501 | 60480 |
| 40 — 44 | 24413 | 9354 | 6602 | 5867 | 46236 | 43742 | 11269 | 6847 | 5473 | 67331 |
| 45 — 49 | 20524 | 8219 | 5526 | 4896 | 39165 | 36986 | 11692 | 7670 | 6493 | 62841 |
| 50 — 54 | 21488 | 8726 | 5928 | 5049 | 41191 | 24739 | 8697 | 6113 | 5379 | 44928 |
| 55 — 59 | 19579 | 8255 | 5730 | 4793 | 38357 | 19509 | 7451 | 5159 | 4386 | 36505 |
| 60 — 64 | 16807 | 7768 | 5257 | 4529 | 34361 | 19316 | 7496 | 5280 | 4193 | 36285 |
| 65 — 69 | 13681 | 6221 | 4614 | 3781 | 28297 | 16282 | 6505 | 4655 | 3678 | 31120 |
| 70 — 74 | 8251 | 4111 | 3199 | 2573 | 18134 | 12292 | 5428 | 3766 | 3105 | 24591 |
| 75 — 79 | 4892 | 2518 | 2020 | 1662 | 11092 | 8105 | 3599 | 2774 | 2153 | 16631 |
| 80 — 84 | 2219 | 1223 | 1024 | 774 | 5240 | 3380 | 1659 | 1425 | 1042 | 7506 |
| 85 — | 1002 | 516 | 450 | 388 | 2356 | 1475 | 717 | 682 | 501 | 3375 |
| TOTAL | 428157 | 158283 | 104113 | 91665 | 782218 | 578059 | 151590 | 85101 | 67060 | 881810 |

Female

| AGE G. | Population as of Oct. 1, 1965 | | | | | Estimated Population as of Oct. 1, 1975 | | | | |
|--------------|-------------------------------|---------------|---------------|--------------|---------------|---|---------------|--------------|--------------|---------------|
| | A | B | C | D | KEN | A | B | C | D | KEN |
| 0 — 4 | 34395 | 11019 | 6474 | 6177 | 58055 | 56290 | 12956 | 5419 | 3850 | 78515 |
| 5 — 9 | 32414 | 13272 | 9065 | 8633 | 63384 | 45467 | 11191 | 5391 | 4520 | 66569 |
| 10 — 14 | 34543 | 15673 | 11956 | 11442 | 73614 | 39968 | 10750 | 6131 | 5571 | 62420 |
| 15 — 19 | 59558 | 20037 | 10707 | 8070 | 98372 | 42173 | 13047 | 7634 | 5589 | 68443 |
| 20 — 24 | 46520 | 13326 | 6014 | 4467 | 70327 | 43601 | 13451 | 7056 | 4399 | 68507 |
| 25 — 29 | 37131 | 10940 | 6220 | 5407 | 59698 | 62612 | 12127 | 4404 | 2979 | 82122 |
| 30 — 34 | 38258 | 12681 | 7890 | 6849 | 65678 | 53779 | 9077 | 3358 | 2695 | 68909 |
| 35 — 39 | 34414 | 13103 | 8920 | 7617 | 64054 | 43611 | 10057 | 5340 | 4274 | 63282 |
| 40 — 44 | 29772 | 11742 | 8063 | 7080 | 56657 | 42186 | 12069 | 7449 | 6012 | 67716 |
| 45 — 49 | 25405 | 10451 | 7279 | 5983 | 49118 | 35964 | 12568 | 8604 | 5839 | 63975 |
| 50 — 54 | 24966 | 10554 | 6847 | 5739 | 48106 | 30049 | 11178 | 7727 | 6441 | 55395 |
| 55 — 59 | 21463 | 9245 | 6108 | 4957 | 41773 | 24947 | 9701 | 6825 | 5461 | 46934 |
| 60 — 64 | 18134 | 8231 | 5682 | 4504 | 36551 | 23924 | 9591 | 6243 | 5136 | 44894 |
| 65 — 69 | 14847 | 6676 | 4721 | 3829 | 30073 | 20009 | 8118 | 5383 | 4265 | 37775 |
| 70 — 74 | 9610 | 4693 | 3415 | 2846 | 20564 | 15582 | 6799 | 4702 | 3560 | 30643 |
| 75 — 79 | 6711 | 3407 | 2375 | 1924 | 14417 | 10919 | 4720 | 3397 | 2596 | 21632 |
| 80 — 84 | 4006 | 1985 | 1368 | 1146 | 8505 | 5028 | 2349 | 1747 | 1377 | 10501 |
| 85 — | 2150 | 1149 | 758 | 706 | 4763 | 2820 | 1329 | 985 | 747 | 5881 |
| TOTAL | 474297 | 178184 | 113862 | 97376 | 863719 | 598929 | 171078 | 97795 | 76311 | 944113 |

In addition to the above, as an example of a violent change in age distribution, we show here the population structures in Region D as of October 1, 1965 and 1975.

"5-Year Age Structure of Population in D Region as of October 1, 1965 and 1975"



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