

なお、年齢 x における年齢別出生率 $f(x)$ は、

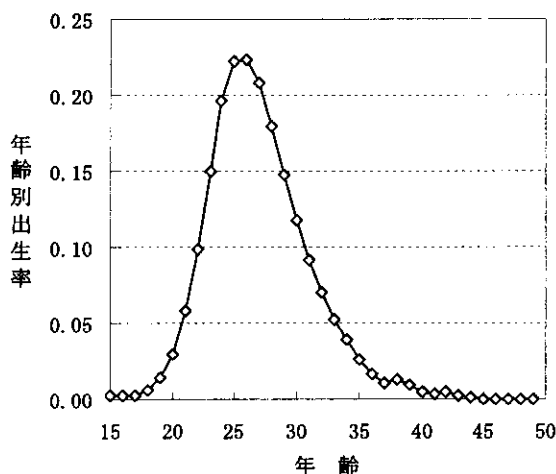
$$f(x) = F(x+1) - F(x)$$

によって求められる。以下では2つのシミュレーションを行い、実績値と比較する。

(3) シミュレーション1

最初のシミュレーションは、初婚過程が標準パターンに従い、夫婦の出生行動も、初婚年齢別累積出生児数の標準パターンに従う場合とした。コーホートの年齢別出生率は一律、図8のようになる。コーホート完結出生率は2.00、平均出生年齢は27.48歳となる。従って、このような結婚行動、夫婦の出生行動パターンが長期的に続けば、期間合計特殊出生率は2.00の水準となることを意味する。

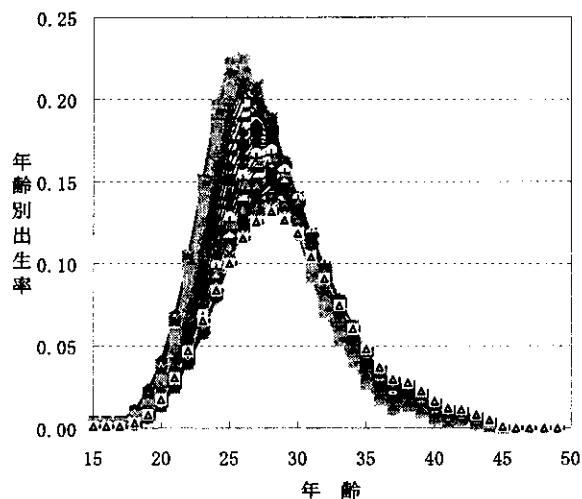
図8 結婚行動および夫婦の出生行動が標準パターンに従った場合に期待される年齢別コーホート出生率



(4) シミュレーション2

もう一つのシミュレーションは、初婚過程については、実績値のとおり1950年以降晩婚化・未婚化が進むものとし、夫婦の出生行動のみ標準パターンに従った場合とする。これにより期待されるコーホートの年齢別出生率は図9のようになる。まだ初婚過程が終わっていないコーホートの初婚率については実績値および平成14年将来推計人口の中位仮定を用いた。若年での初婚率が低下するのに伴って、出生率も低下することがわかる。

図9 初婚年齢別の夫婦の出生行動が標準パターンに従った場合に期待される年齢別コーホート出生率：1935年～2000年コーホートについて



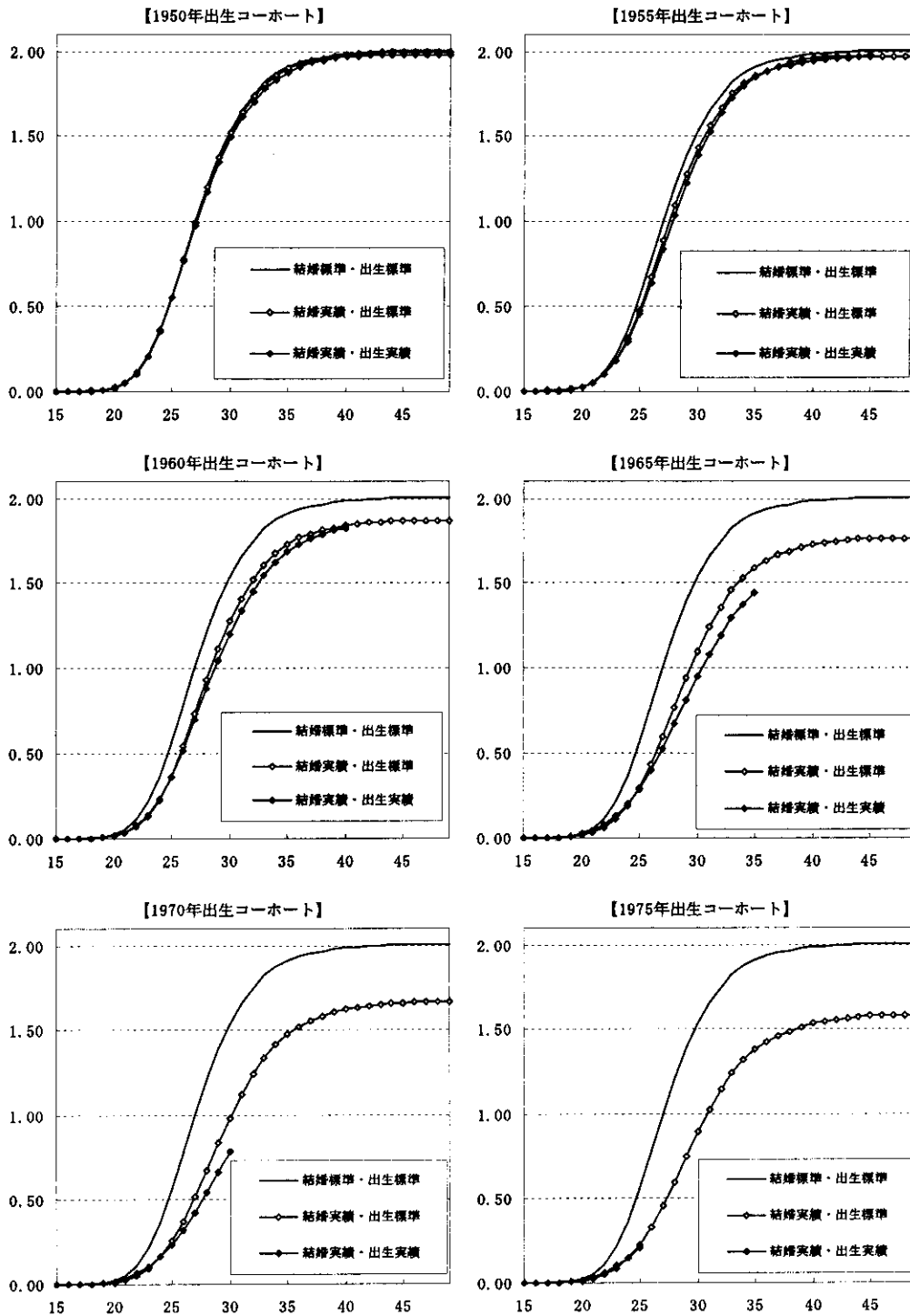
(5) コーホート年齢累積出生率の比較

初婚過程も初婚年齢別の夫婦の出生過程も標準パターンである場合(ケース1)、初婚過程は変化させるが初婚年齢別の夫婦の出生過程は標準パターンである場合(ケース2)、実績値と平成14年推計中位仮定の場合のコーホート年齢累積出生率(実績)を特定コーホートで比較すると、以下のようになる。1965年出生コーホート前後から、出生標準パター

ンを用いたケース2の結果と出生率の実績値に乖離が見られることがわかる。すなわち、この乖離は結婚行動の変化では説明できないものであり、結婚後、夫婦が以前のようなペースで子どもを持っていないことを示唆するものである。

