

The Fertility Level of China's Population: Analysis of Microdata from the 2010 Census

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Abstract: Using microdata from the 2010 census of China, the total fertility rate of China's population is estimated based on the average number of children ever born reported by 35-year-old women. The total fertility rate thus calculated from census data is 1.52 births per woman. The fertility rate can also be estimated based on the number of school-age children counted at age 9, resulting in a total fertility rate between 1.5 and 1.6. China is among the world's many countries that have a low fertility rate today. The fertility levels within China display a trend of convergence between various groups including: different geographic regions, urban and rural areas, different ethnic groups, the whole range of educational levels, various occupations, the agricultural population and the non-agricultural population, and the migrant population compared to the registered permanent non-migrant population.

Keywords: census; microdata; fertility rate; completed fertility; number of children ever born

1. Introduction

The level of fertility is the most important demographic factor in determining the process of population reproduction and the trend of population development, in particular the current and future population size and age structure. Understanding China's fertility rate of the 1990s and beyond can help project future population trends in terms of labour force participation and population aging. These changes in population trends and structures have profound implications for China's economic, social, and environmental sustainability in the coming decades.

China's censuses, surveys, and vital registration systems routinely underreport the number of births and undercount the numbers of young children, leading to underestimation of the level of fertility. Given the complexity of measuring the actual fertility rate, there is a lively public discourse among researchers and policy makers regarding the exact rate of fertility in China (Feeney and Yuan, 1994; Zhang and Zhao, 2006; Morgan et al., 2009; Cai, 2010; Zhao and Zhang, 2010; Guo, 2011; Merli and Morgan, 2011; Hao and Qiu, 2011; Zhu, 2012; Wang, Cai and Gu, 2012; Li and Li, 2012; Cai, 2013; Cui

et.al., 2013; Wang and Ge, 2013; Wang, 2015). Guo (2011, 2015) argues that China's total fertility rate has decreased to less than 1.5 births per woman since the late 1990s, and that data from the 2000 and 2010 population censuses as well as sample survey data show that the total fertility rate is at a low level. However, Zhai et al.(2015) claim that China's total fertility rate is between 1.5 and 1.8. These different estimates reflect the differences in the types of data and methodologies used in calculating fertility rates. Guo (2011), Hao and Qiu (2011) and Zhu (2012) find that census data are more reliable than data from other sources; Cui et al.(2013), Wang and Ge (2013), and Li and Li (2012) base their estimates on census data with adjustments. Yang and Zhao (2013), and Zhai et al. (2015) adopt data from the Ministry of Education and the Ministry of Public Security for estimating China's fertility level. However, Cai (2009) and Guo (2010) argue that employing data from sources other than censuses or surveys for determining the fertility rate is not justified, because data provided by the Ministry of Education and the Ministry of Public Security are not of high enough quality. Guo (2011) claims that it is problematic to use artificially adjusted data from official statistical bulletins because the original source data are incomplete and the adjustments made to reported data by the National Bureau of Statistics (NBS) lack sufficient empirical justification.

The sixth census in 2010 provides information on China's fertility situation for evaluation of the status quo and future projections (Guo, 2011; Zhu, 2012). We estimate the total fertility rate in China by applying indicators of the average number of children ever born by 35-year-old women using microdata from the fifth (2000) and sixth (2010) censuses.

2. Data and Method

2.1 Census Data

Although China has a long history of several thousand years in administering demographic surveys, the development of uniform standards and questionnaires to be applied over all or most of the country has happened only since the founding of the People's Republic of China in 1949. China has carried out population censuses in 1953, 1964, 1982, 1990, 2000 and 2010 to collect information on the number, structure and changes of its national population.

During the last 60 years, the techniques and methods used for Chinese censuses have changed dramatically from manual to electronic processing, and later to the use of scanning and management techniques that resulted in more and more comprehensive data. Beginning in 1990, China has conducted a census every ten years. The decennial census data are supplemented with a large-scale population sample survey halfway between census cycles. The fourth census in 1990 added questions on "places of residence in the past five years" and "causes of migration." In 2000, the fifth census adjusted the registration time to 0:00 on November 1st as a standard and began a new census practice of employing two kinds of questionnaires: a short form filled out for 100 percent of the population, and the long form administered to a 10 percent sample of households nationwide. The short form includes name, the relationship of each individual in the household to the householder, age, ethnicity, education and "hukou" (household population registration) location and status. The long form builds on the short form to include additional questions on dwelling conditions, birth place, recent migration, source of

income and support for non-workers, and details of first marriage. According to the principle of residential registration, the 2010 census takes into consideration all the residents living in mainland China, and records the inflow and outflow locations of the migrant population.

