$$\mu(x,t)=\frac{\alpha(t)\times e^{\beta x}}{1+\alpha(t)\times e^{\beta x}}+\gamma(t) \quad \text{（2）}$$

ここで α は死亡率（死力）の水準を、β は曲線の傾きを、右辺第一項 $\frac{\alpha\times e^{\beta x}}{1+\alpha\times e^{\beta x}}$ は加齢による死亡率（μ_S）を、γ は加齢によらない死亡率を示す。

Bongaarts（2005）は、このモデルを 1950－2000 年の 14 か国について当てはめ、適応度の検証を行っている。その結果として、死亡率の水準を示すである α は、近年若干の低下傾向にあること、曲線の傾きである β は、いずれの国も長期にわたりほぼ一定水準であると述べている。このことから、近年の高年齢部分における「加齢による死亡率」変動について、死亡率の低下という解釈の他、死亡率の遅延とも解釈できると論じている。

他方の「加齢によらない死亡率」γ は低下傾向にあるが、1975 年以降はいずれの国もほぼ一定水準であったとして、近年の低死亡率国では「加齢によらない死亡率」の水準は低下しきっていると結論している。

前掲の式（2）において、曲線の傾きを示す β は時間による変化をせず固定であると仮定した場合、時間依存のパラメータは α、γ の二つになる。ここで、加齢による死亡率 $\mu_S(x,t)$ の変化量 $S(t)$ は t_0 年における年齢 $x-S(t)$ 歳の死亡率に等しい。

$$S(t)=-\frac{\ln\left(\alpha(t)/\alpha(t_0)\right)}{\beta} \quad \text{（3）}$$

したがって、変化量 S および加齢による死亡率 μ_S は、死亡率の水準 α というただ一つのパラメータによって決定される。

Bongaarts は、シフティング・ロジスティック・モデルと前掲の Lee=Carter モデルの比較を行っている（Bongaarts 2005）。その結果、中期の推計では両者に差異はほとんど見られず、Lee=Carter モデルと遜色ない精度で推計が可能であるとしている。また、長期の推計の場合、Lee=Carter モデルによる結果は年齢パターンが不自然に歪むことを指摘している。シフティング・ロジスティック曲線法ではこうした歪みは発生しないため、この点はシフティング・ロジスティック・モデルの長所であると述べている。Lee=Carter モデルにおける不自然な歪みの要因について Bongaarts は、年齢別の死亡率変動パラメータ b_x は変化しないという仮定に起因しているのではないかと推論している（Bongaarts 2005）。

Bongaarts は以上の検討から、β を固定したロジスティック曲線であるシフティング・ロジスティック・モデルは死亡率曲線の年齢シフトを捉えており、これまでの加齢による死亡率変動を単純なモデル（少数のパラメータ）によって比較的よく説明できていると結論している。また、死亡率が変化する中で β が不変ということから、死亡率の上昇・低下は、死亡率曲線が低年齢・高年齢の方向へ移動しているとも解釈できると述べている（Bongaarts 2005）。

4. 将来生命表の作成における課題の検討

将来の生命表を作成するにあたり、現在は Lee=Carter モデルが広く用いられている。しかしながら、特に年齢別死亡率の変動パターンを固定するという仮定には批判もある。モデルの改善として、現実において死亡曲線および生存曲線が高年齢方向へ移動しているとみなせることから、死亡タイミングの遅延としてモデルに取り入れる試みが行われている。生存数曲線および死亡曲線を高年齢方向への移動であると考える場合、将来生命表を作成する際には、この移動がいつ／どの年齢まで続くのかが問題となる。

この稿では長寿国において、平均寿命が上位５位までの時系列推移を観察し、１位は直線的に伸長しているものの、２位以下では曲線であることが示された。したがって、２位以下の推移だけを見るならば、寿命の限界点はさほど遠くない可能性がある。

平均寿命の順位が１位の国は、この 20 年ほどは日本であることから、日本における平均寿命が特別なのか否かについて、より詳細な分析が求められる。

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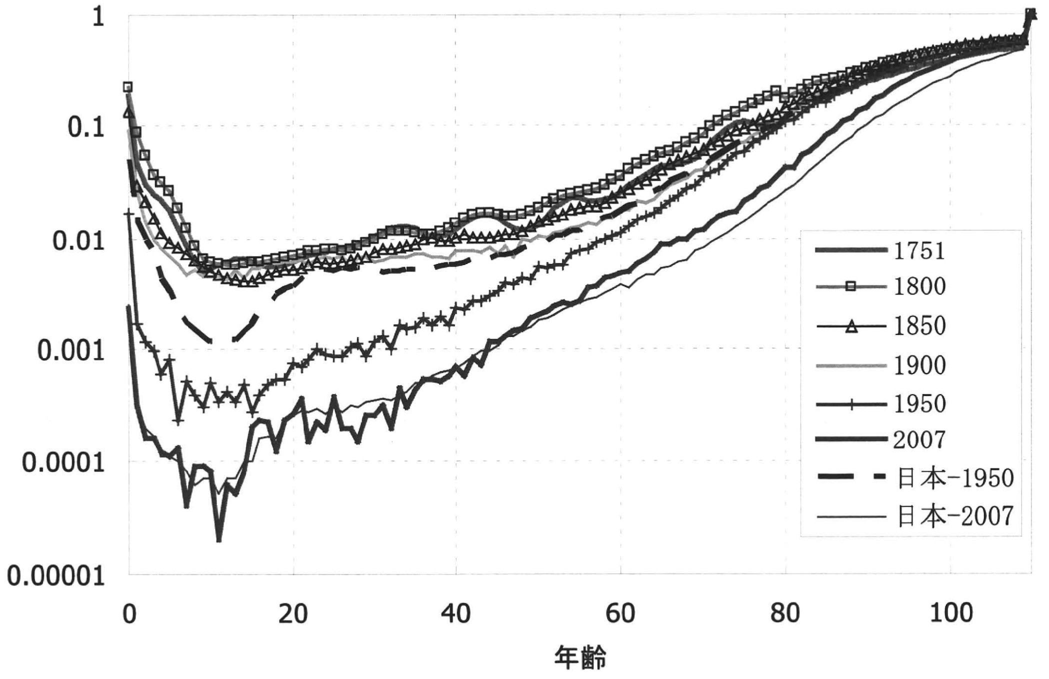
表１．スウェーデンおよび日本における、平均寿命の延びに対する年齢別死亡率変化の寄与率

