# *The Demography of Aging in Japan: 1950—2025*

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**NUPRI Reseach Paper Series No.55**

**February 1990**

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Japan is midway through an aging transition that will multiply the number of old persons in relation to working-age persons by perhaps fourfold. Examination of age-distribution data indicates that this transition began around 1950, and population projections suggest that it will continue through the early decades of the next century. To assess the reliability of projection results, however, it is necessary to consider their robustness against the uncertainty of future trends in fertility and mortality. This is gauged by studying long-term trends in fertility and mortality as well as by considering relevant arguments. Population aging over the next years turns out to be remarkably insensitive to future trends in fertility and mortality. The aging that will occur derives primarily from the current age distribution of the population. In consequence, it may be predicted with more than usual confidence.

## I. Introduction

The aging of the Japanese population has received a great deal of attention, but there does not appear to have been a thorough study of the demography of this aging such as is supplied in this paper. Japan, along with many other countries in the world, is experiencing an historical shift toward larger numbers of old persons. This aging transition is a necessary consequence of the demographic transition to higher longevity and lower fertility, and it is important to view current trends in this broad historical perspective.

Significant advances in the analysis of age-distribution dynamics have been made in recent years--the recent paper by Horiuchi (1989) is indicative--but the analysis given here requires only systematic application of elementary demographic tools. We begin with historical perspective, looking at the record of changing age-distribution over the past century. A projection of the 1985 population forward to 2025 then provides an initial indication of what the record might look like in the future, subject to the uncertainty of the future course of fertility and mortality. The third and final step is, accordingly, to conduct a robustness analysis. We ask just how uncertain future trends of fertility and mortality are, by looking at the long-term historical record as well as at relevant arguments, and then determine how much effect this uncertainty has on the picture of aging provided by the base projection.

An important conclusion of the study, simple and obvious in retrospect, yet unanticipated, may be simply stated. The uncertainty of future trends in fertility and mortality is largely irrelevant to our assessment of the prospects for population aging in Japan over the next 40 years. The aging that will occur turns out to be largely determined by the current age distribution. This means that the future of aging may be predicted with considerable accuracy despite uncertainty about future fertility and mortality--a classic example of what Peter Drucker once called "the future that has already happened."

Population aging refers, of course, to the increase in numbers of older persons relative to the rest of the population. It may be gauged in various ways, of which the most common is probably the proportion of the population over age 65. Since most of the recent interest in aging derives from concern about the economic support of the older population, it is more appropriate to use a ratio of the number of working-age persons to the number of old persons. The working age is generally considered to begin at 15 and end at 65, but for Japan today, and especially in the future, it makes more sense to begin at 20 than at 15. The ratio of persons aged 20-64 to persons aged 65 and over will thus serve as our general index of aging. Age distributions in five-year groups are provided, however, for anyone who wishes to compute different measures for comparative purposes.

## II. Historical Perspective on Aging

Although data relating to age distributions for Japan as a whole became available only in the last decades of the 19th century, the overall shape of the age distribution had probably not changed greatly over the preceding several centuries. An accurate age distribution for 1886 (Feeney and Hamano 1990) shows ten persons aged 20-64 for each person aged 65 or over; the age distribution of the 1950 census shows exactly the same value. Since 1950, however, this ratio has declined rapidly; by 1985 it had fallen slightly below six persons aged 20-64 per person aged 65 or over.

The evolution of the age distribution during these years is shown in Table 1, which gives the age distribution of the total population at each census from 1950 through 1985. Reading down diagonals in the table shows the survivorship of birth cohorts: persons born during 1945-49 were aged 0-4 at the 1950 census (11.21 million persons), 5-9 at the 1955 census (11.04 million), and so on. The numbers do not change very much at the younger ages, where mortality is low. However, if we look at an older cohort, for example, persons aged 70-74 at the 1950 census, we see the numbers of survivors declining sharply, from 128 in 1950, to 88 in 1955, to 48 in 1960. The numbers of persons aged 20-64, 65 and over, and the ratio between them are shown at the bottom of the table.

## III. The 1986 NUPRI Projection

The rapid aging of the Japanese population that has been occurring since 1950 will continue through the second decade of the next century. This prediction can be asserted with confidence because future aging will be determined largely by the shape of the current age distribution, which we know with certainty, and only slightly by the future course of fertility and mortality, about which we can only speculate. Its substantiation, however, requires some detailed empirical analyses. The first and simple step, accomplished in this section, is to see what a current population projection indicates for future aging. The second and more difficult step is to see how sensitive these results are to various possible future trajectories of fertility and mortality. This requires a judgment about the range of possibilities for those trajectories that may be derived both from historical experience and from relevant argument. These matters are addressed in subsequent sections.

Table 2 shows in summary form the results of a 1986 Nihon University Population Research Institute (NUPRI) population projection (Ogawa and others 1986: 93-101). The numbers for 1990 and later years are generated by projecting the 1985 age distribution in the first column into the future based on assumptions about future fertility and future mortality. The first step is to compute numbers of persons who will survive into the future at five-year intervals, applying death rates based on past experience. This fills in the cells in Table 2 that fall below the indicated diagonal line. The cells above this line correspond to survivors of births to the initial population and its descendants. The calculation of numbers of future births will be discussed further below; for the present, we simply accept the numbers of births in the NUPRI projection, shown in the first row of the table. The final step is to determine how many of the persons born in each period will survive to future years, and the procedure here is essentially the same as that used to compute the survivors of the initial population.

Table 2 has the same form and, except for the speculative nature of the entries, the same interpretation as Table 1. The ratio of persons 20-64 to persons 65 and over continues to decline rapidly for three decades, falling from 5.9 in 1985 to 2.3 in 2015. The latter value is not far from what would be observed in a stationary population with current mortality.

According to this projection, then, the Japanese population is slightly more than halfway through an aging transition that will last altogether for about three-quarters of a century and bring the ratio of persons aged 20-64 to persons aged 65 and over down from roughly 10 to two, a decline of 80 percent. Before accepting this conclusion, however, we must consider how it would be affected by future trajectories of fertility and mortality different from those utilized in the NUPRI projection. We begin in the following section with mortality.

## IV. Mortality Decline in Japan: History and Prospects

The survivorship calculations in population projection are made using survivorship ratios, proportions of persons in a given age group at a given time who survive a given number of years into the future. We study mortality trends using the corresponding death rates, the nature of which may be indicated by reference to Table 1. Among the 3.39 million persons aged 50-54 in 1950, for example, only 3.21 million were surviving in 1955. The number dying is thus 0.18 million, and this represents 5.31 percent of the 3.39 million persons we started with. We call this 5.31 percent a period-cohort death rate, both to distinguish it from the age-specific death rate, and to indicate that the set of deaths counted in its numerator is represented in the Lexis diagram by the intersection of a time period and a cohort.

Though these death rates are defined in terms of numbers of persons in successive age groups at two points in time, this is not in general a suitable procedure for calculating them because it is unduly sensitive to small errors in the numbers of persons counted in the censuses and to small numbers of international migrants. We compute them, rather, from the ${}_5L_x$ column of a life table, the rate for persons aged x to x+5 at the beginning of any five-year period being one minus ${}_5L_{x+5}/{}_5L_x$.

Table 3 shows the death rates for males and females computed from the annual life tables constructed by the Institute of Population Problems for 1960 through 1985 (Institute of Population Problems 1961-1985). Rates are shown for age groups 40-44 through 90-94 only, rates for younger age groups being too low (1 percent or less) to have a significant impact on aging.

The life tables give data for five-year age groups to 95-99, so the rate for 90-94 is the highest that can be computed. It should be noted, however, that the population and death data from which the life tables are computed end with an 85+ age group, so that the life table data for 85-99 result from an extrapolation in the life table construction. The truncation of the data at age 85 is imposed by the population data, which are estimates made by the Bureau of Statistics, Prime Minister's Office.

The death rates for males and females are plotted in Figures 1 and 2, respectively. The horizontal axis in every plot represents the years 1960-85, but the vertical axes are scaled according to the range of the values plotted. This variable scaling has the advantage of spreading the plotted points over the whole available plotting space, and thus of maximizing the visibility of fluctuations in the series, but it also means that the plots are not comparable in their indications of level and slope. For example, the slope in all the plots appears roughly the same, but this is a necessary consequence of the scaling of the vertical axes.

The pattern of mortality decline shown in Figures 1 and 2 is simple but remarkable: it is linear. Each plot in the series shows, in addition to the observed data, plotted as points, a fitted straight line. The fits were made visually, but they are sufficiently close that a more formal procedure, such as least squares, would have given negligibly different results. While the fit of these straight lines is not perfect, there is remarkably little evidence of curvature in the observed points. Exceptions to the linear pattern are at the younger ages, 45-49 through 55-59 for males and 40-44 through 55-59 for females, where death rates are lower and the potential for increased survivorship correspondingly limited. It is possible that the relatively high death rates for these age groups in the early 1980s reflect the fact that these cohorts were adolescents and young adults during the Second World War (Okubo 1981; Horiuchi 1983).

This pattern is remarkable because it is contrary to what might have been expected on simple _a priori_ grounds. Since death rates cannot go below zero, the rate of decline of mortality rates over time must eventually decrease as rates approach zero. This leads us to expect curvature in plots of mortality rates against time. While this argument is unexceptionable, it does not rule out linear declines in death rates so long as the rates remain sufficiently above zero. The plots show that the curvature is minimal even at the younger ages, where death rates are only a few percent, and entirely lacking at the older ages.

What are the prospects for future mortality decline in Japan? The simplest answer is given by extrapolating the linear trend of the past 25 years into the future. The linear trend cannot continue indefinitely, of course, but we are not concerned with "indefinitely," only with the next several decades. Table 4 shows the death rates that result from extrapolating the linear declines shown in Figures 1 and 2 twenty years into the future. The extrapolated male rates, which are substantially higher than the female rates, remain above zero during this period, and the extrapolation produces only one irregularity in the age pattern of mortality: rates for the 55-59 age group are below the rates for the immediately surrounding age groups. We smooth out this irregularity by replacing the rate for the 55-59 age group in 2000-05 by the average of the rates immediately above and below it, and replacing the two preceding rates on the same line by values linearly interpolated between the first and last values in the row. For females, the rates for four of the younger age groups go to zero between the mid-1997 and mid-2002 period, for which reason they have been set equal to zero.

To test the age pattern of mortality resulting from this extrapolation we use the extrapolated death rates for the period 2000-05 together with the ${}_5L_x$ values from the Institute of Population Problems 39th life table for 1985 (Institute of Population Problems 1986) to construct synthetic ${}_5L_x$ schedules and $e_0$ values for males and females. This understates survivorship at the younger ages slightly, but adjustment for this would not be worthwhile in the present context because survivorship at these ages is already so close to its maximum value. The result is shown in Table 5. The expectation of life at birth works out to 81 years for males and 88 years for females. Though the survivorship curves are higher than anything observed up to present in a large human population, it is notable that the male curve extrapolated for the years 2000-04 is roughly the same as the current female curve. The mortality pattern resulting from this crude extrapolation is quite reasonable, as may be judged by comparing it with model life tables recently constructed for very low mortality levels (Coale and Guo, no date).

While there is not a great deal of curvature in the time series of death rates shown in Figures 1 and 2, there is enough to suggest that some form of curvilinear extrapolation might improve on linear extrapolation for some age groups (Pollard 1987). We have, nonetheless, preferred the simpler linear extrapolation. The curvature in the observed data is slight and occurs only for the younger age groups, where death rates are low, so that curvilinear extrapolation would not make a great deal of difference in our results. At the same time, curvilinear extrapolation would be substantially more problematic. There are an indefinite number of curvilinear forms, which may give results lying anywhere between the extreme of the linear extrapolation we have adopted and the assumption that future death rates will remain constant at the most recently observed levels. Without some basis for choosing the particular form, the results would be arbitrary and subjective. No theory indicates a choice, hence we must rely on the process of choosing a form according to its fit to past experience. Even on the assumption that the pattern of past mortality change contains information about the future pattern, which is by no means obvious, the fitting will be problematic in this case be-cause the errors or irregularities in the time series are large re-lative to the curvature in the series. The argument against curvilinear extrapolation is not that these difficulties are insurmountable, but that the benefits they would bring to the analysis of population aging are not worth the various costs involved.

A recent study (Institute of Population Problems 1986) extrapolates mortality through the year 2075, 90 years into the future, and obtains $e_0$ values for that year slightly lower than those we have obtained for 2000-04, only 15-20 years into the future. This large discrepancy is puzzling, given the clear trends in Figures 1 and 2, and requires explanation. The study presents cause-specific standardized death rates for 1955 through 1984 (Table 3, page 36), fits various curvilinear forms to these data (Table 4, page 37), extrapolates the rates forward to 2075 (Table 5, page 38), and uses these extrapolations to construct unabridged life tables at intervals from 1985 through 2075 (appendix tables). Age-adjusted death rates are weighted averages of age-specific death rates, with the weights being defined by the age distribution of a "standard" population. The rates with which the extrapolation begins are thus heavily weighted by mortality rates at ages under 60, for which mortality rates are already so low that they cannot decline very rapidly. The problem is compounded by the use of the 1935 age distribution of Japan as the standard, an age distribution for which the proportion of old persons is very small indeed. The extrapolation thus puts very little weight on the death rates of the very old, though it is precisely changes in mortality rates at these ages that must of necessity be the principle source of future mortality decline. The slow rate of decline is thus a consequence of the extrapolation procedure and does not accurately reflect recent declines in mortality.

## V. The Effect of Future Mortality on Aging

Lower death rates in the future mean larger numbers of survivors at older ages, but the potential for larger numbers of survivors depends on the level of the death rate. For the younger ages, where death rates are already very low, even large relative declines in the death rate will have little effect on the numbers of persons surviving. Given the levels of mortality prevailing in 1985, for example, roughly 1 percent of those aged 40-44 will die within five years, leaving 99 percent of the group surviving. In this case, bringing the death rate down to zero will only increase the percentage of survivors from 99 to 100 percent, a minor change.

The more important effects of future declines in mortality are at older ages, where death rates are higher and the potential for increases in numbers of survivors greater. Considering again the level of mortality prevailing in 1985, roughly 30 percent of persons aged 75-79 will die within five years, leaving only 70 percent surviving. In this case, a 50-percent decline in death rates will raise the percent surviving from 70 to 85, an increase of slightly over 20 percent.

In general, simple extrapolation of a linear trend may give values that are either too high or too low. In the present case, however, it seems reasonable to argue that the linear extrapolations shown in Table 4 give the most rapid rate of mortality decline and the lowest death rates we can reasonably expect. We would not be surprised to see mortality decline more slowly than this, and while we might not be too surprised to see it continue to decline at this rate, we would certainly be surprised to see it decline more rapidly.