For estimating China's level of fertility, and to circumvent some problems of data completeness and quality in the 1990, 2000 and 2010 censuses (Cui et al., 2013), we employ census data known to have high validity and reliability, such as the number of children ever born by 35-year-old women, and the number of women in and above childbearing ages between 15 and 60. There were 1.265 billion people counted in the 2000 census, of whom 0.35 billion were women between the ages of 15 and 49. In 2010, the total population count rose to 1.33 billion, 0.38 billion of whom were women of childbearing-age. The long form of the 2000 census restricted questions on fertility to females of child bearing ages (15-49 years), totaling 33.5 million women. The 2010 long form expanded fertility questions to encompass females aged 15-64 years, totaling 46.4 million. We randomly selected 1% samples from each census and then combined them to analyze fertility rates of the Chinese population.

2.2 Methodology

Two of the most frequently used indicators to describe fertility levels are total and completed fertility rates. The total fertility rate is calculated based on the average fertility rates of women of childbearing ages at one point in time, whereas completed fertility rates express the actual number of children ever born to women over their lifetime. Total fertility rates reflect cross-sectional fertility in a specific year or time period, while completed fertility rates express the longitudinal fertility of cohorts of women.

There are four advantages of using completed fertility rates. First, problems associated with missing data due to unreported births can be easily addressed compared to using period fertility rates. In China, period birth data are always underreported—by the family planning system, by surveys, by birth registration data, and by the censuses. As only one of many examples, births directly reported in the 2010 census for the 12-month period immediately preceding the census date resulted in a period total fertility rate of only 1.19 births per woman nationwide. This figure is universally acknowledged to be lower than China's true period fertility level for 2010, but there is no agreement on how much of an underestimate it is. Instead of trying to derive fertility rates from recent births directly reported by childbearing-age women, we can infer China's fertility level from census data on completed fertility rates. Second, China has reached a stage of slowly declining and then stable low fertility, where there are no booms or busts in fertility levels without special events. In such circumstances, completed fertility rates are similar to period rates. Third, data on completed fertility can avoid difficulties in estimating the differential degrees of underreporting of births in different regions and effectively summarize the fertility level for different provinces and for diverse sub-populations (for example, ethnic groups) classified by various criteria. Fourth, the completed fertility rate that depicts women's fertility status across the whole childbearing period may precisely reflect the effects of China's population and family planning policies in the decades before 2010.

Strictly speaking, the average number of children ever born by 49-year-old women is the classic definition of the completed fertility rate. However, as we shall show in the case of China, calculating completed fertility rates from age 35, by avoiding the time lag to age 49, is more timely for fertility estimation and policy-making purposes. According to empirical data on period age-specific births, childbearing for Chinese women after age 35 is minimal (table 1). From the year 2000 through 2014, births to women aged 36 and 49 have constituted on average 8% of all births (table 1, column 1). In addition, during the same time period the standardized total fertility rate for women between 36 and 49 has averaged 0.07. That is to say, the period total fertility rate for women aged 36-49 constitutes 7% of the rate for women of all childbearing-ages.

