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Extended Abstract

Cohort Process to the Lowest Fertility in Poland and Japan: Finding A Common Path in Distant Societies

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Abstract

In this study, the cohort processes of the recent decline of the Polish and Japanese fertility to historical low are compared in terms of lifetime measures of first marriage and birth by birth order. Timing and prevalence measures of those life events are estimated and projected with empirically adjusted Coale-McNeil model for female cohorts of both countries. The results indicate yet unrevealed changes in demographic behaviors of young cohorts in both societies despite numerous different settings. Delay in marriage and birth due to compositional changes such as prevalence of high educational attainment in cohorts initiates the process, followed by the diffusion of never marrying caused by the further postponement, and finally continuing diffusion of never-marrying and childlessness at an accelerating pace caused by intentional retreat from reproduction. The observed similarities of the process in both countries shed light on search of universal path toward the lowest fertility in many followers.

Introduction

The present study aims at developing a better understanding of the process of fertility reduction that is almost universally witnessed in the developed world by observing and comparing life time measures of fertility in two societies which are distant from each other geographically, economic and culturally, yet indicating the same level of fertility of historical low.

Period measures of nuptiality and fertility are subject to compositional and distributional "distortions" such as those from flux in marital and parity composition and tempo effects. Although some effective remedies have been proposed to correct for these distortions (Bongaarts and Feeney 1998, Kohler and Philipov 2001, Kohler and Ortega 2002, Ryder 1964, 1980), cohort nuptiality and fertility measures which are free from those effects are of primary importance in understanding what is taking place in people's life course in the demographic sense. The only drawback of cohort measures is that they cannot be evaluated until the life course processes of the events are completed, and therefore they do not provide information on the current situation of uncompleted phenomena experienced by young cohorts. It is impossible to “measure” cohort experiences that are not completed (Ryder 1964, van Imhoff 2001). However, a model embodying lifetime regularities of the events (i.e. the "law" of nuptiality and fertility) may provide useful predictions of the current situation. The

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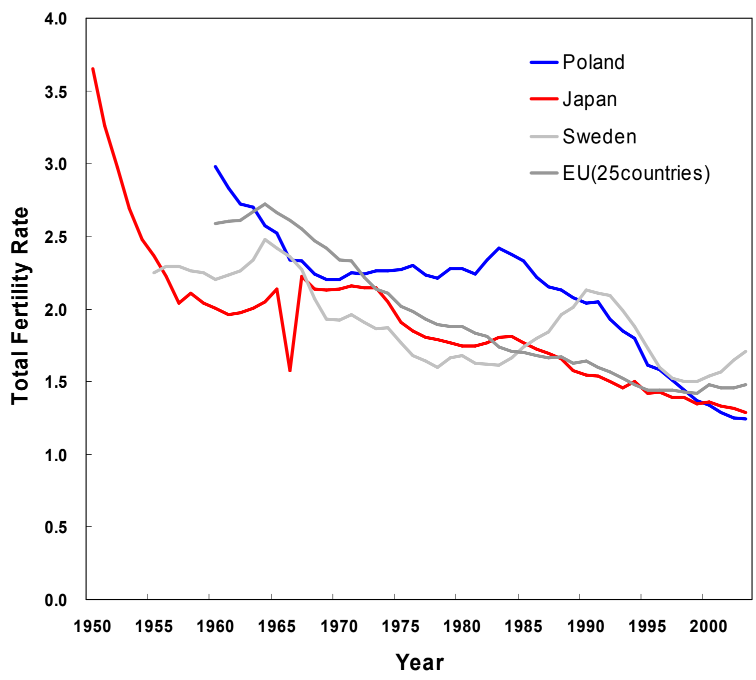
Coale-McNeil standard model schedule for first marriages is the most widely used tool for this purpose (Bloom, 1982, Bloom and Bennett, 1990, Goldstein and Kenney, 2001, etc.). We developed a practical modification to the model to capture the regularities with further precision extending it to births by birth order (Kaneko, 2003), since it is critical when a model is applied in prediction of future life course[1]. With the enhanced model we reconstructed the long-term trends of the lifetime measures of fertility over cohorts born from 1935 to 1970 for Japan and from 1945 to 1970 for Poland. They give an essential basis of assessing cohort processes toward the ever lowest period fertilities in both societies, and their similarities and dissimilarities with key background factors.

Fertility in Poland and Japan

The fertility transition in course of the (first) demographic transition took place in Poland and Japan both after the Second World War II, though their speeds of decline to the replacement level were quite high. Japanese fertility reached that level in late 1950's, and at around 1970 in Poland. Japanese fertility has started to decline again mid 1970's toward the level of historical low today, followed by Poland in mid 80's with even faster pace eventually to outrun after year 2000.

Figure 1. Process of Total Fertility Rate to the Lowest Level in Poland and Japan

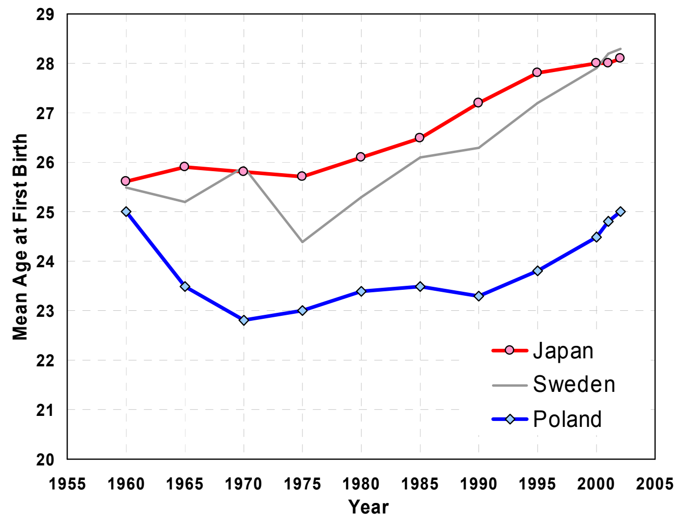


Two societies have shared a common feature in quick response of life course behavior to the socioeconomic changes, and now have the same level of fertility. However, some features of their components are quite different. The timing of childbearing is among those. Figure 2 indicates marked

[1] It has been pointed out that the Coale-McNeil model schedule bears substantial deviations from observed schedules, even in the maximally flexible free-shape form, especially when it is applied to a non-European society such as Japan (Takahashi, 1978, Kojima, 1985, Kaneko, 1991).

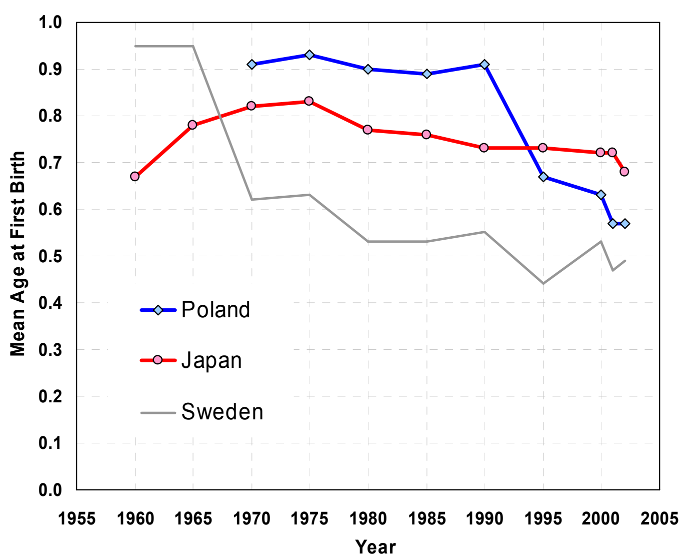
differences in lever and historical path of the mean age at first birth between two countries with reference of those of Sweden.