Since more rapid mortality decline implies more rapid aging, we recalculate the NUPRI projection shown in Table 2, using our extrapolated death rates, to obtain what may be considered a lower bound on the decline of the aging ratio over the next 20-40 years. The results are given in Table 6, which shows the results of using the extrapolated death rates in Table 4 for the first four quinquennial periods and the death rates in the last column of Table 4 for the following four periods. Though the numbers shown in Table 6 are for total population, they have been computed by projecting the numbers of males and females separately and adding the results.

The middle panel of Table 6 shows the total numbers 20-64 and 65+ and the aging ratio and, for convenience, the corresponding values for the NUPRI projection from Table 2. We see that with rapidly declining mortality the aging ratio comes down to 2.9 in 2005, as compared with 3.2 in the NUPRI projection, a difference of 10 percent, and down to 1.9 in 2025, as compared with 2.3 in the NUPRI projection, a difference of 20 percent. Thus, the effect of rapidly declining mortality on population aging is to decrease the aging ratio by a maximum of 20 percent. Though not insignificant, this is still minor in relation to the overall decline in the NUPRI projection, which brings the aging ratio from 5.9 to 2.3, a decline of over 60 percent.

There is one potentially important respect, however, in which the effects of rapidly declining mortality are important. While overall aging is not much affected by rapid mortality decline, the numbers of persons at very old ages are greatly affected. The bottom panel of Table 6 shows the ratio of the numbers of persons given in the upper panel, projected on the assumption of rapid mortality decline, to the corresponding numbers in the NUPRI projection. We see that the numbers in the oldest age groups are much larger under the assumption of rapidly declining mortality, particularly in the more distant future. In the extreme case, the number of persons 85 and over in 2025 for the rapid mortality decline projection is nearly double the corresponding number in the NUPRI projection.

## VI. Mortality Forecasts in Previous Projections

Before turning to the study of fertility trends we note that previous population projections for Japan have substantially underestimated the rate of mortality decline. Tables 7-10 show the mortality rates assumed in four past projections, the Institute of Population Problems projections of 1976, 1981 and 1986 and the Nihon University Population Research Institute projection of 1986 (Institute of Population Problems, 1976, 1982, 1987; Ogawa and others, 1986). They have been computed directly from the projected age distributions. These projected death rates are compared with actual death rates in Figures 3 and 4, for males and females, respectively.

The mortality assumed by the 1976 IPP projections for 1976-85 has turned out to be substantially higher than the observed mortality for this period for nearly every age group and for both sexes. The same is true of the 1981 Institute of Population Problems projection, though there is less data for comparison here and the results are not so clear. The general pattern in the plots is for the observed series to slope down substantially more sharply than the projected series. Since the projected series generally begin with values close to the corresponding observed values, there is an increasing divergence as we move into the future.

For the 1986 projections, of course, we have no comparison to observed values, but we can compare the mortality assumptions used in the NUPRI projection with those used in the Institute of Population Problems projection. In general, the NUPRI projection assumes substantially lower mortality, and past experience suggests that this may be closer to the mark than the Institute of Population Problems values. However, even the NUPRI values level off after 10 years and do not correspond to anything observed in the past data.

## VII. Fertility Decline in Japan: History and Prospects

We turn now to the history of fertility decline in Japan. Figure 5 shows the trend of completed fertility between 1910 and 1982, a period that covers the entire demographic transition in Japan. The values for 1960-1982, calculated from period parity progression ratios, are from Feeney (1986: 20). The values for earlier years are mean numbers of children ever born from the censuses of 1950, 1960 and 1970, given in the first rows of Tables 11-13. Data from the 1980 census would have been used as well, but the children ever born item was inexplicably dropped from the 1980 census.

The mean children ever born values are dated by imputing all childbearing to woman's age 25. This simple device, which uses mean children ever born values for cohorts to estimate period completed fertility, provides an approximation only, but works remarkably well. This is indicated by the consistency of the values derived from the three censuses which also shows the quality of the data and relatively minor influence of mortality selection effects, as well as the consistency with the later period values. The same device is used below to date the corresponding parity progression ratios, and also (as in Feeney and Saito 1985: 2-4) the proportion of women born who ever marry.

Completed fertility was about four-and-a-half children per woman during the 1920s. By the early 1960s it had fallen to slightly over two children per woman. From 1961 through 1973, it was very nearly constant at 2.08, (population replacement level), punctuated only by the sharp drop in 1966, hinoeuma (Year of the Fire Horse). It dropped sharply between 1973 and 1976, a period of economic adjustment following the first oil shock, and then stayed level through 1982 at 1.83 children per woman.

Figures 6 through 10 break this trend of completed fertility down into its parity progression components. Progression of women from their own birth to birth of their first child is further broken down into progression from birth to first marriage and progression from marriage to first birth. The figures for progression from birth to first marriage for the years 1960-1982 are from Feeney and Saito (1985: 24). Values for earlier years are computed from census data on marital status (Feeney and Saito 1985: 2-4). Progression from marriage to first birth and higher order progressions for the years 1952-1982 are from Feeney (1986: 20). Values for earlier years are calculated from the census distributions of women by number of children ever born data. They are given in Tables 11-13.

Figure 6 shows what proportion of women ever married over the period. Roughly 99 percent of all women married during the 1910s and

1920s. A gradual decline set in during the 1920s, bringing the proportion ever marrying down to around 95 percent in the early 1950s. The pattern of the period statistics from the early 1950s through 1982 is erratic. The early decline was abruptly reversed in 1956, with period proportions ever marrying rising sharply to about 97 percent in 1964, a level that held approximately until 1970, at which time the series plunges down with equal abruptness to an historical low of 92.5 percent, at which point it appears--though with very little data in--to have leveled off.

Should we wish to extrapolate this series into the future, there are two obvious extremes. We might assume, first, that the fluctuations over the past 30 years have been due primarily to shifts in age at marriage. This would lead to taking some sort of average level of proportion ever marrying, drawn in here as 95.6 percent, as representative both of the past and of the immediate future. We would accordingly extrapolate a rise in the series back toward this level. Alternatively, we might take the most recent levels as indicative of what the future holds and extrapolate this most recent level, 92.5 percent. The choice between these alternatives hinges on our interpretation of what has happened in the past, whether or not there have been fundamental changes bearing on marriage that would tend to reduce the proportion of women who ever marry. Both the long-term historical trend and current tendencies toward higher education and labor force participation for women argue for some fundamental change.

Extrapolation of further decline is another possibility, but we would be hard pressed to decide what the rate of decline should be. Extrapolating the decline observed during the 1970s would reduce proportions ever marrying radically and would be unreasonable without compelling additional evidence and/or argument.

Figure 7 shows the trend of progression from marriage to first birth. The census data for the years before 1960 indicate that proportions of women having a first birth were slowly but steadily rising, from around 90 to 93 percent, between 1910 and 1950--during which period overall fertility declined sharply. To put it differently, childlessness was decreasing during this period, from about 10 to about 7 percent. It is possible that this indication is spurious, due only to errors in the census data, but the consistency of the results from the three different censuses, though imperfect, suggests that this is not the case. The annual period statistics to the right of the plot show a bilevel pattern similar to that observed for the total fertility rate, with a level of about 94 percent (punctuated by hinoeuma) up to 1973 followed by a sharp drop (somewhat more extended here than in Figure 5) to just under 92 percent in the early 1980s.

Figure 8 shows proportions of women progressing from first to second birth. Prior to 1930, some 91 percent of women having a first birth went on to have a second. This proportion began to turn down in the 1930s, reaching a level of about 86 percent in the 1950s. The period statistics on the right of the plot show a somewhat erratic pattern, fluctuating around 84 percent circa 1960, then rising sharply (with the usual hinoeuma spike) to a peak slightly over 88 in 1973, only to fall even more abruptly over the next four years. The bi-level pattern is hardly present here, but we have nonetheless drawn in two levels that might be extrapolated into the future. The lower level, 85.4 percent, is the average level for the last five years of the series. The higher level, 96.5 percent, is an eye-balled value chosen to tie together the period statistics on the right with the tail end of the census figures on the left.

Figure 9 shows proportions of women having two or more children who go on to have a third. Observe the change in vertical scale here to accommodate the much greater movement in this series. The pre-transition level of progression to third birth was about 90 percent, as consistently indicated by all three censuses. It turned down sharply in the late 1930s, falling to something over one half in the mid-1950s. The decline in these census values is picked up by the annual period statistics on the right-hand side of the plot, bringing progression to third birth down to 36 percent just prior to the hinoeuma dip.

This plot of progression from second to third birth shows the greater part of the demographic transition in Japan. Most women progress through the earlier stages, marriage and first and second birth, both before and after the transition, and while progression to higher birth orders declines sharply as well, the impact of these declines is strongly attenuated by the decline in proportions of women who reach higher parities.

The bilevel pattern for recent years is very pronounced here, with values nearly level at 36 percent prior to 1973 and at 30 percent after 1975. It is notable that the drop in this series occurs over only two years, as compared with four years in the preceding two plots.

Figure 10 shows the next progression, from third to fourth birth. It is also the last progression we shall consider, for we are interested primarily in recent fertility, for which fifth and higher order births are of negligible importance. The broad pattern is almost identical to that of the preceding plot. The gap between the census values on the left and the annual period statistics on the right is more pronounced, no doubt partly because fifth births occur at significantly older ages, and perhaps also partly due to errors in the early years of the annual series. Pretransition levels of progression to fourth birth are about 86 percent, 4 percent below the level for progression to third birth, and the decline brings them down to 20 percent by the mid-1960s. The bilevel pattern since then is very clear, with the decline from the higher to the lower level taking place, as in the previous plot, over two years.

What are the prospects for fertility in Japan? The demographic transition began around 1930 and ended in the early 1960s. From this time until 1973, fertility remained nearly constant and almost exactly at replacement level. Between 1973 and 1976, a period of social and economic adjustment following the first oil shock, fertility fell from 2.1 to 1.8 children per woman--a level which has been maintained through the end of our data series in 1982. Given the trend of fertility in recent years, the only sensible extrapolation into the future is the continuation of recent levels, recognizing that movements up or down of a magnitude similar to the change of the mid-1970s are possible at any time. While it is not possible to go much beyond this, we can argue that movements down are marginally more likely than movements up in the near future. Figures 11 and 12 show the completed family size distributions implied by the two levels identified in Figures 6-10. Comparing them, we see that the proportion of women having two children in each case are almost identical. Nor is there any difference in the proportions of women having a single child. The low fertility in the recent past results entirely from a rise in the proportion of women having no children, with both a rise in the proportion never marrying and in the proportion marrying and remaining childless, and a corresponding fall in the proportion of women having three or more children.

The recent rise in childlessness reflects both increasing nonmarriage and increasing childlessness within marriage. In considering the trend toward increasing nonmarriage, it is necessary to distinguish the long-term increase associated with the demographic transition from the fluctuations observed since 1950. As shown in Figure 6, the former brought proportions of women ever-marrying down from about 99 to about 95 percent, roughly a five-fold increase in proportions of women never marrying. This increase is not likely to be reversed. These are cohort statistics, unaffected by changes in the timing of marriage, so that there is no question of the reality of the change. One is tempted to infer an increase in social options for nonmarried women, though this is no more than a speculation pointing toward research of a less statistical and more documentary nature. In particular, the decline in mortality since the turn of the century has increased the possibility of women remaining for extended periods with their family of origin. While the period statistics for recent decades fluctuate widely, the pattern taken as a whole suggests a continuation of the long-term historical decline at a slower rate.

The situation with respect to childlessness within marriage is quite different. Here the long-term historical trend is down, as shown in Figure 7, from about 10 percent early in the century to about six percent in the 1960s and early 1970s, suggesting continued cultural emphasis on childbearing in marriage. The increase that occurred between 1973 and 1977, bringing period childlessness up from six to eight percent, occurred during the general readjustment of fertility that followed the first oil shock and may have represented an intention on the part of the couples involved to delay first birth rather than to remain childless. The failure of the period indicators to rise over the following five years casts some doubt on this, however, and in any case the parents' intentions at the time will not necessarily be realized. All in all, the indications of the future are neutral. The traditional cultural emphasis on childbearing within marriage suggests the likelihood of a resurgence, but cultural pressure will not necessarily reach the very small number of women involved. This, combined with the expectation that proportions ever-marrying are more likely to fall than to rise, suggests the same for fertility.

## VIII. The Effect of Future Fertility on Aging

Though the element of uncertainty regarding the future of fertility is greater than that regarding the future of mortality, the effect on population aging over the next 20-40 years is smaller than that for mortality. This is a result of purely formal demographic structure. Looking forward from 1985, as in Table 2, the level of fertility for the first 20 years, through 2005, has no effect on aging for the simple reason that the aging ratio depends only on the population over age 20. The values of the ratio of persons 20-64 to persons 65 and over for the first 20 years of the projection are completely determined by the initial age distribution and stipulated future mortality.

When we move 25 years into the future, future fertility begins to have an effect on population aging, but the effect is necessarily small. Looking at the numbers for the year 2010 in Table 2, we see that only the 6.91 million persons who are the survivors of births during 1985-90 appear in the calculation of the aging ratio. Thus, even a large change in the projected number of births will have a relatively small effect on the aging ratio. The same holds, with somewhat less force, 30 years forward. Even after 40 years, roughly half the numerator of the aging ratio consists of survivors of the initial population, so that any deviation of future numbers of births from the NUPRI projected values will be attenuated by about one-half.

To get an idea of the importance of future fertility for aging 20-40 years into the future, we consider a scenario of "low births" that will almost surely fall below future numbers of births and a scenario of "high births" that will surely lie above future numbers of births. In the low-birth scenario, numbers of births decline by 10 percent in each five-year period, which corresponds to period total fertility falling to 1.1 children per woman in the period 2000-2004. In the high-birth scenario, numbers of births increase by 10 percent in each period, which corresponds to period completed fertility rising to 2.5 children per woman in this same period.

The most extreme effect is, as expected, in farthest out ratio, for 2025, for which the low-birth scenario raises the aging ratio from 2.3 to 2.5, and the high-birth scenario lowers it from 2.3 to 2.1. Thus, the effect of any likely changes in fertility over the first 20 years of the projection will be under 10 percent in the year 2025 and substantially less than this for the preceding periods. While not entirely negligible, this effect is minor indeed compared to the long-term trend, which is bringing the ratio from around 10 to something over two, a decline of nearly 80 percent.

## IX. Conclusion

Japan is in the middle of an aging transition that appears to have begun in 1950, when there were some 10 working-age persons for each old person. It will continue through the early decades of the next century, when there will be about two and one-third working-age persons for each old person. This is close to what would be observed in a stationary population with our extrapolated mortality schedule for 2000-04, which will mark the end of the long-term historical transition.

