Progression to First Marriage in Japan: 1870-1980

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NUPRI Research Paper Series No. 24

March 1985

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C O N T E N T S

T A B L E S

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A B S T R A C T

Estimates of period progression to first marriage for females are provided for Japan for the years 1870-1980. Estimates at five year intervals for the period 1870-1950 are obtained from census data on marital status from the censuses of 1920-1980. Estimates for calendar years from 1951-1982 are obtained by an indirect estimation procedure, "inverse projection," using census and marriage registration data for this period. "Period progression to first marriage" for a given year refers to the proportion of women in an hypothetical cohort who would ever marry if this cohort experienced the first marriage rates observed in the given year. First marriage rates are calculated with first marriages in the numerator and never-married women in denominator.

This work is part of an effort to produce parity progression projections for Japan. Implications of the results for projections are discussed. In particular, the relation of trends in period progression to first marriage to trends in the total fertility rate (TFR) is analyzed. This analysis suggests that trends in the TFR, as conventionally computed from age-specific birth rates, may substantially distort real trends in fertility. The reason advanced is that when marital status, parity and birth order are considered, the usual TFR does not properly relate events to exposure.

The bulk of this work was done in November 1984, during which period the first author was a visiting fellow at Nihon University Population Research Institute. It was completed in March 1985, during which time the second author was a research intern at East-West Population Institute. The support of both institutions is gratefully acknowledged.

I. Introduction

The idea of measuring fertility in terms of parity progression, rather than in terms of age-specific fertility rates, goes back to Henry (1953) and has been elaborated recently in a number of papers. Feeney (1980) shows that parity progression measures may be incorporated into a model of population dynamics that provides a complete, formal alternative to conventional age-based approaches to the study of fertility and population growth, including a method of population projection and a stable population theory. Feeney (1985) considers projection in detail, including a number of methods for estimating the input data necessary for parity progression projections. See also Feeney and Wijeyesekera (1983) and Feeney and Ross (1984).

It is customary to distinguish between progression to first birth and progression to higher order births. The interval between the birth of a woman and the birth of her first child, if any, is much longer than the typical interbirth interval; it includes a long interval during which a first birth is impossible; and the variation in intervals to first birth is much greater than the variation in intervals between higher order births. Nonetheless, the formal conceptual machinery of parity progression analysis requires only that we have two events that must occur in a prescribed order. Thus the interval between a woman's own birth and the birth of her first child may be analyzed in the same way as the interval between the birth of any two children. In particular, we may distinguish ultimate progression (the proportion of women who ever have a first birth) from the timing of progression for the women who do progress (the age distribution of first birth), and we may define period statistics by asking what ultimate progression or timing would be in an hypothetical cohort that experiences the rates observed in a given time period.

Observe that "parity progression" refers broadly to the timing of progression for women who do progress, as well as to the ultimate proportion progressing; to progression to first birth as well as progression to higher order births; and to period as well as to cohort statistics.

If most or all fertility occurs within marriage, it is natural to divide progression to first birth into progression to first marriage

and progression from first marriage to first birth, and to study these two components separately.

The work reported in this paper is part of an effort to produce parity progression projections for Japan. One aspect of this effort involves the compilation historical series on the statistics to be projected. Series for progression from first marriage to first birth and progressions to higher order births may be obtained relatively easily from vital statistics data by the indirect procedure described in Feeney (1985). Progression to first marriage is more difficult.

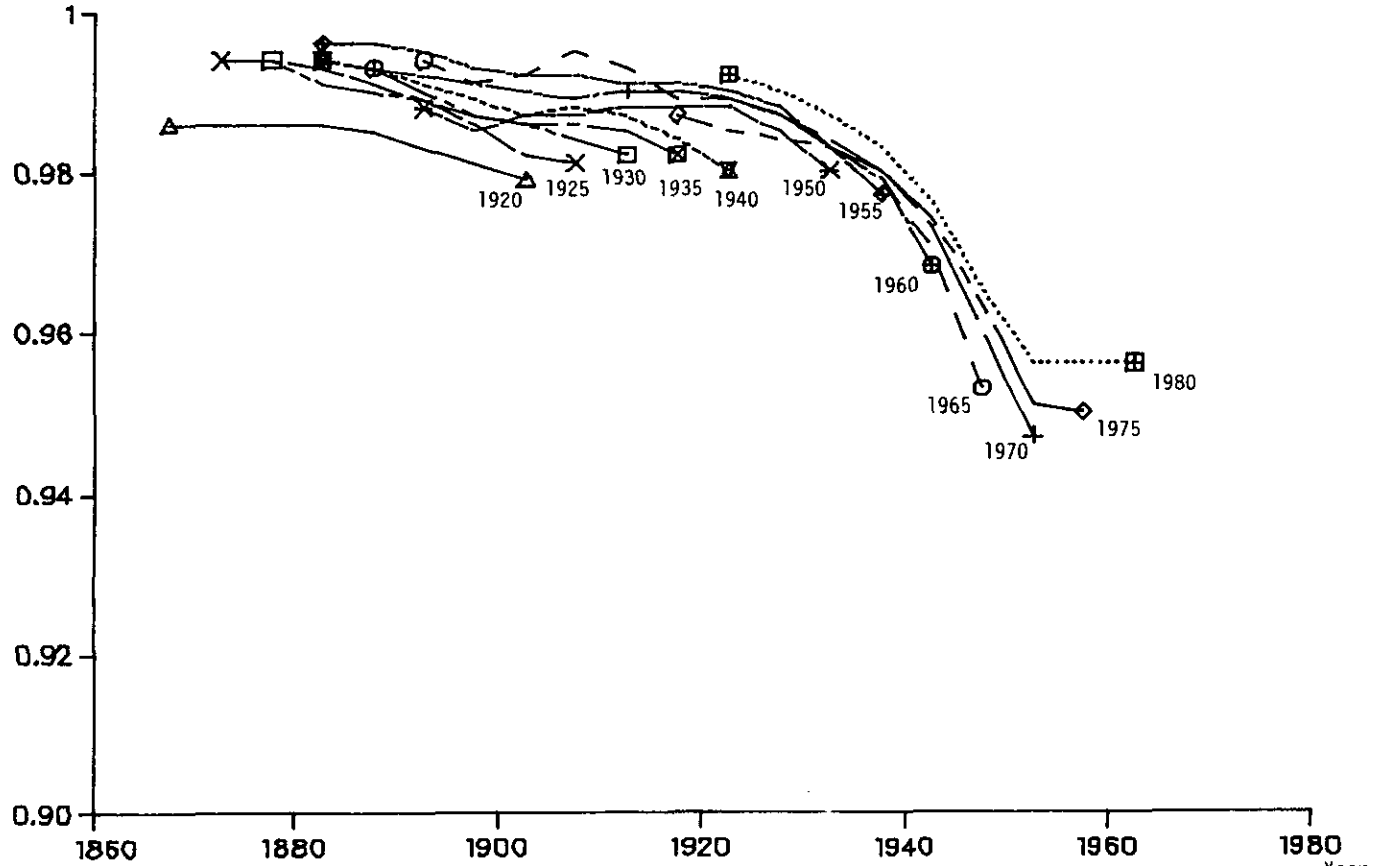
This paper utilizes census and vital registration data for Japan together with indirect estimation techniques to provide a series of data on female progression to first marriage in Japan in long historical perspective. Using a simple approximation, age by marital status tabulations from the censuses of 1920 through 1980 provide a reasonably good picture of the level and trend of ultimate progression to first marriage up to about 1950. The results are plotted in Figure 1.

From 1950 onward we construct, in effect, single year first marriage tables from the census and vital registration data. Substantial and changing levels of delays in marriage registration threaten the validity of this enterprise and require an extended detour from the main line of the work. Fortunately, and remarkably, we find that, due to cancellation of opposing effects, the registered data are in fact reasonably accurate. Though we provide single year estimates of first marriage rates for each year, our principal interest here is in period statistics of ultimate progression to first marriage. Thus we want, for each year, a figure telling us what proportion of women in an hypothetical birth cohort would first marry by age 50 if this cohort experienced the first marriage rates observed in the given year.

II. Historical Perspective

Census data on marital status indicate that marriage was virtually universal in Japan from the late 19th century through 1925, with more than 98 percent of the women in each five year birth cohort ever marrying. From 1925 through 1955 this percentage declined to slightly over 95, at which point it appears to have leveled off. The data, available from 12 censuses taken between 1920 and 1980 (quinquennially

Figure 1. Census Estimates of Progression to First Marriage



Note: See text for explanation.

Source: Table 1.

except for 1945), are shown in Table 1. The time perspective is supplied by imagining marriages to be concentrated at age 25 for all cohorts. The proportion ever-married for the age group x, x + 5 at time t may then be ascribed to time t - (x + 2.5 - 25). Thus, the proportion 0.956 at the lower left in Table 1 is dated 1962.5, and each movement to a higher age group or an earlier census moves this value back five years, except of course for the movement from the 1950 to the 1940 census, which moves it back 10 years. The values are plotted in Figure 1 on this basis. The consistency of the trends from the various censuses provides a rather convincing picture of the overall level and trend in ultimate progression to first marriage. Neither errors in the census data, bias due to differential mortality by marital status, nor the crudity of the dating procedure appear serious enough to distort the overall picture significantly. The discrepancies that are displayed indicate that a conservative lower limit for the procession associated with the values would be about 0.005, or 1/2 percent in absolute terms.

III. Marriage Registration Data

Since 1950, marriages registered each year have been tabulated by month of registration and, with various degrees of detail, year and month of occurrence. Classifications of marriages by other characteristics, including age and previous marital status of bride and groom, are as a rule restricted to marriages occurring in the year of registration. Of the approximately 640.0 first marriages of females (numbers in thousands) in 1950, only some 346.0, or about 55 percent, were registered in this same year. The percentage of marriages occurring in a given year that are registered in the same year has increased in subsequent years, reaching about 90 percent in 1980. This rather substantial incidence of the late registration must be taken into account in using the data. See Kobayashi and Tsubouchi (1978; 13) for further information on marriage registration statistics in Japan.

Table 2 shows total marriages registered each year by the difference between year of registration and year of occurrence. Thus there were a total of 715.1 (in thousands) marriages registered in 1950, of which 346.0 occurred in this same year, 275.4 in 1949, 47.09

Table 1. Proportions of Japanese Women Ever Married

Year	Age Group											
	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99
1920	.979	.981	.983	.985	.986	.986	.986	.986	(.987)	--	--	--
1925	.981	.982	.986	.989	.991	.993	.994	.994	(.995)	--	--	--
1930	.982	.984	.986	.987	.989	.990	.991	.992	(.993)	--	--	--
1935	.982	.985	.986	.986	.987	.990	.993	.994	(.995)	--	--	--
1940	.980	.984	.987	.988	.987	.989	.991	.993	.994	(.994)	--	--
1950	.980	.985	.988	.988	.988	.987	.987	.985	(.988)	--	--	--
1955	.977	.983	.988	.990	.991	.991	.992	.992	.993	.995	.996	.996
1960	.968	.979	.983	.987	.989	.990	.990	.989	.990	.991	.992	.993
1965	.953	.970	.979	.983	.987	.989	.989	.993	.995	.992	.991	.994
1970	.947	.960	.973	.980	.984	.987	.989	.990	.990	(.991)	--	--
1975	.950	.951	.963	.974	.980	.983	.984	.985	.987	(.989)	--	--
1980	.956	.956	.956	.965	.976	.983	.987	.990	.992	(.993)	--	--

Note: Parentheses indicate that the enclosed number refers to the open-ended age group beginning at the initial age indicated.