Table 1. Ratio of Total Fertility Rates of Women Aged 36-49 to Those Aged 15-49

| Year | The Proportion of Births For Women Aged 36-49 to All Births (%) | Ratio of Total Fertility Rate Aged 36-49 to 15-49 | Number of Women Aged 36-49 |
|-------------|--|--|-----------------------------------|
| 2014 | 6.21 | 0.07 | 131,406 |
| 2013 | 8.08 | 0.08 | 134,320 |
| 2012 | 8.35 | 0.08 | 138,044 |
| 2011 | 7.12 | 0.07 | 140,660 |
| 2010 | 12.15 | 0.11 | 15,240,878 |
| 2009 | 12.91 | 0.10 | 147,162 |
| 2008 | 14.24 | 0.11 | 144,753 |
| 2007 | 12.12 | 0.09 | 144,012 |
| 2006 | 8.59 | 0.06 | 143,381 |
| 2005 | 4.94 | 0.04 | 1,961,051 |
| 2004 | 3.73 | 0.03 | 141,107 |
| 2003 | 3.20 | 0.03 | 137,929 |
| 2000 | 2.36 | 0.02 | 11,684,262 |
| 1990 | 3.83 | 0.05 | 81,555,368 |
| 1982 | 6.06 | 0.10 | 65,329,441 |

Note. Computations produced at the authors' request by the National Bureau of Statistics of China.

Sources: 1982, 1990: population census; 2000 and 2010: 10% long-form sample for each census; 2005: 1% sample; 2003, 2004, 2006, 2007, 2008, 2009, 2011, 2012, 2013, and 2014: 0.1% samples.

From the perspective of cohorts, the average relative difference of the total fertility rate between 49-year-old cohorts and 35-year-old cohorts born from 1950 to 1961 is 4% (table 2). This

means that the difference in estimating the number of children ever born to 49-year-old women by using the number of children ever born to 35-year-old women is 4%. Consequently, it is appropriate to take the average number of children ever born by 35-year-old women, adjust this figure to account for the expected births to women 36-49, and take the result as a good estimator for the completed fertility rate. For the cohort of women who were age 35 in 2010, 25 in 2000 and 15 in 1990, the average number of children ever born by 2010, after a small adjustment for births to women 36-49, robustly approximates the completed fertility rate under China's birth and family policies of the 1990-2010 period.

Table 2. Estimation of Completed Fertility Rates of Birth Cohorts From 1950 to 1961

| Year of birth | Age-15 year | Age-35 year | Age-49 year | 35CTFR ① | 49CTFR ② | Relative Difference (②-①) / ② (%) |
|----------------------|------------------------|------------------------|------------------------|---------------------|---------------------|--|
| 1950 | 1965 | 1985 | 1999 | 2.82 | 2.95 | 4.4 |
| 1951 | 1966 | 1986 | 2000 | 2.67 | 2.78 | 4.0 |
| 1952 | 1967 | 1987 | 2001 | 2.55 | 2.64 | 3.4 |
| 1953 | 1968 | 1988 | 2002 | 2.45 | 2.53 | 3.2 |
| 1954 | 1969 | 1989 | 2003 | 2.33 | 2.41 | 3.3 |
| 1955 | 1970 | 1990 | 2004 | 2.25 | 2.32 | 3.0 |
| 1956 | 1971 | 1991 | 2005 | 2.18 | 2.25 | 3.1 |
| 1957 | 1972 | 1992 | 2006 | 2.14 | 2.22 | 3.6 |
| 1958 | 1973 | 1993 | 2007 | 2.12 | 2.20 | 3.6 |
| 1959 | 1974 | 1994 | 2008 | 2.12 | 2.20 | 3.6 |
| 1960 | 1975 | 1995 | 2009 | 2.12 | 2.21 | 4.1 |
| 1961 | 1976 | 1996 | 2010 | 1.90 | 1.97 | 3.6 |

Note: Fertility rate data in table 2 are derived by authors from 1‰ samples of the 1982, 1990, 2000, and 2010 censuses. Completed total fertility rates at age 35 and age 49 are interpolated for data points between census dates. This process yields consistent and reliable results because of exceptionally accurate single-year age reporting in all censuses and because of rather complete reporting of children ever born for women at ages 35 and 49.

3. Results

3.1 The national fertility level

According to the 1% sample data from the sixth national population census, the completed fertility rate for women age 35 was 1.46 birth in 2010. Considering a relative difference of 4%, the adjusted completed fertility rate for women when they reach age 49 is 1.52 births per woman. As shown in figure 1, births in China in recent years are overwhelmingly concentrated in the age range 20-35, which means that the completed fertility of 1.52 births per woman broadly applies to the years when this cohort of women were bearing their children, 1995-2010. The graph also shows that the highest fertility rates are to women at ages 22-29. Therefore, the figure 1.52 most accurately represents the period total fertility rate of the years 1997-2004, the peak fertility period for those women who were age 35 in the 2010 census.