（年，％）

国名	スウェーデン											日本				
男女，年齢階級	1800～1820年	1820～1840年	1840～1860年	1860～1880年	1880～1900年	1900～1920年	1920～1940年	1940～1960年	1960～1980年	1980～2000年	2000～2007年	1921-25～1935-36年	1935-36～1960年	1960～1980年	1980～2000年	2000～2007年
男子																
期首の平均寿命	31.11	38.57	41.81	46.59	46.07	50.79	57.44	65.36	71.23	72.78	78.69	42.06	46.92	65.32	73.35	77.72
平均寿命の延び	7.46	3.24	4.78	-0.51	4.72	6.65	7.92	5.87	1.55	4.60	1.55	4.86	18.40	8.03	4.38	1.46
0	37.1	19.0	35.3	46.4	22.8	31.4	28.4	30.9	49.8	6.8	6.9	51.6	29.5	23.0	8.6	3.8
1～4	41.3	45.9	-0.4	-131.4	36.8	26.2	17.4	7.0	10.3	1.6	-0.0	19.4	21.4	6.6	2.7	2.0
5～14	13.4	13.7	5.1	-137.3	21.1	10.0	13.0	5.5	8.4	1.8	1.2	6.1	6.5	4.1	2.2	1.8
15～39	1.5	10.5	25.3	-38.1	2.2	9.3	35.6	27.0	4.0	11.2	5.9	10.0	25.8	16.0	7.3	7.5
40～59	2.7	6.0	24.6	116.7	7.4	12.6	7.7	18.1	-5.5	27.2	14.9	7.5	11.2	18.2	17.9	18.0
60～79	3.8	4.9	9.7	41.8	9.5	8.8	-1.5	9.5	24.0	43.8	54.3	5.0	5.3	29.1	45.1	47.4
80歳以上	0.1	-0.0	0.5	1.9	0.2	1.7	-0.5	2.0	9.1	7.6	17.0	0.4	0.3	2.9	16.2	19.5
女子																
期首の平均寿命	33.15	41.84	46.10	50.26	49.08	53.62	60.13	68.11	74.87	78.85	82.90	43.20	49.63	70.19	78.76	84.60
平均寿命の延び	8.70	4.26	4.16	-1.19	4.54	6.51	7.98	6.77	3.98	3.17	0.93	6.43	20.56	8.57	5.84	1.39
0	37.8	15.1	30.0	44.4	24.2	28.8	23.4	21.9	16.6	7.4	4.7	38.1	25.1	19.2	5.2	3.4
1～4	41.2	36.2	0.8	-74.5	41.2	25.8	18.7	4.7	3.2	2.3	-2.7	17.7	20.7	5.8	1.6	1.5
5～14	11.7	13.7	5.2	-73.9	19.6	14.4	14.1	6.0	2.0	1.5	2.8	7.7	8.1	3.3	1.1	0.7
15～39	2.0	17.9	25.2	-37.6	-3.9	14.5	36.0	24.8	4.6	8.7	3.5	23.1	29.7	14.3	3.6	2.3
40～59	3.8	9.4	23.4	18.6	8.8	7.1	10.3	18.8	11.0	15.8	27.0	7.4	9.8	18.6	10.2	9.5
60～79	3.4	7.0	14.5	23.1	10.3	7.2	-1.1	20.4	46.5	42.6	38.8	5.7	5.8	33.0	46.3	38.7
80歳以上	0.2	0.7	0.9	0.0	-0.2	2.2	-1.5	3.4	16.1	21.6	26.1	0.4	0.9	5.7	31.9	43.9

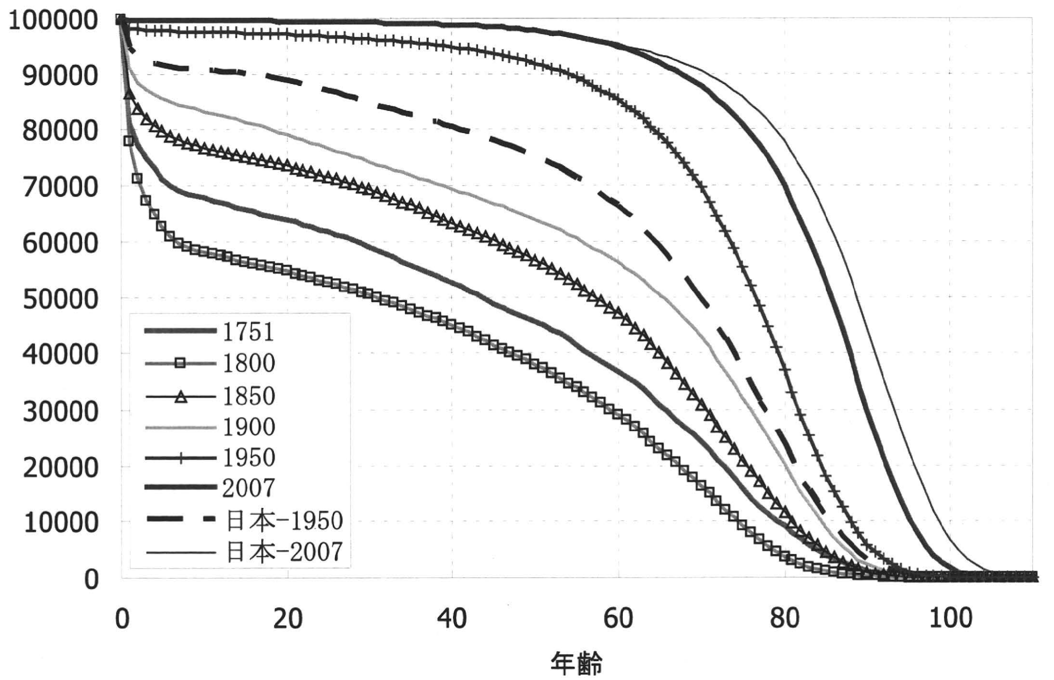
Human Mortality Database による。日本は厚生労働省『完全生命表』，『簡易生命表』による。

図1　スウェーデン人女子および日本人女子における死亡確率(q_x)の推移



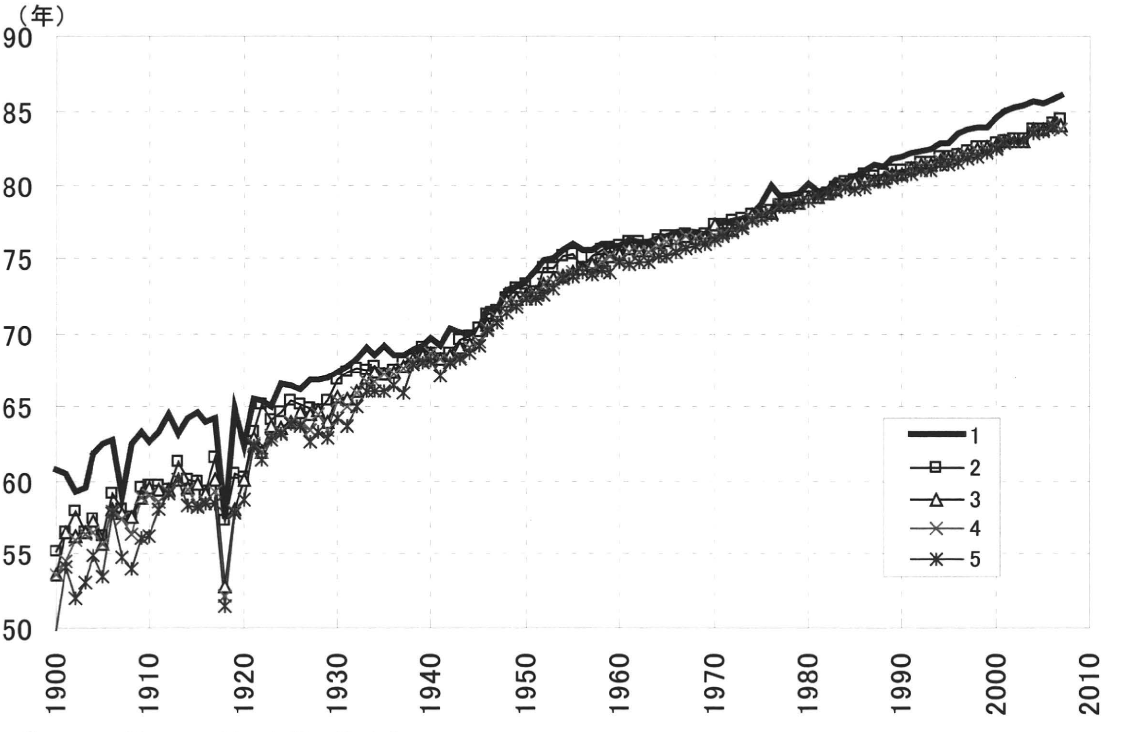
資料：Human Mortality Database による。

図2　スウェーデン人女子および日本人女子における生存数(l_x)の推移



資料：Human Mortality Database による。

図３．寿命順位別にみた女性における平均寿命の推移



Source: Human Mortality Database.