Source: Population Census of Japan, as follows: 1920, Vol. 1, Table 18, pp. 58-59; 1925, Vol. 2, Table 10, pp. 34; 1930, Vol. 1, Table 12, pp. 60-61; 1935, Vol. 1, Table 11, pp. 70-71; 1940, Vol. 1, Table 4, pp. 314-315; 1950, Vol. 4, Table 4, pp. 10-11; 1955, Vol. 3, Table 4, pp. 70-71; 1960, 10% sample special tabulation, Vol. 1, Table 1, pp. 12-13; 1965, Vol. 5, Table 2, pp. 26-27; 1970, Vol. 5, Table 3, pp. 10-11; 1975, Vol. 5, Table 3, pp. 10-11; 1980, Vol. 2, Table 4, pp. 60-61.

Table 2. Marriage Registration Data for Japan: 1950-1982

Year of reg.	Total reg. (R)	Year of registration minus year of occurrence						Est. occ. (O)	Ratio (O/R)	Diff. (O-R)
		0	1	2	3	4	5+			
1950	715.1	346.0	275.4	47.09	13.67	8.287	23.59	640.0	.895	-75.1
1951	671.9	365.9	217.8	45.01	13.09	7.197	22.31	651.4	.969	-20.5
1952	677.0	378.4	214.2	37.82	12.25	7.161	26.59	657.6	.971	-19.4
1953	682.1	397.2	208.4	35.55	10.71	5.951	24.29	675.0	.990	-7.1
1954	697.8	416.7	207.7	35.25	9.869	5.790	22.54	689.5	.988	-8.3
1955	714.9	438.0	204.7	35.20	9.842	5.280	21.86	741.6	1.037	26.7
1956	715.9	420.5	227.6	32.88	9.504	4.860	20.63	673.9	.941	-42.0
1957	773.4	510.1	191.0	36.54	9.757	5.096	20.82	805.4	1.041	32.0
1958	826.9	533.1	228.1	28.96	11.56	4.868	20.30	821.9	.994	-5.0
1959	847.1	553.7	225.8	32.15	8.530	6.304	20.64	832.0	.982	-15.1
1960	866.1	579.9	220.3	30.52	9.365	4.403	21.59	850.0	.981	-16.1
1961	890.2	616.0	212.8	27.35	8.870	4.828	20.47	887.9	.997	-2.3
1962	928.3	644.8	223.1	27.21	7.961	4.451	20.84	883.5	.952	-44.8
1963	937.5	687.2	195.7	23.46	7.975	4.065	19.11	929.1	.991	-8.4
1964	963.1	715.5	197.4	20.54	6.679	4.335	18.62	944.1	.980	-19.0
1965	954.9	720.3	188.0	19.32	6.010	3.417	17.78	933.5	.978	-21.4
1966	940.1	732.1	168.2	16.15	5.653	2.755	15.27	919.2	.978	-20.9
1967	953.1	763.6	149.4	17.51	5.724	3.219	13.65	950.3	.997	-2.8
1968	956.3	764.3	150.5	14.72	7.127	3.313	16.28	933.1	.976	-23.2
1969	984.1	811.2	133.5	14.61	5.039	4.361	15.45	978.1	.994	-6.0
1970	1,029	855.4	135.8	14.10	5.351	2.789	15.97	1,016	.987	-13
1971	1,091	926.3	129.1	12.54	5.227	2.857	15.20	1,074	.984	-17
1972	1,100	946.8	119.7	12.75	4.402	2.951	13.37	1,083	.985	-17
1973	1,072	931.1	109.3	11.12	4.920	2.496	13.04	1,060	.989	-12
1974	1,000	868.6	102.6	10.63	4.118	2.897	11.62	976.8	.975	-23.2
1975	941.6	829.5	84.33	10.13	3.917	2.287	11.42	935.5	.995	-6.1
1976	871.5	765.1	80.78	8.736	4.060	2.097	10.75	853.0	.976	-18.5
1977	821.0	729.5	66.54	8.889	3.552	2.323	10.18	813.8	.992	-7.2
1978	793.3	708.1	62.00	7.299	3.949	1.922	9.984	790.5	.997	-2.8
1979	788.5	706.3	59.41	7.714	3.087	2.379	9.622	786.2	.997	-2.3
1980	774.7	694.4	57.27	8.016	3.252	1.731	9.989	772.9	.998	-1.8
1981	776.5	698.5	55.64	7.775	3.393	1.950	9.263	772.6	.995	-3.9
1982	781.3	706.5	52.16	7.873	3.248	1.994	9.421	781.4	1.000	0.1
1983			52.75	7.380	3.289	1.909	9.589			
1984				7.465	3.083	1.933	9.658			
1985					3.118	1.812	9.736			
1986						1.832	9.701			
1987							9.687			

Source: Annual vital statistics publications, 1950-1982. Vital Statistics of Japan, Statistics and Information Department, Minister's Secretariat, Ministry of Health and Welfare, Tokyo, Japan. E.g., 1950, Vol. 1, Table 14, pp. 430-431; 1979, Vol. 2, Table 1, pp. 428-429; 1982, Vol. 2, Table 1, pp. 426-427; and so on.

in 1948, through 23.59, which is the number of marriages registered in 1950 that occurred five or more years ago, i.e., in the year 1945 or earlier.

The number of marriages occurring in each year from 1950 through 1977 may be estimated by summing down diagonals, e.g., for 1950, 346.0 + 217.8 + 37.82 + 10.71 + 5.790 + 21.86 = 640.0. The first five terms in the sum are exact, of course, but for errors in the data. The approximation enters in the last term. It is useful in this connection to think of first married women whose marriages have not yet been registered as a population that women enter when they first marry and leave when this marriage is registered. Marriages occurring each year are entry cohorts, analogous to birth cohorts, and registrations of these marriages in this or subsequent years are exits, analogous to deaths. The last term in the above mentioned sum gives a period rather than a cohort number of exits, and this is the source of the approximation.

The estimated numbers of marriages occurring each year are quite close to the numbers registered in the same year for the entire length of the series, as evidenced by the closeness of the occurred/registered ratios to one throughout. This consistency is the result of a rather remarkable cancellation of opposing effects. Increasing numbers of marriages tends to reduce registrations below occurrences, because lower numbers married in previous years means lower numbers registrating late in each current year. That is, the numbers moving across the 1950 row from 346.0 will be lower than the numbers moving diagonally down from this same value. Declines in delayed registration tend to increase registrations above occurrences, as each period experiences relatively high proportions registered both from the current cohort, whose members are registering sooner, and from past cohorts, whose members are registering later. Improbable as the result may seem, the data in Table 2 show near perfect cancellation of these opposing effects.

The data in Table 2 may be used to calculate life-table like rates of registration for cohorts of marriages occuring each year. The procedure, the results of which are shown in Tables 3 and 4, may be illustrated by example for the 1950 cohort. We see from Table 2 that, of 640.0 first marriages estimated to have occurred in 1950, 346.0 were registered in this same year. This is a rate of 0.541, and

Table 3. Numbers of First Marriages Unregistered at the Ends of Successive Calendar Years, for First Marriage Cohorts, 1950-1982

Year of First Marriage Cohort	Estimated Marriage in Cohort	Still Unregistered at the End of i-th Subsequent Year				
		i = 0	i = 1	i = 2	i = 3	i = 4
1950	640.0	--	--	--	--	--
1951	651.4	294.0	--	--	--	--
1952	657.6	285.5	76.20	--	--	--
1953	675.0	279.2	71.30	38.38	--	--
1954	689.5	277.8	70.80	35.75	27.67	--
1955	741.6	272.8	70.10	35.55	25.88	21.88
1956	673.9	303.6	68.10	34.90	25.71	20.60
1957	805.4	253.4	76.00	35.22	25.40	20.85
1958	821.9	295.3	62.40	39.46	25.46	20.30
1959	832.0	288.8	67.20	33.44	27.90	20.60
1960	850.0	278.3	63.00	35.05	24.91	21.60
1961	887.9	270.1	58.00	32.48	25.69	20.51
1962	883.5	271.9	57.30	30.65	23.61	20.86
1963	929.1	238.7	48.80	30.09	22.69	19.16
1964	944.1	241.9	43.00	25.34	22.12	18.62
1965	933.5	228.6	44.50	22.46	18.66	17.78
1966	919.2	213.2	40.60	25.18	16.45	15.24
1967	950.3	187.1	45.00	24.45	19.53	13.70
1968	933.1	186.7	37.70	27.49	18.73	16.31
1969	978.1	168.8	36.20	22.98	20.36	15.41
1970	1,016	166.9	35.30	21.59	17.94	16.00
1971	1,074	160.6	31.10	21.20	16.24	15.15
1972	1,083	147.7	31.50	18.56	15.97	13.38
1973	1,060	136.2	28.00	18.75	14.16	13.02
1974	976.8	128.9	26.90	16.88	13.83	11.66
1975	935.5	108.2	26.30	16.27	12.76	10.93
1976	853.0	106.0	23.87	16.17	12.35	10.48
1977	813.8	88.00	25.22	15.13	12.11	10.26
1978	790.5	84.30	21.46	16.33	11.58	9.787
1979	786.2	82.40	22.30	14.16	12.38	9.660
1980	772.9	79.90	22.99	14.59	11.07	10.00
1981	772.6	78.50	22.63	14.97	11.33	9.343
1982	781.4	74.10	22.86	14.86	11.58	9.384

Note: Estimated first marriages in cohort from Table 2, third column from left. Numbers still unregistered by subtraction of numbers registered, also from Table 2, from this number. E.g., for 1950 cohort: 640.0 - 346.0 = 294.0; 294.0 - 217.8 = 76.20; and so on.

Table 4. Rate of Registration of Marriages Not Yet Registered, for First Marriage Cohorts, 1950-1982

Year	Rate of Registration				
	E	0	1	2	3
1950	.541	--	--	--	--
1951	.562	.741	--	--	--
1952	.575	.750	.496	--	--
1953	.588	.746	.499	.279	--
1954	.604	.748	.498	.276	.209
1955	.591	.750	.502	.277	.204
1956	.624	.750	.483	.272	.189
1957	.633	.754	.481	.277	.201
1958	.649	.772	.464	.293	.191
1959	.666	.782	.478	.255	.226
1960	.682	.792	.484	.267	.177
1961	.694	.788	.472	.273	.188
1962	.730	.821	.475	.260	.189
1963	.740	.820	.481	.265	.179
1964	.758	.816	.478	.264	.196
1965	.772	.822	.434	.268	.183
1966	.796	.789	.398	.225	.167
1967	.804	.799	.389	.234	.165
1968	.819	.806	.390	.259	.177
1969	.829	.791	.404	.219	.214
1970	.842	.814	.399	.248	.155
1971	.862	.804	.403	.247	.176
1972	.874	.810	.405	.237	.185
1973	.878	.802	.397	.262	.176
1974	.889	.796	.395	.244	.209
1975	.887	.779	.385	.241	.179
1976	.897	.762	.366	.251	.170
1977	.896	.756	.352	.235	.192
1978	.896	.735	.340	.242	.166
1979	.898	.721	.346	.218	.192
1980	.898	.717	.349	.223	.156
1981	.904	.709	.344	.227	.172
1982	.904	.704	.344	.219	.172

Note: Calculated from Table 3. E.g., for 1950: (640.0 - 294.0) /640.0 = 0.541; (294.0 - 76.20)/294.0 = 0.741; and so on.

it leaves 294.0 women in the cohort with marriages still unregistered. Table 2 shows that an additional 217.8 of these marriages were registered in 1951. This is a rate of 0.741 (217.8 divided by 294.0) and leaves 76.20 marriages in the cohort still unregistered. Table 3 shows the numbers of marriages remaining unregistered each year in each cohort, Table 4 the corresponding rates of registration of the still-unregistered marriages.