Figure 1 : China age-specific fertility rates in 2010

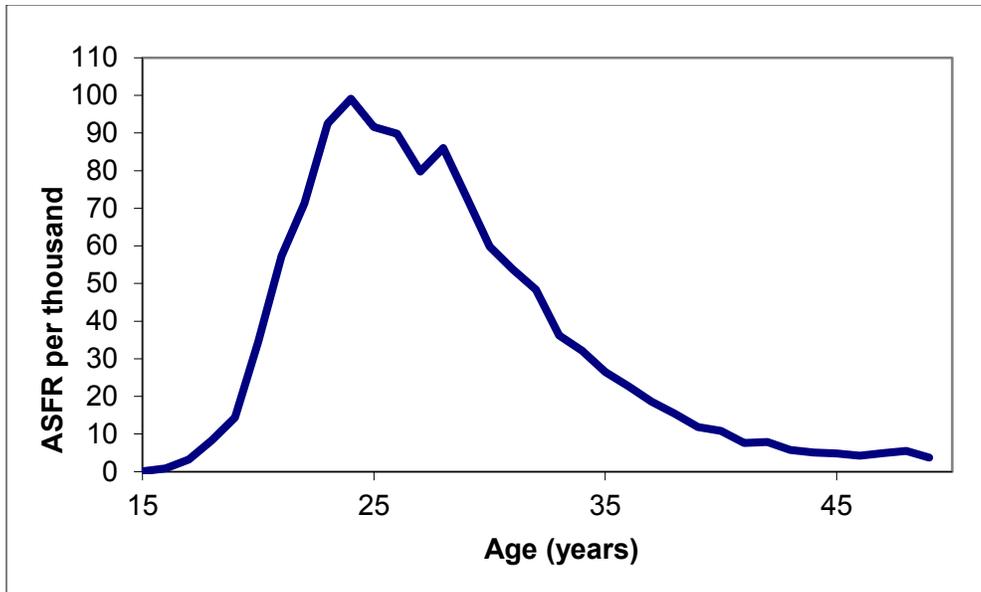


Table 3. Estimation of Completed Fertility Rates of China's Cohorts Born From 1962 to 1975

| Birth year | Age-15 year | Age-35 year | Age-49 year | 35CTFR | 49CTFR |
|------------|-------------|-------------|-------------|--------|--------|
| 1962 | 1977 | 1997 | 2011 | 1.89 | 1.97 |
| 1963 | 1978 | 1998 | 2012 | 1.80 | 1.87 |
| 1964 | 1979 | 1999 | 2013 | 1.77 | 1.85 |
| 1965 | 1980 | 2000 | 2014 | 1.76 | 1.83 |
| 1966 | 1981 | 2001 | 2015 | 1.74 | 1.82 |

| | | | | | |
|-------------|------|------|------|------|------|
| 1967 | 1982 | 2002 | 2016 | 1.72 | 1.79 |
| 1968 | 1983 | 2003 | 2017 | 1.68 | 1.75 |
| 1969 | 1984 | 2004 | 2018 | 1.64 | 1.71 |
| 1970 | 1985 | 2005 | 2019 | 1.65 | 1.72 |
| 1975 | 1990 | 2010 | 2024 | 1.46 | 1.52 |

Notes: Table 3 extrapolates from the completed fertility data of women aged 35 and 49 in table 2 to estimate completed fertility at age 49 from reported data on completed fertility at age 35 in the 2000 and 2010 censuses.

Table 3 shows a persistent decline from 2 children for women born in 1962 to 1.8 for those born five years later followed by a more pronounced drop to 1.5 for women born in 1975. We can see the significantly difference of completed fertility rate between those born in 1960 and those born 1970, which almost has 0.3 differences. Moreover, there are also 0.2 differences between those born in 1970 and those born in 1975, which means the completed fertility rates for those born in 1970s will decline more quickly. Partly because the socioeconomic change happened in past thirty years changed the fertility desire of younger couples, and partly because the one-child policy limited the fertility dreams of younger couples. Anyway, it is an important alert for government to make a change of the fertility policy to avoid the low fertility trap.