Figure 2. Trends of Mean Age at First Birth in Poland, Japan and Sweden



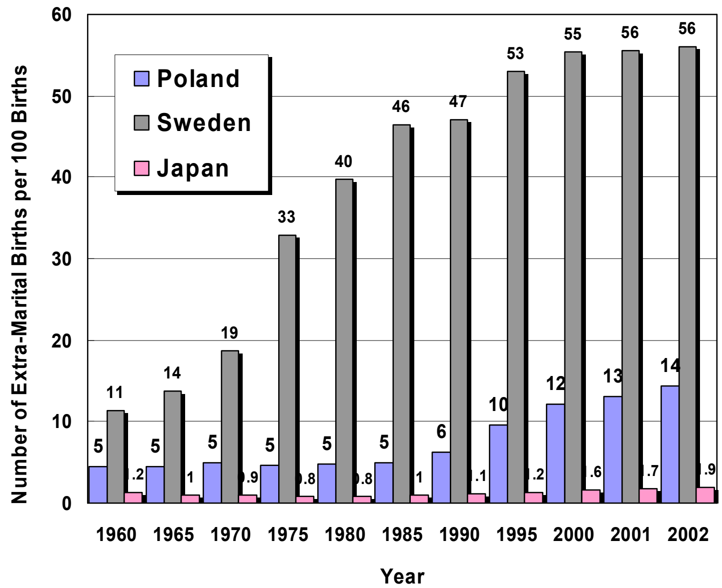
Marriage is another disparity with about ten percent differences of the total first marriage rates constantly hold between those countries until 1980's as shown in Figure 3, though the major alternative approach to partnership have been prevailed elsewhere as indicated by case of Sweden in the figure.

Figure 3. Trends of First Marriage Rate in Poland, Japan and Sweden



Proportions of the extra-marital birth have been higher in Poland than in Japan, although again the quite different situations of fertility behavior are seen in other countries in the western countries. In this connection, Poland and Japan seems to have a same regime in relationships between marriage and birth.

Figure 4 Number of Extra-Marital Births per 100 Births



In searching for a generalized view of the lowest low fertilities prevailed among countries in various geographical, economic, and cultural settings in the developed world, and prevailing to other domains, we examine lifetime behaviors of Polish and Japanese female cohort with the lifetime demographic measures recorded and estimated even for young cohorts that have not completed "lifetime" by projecting the rest of fertility courses so that we should have long term history including current one as possible.

Method and Data

The Generalized Log-Gamma Model (Coale-McNeil Model) and empirical adjustment

The Coale-McNeil model specifies the probability density function (PDF) for the age distribution of first marriages as:

$$g(x) = \frac{\beta}{\Gamma(\alpha/\beta)} \exp\left[-\alpha\left(x-\mu\right) - \exp\left\{-\beta\left(x-\mu\right)\right\}\right] \qquad (1)$$

where Γ denotes the gamma function [2], $\alpha(>0)$, $\beta(>0)$, and $\mu(-\infty < \mu < \infty)$ are three parameters (Coale and McNeil, 1972). A fixed-shape version of this model derived from Swedish female cohort data with two free dimensions, i.e. location and scale parameters is called the

[2] $\Gamma(x) = \int_0^\infty t^{x-1} e^{-t} dt$

Coale-McNeil (CM) standard schedule[3], and has been widely used both for estimating the underlying distribution from defective data and projecting a halfway-completed process to the end of the schedule (Bloom, 1982, Bloom and Bennett, 1990, Goldstein and Kenney, 2001, etc.).

The CM distribution given by (1) is mathematically identical to the generalized log gamma (GLG) distribution with a somewhat different parameter space (Kaneko 1991, 2003). According to Prentice's parameterization (1974), the CM distribution is expressed in PDF form of the GLG distribution by:

$$g(x)=\frac{|\lambda|}{b\Gamma(\lambda^{-2})}(\lambda^{-2})^{\lambda^{-2}}\exp\left[\lambda^{-1}\left(\frac{x-u}{b}\right)-\lambda^{-2}\exp\left\{\lambda\left(\frac{x-u}{b}\right)\right\}\right] \tag{2}$$

where $\lambda\ (-\infty<\lambda<0)$, $u\ (-\infty<u<\infty)$, $b\ (>0)$ are three parameters[4], Γ denotes the gamma function defined above. With the age distribution of first marriages $g(x)$, the corresponding age schedule $f(x)$ (age specific first marriage rate at age *x*) is given as:

$$f(x;C,u,b,\lambda)=C\ g(x;u,b,\lambda). \tag{3}$$

where *C* denotes the proportion eventually marrying in the cohort.

Performance of the GLG model (equivalently CM model) to trace the observed data is generally good. However, for cohorts of some countries such as Japan, it shows visible discrepancies even with allowing a free-shape (4-parameter model) (Kaneko 1991, 2003). In order to improve the fit, an empirical adjustment is devised according to Kaneko (2003). The resulting GLG model with the adjustment, $\bar{F}(x;\boldsymbol{\theta}), \boldsymbol{\theta}=\left(C,\lambda,u,b\right)$, is expressed as:

$$\bar{F}(x;C,\lambda,u,b)=\hat{F}(x;C,\lambda,u,b)+\delta\,\hat{\xi}\left(\frac{x-u}{b}\right), \tag{4}$$

where $\hat{F}(x;\boldsymbol{\theta})$ is the GLG model, δ is a parameter that indicates level of the average error function of the standardized age which is denoted as $\hat{\xi}$[5]. The function $\hat{\xi}(z)$ should be treated as a continuous function of age by means of spline interpolation, for example. In Figure 1, we see an improvement of the model's fit as a consequence of the adjustment in the adjusted model traces the observed rates almost exactly, while the model with no adjustment (broken line) shows visible

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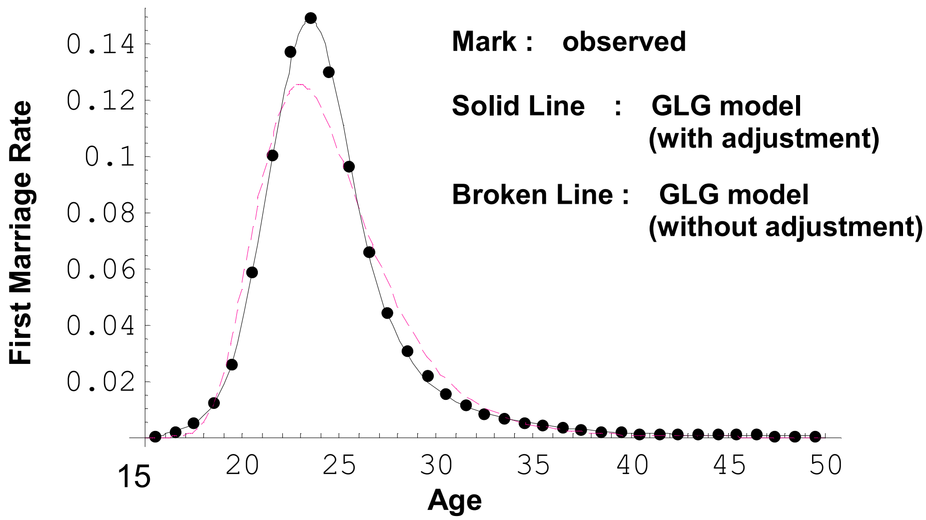
[3]Rodriguez and Trussell (1980) proposed parameter values as $\alpha=1.145, \beta=1.896, \mu=-0.805$ to have mean 0 and variance 1.

