Fertility Level, Changing Trends and Possible Relaxation of the One-Child Policy in China

Abstract

Age-specific fertility rates in China decrease from 1990 to 2000. From 2000 onward, these rates for first-born babies increase everywhere and at all ages except for women under 27 in cities, under 26 in towns, and under 25 in counties (rural villages, excluding towns) because young people marry late. For second and above babies, fertility rates have also increased, exceeding the limits set by the one-child policy. Comparisons of the predicted age-specific rates for 2009 and the observed rates from an annual survey of the 0.1% of the entire population in 2009 validate the conclusions on the assessments of the fertility level and the changing trends. Based on the estimated age-specific fertility rates over years and current women's age distribution, China is supposed to be experiencing a peak or peaks of new born babies, and it is not a good timing to relax the one-child policy right now.

KEY WORDS: age-specific fertility, cubic spline, Lee-Carter model, logistic regression model, period total fertility rate, one-child policy

1. Introduction

Fertility in China is affected by the government's one-child policy, which is one for women with non-agriculture household registration, 1.5 children for women with agriculture household registration, and 2+ children for ethnic minorities. The policy was launched in 1979 when the country counted a quarter of the world's population. In 2011, though the population is still increasing, it represents one fifth of the world's population.

Hesketh, Lu, and Xing (2005) and Wang (2005) review the implementation and the consequences of the policy regarding the decreasing TFRs, unbalanced sex ratio, the growing proportion of elderly people, and the increasing ratio between elderly parents and adult children. Hesketh, Lu, and Xing (2005) and Greenhalgh and Bongaarts (1987) suggested that everyone could be allowed to have up to two children, with a birth space of at least five years. Wang (2005) suggested an immediate change of the policy.

We shall assess the age-specific fertility rates and the TFR over years in China. The data are from the China Population Statistics Yearbooks (National Bureau of Statistics of China 1988-2009) and The Fifth Population Census Data (National Bureau of Statistics of China 2000), and the model is a modified Lee-Carter model (Zhao 2011).

2. Fertility Level and Changing Trend in China

2.1 **Fertility Data in China**

In recent years in China, censuses were carried out in 1982, 1990, 2000, and 2010, surveys of about 1% of the entire population were conducted in 1987, 1995, and 2005, and smaller surveys of about 0.1% of the entire population were conducted in the rest of the years. The China Population Statistics Yearbooks (National Bureau of Statistics of China 1988-2009) and The Fifth Population Census Data (National Bureau of Statistics of China 2001) contain valid age-specific and birth order-specific fertility data of four groups of women, the country, cities, towns, and counties for 1987, 1990, 1995, 1997, and 1999-2008, where the three no overlapping groups: cities, towns, and counties(rural villages, excluding towns), make up the country. Birth order in the original data contains four categories, all babies, first-born babies, second babies, and third and above babies. In this study, the data for second babies and third and above babies are put in one group, the second and above babies. There are 35 age groups for women of ages between 15 and 49, and we use the middle point of an age period to represent the age of the group. For instance, 15.5 is used to represent the age of the group of women between 15 and 16.

The data for 1996 and 1998 are dropped, as the data for 1996 are in 5-age groups and the numbers of babies born in 1998 in cities, towns and counties do not add up to the numbers in the country where the number for cities and towns are recorded as the same for all ages and birth orders by mistake. Besides the number of babies, we have also added up the average numbers of women in cities, towns, and counties, and have checked if they match the corresponding numbers in the country. The data for 2009 were not available when we started the analysis; the census data for 2010 are not

available yet.

Overall, there are 12 subsets of data, three birth orders (all babies, first-born babies, and second and above babies) for each of the four groups of women (the country, cities, towns, and counties). In each subset, the average number of women aged x in year t and the number of babies these women give birth to can be written as $(n(t,x),d(t,x))$.

For all babies in the country, the observed age-specific fertility rates $d(t,x)/n(t,x)$ for the major years, 1987, 1990, 1995, 2000 and 2005 are shown in Figure 1. For each age group, over the years, the fertility rate reaches its peak and dip in 1990 and 2000, respectively, except for women of ages between 23.5 and 25.5, for which the lowest fertility rates are achieved in 2005. The peak in 1990 reflects the phenomenon of the so called “extra-birth guerrilla” era in China, during which some families with daughters move secretly from place to place to escape the birth-control regulators hoping to produce a son. There is a dramatic drop in fertility after 1990, and the main reason is the promulgation of the “Provisional Regulations on the Enrollment of Tuition-paying Students in the Regular Higher Education Institutions” by the National Education Committee (1990), effective as of July 9, 1990, which made parents feel the financial pressure of raising a child. The higher education (four years college) used to be tuition free in China but was accessible only for the elite. Those students who did not have a chance to enter college before used to get married earlier and to give birth to babies. Attending college postponed their ages for having a baby. In addition, some of those who had paid tuition by themselves preferred the DINK

(Double Income No Kids) lifestyle after their graduation, which also contributes to the low fertility in the late 1990s.

The observed age-specific fertility rates *d(t,x)/n(t,x)* are good estimates of the true age-specific fertility rates for census years, but not for the survey years of the 0.1% or 1% of the entire population. Using the well-known Lee-Carter model (Lee and Carter 1992), Lee (1993) analyzed age-specific fertility in US. For the fertility data in China (2000-2008), we estimate the expected age-specific fertility rates using a modified Lee-Carter model (Zhao 2011).