We see from Table 4 that the principal trend over the period in question has been the increase in the rate of registration of marriages in the year of occurrence, which rises from about 55 in 1950 to about 90 percent in 1982. Rates of registration for marriages not registered in the year of occurrence decrease sharply with increasing duration of marriage, but have remained relatively stable over time. Indeed, there has been some tendency for the rates at higher durations to decline over time, signifying poorer rather than better registration performance. These results depend, of course, on the estimated numbers of marriages occurring each year, but the patterns are strong enough not to be affected significantly by any likely error in the estimates given in Table 2.

The estimated numbers of marriages occurring each year are in fact so close to the numbers registered each year that the practical value of the estimation may be rather small. The differences between the numbers registered each year and estimated numbers occurring each year, shown in the last column of Table 2, are of the same general magnitude as the numbers in the problematic "5+" column. One might have hoped that marriages not registered in the year of occurrence would be quickly registered in the following few years. The analysis of Table 3, however, shows that this is by no means the case, that the longer the registration delay, the lower the chances of registration of the still unregistered marriages in any given year. What this means in practice is that the residual group of marriages not quickly registered is intractable. We must be satisfied with a rough estimate because nothing else is possible. Fortunately, most marriages are registered within four years following year of occurrence, so that the role of estimation is small. Thus from Table 3 we estimate that all but 21.88, or 3.4 percent, of the 640.0 marriages occurring in 1950 had been registered by the end of the fourth following year. By 1975 this percentage had fallen to 1.1 percent.

Our concern in this paper is not with total marriages, but with first marriages of females, for which no occurrence-registration tables are available. It would of course be possible to impute patterns for total marriages to first marriages of females, but in view of the relatively small differences between registrations and occurrences, and in view of the possibility that registration delay patterns may be different for these marriages, there would be little point to this. The result of the analysis given here is simply to give an indication of the precision that can be expected from the data on first marriages of females. The numbers are very likely accurate to within one or two percentage points of relative error, with occasional larger deviations possible. Further analysis and attempts at adjustment are always possible, of course, but it seems unlikely in this case that the results would justify the effort.

IV. Indirect Estimation of First Marriage Rates

The rates we wish to estimate take single women aged x in completed years at the beginning of a calendar year as their denominator and the number of first marriages of these women during the year as their numerator. They are thus cohort-period rates, analogous to life table $(L_x - L_{x+1})/L_x$ values, rather than age-cohort rates, analogous to $(l_x - l_{x+1})/l_x$ values. We shall provide estimates for ages 15-49 for the years 1951 through 1982.

Denominators will be derived from the quinquennial censuses of 1950 through 1980, taken as of October 1 of each year, which provide tabulations of population 15 years old and over by sex, single year of age, and marital status. Though we require numbers referring to the beginning of each calendar year, no adjustment has been made for the difference between October 1 and January 1. We treat the census data as it referred to the end of the year in which the census was taken. In view of the rapid pace of first marriage in young adulthood, and the sharp irregularity in the Japanese age distribution, some adjustment might prove desirable. We prefer to get the broad picture, however, before descending to such technical detail.

Marriages registered in the year of occurrence are available by single year of age of bride, as well as by previous marital status of bride and groom, throughout the period, and we might attempt to use

this information in combination with census data to derive first marriage rates directly. Some inflation of numbers of marriages would have to be made to account for delayed registration, however, and the analysis of the preceding section shows that the adjustment would be rather large over much of the period. Given the magnitude of delayed registration and the possibility of differential registration delays by age and previous marital status, we are skeptical of whether the data would support a direct calculation. This, together with the mass of data and intricacy of the direct calculation, leads us to prefer an indirect approach.

The indirect approach is based on the technique of inverse projection developed by Lee (1974; see also Wachter 1985). We begin with (a) the single year age distribution of single women at the beginning of a year, (b) a "model" schedule of first marriage rates, and (c) total numbers of first marriages in the given year and in following years. We then project the population of single women formed year by year, adjusting the model rate schedule up or down by a constant factor k in such a way that the projected numbers of first marriages match the observed numbers. The details of the prediction are given in Table 5.

Table 6 shows the initial distributions of single women for each census, 1950-1980; Table 7, annual numbers of registered first marriages from 1950 through 1982. Table 8 shows first marriage rates calculated from the initial distributions in Table 6 and registered marriages occurring in the following year. Table 9 gives life table L_x values for the various quinquennial periods, interpolated for official life tables.

The projected age distributions of single women resulting from each inverse projection may be compared with the distributions recorded in the subsequent census, and this provides a useful check on the quality of the results, which depend on the "multiplication by a constant" model of changing schedules of first marriage rates as well as on the quality of the census and marriage registration data. Table 10 shows 1,000 x (C - P)/C, where C and P denote, respectively, the value recorded in the census and the projected value. The results of this comparison are not spectacularly good, but neither are they spectacularly bad. Deviations of 5-10 percent are the norm, with occasional 10-20 percent deviations. The deviations of the total of

Table 5. Inverse Projection Procedure for Indirect Estimation of First Marriage Rates

Notation

P(a,y) - number of never married women aged a at the beginning of year y

FM(a,y) - number of these women who first marry in year y

TM(y) - total number of first marriages in year y

R(a,y) - rates of first marriage, FM(a,y)/P(a,y)

MR(a,y) - model schedule of first marriage rates

S(a) - survivorship rates, La+1/La

Input Data

(1) N - number of years inverse projection is to carried out, N<15

(2) P(a,1), a = 0, 1, . . . , 49

(3) MR(a), a = 15, . . . , 49

(4) S(a), a = 0, 1, . . . , 49

(5) TM(y), y = 1, . . . , N

Procedure

For y = 1, . . . , N, do the following steps:

(1) $K(y) = TM(y) / \sum_{a=15}^{49} P(a,y)MR(a)$

(2) R(a,y) = MR(a)K(y), a = 15, . . . , 49

(3) FM(a,y) = P(a,y)R(a,y), a = 15, . . . , 49

(4) P(a+1,y+1) = P(a,y)[1 - R(a,y)]S(a), a = 0, 1, . . . , 49

Output

(1) P(a,y), a = 0, 1, . . . , 49, y = 2, . . . , N

82) R(a,y), a = 15, . . . , 49, y = 2, . . . , N

(3) FM(a,y), a = 15, . . . , 49, y = 2, . . . , N,
with $\sum_{a=15}^{49} FM(a,y) = TM(y)$

Table 6. Single Women Aged 0-49 by Single Years of Age: Japan Censuses of 1950-1980

Age	Census Year						
	1950	1955	1960	1965	1970	1975	1980
0	1,134	833.4	769.1	852.9	913.6	932.9	772.8
1	1,236	835.4	778.8	812.4	907.6	987.7	796.5
2	1,215	890.0	757.5	791.0	886.3	1,007	832.2
3	1,148	949.5	739.7	767.9	889.4	984.0	852.6
4	735.6	1,013	786.9	759.7	695.6	961.7	895.2
5	808.8	1,098	834.5	769.2	863.8	931.7	939.2
6	982.0	1,214	830.4	785.0	810.1	917.1	990.1
7	955.4	1,206	888.8	767.0	790.5	898.6	1,009
8	980.0	1,142	942.0	744.5	765.5	902.9	986.1
9	971.1	745.7	1,007	788.6	758.4	704.1	964.8
10	887.5	805.2	1,094	831.5	770.2	876.7	934.4
11	781.5	978.0	1,212	830.7	783.9	820.2	920.6
12	848.3	954.7	1,205	893.2	766.5	801.9	900.3
13	885.5	985.2	1,147	948.0	745.5	777.5	903.9
14	896.7	968.9	738.6	1,010	786.1	768.7	705.5
15	886.2	887.3	790.5	1,095	815.6	777.8	875.6
16	840.2	781.5	964.6	1,205	821.5	793.5	819.5
17	840.2	837.0	939.7	1,185	875.0	771.0	797.1
18	809.6	859.7	957.5	1,111	914.3	745.4	769.0
19	748.3	843.9	911.6	691.0	950.9	765.4	746.9
20	642.1	766.0	798.2	711.8	982.4	762.9	728.9
21	535.2	663.1	630.8	790.5	996.9	698.8	703.3
22	421.6	572.9	578.7	664.8	863.4	646.3	627.5
23	318.9	455.9	485.4	543.7	657.8	555.3	521.3
24	234.6	341.3	375.5	392.7	317.1	450.8	434.0
25	167.7	249.5	279.1	262.6	242.5	358.0	338.1
26	121.1	187.0	204.1	167.2	205.1	290.2	245.6
27	93.90	144.1	165.3	134.9	154.0	219.2	195.2
28	72.25	114.4	132.9	112.7	122.3	166.2	160.5
29	57.05	94.06	108.2	95.63	98.04	85.94	137.4

Table 6. (continued)

Age	Census Year						
	1950	1955	1960	1965	1970	1975	1980
30	49.35	74.82	90.15	83.85	77.28	78.25	123.4
31	33.94	60.14	76.99	72.01	58.49	79.42	117.1
32	29.94	50.99	68.13	69.76	56.85	69.32	104.8
33	25.55	42.12	60.92	65.64	55.00	65.70	89.17
34	23.00	35.16	55.15	60.52	53.00	59.74	51.55
35	19.84	31.73	46.76	55.52	49.87	50.81	50.95
36	18.63	23.12	39.88	50.90	46.75	41.78	55.02
37	15.73	20.62	36.06	46.90	47.69	43.20	51.09
38	14.28	17.98	30.71	45.93	45.65	42.44	49.65
39	11.81	16.57	25.78	41.28	44.30	42.25	47.06
40	10.47	14.60	23.86	37.02	41.94	41.62	41.11
41	9.853	13.91	17.52	31.50	39.30	38.53	34.44
42	8.965	12.11	15.80	28.24	37.11	40.42	35.93
43	8.878	11.22	14.77	25.50	37.41	40.47	37.05
44	7.267	9.642	13.45	22.32	35.21	39.02	37.26
45	6.647	8.959	11.43	20.92	31.17	37.99	36.94
46	5.855	8.099	11.42	15.36	28.25	36.50	34.94
47	5.903	7.469	10.12	13.62	24.74	35.81	35.90
48	5.433	7.454	9.500	13.04	22.66	34.24	36.54
49	5.192	6.169	9.160	11.61	19.76	31.84	36.10
15-49	7,105	8,271	8,990	9,980	9,869	9,036	9,206

Source: Population Census of Japan, as follows: 1950, Vol. 4, Table 4, pp. 10-11; 1955, Vol. 3, Part 1, Table 4, pp. 70-71; 1960, Vol. 1, Table 1, pp. 12-13; 1965, Vol. 5, Table 2, pp. 26-27; 1970, Vol. 5, Part 1, Division 1, Table 3, pp. 10-11; 1975, Vol. 5, Part 1, Division 1, Table 3, pp. 10-11; 1980, Vol. 2, Part 1, Table 4, pp. 60-61.