図10 コーホート年齢累積出生率の比較

結婚標準…1940～1951年出生コーホート 出生標準…1932～1957年出生コーホート

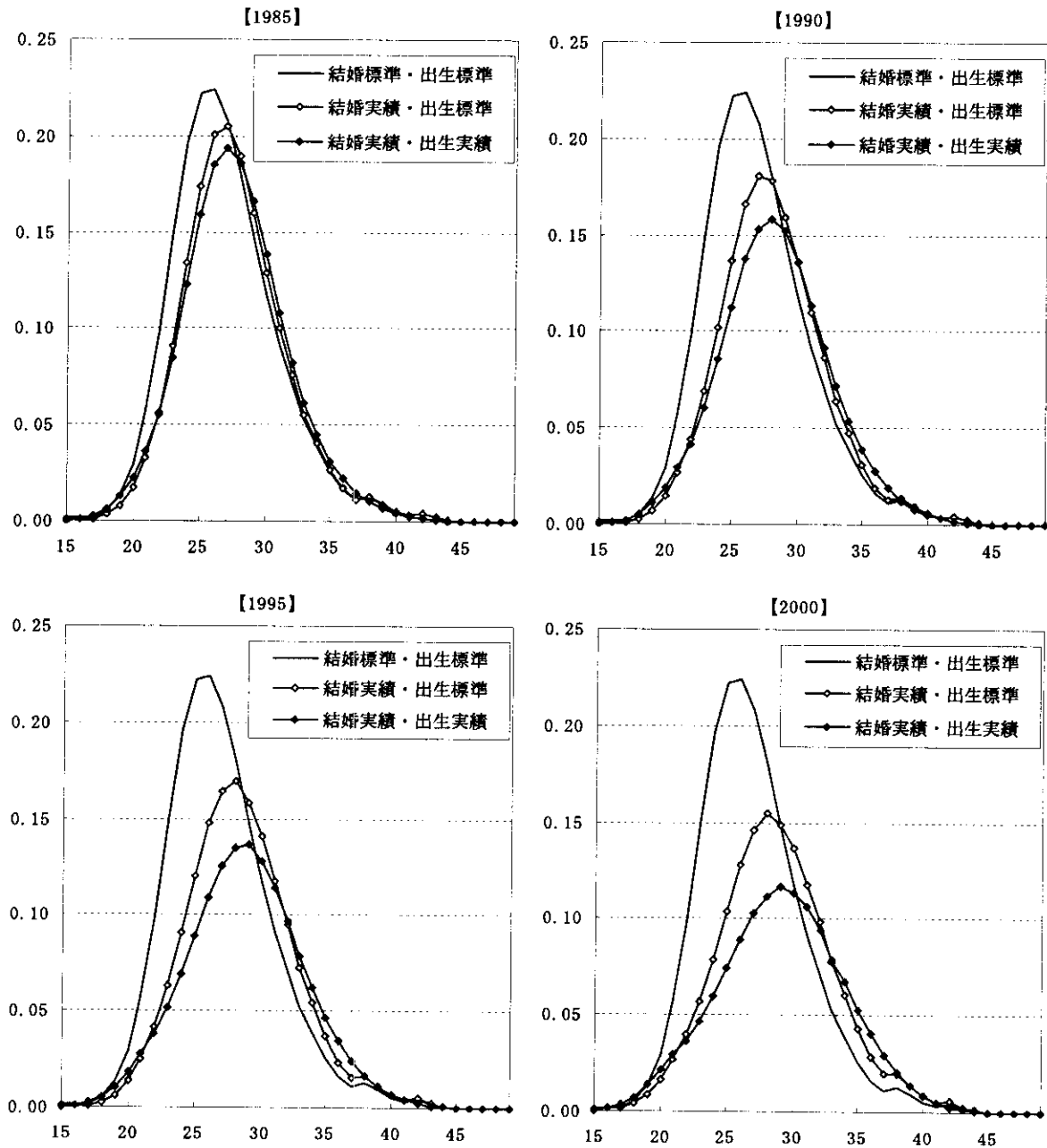


(6) 期間出生率への変換

以上のシミュレーションで求められたコーホートの年齢別出生率を年次ごとに組みかえ、2000年までについて実績値と比較すると図11のようになる。1990年に入り、20代後半における夫婦の出生行動変化が、期間合計特殊出生率の低下に寄与していることがわかる。また合計特殊出生率と年齢5歳階級別の出生率を図12に示した。

図11 期間年齢別出生率の比較

結婚標準…1940～1951年出生コーホート 出生標準…1932～1957年出生コーホート

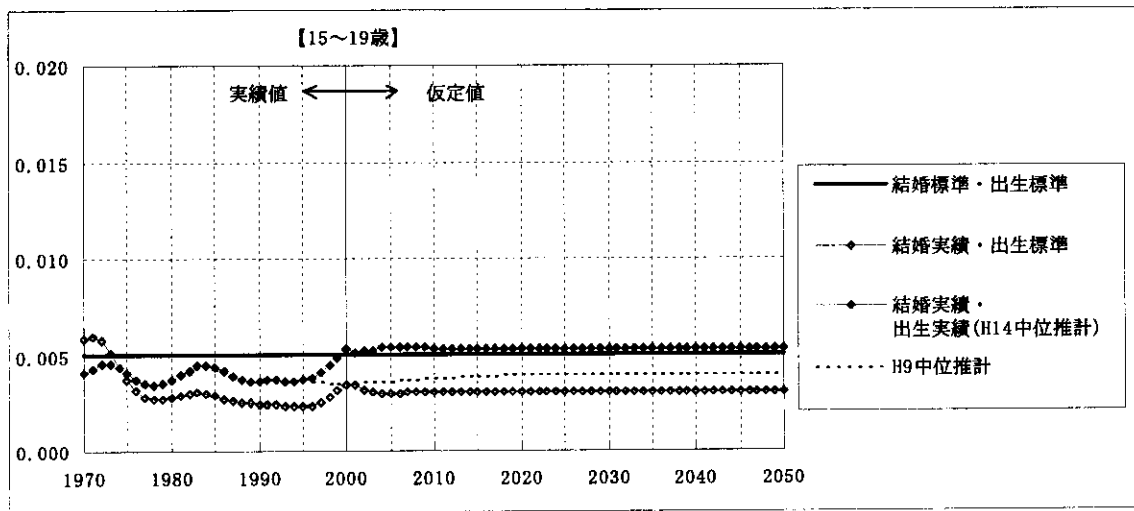
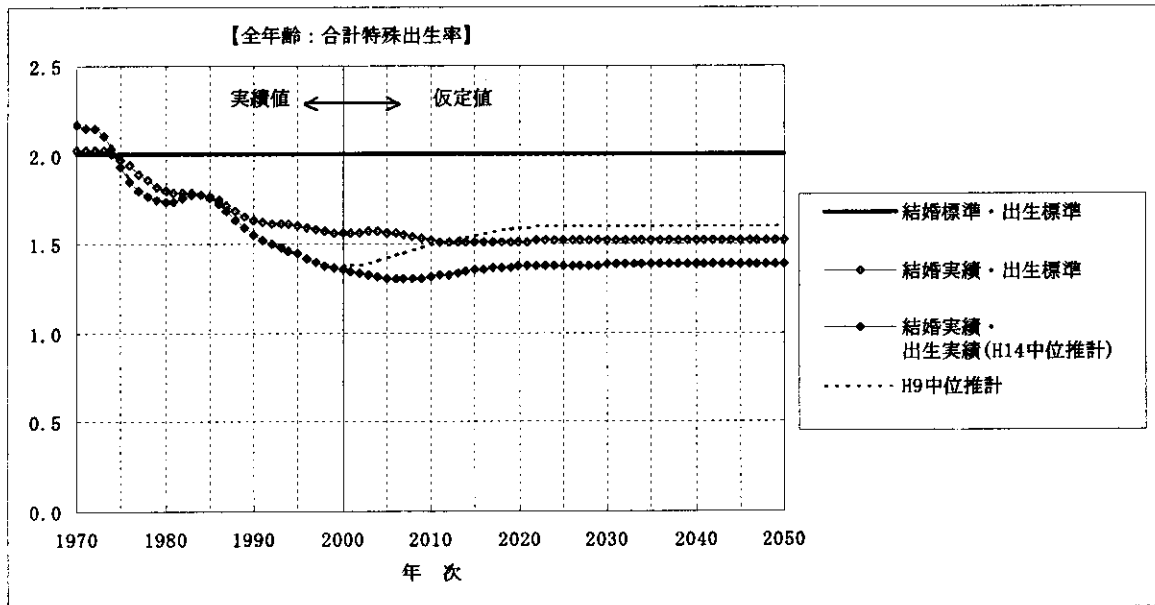