[4] This parameterization is one proposed by Prentice (1974).

[5] $\hat{\xi}(z)$ is to be zero as z goes to plus or minus infinity to keep parameter C intact in the adjustment. Definite integral of $\hat{\xi}(z)$ over the domain of z should be zero to keep the mean age of the schedule intact. We slightly adjust the average pattern to derive $\hat{\xi}(z)$ so that these properties of schedule are kept.

deviations.

Figure 5. Observed Age Specific First Marriage Rates and Fitted GLG Model (with Adjustment): Japanese Female Cohort born in 1950



Results

Parametric Estimation and Projection of Cohort Fertility Schedules

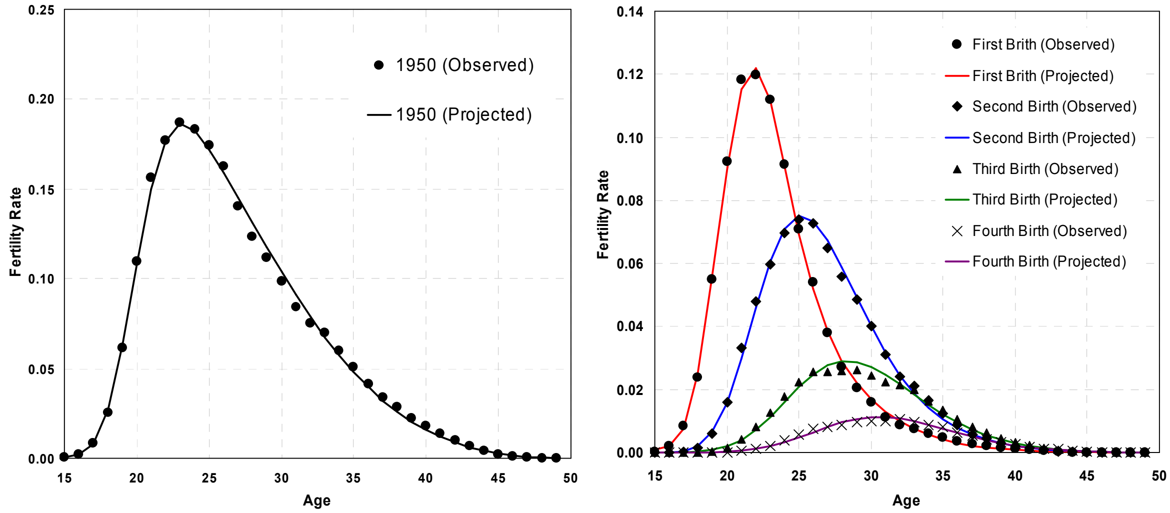
We estimated a set of parameters of the adjusted-GLG model applied for the observed fertility rates of Polish and Japanese female cohorts via the maximum likelihood procedure following Kaneko (2003). Predicted fertility schedules by birth order from the results of parameter estimation are contrasted with those schedules observed for selected cohorts in Figure 6 for Poland and in Figure 7 for Japan. The model follows the actual experiences fairly well, though the exactness of fit becomes slightly weaker in younger cohorts. The fit is somewhat better for Japanese cohorts than for Polish[6].

The whole profiles of cohort fertility schedules are assembled from the observed rates together with the projected for young cohorts that have yet to complete their processes so that long histories of cohort fertility experiences in Poland and Japan are reconstructed. Whole contours of the cohort changes in fertility schedule be seen in Figure 8. We see the abrupt reduction of the quantum of fertility in female cohorts born after around 1970 in Poland, although a steady decline is observed since cohort born in mid 1959's in Japan.

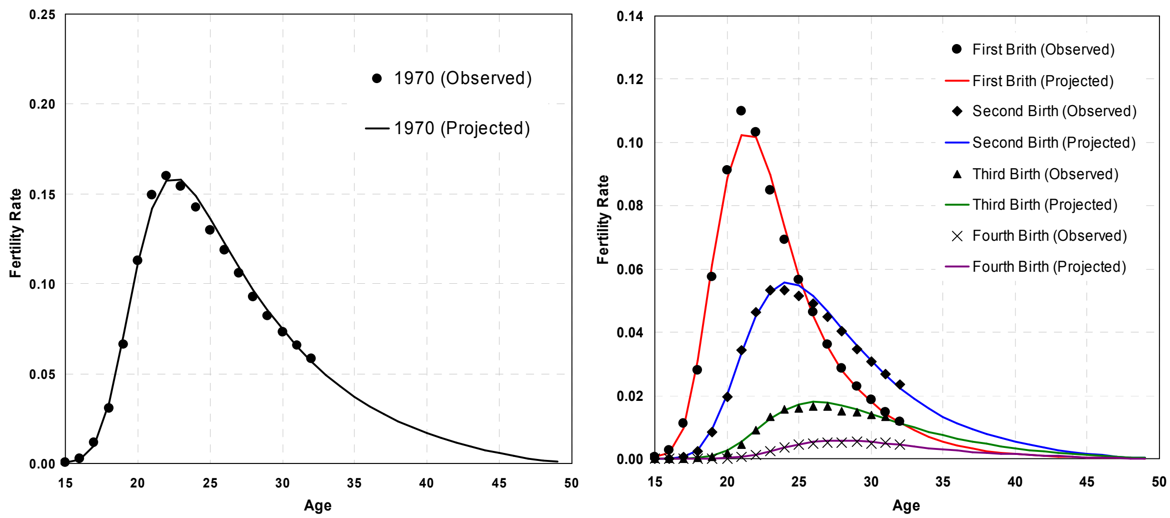
[6] The performance of the model in reproducing observed rates for Polish cohorts should be improved when the empirical adjustments of the model are tuned for the target, since the present adjustments are for Japanese cohorts.