Table 7. Annual Registered First Marriages in Japan: 1950-1982

Year	No.	Year	No.	Year	No.	Year	No.
1950		1960	812.6	1970	967.7	1980	701.4
1951		1961	838.4	1971	1,027	1981	702.3
1952	606.5	1962	874.7	1972	1,033	1982	704.8
1953	618.7	1963	884.8	1973	1,003		
1954	637.4	1964	909.2	1974	929.8		
1955	656.6	1965	900.3	1975	871.4		
1956	659.7	1966	886.1	1976	801.3		
1957	717.3	1967	897.1	1977	750.8		
1958	771.5	1968	900.6	1978	722.6		
1959	793.4	1969	925.5	1979	715.6		

Source: Annual vital statistics publications, 1952-1982. Vital Statistics of Japan, Statistics and Information Department, Minister's Secretariat, Ministry of Health and Welfare, Tokyo, Japan. E.g., 1952, Vol. 1, Table 28, pp. 348; 1979, Vol. 2, Table 3, pp. 434-435; 1982, Vol. 2, Table 3, pp. 432-433; and so on.

Table 8. First Marriage Rates (x 10000) Calculated from Registered First Marriages of Females, at Five Year Intervals, 1951-1981

Age	Year						
	1951	1956	1961	1966	1971	1976	1981
15	147	54	37	34	42	48	49
16	491	226	156	170	190	182	181
17	1,255	674	538	518	614	542	495
18	2,669	1,716	1,416	1,411	1,587	1,400	1,183
19	4,607	3,521	3,150	3,690	3,759	3,416	2,630
20	6,965	6,039	6,228	7,195	7,394	7,112	4,976
21	9,264	9,138	10,648	11,692	12,535	12,090	8,272
22	10,814	11,772	14,582	17,095	17,683	17,522	13,036
23	11,408	13,345	17,371	21,259	22,232	22,129	18,066
24	11,309	13,851	18,834	22,988	25,714	24,353	21,331
25	10,405	13,146	18,492	23,099	25,897	23,330	22,225
26	9,297	11,367	17,064	21,598	22,951	20,407	20,648
27	8,153	9,510	14,629	18,307	19,181	16,527	17,920
28	7,355	7,827	11,960	14,991	15,647	13,431	15,341
29	6,249	6,214	9,749	12,279	12,341	11,614	12,678
30	5,233	5,220	8,141	9,980	10,087	9,622	10,064
31	4,704	4,507	6,763	8,565	8,622	7,907	8,016
32	4,237	3,913	5,517	7,308	7,263	6,669	6,346
33	3,770	3,681	4,642	6,220	6,257	5,607	5,298
34	3,381	3,150	3,943	5,389	5,430	4,675	4,822
35	3,117	2,617	3,512	4,678	4,618	4,083	4,203
36	2,833	2,526	3,070	4,124	4,057	3,597	3,419
37	2,512	2,283	2,701	3,424	3,641	3,171	2,822
38	2,246	2,044	2,585	2,938	3,198	2,799	2,391
39	2,178	1,828	2,171	2,599	2,781	2,346	1,973
40	2,120	1,608	1,838	2,271	2,575	2,070	1,690
41	1,932	1,467	1,852	2,149	2,310	1,946	1,530
42	1,577	1,425	1,668	1,937	1,952	1,751	1,369
43	1,316	1,347	1,352	1,731	1,711	1,642	1,234
44	1,225	1,138	1,284	1,603	1,558	1,487	1,117
45	1,272	980	1,200	1,520	1,394	1,273	1,002
46	1,343	1,011	971	1,469	1,230	1,101	930
47	1,289	973	934	1,321	1,138	956	808
48	1,090	795	900	1,195	1,039	928	720
49	789	685	818	993	828	852	680

Note: Calculated from numbers of first marriages registered in indicated years (excludes marriages occurring in given year and registered in future years and includes marriages registered in given year that occurred in past years) and the census numbers of never married women in Table 6 (assumed for the purpose of this calculation to refer to December 31 of the census year).

Source: Annual vital statistics publications, 1950-1982. Vital Statistics of Japan, Statistics and Information Department, Minister's Secretariat, Ministry of Health and Welfare, Tokyo, Japan. E.g., 1950, Vol. 1, Table 16, pp. 438-439, Table 18, pp. 466-467; 1955, Vol. 1, Table 39, pp. 392-393, Table 39, pp. 400-401; 1960, Vol. 1, Table 38, pp. 440-441, Table 38, pp. 448-449; 1965, Vol. 1, Table 44, pp. 462-463, Table 44, qpp. 470-471; 1970, Vol. 1, Table 4, pp. 636-637, Table 4, pp. 644-645; 1975, Vol. 1, Table 4, pp. 652-653, Table 4, pp. 660-661; and so on.

Table 9. Life Table L_x Values for Inverse Projection Calculation of Rates of Progression to First Marriages

	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80
0	97,232	97,438	98,291	98,881	99,170	99,371
1	95,249	96,660	97,792	98,570	98,950	99,203
2	94,546	96,329	97,605	98,449	98,854	99,125
3	94,003	96,054	97,455	98,356	98,781	99,067
4	93,603	95,844	97,344	98,287	98,728	99,026
5	93,323	95,684	97,256	98,232	98,686	98,994
6	93,132	95,564	97,184	98,184	98,650	98,966
7	92,997	95,475	97,126	93,144	98,619	98,943
8	92,896	95,408	97,078	98,110	98,593	98,922
9	92,812	95,352	97,038	98,080	98,569	98,904
10	92,737	95,301	97,003	98,053	98,549	98,888
11	92,664	95,252	96,970	98,029	98,528	98,873
12	92,593	95,204	96,937	98,003	98,508	98,858
13	92,518	95,157	96,905	97,977	98,487	98,843
14	92,439	95,109	96,370	97,949	98,464	98,825
15	92,352	95,057	96,832	97,918	98,438	98,806
16	92,252	94,996	96,789	97,384	98,409	98,782
17	92,133	94,922	96,737	97,843	98,375	98,755
18	91,989	94,829	96,676	97,797	98,337	98,723
19	91,818	94,719	96,604	97,744	98,291	98,688
20	91,625	94,593	96,524	97,686	98,241	98,649
21	91,414	94,455	96,434	97,620	98,186	98,608
22	91,186	94,307	96,338	97,550	98,129	98,565
23	90,940	94,151	96,234	97,476	98,068	98,522
24	90,682	93,990	96,126	97,393	98,005	98,476
25	90,417	93,826	96,014	97,317	97,940	98,429
26	90,148	93,658	95,897	97,232	97,874	98,379
27	89,873	93,487	95,778	97,143	97,806	98,327
28	89,593	93,313	95,656	97,051	97,736	98,273
29	89,311	93,135	95,532	96,958	97,663	98,217
30	89,026	92,954	95,406	96,862	97,586	98,158
31	88,739	92,767	95,275	96,763	97,507	98,096
32	88,450	92,575	93,937	95,857	97,423	98,031
33	88,157	92,377	94,992	96,545	97,334	97,961
34	87,860	92,172	94,339	96,425	97,240	97,887
35	87,556	91,959	94,680	96,299	97,139	97,807
36	87,243	91,738	94,514	96,164	97,031	97,722
37	86,923	91,506	94,338	96,022	96,917	97,630
38	86,593	91,264	94,152	95,871	96,793	97,531
39	86,253	91,010	93,953	95,709	96,660	97,424
40	85,900	90,744	93,743	95,536	96,516	97,308
41	85,538	90,468	93,522	95,350	96,359	97,182
42	85,163	90,181	93,289	95,143	96,188	97,046
43	84,775	89,877	93,037	94,929	96,004	96,898
44	84,369	89,551	92,764	94,694	95,806	96,736
45	83,944	89,201	92,465	94,439	95,594	96,561
46	83,496	88,823	92,138	94,163	95,365	96,370
47	83,014	88,413	91,781	93,862	95,115	96,161
48	82,494	87,966	91,393	93,531	94,339	95,932
49	81,935	87,484	90,975	93,168	94,538	95,681

Note: Interpolated from some life tables

Source: *The 15th Life Tables. Statistics and Information Department*, Minister's Secretariat, Ministry of Health and Welfare, Tokyo, Japan, as follows: 9th, pp. 68-69; 10th, pp. 72-73; 11th, pp. 76-77; 12th, pp. 80-81; 13th, pp. 84-85; 14th, pp. 88-89; 15th pp. 92-93; and so on.

Table 10. Five Year Residuals: Inverse Projection

Age	Year					
	1955	1960	1965	1970	1975	1980
15	4	-16	2	-18	11	-0
16	7	-10	-3	-9	14	1
17	2	-8	-12	-16	10	-3
18	7	-8	-18	-25	11	-2
19	22	-10	-30	-31	3	-7
20	40	9	-16	-29	6	-9
21	47	10	-7	-12	-2	5
22	62	21	28	23	9	41
23	53	30	60	59	34	68
24	15	16	89	103	65	85
25	-7	14	102	108	111	78
26	-39	-22	117	92	157	39
27	-55	-52	110	132	182	-9
28	-56	-100	101	121	207	-59
29	-25	-135	81	107	190	-109
30	-20	-161	63	104	167	-140
31	-14	-187	23	65	118	-145
32	-15	-175	20	53	63	-117
33	-19	-156	-0	24	70	-111
34	-33	-129	-5	21	67	-82
35	-45	-117	-8	-7	53	-74
36	-26	-102	-15	6	64	-71
37	-49	-69	-49	-12	67	-53
38	-60	-66	10	-41	39	-65
39	-64	-89	-30	-34	33	-51
40	-63	-85	-2	-40	46	-48
41	-67	-95	-31	-50	10	-49
42	-50	-103	-60	-51	17	-57
43	-45	-42	-16	-41	41	-21
44	-21	-66	8	-9	18	-22
45	10	-117	7	-35	31	-24
46	-45	-76	-2	20	42	-9
47	-41	-63	-32	-11	67	-38
48	-37	-56	-17	-4	7	-28
49	-28	52	-46	-13	-11	-10
15-49	15	-13	10	6	36	10

Note: See text for explanation.

15-45 years old single women, however, are quite small; the discrepancies reflect the age pattern rather than the level of first marriage.

The residuals in Table 10 reflect (a) the initial age distributions of single women from the censuses, (b) the total numbers of first marriages from marriage registration, (c) the "model" age schedule of first marriage rates used, and (d) the assumption that changes in first marriage rates in each five year period may be represented by multiplying a model schedule by a constant factor. One would expect the census data (a) to be the most reliable of these factors, and to be quite accurate in absolute terms. As indicated in the preceding section, the marriage registration data (b) are probably good to within a few percentage points. Neither of these factors seems likely to account for the differences recorded in Table 10.