2.2 Modeling Age-specific Fertility

For a fixed set of knots $\Omega_m = \{x_1, \cdots, x_m\}$, the general form of the modified Lee-Carter model is

$$\begin{aligned} \ln\left(\frac{p(t,x)}{1-p(t,x)}\right) &= \alpha_{00} + \alpha_{01}Z_{01}(x) + \alpha_{02}Z_{02}(x) + \alpha_0 Z_0(x) + \sum_{i=1}^{m}\{\alpha_i Z_i(x)\} \\ &+ \gamma Z(x) + \beta_{00}t + \beta_{01}tZ_{01}(x) + \beta_{02}tZ_{02}(x) + \beta_0 tZ_0(x) + \sum_{i=1}^{m}\{\beta_i tZ_i(x)\} \end{aligned} \quad (1)$$

where p(t,x) is the unknown fertility rate at age x and year t, and $\gamma, \alpha_{0j}, \beta_{0j}$,($j$=0,1,2), α_i , β_i $(i = 0,1,\ldots,m)$ are all unknown parameters; the functions of age, $Z_{01}(x), Z_{02}(x), Z_0(x), Z_1(x), \ldots, Z_m(x)$ are defined as (a1), (a2) and (a3) (see Appendix) for models with cubic, quadratic and linear functions above the last knot, respectively. $Z_0(x) = 0$ and $Z_{02}(x) = Z_0(x) = 0$ are defined for models with quadratic and linear restrictions below the first knot, respectively. For each of the nine scenarios of the linear, quadratic, and cubic restriction combinations at the two tails, model (1) is a logistic regression when fitted to annually collected binomial data

$(n(t,x),d(t,x))$.

For each of the 12 subsets of fertility data, following a two-step procedure, a final best model is selected. The procedure is: a. For a fixed scenario and a fixed number of knots *m*, an optimal set of knots that produces the smallest residual deviance is selected among all possible integer knots by running an optimal search program, and the model with the optimal knots is stored as a candidate for the final best model; b. Among all the candidates models, a model with relatively smaller residual deviance and smaller p values is chosen as the final best model. Note that using different model selection criteria, we may have different final best models, but the expected age-specific rates do not differ much.

Table 1 lists the final best model with the optimal knots, the scenario of restrictions at the tails, and the residual deviance for each of the 12 subsets. For example, the final model for all babies in the country is:

$$\ln\left(\frac{p(t,x)}{1-p(t,x)}\right) = 37.555 - 15.996Z_{01}(x) + 3.438Z_1(x) - 14.096Z_1(x) + 11.288Z_3(x)$$
$$(.049)\ (<.0001)\qquad (<.0001)\qquad (<.0001)\qquad (<.0001)$$
$$-1.991Z_4(x) + 3.365Z_5(x) - 0.023t + 0.009tZ_{01}(x) - 0.002tZ_1(x)$$
$$(<.0001)\qquad (<.0001)\qquad (.0151)\ (<.0001)\qquad (<.0001)$$
$$+ 0.007tZ_2(x) - 0.006tZ_3(x) + 0.001tZ_4(x) - 0.002tZ_5(x)$$
$$(<.0001)\qquad (<.0001)\qquad (<.0001)\qquad (<.0001)$$

Where $Z_{01}(x) = (x-15)_+$, $Z_1(x) = (x-21)_+^3 - (x-19)_+^3$, $Z_2(x) = (x-22)_+^3 - (x-21)_+^3$,

$Z_3(x) = (x-30)_+^3 - (x-22)_+^3$, $Z_4(x) = (x-32)_+^3 - (x-30)_+^3$, $Z_5(x) = (x-33)_+^3 - (x-32)_+^3$

and the values in the brackets below the estimates are the corresponding p-values.

For each of the three birth orders, all babies, first-born babies, and second and above babies, Figures 2-4 show the observed and fitted (2000, 2005 and 2008)

age-specific fertility rates for women in each of the four groups of people. In general, the observed and fitted rates fit each other well for years 2000 and 2005 - the year with a larger sample size plays a bigger role in estimating the unknown parameters in the model, but not so well for year 2008. It is worth noting that the so called observed rates are actually the estimates of the real rates except for census years, therefore the observed rates for 2008 and 2005 exhibit larger volatility than that for 2000.

In Figure2, there is a hump around 30 in each of the figures for the country, towns and counties, but not for cities, which reflect the special “1.5 children” policy for women holding an agricultural household registration, i.e., a second birth is allowed if the first child is a daughter over five years old. The women with “agricultural household registration” are in the group of towns or counties while none of them are in the group of cities by definition.

In Figure3, for first-born babies, the fertility reaches its peak at about age 23 for counties' group, 24 for towns' group and 25 for cities' group. Over the years, the fitted fertility increases for women over 28 in cities, over 26 in counties and over 27 in the country and towns, and decreases significantly for women ages 23.5-26.5 in the cities' group. For women under 26 in cities and under 25 in towns and counties, the observed rates are lower than the fitted values, a sign that the fertility rates might have reached their peaks in 2005.

In Figure4, for second and above babies, the observed and the fitted fertility rates fit each other well for towns, but not so well for cities, counties, and the country in 2008. The fertility reaches its peak at 30-31 for cities, 29-30 for towns, and 28-29 for

counties, which is a five-year shift from that of the first-born babies, and hence produces the humps around 30 for all babies as in Figure4, as the fertility rate for all babies is the sum of the fertility rates for first-born babies and second and above babies.

2.3 Period Total Fertility Rates

To avoid confusion, TFR1 and TFR2+ are used to denote the total first and second and higher fertility rates respectively, i.e., TFR is the sum of the corresponding TFR1 and TFR2+. The observed (2000-2008) and the fitted and predicted period total fertility rates over the years based on the final models listed in Table 1 are shown in Figure 5, where the fitted (2000-2008) and the predicted (2009-2010) rates are presented in lines.