Figure 6. Graphical Check of Projected Fertility Rate: Selected Polish Cohorts

A. Cohort born in 1950 : Poland



B. Cohort born in 1970 : Poland



C. Cohort born in 1975 : Poland

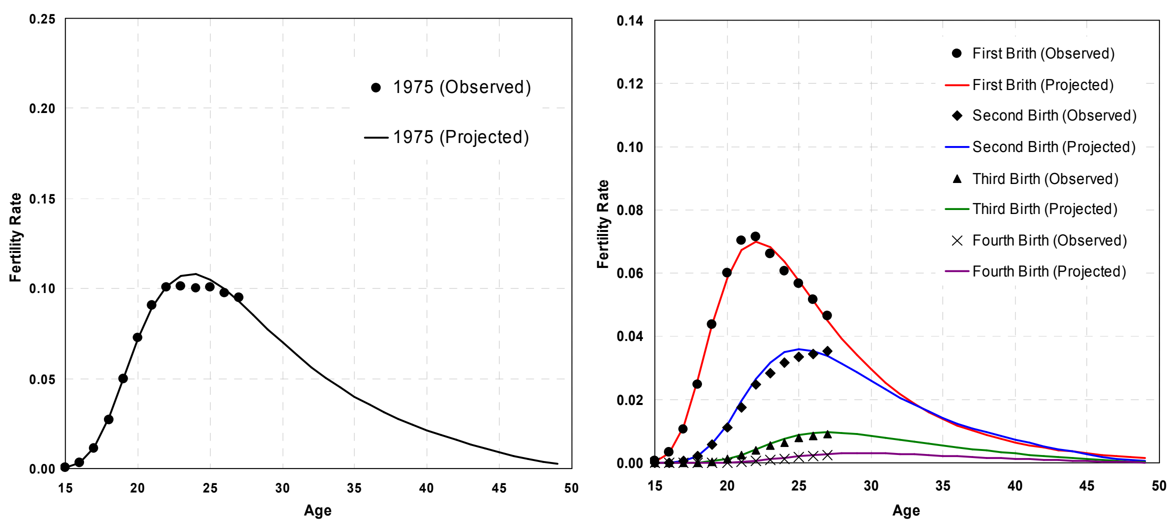
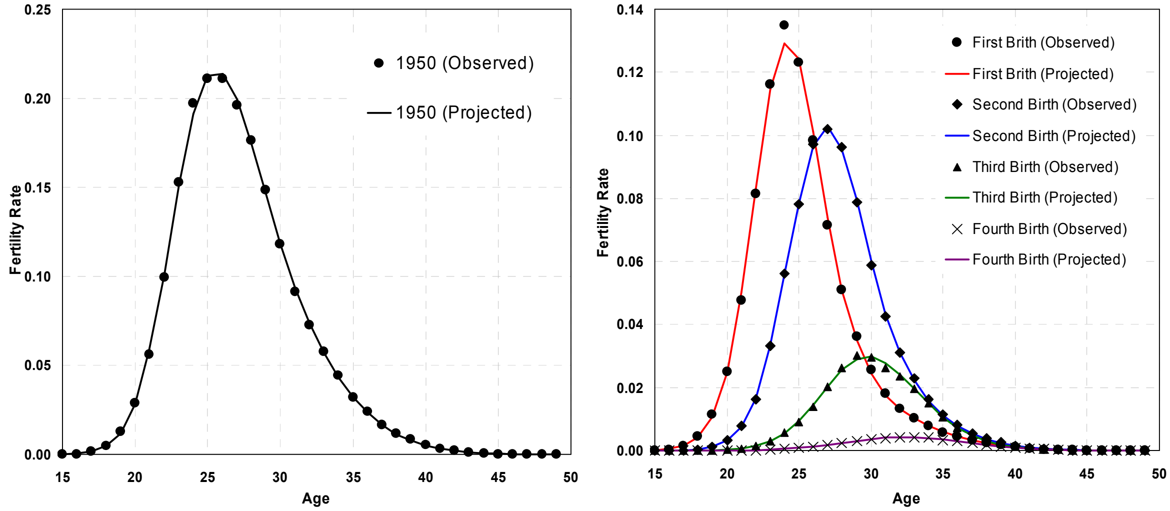
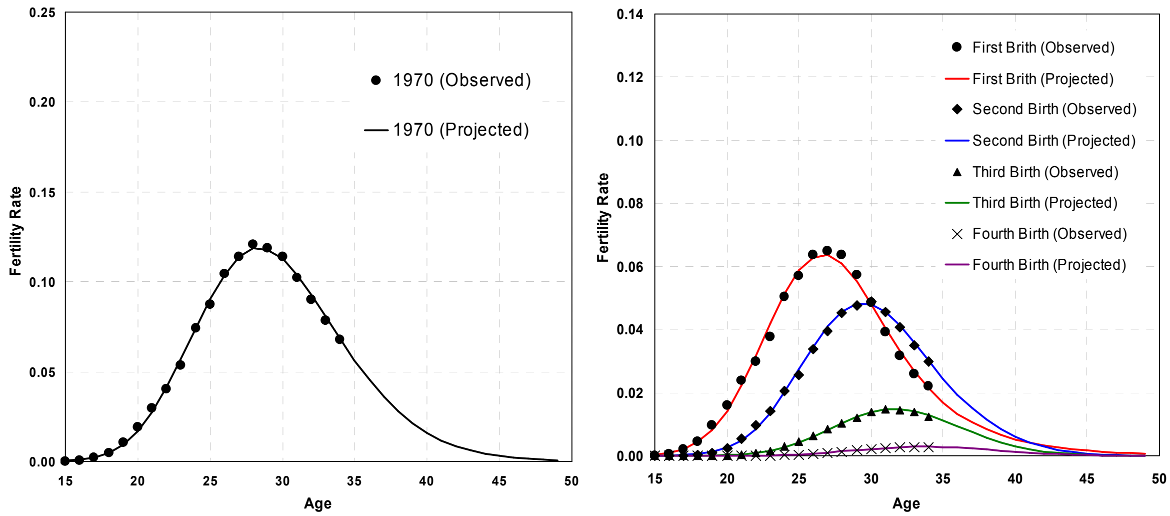