There is more than a little artifice in choosing a particular age and declaring by statistical fiat that everyone over this age is "old." This is an innocent enough proceeding when studying the formal demography of aging, as is done in this paper. Its institutionalization in government "social security" programs, particularly of the unfunded variety, is another matter. The welfare aspects of these programs are well recognized and generally accepted. An individual's decision to retire, however, naturally involves various trade-offs, including a reduction as opposed to complete cessation of work, and retirement at an earlier age with lower benefits versus retirement at a later age with higher benefits. Some indication of the variability of the results may be gained by looking at labor force participation rates at older ages (Statistics Bureau 1982: 194-195), which decline gradually from close to 100 percent at age 55 to slightly over 10 percent at age 85. Government programs tend to transform what would otherwise be large numbers of individual retirement decisions into a small number of highly visible and problematic political decisions about program structure. What is sometimes referred to as "the aging problem" might better be regarded as a problem of old-age support programs ill-adapted to emerging demographic realities.

## Acknowledgements

This work has been carried out in cooperation with the Nihon University Population Research Institute (NUPRI) of Nihon University, with the support of NUPRI and of the East-West Population Institute. Naohiro Ogawa, Linda Martin, Shiro Horiuchi and Glenda Roberts supplied valuable comments on an earlier draft. I was assisted in dealing with Japanese-language sources by many persons at NUPRI. My thanks and appreciation to all.

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Table 1. Historical Experience of Population Aging: 1950-1985
(both sexes, numbers in 0,000)

| Age | Year 1950 | 1955 | 1960 | 1965 | 1970 | 1975 | 1980 | 1985 |
|---|---|---|---|---|---|---|---|---|
| 0-4 | 1121 | 925 | 784 | 813 | 881 | 1000 | 852 | 746 |
| 5-9 | 952 | 1104 | 920 | 785 | 816 | 894 | 1003 | 853 |
| 10-14 | 870 | 951 | 1102 | 918 | 786 | 828 | 896 | 1004 |
| 15-19 | 857 | 863 | 931 | 1085 | 906 | 795 | 827 | 898 |
| 20-24 | 773 | 840 | 832 | 907 | 1066 | 907 | 784 | 820 |
| 25-29 | 619 | 760 | 821 | 836 | 909 | 1079 | 904 | 782 |
| 30-34 | 520 | 612 | 752 | 826 | 837 | 925 | 1077 | 905 |
| 35-39 | 505 | 512 | 604 | 750 | 821 | 842 | 920 | 1074 |
| 40-44 | 448 | 495 | 502 | 596 | 734 | 822 | 834 | 913 |
| 45-49 | 400 | 437 | 482 | 492 | 588 | 736 | 809 | 824 |
| 50-54 | 339 | 385 | 420 | 466 | 481 | 578 | 720 | 793 |
| 55-59 | 275 | 321 | 364 | 400 | 442 | 467 | 561 | 700 |
| 60-64 | 230 | 250 | 293 | 334 | 373 | 428 | 447 | 541 |
| 65-69 | 177 | 197 | 216 | 256 | 298 | 345 | 396 | 419 |
| 70-74 | 128 | 139 | 156 | 174 | 213 | 258 | 302 | 356 |
| 75-79 | 69 | 88 | 96 | 110 | 127 | 164 | 204 | 249 |
| 80-84 | (37) | 38 | 48 | 53 | 65 | 81 | 109 | 143 |
| 85+ | - | 13 | 19 | 25 | 30 | 39 | 53 | 78 |
| Total | 8320 | 8930 | 9342 | 9826 | 10373 | 11188 | 11698 | 12099 |
| 20-64 | 4109 | 4612 | 5070 | 5607 | 6251 | 6784 | 7056 | 7352 |
| 65+ | 411 | 475 | 535 | 618 | 733 | 887 | 1064 | 1245 |
| Ratio | 10.0 | 9.7 | 9.5 | 9.1 | 8.5 | 7.6 | 6.6 | 5.9 |

Sources: Population Census of 1950, Vol. IV, All Japan 1, Table 2, p. 4; 1955 Population Census of Japan, Vol. III, Part 1, Table 2, pp. 42-43; 1960 Population Census of Japan, Vol. 3, Part 1, Table 1, pp. 18-20; 1965 Population Census of Japan, Vol. 3, Part 1, Table 1, pp. 2-3; 1970 Population Census of Japan, Vol. 2, Whole Japan, Table 2, pp. 6-7; 1975 Population Census of Japan, Vol. 2, Whole Japan, Table 2, pp. 6-7; 1980 Population Census of Japan, Vol. 2, Part 1, Table 2, pp. 6-7; 1985 Population Census of Japan, Vol. 2, Part 1, Table 3, pp. 8-9.

Table 2. The NUPRI Baseline Projection: 1985-2025
(both sexes, numbers in 0,000)

| | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
| Births | - | 698 | 726 | 798 | 768 | - | - | - | - |
| 0-4 | **746** | 694 | 722 | 793 | 763 | - | - | - | - |
| 5-9 | 854 | **745** | 693 | 721 | 792 | 762 | - | - | - |
| 10-14 | 1004 | 853 | **744** | 692 | 721 | 791 | 761 | - | - |
| 15-19 | 898 | 1003 | 852 | **744** | 692 | 720 | 790 | 760 | - |
| 20-24 | 820 | 896 | 1000 | 850 | **742** | 691 | 719 | 789 | 759 |
| 25-29 | 783 | 818 | 894 | 998 | 848 | **741** | 689 | 718 | 787 |
| 30-34 | 906 | 780 | 816 | 892 | 996 | 846 | **739** | 688 | 716 |
| 35-39 | 1074 | 902 | 777 | 813 | 889 | 993 | 844 | **737** | 686 |
| 40-44 | 914 | 1067 | 896 | 773 | 808 | 884 | 988 | 839 | **733** |
| 45-49 | 824 | 904 | 1056 | 887 | 765 | 801 | 876 | 978 | 831 |
| 50-54 | 794 | 810 | 890 | 1042 | 876 | 755 | 791 | 864 | 966 |
| 55-59 | 700 | 774 | 792 | 874 | 1025 | 862 | 744 | 778 | 851 |
| 60-64 | 541 | 675 | 750 | 773 | 854 | 1003 | 844 | 728 | 763 |
| 65-69 | 420 | 512 | 643 | 721 | 746 | 826 | 971 | 816 | 705 |
| 70-74 | 357 | 381 | 471 | 598 | 674 | 698 | 773 | 912 | 764 |
| 75-79 | 249 | 299 | 326 | 409 | 520 | 588 | 609 | 674 | 799 |
| 80-84 | 143 | 181 | 220 | 245 | 310 | 393 | 443 | 459 | 507 |
| 85+ | 78 | 108 | 138 | 168 | 192 | 235 | 291 | 337 | 362 |
| Total | 12106 | 12402 | 12680 | 12993 | 13213 | - | - | - | - |
| 20-64 | 7356 | 7626 | 7871 | 7902 | 7803 | 7576 | 7324 | 7119 | 7092 |
| 65+ | 1248 | 1481 | 1798 | 2141 | 2442 | 2740 | 3087 | 3198 | 3137 |
| Ratio | 5.9 | 5.1 | 4.4 | 3.7 | 3.2 | 2.8 | 2.4 | 2.2 | 2.3 |

Source: Ogawa and others (1986: 83-101).
Note: Number of births shown in column corresponding to end of time period. Thus 698 gives the number of births during 1985-89. Births calculated from projected number 0-4 by reverse-survival using life table values given in Table 5 below.

Table 3. Period-Cohort Death Rates (per 100) Computed from the Institute of Population Problems Life Tables: 1960-1985

| Sex and Age | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| Male | | | | | | | | | | |
| 40-44 | 2.55 | 2.40 | 2.42 | 2.35 | 2.35 | 2.26 | 2.21 | 2.16 | 2.12 | 2.14 |
| 45-49 | 3.98 | 3.89 | 3.75 | 3.62 | 3.62 | 3.47 | 3.36 | 3.28 | 3.23 | 3.23 |
| 50-54 | 6.42 | 6.34 | 6.01 | 5.81 | 5.79 | 5.56 | 5.44 | 5.27 | 5.15 | 5.17 |
| 55-59 | 10.3 | 10.1 | 9.61 | 9.39 | 9.48 | 9.05 | 8.97 | 8.63 | 8.46 | 8.52 |
| 60-64 | 16.2 | 16.1 | 15.0 | 14.8 | 15.3 | 14.3 | 14.3 | 14.0 | 13.7 | 14.1 |
| 65-69 | 24.7 | 24.8 | 23.0 | 22.7 | 23.8 | 22.2 | 22.2 | 22.1 | 21.3 | 22.1 |
| 70-74 | 36.5 | 36.8 | 34.2 | 33.7 | 35.6 | 33.2 | 33.3 | 33.7 | 32.1 | 33.1 |
| 75-79 | 51.7 | 52.3 | 49.0 | 48.0 | 50.8 | 48.0 | 48.1 | 49.2 | 46.4 | 47.3 |
| 80-84 | 69.1 | 69.9 | 66.4 | 65.0 | 68.3 | 65.5 | 65.7 | 67.4 | 63.5 | 64.0 |
| 85-89 | 85.4 | 86.1 | 83.4 | 81.8 | 84.8 | 82.8 | 83.0 | 84.7 | 80.8 | 80.6 |
| 90-94 | 62.5 | 69.6 | 95.3 | 41.4 | 59.9 | 50.4 | 52.0 | 96.2 | 93.8 | 93.2 |
| Female | | | | | | | | | | |
| 40-44 | 1.81 | 1.74 | 1.66 | 1.55 | 1.56 | 1.44 | 1.41 | 1.36 | 1.32 | 1.30 |
| 45-49 | 2.71 | 2.61 | 2.56 | 2.34 | 2.34 | 2.19 | 2.15 | 2.07 | 2.00 | 1.99 |
| 50-54 | 4.08 | 3.98 | 3.82 | 3.54 | 3.51 | 3.33 | 3.28 | 3.19 | 3.07 | 3.06 |
| 55-59 | 6.28 | 6.20 | 5.74 | 5.45 | 5.48 | 5.20 | 5.15 | 5.05 | 4.83 | 4.87 |
| 60-64 | 10.2 | 10.1 | 9.36 | 8.98 | 9.00 | 8.73 | 8.49 | 8.42 | 7.93 | 8.20 |
| 65-69 | 16.7 | 16.6 | 15.4 | 15.3 | 15.4 | 14.8 | 14.2 | 14.2 | 13.0 | 13.8 |
| 70-74 | 26.8 | 26.8 | 25.1 | 25.0 | 25.7 | 24.2 | 23.7 | 23.8 | 22.5 | 22.9 |
| 75-79 | 41.6 | 42.0 | 39.7 | 38.7 | 40.5 | 38.1 | 38.4 | 38.6 | 36.2 | 36.8 |
| 80-84 | 60.9 | 61.8 | 59.1 | 56.5 | 59.4 | 56.4 | 57.4 | 58.8 | 55.6 | 55.8 |
| 85-89 | 81.1 | 82.5 | 80.1 | 76.0 | 79.4 | 76.8 | 77.6 | 80.5 | 77.7 | 77.1 |
| 90-94 | 54.1 | 63.5 | 95.0 | 91.8 | 94.2 | 92.9 | 93.3 | 95.7 | 93.4 | 93.0 |

Sources: "The 14th Abridged Life Table (April 1, 1960-March 31-1961)," Research Series, No. 143, November 15, 1961, Institute of Population Problems, Ministry of Health and Welfare, Japan, Table 1, pages 10-11, and corresponding publications for subsequent years through 1985.

Table 3 (continued). Period-Cohort Death Rates (per 100) Computed from the Institute of Population Problems Life Tables: 1960-1985

| Sex and Age | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year | | | | | | | | | |
| Male | | | | | | | | | | |
| 40-44 | 2.08 | 2.05 | 2.03 | 2.01 | 1.95 | 1.89 | 1.83 | 1.78 | 1.72 | 1.72 |
| 45-49 | 3.08 | 2.99 | 2.97 | 2.93 | 2.84 | 2.77 | 2.72 | 2.69 | 2.63 | 2.64 |
| 50-54 | 4.85 | 4.67 | 4.56 | 4.48 | 4.29 | 4.16 | 4.03 | 3.97 | 3.87 | 3.89 |
| 55-59 | 7.98 | 7.64 | 7.33 | 7.22 | 6.89 | 6.60 | 6.32 | 6.14 | 5.91 | 5.96 |
| 60-64 | 13.1 | 12.7 | 12.1 | 12.0 | 11.5 | 11.0 | 10.5 | 10.1 | 9.69 | 9.74 |
| 65-69 | 20.5 | 20.5 | 19.8 | 19.7 | 19.1 | 18.3 | 17.5 | 16.9 | 16.2 | 16.4 |
| 70-74 | 31.0 | 30.7 | 30.1 | 30.3 | 29.5 | 28.4 | 27.2 | 26.5 | 25.4 | 25.9 |
| 75-79 | 44.8 | 43.4 | 43.1 | 43.8 | 42.7 | 41.4 | 39.9 | 39.0 | 37.6 | 38.4 |
| 80-84 | 61.5 | 58.1 | 58.3 | 59.8 | 58.3 | 57.1 | 55.1 | 54.4 | 52.7 | 53.8 |
| 85-89 | 78.7 | 73.4 | 74.2 | 76.4 | 74.6 | 73.7 | 71.6 | 71.1 | 69.4 | 70.8 |
| 90-94 | 92.3 | 86.8 | 87.9 | 90.1 | 88.6 | 88.1 | 86.4 | 86.3 | 85.0 | 86.2 |
| Female | | | | | | | | | | |
| 40-44 | 1.25 | 1.18 | 1.14 | 1.11 | 1.07 | 1.02 | 0.97 | 0.92 | 0.88 | 0.88 |
| 45-49 | 1.89 | 1.79 | 1.73 | 1.71 | 1.62 | 1.56 | 1.48 | 1.43 | 1.35 | 1.35 |
| 50-54 | 2.89 | 2.75 | 2.66 | 2.62 | 2.48 | 2.38 | 2.25 | 2.18 | 2.05 | 2.04 |
| 55-59 | 4.57 | 4.34 | 4.19 | 4.12 | 3.92 | 3.69 | 3.50 | 3.38 | 3.19 | 3.18 |
| 60-64 | 7.59 | 7.32 | 7.00 | 6.90 | 6.61 | 6.22 | 5.89 | 5.67 | 5.37 | 5.33 |
| 65-69 | 12.8 | 12.7 | 12.3 | 12.2 | 11.8 | 11.3 | 10.6 | 1.02 | 9.70 | 9.63 |
| 70-74 | 21.5 | 21.0 | 20.6 | 20.7 | 20.2 | 19.4 | 18.4 | 17.6 | 16.8 | 16.8 |
| 75-79 | 35.0 | 33.0 | 32.7 | 33.5 | 32.5 | 31.3 | 30.2 | 28.9 | 27.7 | 28.1 |
| 80-84 | 54.1 | 49.0 | 49.1 | 50.9 | 49.4 | 47.6 | 46.7 | 45.0 | 43.4 | 33.4 |
| 85-89 | 75.9 | 67.8 | 68.4 | 71.3 | 69.4 | 67.0 | 66.9 | 65.1 | 63.2 | 65.0 |
| 90-94 | 91.8 | 85.4 | 86.4 | 89.1 | 87.4 | 85.5 | 85.2 | 84.6 | 83.1 | 84.9 |