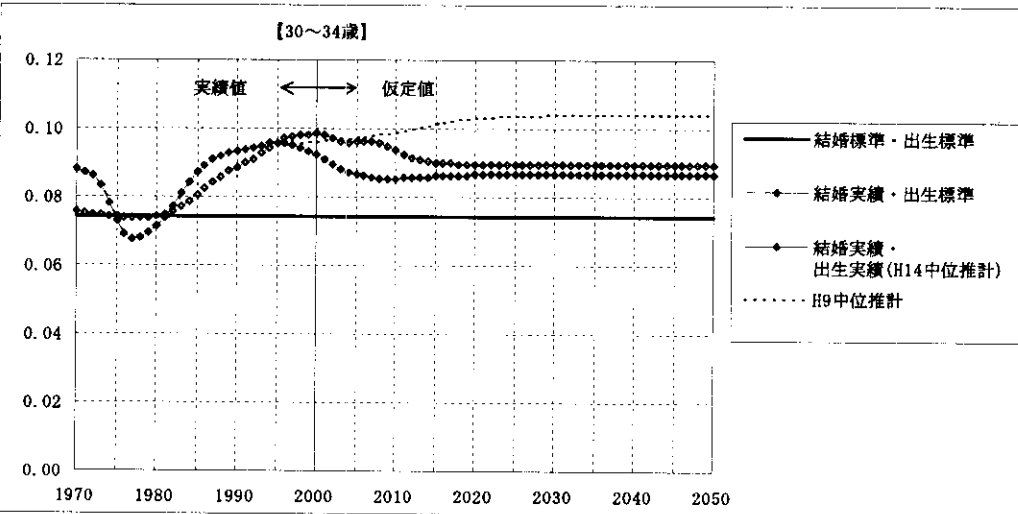
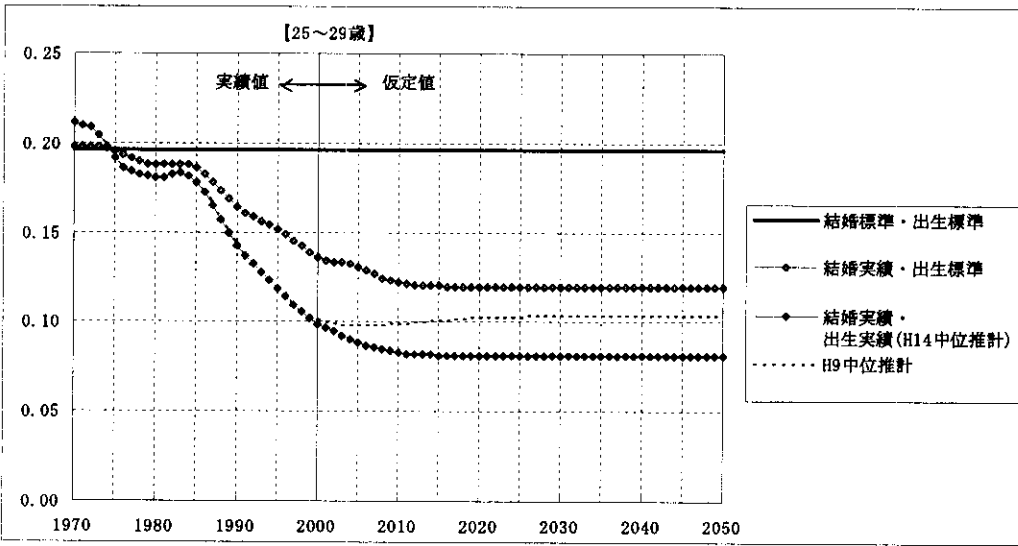
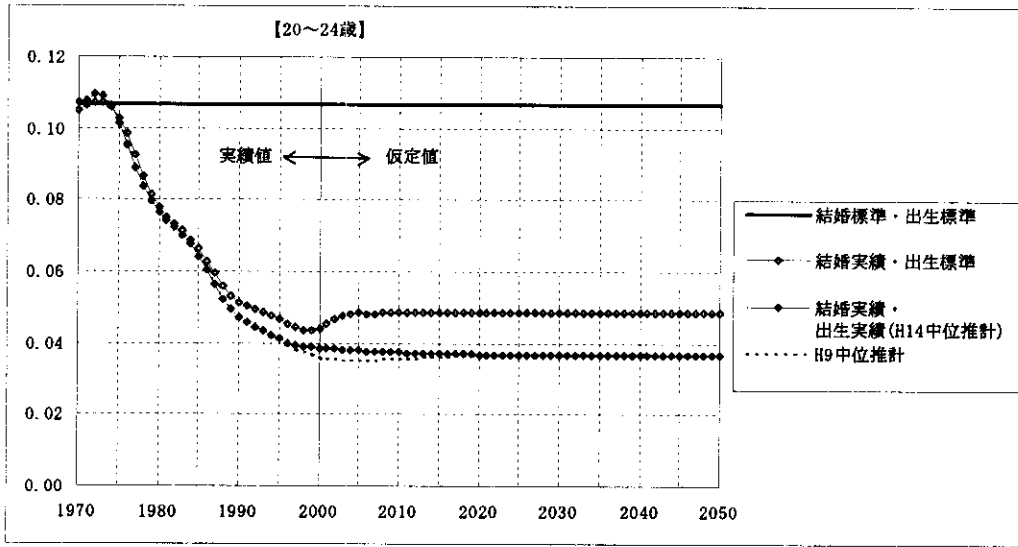
全体について見ると、1990年代に入り、徐々に夫婦の出生行動の変化が顕著になっているのがわかる。2000年時点では、結婚と夫婦出生行動の標準パターンに基づく出生率と実績