寿命順位は、各年次における国別の平均寿命を長い順に並べた際の順位である。この図では、１位から５位までをそれぞれ時系列で示している。

Ⅱ．　個別研究報告
（人口動態事象の動向ならびに見通しに関する研究）

出生動向とその要因に関する分析

9 近年のわが国出生動向の分析 －ライフコース的視点から－

Life-course Transformation of Fertility Process in Japan; Where did the Reduction Occur to Which Cohort by What Causes?

金子　隆一
三田　房美

要約

本稿ではわが国における出生動向の長期にわたる女性コーホート別変化を人口動態統計、全国標本調査等を用いて再構築し、出生低下の過程を記述する中で、どの世代のどの年齢において、どのような直接因によってそれが生じたのかを特定しようとするものである。

まず、人口動態統計による年次別に観察される女性の年齢別累積出生率、ならびに年齢別累積初婚率のコーホート変化に関する観察を行った。これらはコーホート的な変化を比較するために、1935 年生まれ世代を基準として、年齢ごとに差を算出しレキシスマップとして表した。年齢別累積出生率については、Figure 1、年齢別累積初婚率（ここでは既婚率と見なしている）は、Figure 2 に図示されている。これらの図によれば、出生率の変化は1950 年代前半コーホートより始まっていることが明らかである。ただし、Figure 2 によって初婚の変化についてみると、50 年代後半に至るまでは、若年層のみによる初婚率の低下、すなわち晩婚化が生じていたのであり、いわゆる生涯未婚率・既婚率に対する影響は及んでいないことがわかる。これに対して、Figure 1 の出生率の変化では、非常に微弱な低下が 50 年代前半より見られる。これは晩婚化の夫婦出生に対する構造的な効果によるものと見られる。

次に夫婦出生について、詳細に見ると妻 1930 年頃から 1951 年生まれまでの夫婦では出生には際立った変化はなかった。52～3 年コーホートから出生の遅れが見られるようになったが、60 年コーホートまでは 30 歳代でのキャッチアップが見られ最終的な子ども数には変化は見られない。これら世代の出生の遅れはすべて晩婚化、高学歴化の効果であり、夫婦はむしろこれらによって失われる出生に対して補填的な行動をとっていたと見られる。つまり、少子化に関わる行動変化は 1952 年前後生まれ女性世代に始まる晩婚化からと見られるが、夫婦出生についてはこの晩婚化とその原因でもある高学歴化によって出生に遅れが生じたものの、60 年生まれ世代までは最終的子ども数はほとんど変わらず、出生行動としてはむしろ減少を補おうとする反応があったと見られる。

ただし、この間に見られた一つの重要な変化としては、1957 年コーホート以降では、それまで晩婚化に対しても主要な動力となっていた高学歴化が一段落し、夫婦出生の変化に対する寄与も急速に減衰していることである。すなわち、結婚タイミングも夫婦出生も、当初の高学歴者の増加という構造変化の推進からしだいに離れ、属性によらない総員的な変化の形にメカニズムが移行してきたことを示す。

続く妻 1961 年以降のコーホートの夫婦出生では、引き続く晩婚化の効果に加えて、行動的にも変化が現れた。すなわち、夫婦は晩婚化、高学歴化による子ども数（の供給力）の減少を受け入れるようになり、さらにそれを下回る子ども数をも容認し始めた。それでも 60 年代前半コーホートでは、妻 37 歳までに 32 歳時点の減少の 6 割を取り戻しており、

晩産に対する一定のキャッチアップの努力はなされており、その及ばない部分が最終的子ども数の減少となっている。また、夫婦が諦めたのは出生順位第2子以降であり、第1子は遅れは著しいものの、最終的出生確率はいぜんとして高い水準を保っている。したがって、これら世代では一人っ子が増える形で出生低下が生じていると見られる。

これら出生途上のコーホートのうち1964～5年以降のコーホートではとくに出生の遅れが著しく、その構造変化に比べた行動変化の効果の比重も高まった。すなわち、意図的な低下ないしは低下の容認が広まっていると見られ、出生過程は途中経過しか得られないものの、その遅れの程度が大きくキャッチアップが難しいことも考慮すると、これらの世代の夫婦では一人っ子化の形を取りながら、最終的子ども数はかなり減少することが見込まれる。

以上において少子化過程の分水嶺となっているのは、晩婚化とそれにともなう晩産化を始めた女性1952～3年コーホート、および、夫婦が少産への行動に移行を始めた1960～1年コーホートである。前者から始まるコーホートは、当初結婚・出産の遅れによって70年代半ばから80年代半ばの年次出生率にいわゆるテンポ効果[1]をもたらしてこれを低下させ、少子化をスタートさせた。しかし、1958年コーホートまでは生涯未婚率は安定的であり、また夫婦の完結子ども数もさほど変化しなかった。すなわち、これら世代は少子化をスタートさせたにもかかわらず、世代の最終的な子ども数にはほとんど変化はなかったのである。ところが1960～1年コーホートからは非婚化（生涯未婚率の増加）と夫婦出生の低下が目立つようになり、夫婦出生については晩婚化の効果に加えて行動的にも子ども数の減少を受け入れるようになったと見られる。したがって、少子化過程は1960年前後出生の女性コーホートを境にして前半と後半で出生低下のメカニズムに転換が起きており、前半は晩婚化に誘発されたテンポ効果による「見かけ」の少子化、後半はこれに非婚化、夫婦の行動変化が加わった実質的少子化ということができる。すなわち、人口学的メカニズムの観点からは少子化は一時的低下型から恒久的低下型にすでに移行したことを示している。

以上、少子化過程を含む期間の出生力夫婦出生力の変遷について、妻年齢、出生コーホートを分析軸として見てきた。その結果1960年前後に生まれた女性コーホートを境に出生低下メカニズムに転換があり、テンポ効果による一時的低下型から、非婚化、夫婦の行動変化が加わった実質的低下型へと移行したことなどがわかった。そこで見られた結婚・出生のコーホート変化が、どのような社会経済要因の影響を受けて生じたものか、さらにはどのような施策がこれに影響したか（または影響し得るのか）については、広範な分野からのアプローチが必要である。しかし、その際には本研究で行なったように、対象とする指標から構造的変化の効果を分離し、できるだけ純粋な行動変化に注目することが必要であると考えるものである。

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[1] テンポ効果とは、コーホートごとに出生タイミング（出生年齢）が順次シフトしているときに、期間出生率（年次出生率）の水準に生ずる変動であり、コーホートの出生率水準にまったく変化がなくとも、タイミングが変化するだけで生ずる効果である。テンポ効果は、コーホートに晩産化が生じている場合には期間出生率を下げる方向に働く。

Life-course Transformation of Fertility Process in Japan; Where did the Reduction occur to Which Cohort by What Causes?

Ryuichi Kaneko, Fusami Mita

Abstract

In this study, first I reconstruct the historical development of the age specific fertility rates experienced by Japanese female cohorts to identify when the reduction was initiated by which cohort and what was followed among the successive cohorts. According to the observation on the Lexis mapping of reconstructed rates, it was the female cohort born in early 1950's that initiated the transformation process lasting until today with simple childbearing delay caused by marriage postponement. The detailed observation reveals more comprehensive view on the life course transformation in the society. Then I decomposed the rate changes into those caused by changes in marital composition and in marital fertility which is further decomposed into contribution of structural factors like educational upgrading and/or marriage delay, and of behavioral factor as residual of marital fertility by parity. The result reveals that the possibly intentional behavioral changes of married couples stated among those with wives born in 1960's.