Table 3 (concluded). Period-Cohort Death Rates (per 100) Computed from the Institute of Population Problems Life Tables: 1960-1985

| | Year | | | | | | Straight Line Fits | | |
|---|---|---|---|---|---|---|---|---|---|
| Sex and Age | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1960 | 1980 | Slope |
| Male | | | | | | | | | |
| 40-44 | 1. 64 | 1. 60 | 1. 55 | 1. 54 | 1. 47 | 1. 43 | 2. 50 | 1. 75 | 0. 0410 |
| 45-49 | 2. 58 | 2. 56 | 2. 58 | 2. 61 | 2. 46 | 2. 41 | 3. 81 | 2. 64 | 0. 0585 |
| 50-54 | 3. 82 | 3. 81 | 3. 78 | 3. 87 | 3. 80 | 3. 78 | 6. 20 | 3. 97 | 0. 112 |
| 59-54 | 5. 78 | 5. 72 | 5. 58 | 5. 51 | 5. 44 | 5. 41 | 10. 3 | 5. 96 | 0. 217 |
| 60-64 | 9. 47 | 9. 23 | 8. 69 | 8. 55 | 8. 33 | 8. 19 | 16. 6 | 9. 72 | 0. 343 |
| 65-69 | 16. 0 | 15. 6 | 14. 2 | 13. 9 | 13. 4 | 13. 2 | 25. 5 | 16. 0 | 0. 473 |
| 70-74 | 25. 4 | 24. 7 | 23. 7 | 23. 2 | 22. 4 | 22. 2 | 37. 3 | 26. 3 | 0. 595 |
| 75-79 | 37. 9 | 37. 0 | 36. 8 | 36. 3 | 35. 2 | 35. 5 | 52. 0 | 38. 3 | 0. 688 |
| 80-84 | 53. 4 | 52. 2 | 52. 4 | 52. 0 | 50. 7 | 51. 2 | 70. 6 | 53. 8 | 0. 838 |
| 85-89 | 70. 6 | 69. 2 | 68. 5 | 68. 3 | 67. 2 | 67. 2 | 85. 8 | 69. 9 | 0. 845 |
| 90-94 | 86. 3 | 85. 1 | 83. 5 | 83. 2 | 82. 6 | 80. 9 | 98. 0 | 84. 1 | 0. 695 |
| Female | | | | | | | | | |
| 40-44 | 0. 84 | 0. 82 | 0. 80 | 0. 78 | 0. 76 | 0. 75 | 1. 71 | 0. 86 | 0. 0425 |
| 45-49 | 1. 30 | 1. 26 | 1. 25 | 1. 21 | 1. 18 | 1. 15 | 2. 58 | 1. 34 | 0. 0618 |
| 50-54 | 1. 96 | 1. 90 | 1. 83 | 1. 80 | 1. 72 | 1. 72 | 3. 97 | 2. 15 | 0. 0980 |
| 55-59 | 3. 04 | 2. 95 | 2. 86 | 2. 74 | 2. 64 | 2. 59 | 6. 20 | 3. 18 | 0. 151 |
| 60-64 | 5. 12 | 4. 94 | 4. 65 | 4. 55 | 4. 31 | 4. 26 | 10. 2 | 5. 29 | 0. 245 |
| 65-69 | 9. 30 | 8. 93 | 8. 04 | 7. 78 | 7. 40 | 7. 23 | 16. 9 | 9. 88 | 0. 380 |
| 70-74 | 16. 3 | 15. 7 | 14. 7 | 14. 3 | 13. 5 | 13. 2 | 27. 5 | 16. 5 | 0. 554 |
| 75-79 | 27. 1 | 26. 4 | 26. 0 | 25. 4 | 24. 3 | 24. 1 | 43. 0 | 28. 8 | 0. 764 |
| 80-84 | 42. 9 | 42. 3 | 42. 3 | 41. 8 | 40. 0 | 40. 1 | 62. 6 | 44. 0 | 0. 930 |
| 85-89 | 63. 1 | 62. 9 | 60. 3 | 60. 6 | 58. 6 | 59. 0 | 82. 2 | 63. 3 | 0. 980 |
| 90-94 | 83. 5 | 83. 4 | 76. 9 | 78. 1 | 76. 6 | 75. 7 | 97. 3* | 79. 6* | 0. 886 |

*These values refer to 1962 and 1982, respectively.

Table 4. Extrapolated Period-Cohort Death Rates: 1985-2005

| Sex and Age | Year | | | |
|---|---|---|---|---|
| | 1985-90 | 1990-95 | 1995-00 | 2000-05 |
| Male | | | | |
| 40-44 | 1.37 | 1.17 | 0.96 | 0.76 |
| 45-49 | 2.20 | 1.91 | 1.62 | 1.32 |
| 50-54 | 3.13 | 2.57 | 2.01 | 1.45 |
| 55-59 | 4.33 | 3.46 | 2.60 | 1.73 |
| 60-64 | 7.15 | 5.43 | 3.72 | 2.00 |
| 65-69 | 12.45 | 10.09 | 7.72 | 5.36 |
| 70-74 | 20.94 | 17.96 | 14.99 | 12.01 |
| 75-79 | 33.14 | 29.70 | 26.26 | 22.82 |
| 80-84 | 47.52 | 43.33 | 39.14 | 34.95 |
| 85-89 | 63.56 | 59.34 | 55.11 | 50.89 |
| 90-94 | 78.89 | 75.41 | 71.94 | 68.46 |
| Female | | | | |
| 40-44 | 0.54 | 0.33 | 0.12 | 0.00 |
| 45-49 | 0.88 | 0.57 | 0.26 | 0.00 |
| 50-54 | 1.28 | 0.79 | 0.30 | 0.00 |
| 55-59 | 2.05 | 1.29 | 0.54 | 0.00 |
| 60-64 | 3.45 | 2.23 | 1.00 | 0.00 |
| 65-69 | 6.44 | 4.54 | 2.64 | 0.74 |
| 70-74 | 12.35 | 9.58 | 6.81 | 4.04 |
| 75-79 | 21.97 | 18.15 | 14.33 | 10.51 |
| 80-84 | 37.03 | 32.38 | 27.73 | 23.08 |
| 85-89 | 55.95 | 51.05 | 46.15 | 41.25 |
| 90-94 | 74.73 | 70.30 | 65.87 | 61.44 |

Note: Values extrapolated from the straight line fit parameters shown in the last three columns of Table 3. Extrapolated values for males 55-59 adjusted as described in text. Original values for this row were 4.33, 3.46, 2.60 and 1.73.

Table 5. Extrapolated Life Table $_5L_x$ Values for 2000-04

| | Age | Male | Female | Total |
|---|---|---|---|---|
| | 0-4 | 49665 | 49718 | 49691 |
| | 5-9 | 49566 | 49649 | 49606 |
| | 10-14 | 49515 | 49619 | 49565 |
| | 15-19 | 49415 | 49575 | 49493 |
| | 20-24 | 49213 | 49506 | 49355 |
| | 25-29 | 49016 | 49418 | 49211 |
| | 30-34 | 48814 | 49304 | 49052 |
| | 35-39 | 48542 | 49146 | 48835 |
| | 40-44 | 48113 | 48903 | 48496 |
| | 45-49 | (47747) | (48903) | (48308) |
| | 50-54 | (47117) | (48903) | (47984) |
| | 55-59 | (46434) | (48903) | (47633) |
| | 60-64 | (45631) | (48903) | (47219) |
| | 65-69 | (44718) | (48903) | (46750) |
| | 70-74 | (42321) | (48541) | (45340) |
| | 75-79 | (37238) | (46580) | (41773) |
| | 80-84 | (28741) | (41684) | (35024) |
| | 85-89 | (18696) | (32064) | (25185) |
| | 90-94 | (9181) | (18837) | (13868) |
| | 95-99 | (2896) | (7264) | (5016) |
| | $e_0$ | 81.3 | 88.4 | 84.7 |
| Stationary | 20-64 | 430627 | 441889 | 436093 |
| Population | 65+ | 183791 | 243873 | 212956 |
| | Ratio | 2.34 | 1.81 | 2.05 |

Note: See text for explanation.

Table 6. Projection with Rapid Mortality Decline
(both sexes, numbers in 0,000)

| | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 |
| 45-49 | 824 | 906 | 1059 | 891 | 769 | 806 | 881 | 984 | 836 |
| 50-54 | 794 | 810 | 894 | 1049 | 885 | 764 | 801 | 875 | 978 |
| 55-59 | 700 | 777 | 797 | 884 | 1042 | 878 | 758 | 795 | 868 |
| 60-64 | 541 | 678 | 759 | 785 | 877 | 1033 | 871 | 752 | 788 |
| 65-69 | 420 | 514 | 653 | 741 | 777 | 868 | 1023 | 862 | 745 |
| 70-74 | 357 | 381 | 478 | 620 | 719 | 754 | 842 | 992 | 837 |
| 75-79 | 249 | 300 | 332 | 429 | 572 | 663 | 696 | 777 | 915 |
| 80-84 | 143 | 183 | 232 | 269 | 363 | 480 | 557 | 584 | 653 |
| 85-89 | 60 | 84 | 117 | 158 | 195 | 264 | 347 | 402 | 421 |
| 90-94 | 16 | 25 | 39 | 59 | 88 | 109 | 147 | 192 | 222 |
| 95-99 | 2 | 4 | 7 | 12 | 21 | 32 | 39 | 54 | 69 |
| 20-64 | 7356 | 7634 | 7894 | 7933 | 7858 | 7635 | 7290 | 7178 | 7152 |
| 65+ | 1247 | 1491 | 1858 | 2288 | 2735 | 3170 | 3651 | 3863 | 3862 |
| Ratio | 5. 9 | 5. 1 | 4. 2 | 3. 5 | 2. 9 | 2. 4 | 2. 0 | 1. 9 | 1. 9 |
| NUPRI | 5. 9 | 5. 2 | 4. 4 | 3. 7 | 3. 2 | 2. 8 | 2. 3 | 2. 2 | 2. 3 |
| 85+ | 78 | 113 | 163 | 229 | 304 | 405 | 533 | 648 | 712 |
| | (RATIO OF ABOVE TO NUPRI BASELINE) | | | | | | | | |
| 45-49 | 100 | 100 | 100 | 100 | 101 | 101 | 101 | 101 | 101 |
| 50-54 | 100 | 100 | 100 | 101 | 101 | 101 | 101 | 101 | 101 |
| 55-59 | 100 | 100 | 101 | 101 | 102 | 102 | 102 | 102 | 102 |
| 60-64 | 100 | 100 | 101 | 102 | 103 | 103 | 103 | 103 | 103 |
| 65-69 | 100 | 100 | 102 | 103 | 104 | 105 | 105 | 106 | 106 |
| 70-74 | 100 | 100 | 101 | 104 | 107 | 108 | 109 | 109 | 110 |
| 75-79 | 100 | 100 | 102 | 105 | 110 | 113 | 114 | 115 | 115 |
| 80-84 | 100 | 101 | 105 | 110 | 117 | 122 | 126 | 127 | 129 |
| 85+ | 100 | 105 | 118 | 136 | 158 | 172 | 183 | 192 | 197 |
| 65+ | 100 | 100 | 103 | 107 | 112 | 116 | 118 | 121 | 123 |

Note: Calculated by projecting 1985 initial distributions by sex using extrapolated survival ratios. See text for further explanation.

Table 7. Period-Cohort Death Rates (per 100) for the 1976 Institute of Population Problems Projection

| Sex and Age | Year '75-79 | '80-84 | '85-89 | '90-94 | '95-99 | '00-04 | '05-09 | '10-14 |
|---|---|---|---|---|---|---|---|---|
| Male | | | | | | | | |
| 40-44 | 1.82 | 1.73 | 1.65 | 1.60 | 1.64 | 1.63 | 1.61 | 1.62 |
| 45-49 | 2.71 | 2.64 | 2.59 | 2.59 | 2.55 | 2.60 | 2.59 | 2.58 |
| 50-54 | 4.14 | 4.16 | 4.16 | 4.19 | 4.18 | 4.09 | 4.20 | 4.15 |
| 5-59 | 6.74 | 6.57 | 6.65 | 6.67 | 6.68 | 6.71 | 6.57 | 6.73 |
| 60-64 | 11.1 | 10.9 | 10.5 | 10.6 | 10.7 | 10.7 | 10.8 | 10.6 |
| 65-69 | 18.1 | 16.9 | 16.2 | 16.0 | 16.2 | 16.2 | 16.3 | 16.3 |
| 70-74 | 27.8 | 24.9 | 23.5 | 23.6 | 23.2 | 23.5 | 23.6 | 23.6 |
| 75-79 | 39.8 | 35.6 | 32.9 | 33.1 | 33.1 | 32.8 | 33.0 | 33.2 |
| Female | | | | | | | | |
| 40-44 | 1.00 | 0.96 | 0.92 | 0.89 | 0.90 | 0.89 | 0.91 | 0.89 |
| 45-49 | 1.52 | 1.46 | 1.42 | 1.41 | 1.39 | 1.43 | 1.43 | 1.40 |
| 50-54 | 2.40 | 2.28 | 2.18 | 2.20 | 2.23 | 2.18 | 2.23 | 2.21 |
| 55-59 | 3.75 | 3.55 | 3.49 | 3.49 | 3.51 | 3.51 | 3.43 | 3.53 |
| 60-64 | 6.33 | 6.02 | 5.83 | 5.85 | 5.85 | 5.89 | 5.91 | 5.77 |
| 65-69 | 11.2 | 10.4 | 10.0 | 9.99 | 10.1 | 10.0 | 10.1 | 10.2 |
| 70-74 | 18.8 | 16.8 | 16.0 | 15.9 | 15.9 | 15.9 | 15.9 | 16.0 |
| 75-79 | 30.0 | 26.6 | 24.4 | 24.5 | 24.5 | 24.5 | 24.6 | 24.6 |

Source: Calculated from projected age distributions in Institute of Population Problems (1976: 38-52).