We can also calculate the number of births and the fertility level in previous years through the number of school-age children published by the Ministry of Education every year, but there is a lag of at least six years in the reported data. We adopt age-distribution data of primary school-age children because of the variations of “school age” among provinces. Primary school enrollment begins at age 5 or 6 in some parts of China, but in other areas school entry is at age 7 or older. The highest number of children enrolled in primary school is at age 9, implying that by age 9 essentially all those children who are going to be enrolled in school have already entered, and only small numbers have dropped out of school by that age. Taking the dropout rate and infant and child mortality rates between 0 and 9 into account, we estimate the number of births each year from 1994 to 2005. Table 4 shows that, based on enrollment data on children age 9 from the Ministry of Education, from 1995 to 2005, China's period total fertility rate (PTFR) dropped from 1.71 in 1994 to 1.59 in 1997, stabilized at approximately that level from 1997 through 2002, declined slightly in 2003-4, and rose again to 1.59 in 2005.

One advantage of using primary school enrollment data at age 9 to gauge China's fertility level 9 years earlier is that an annual data series is available from the Ministry of Education. The data series in table 4 shows trends in China's national fertility level from 1994 through 2005. However, there is a small problem with use of China's school enrollment data at age 9 to estimate the country's level of fertility, namely that local level enrollment data compiled by the Ministry of Education appears to somewhat over-report the actual number of children age 9 in China. This produces a slight overestimate of annual fertility levels. The causes of this minor exaggeration may be due to various

causes: sloppy record-keeping in primary schools, some age misreporting or age heaping on 9 in reports from the schools, double-counting of some children, a bias in favor of rosy full enrollment figures by local officials, or other unknown causes.

One way to test the accuracy of the Ministry of Education's enrollment figures at age 9 is to compare the 2010 number to the count of children at age 9 in China's 2010 census. Unfortunately, census counts at age 9 are underreported, and have to be adjusted upward. Fortunately, it is possible to get a very good estimate of the extent of the undercounting of children age 9 in China's censuses by tracing that age cohort through succeeding censuses. In China, adults tend to be completely reported or almost completely reported in the decennial censuses. Reconstructing the count of men and women age 29 in the 2010 census back to the 2000 census by adding in those who died at ages 19-29 shows that men were completely counted at age 19 in 2000 and 19-year-old women were slightly undercounted in the 2000 census. Further back-projecting the cohort to age 9 shows that the 1990 census undercounted children age 9 by 8%.

In a similar manner, the count age 19 in the 2010 census can be reconstructed back to when they were age 9 in the 2000 census. If it is assumed that both men and women were completely counted at age 19 in 2010, then the 2000 census undercounted the age 9 population by 7.9-8.1%. But if it is assumed that in 2010, men age 19 were 100% counted (as in the 2000 census) and women were undercounted by the same amount as estimated in the 2000 census, then the population age 9 was undercounted in the 2000 census by 9.2-9.4%.

Assuming that in the 2010 census, the tendency to undercount the population age 9 did not improve or deteriorate from the consistent tendency in 1990 and 2000, and giving equal weight to the undercounts in 1990 and 2000, the undercount of the population age 9 in the 2010 census was between 8.0% and 8.8%. Arbitrarily choosing 8.4%, the center of that range, the count of children age 9 in the 2010 census (14,248,825) was undercounted by 8.4% and the true number of children age 9 in 2010 was approximately 15,555,500. This suggests that the Ministry of Education enrollment figures for age 9 in 2010 were over-reported by about 4.5%.

A problem with population censuses is that they occur only every 10 years. To derive an adjusted annual series of children age 9, it is possible to assume the same degree of moderate over-counting at age 9 by Ministry of Education enrollment figures each year. Table 4 shows a column of the age 9 population for each year 2003-2014 anchored by the 2010 adjusted count of children age 9, and extrapolated to the other years by similarly adjusting the reported Ministry of Education number each year.

The resulting fertility estimates for China are presented in table 4. If this estimation procedure is valid, then China's period total fertility rate declined from around 1.64 births per woman in 1994 to about 1.52 in 1997, then stabilized at or close to 1.52 from 1997 through 2002, followed by a slight fertility decline in 2003-4 and reversion to 1.52 in 2005. This result agrees with the estimated total fertility rate of 1.52 focused on the years 1997-2004 derived from the completed fertility of women age 35 in the 2010 census.