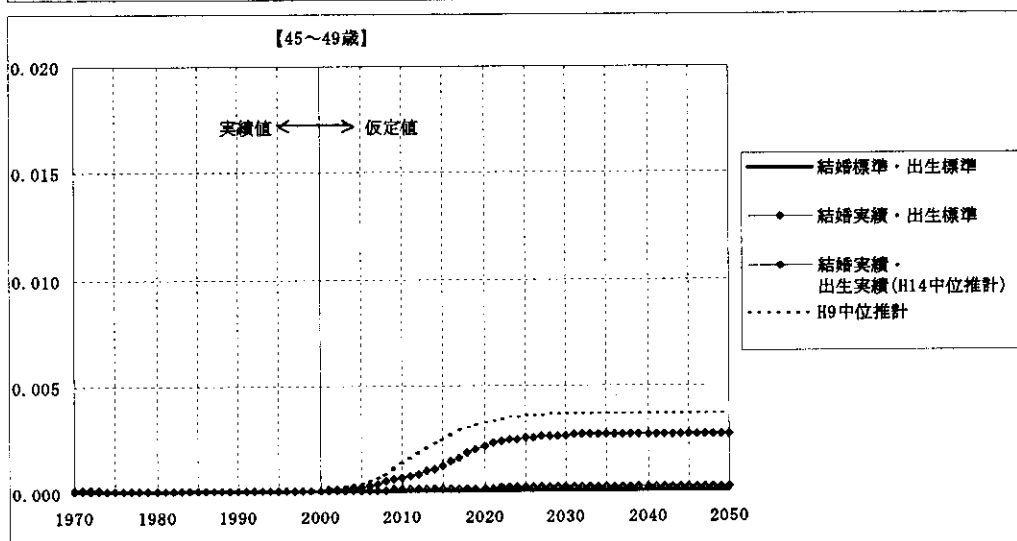
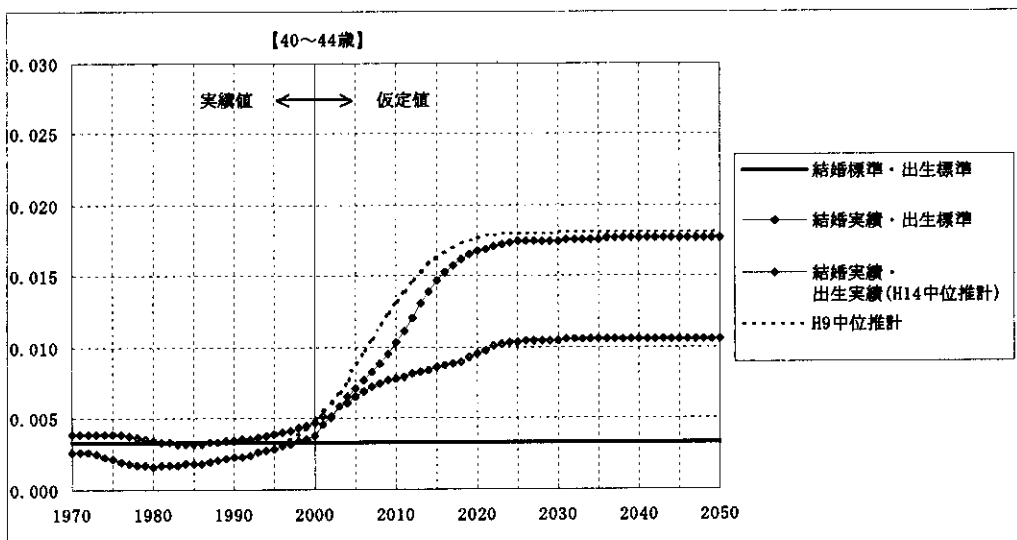
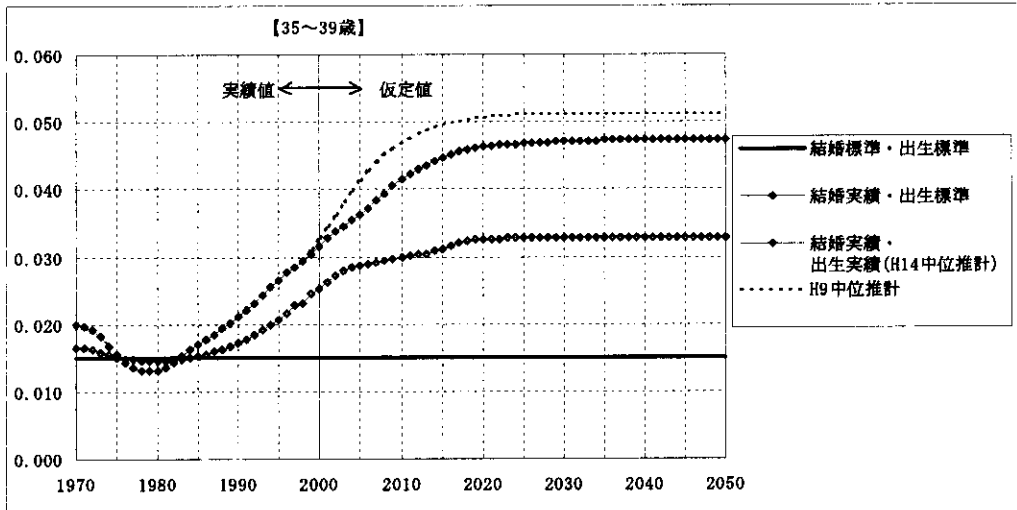
値との差のうち、7割が結婚行動の変化、3割が夫婦の出生行動の変化によって説明できそうである。2000年以降は推計人口の中位仮定にもとづく値であるが、この結果に従うと、最終的にも夫婦の出生行動変化の効果が2割程度ということになる。夫婦の行動変化には、最終的な子ども数の低下のみならず、タイミングの遅延効果も含まれている。出生過程の途上にある世代が関わる出生率については、両者の効果を区別できないが、2000前後の出生率は、タイミングの遅れによる変動（いわゆる tempo 効果）がある程度存在すると考えられる。

図12 期間合計特殊出生率の比較：
全年齢および年齢5歳階級別出生率

結婚標準…1940～1951年出生コーホート 出生標準…1932～1957年出生コーホート







次に年齢別に見てみよう。まず、10代については、結婚が従来に比べて発生していないことがわかる。ところが、出生率の実績値は、ケース2（結婚実績・出生標準）の結果を上回るのみならず、ケース1（結婚標準・出生標準）の結果をも、2000年で上回っている。

これは、10代については、従来よりも結婚後の出生の累積ペースが速いことを意味するが、これらの多くが10代で増加の著しい婚前妊娠結婚および婚外子の影響であると考えられる。20代前半については、1990年に入ってから、夫婦の出生行動変化（ペースの遅れ）の影響がわずかにみられる。最も夫婦出生行動の変化が出生率低下に効いているのが20代後半である。この年齢層における出生率低下の4割程度が夫婦の結婚後の出生行動が低迷していることによって説明できることがわかる。2000年以降もこの乖離が続くことから、平成14年中位推計は、20代後半において夫婦が以前のように結婚後すぐに子どもを持たない傾向が、今後も続くことを想定していることがわかる。

一方30代前半の動きは多少複雑である。1980年代を通じて、以前よりも出生率が高いが、このほとんどが結婚行動の変化、すなわち晩婚化によって出生タイミングが遅くなったことによって説明ができるが、1990年代半ば以降、結婚変化のみによって期待される出生率を実績が下回っていることがわかる。これは20代の晩婚化による遅れが、必ずしも30代前半で取り戻されていないことを示唆するものである。ただし30代後半については夫婦の出生行動変化が出生率に正の影響を与えていた。控えられていた出生が多少取り戻されている結果かもしれない。