Table 8. Period-Cohort Death Rates (per 100) for the 1981 Institute of Population Problems Projection

| Sex and Age | Year '75-79 | '80-84 | '85-89 | '90-94 | '95-99 | '00-04 | '05-09 | '10-14 |
|---|---|---|---|---|---|---|---|---|
| Male | | | | | | | | |
| 40-44 | - | 1.64 | 1.58 | 1.54 | 1.54 | 1.51 | 1.51 | 1.48 |
| 45-49 | - | 2.52 | 2.45 | 2.41 | 2.32 | 2.38 | 2.36 | 2.32 |
| 50-54 | - | 3.67 | 3.52 | 3.47 | 3.45 | 3.37 | 3.42 | 3.39 |
| 55-59 | - | 5.52 | 5.32 | 5.19 | 5.16 | 5.14 | 5.04 | 5.15 |
| 60-64 | - | 9.17 | 8.62 | 8.56 | 8.49 | 8.49 | 8.53 | 8.31 |
| 65-69 | - | 16.3 | 14.9 | 14.3 | 14.4 | 14.4 | 14.4 | 14.5 |
| 70-74 | - | 24.5 | 23.8 | 23.3 | 22.8 | 23.0 | 23.0 | 23.0 |
| 75-79 | - | 36.9 | 35.4 | 34.9 | 34.5 | 34.0 | 34.4 | 34.3 |
| Female | | | | | | | | |
| 40-44 | - | 0.81 | 0.78 | 0.73 | 0.76 | 0.76 | 0.76 | 0.74 |
| 45-49 | - | 1.26 | 1.16 | 1.14 | 1.12 | 1.13 | 1.13 | 1.10 |
| 50-54 | - | 1.89 | 1.75 | 1.73 | 1.73 | 1.69 | 1.72 | 1.70 |
| 55-59 | - | 2.95 | 2.82 | 2.76 | 2.76 | 2.74 | 2.67 | 2.75 |
| 60-64 | - | 5.09 | 4.86 | 4.75 | 4.72 | 4.70 | 4.74 | 4.61 |
| 65-69 | - | 9.28 | 8.87 | 8.66 | 8.67 | 8.59 | 8.66 | 8.69 |
| 70-74 | - | 16.0 | 15.7 | 15.2 | 15.1 | 15.1 | 15.1 | 15.2 |
| 75-79 | - | 26.7 | 25.7 | 25.4 | 25.0 | 24.9 | 25.0 | 25.0 |

Source: Calculated from the projected age distributions given in Institute of Population Problems (1982: 67-79).

Table 9. Period-Cohort Death Rates (per 100) for the 1986 Institute of Population Problems Projection

| Sex and Age | '75-79 | '80-84 | '85-89 | '90-94 | '95-99 | '00-04 | '05-09 | '10-14 |
|---|---|---|---|---|---|---|---|---|
| Male | | | | | | | | |
| 40-44 | - | - | 1.30 | 1.18 | 1.13 | 1.11 | 1.05 | 1.02 |
| 45-49 | - | - | 2.25 | 2.14 | 2.00 | 2.00 | 1.90 | 1.86 |
| 50-54 | - | - | 3.49 | 3.32 | 3.18 | 3.04 | 3.02 | 2.97 |
| 55-59 | - | - | 5.07 | 4.83 | 4.63 | 4.51 | 4.31 | 4.35 |
| 60-64 | - | - | 7.77 | 7.44 | 7.15 | 6.99 | 6.84 | 6.58 |
| 65-69 | - | - | 12.7 | 11.8 | 11.5 | 11.2 | 10.9 | 10.8 |
| 70-74 | - | - | 21.2 | 20.0 | 18.8 | 18.3 | 17.8 | 17.6 |
| 75-79 | - | - | 33.3 | 31.6 | 30.1 | 28.7 | 28.2 | 27.7 |
| 80-84 | - | - | 48.7 | 46.4 | 44.9 | 43.7 | 42.2 | 42.0 |
| Female | | | | | | | | |
| 40-44 | - | - | 0.72 | 0.66 | 0.65 | 0.63 | 0.60 | 0.60 |
| 45-49 | - | - | 1.13 | 1.08 | 1.00 | 0.99 | 0.94 | 0.93 |
| 50-54 | - | - | 1.60 | 1.51 | 1.44 | 1.36 | 1.34 | 1.30 |
| 55-59 | - | - | 2.48 | 2.31 | 2.18 | 2.10 | 2.00 | 1.98 |
| 60-64 | - | - | 4.03 | 3.77 | 3.56 | 3.42 | 3.31 | 3.16 |
| 65-69 | - | - | 6.92 | 6.37 | 5.99 | 5.73 | 5.53 | 5.40 |
| 70-74 | - | - | 12.5 | 11.4 | 10.6 | 10.1 | 9.68 | 9.44 |
| 75-79 | - | - | 22.4 | 20.8 | 19.3 | 18.2 | 17.6 | 17.0 |
| 80-84 | - | - | 37.8 | 35.1 | 33.5 | 32.1 | 31.0 | 30.4 |

Source: Calculated from the projected age distributions given in Institute of Population Problems (1987: 57-61).

Table 10. Period-Cohort Death Rates (per 100) for the 1986 Nihon University Population Research Institute (NUPRI) Projection

| Sex and Age | Year | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | '85-89 | '90-94 | '95-99 | '00-04 | '05-09 | '10-14 | '15-19 | '20-24 |
| Male | | | | | | | | |
| 40-44 | 1.47 | 1.46 | 1.49 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 |
| 45-49 | 2.34 | 2.21 | 2.03 | 1.99 | 1.96 | 1.91 | 1.92 | 1.92 |
| 50-54 | 3.46 | 3.05 | 2.62 | 2.36 | 2.33 | 2.27 | 2.25 | 2.23 |
| 55-59 | 4.90 | 4.25 | 3.53 | 3.18 | 3.03 | 3.02 | 2.97 | 2.95 |
| 60-64 | 7.39 | 6.47 | 5.43 | 4.92 | 4.78 | 4.56 | 4.64 | 4.58 |
| 65-69 | 12.4 | 10.9 | 9.76 | 9.14 | 9.00 | 8.96 | 8.65 | 8.95 |
| 70-74 | 21.0 | 19.4 | 17.5 | 17.0 | 16.8 | 16.7 | 16.8 | 16.3 |
| 75-79 | 33.6 | 32.1 | 30.7 | 29.4 | 29.6 | 29.6 | 29.7 | 29.8 |
| Female | | | | | | | | |
| 40-44 | 0.70 | 0.60 | 0.52 | 0.47 | 0.45 | 0.44 | 0.43 | 0.44 |
| 45-49 | 1.09 | 0.92 | 0.70 | 0.63 | 0.60 | 0.60 | 0.58 | 0.60 |
| 50-54 | 1.55 | 1.27 | 1.00 | 0.88 | 0.86 | 0.82 | 0.78 | 0.79 |
| 55-59 | 2.37 | 1.93 | 1.51 | 1.28 | 1.19 | 1.17 | 1.14 | 1.15 |
| 60-64 | 3.83 | 3.14 | 2.43 | 2.08 | 2.02 | 1.89 | 1.94 | 1.91 |
| 65-69 | 6.71 | 5.67 | 4.65 | 4.16 | 4.05 | 3.98 | 3.81 | 3.96 |
| 70-74 | 12.7 | 11.3 | 10.0 | 9.51 | 9.37 | 9.34 | 9.38 | 9.01 |
| 75-79 | 23.2 | 22.3 | 21.2 | 20.6 | 20.6 | 20.6 | 20.7 | 20.8 |

Source: Calculated from the projected age distributions given in Ogawa and others (1986: 93-101).

Table 11. Parity Progression Ratios (per 1000) from Children Ever Born Data: 1950 Census

| Item/ Parity | Age 40-44 | 45-49 | 50-54 | 55-59 |
|---|---|---|---|---|
| Mean | 4.424 | 4.710 | 4.739 | 4.742 |
| B | 980 | 984 | 987 | 988 |
| M | 915 | 910 | 901 | 887 |
| 1 | 904 | 906 | 904 | 907 |
| 2 | 891 | 898 | 902 | 903 |
| 3 | 852 | 869 | 874 | 878 |
| 4 | 802 | 830 | 838 | 845 |
| 5 | 741 | 783 | 789 | 797 |
| 6 | 676 | 729 | 738 | 745 |
| 7 | 603 | 670 | 678 | 693 |
| 8 | 515 | 581 | 588 | 595 |
| 9 | 453 | 524 | 537 | 543 |
| 10 | 359 | 420 | 431 | 415 |
| Date | '33.5 | '28.5 | '23.5 | '18.5 |

Source: Population Census of 1950, Volume III, Results of Ten Percent Sample Tabulation, Part I. Table 3, pages 58-59, for marital status data, and Table 29, pages 188-89, for children ever born data.

Table 12. Parity Progression Ratios (per 1000) from Children Ever Born Data: 1960 Census

| Item/ Parity | Age 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 |
|---|---|---|---|---|---|---|---|---|
| Mean | 3.181 | 3.837 | 4.373 | 4.597 | 4.607 | 4.619 | 4.623 | 4.505 |
| B | 968 | 979 | 983 | 987 | 989 | 990 | 990 | 989 |
| M | 923 | 924 | 920 | 912 | 902 | 900 | 892 | 891 |
| 1 | 885 | 894 | 902 | 907 | 902 | 908 | 907 | 907 |
| 2 | 803 | 864 | 884 | 890 | 901 | 895 | 898 | 893 |
| 3 | 672 | 792 | 844 | 859 | 866 | 862 | 866 | 859 |
| 4 | 556 | 705 | 799 | 823 | 826 | 833 | 841 | 822 |
| 5 | 481 | 619 | 736 | 767 | 769 | 782 | 783 | 776 |
| 6 | 450 | 549 | 672 | 709 | 715 | 719 | 728 | 719 |
| 7 | 398 | 500 | 574 | 658 | 662 | 663 | 655 | 628 |
| 8 | 408 | 448 | 498 | 570 | 567 | 544 | 562 | 551 |
| 9 | 436 | 391 | 466 | 517 | 549 | 504 | 531 | 494 |
| Date | '43.5 | '38.5 | '33.5 | '28.5 | '23.5 | '18.5 | '13.5 | '08.5 |

Source: 1960 Population Census of Japan, Vol. 3, All Japan, Part 1, Table 3, pp. 138-139, for marital status data; Population of Japan, Summary of the Results of the 1970 Population Census of Japan, Table 23, pp. 320-321, for children ever born data.

Table 13. Parity Progression Ratios (per 1000) from Children Ever Born Data: 1970 Census

| Item/ Parity | Age 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 2.257 | 2.656 | 3.173 | 3.792 | 4.253 | 4.488 | 4.504 | 4.564 | 4.568 |
| B | 948 | 960 | 973 | 980 | 984 | 987 | 989 | 990 | 990 |
| M | 928 | 921 | 917 | 915 | 910 | 908 | 901 | 900 | 900 |
| 1 | 859 | 878 | 888 | 900 | 905 | 907 | 906 | 910 | 909 |
| 2 | 539 | 701 | 807 | 863 | 883 | 892 | 895 | 896 | 899 |
| 3 | 359 | 503 | 670 | 789 | 837 | 851 | 854 | 857 | 857 |
| 4 | 312 | 405 | 547 | 699 | 782 | 808 | 816 | 825 | 824 |
| 5 | 321 | 378 | 472 | 611 | 716 | 753 | 759 | 764 | 764 |
| 6 | 342 | 372 | 427 | 538 | 645 | 695 | 700 | 707 | 707 |
| 7 | 385 | 380 | 406 | 485 | 578 | 635 | 639 | 649 | 650 |
| 8 | 390 | 365 | 362 | 418 | 483 | 544 | 545 | 544 | 543 |
| 9 | 397 | 387 | 382 | 392 | 453 | 509 | 527 | 530 | 529 |
| Date | '53.5 | '48.5 | '43.5 | '38.5 | '33.5 | '28.5 | '23.5 | '18.5 | '13.5 |

Source: 1970 Population Census of Japan, Vol. 5, Part 1, Division 1. Table 3, pp. 10-11, for marital status data, Table 11, pp. 212-213, for children ever born data.