Figure 7. Graphical Check of Projected Fertility Rate: Selected Polish Cohorts

A. Cohort born in 1950 : Japan



B. Cohort born in 1970 : Japan



C. Cohort born in 1975 : Japan

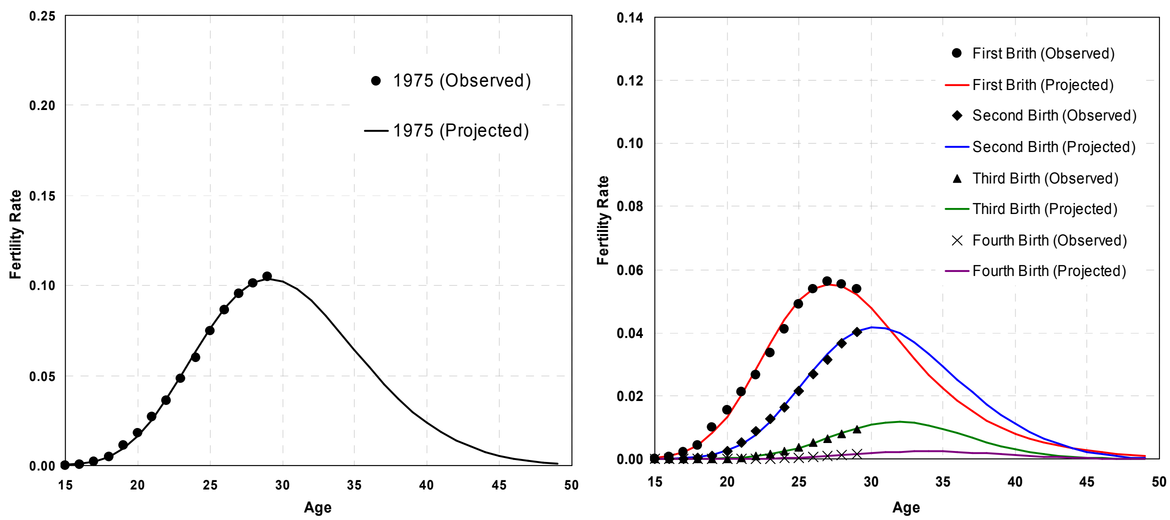
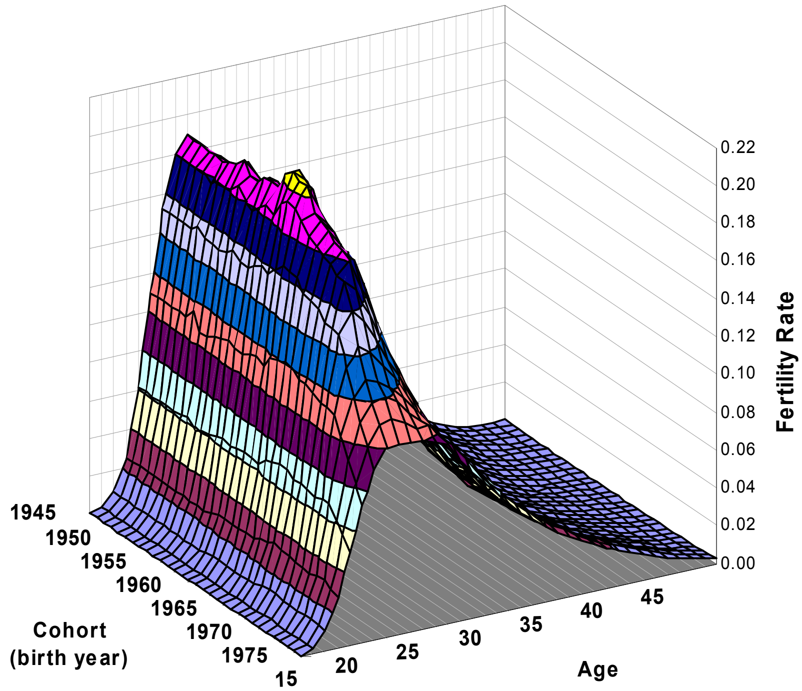
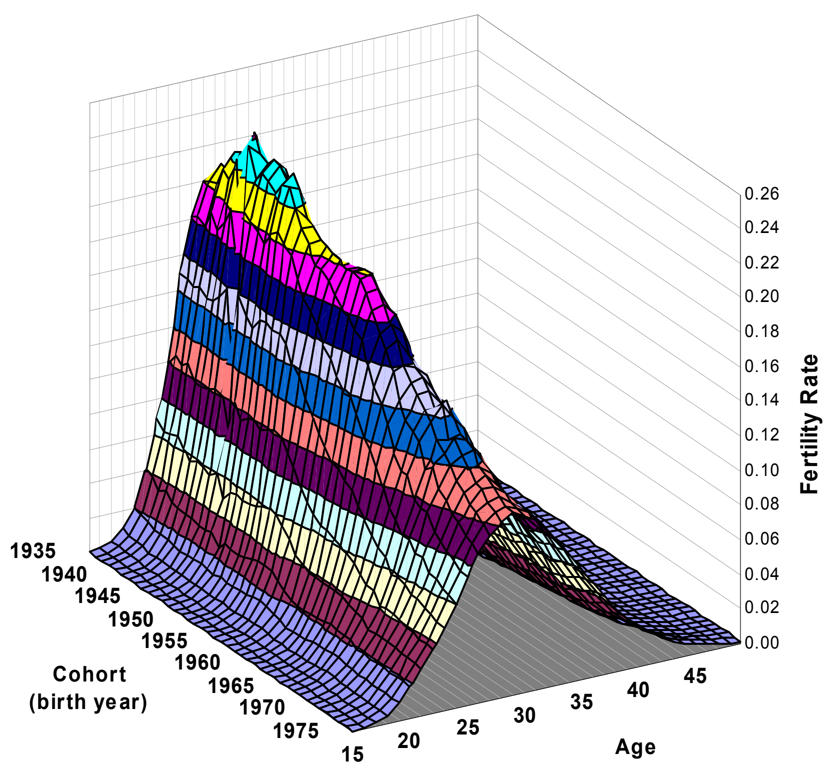


Figure 8. Changes in Cohort Fertility Rate of Poland and Japan with Projection

A. Polish Cohorts born in 1945-75



B. Japanese Cohorts born in 1935-75

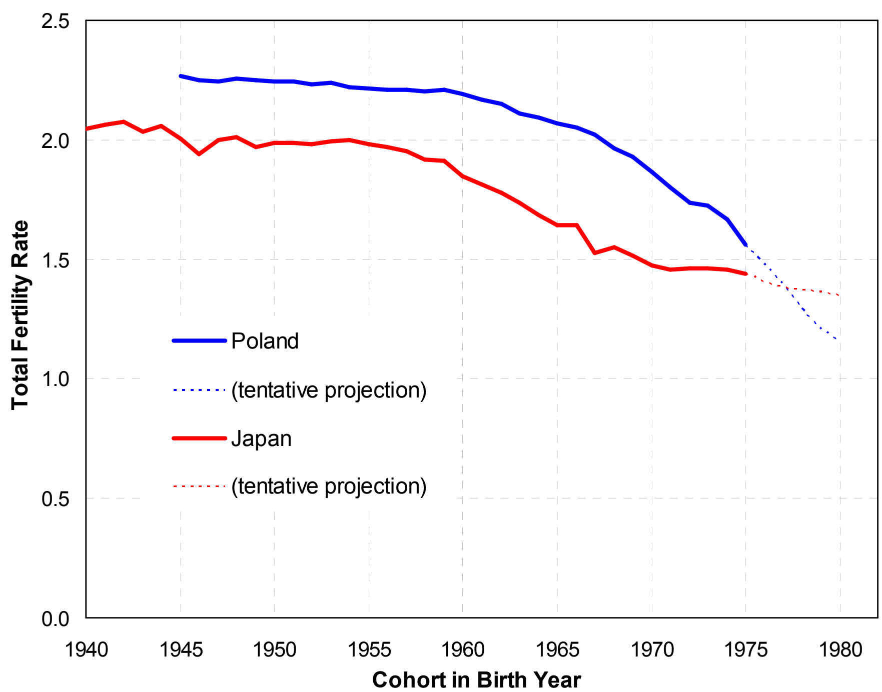


Descriptive Analyses of Lifetime Fertility Measures and Some Comparison

For the Polish female cohorts of 1945-1975[7], trends of the total fertility rate (TFR), and the mean age at birth and those by birth order are shown in Figure 9, and 10 respectively.