Introduction

In this study, I describe the results of decomposition analysis of the historical development of the age specific fertility rates of Japanese female cohorts. Fertility rate is sum of the probabilities of having child by birth order, and each of the probability is composed of some structural and behavioral factors such as marital status and reproductive behavior of married couples. In Japan, it is observed that marriage delay have had major impact on the unprecedented fertility decline since mid 1970s. Especially in the former half of the process until the late 1980s, it is said that marriage delay was almost exclusive drive of the phenomenon, which means that rise in marital behavior like never marrying for life and divorce was not seen and marital fertility was stable, unlike the other developed countries experiencing fertility reduction(Kaneko 1999). Here I attempt to identify the uniqueness of Japanese fertility development by looking at the components of the fertility rate with the decomposition analysis technique. Since some effects of socioeconomic factors on the process mediated by components of the demographic dynamics are major concern, quantitative contribution of the educational upgrading to marital fertility change through or not through marriage delay is examined. I used the logistic regression to attribute reduction in the birth probability of each birth order to educational upgrading, and marriage delay induced and not induced by educational upgrading.

Since all of those phenomena evolve in the context of life course transformation, we come to have better understanding if the changes are traced on lives of successive cohorts. The locations of the events on age and cohort space are well identified by the Lexis mapping of fertility or probability developments. The Lexis mapping serves as a functional screen to express multi-dimensional changes in vital events(Vauple et al. 1997). It is especially useful when observation becomes with numerous dimensions such as parity and other characteristics as well as age, period and cohort. I demonstrate the technique to describe the fertility reduction from various dimensions and causes.

According to the result, the ever lasting delay in marriage spread until today is initiated by cohort (born in) early 1950's, though increase in the proportion never married did not started until those born in later 50's. The celibacy at age 50 seems prevail very rapidly among cohorts afterward. Marital fertility has almost no change until cohort of 1950. The reduction in younger ages (under age 35) is seen in the following cohorts by postponement of child bearing corresponding to marriage delay. However, the average number of children ever born to couples did not apparently change until those born in 60's. For cohort born in mid 60's and afterward, the delay is so massive that catch up in their later life could not compensate the loss in youth, even if it does exit. The distinctive stability in marital fertility in Japan is now dissolving. The second birth is most affected, which implies that only child family is diffusing. The early changes in marital fertility were mainly brought by educational upgrading (increase in proportion with higher education) among cohorts via delaying marriage, while it ceased from being cause after cohorts of 1957. In any case, the educational upgrading has not contributed ever to the reduction of the completed fertility of married couples, though it affected total fertility by raising the proportion never married.

With these observation and findings, we proceed to construct the fertility outlook in Japan. This is necessary to have precise prospects on future population as demographic projection for the society whose fertility is among the lowest low together with the world longest longevity. In the latter half of the presentation, I explain the outlook of fertility and population in the official population projection based on analyses such as those described above. The fertility assumptions underlying the projection were made on the basis of the cohort-fertility method, or the life course approach. That is a statistical projection of the level of completed fertility and the birth timing of each female birth cohort including those who have not yet completed their reproductive processes. Therefore, detailed results from close examination on the changing process of fertility components are required. On the other way around, since the future age-specific fertility rates of cohorts were estimated or assumed separately by birth order, the future life courses concerning reproductive process are constructed via the multi-state life table approach. Together with the traits of the population such as rapidly declining size and the world oldest age structure, the latest official population for Japan provides woman's life time probabilities of having birth, family size distributions, and the average life time length spent in specific family status. The micro type information on the future look of individual life may be useful than being provided macro indices, as is the case so far.

Data: the National Fertility Survey

Beside the vital statistics and censuses in obtaining age specific fertility rates, the dataset that I use in the analysis of marital fertility is built from six surveys among the National Fertility Survey (NFS), which has been conducted every five year by National Institute of Social Security and Population Research (NIPSSR 2003). Individual information on conception and birth histories of first-marriage couples of wife's cohorts born in 1928 through 1975 are extracted from the results of the Seventh (1977) through Twelfth (2002) NFS, and converted into statistical birth process of cohort life course. The result from the Thirteenth (2005) survey is also tentatively used (see Appendix).

Models and methods

The common overview of the fertility rate, or equivalently the average number of children and probability of having birth of certain order to analysis and projection is as follows. The cohort fertility is here constituted by a number of sub-models broken down by probabilities. Specifically, if the average number of birth and the birth probability of having the n-th birth at certain age is respectively denoted CTFR and CTFRn, then;

$$CTFR_n = (1-\gamma)\cdot CEB_n \cdot \delta_n, \text{ and;}$$

$$CTFR = \sum_{n=1}^{4+} CTFR_n$$

where γ is the proportion of never-married (the complement of the cumulative first marriage rate), CEB_n is the probability giving birth by married women, and δ represents the effects of divorce, bereavement, remarriage and childbearing out of wedlock on fertility and expresses the ratio between fertility of first-married couples and the fertility of all married women including the former group. Though suffix for age does not appear in the equation for simplicity, all these quantities are defined at each age as well as lifetime value as evaluated at certain age such as 50.

The completed number of births from married couples, *CEB*, is the product of the expected completed number of births from married couples, $CEB^*(afm)$, which is a function of age at first marriage, *afm*, and a fertility variation coefficient of married couples, κ, as (omitting the suffix n for birth order);

$$CTFR = (1-\gamma)\cdot\left(CEB^*(afm)\cdot\kappa\right)\cdot\delta$$

$CEB^*(afm)$ is a common function to all cohorts, while the fertility variation coefficient of married couples, κ, is an indicator expressing changes in reproductive behaviors of married couples. It is observed that the *CEB* is quite stable when *afm* is controlled at least for early cohorts. This is the rationale to fix the relationships between *CEB* and *afm* as $CEB^*(afm)$, which is conformed by cohorts born during 1935-54. Therefore marital fertility (the average number of children ever born *CEB* or the probability of having birth of n-th order CEB_n) varies according to *afm* (the mean age at first birth) and κ (relative intensity of marital fertility) of a specific cohort. Furthermore, the *afm* could depend on cohort characteristics. In this presentation, the effects of compositional change of educational attainment for cohorts are examined as a driving force of fertility reduction through delaying marriages.

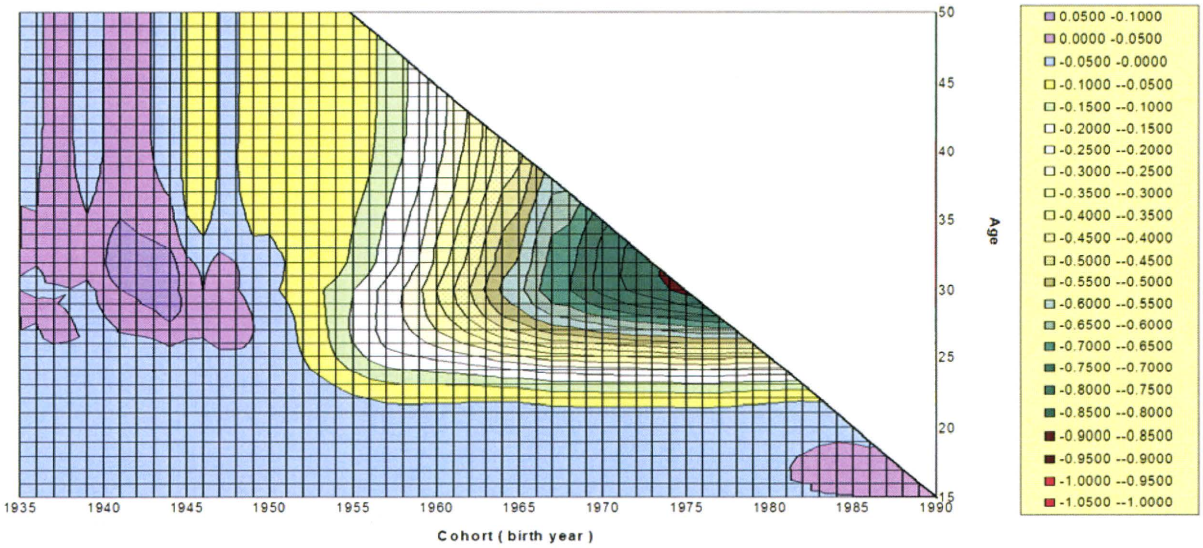
In the decomposition analysis on marital fertility, the logistic regression technique is used to identify the amount of reduction in the birth probability of each birth order at each age caused by educational upgrading and marriage delay induced and not induced by educational upgrading. Detailed method of the decomposition technique used in this presentation is described in Appendix.