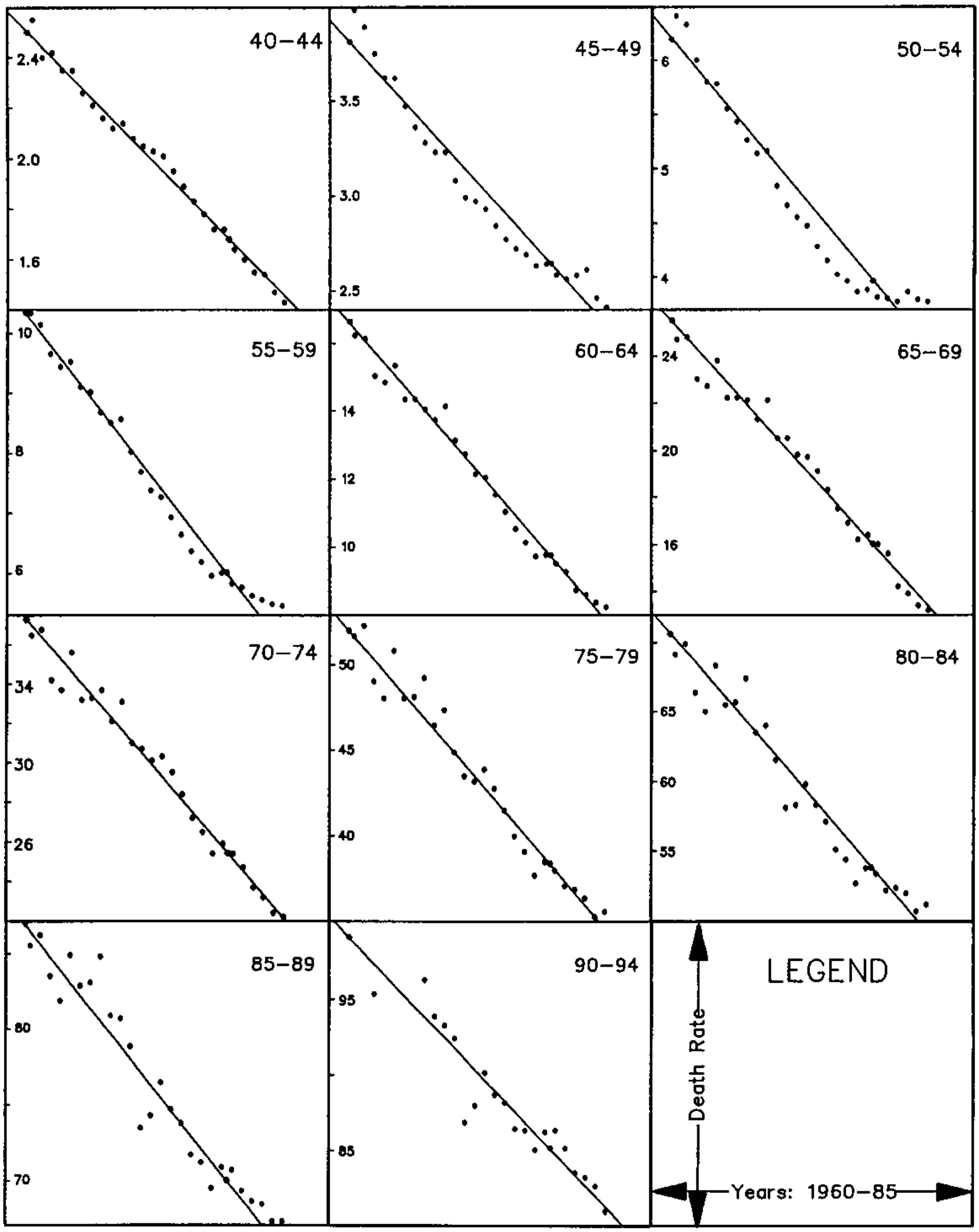


FIGURE 1. Male Period–Cohort Death Rates for Japan: 1960–1985
Source: Table 3

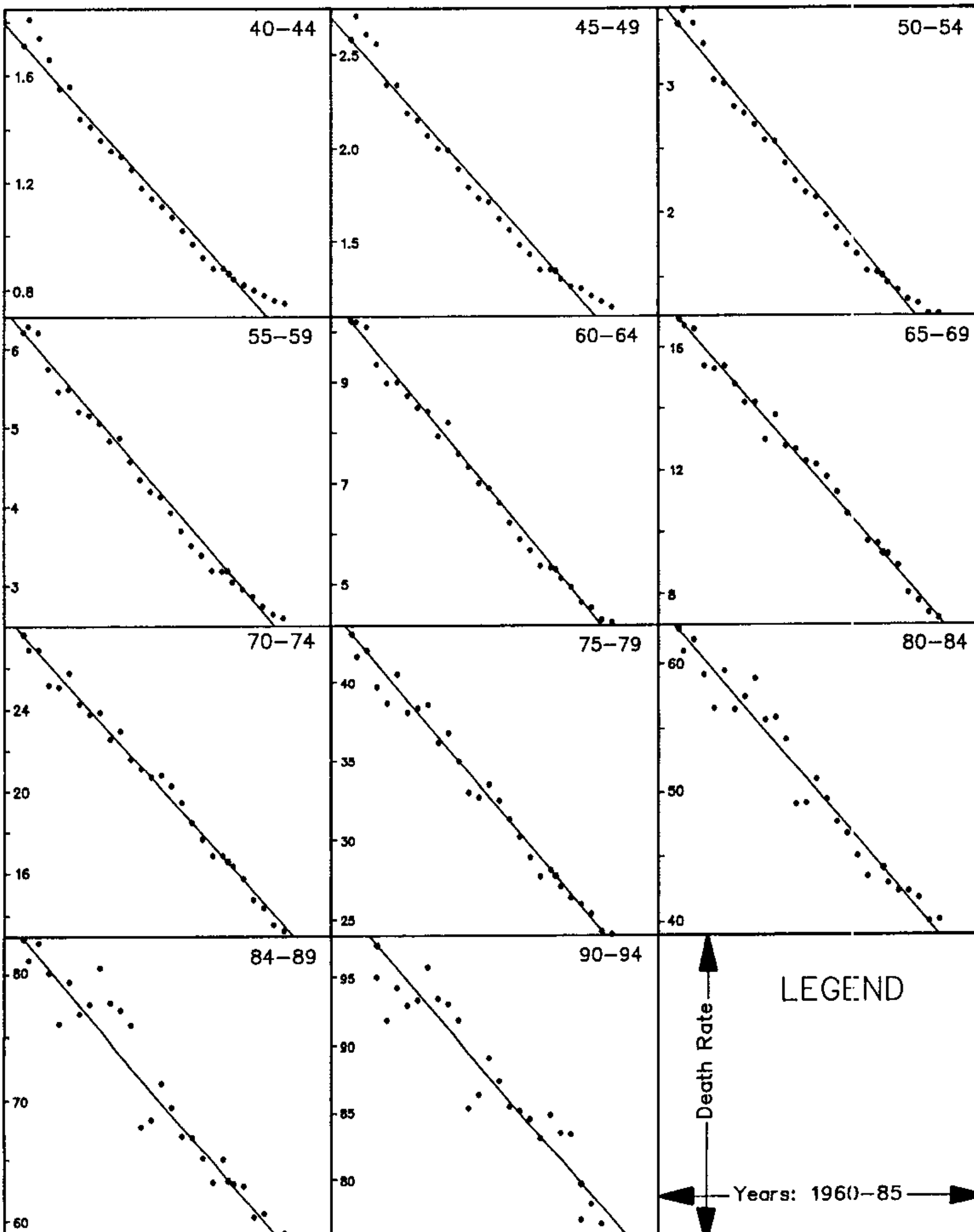


FIGURE 2. Female Period–Cohort Death Rates for Japan: 1960–1985
Source: Table 3.

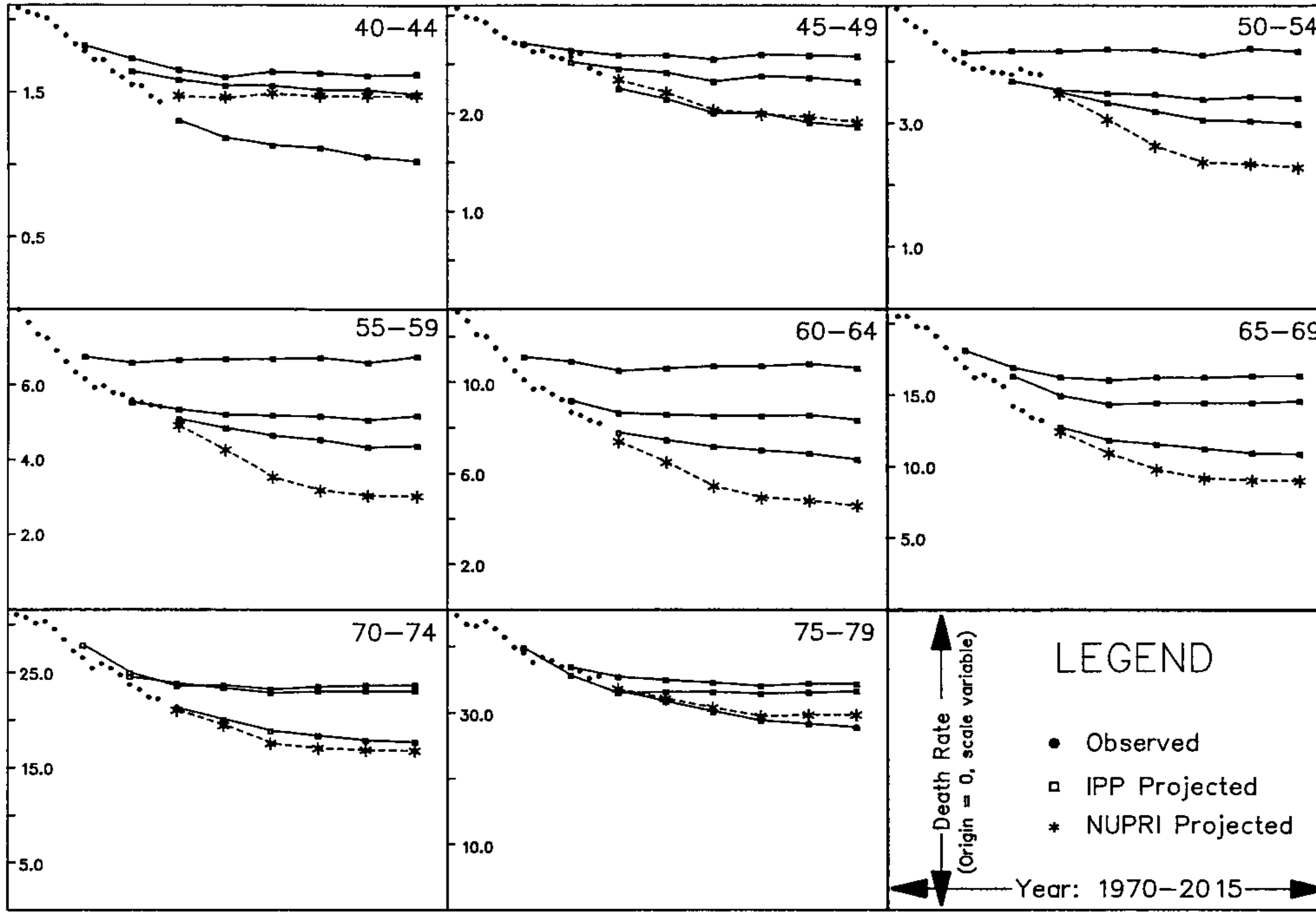


FIGURE 3. Observed and Projected Death Rates: Japan Males 1970–2015
Source: Table 3 for observed rates, Tables 7–10 for projected rates

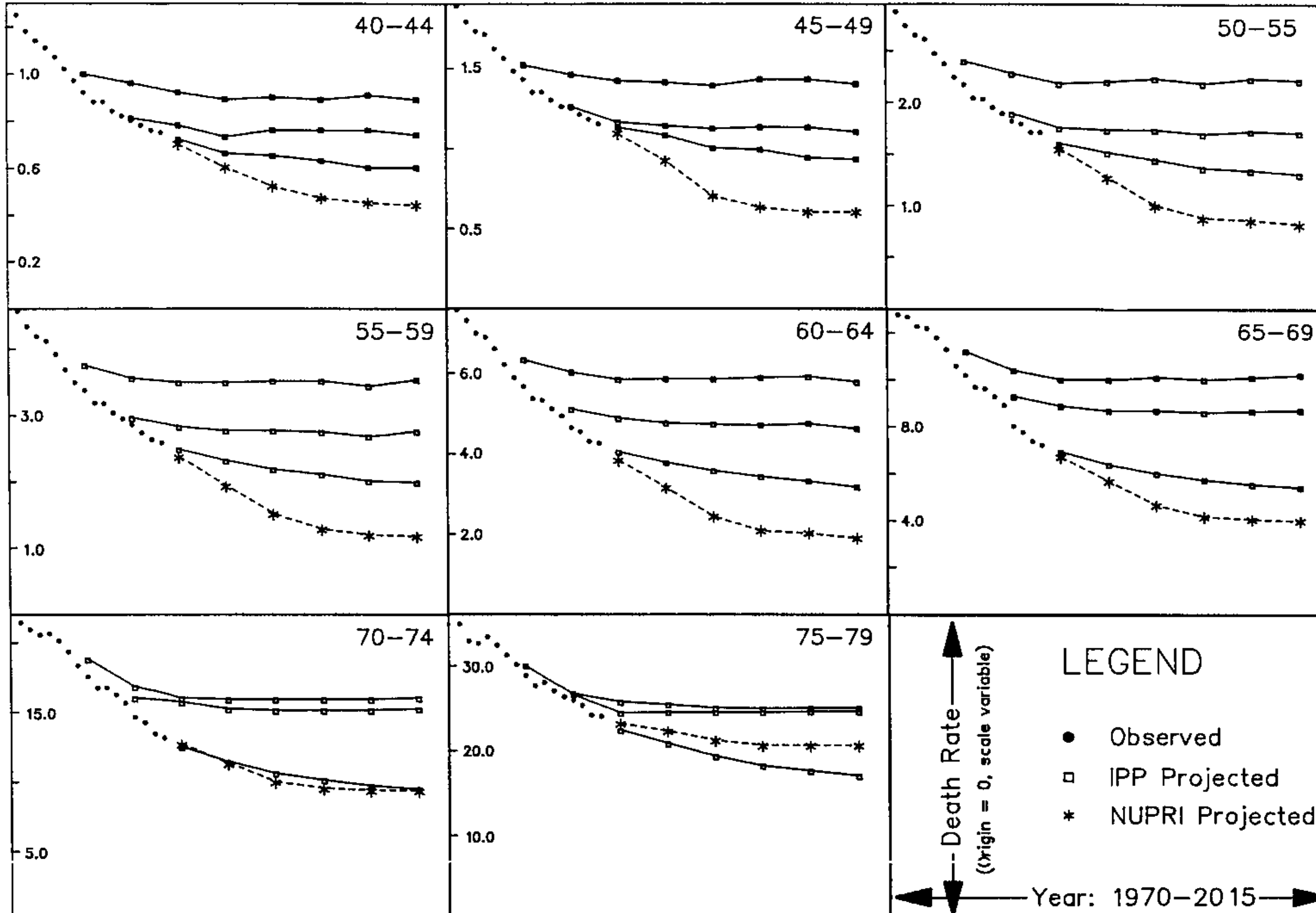


FIGURE 4. Observed and Projected Death Rates: Japan Females 1970–2015
Source: Table 3 for observed rates, Tables 7–10 for projected rates

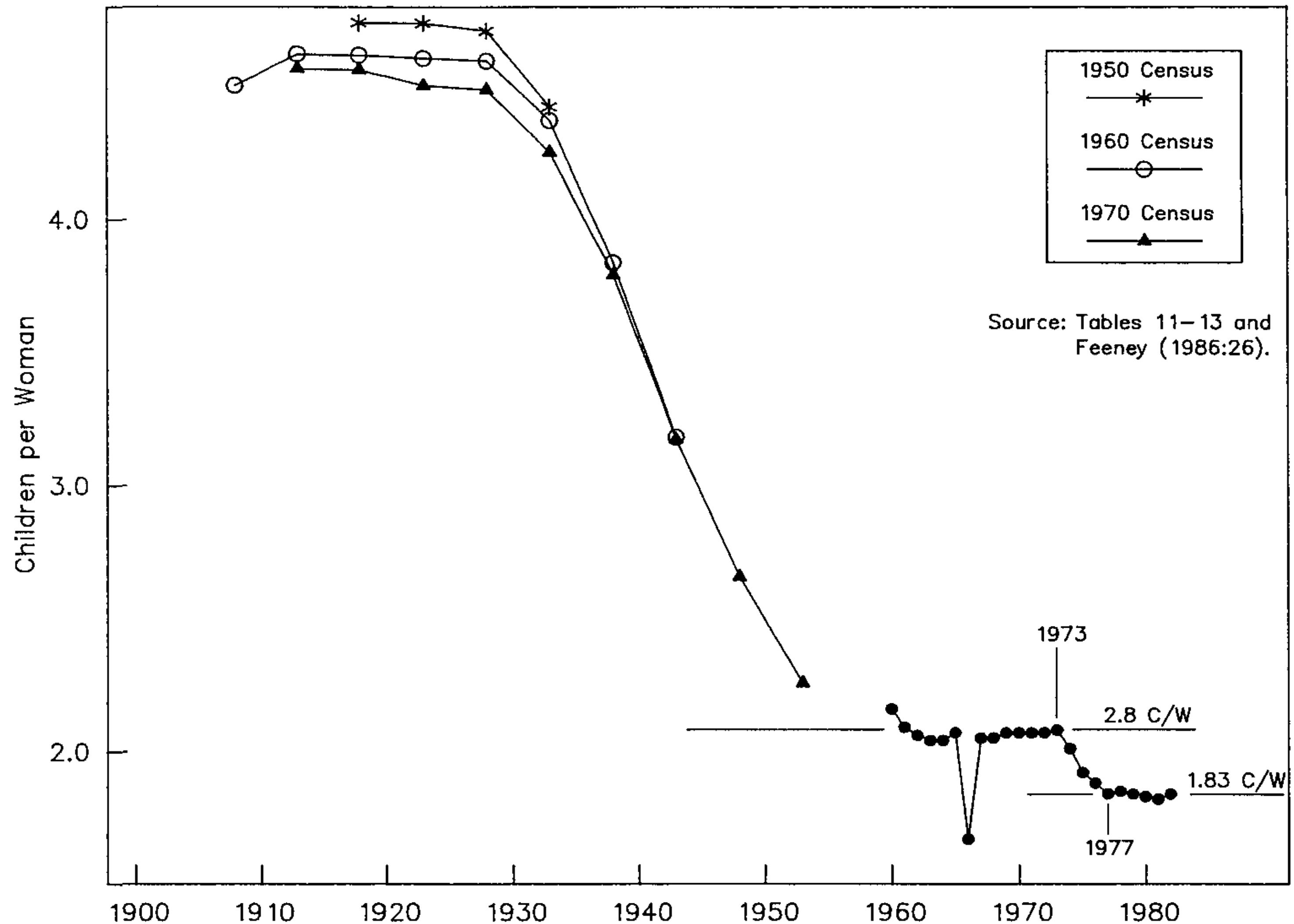


Figure 5. Completed Fertility in Japan, 1910–1982.