For second and above babies, the observed and the fitted TFR2+s fit well for towns, but the fitted TFR2+s seem a little higher than the observed values for cities and counties after 2005. Examining the values of the observed TFR2+s, we find that in the most recent years, 2005-2008, the values are over 0.15 and 0.65 for cities and counties, respectively, which have exceeded the birth limits set by the one-child policy of one for cities and “1.5 children” for towns and counties. Though there are some rich people who prefer to pay the penalty to have a second baby, the number of such people is limited. The observed and the fitted TFR2+s for the towns' group are reaching 0.50.

For first-born babies, the observed and the fitted TFR1s fit well for all four groups

for 2000-2008. For towns and counties, the observed values are already beyond 1 in 2008, and there is not much space to grow.

For all babies, the observed and the fitted TFRs fit well for cities and towns, but the fitted TFRs appear higher than the observed TFRs for counties for 2007 and 2008, as both TFR1 and TFR2+ exceed the limits set by the one-child policy.

In the country, the observed and the fitted TFRs fit well for all the birth orders. The comparison of the observed and fitted total fertility rates provide a reason why the observed and fitted age-specific fertility rates do not match each other well for some of the subsets.

2.4 Predicted and Observed Age-specific Fertility Rates for 2009

The discrepancy between the observed and expected age-specific rates in 2008 indicates the existence of nonlinear change of fertility over period 2000-2008 and reflects the fact that data in 2000 and 2005 play larger roles in estimating the unknown parameters than that in 2008. For first-born babies and all babies, the fertility rates may have reached their peaks in 2005 for young women, which may be caused by the rebound after extreme low fertility around 2000 and the fact that young women tend to get married relatively late in the very recent years (Zhao, Hou, and Zhao 2011).

Because of the delay, we can re-estimate the age specific rates based on the 2005-2008 data. For example, in the country, a final best model is chosen using the two-step procedure, and the observed and fitted age-specific rates for 2005 and 2008

are presented in Figure 6. They match each other well.

After we had finished the analysis, we obtained the China Population Statistics Yearbook (2010), which contains the fertility data for 2009 from an annual survey of 0.1% of the entire population. The observed age-specific fertility for the country are calculated and added to Figure 6 with the predicted rates for 2009 based on 2005-2008 data. They fit each other well for ages under 25, which confirm the delay in giving birth to babies. Unfortunately, there is still a difference between the observed and predicted rates for ages over 25 in 2009, which may be a result of possible under-counting of new born babies in 2005 or 2009, or over-counting from 2006-2008 or nonlinear change over the years for these ages.

We added the observed TFRs, TFR1, and TFR2+s for 2009 to Figure 5. As we have expected, due to the limits set by the one-child policy, for second and above babies, the observed TFR2+ and age-specific fertility rates for 2009 are at about the same level as that in 2008, lower than the predicted values for 2009 based on the model, but higher than the level in 2000 for all the four groups. For first-born babies and all babies, the observed TFR1 and TFR for 2009 are close to the predicted values in cities but lower than the predicted values in towns and counties.

3 Discussion and Conclusion

Prediction of age-specific fertility is difficult especially for a huge and constantly changing country like China. Yet, we have no doubt that with the continued economic prosperity in the recent years in China, the fertility is increasing and has grown

beyond the limits set by the one-child policy for certain groups of women.

Over the years, more and more women in cities attended higher education, four years of college, and even graduate school over the years, hence they postponed giving birth. But why are the changes for the women in towns and counties relatively slow? In China, those who were in towns or counties, as long as they passed the college entrance exam and entered a regular college, their registrations (“hukou”) were changed from “agriculture household registrations” to “non-agriculture household registrations (cities)”. As long as they can find a job in a city, they will remain holding their “non-agriculture household registrations”, thus classifying them in the group of cities. For those who did not pass the exam, they may have a chance to be admitted to a short-term college (two-year or three-year) to receive technical training if their scores are not too low, but their registrations will not be changed. After two or three years' training, most of them prefer to find a job in a city or town, and few would like to return to counties. Therefore, the percentage of women in the groups of cities and towns are increasing over the years, but the percentage in the group of counties is decreasing. From the 2000 census, there were totally 32,736,216 women between ages 15 and 49 in the country, 8,681,998 (26.5%) from cities, 4,620,932 (14.1%) from towns, and 19,433,286 (59.4%) from counties. From the 2005 survey, the total number is 4,676,587 in the country, 1,435,645 (30.7%) from cities, 835,360 (17.9%) from towns and 19,433,286 (51.4%) from counties. That is, some women in the counties' group have moved into the cities' or towns' group; some women in the towns' group have moved into the cities' group; those who stay behind

would observe the local culture of getting married and giving birth to babies at the traditionally expected ages, though there is a slight delay in ages of getting married (Zhao, Hou, and Zhao 2011) which certainly results a slight delay of giving birth to new babies.

There are sudden drops in the observed TFR1 in 2009 in towns and counties, besides the possible under-counting of new born babies in the annual survey of 0.1% entire population in 2009, the rapid urbanization that is happening in China may be another possible reason. In the very recent years, more and more people in towns or counties had been relocated to spare their house or land for massive construction projects such as new roads, highways, shopping centers and residential buildings. Most of these people have to live in rented apartments or houses for 2-3 years before moving in the new apartments compensated by the government. The relocations may also caused delay in producing new babies.