3節 結論

本稿では年齢別初婚率から発生する有配偶女性が、初婚年齢に依存する年齢別出生率にしたがって子どもを生むという行動モデルを考えた。出生動向基本調査によって行動パターンが安定していた世代を特定し、その平均的な年齢別初婚率（1940～51年出生コーホート）と、初婚年齢別各年齢時の出生率（1932年～57年出生コーホート）を求め、標準パターンとしてモデル化した。標準パターンに従った場合に期待される年次出生率と実際の年次出生率の差は、結婚行動あるいは夫婦の出生行動の基準世代からの変化を意味する。そこで、結婚・夫婦出生とも標準パターンに従った場合、結婚のみ実績に従った場合、結婚も夫婦出生も実績に従った場合の年次出生率を比較した。その結果、1990年代に入るまでの年次期間出生率の低下のほとんどは結婚行動の変化によって説明できたが、90年代に入り、徐々に夫婦の出生行動が従来のパターンと変化し、その影響が年次出生率を低下させていることがわかった。1990年代半ば以降も、夫婦の出生行動変化の影響は続いていることから、このような変化は、夫婦の一時的な生み控えではなく、最終的な夫婦完結出生児数を低下させる可能性が濃厚となっている。1990年代から夫婦の子どもの生み方に変化が起きていることはすでに指摘されており（佐々井,1998;小川,2000;廣嶋,2000など）、本稿での結果もこれらを追認するものではあるが、現在の40代後半の女性の結婚や出生行動を基準とした場合に、現在の出生率低下分の7割が結婚行動の変化、3割が夫婦の出生行動変化ということとなる。また、平成14年推計人口の仮定値を用いて同様の分析をした場合、最終的に低下分の2割が夫婦の出生行動変化によって説明できることになる。夫婦の出生行動変化という新たな局面对して、新たな分析枠組みや政策立案が求められることになろう。

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6. ESTIMATION OF UNINTENDED FERTILITY IN JAPAN

Miho Iwasawa

1. Introduction

The number of births that occur in one-year period is a portion of the pregnancy outcomes for a given period. Some of these pregnancies are welcomed, and some of them may be unintentional. Furthermore, even if the birth of a child is desired, cases of non-pregnancy are obviously not included. In modern society, fundamentally, the decision to have or not have children is made by the individual or couple, but observations of actual reproductive behavior include unintended pregnancy and infertility other than intended pregnancies and intended contraception. Changes in fertility are not only based on changes in the intent of the individual or couple (for example, changes in the planned number of children); there is also a large effect from the incidence of those unintended results. In fact, the drop in fertility in UK from the 1960s into the 1970s is reported to have been caused by a reduction in unwanted pregnancies as a result of the widespread acceptance and use of modern methods of contraception and sterilization (Murphy 1993).

One method that can be used to analyze this is to gain some understanding by classifying the number of pregnancies and deliveries within a certain period according to fertility intentions and contraceptive behavior. In this study the reproductive behavior of females of reproductive age (20 - 44 years) as indicated by the data from a nationally representative survey, and the number of deliveries and induced abortions obtained from official statistics (vital statistics and abortion and sterilization statistics) were used to attempt to create a model of the process of conception. The model was then applied to estimate the number of unintended pregnancies and unintended births.

For this study, pregnancy occurring when there was a desire for additional children as soon as possible is called "intended pregnancy". Pregnancy occurring when there was no desire for additional childbearing is called "unwanted pregnancy", and pregnancy occurring when additional children were desired, but at a later time is called "mistimed pregnancy". Both of these latter two cases are included in the category called "unintended pregnancy".

2. Prior Research and Models of Pregnancy and Childbirth

The pregnancy or childbearing trends in a given region can be grasped to a certain degree from the statistics on live births and stillbirths for that region. However, the changes apparent from this kind of macro viewpoint only reveal the totalized effect of all the various factors influencing fertility. In order to interpret changes in fertility it is necessary to specify the details of these factors as well as their influences on fertility. Fortunately, since the 1950s there have been many fertility models presented. Initially, Davis and Blake (1956) classified the groups of demographic factors regulating fertility using a concept of intermediate fertility variables. The reproductive process was broken up into stages of (1) intercourse, (2) conception, and (3) gestation and parturition. The factors related to (1) were given as marriage and frequency of sexual intercourse;

those related to (2) were fecundity, contraception and sterilization; while the factors related to (3) were assumed to be fetal losses and induced abortion. Applying this concept made it possible to establish a framework for analysis and define fertility within the context of biological factors and socio-economic factors.

John Bongaarts presented an analytic framework that focused on the relationship between the theoretical maximum fertility and fertility control behaviors (Bongaarts 1978). Bongaarts' model uses (1) marriage, (2) contraception, (3) induced abortion, (4) post-partum infecundability (usually temporary sterility due to breastfeeding) as the basic variables regulating the theoretical maximum fertility. Since all of these variables can be quantified, this approach has been used for many fertility studies. It has been pointed out that there are some problems regarding the statistical precision of the factor analysis using the Bongaarts method, but the basic concepts concerning fertility control results are still valid today.¹

This study focuses on reproductive intent, while using these fertility analytic frameworks as a basis. From various survey data, we can clarify that the occurrence of unintended pregnancy and unintended births is not inconsiderable even in developed nations (Drife 1993; Forrest 1994; AGI 1995). From the perspective of reproductive health and rights as well, it is important to gain an accurate understanding of the pregnancy and childbearing trends that are contrary to reproductive intent.

There have been studies of reproductive intent and fertility control behaviors using large amounts of data in Japan as well (Atoh 1982; Sato and Iwasawa 1998). However, these studies have targeted only married couples, and do not include the pregnancies of unmarried women. Today, as a result of the increase of the number of sexually active singles, and a trend toward later marriage, there is also an increase in the size of this segment; so, it is necessary to clarify the actual circumstances of pregnancy including unmarried women. In recent years, basic surveys of fertility trends (conducted by the National Institute of Population and Social Security Research 1999), public opinion surveys on national family planning (PPRC 2000), and investigations of the sexual behavior of teens and young adults (JASE 2000) have made it possible to gain some understanding of the sexual behavior and contraception practices of unmarried persons, as well as their experience with induced abortion. However, with respect to the relationship to the incidence of births in Japan as a whole, a clear explanation of effects for these behaviors has not yet been fully clarified.

On the other hand, there have been efforts to estimate the number of unwanted pregnancies in Japan as a whole using the number of children conceived or born prior to registration of a marriage, the number born to unmarried women, and the number of abandoned children (Noda 1995). There are many questionable points regarding the understanding provided from these statistics alone, so it is difficult to draw reliable conclusions.

Therefore, this study uses all females of reproductive age as subjects and attempts to estimate the percentages and numbers of occurrences of unintended pregnancies and deliveries in a one-year period, based on data from the Japanese National Fertility Survey (National Institute of Population and Social Security Research

¹ Refer to Sato (1992) regarding details of the historical development of these analysis methods.

1997) and official government statistics. The model of this study refers to the model developed by Dalla Zuanna *et al.* (1998) for the Puglia region of southern Italy with a population of 4,000,000 (hereafter called the "Italian model"), and some modifications were made for the estimations.

3. Models

3.1 Outline of the Italian Model

The Italian model of Dalla Zuanna *et al.* presents the incidence of pregnancy and the outcomes for a one-year period for all females of reproductive age (15 – 44 years) in 1989. This model incorporates the variables described below.

First, all females were classified as either married or unmarried, and the married women were further classified according to whether they regularly have sexual relations. The group that did engage in sex regularly was further divided into one of the following categories; "currently pregnant", "do not currently want children", or "currently want a child". However, there was no direct inquiry regarding the reproductive intention, instead the classification of "do not currently want a child" was made for those who were practicing contraception, while those who used no form of contraception were classified as "currently want a child". Yet, there are probably more than a few cases in which pregnancy is not welcome, even though contraception is not being used (unmet needs), so it is important to be aware of the possibility that the Italian model underestimates the number of unintended pregnancies. If it is possible, it is probably desirable for a model to separate the actual practice of contraception from the measurement of reproductive intent.

The unmarried women in the Italian model are also subdivided according to whether they regularly engage in sexual activities. The regularly active group was further classified as either "currently pregnant" or "do not currently want a child". In Italy, cohabitation and childbearing outside of marriage are not common, so it was assumed that there would be no unmarried women in the category of "currently want a child".