In contrast, as shown in the right-hand columns of table 4, annual official fertility estimates from China's National Bureau of Statistics (NBS) are consistently somewhat too high. The reason is that China's provinces compile and report registered births each year to the NBS, and the resulting reported fertility level for China is of course too low. Therefore the Statistical Bureau inflates the number of births and the period total fertility rates by an estimated fraction each year, and the tendency was to over-adjust the reported numbers.

Analysis of the completed fertility of women age 35 in the 2010 census, and of enrollment and census-derived figures in table 4, have provided rather robust estimates of China's national level of fertility in the years 1994-2005. What has happened to China's level of fertility in the years since 2005? From table 4, if the National Bureau of Statistics has made the same percent adjustment to the reported and compiled birth data from the provinces each year, then China's population experienced further fertility decline from 2005 through 2010. In addition, the data and analyses in the following sections will demonstrate that at least through the year 2010, fertility in China continued slowly declining via the process of convergence. Specifically, the level of fertility of those categories of people who already had very low fertility either did not change or declined a little more, while the higher fertility regions and sub-groups experienced continuing fertility decline.

Table 4. Measures of China Total Fertility Rates From Various Data Sources

Unit: 10,000

| Statistical year | Number of school-age children age 9 from Ministry of Education | Number of school-age children age 9 adjusted from censuses | Year of birth | Number of births based on Ministry of Education age 9 data | Corresponding PTFR based on Ministry of Education age 9 data | Number of births based on adjusted census age 9 data | Corresponding PTFR based on adjusted census age 9 data | Year of birth | Number of births based on National Bureau of Statistics estimates | Corresponding PTFR based on National Bureau of Statistics estimates |
|------------------|--|--|---------------|--|--|--|--|---------------|---|---|
| 2003 | 1867 | 1787 | 1994 | 1958 | 1.71 | 1874 | 1.64 | 1994 | 2104 | 1.85 |
| 2004 | 1840 | 1761 | 1995 | 1930 | 1.67 | 1847 | 1.60 | 1995 | 2063 | 1.80 |
| 2005 | 1764 | 1688 | 1996 | 1850 | 1.61 | 1770 | 1.54 | 1996 | 2067 | 1.82 |
| 2006 | 1717 | 1643 | 1997 | 1802 | 1.59 | 1725 | 1.52 | 1997 | 2038 | 1.81 |
| 2007 | 1681 | 1609 | 1998 | 1764 | 1.58 | 1688 | 1.51 | 1998 | 1942 | 1.75 |
| 2008 | 1612 | 1543 | 1999 | 1691 | 1.55 | 1618 | 1.48 | 1999 | 1834 | 1.69 |
| 2009 | 1637 | 1567 | 2000 | 1708 | 1.60 | 1635 | 1.53 | 2000 | 1771 | 1.67 |
| 2010 | 1626 | 1556 | 2001 | 1686 | 1.59 | 1614 | 1.52 | 2001 | 1702 | 1.61 |
| 2011 | 1594 | 1525 | 2002 | 1652 | 1.59 | 1581 | 1.52 | 2002 | 1647 | 1.58 |
| 2012 | 1514 | 1449 | 2003 | 1569 | 1.53 | 1502 | 1.46 | 2003 | 1599 | 1.56 |
| 2013 | 1524 | 1458 | 2004 | 1580 | 1.54 | 1512 | 1.47 | 2004 | 1593 | 1.56 |
| 2014 | 1567 | 1500 | 2005 | 1624 | 1.59 | 1554 | 1.52 | 2005 | 1617 | 1.59 |
| 2015 | ---- | ---- | 2006 | ---- | ---- | ---- | ---- | 2006 | 1585 | 1.56 |

| | | | | | | | | | | |
|------|------|------|------|------|------|------|------|------|------|------|
| 2016 | ---- | ---- | 2007 | ---- | ---- | ---- | ---- | 2007 | 1595 | 1.57 |
| 2017 | ---- | ---- | 2008 | ---- | ---- | ---- | ---- | 2008 | 1608 | 1.56 |
| 2018 | ---- | ---- | 2009 | ---- | ---- | ---- | ---- | 2009 | 1591 | 1.52 |
| 2019 | ---- | ---- | 2010 | ---- | ---- | ---- | ---- | 2010 | 1592 | 1.49 |