Up to cohort born in 1975, which is the youngest cohort for which the projected fertility rates and measures derived from them are considered to be fairly reliable, Polish cohort total fertility rate has been surpassed those of Japanese by 0.2 to 0.4 except by 0.5 with irregular Japanese fluctuation in 1967 related to the Fire Horse (Hinoeuma) cohort (mostly from artificial effect). However with accelerated decline in Polish fertility after cohort of 1970 together with slow down early 70's cohorts in Japan, the gap has rapidly reduced expecting for them to cross each other among cohorts of late 70's.

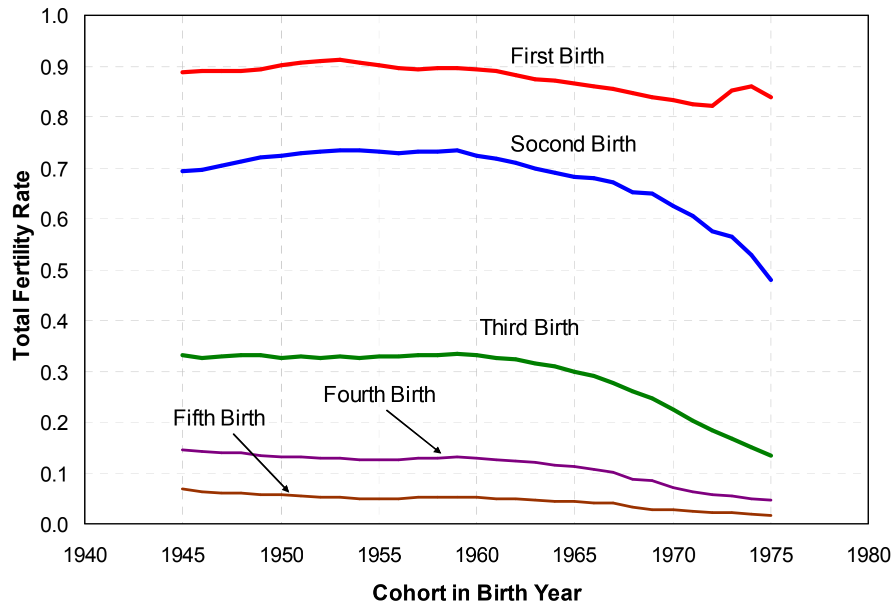
Figure 9. Trends of Recorded and Projected Total Fertility Rate and those by Birth Order:
A. Polish and Japanese Cohorts



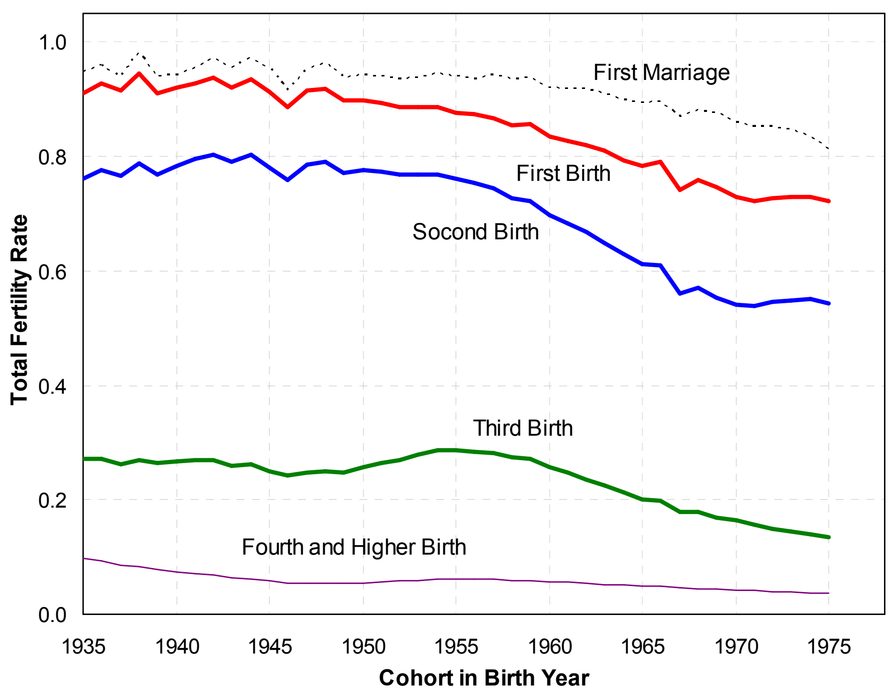
[7] In the figures and tables tentative estimates for cohorts born in 1933 and 1934 are included.

Figure 9. Trends of Recorded and Projected Total Fertility Rate and those by Birth Order (continued)

B. Polish Cohorts by Birth Order

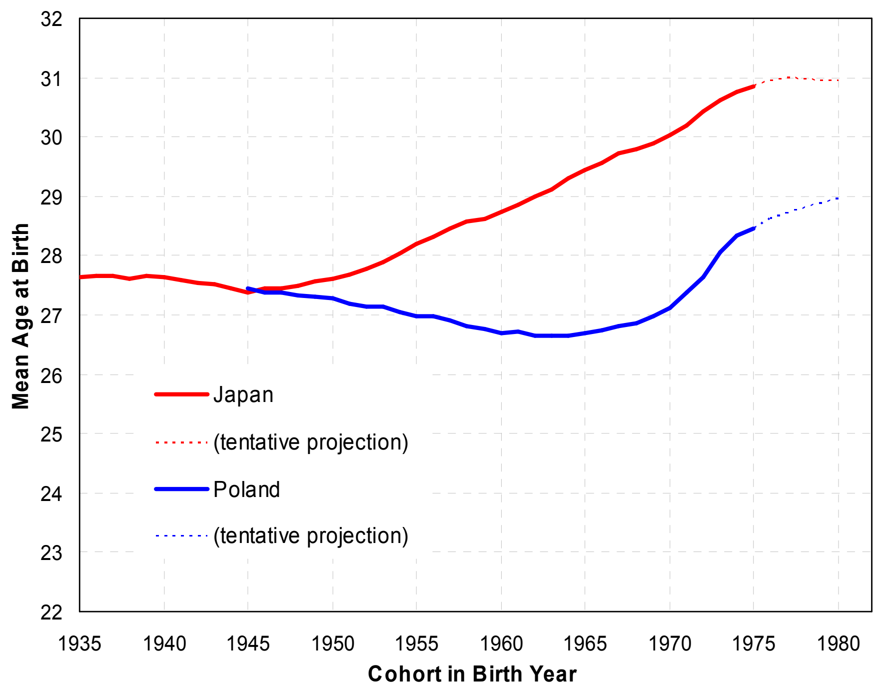


C. Japanese Cohorts by Birth Order



The rapid reduction in fertility among cohorts born after 70's in Poland is brought about by reduction in second and third birth as is seen in Figure 9.B.