Results of the decomposition analysis on fertility reduction

In this section, the parity and factor strata of fertility decline in Japan are visualized by the layers of component effects in the reproductive life course. The most basic is the contour map of

Japanese fertility decline over successive cohorts in form of reduction in the average number of children per woman at each age in reproductive process as compared to those of the cohort born in 1935 as Baseline (Figure 1).

Figure 1 Reduction in the Cumulative Fertility Rate of Japanese Female Cohorts from Cohort born in 1935 as Baseline



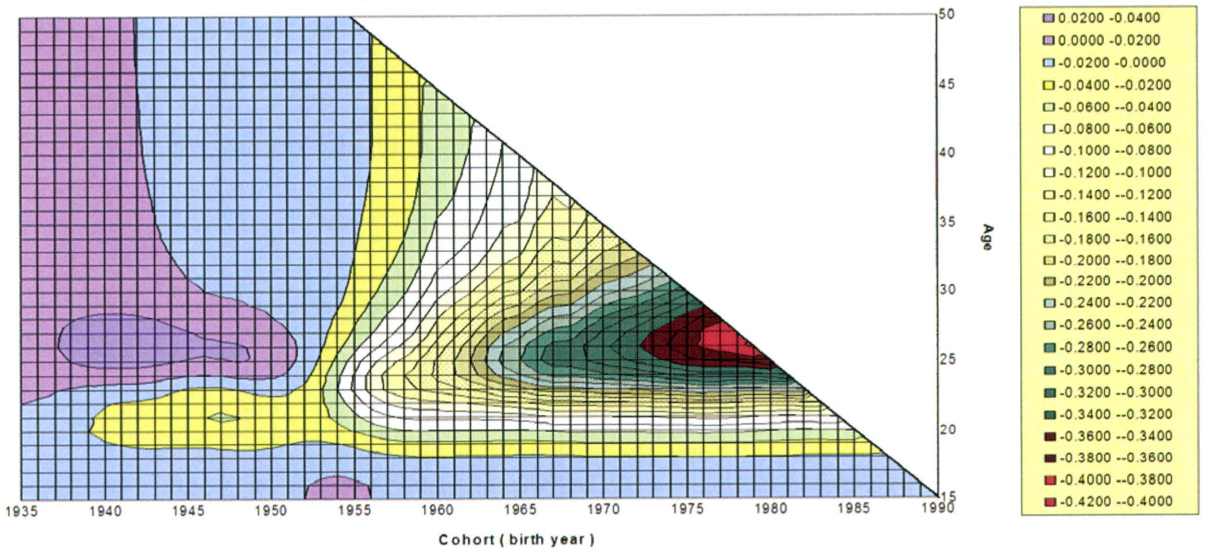
Note: Reduction in the cumulative age-specific fertility rate (≈the average number of children ever born) at each age from the female cohort born in 1935 is mapped on the age-cohort coordinates plane (the Lexis surface). The larger the reduction observed, the darker the pattern painted. The blank area in upper portion for cohorts born in 1954 and after is unattained age for them at the time of data collection (the Vital Statistics).

This is a type of the Lexis map in which the horizontal axis represents procession of cohorts indicated by birth year, and the vertical axis is age development from age 15 at bottom to 50 at the top. Therefore the life course of each cohort corresponds to vertical section of the chart. The larger the reduction observed, the darker the pattern painted. In this particular picture, blue area indicates parts in which no or little reduction is observed. The blank area in upper portion for cohorts born in 1956 and after is unattained age for the cohorts at the time of data collection (the Vital Statistics).

The chart indicates that there is successive fertility reduction that is concentrated around ate 30 cohorts born in later 1950's and later. It is seen that a part of reduction in some cohorts is recuperated along with life course (vertical line). The pattern epitomizes delay in childbearing since the fertility reduces only temporally in the life course of cohorts. With this type of the Lexis mapping, it is easy to see in which part of the life course of which cohort the fertility changes take place. In the following, we visually examine the life course transformations concerning reproductive process of Japanese women in detail.

In Figure 2, development of the proportion ever married by age measured by the cumulative first marriage rate for the female cohorts is painted. Basically the same pattern is observed in marriage change as the fertility seen in Figure 1. In addition, an interesting pattern, which indicates slight delay in youth and acceleration immediately after, is observed in cohorts born late 1930's through 40's.

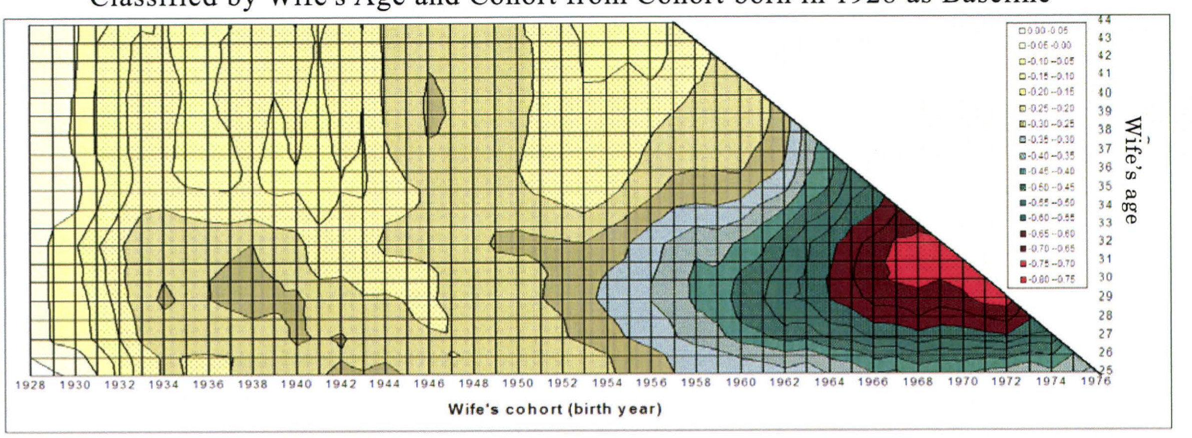
Figure 2 Reduction in the Proportion Ever Married of Female Cohorts from Cohort born in 1935 as Baseline



Note: This is a chart with same framework as Figure 1 for the cumulative first marriage rate (≈the proportion ever married) of the female cohorts.

Reduction in the average number of children ever born among the first-married couples at each wife's age (ranged 25 to 44) from that of wife's cohort born in 1928 is mapped on the age-cohort coordinates plane in Figure 3. The larger the reduction turn out to be, the darker the paint pattern appears. The only visual representations of the results are presented below in this section. The implications are presented and discussed collectively in the next section.