With regard to pregnancy outcomes, the categories for the married women were "induced abortion", "fetal loss", "unintended birth", and "intended birth". For the unmarried women the outcomes were "induced abortion", "fetal loss", and "unintended birth".

3.2 Model of This Study

Figure 1 shows the model for this study. The points that differ in this model in comparison to the Italian model are that there is no variable for "married/unmarried" and none indicating whether the individual regularly engages in sexual activities. For this study all women were classified according to whether they currently were involved with a partner. The classification of "have an intimate partner" was based on a woman currently having an intimate partner, such as a lover or husband, and also that they had prior experience with sexual intercourse. It is possible that there will be cases of single women who currently do not have a partner becoming pregnant, but this is assumed to be a small number, with little effect on the model

as a whole².

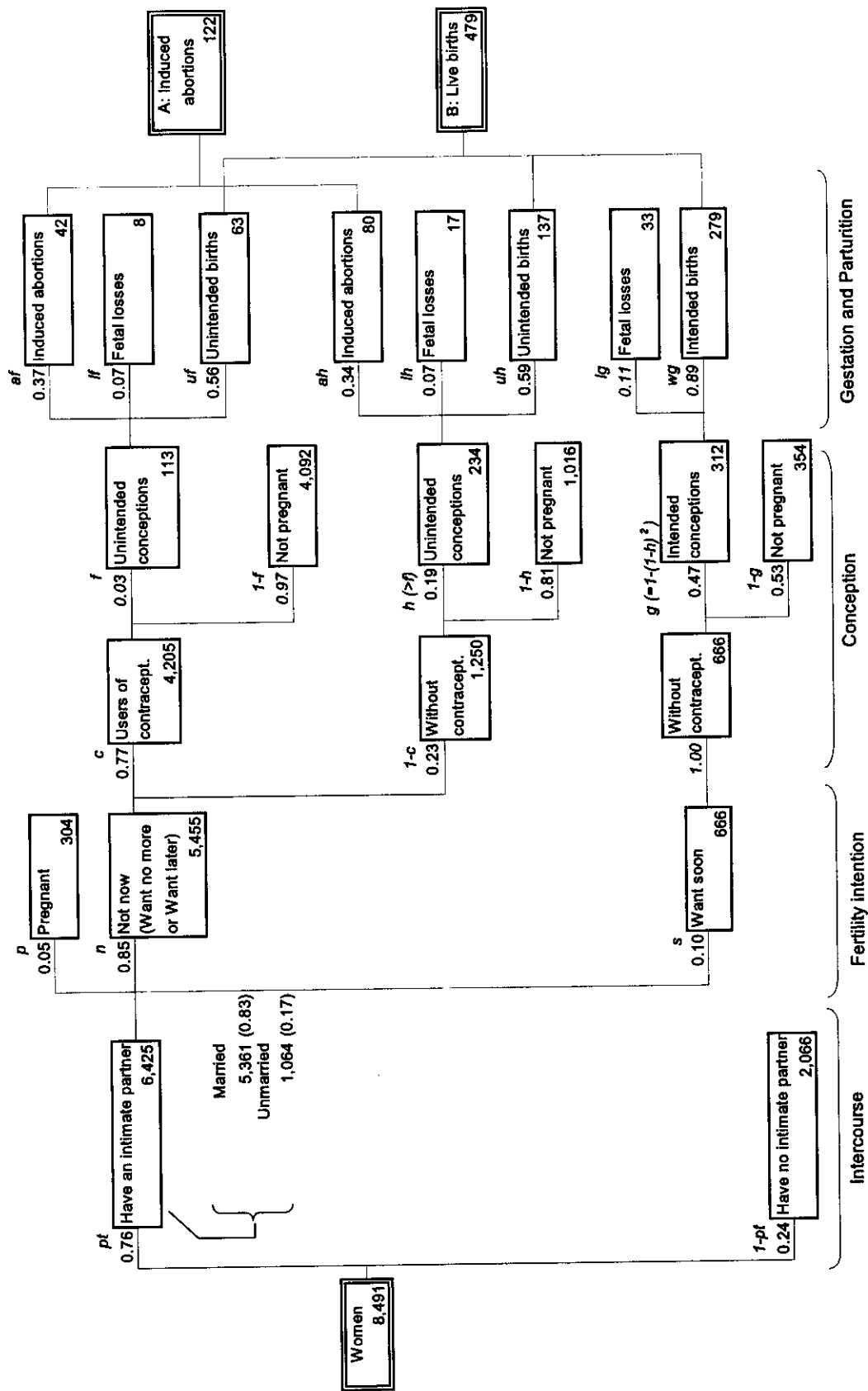
In addition, "reproductive intention" and "contraceptive practices", which do not appear in the Italian model, are added for this study. The group that has partners is further divided according to three classifications of reproductive intention. The first sub-group is women who are already pregnant. For this group, if there was a delivery, it can be assumed that there is a low probability of a new pregnancy within the study period due to the period of post-partum infertility. The next group is the "not now" group, consisting of those who do not currently wish to become pregnant. This group includes both women who intend to permanently suppress childbearing (intent to stop childbearing) as well as those who do desire children, but at a later time (delayed childbearing intent). The final "want soon" group consists of those who want a first or additional child in the immediate future.

For the "want soon" group there is no use of contraception, and the results are "intended conceptions (pregnancies)" and "not pregnant". For an intended pregnancy the possible outcomes are "fetal loss (stillbirth, miscarriage)", and "intended birth". For the "want soon" group it is assumed that there are no induced abortions. The "not now" group is sorted into a "users of contraception" group and a "without contraception" group. Even in the group employing methods of contraception, there can be cases of pregnancy when contraception fails (unintended conceptions). There will also be cases in which pregnancy is avoided, as intended. For this group, in the case of pregnancy, the possible outcomes include "induced abortion" in addition to the "fetal loss" and "unintended birth". The same outcomes are possible for the group that is not using contraception.

Both the Italian model and the Japanese model in this study assume that individuals who either deliver a child, have an induced abortion, or experience a fetal loss within the one year period are subsequently excluded from the incidence of pregnancy model. In other words, these models do not consider a second pregnancy by the same person within the target period. Considering the period of gestation, a single instance of induced abortion does not necessarily mean the avoidance of a single delivery (Kono 1983). However, it

² According to 'the Survey on Sexual behavior, Pregnancy, Contraception and Childbearing' conducted by Kitamura in 1994 and 1995, among the partners of women who became pregnant at the age of 21, 54 percent was a friend or a lover, 32 percent was a husband, 11 percent was a fiancé, and other relationship such as a colleague, an acquaintance or a relative was below 5 percent. Additionally, 74 percent agree that 'premarital intercourse is acceptable, if there is love or two of them are engaged,' while only 14 percent agree that 'if there is agreement, premarital intercourse without love is acceptable' (Kitamura 1996). From these results, we can assume that most of pregnancies were experienced by women who have intimate partners such as a husband or a lover.

is assumed that in contemporary Italy and Japan there are few instances in which pregnancy is desired immediately after the completion/termination of a prior pregnancy. Since it is also fairly common for physicians to recommend waiting for a certain time between pregnancies (Dalla Zuanna *et al.* 1998), there are only a very few repeat pregnancies, and it is assumed that there will be almost no error as a result of ignoring such cases.



Note: For 8,491 women aged 20 - 44 who are respondents of the JNFS conducted in June 1997. Data on partnerships, fertility intentions and contraceptive use are taken from the JNFS, and data on the number of induced abortions and live births are taken from the statistics of abortions and sterilizations (1997,1998) and vital statistics of Japan(1998), respectively.