Figure 10. Trends of Estimated and Projected Mean Age at Birth and those by Birth Order:
A. Polish and Japanese Cohorts

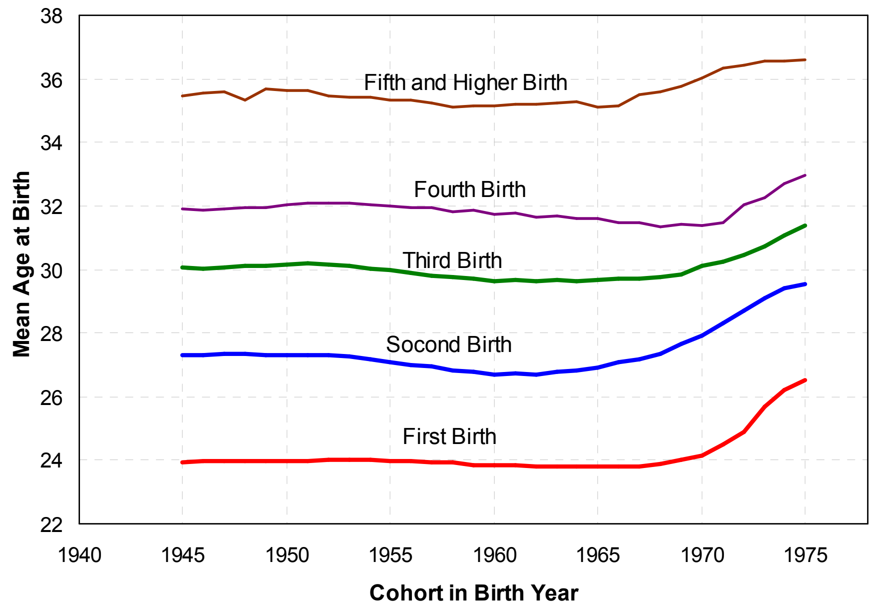


The most marked difference among fertility measures between Poland and Japan is seen in timing of birth. As shown in Figure 10.A, the mean age at birth had started to rise among cohorts born in 50's in Japan continuing ever since producing significant amount of temp effects on period fertility. In contrast, the timing of birth became earlier in life among Polish cohorts born until early 60's, and has quickly turned upward resulting accelerated ascend of age at birth. Yet between cohorts of 1975 the mean age at birth of Japanese cohort is later by 2.4 years than those of Polish.

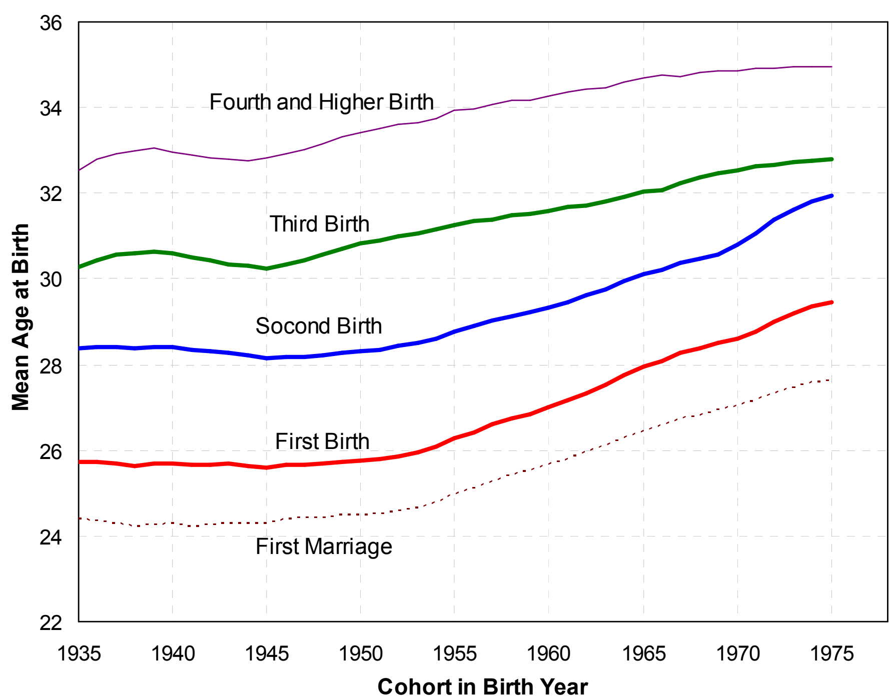
This schema applies as a whole for birth of each order (Figure 10.B and C). Timing of birth for each birth order started to raise among cohort born in mid 60' with some variation by birth order. The timing of second birth started somewhat earlier than other orders. The first birth started to delay among cohort of late 60'. Delay in birth timing in Japan, on the contrary, started among cohorts of early 50's simultaneously for all birth orders, even together with timing of first marriage, which is estimated with same method as birth only for Japanese cohorts (Figure 10.C). Although mean age at birth of each birth order rises into line with each other, only the second birth slightly accelerated in postponement among cohorts of 70'.

Figure 10. Trends of Estimated and Projected Mean Age at Birth and those by Birth Order (continued)

B. Polish Cohorts by Birth Order



C. Japanese Cohorts by Birth Order



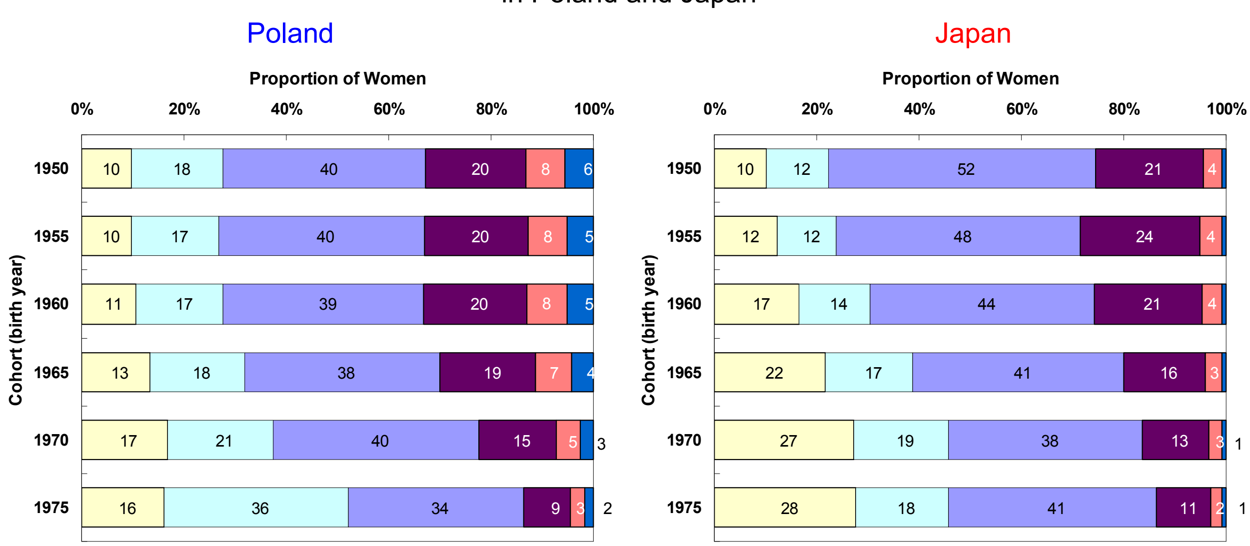
Compositional distribution of women in each cohort by number of children ever born untile age 50 are presented in Table 1, and compared graphically n Figure 11. In spite of the former observation that the cohort total fertility rate approaching to each other country between Poland and Japan, the parity composition is remarkably different especially in proportion of childless women and that of women with one child. In Poland, childless women would not increase as large in proportion as it would be in Japan. It is around 17 percents in Poland in cohorts born in 1970's as compared with 27-8 percents in Japan. This increasing prevalence of childlessness in Japan may be induced by decline in proportion eventually marry in those cohorts and the comparatively firm relationships between marriage and birth in this society. Conversely, the proportion of women with only child would expand among cohorts of early 70's in Poland as high as more than one out of three women as compared with only about 18 percents in Japan. In Japan, had a woman once a child, she is likely to have one more. This is clearly indicated in the parity progression ratio presented in Table 2 and Figure 12.