The 2010 census data in China are not available yet, to get a preliminary population projection in the country, the fitted rates for 2000-2004 for all babies in Figure2 and the fitted rates for 2005-2008 in Figure 6 can be used as the fertility rates for the years, and the estimated fertility rates for 2009 can be corrected by replacing the rates over 25 with the rates of the corresponding ages in 2008. After the correction, the estimated TFR is 1.5083 for 2008 and 1.4779 for 2009.

Should China relax the one-child policy right now? Besides the fertility level, other factors that are related to the size of population should also be considered, such as the rapidly decreasing mortality in China (Zhao et al. 2011), which contributes to

the increase of total population in China. In fact, the population in China is still increasing each year and the increase will last for over a decade according to our preliminary results in a population projection study. Also, the distribution of woman's age should also be considered. In China, females born around 1990 (“extra-birth guerrilla” era) are about to give birth to new babies. Though we do not have access to the 2010 census data, based on 2000 census data, a bar plot of the number of women for different age groups in 2000 is presented in Figure 7, which shows that there were much more women aged 10-15 in 2000. These women should be 20-25 in 2010, and they are about to at the ages of high fertility. Therefore, there is supposed to be a peak in the number of new born babies in the very near future, and it is not a good timing to relax the one-child policy right now. Since the urbanization and the shift of the composition of women's registration do affect the fertility in the long run, further studies are needed to find a good time to relax the policy in the future.

Appendix

Three sets of formulae used in the modified Lee-Carter model

$$Z_{0j}(x) = (x - x_0)_+^j, \quad j = 1,2, \qquad Z_i(x) = (x - x_i)_+^3, \quad i = 0,1,\ldots,m, \tag{a1}$$

$$\begin{cases} Z_{0j}(x) = (x - x_0)_+^j, \quad j = 1,2; \\ Z_i(x) = (x - x_i)_+^3 - (x - x_m)_+^3, \quad i = 0,1,\ldots m-1; \\ Z_m(x) = 0, \end{cases} \tag{a2}$$

and

$$\begin{cases} Z_{01}(x) = (x - x_0)_+;\ Z_{02}(x) = (x - x_0)_+^2 - \dfrac{(x - x_{m-1})_+^3 - (x - x_m)_+^3}{3(x_m - x_{m-1})}; \\ Z_i(x) = (x - x_i)_+^3 - (x - x_{m-1})_+^3 \dfrac{x_m - x_i}{x_m - x_{m-1}} + (x - x_m)_+^3 \dfrac{x_{m-1} - x_i}{x_m - x_{m-1}},\ i = 0,1,\ldots m-2; \\ Z_m(x) = Z_{m-1}(x) = 0. \end{cases} \tag{a3}$$

where $(x - x_i)_+^j$ is defined as $(x - x_i)^j$ for $x \geq x_i$ and 0 for $x < x_i$.

References

[1] Agresti, Alan. 2002. *Categorical Data Analysis* (2nd edition). New York: Wiley.

[2] Greenhalgh S. and J. Bongaarts. 1987. Fertility Policy in China: Future Options. *Science* 235: 1167-1172.

[3] Hesketh, Therese, Li Lu, and Zhu Wei Xing. 2005. The Effect of China's One-Child Family Policy After 25 Years. *The New England Journal of Medicine* 353: 1171-1176.

[4] Lee, Ronald D. 1993. Modeling and Forecasting the Time Series of US Fertility: Age Patterns, Range, and Ultimate Level." *International Journal of Forecasting* 9:187–202.

[5] Lee, Ronald D. and Lawrence Carter. 1992. Modeling and Forecasting U.S. Mortality. *Journal of American Statistical Association* 87: 659-671.

[6] National Bureau of Statistics of China (Eds.) 1988-2010. *China Population Statistics Yearbook of 1988 (-2010)*. Beijing: China Statistics Press (in Chinese).

[7] National Bureau of Statistics of China. 2001. *The Fifth Population Census Data* (2000), in Chinese, retrieved April 25, 2011 (http://www.stats.gov.cn/tjsj/ndsj/renkoupucha/2000pucha/pucha.htm)

[8] National Education Committee. 1990. Provisional Regulations on the Enrollment of Tuition-Paying Students in the Regular Higher Education Institutions, in Chinese, retrieved May 4, 2011 (http:// www.51labour.com/lawcenter/lawshow-16557.html).

[9] Wang, Peng. 2005. Can China Afford to Continue Its One-Child Policy? Asia Pacific Issues, East-West Center #77.

[10] Zhao, Bojuan Barbara. 2011. A modified Lee-Carter Model for Analyzing Short Base Period Data, *Population Studies*, online: 16 Dec 2011, http://www.tandfonline.com/doi/abs/10.1080/00324728.2011.636839#preview

[11] Zhao, Bojuan B., Xiangliang Liang, Wenke Zhao, and Delong Hou. 2011. Modeling of Group-Specific Mortality in China Using a Modified Lee-Carter Model, *Scandinavian Actuarial Journal*, online: 24 Oct 2011, *http://www.tandfonline.com/doi/abs/10.1080/03461238.2011.619271#preview*

[12] Zhao, Bojuan B., Delong Hou, and Wenke Zhao. 2011. Trends and Patterns in Marital Status in Recent China (under review).