Figure 3 Reduction in the Average Number of Children Ever Born for Married Couples Classified by Wife's Age and Cohort from Cohort born in 1928 as Baseline

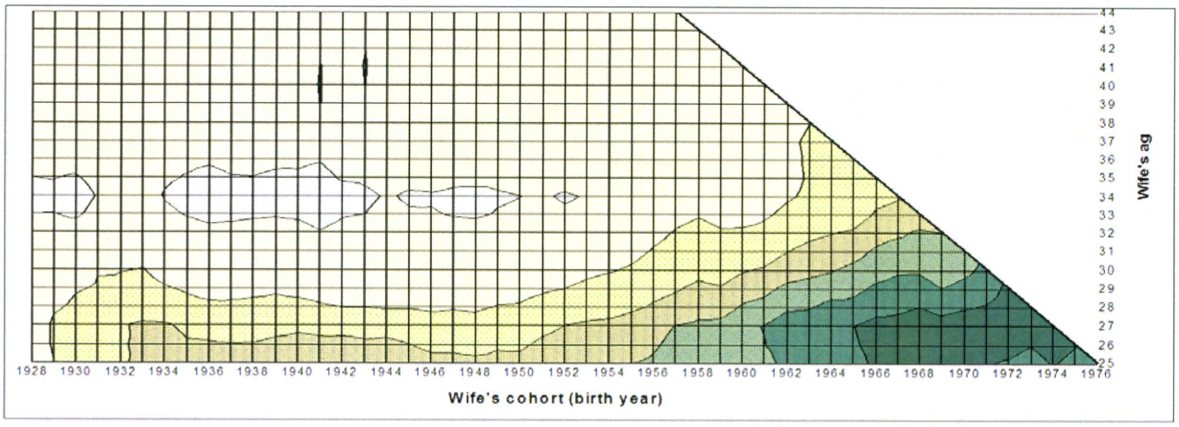


Note: Reduction in the average number of children ever born among the first-marriage couples at each age of wives (ranging from 25 to 44) from those of wife's cohort born in 1928 is mapped on the age-cohort coordinates plane (the Lexis surface). The larger the reduction observed, the darker the pattern painted. The blank area in upper portion for cohorts born in 1958 and after is unattained age for them at time of .the survey (the Twelve's National Fertility Survey)

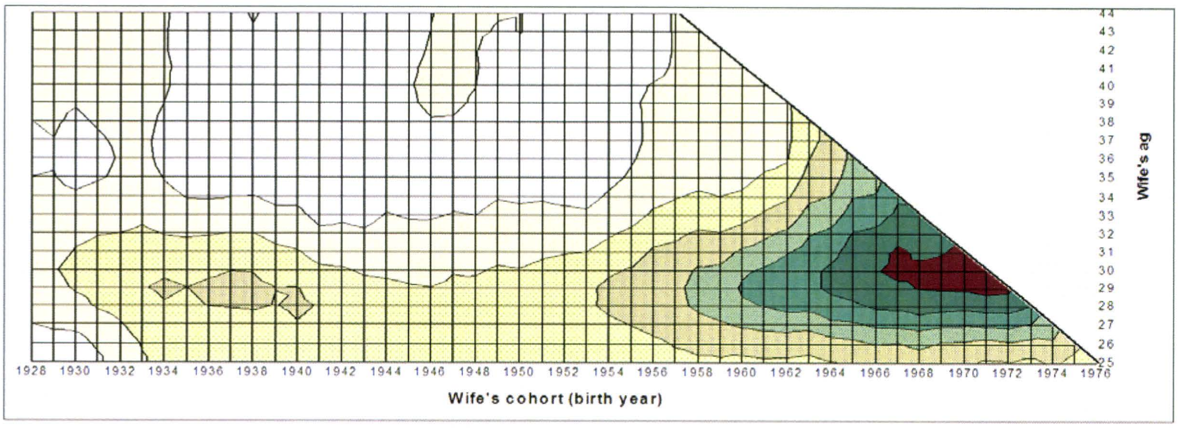
Since reduction of marital fertility can be attributed to reduction of birth probability by birth order, separate observation is given in Figure 4. The largest part is notable attributed to the reduction of second birth. Most of early reduction in first birth probability in life stage is recuperated. So dose the second birth probability until cohort born in early 1960's, but the recovery weakens in cohorts afterwards.

Figure 4 Reduction in the Probability Having the First to Third Birth for Married Couples Classified by Wife's Age and Cohort from Cohort born in 1928 as Baseline

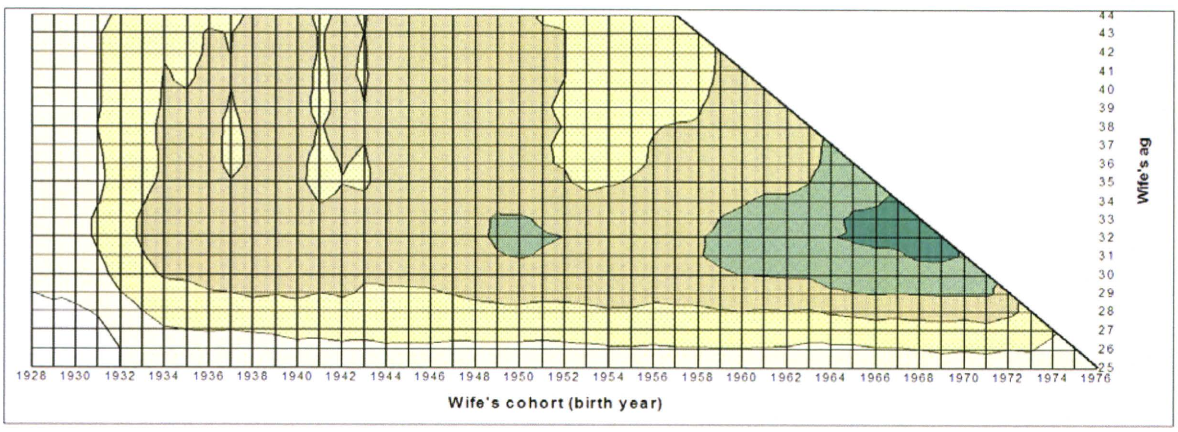
a. The First Birth



b. The Second Birth



c. The Third Birth

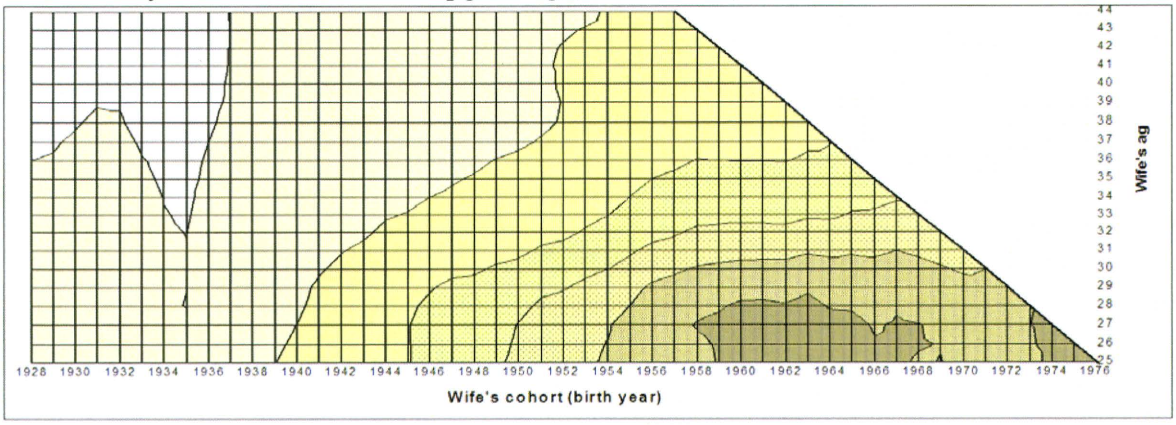


Note: These are charts with same framework as Figure 3 for the probability having live birth of the first to third order to the female cohorts. Three planes sum up to the one in Figure 3 together with those for higher order births.