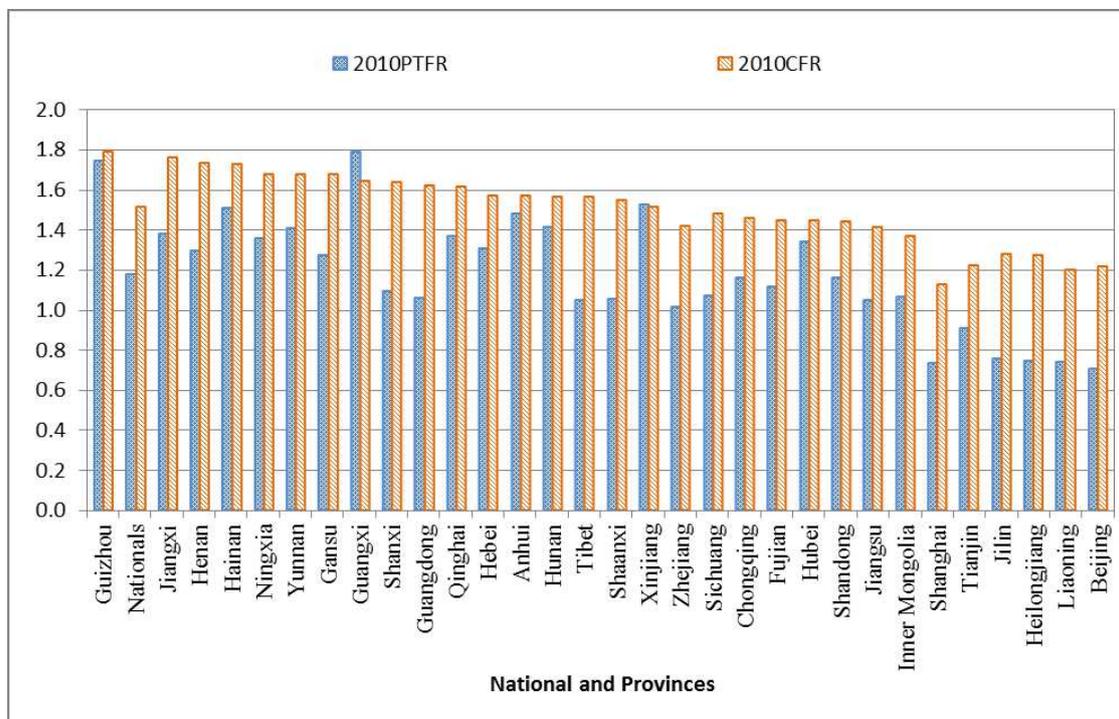
Source: Data on the number of school-age children age 9 come from the China Education Statistics Yearbook (2003-2014); data on the number of births calculated by the National Bureau of Statistics come from China Statistical Yearbook (1994-2010), and the total fertility rates are calculated by the authors. The adjusted count of children age 9 in the 2010 census is calculated using age structure and mortality data from China's censuses of 1990, 2000, and 2010 and mortality estimates in Banister and Hill (2004). Data on age distribution for childbearing-age women between 15 and 49 come from the 2000 and 2010 population censuses; the number of childbearing-age women between age 15 and 49 from 2009 to 2001 is inferred through the age-specific mortality rate for women aged 16-58 in 2010. The number of childbearing-age women between the age of 15 and 49 from 1999 to 1994 is estimated according to the age-specific mortality rate for women aged 16-55 in 2000. Data on the age-specific mortality rate for women of childbearing age are derived from the United Nations' latest updated life table for the average life expectancy of 70-77-year-old women in the Coale-Demeny Western model life tables. "----" in the table means that data are unavailable.