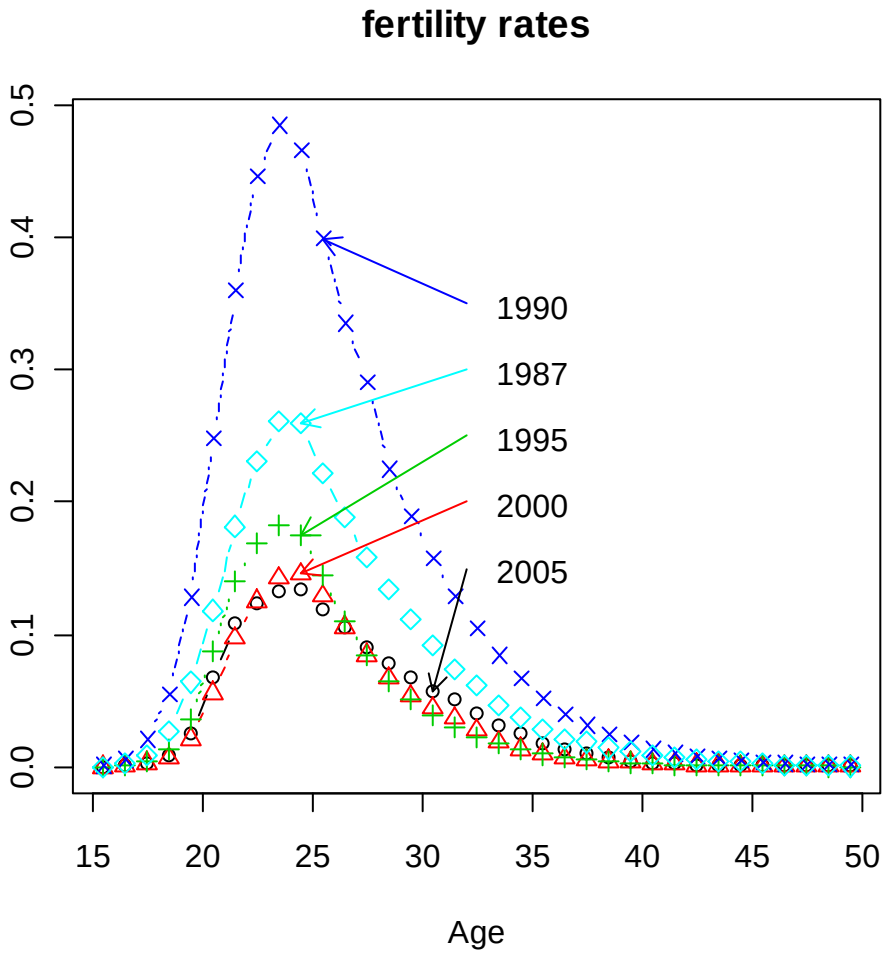

Figure 1: For all babies, observed age-specific fertility rates for the major years in the country.

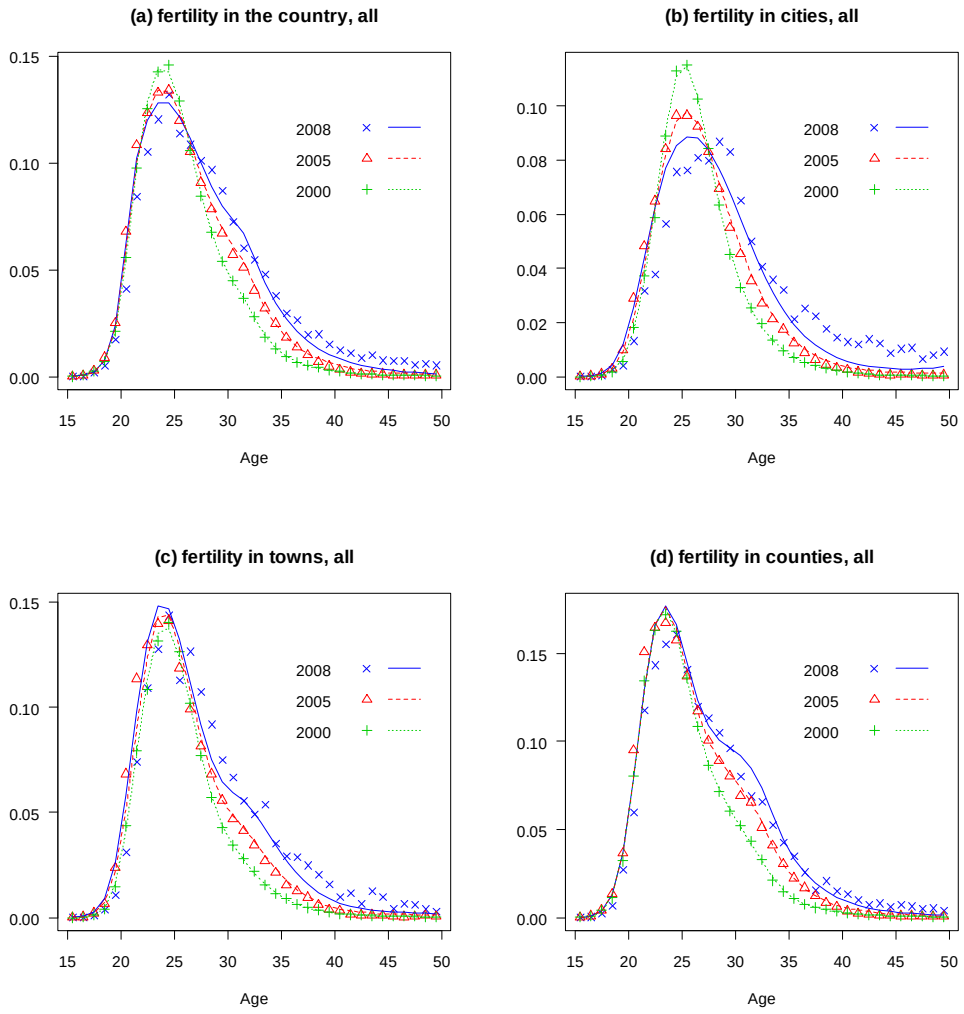

Figure 2: For all babies, the observed and fitted age-specific fertility rates for each of the four groups of women for 2000, 2005, and 2008 based on models listed in Table 1.