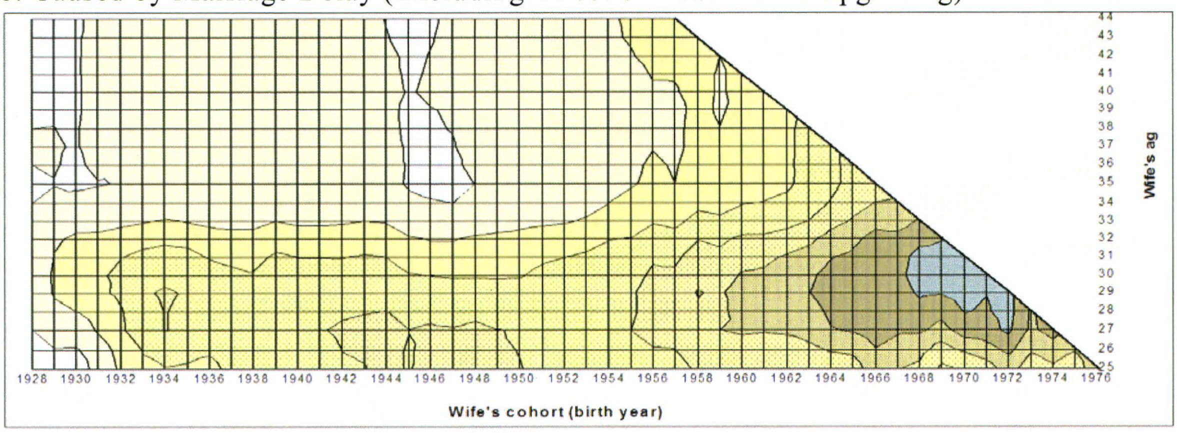
Reduction of marital fertility in total shown in Figure 3 can be decomposed into reduction caused by educational upgrading (increase in proportion with high educational grade), marriage delay (including or excluding effect from educational upgrading), and other behavioral changes of couples (residual). The results are shown in Figure 5.

Figure 5 Reduction in the Average Number of Children Ever Born for Married Couples Classified by Wife's Age and Cohort from Cohort born in 1928 as Baseline

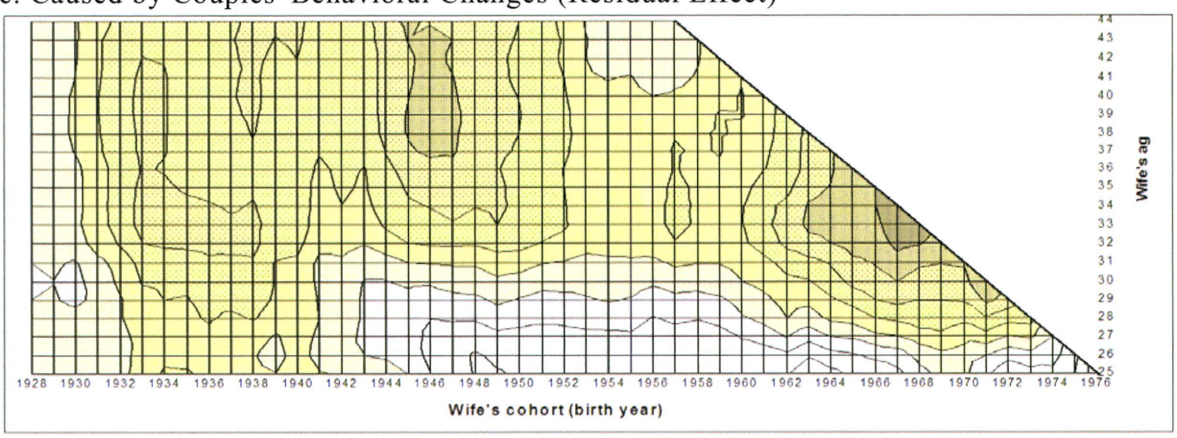
a. Caused by Wife's Educational Upgrading (Total Effect)



b. Caused by Marriage Delay (Excluding Effect of Educational Upgrading)



c. Caused by Couples' Behavioral Changes (Residual Effect)

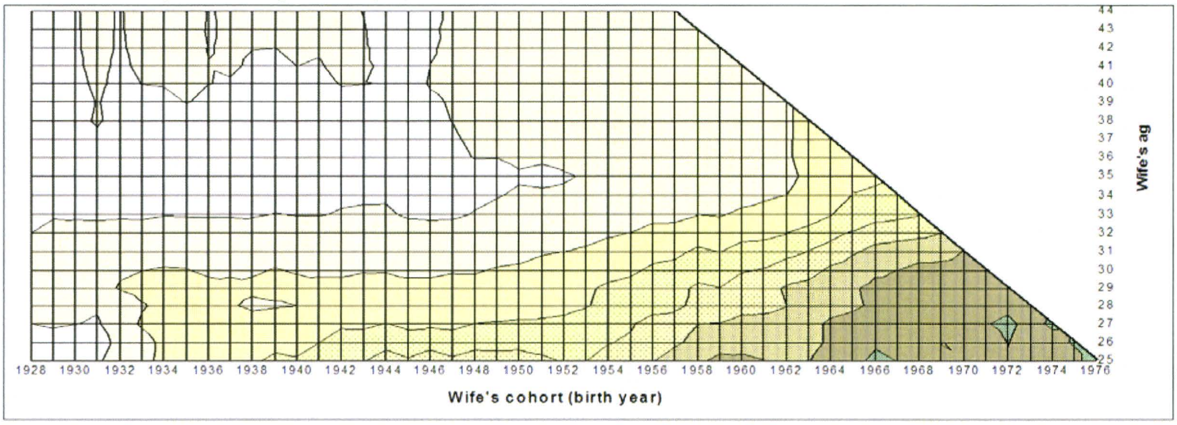


Note: These are charts with same framework as Figure 3 for the reduction in the average number of children ever born caused by three major factors for fertility reduction. Three planes sum up to the one in Figure 3.

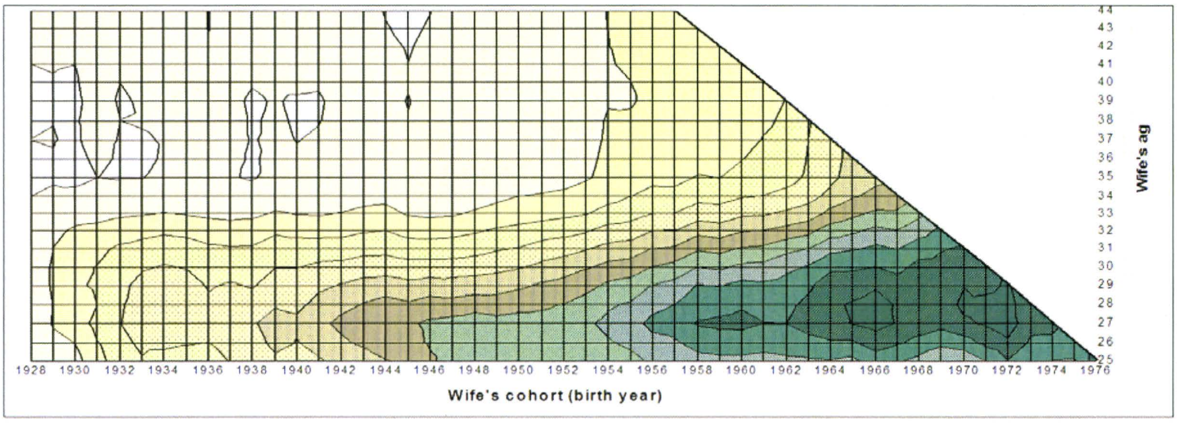
The decomposition of fertility reduction by factors can be applied to the probability of having birth of each order. The reductions attributed to marriage delay as a whole for the first and second birth are indicated in Figure 6.