FIG. 1. Estimated number of conceptions by outcome during a year among Japanese women of reproductive ages in 1997

4. Data

Basically, panel data is required in order to retrieve this kind of model completely from the data. It is possible to obtain consistent data at the individual level regarding the attitudes toward reproductive behavior and childbearing for a given period, whether pregnancy later occurred, and what was the outcome of the pregnancy. Unfortunately, at the present time there is no panel data in Japan that allows this kind of information to be obtained. Even if we can obtain it, usually in the survey using direct questioning technique, the incidence of induced abortions or fatal losses tends to be underreported (Rossier 2001). Furthermore, originally unintended childbirths might be recognized as intended ones later to avoid the cognitive dissonance. These problems can be overcome by using sampling surveys only to evaluate reproductive intent and reproduction control behaviors, and officially released data to know pregnancy outcomes. In this case, we need to estimate some parameters that connect the results from the different sources. The following sections will explain the specific details of the variables, the calculation methods of the parameters pt , p , n , s , c , f , h , g , af , lf , uf , ah , lh , uh , lg , and wg in figure 1, as well as how the parameters were fixed and constrained.

4.1 Current State of Reproductive Behavior

The actual circumstances of reproductive behavior of females of reproductive age were obtained from the 11th Japanese National Fertility Survey conducted in June 1997 (National Institute of Population and Social Security Research 1998, 1999). This survey included surveys of married couples as well as unmarried individuals.

The survey of married couples contained a question about whether they planned to have children in the future. If the couple did have such intent, they were asked about the planned time of the next birth, and about their current use of contraception. If contraceptive methods were being employed, they were asked to specify the method. For past pregnancies, since the planned delivery prior to pregnancy, contraception usage, success of contraception, and pregnancy outcome were known for each pregnancy sequence, it was possible to use some of this data for the parameters related to contraceptive results and pregnancy outcomes.

The survey of unmarried people included questions about whether they had a sexual partner, whether they had any sexual experience, and their contraceptive use for the most recent instance of sexual intercourse.

For pt , "have an intimate partner", it was possible to determine the proportion of the total female population because the number of women with spouses as well as the number of single women who were sexually experienced and currently had a lover (fiancé) were known.

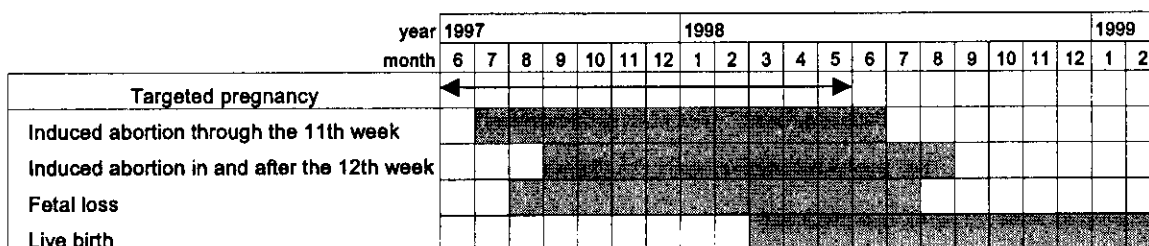
The number of females in the "currently pregnant" group was estimated as follows. First, the number of married women who were pregnant at the time of the survey was obtained from the couple survey. Since it is possible that there were women who were actually pregnant at that time, but had not yet realized it, only the answers of those who were at least four months pregnant were considered. For the unmarried women, there was no question on the survey for single people asking whether they were currently pregnant, so it is not possible to obtain a number directly. As described in detail later, the total number of pregnancies for

the one-year period was deduced from the number of births, number of fetal losses and number of induced abortions. Using this total, the number of pregnancies of at least four months duration at the time of the survey was calculated (determined to be 6/9 of the total number of pregnancies). The number of four-month or longer pregnancies reported in the couple survey was subtracted from the calculated total to obtain the number of unmarried women who were pregnant. The parameter p was determined from knowing the total number of females who were pregnant (and aware of the fact) at the time of the survey.

The married women who responded "do not intend to have any more children" or "intend to have a child later" to the question about their current reproductive intentions were included in the "not now" group. In the same way as in Italy, there are few cases of cohabitation and childbearing outside of marriage in Japan, so it was assumed that all single women who had partners and were not currently pregnant were in the "not now" group. The "want now" group consisted of married women who answered "as soon as possible" to the question on the planned timing for the delivery of the next child.³ In this way, n and s were determined.

With regard to the contraceptive usage, it was possible to obtain data for the married couples from the answers to direct questions about whether contraceptive methods were currently being used. For the unmarried women, contraception practices were estimated according to the answer to questioning about the use of contraception during the most recent instance of sexual intercourse. In this way, c was determined.

FIG.2. Main period in which pregnancy outcomes occurred



4.2 Pregnancy Outcomes

The Japanese National Fertility Survey, from which the data on reproductive behavior was acquired, was conducted so as to obtain the information current as of June 1, 1997. Accordingly, the constructed model is for the pregnancies that occurred in the one-year period from June 1997 through May 1998. There are

³ One of the response choices for the question on the planned time of delivery of the next child was "haven't really thought about it". For this study, those that chose "haven't really thought about it" were placed in the "not now" group if they were currently using a form of contraception, and placed in the "want now" group if they were not practicing contraception.

three defined pregnancy outcomes; fetal loss, induced abortion, and live birth.⁴ Figure 2 shows a diagram for the main period in which these outcomes occurred. First, for the live births, based on the fact that the term of pregnancy is 40 weeks, the target group should include births between March 1998 and February 1999. It is possible to obtain the number of births from vital statistics, but due to restrictions on publicly released data, for this study, the number of births in 1998 was used.

With regard to the induced abortions, we can use the number of artificially aborted pregnancies from the vital statistics for procedures performed in and after the 12th week of pregnancy. The number of induced abortions performed through the 11th week of pregnancy can be obtained from *Maternal Body Protection Statistics Report*. Based on the pregnancy history data from the Japanese National Fertility Survey, the average time at which an induced abortion is performed is 2.6 months into the pregnancy, with 90 percent of all induced abortions performed in the second or third month of the pregnancy. Therefore, most of the abortions for pregnancies occurring in the one-year period beginning in June 1997 can be expected to occur between August 1997 and July 1998. For this study, the total number of induced abortions for pregnancies in and after the 12th week for a one-year period in 1998 was used. The total number of induced abortions for pregnancies through the 11th week was obtained by adding half of the total number in 1997 and half of the total for 1998. It has been pointed out that the reported number of induced abortions may be significantly lower than the actual number performed (Matsuyama 1988; Sato 1995). However, since there are difficulties in making an accurate estimate of the actual number, the reported number is used for this basic model.

There are two main reasons that it is difficult to obtain the actual number of fetal losses. For fetal losses occurring in pregnancies of 12 weeks or longer, it is possible to use the data on spontaneous abortions in the vital statistics. For pregnancies of 11 weeks or less, however, there are no statistics of any kind on fetal losses. In addition, these are also fetal losses in early stages of pregnancies, before even the mother herself is aware of it. In other words, obtaining an accurate measure of fetal losses leads to an involvement in the issue of the definition of "pregnant". Therefore, for the purposes of this study, "pregnant" is defined as the stage at which the mother is aware of the pregnancy⁵. Accordingly, the number of fetal losses was determined as follows. It is possible to determine the breakdown of pregnancy outcomes, that is, the proportions of live births and stillbirths or miscarriages, from the pregnancy history data of the Japanese National Fertility Survey. Using these percentages, the number of fetal losses relative to the number of live births can be estimated. The

⁴ Actually, since there are cases of multiple births, it is estimated that the actual number of pregnancies is somewhat lower than the total number of pregnancy outcomes. This study uses a model that does not account for multiple births, although it has been pointed out that the incidence of multiple births has been increasing since the 1980s (Imaizumi (1998)). Adjustment for multiple births is one of the important issues for future work on this model.