The obvious place to begin to attempt to improve the results is with the model schedule (c). If it were possible to determine quickly and easily the model schedule that minimizes any given measure of goodness of fit, this would be the natural way to proceed. Assuming the data (a-b) to be essentially correct, this procedure would indicate the limitation imposed by the assumption (d). The minimization would in fact be quite labourious, however, and since the choices of a goodness of fit measure is more or less arbitrary, this approach has little practical appeal. We try a simpler approach by first adjusting, by linear interpolation, the results of the inverse projection to conform exactly to the subsequent census and then calculating the first marriage schedule from these adjusted results aggregating over the entire five year period. We then reexecute the inverse projection using this modified model schedule.

Table 11 shows the results of this procedure in the same form as Table 10. The improvement is substantial, with all residuals now under 10 percent except for ages 25-29 in 1975, and with generally lower residuals across the board. One might hope that iterations of this adjustment procedure would improve the results further, but this turns out not to be the case, with the present data, at any rate. This might be because the model is already close to minimizing the residuals, but this seems unlikely in view of the relatively regular age pattern of the residuals.

The adjusted model schedules resulting from this procedure are

Table 11. Five Year Residuals: Final Estimation Procedure (Inverse Projection, Model Schedule Adjustment, Inverse Projection)

Age	Year					
	1955	1960	1965	1970	1975	1980
15	4	-16	2	-18	11	-0
16	4	-5	5	2	13	2
17	-4	-3	-0	-1	8	-1
18	-4	-4	-5	-7	9	-1
19	5	-8	-17	-11	1	-8
20	18	4	-6	-11	6	-16
21	26	-7	-7	-8	3	-11
22	44	-8	18	16	23	13
23	45	-11	40	38	56	29
24	25	-34	59	70	95	38
25	23	-36	63	61	139	30
26	14	-60	72	32	168	3
27	16	-65	61	63	168	-19
28	23	-77	54	45	166	-33
29	50	-72	40	29	128	-42
30	48	-63	33	32	94	-39
31	44	-63	6	2	49	-24
32	35	-40	29	15	9	6
33	27	-23	-5	-14	31	7
34	15	-7	12	9	33	22
35	7	-7	16	-5	22	17
36	29	-6	11	18	35	8
37	12	15	-31	3	39	15
38	7	12	50	1	14	-3
39	6	-12	0	6	12	5
40	7	-10	28	4	28	4
41	2	-19	-0	-3	-5	-2
42	11	-25	-30	-7	3	-15
43	9	29	10	-2	24	14
44	24	5	28	21	-2	8
45	48	-46	25	-10	10	3
46	-6	-15	14	36	18	15
47	-2	-13	-17	1	44	-15
48	3	-17	-3	6	-9	-7
49	11	74	-33	-5	-22	8
15-49	15	-14	10	6	36	8

Note: See text for explanation.

shown in the first six columns of Table 12. For the years 1951-1980, our final estimates of first marriage rates for any given year are the rates obtained by multiplying the model schedule for the five year period within which the year falls by the inverse projection k value for this year. Values of k are given at the bottom of the table. For the years subsequent to the most recent census, of course, the procedure of adjusting the initial model schedule does not apply. Thus our final first marriage rates for the years 1981 and 1982 are obtained by multiplying the initial model schedule for 1981, i.e., the observed rates in the 1981 column of Table 8, by the inverse projection k values. Thus Table 12 contains, implicitly, our final estimates of first marriage rates for each year from 1951 through 1982.

V. Progression to First Marriage: 1950-1982

Given a set of single year first marriage rates for a given year, we compute ultimate progression to first marriage by subtracting each rate from one, taking the product of all the rates, and subtracting this product from one.

Table 13 shows four estimates of the time series of ultimate progression to first marriage. Series 2 shows the values that result from using a single round of inverse projection. The rates from which these values are calculated are not shown, but they correspond to the residuals shown in Table 10. Series 1 shows the values that result from the same calculation if mortality is ignored (S(a) = 1 for all a in Table 5). The comparison of series 1 and 2, shown in Figure 2, shows that taking account of mortality makes very little difference. Knowing this, one might choose to ignore mortality in future calculations.

Series 3 shows our final estimates, calculated from the first marriage rates estimated by inverse projection, followed by adjustment of the model schedules, followed by a second inverse projection, as described in the last section. These rates are shown (implicitly) in Table 12 and correspond to the residual values shown in Table 11. Series 4 shows the values that result from the same procedure, but with registered first marriages each year replaced by registered first marriages multiplied by the O/C ratio in Table 2. The idea of the

Table 12. Adjusted Model Schedules of First Marriage Rates (x 10000)

Age	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85
15	0	580	791	1,101	0	198	49
16	447	442	549	647	122	243	181
17	1,582	1,104	1,021	947	629	453	495
18	3,850	2,720	2,149	1,875	1,729	1,096	1,183
19	7,103	5,597	4,576	4,579	4,157	2,837	2,630
20	11,145	9,735	9,118	8,783	8,264	6,214	4,976
21	15,165	14,888	15,621	14,179	14,012	10,883	8,272
22	18,141	19,363	21,372	20,736	19,665	16,171	13,036
23	19,619	22,253	25,403	25,819	24,437	20,864	18,066
24	19,758	23,474	27,547	27,947	27,575	23,553	21,331
25	18,431	22,943	27,010	27,944	26,828	23,339	22,225
26	16,539	20,643	24,958	25,735	23,089	21,238	20,648
27	14,435	18,165	21,439	21,675	19,081	17,999	17,920
28	12,855	15,741	17,685	17,747	15,916	15,300	15,341
29	10,964	13,181	14,625	14,633	12,496	13,633	12,678
30	9,303	11,499	12,469	12,175	10,292	11,570	10,064
31	8,459	10,078	11,613	11,327	8,832	9,596	8,016
32	7,801	8,762	6,454	7,731	7,205	8,114	6,346
33	7,171	8,080	8,624	8,843	6,160	6,798	5,298
34	6,628	6,997	6,463	7,239	5,361	5,778	4,822
35	6,241	5,923	5,812	6,449	4,448	5,110	4,203
36	5,948	5,704	5,185	5,961	3,981	4,550	3,419
37	5,437	5,421	4,563	5,224	3,704	4,153	2,822
38	4,951	5,041	4,554	4,602	3,183	3,628	2,391
39	4,716	4,599	3,793	4,108	2,754	3,071	1,973
40	4,388	4,273	3,305	3,672	2,583	2,705	1,690
41	3,930	3,954	3,233	3,295	2,137	2,441	1,530
42	3,253	3,732	2,726	2,859	1,515	2,173	1,369
43	2,747	3,724	2,207	2,424	1,357	2,096	1,234
44	2,620	3,041	2,298	2,273	1,267	1,902	1,117
45	3,014	2,472	2,113	1,987	1,101	1,702	1,002
46	3,014	2,222	1,767	2,043	1,074	1,506	930
47	2,793	1,889	1,571	1,811	1,273	1,218	808
48	2,309	1,316	1,433	1,638	1,187	1,078	720
49	1,679	1,412	1,070	1,302	870	970	680
K values							
Year							
1	1.12432	0.89056	0.98434	1.00731	1.12706	1.06149	1.08406
2	1.06763	0.92978	1.02909	1.02019	1.12925	1.01344	1.08586
3	1.03092	0.97398	1.03679	1.01961	1.11543	0.98415	--
4	1.00737	0.98927	1.05709	1.02662	1.06828	0.97716	--
5	0.98928	1.00588	1.04391	1.03648	1.03356	0.95841	--

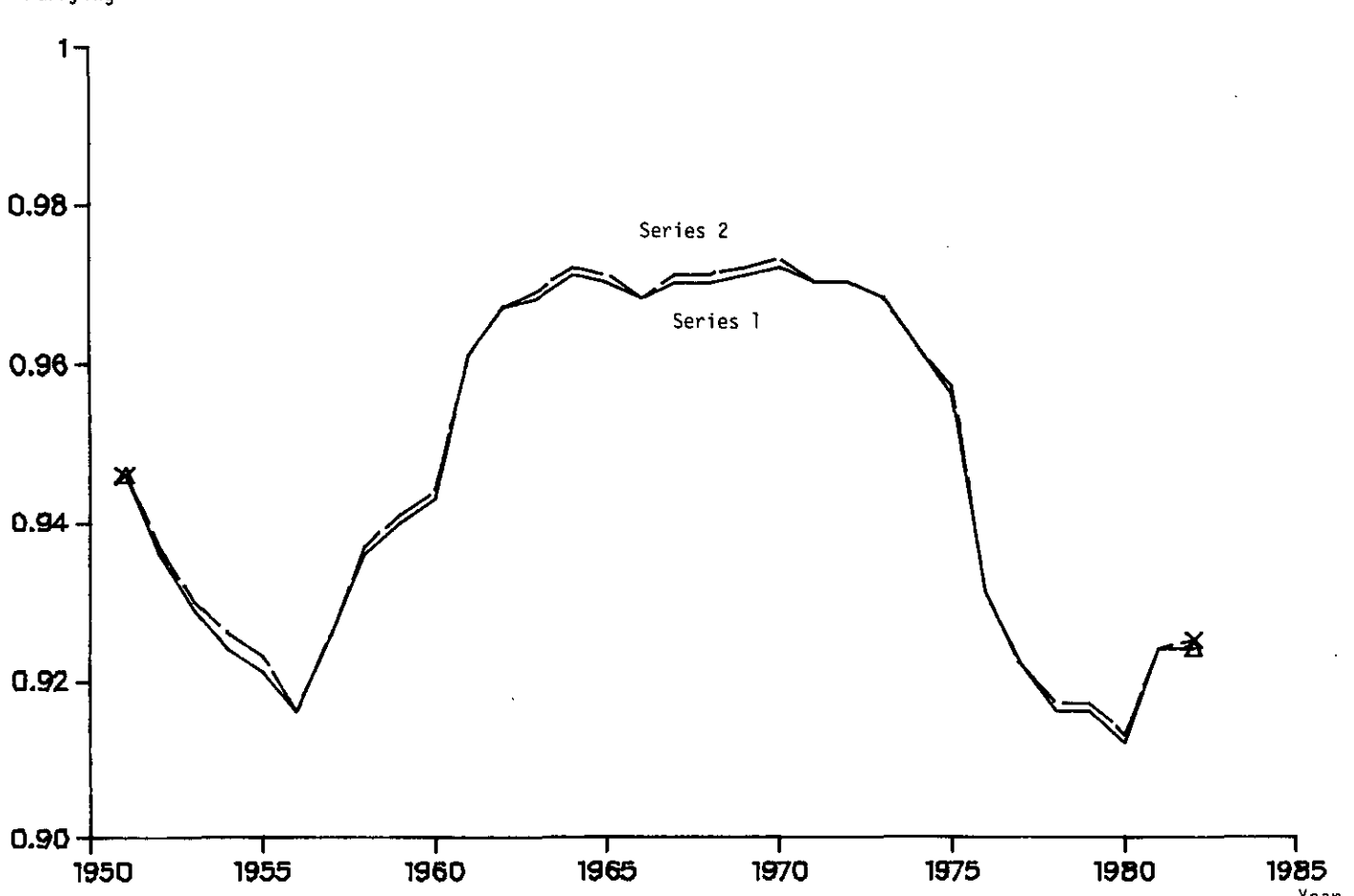
Note: See text for explanation. To obtain final estimate of first marriage rate for age a and year y, multiply the model rate for the period within which year y falls by the k value for the number of this year within the period. E.g.: the rate for age 15 in 1958 is 0.00580 x 0.97398.