Table1 Proportion of Women by Number of Children Ever Born for Selected Cohorts of Poland and Japan

(%)

Cohort (birth year)	Poland								Japan							
	cTFR	Total	Childless	1	2	3	4	5+	cTFR	Total	Childless	1	2	3	4	5+
1950	2.25	100 %	9.9	17.8	39.6	19.5	7.6	5.6	1.99	100 %	10.1	12.2	52.0	21.1	3.6	0.9
1955	2.21	100	9.7	17.0	40.3	20.3	7.6	5.1	1.98	100	12.3	11.5	47.6	23.5	4.1	0.9
1960	2.19	100	10.6	17.0	39.3	20.2	7.8	5.2	1.85	100	16.6	13.7	43.9	21.0	3.8	0.9
1965	2.07	100	13.5	18.3	38.2	18.7	6.9	4.3	1.65	100	21.6	17.1	41.2	16.0	3.2	0.8
1970	1.86	100	16.7	20.8	40.1	15.2	4.5	2.6	1.48	100	27.2	18.6	37.9	12.8	2.6	0.8
1975	1.56	100	16.1	36.0	34.3	9.0	3.0	1.6	1.44	100	27.7	17.9	40.8	10.6	2.1	0.8

Figure11 Cohort Changes of Proportion of Women by Number of Children Ever Born in Poland and Japan



Though the parity progression ratios to the first child have decreased in younger cohorts in both societies, changes are much milder in Polish women having started from 90 percents in cohort of 1950 to 84 percents in 1975, as compared with Japanese cohorts having started from the same level ending up to 72 percents. The ratios of progressing to the second child are also quite dissimilar between two countries. In this connection, an acute decline is anticipated among cohorts born in early 70's in

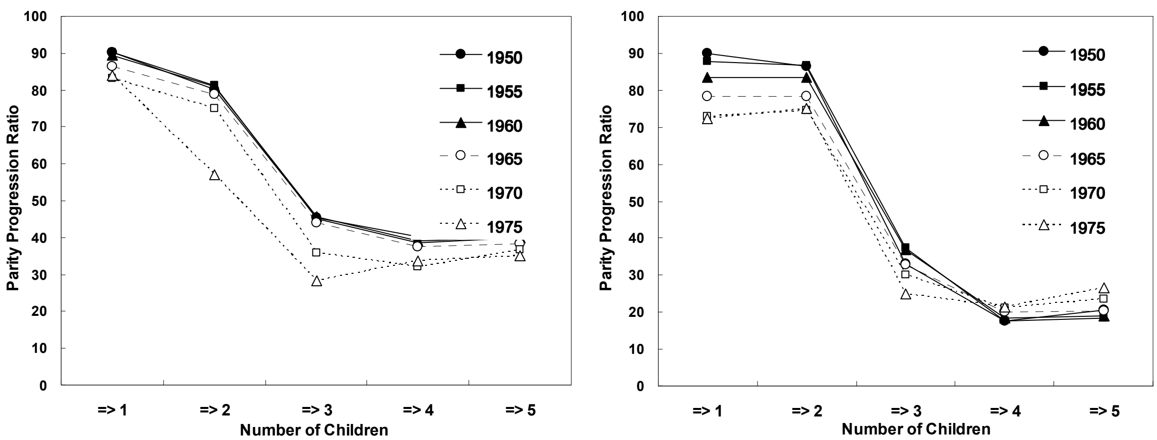
Poland. Among those who would have had the first child in cohort of 1975, only 57 percents, somewhat more than a half, should have the second one. In Japan, the ratio is three fourth, and is about same level as ratio having the first child. High levels of the parity progression ration among third and higher birth order are one of the distinctive feature of Polish women, though the ratio to the third child clearly diminished in the youngest cohorts in table. For Japanese the ratios to the fourth and higher order are conventionally not very high at around one out of five women who had previous children, and even slightly increasing in young cohorts.

Table2 Parity Progression Ratio for Selected Cohorts of Poland and Japan

(%)

Cohort (birth year)	Poland						Japan					
	cTFR	=> 1	=> 2	=> 3	=> 4	=> 5	cTFR	=> 1	=> 2	=> 3	=> 4	=> 5
1950	2.25	90.1	80.2	45.3	40.3	42.6	1.99	89.9	86.4	33.0	17.6	20.7
1955	2.21	90.3	81.1	45.0	38.5	40.0	1.98	87.7	86.8	37.5	17.7	18.5
1960	2.19	89.4	81.0	45.8	39.0	39.9	1.85	83.4	83.5	37.0	18.4	19.0
1965	2.07	86.5	78.8	43.9	37.5	38.2	1.65	78.4	78.2	32.8	20.2	20.3
1970	1.86	83.3	75.0	35.9	32.0	36.7	1.48	72.8	74.4	30.1	21.3	23.6
1975	1.56	83.9	57.1	28.3	33.7	35.2	1.44	72.3	75.2	24.9	21.5	26.7

Figure13 Cohort Changes of Parity Progression Ratio in Poland and Japan



Discussion

So far dissimilarities in cohort processes to the lowest fertility between the two distinct societies, Poland and Japan, come to the fore. Even the basic features of the process such as period of onset of the change, pace of change, and destination in demographic measures, differ between them. However, it is found that the processes proceed through some common phases in which certain distinct mechanisms are activated. According to the previous study of close assessment of the Japanese cohort process, we found that delay in marriage and birth due to compositional changes such as prevalence of high educational attainment in cohorts initiates the whole process, followed by the diffusion of never marrying and childlessness caused by the postponement, therefore without intention of retreat from such reproductive activities, and finally continuing diffusion of never-marrying and childlessness at an accelerating pace caused by intentional retreat (Kaneko 2006). Kohler, Billari, and Ortega (2002b) thoroughly examined the *period* process to the lowest low fertility, with special attention to onset and pace of the postponement transition in many European countries. They showed that the most low fertility countries with various onset timing and pace of the transition have common characteristics in the processed to the ever lowest fertility situation across a wide range of socioeconomic conditions, i.e. the onset of delayed childbearing is a break with an earlier regime characterized by relative stable first-birth timing, and the process is persistent to result in large rises in the mean age at first birth (Kohler et al. 2002b). We found the similar generality in the *cohort* processes to the lowest fertility in Polish and Japanese societies by extending the cohort fertility experiences to the foreseeable future by utilizing the strength of the enhanced Coale-McNeil model of first marriage and birth schedules.

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