Figure 6 Reduction in the Probability having First and Second Birth for Married Couples Caused by Marriage Delay (Total Effect) Classified by Wife's Age and Cohort from Cohort born in 1928 as Baseline

a. Caused by Marriage Delay (Total Effect) of the First Birth



a. Caused by Marriage Delay (Total Effect) of the Second Birth



On the process of fertility decline in Japan

In the previous section, the history of Japanese marital fertility along with 48 years of wife's birth cohort since cohort born in 1928 is reconstructed by means of six national representative surveys extended over 25 years. As a result, detailed process of onset of the recent marital fertility reduction is revealed. An outline is as follows. (1) Until cohort (born in) 1950, there has been almost no change found in marital fertility, though educational upgrading started to have slight effect on marital fertility during cohorts born in 1940s. (2) Marriage delay started by cohort 1952/53 (Kaneko 2003) having influences on the timing of having first and second child, however, without changing the completed fertility for cohort born in 1950s. They caught up to the previous level by age 40. Effect of educational upgrading expanded until cohort 1957 having little change thereafter. The probability having third child showed an slight upward tendency during cohorts 1952-58 followed by recession to the previous level. (3) After cohort 1960 the pace down seen before age 35 becomes conspicuous and it gradually remained until late 30s. For cohorts 1960-64 the catch up to the level of the previous cohorts is not enough at age 37. The effect from couples behavioral change become large (36% at wife's age 32, 25% at age 37), though the effect of marriage delay is still substantial (58% at age 32, 70% at age 37%). (4) For cohorts born after 1965, the pace down before age 35 becomes even outstanding (-0.4 children from the previous 5-year cohort at age 32). The effect from couple's behavioral change expanded to 44% at age 32. Effect on second child is greater than other birth order implying diffusion of only child family in these young cohorts. Similar but not extending traits are found in succeeding cohorts born in early 1970s.

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Appendix: The Logistic Regression Model for Removal of Exogenous Effects of the Age-specific (Marital) Fertility Rate

The probability of having a child of each birth order and (as the sum of them) the average number of children for couples are expressed in terms of the logistic regression model with exogenous factors. The probability having n-th order child by some age of wife (say age 35) for wife i is given by;

$$\ln p_{i,n}/(1-p_{i,n}) = \beta_{n,0} + \sum_{j=1}^{k} \beta_{n,j} X_{i,j} + \sum_{m=1}^{k_m} \gamma_{n,m} a_i^m + \sum_{c=1}^{k_c} \delta_{n,c} Y_{i,c} + e_{i,n}$$

where a_i, $X_{i,j}$, $Y_{i,c}$ are age at marriage, dummy for covariates, and cohort dummy for i, $\beta_{n,j}\ (j=1\cdots k), \gamma_{n,m}\ (m=1\cdots k_m), \delta_{n,c}\ (c=1\cdots k_c)$ are regression coefficients for those regression variables(k, k_{m}, k_c are number of categories of each variable, regression coefficients for reference categories are zero), and $e_{i,n}$ is regression error. Then

The probability of having the n-th child (observed): $p_n = 1/\left[1+\exp\{-(\beta_0+\delta_c)\}\right]$

The probability without effect of marriage delay: $p_{n|M^-} = 1/\left[1+\exp\left\{-(\beta_0+\delta_{c|M^-})\right\}\right]$

The probability without effect of educational upgrading: $p_{n|E^-} = 1/\left[1+\exp\left\{-(\beta_0+\delta_{c|E^-})\right\}\right]$

The probability without both effects: $p_{n|EM^-} = 1/\left[1+\exp\left\{-(\beta_0+\delta_{c|EM^-})\right\}\right]$

Total effect of marriage delay: $\nabla\hat{p}_{n|M} = \hat{p}_n - \hat{p}_{n|M^-}$,

Pure effects of marriage delay: $\nabla\hat{p}_{n|M^*} = \hat{p}_{n|E^-} - \hat{p}_{n|EM^-}$,

Total effect of educational upgrading: $\nabla\hat{p}_{n|E} = \hat{p}_n - \hat{p}_{n|E^-}$,

Pure effects of educational upgrading: $\nabla\hat{p}_{n|E^*} = \hat{p}_{n|M^-} - \hat{p}_{n|EM^-}$,

Common effect: $\nabla\hat{p}_{n|EM^*} = \hat{p}_n - \hat{p}_{n|M^-} - \hat{p}_{n|E^-} + \hat{p}_{n|EM^-}$,

Effect of marital behavioral change: $\nabla\hat{p}_{n|B^*} = \hat{p}_{n|EM^-} - \hat{p}_n[0]$,

($\hat{p}_n[0]$ is the probability of reference cohort).

Then, reduction of probability having n-th child is decomposed as follows,

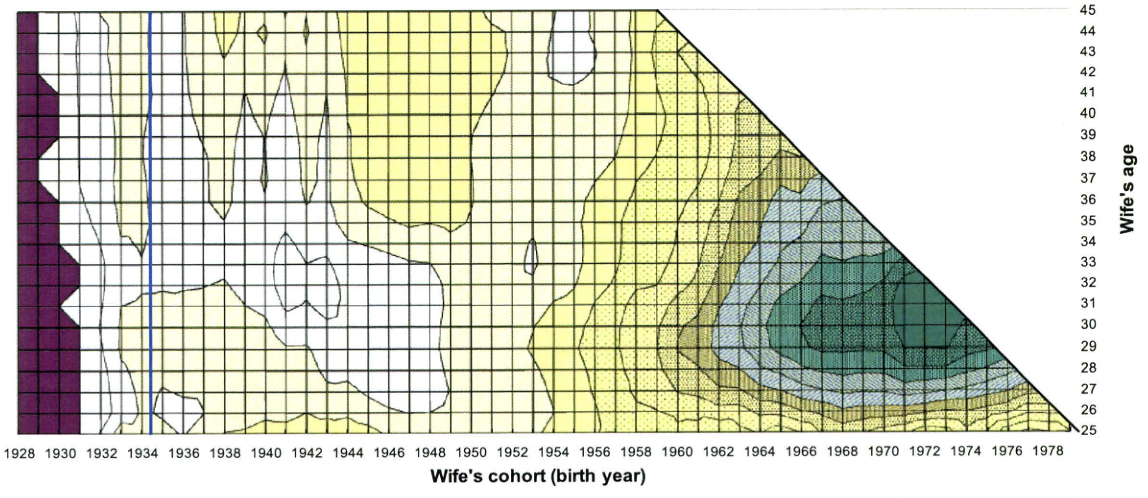
$$\Delta p_n = \nabla p_{n|E^*} + \nabla p_{n|EM^*} + \nabla p_{n|M^*} + \nabla p_{n|B^*}$$

Change in the average number of children is sum of those effects by birth order. All variables and relationships above apply at each single age of woman.

Appendix: Tentative Results from the Data Set with the Latest Survey

The following Lexis maps are result from the data set including data from the latest, Thirteenth National Fertility Survey conducted in 2005.

Figure A3 Reduction in the Average Number of Children Ever Born for Married Couples Classified by Wife's Age and Cohort from Cohort born in 1935 as Baseline



Note: Reduction in the average number of children ever born among the first-marriage couples at each age of wives (ranging from 25 to 44) from those of wife's cohort born in 1935 is mapped on the age-cohort coordinates plane (the Lexis surface). The larger the reduction observed, the darker the pattern painted. The blank area in upper portion for cohorts born in 1960 and after is unattained age for them at time of .the survey (the Twelve's National Fertility Survey)

Figure A5 Reduction in the Average Number of Children Ever Born for Married Couples Classified by Wife's Age and Cohort from Cohort born in 1928 as Baseline

a. Caused by Wife's Educational Upgrading (Total Effect)