Table 13. Estimated Period Progression to First Marriage: Various Estimations

	Series 1	Series 2	Series 3	Series 4
1951	.946	.946	.960	.956
1952	.936	.937	.953	.948
1953	.929	.930	.947	.945
1954	.924	.926	.943	.940
1955	.921	.923	.940	.945
1956	.916	.916	.938	.926
1957	.926	.926	.945	.951
1958	.936	.937	.953	.952
1959	.940	.941	.955	.952
1960	.943	.944	.958	.954
1961	.961	.961	.963	.963
1962	.967	.967	.969	.962
1963	.968	.969	.970	.967
1964	.971	.972	.972	.968
1965	.970	.971	.970	.966
1966	.968	.968	.968	.966
1967	.970	.971	.970	.969
1968	.970	.971	.970	.966
1969	.971	.972	.971	.969
1970	.972	.973	.972	.969
1971	.970	.970	.965	.963
1972	.970	.970	.966	.963
1973	.968	.968	.964	.962
1974	.962	.962	.958	.953
1975	.956	.957	.953	.949
1976	.931	.931	.947	.943
1977	.922	.922	.939	.937
1978	.916	.917	.933	.932
1979	.916	.917	.932	.930
1980	.912	.913	.928	.926
1981	.924	.924	.924	.923
1982	.924	.925	.925	.925

Case 1: Inverse Projection Only, No Mortality
Case 2: Inverse Projection Only, Mortality
Case 3: INV PRJ, ADJ, 2ND INV PRJ
Case 4: Inverse Projection Only, with est. first marriages occuring in year

Figure 2. Effect of Mortality on Inverse Projection



Note: See text for explanation.

comparison of series 3 and 4 is to see the effect of adjusting the registered numbers of first marriages on the basis of our Table 2 estimate of completeness of registration of total marriages. Our expectation is that this adjustment will not improve the results, both because of the likely differences between registration of first and total marriages, and because the adjustments are small relative to the error inherent in the adjustment procedure. Series 4 was calculated, indeed, only as an afterthought, the original decision having been not to make this adjustment. The comparison of the two series, shown in Figure 3, suggests that the original decision was correct. Although it is possible that Series 4 improves on Series 3, the erratic pattern displayed by series 4 suggests the reverse.

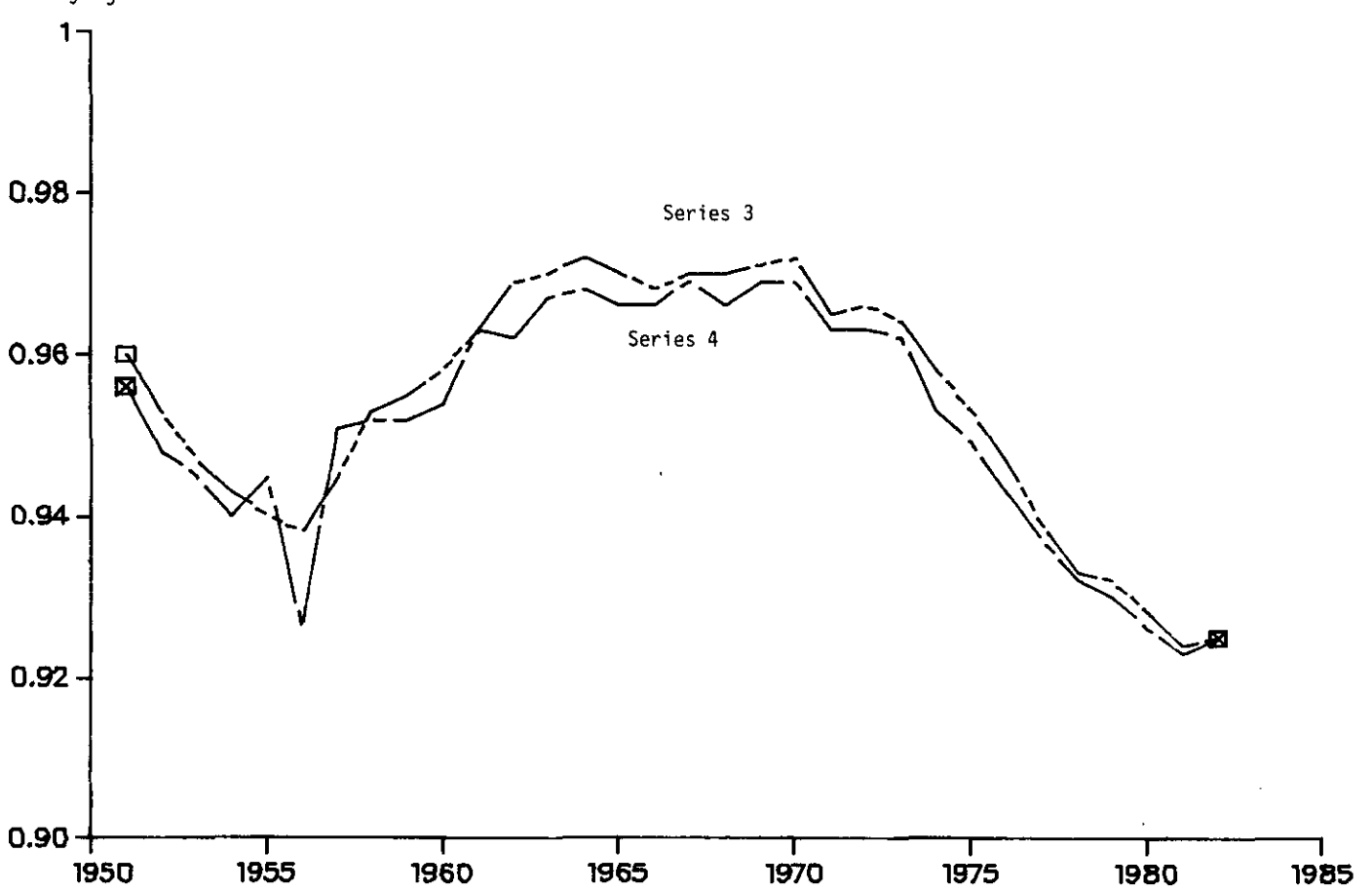
Figure 4 summarizes our information on period progression to first marriage, joining the series 3 indirect estimates to the census proportions ever married shown in Figure 1. Given the very different nature of the two series, the match between them is remarkably good.

VI. Discussion

Having gone to considerable trouble to obtain the estimated series of progression to first marriage shown in Figure 4, we now consider what may be learned from them. Looking first at the pattern over time, we see the following: (i) a high and constant level of about 99 percent from the beginning of the series in about 1870 to about 1920; (ii) a gradual and then accelerating decline from about 1920 to about 1950; (iii) a continued decline to a sharp bottom of 94 percent in 1956 (here and in the following points, see the numbers in Table 12 as well as the Figure 4 plot); (iv) an immediate and sharp rise back to 97 percent in the early 1960s, followed by a leveling off with minor fluctuations for half a dozen years; (v) a precipitous decline, beginning in 1970 and taking the level down to 92 percent in 1981, the next to the last year of the series; (vi) no change in level between 1981 and 1982, suggesting that this level may be, for the present at least, a bottom.

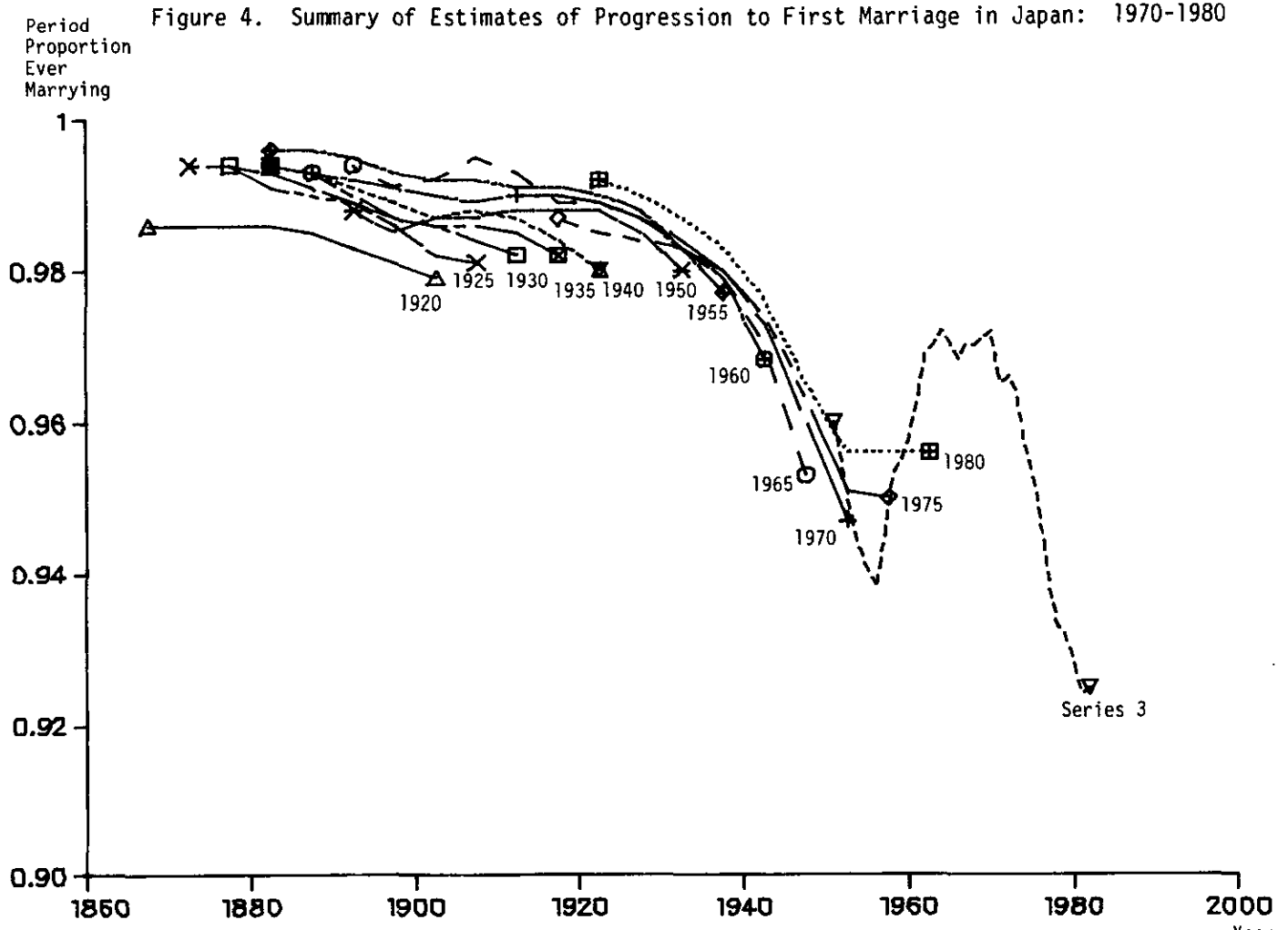
Recalling now that the purpose of our work is to provide historical series for the purpose of population projections, what does the series we have obtained suggest? One might regard Figure 4 as a picture of a transition from a state of extremely high and stable

Figure 3. Effect of Marriage Registration Data Adjustment on Estimates of Period Progression to First Marriage, Final Estimation Procedure



Note: See text for explanation.