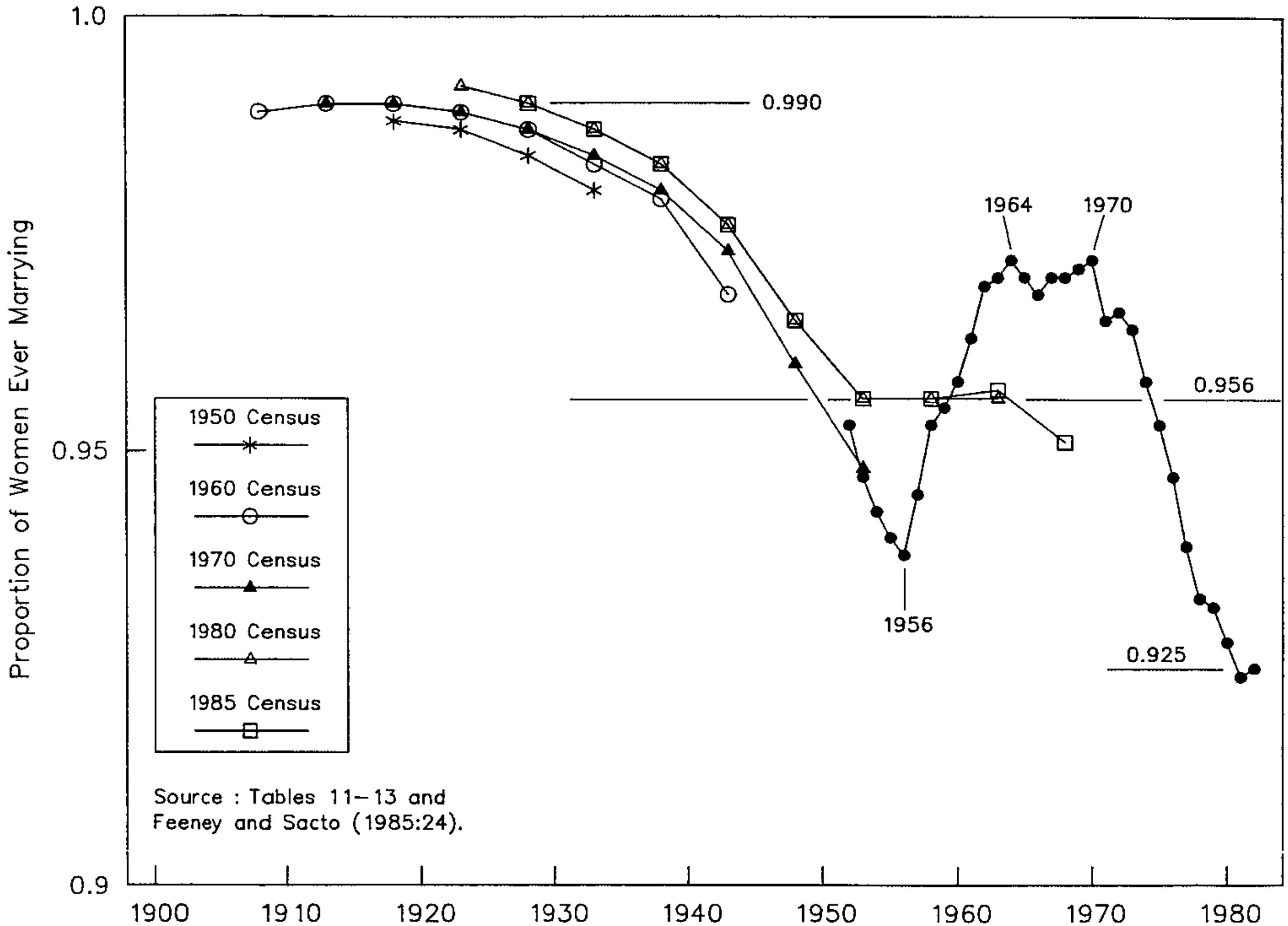


Figure 6. Progression from Birth to First Marriage: Japan Females, 1910–1982

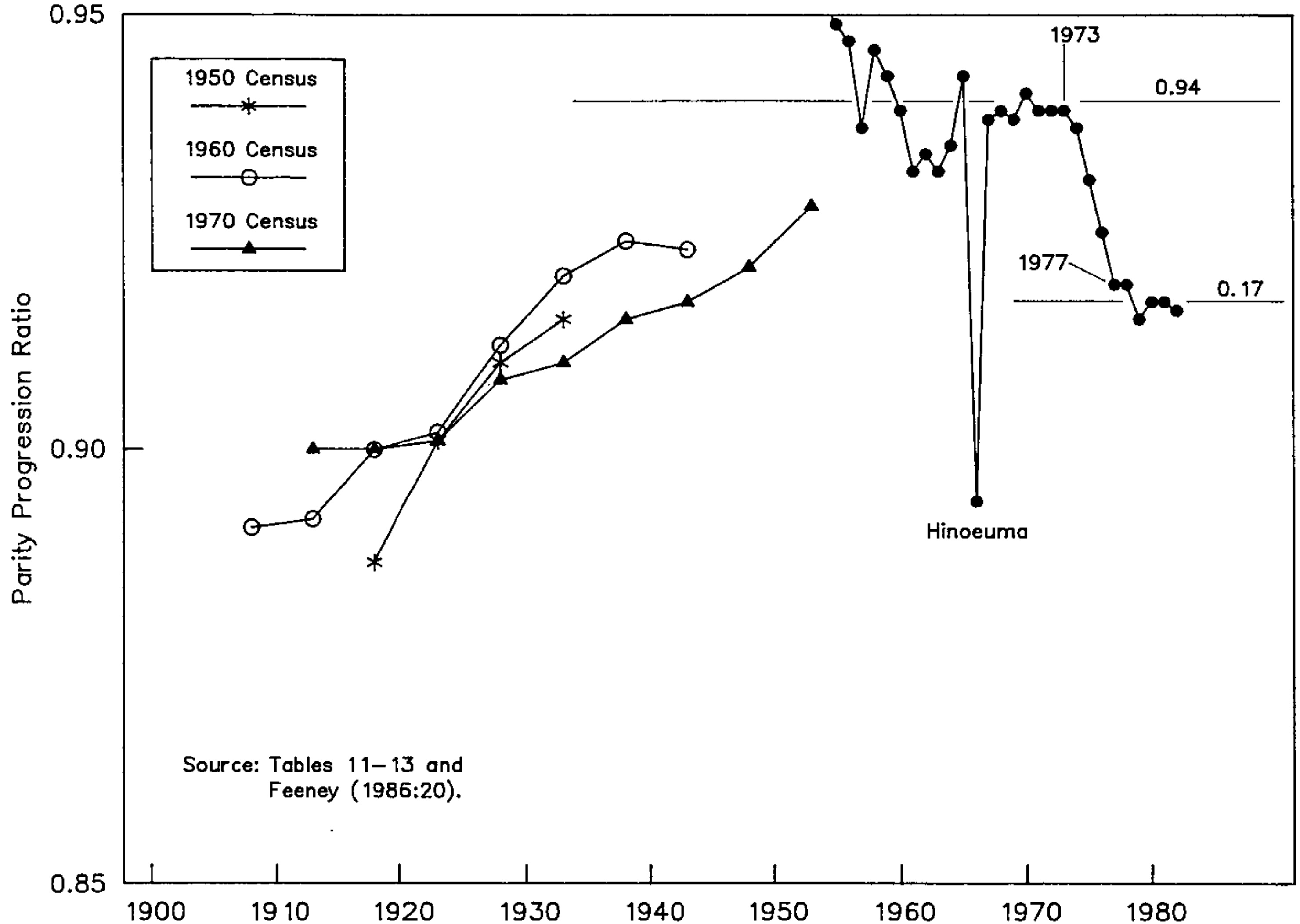


Figure 7. Progression from Marriage to First Birth: Japan, 1910–1982.

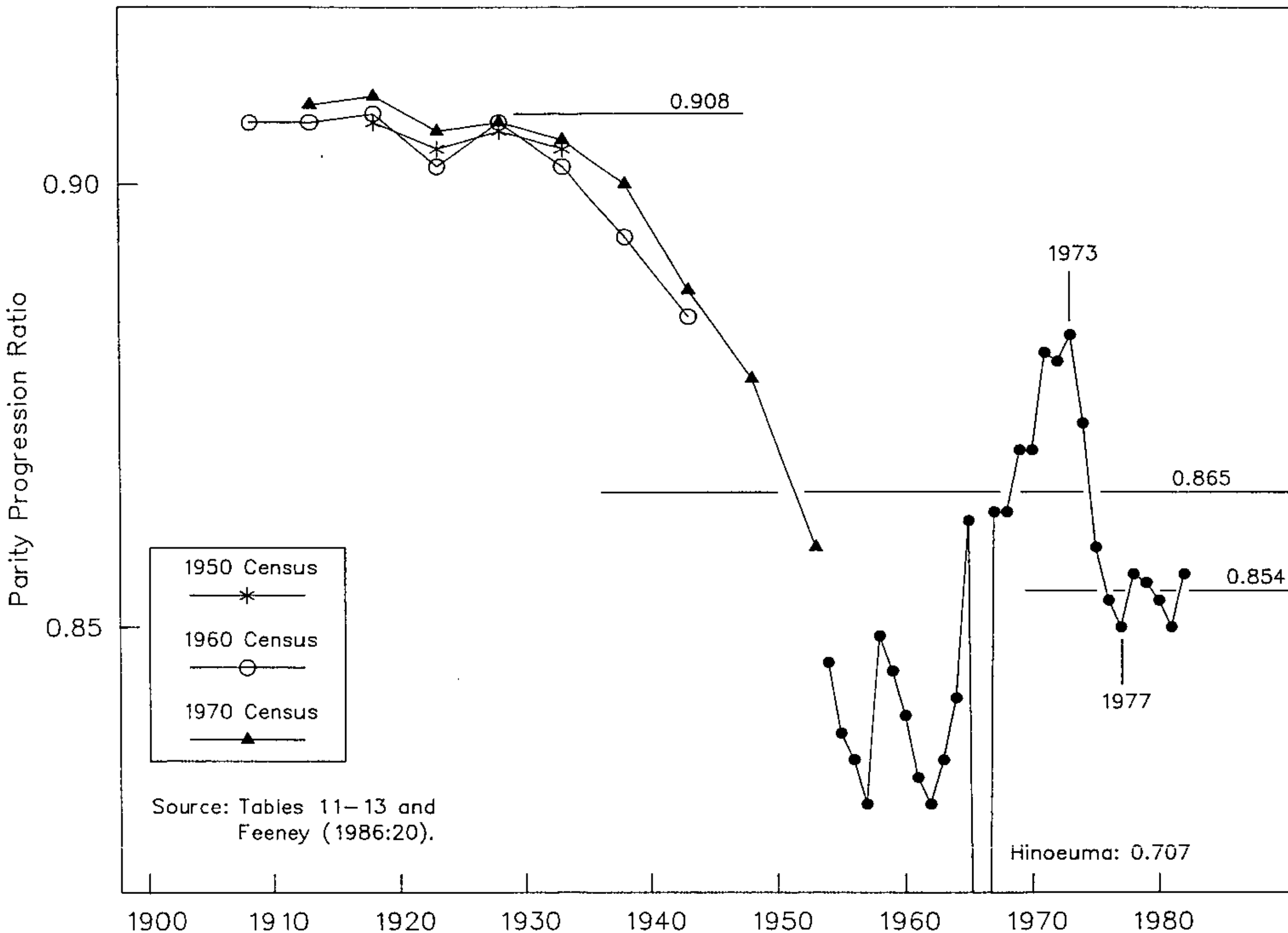


Figure 8. Progression from First to Second Birth: Japan, 1910–1982.