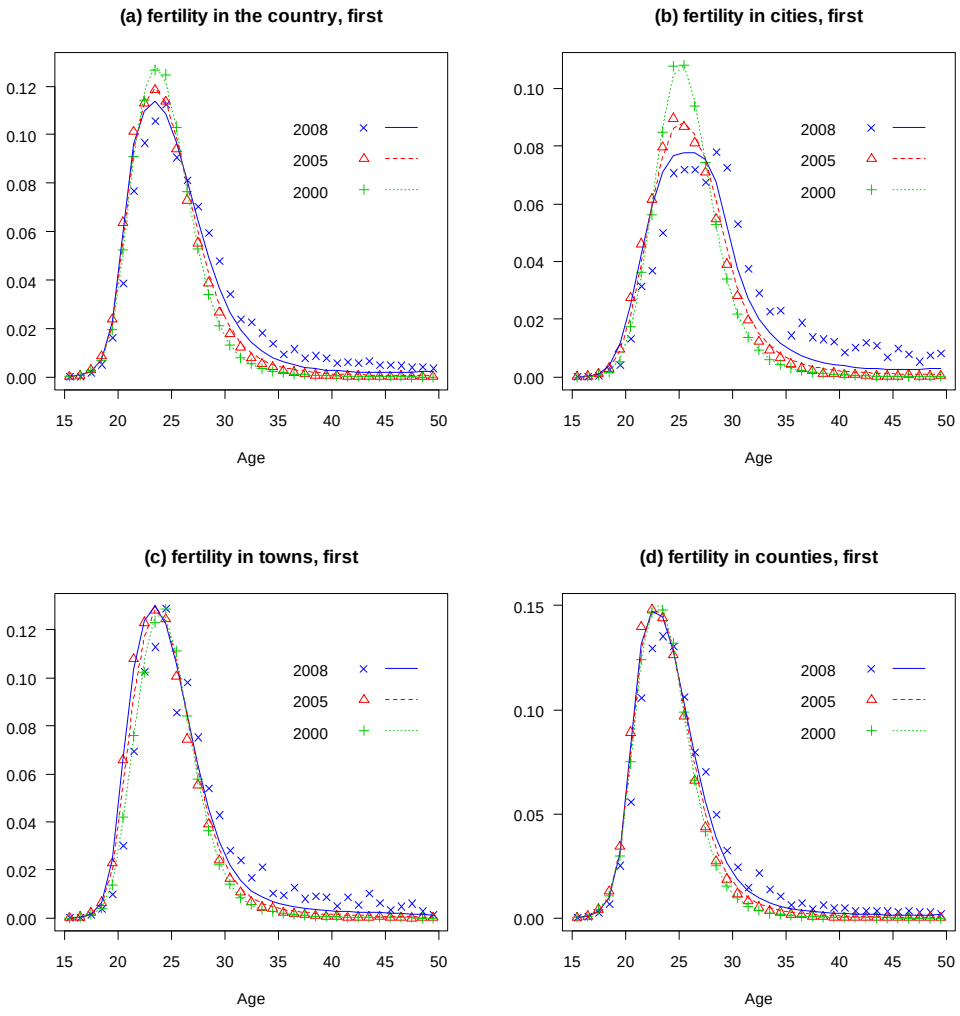

Figure 3: For first born babies, the observed and fitted age-specific fertility rates for each of the four groups of women for 2000, 2005, and 2008 based on models listed in Table 1.