Figure 4. Summary of Estimates of Progression to First Marriage in Japan: 1970-1980



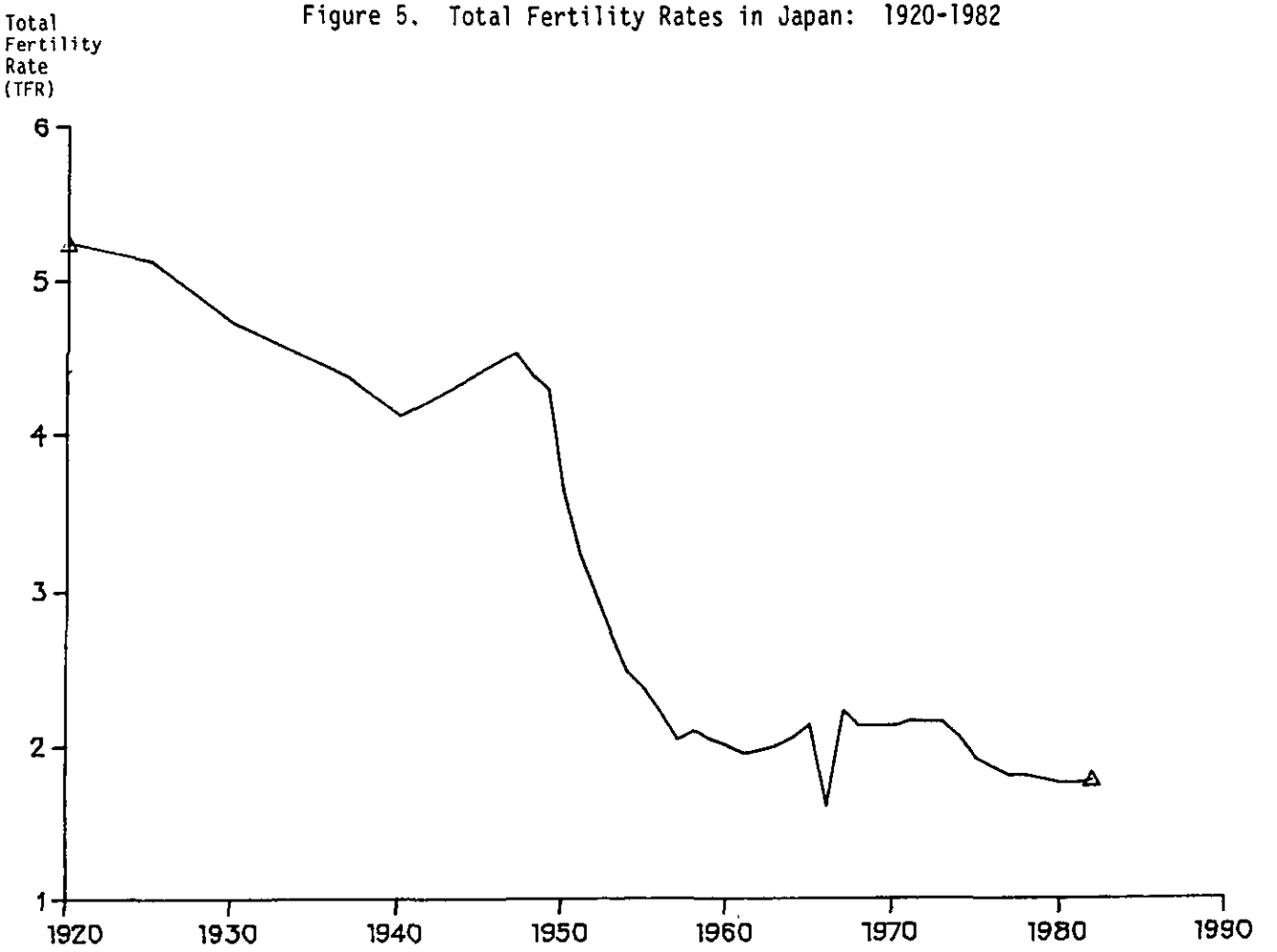
Source: Tables 1 and 13.

rates of progression prior to 1920 to a state of fairly high but substantially fluctuating rates after 1920. Although the fluctuations are clearly defined, they are not terribly large in absolute terms. Over the entire 60 year period from 1920 to 1980 we see a decline from 99 to 92 percent, a decline of about seven percent, and the fluctuations involve smaller movements than this. To put this in perspective, consider the trend of the total fertility rate (TFR) over the same period, shown in Figure 5. The TFR declined from slightly over 5 in 1920 to about 1.8 in 1982, a decline of about 60 percent.

We cannot assume, however, that a given percent change in period progression to first marriage will result in a similar change in the total fertility rate. We have calculated period progression to first marriage by life table methods, recognizing that only never married women can first marry. Thus, for each year, we determine the number of never married women aged x at the beginning of the year, the number of first marriages of these women during the year, and calculate the rate of first marriage by taking the quotient of these two numbers. Period progression to first marriage is then defined by asking what proportion of women would ever marry in a birth cohort that experienced these rates of first marriage, and the answer to this question is obtained by subtracting the first marriage rate for each age x from one, taking the product over all ages x, and then subtracting this product from one. This calculation is essentially that which gives life table l_x values from life table q_x values, the difference being only that we are using cohort-period rates, whereas the q_x values of the life table are age-cohort rates.

Compare this life table calculation with the conventional calculation of the TFR. The underlying idea is of course similar. Given age-specific fertility rates for a given year, we consider an hypothetical cohort experiencing these rates, and no mortality in the reproductive ages, and ask how many children these women would have on the average at the end of reproduction. In doing so, however, we ignore both the order of the births in the numerator of the age-specific rates and the parity of the women in the denominator. It is easy enough to introduce birth order. We simply break total births in each age group down into births of each order and compute age-order-specific birth rates m_{ij}, say, taking all women in the i-th age group in the denominator and j-th order births to women in the i-th age

Figure 5. Total Fertility Rates in Japan: 1920-1982



Source: Japan Statistical Yearbook, various years. Statistics Bureau, Management and Coordination Agency.
E.g., 1980, Table 22, pp. 36; and so on.

group in the numerator. Summing over j gives age-specific rates, and summing further over i gives the TFR. Moreover, if we sum first over age i we obtain, for any given birth order j, a number that can be interpreted as the proportion of women who ever progress to a j-th birth. The rationale for this interpretation is that, in a birth cohort that experienced no mortality in the reproductive ages, the two quantities specified would be identically equal.

In particular, for first births, j = 1, we would interpret the sum of the age-specific first birth rates as the proportion of women ultimately progressing to first birth. Now this is analogous to calculating proportions of women ultimately progressing to first marriage by summing over all ages first marriage rates that take first marriages in the numerator and all women--not never married women--in the denominator. We may call this the "additive" calculation, and the life table calculation that we have used--based on first marriage rates that take never married women in the denominator--the "multiplicative" calculation.

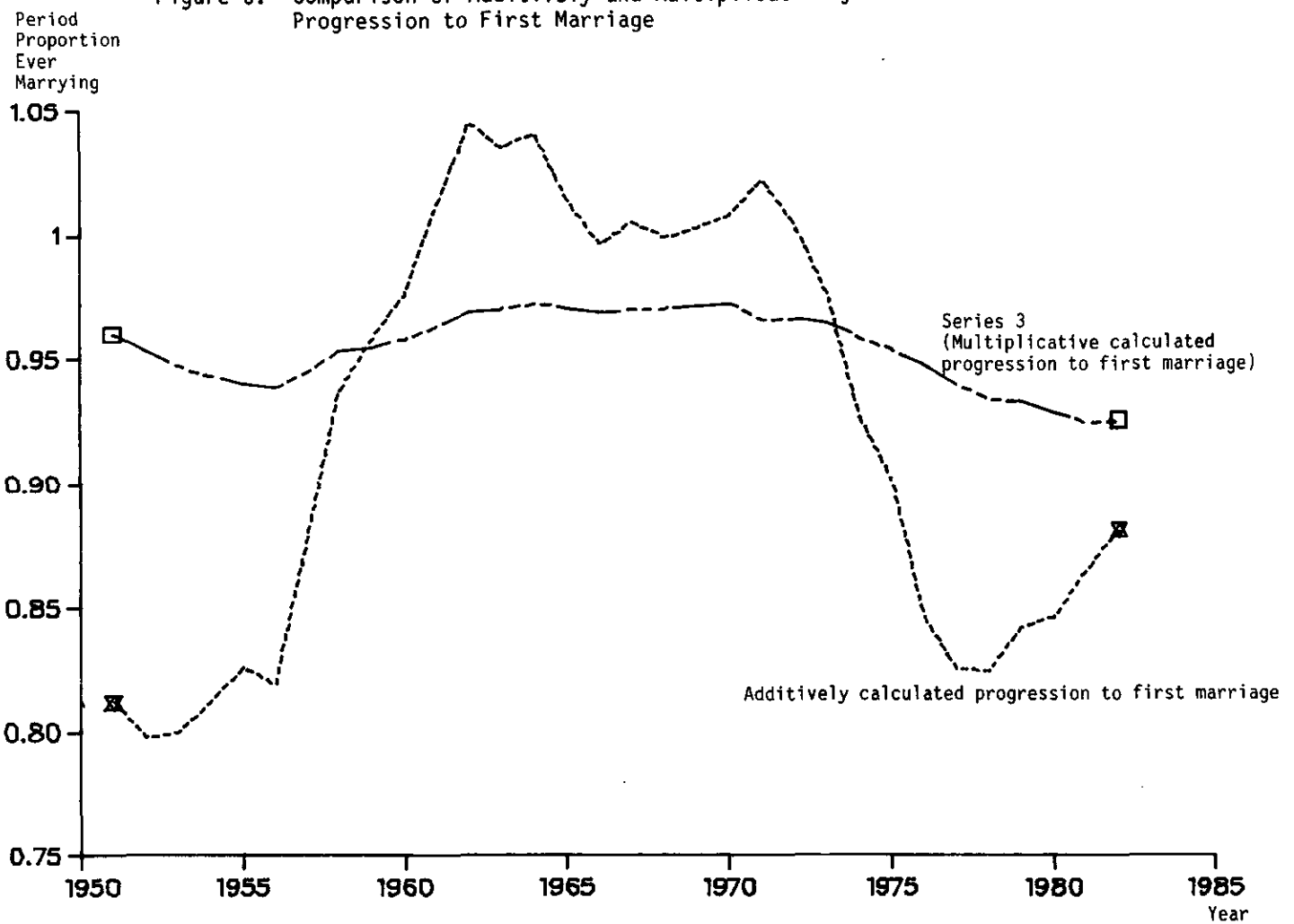
The multiplicative calculation is clearly the correct one, in the fundamental sense of properly relating events to exposure to risk: only never married women are capable of first marrying, and this fact should be recognized in computing first marriage rates. As conventionally calculated, however, the TFR is based on an additive calculation. This raises doubts about the validity of the TFR as a measure of fertility, but our immediate purpose here is not to criticize the TFR, as conventionally computed, but to elucidate its relationship to our period measure of ultimate progression to first marriage. The simplest way to do this is to see what happens if we calculate ultimate progression to first marriage additively instead of multiplicatively. Thus we take the numerators of the rates upon which series 3 in Table 12 are based, calculate a new set of first marriage rates that take all women in the denominator, and sum the rates for each year over all ages to give a time series of additively calculated figures for ultimate progression to first marriage.