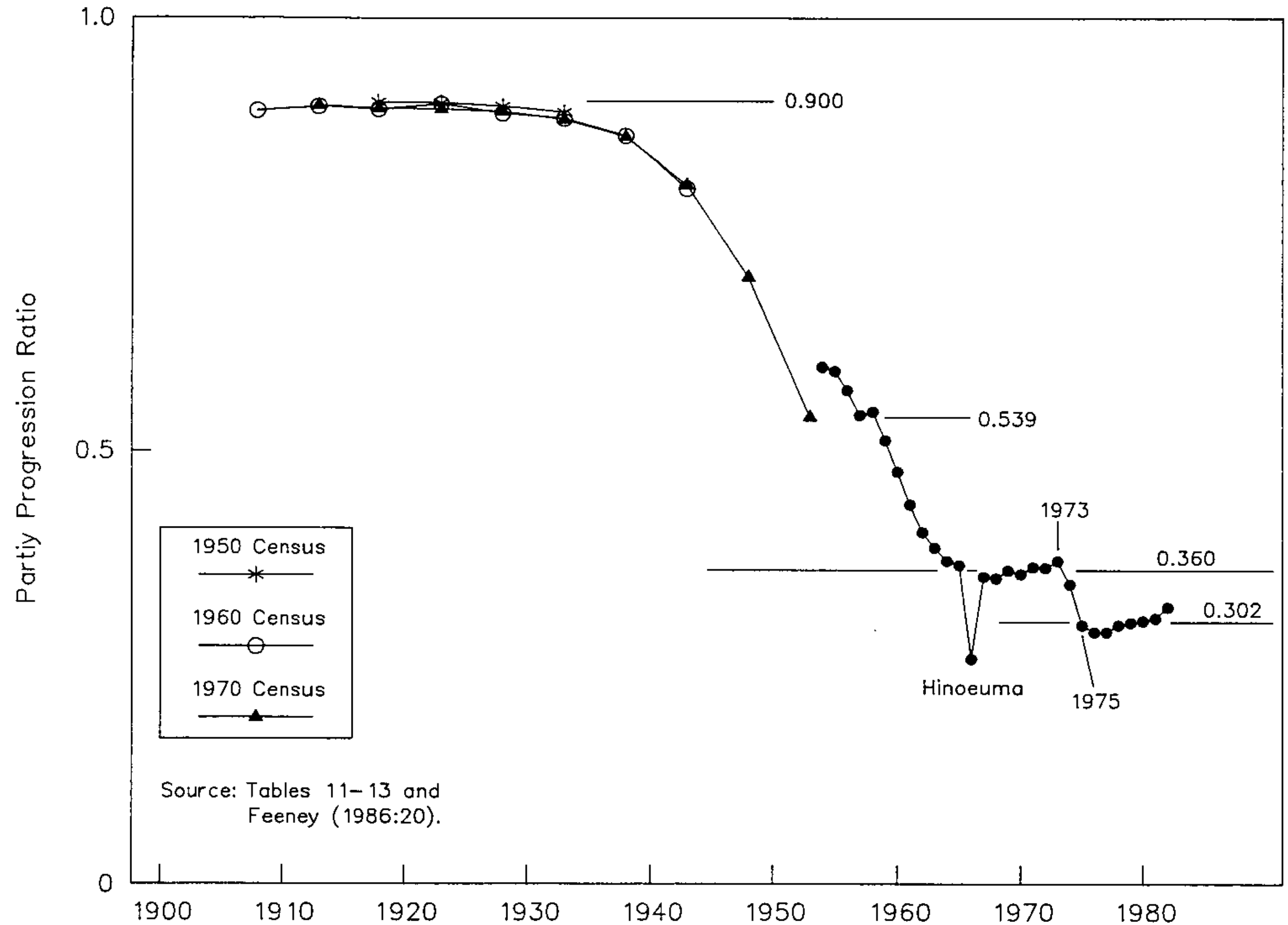


Figure 9. Progression from Second to Third Birth: Japan, 1910–1982.

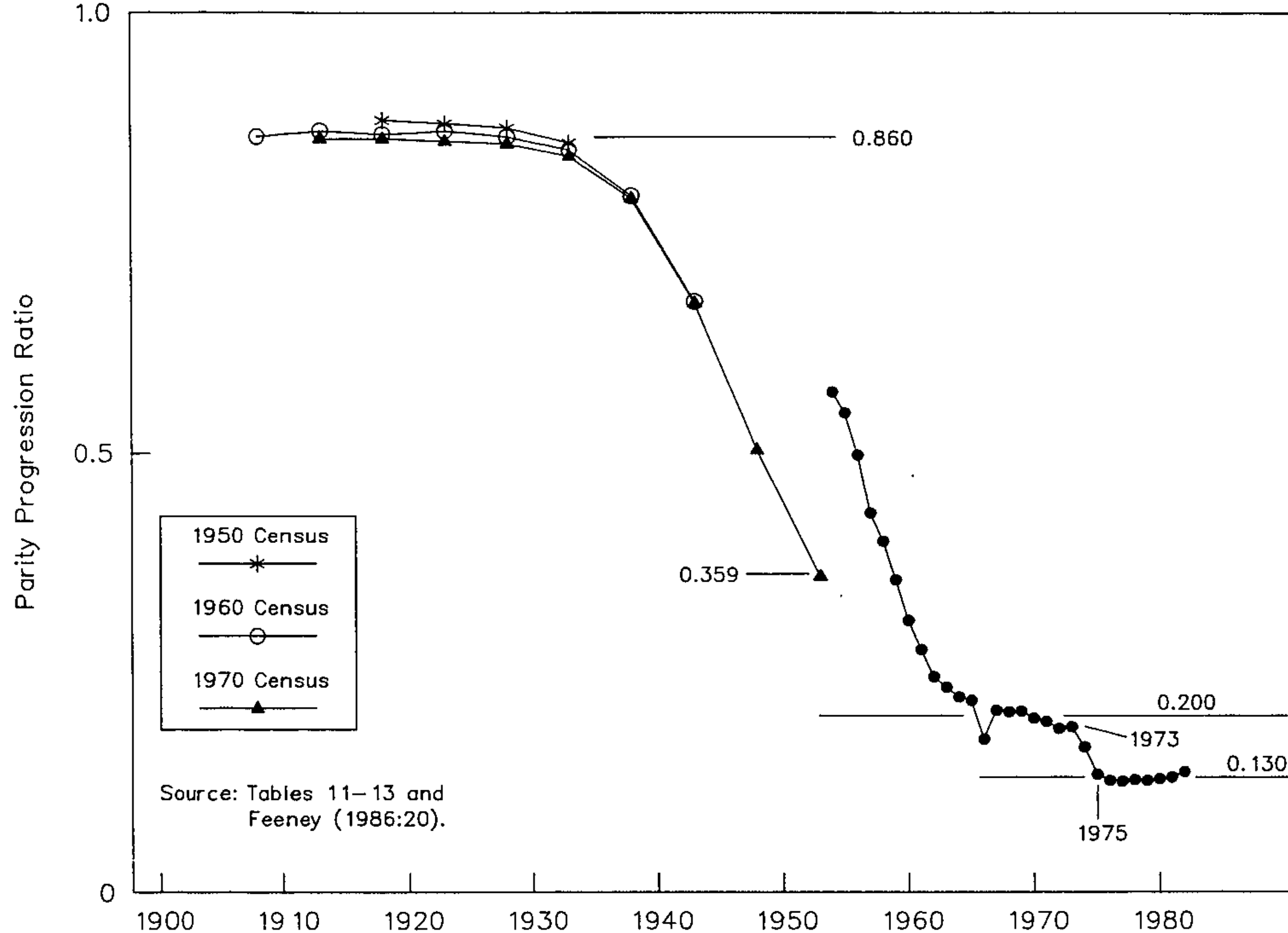


Figure 10. Progression from Third to Fourth Birth: Japan, 1910–1982.

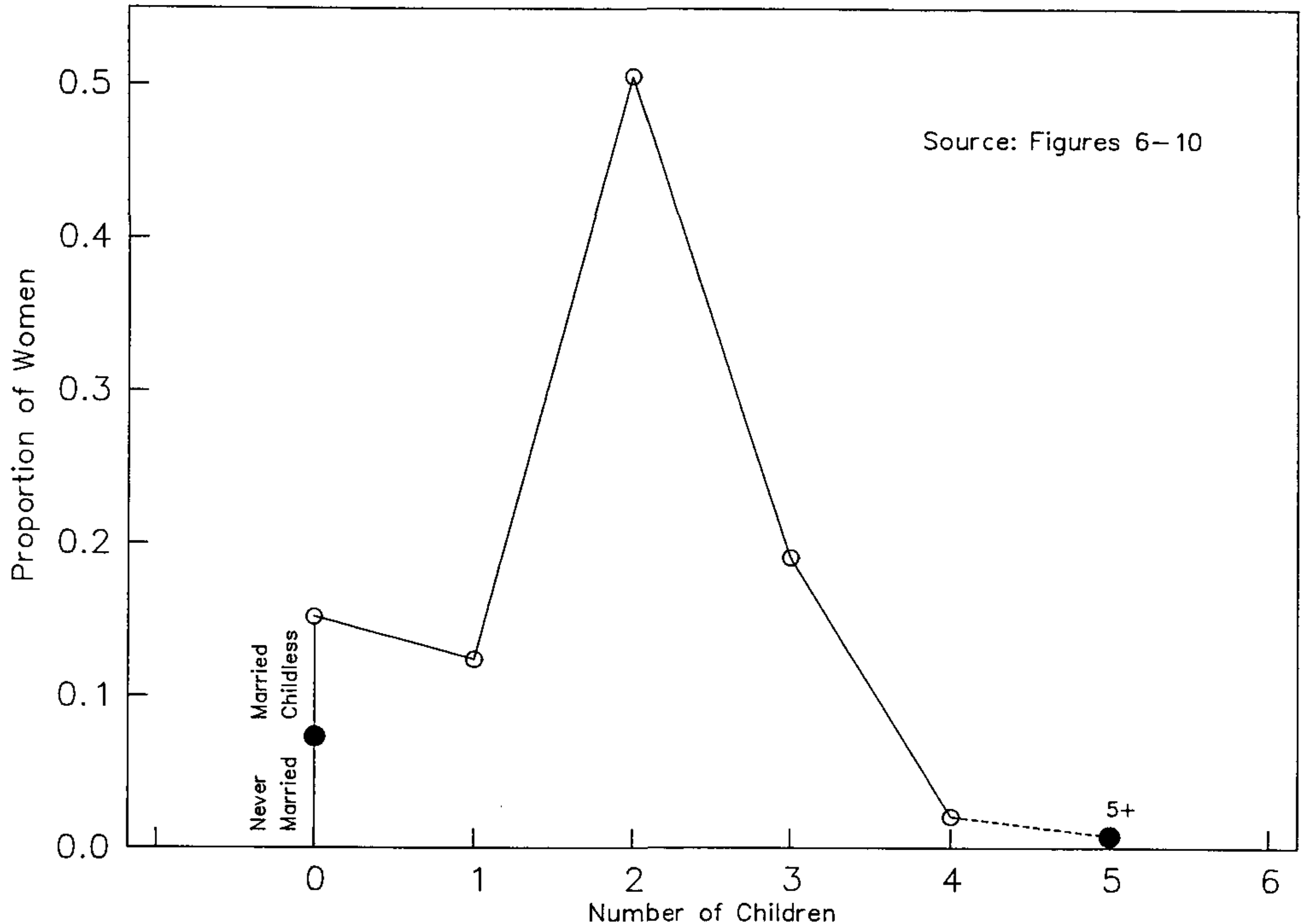

Figure 11. Completed Parity Distribution Implied by Base-Line Parity Progression Ratios-Low Level-Mean CEB = 1.83 Children per Woman.

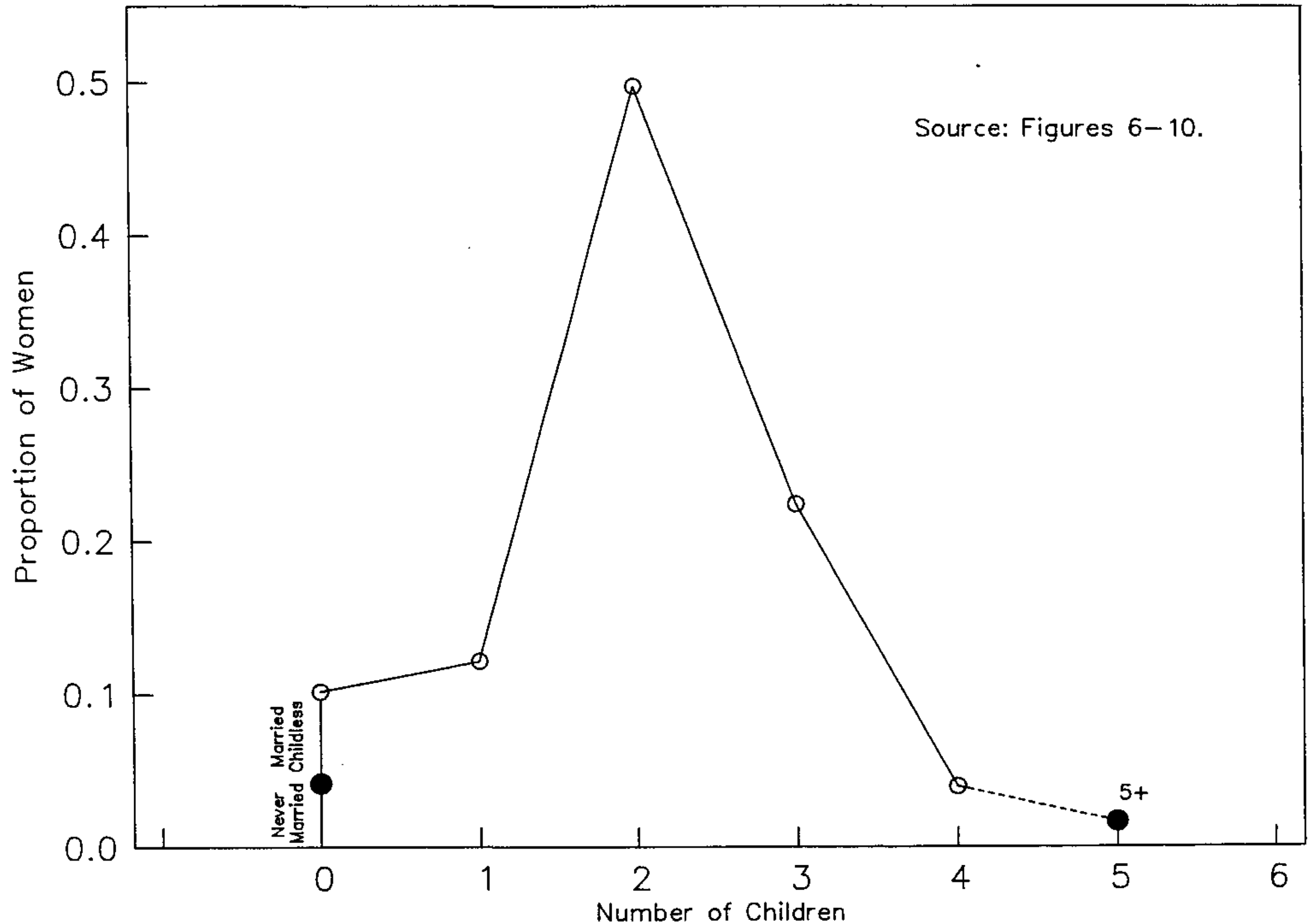


Figure 12. Completed Parity Distribution Implied by Base–Line Parity Progression Ratios–High Level–mean CEB = 2.03 Children per Woman.