⁵ Golden and Millman (1993) classified pregnancies into three categories for their measurements of fertility. (1) All pregnancies that occurred within the period of the usual menstrual cycle, including miscarriages during that cycle. (2) Pregnancies that can be recognized at the very end of a menstrual cycle because menses does not occur. (3) Pregnancies that result in births. According to these definitions, this study uses definition (2).

pregnancy history data was only obtained in the survey of married couples, but there is probably no difference between married and unmarried women with respect to the proportions of live births, stillbirths, and miscarriages. The percentages of stillbirths and miscarriages obtained from the survey data correspond to lg and wg in this model. Table 1 shows the estimated values obtained from the survey data. The relationships between lf and uf , as well as between lh and uh are also based on these proportions.

In this way, it is possible to obtain the number of live births, the number of induced abortions, and the number of fetal losses for the pregnancy outcomes. Table 2 summarizes the data used for the pregnancy outcomes. Assuming that these results occurred in accordance with this model, it is possible to obtain the estimates of the number of pregnancies and numbers of each possible pregnancy outcome according to the reproductive intent. For the estimation of the parameters, the probability of an induced abortion for the group practicing contraception and for the group not practicing contraception was assumed to be the same; in other words, it was assumed that af and ah were equal. Accordingly, lf and lh are equal, and uf and uh are equal.

TABLE.1. Parameters for probability of fetal loss and contraceptive failure

	20-24	25-29	30-34	35-39	40-44
Fetal loss(lg)	0.083	0.087	0.118	0.186	0.171
Intended birth(wg)	0.917	0.914	0.882	0.814	0.829
Unintended conception (Contraceptive failure rates)(f)	0.050	0.040	0.030	0.020	0.010

TABLE.2. Statistics on pregnancy outcome

Live birth	The number of live birth for one year based on <i>Vital Statistics</i> of 1998
Induced abortion	(1)The number of induced abortion performed through the 11th week based on <i>Maternal Body Protection Statistics Report</i> of 1997 $\times 1/2$ (2)The number of induced abortion performed through the 11th week based on <i>Maternal Body Protection Statistics Report</i> of 1998 $\times 1/2$ (3)The number of induced abortion performed in and after 12th week based on <i>Vital Statistics</i> of 1998 Total number of induced abortion = (1)+(2)+(3)
Fetal loss	The number of live births in 1998 \times effect coefficient for fetal loss* * Ratio of stillbirths or miscarriages to live births calculated from pregnancy history data of the JNFS.

TABLE 3. Contraceptive failure rates
(one-year use)

	USA ¹⁾ 1970	USA ²⁾ 1982	Italy ³⁾ 1989
Pill	0.02	0.01	0.01
IUD	0.04	0.07	0.03
Condom	0.09	0.02	0.06
Sterilization	0.00	0.00	-
Spermicides	0.13	-	-
Diaphr.	0.12	-	0.08
Rhythm/PA	0.18	-	0.10
Withdrawal	-	-	0.10
Others	0.10	0.08	-

1)Bongaarts(1978).

2)Westoff *et al.* (1987). For white married women who wanted no more child.

3)Dalla Zuanna(1998). For married women aged 25~34.

TABLE 4. Method of contraception

	USA ¹⁾ 1995	Italy ²⁾ 1989	Japan ³⁾ 1997
Pill	26.9 %	21.3 %	0.7 %
IUD	0.8	13.8	2.4
Condom	20.4	12.6	74.5
Sterilization	38.6	-	3.9
Spermicides	0.0	-	0.7
Diaphr.	1.9	0.5	0.0
Rhythm/PA	2.3	8.9	1.9
Withdrawal	3.1	42.8	13.0
Others	5.9	-	2.8

1)NCHS(1997). For 15~44 aged women.

2)Dalla Zuanna(1998). For 25~34 aged married women.

3)JNFS(1997). For 20~44 aged married women. For the most effective method.

4.3 Specification of other Parameters and Constraints

At this point, the parameters that have not yet been fixed are f , h , g , and af . Since f is the probability of becoming pregnant even though contraception is being used, it corresponds to the contraception failure rate. This value is fixed for each age group.

The rate of contraception failure for different methods of contraception has been investigated in prior studies (Bongaarts 1978; Westoff *et al.* 1987). Table 3 contains the results of the prior studies on contraception failure rates. It has also been reported that contraceptive failure decreases as age and experience increases (Dalla Zuanna *et al.* (1998). In Japan, the main form of contraception is the use of condoms (Table 4). In light of this, and the fact that those practicing contraception include unmarried people who are not cohabitating with a partner, for this study the assumptions are as shown in Table 1.

There are also several constraints on the estimated parameters. Since all the parameters represent probabilities, the values must be between 0.0 and 1.0, and the sum of the parameters for all the subdivisions of a group must equal 1.0. In addition, it is assumed that $f < h < g$. The reason that $f < h$ is to reflect the contraceptive efficiency. $h < g$ is used because it is assumed that among those who do not use contraception there will be a difference in the frequency of intercourse according to the reproductive intention. In addition, the "want now" group is entirely composed of married women, while the "not now" group includes single women who are not cohabitating with a partner. The frequency of sexual intercourse by single women and married women has been reported to differ by a factor of two or more by researchers in the United States (Weinstein *et al.* 1993). In Japan, according to the Japanese General Social Survey(JGSS) conducted in 2000,

the average frequency of intercourse per month of married women was generally 50 percent more than that of unmarried women of the same age who had sex over the past year at least once. ⁶

So the following constraint for g and h is specified; $(1-g)=(1-h)^\alpha$, and estimates were made under three hypotheses of $\alpha = 1, \alpha = 2, \alpha = 4$. For $\alpha = 1, g = h$. This assumes that in the same age group, there is no difference in the frequency of intercourse and rate of pregnancy between the "not now" group that includes the single women and the "want now" group consisting entirely of married women, but this is not actually the case. Furthermore, if h is significantly smaller than g , there is effectively no difference between f and h , indicating that contraceptive efficiency is not considerable, which is also not consistent with reality. The results described below, unless stated otherwise, use $\alpha = 2$. Pregnancy outcomes can be formularized as follows using these parameters.

For a female population P , the total number of induced abortions A is,

$$A = P \times (pt \times n \times c \times f \times af + pt \times n \times (1-c) \times h \times ah), \quad (1)$$

Total number of births B is,

$$B = P \times (pt \times n \times c \times f \times uf + pt \times n \times (1-c) \times h \times uh + pt \times s \times g \times wg), \quad (2)$$

The constraint conditions are

$$af = ah, \quad (3)$$

$$lf = lh, \quad (4)$$

$$uf = uh, \quad (5)$$

$$af + lf + uf = 1, \quad (6)$$

$$lf = \frac{lg \times uf}{wg}, \quad (7)$$

$$(1-g) = (1-h)^\alpha, \quad (8)$$

The total number of abortions, A , and the number of live births, B , was obtained from official data as described previously. Inserting the values calculated from the survey data for the fixed parameters pt, p, n, s , and c , as well as the hypothetical values for f, lg , and wg , it is possible to determine values for the unknowns af and h that satisfy the relationship given above. Three values of 1, 2 and 4 were used for α , which determined the relationship between g and h .

⁶ JGSS(2000). Shinji Anzo, personal communication.