This comparison is shown in Table 14 and is plotted in Figure 6. It is perhaps worth reiterating here that what we are looking at in Figure 6 are two time series, both of which represent period statistics of ultimate progression to first marriage. Both series are based on the same idea of taking first marriage rates observed in a given

Table 14. Comparison of Additively and Multiplicatively Calculated Period Rates of Progression to First Marriage: Japan, 1951-1982

Year	Multiplicative	Additive	Difference	(Add./Mult.) Ratio
1951	.960	.812	.148	.846
1952	.953	.798	.155	.837
1953	.947	.800	.147	.845
1954	.943	.812	.131	.861
1955	.940	.826	.114	.879
1956	.938	.819	.119	.873
1957	.945	.879	.066	.930
1958	.953	.937	.016	.983
1959	.955	.958	-.003	1.003
1960	.958	.976	-.018	1.019
1961	.963	1.012	-.049	1.051
1962	.969	1.045	-.076	1.078
1963	.970	1.035	-.065	1.067
1964	.972	1.041	-.069	1.071
1965	.970	1.014	-.044	1.045
1966	.968	.996	-.028	1.029
1967	.970	1.005	-.035	1.036
1968	.970	.999	-.029	1.030
1969	.971	1.003	-.032	1.033
1970	.972	1.008	-.036	1.037
1971	.965	1.022	-.057	1.059
1972	.966	1.004	-.038	1.039
1973	.964	.976	-.012	1.012
1974	.958	.927	.031	.968
1975	.953	.902	.051	.946
1976	.947	.846	.101	.893
1977	.939	.825	.114	.879
1978	.933	.824	.109	.883
1979	.932	.842	.090	.903
1980	.928	.846	.082	.911
1981	.924	.865	.059	.936
1982	.925	.881	.044	.952

Figure 6. Comparison of Additively and Multiplicatively Calculated Rates of Period Progression to First Marriage



Source: Table 14.

year and asking what proportion of women would ever marry in an hypothetical birth cohort that experienced these rates. The difference between the two series lies in the way in which the first marriage rates are calculated, and in the way in which ultimate progression to first marriage is calculated from these rates. The multiplicative series values are obtained by the multiplicative calculation from rates that take never married women in the denominator, the additive series values by the additive calculation from rates that take all women in the denominator.

The essential lesson of Figure 6 is of course the radical difference between the two series. The range of variation in the additive series is 80 to 105 percent, as compared with a range of 92 to 97 percent for the multiplicative series, a range of 25 as compared with a range of five. The swings in the additive series are five times as great as those in the multiplicative series. The importance of this difference for projection can hardly be overemphasized. The additive calculation suggests a history of large fluctuations, the multiplicative calculation a history of relative stability, with fluctuations that are pronounced but small in magnitude.

There is a clear tendency for the additive calculation to exaggerate the fluctuations shown by the multiplicative calculation. Thus when the multiplicative values rise from .94 to .97 between 1955 and 1963, the additive values rise from .83 to 1.04, and when the multiplicative values fall from .97 in 1970 to .92 in 1981, the additive values fall from 1.00 to .86. The difference between the two series is not limited to exaggeration, however. The additive calculation also introduces significant distortions. Thus during the period prior to 1955, the additive rates are rising while the multiplicative rates are falling. The same holds true during the late 1970s and early 1980s, where the additive and the multiplicative calculations suggest a totally different picture.

It is perhaps worth emphasizing that the multiplicative trend shown in Figure 6 is indeed the same as the series three trend shown in Figure 4. The large difference in appearance is due to the differences in the horizontal and vertical scales.

It will be observed that the additively calculated values for progression to first marriage are greater than one for most years between 1961 and 1972. It is of course impossible for more than 100

percent of the women in a birth cohort to progress to first marriage. Values greater than one may result from the additive calculation, however, because of the failure to properly relate events to exposure.

Figure 7 elaborates the comparison by adding the total fertility rate to the picture and displacing the additively calculated trend of progression to first marriage to emphasize the covariation between the two series. The suggestion is that a substantial component of the variation in the TFR series may be due to the distortion introduced by not properly relating events to exposure, illustrated by the additively calculated progression to first marriage series.

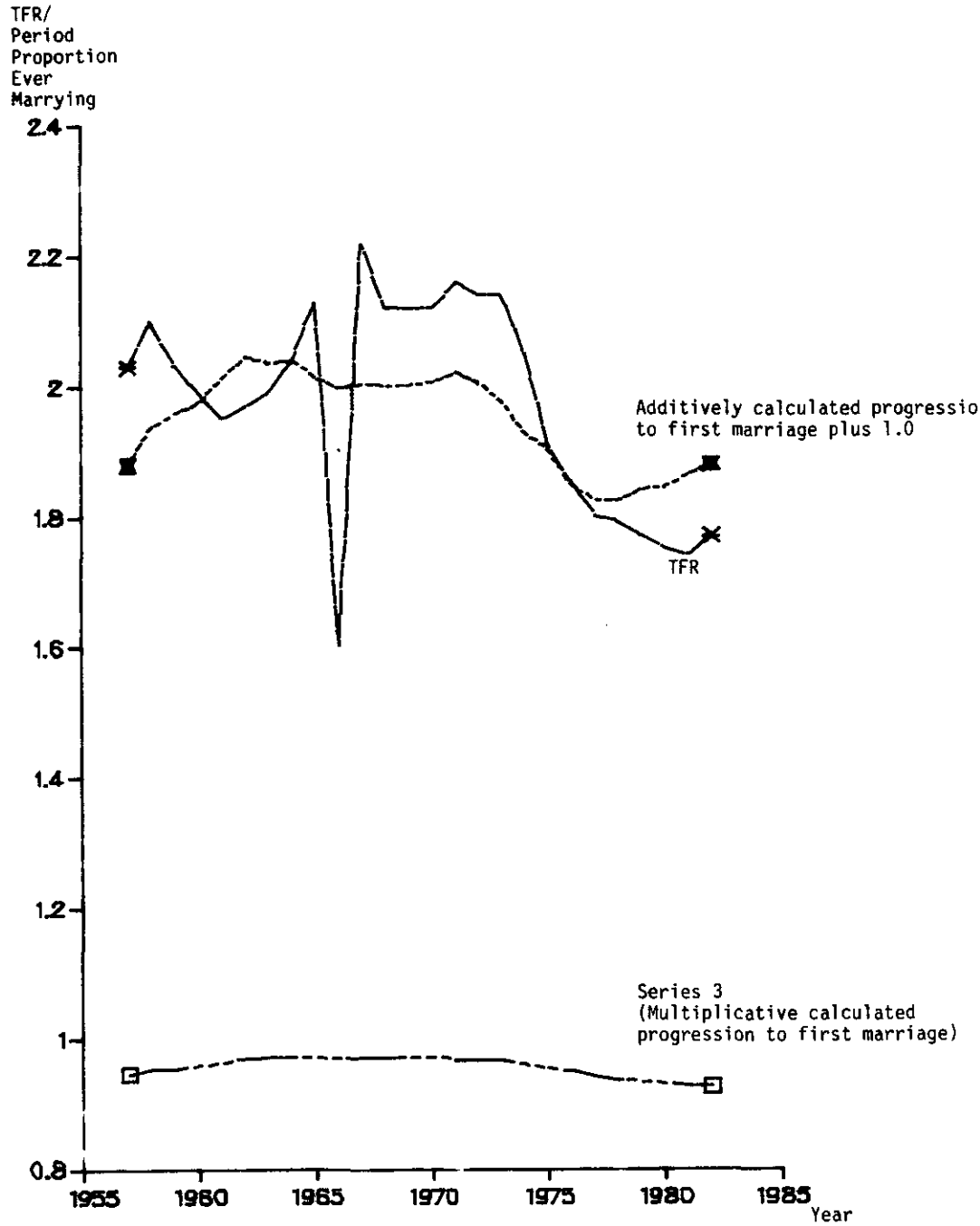
VII. Conclusion

The purpose of our work here has been to generate an historical series on period progression to first marriage for Japan. Using census data on marital status and a crude dating device, we were able to establish a trend from about 1870 through 1950. We then applied an indirect estimation procedure to estimate annual, single year first marriage rates for the years 1951 through 1982. Combining these two series gives us an overview of trends in progression to first marriage over slightly more than a century.

The method of indirect estimation for the later period is certainly not elegant, and we would be delighted to see further methodological work along this line. We are reasonably confident in the results, however, and despite the temptation to do so, it would not serve our present purpose to refine the estimation techniques further. Individual estimates in our series may be off by a percentage point or so, but the overall pattern is probably quite close to the truth.

Concerning the projection of future trends, the results obtained suggest two conclusions. First, on the negative side, the estimated trend of progression to first marriage suggests that it will not be possible to extrapolate detailed future levels of progression to first marriage with confidence. Observing the trend of the past three decades shown in Figure 4, we might project progression to first marriage (i) leveling out at the most recently observed level, (ii) continuing downward after a pause (How long a pause? Downward for how long? To what level?), or (iii) recovering and returning to higher levels (How soon? How much higher?). One could undoubtedly build a

Figure 7. Additively Calculated Progression to First Marriage Compared with the TFR, Japan, 1957-1982



Source: Progression to first marriage series from Table 13.
TFR values as in Figure 5.

case for any one of these three scenarios, and discriminating between them would almost certainly involve a good deal of very subjective guessing.

We have not addressed the question of why progression to first marriage has changed in the way it has, and it is certainly fair to suggest that no extrapolation ought to be carried out until this question has been studied in some detail. While we agree completely with this position, we are skeptical over whether the answers will in fact change the situation described in the preceding paragraph very much. Brass (1972) and Keyfitz (1982) provide a fairly substantial basis for this view, and we know of nothing objective to counter it.

On the positive side, we have shown that the variation in progression to first marriage in the past, when suitably measured, has been relatively small, this in the face of extraordinary social and economic changes in the society at large. This suggests that a simple extrapolation of the most recent level is sensible and will probably give a good result in the medium term of one to several decades.

Finally, we have suggested that the conventional approach to measuring trends in fertility, by calculating time series of age-specific fertility rates, and total fertility rates, may substantially distort real trends in fertility. It seems reasonable to assume that the distortions in TFR trends are qualitatively similar to the distortions that result from calculating progression to first marriage additively instead of multi-plicatively (we resort to the terminology introduced in the preceding section for want of any alternative). These distortions are graphically illustrated in Figures 6 and 7. If the distortions inherent in the conventional TFR calculation turn out to be comparable, a rather substantial overhaul of techniques for measuring fertility would be indicated. It might even turn out that a substantial element of our difficulties with population forecasts and projections may derive from a faulty technique of fertility measurement.

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