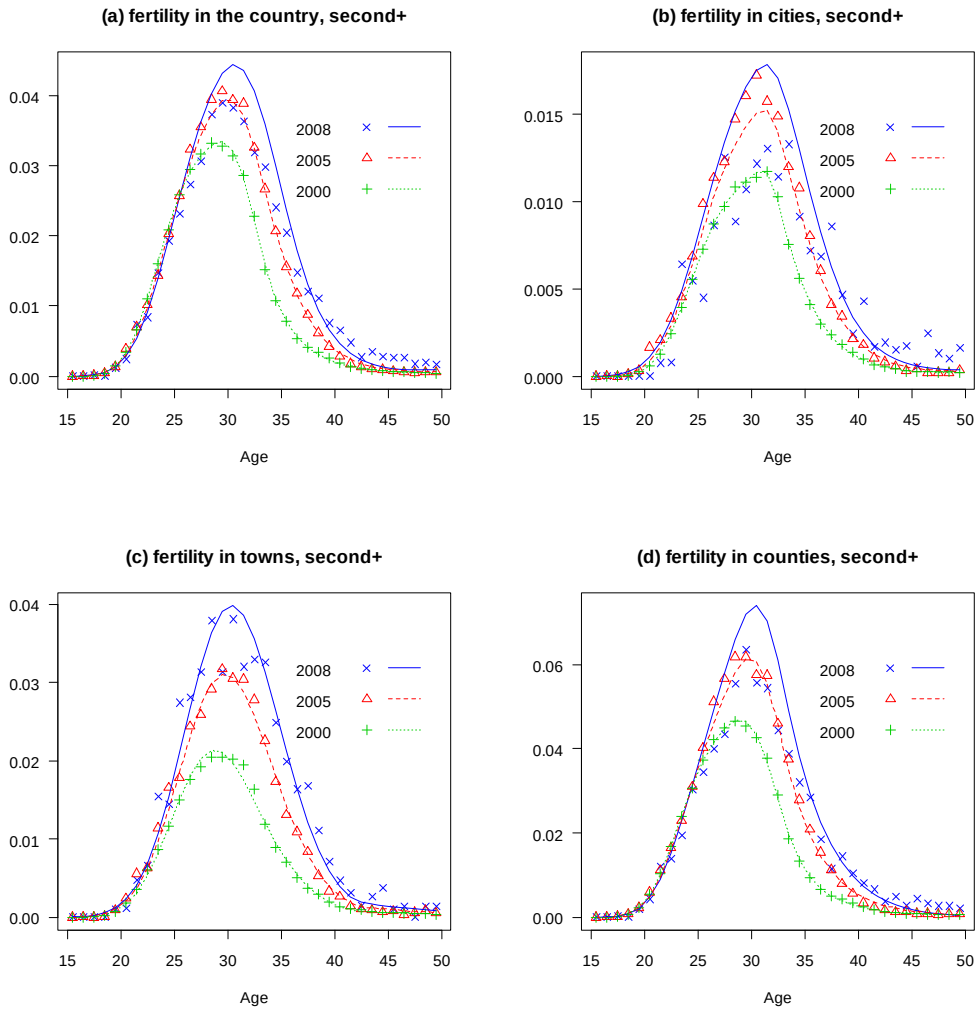

Figure 4: For second and above babies, the observed and fitted age-specific fertility rates for each of the four groups of women for 2000, 2005, and 2008 based on models listed in Table 1.

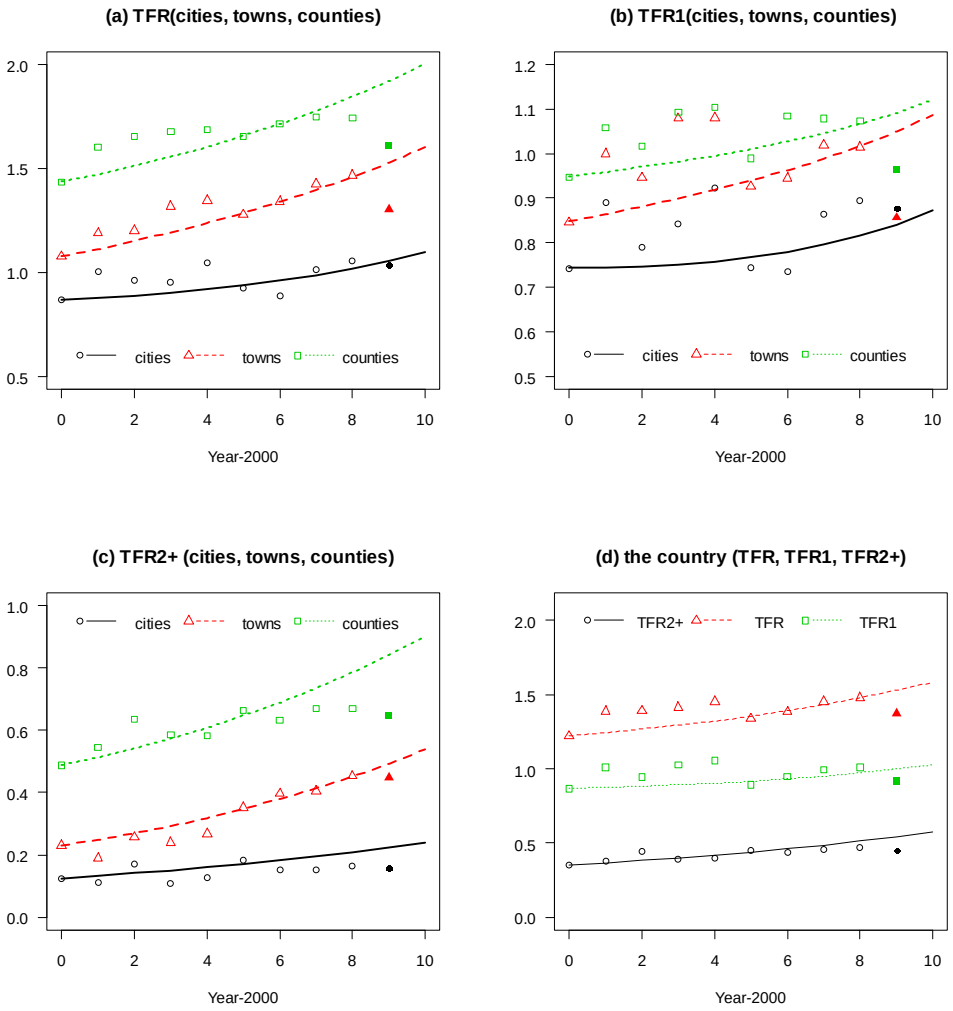

Figure 5: Observed, fitted and predicted period total fertility rates based on the models listed in Table 1 (based on 2000-2008 data). Newly obtained observed rates for 2009 are added and marked with solid points.

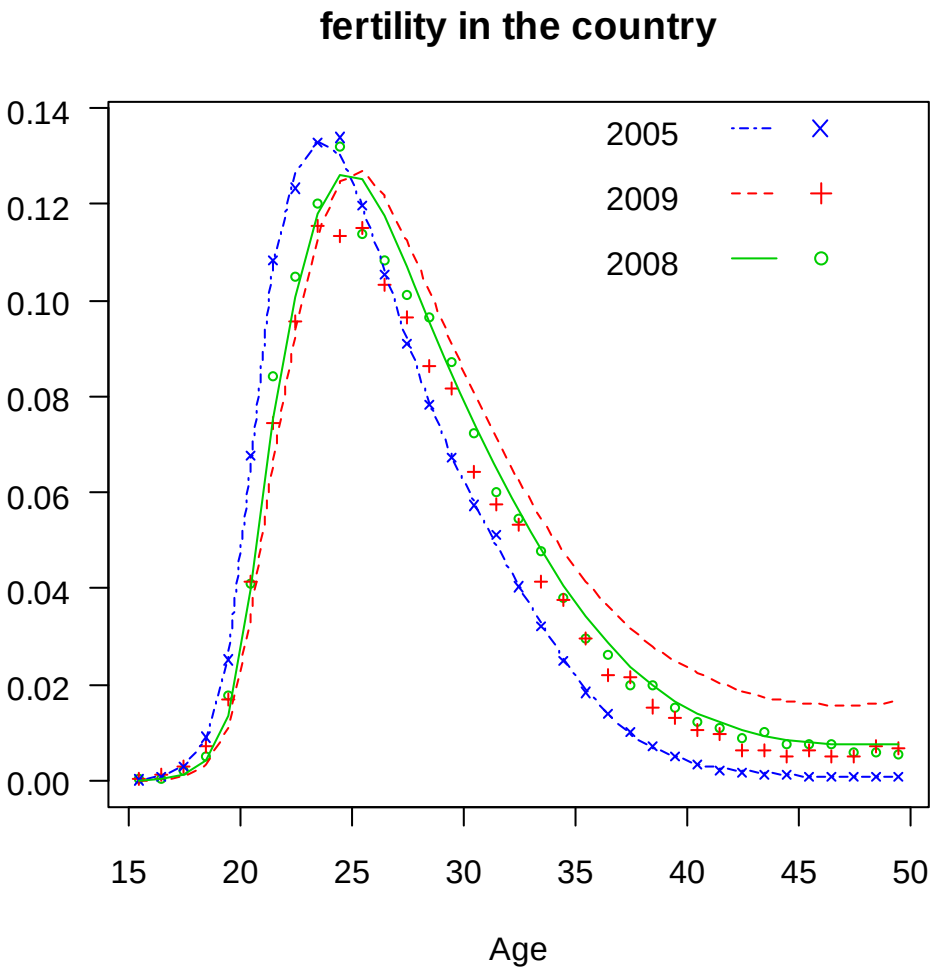

Figure 6: Observed, fitted (2005 and 2008) and predicted (2009) age-specific fertility based on the 2005-2008 fertility data in China. Newly obtained observed rates for 2009 are added and marked with crosses.

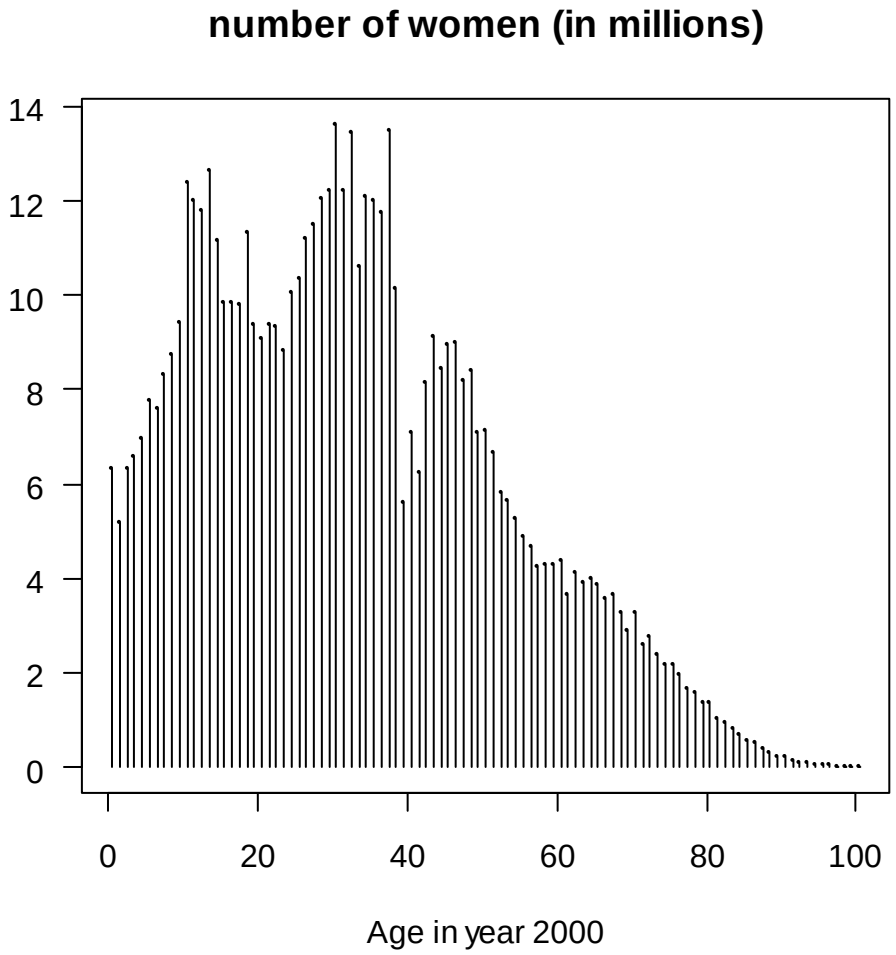

Figure 7: Bar graph of the number of women in different age groups in 2000 (Data source: The Fifth Population Census Data in China (2000)).