3.2 Fertility levels in different geographic regions

According to data from the 1‰ sample of the 2010 national population census, from the perspective of various regions as shown in figure 2, provinces with a completed fertility rate under 1.3 births per woman include Jilin, Heilongjiang, Tianjin, Beijing, Liaoning, and Shanghai; provinces with a completed fertility rate between 1.3 and 1.5 involve Zhejiang, Sichuan, Chongqing, Fujian, Hubei, Shandong, Jiangsu, and Inner Mongolia; provinces with the rate between 1.5 and 1.7 are Ningxia, Yunnan, Gansu, Guangxi, Shanxi, Guangdong, Qinghai, Hebei, Anhui, Hunan, Tibet, Shaanxi, and Xinjiang; and there are only four provinces with completed fertility rates over 1.7, namely Guizhou, Jiangxi, Henan, and Hainan, while there are no provinces with completed fertility rates over 1.8. Although the more developed regions are likely to have lower fertility rates, the gap between different provinces is narrowing (figure 3). As of the 2000 census, completed fertility rates varied from about 1.13 to over 2.8 children ever born in various provinces. By 2010, the census showed completed fertility rates by province ranging from only 1.13 to under 1.79 children ever born per woman.

Compared with 2000, completed fertility levels declined by 2010 in all provinces except Shanghai, as shown in figure 3. In 2000, women in Tibet had the highest completed fertility level of 2.80 children ever born while Shanghai had the lowest fertility level. The ratio of the maximum level of completed fertility to the minimum level by province was 2.47. By 2010, the completed fertility level in Tibet and many other provinces had decreased rapidly, exhibiting convergence among China's regions.

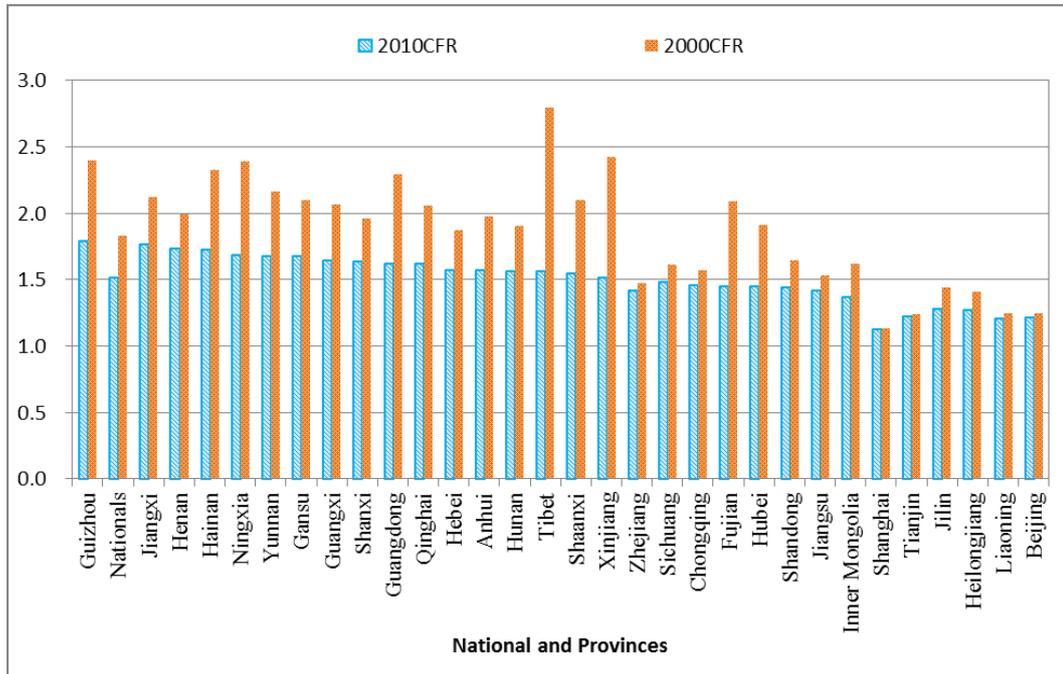
Figure 2: Comparisons of period total fertility rates and the completed fertility rate among provinces in 2010



Source: Summary based on 1‰ sample data from the 2010 national population census.

Note: Blue bar is the total fertility rate in 2010, based on reported births in the year prior to the Nov. 1, 2010 census date, while the red bar is the Completed Fertility Rates in 2010 estimated by adjustment of the average number of children ever born at age 35 up to age 49.

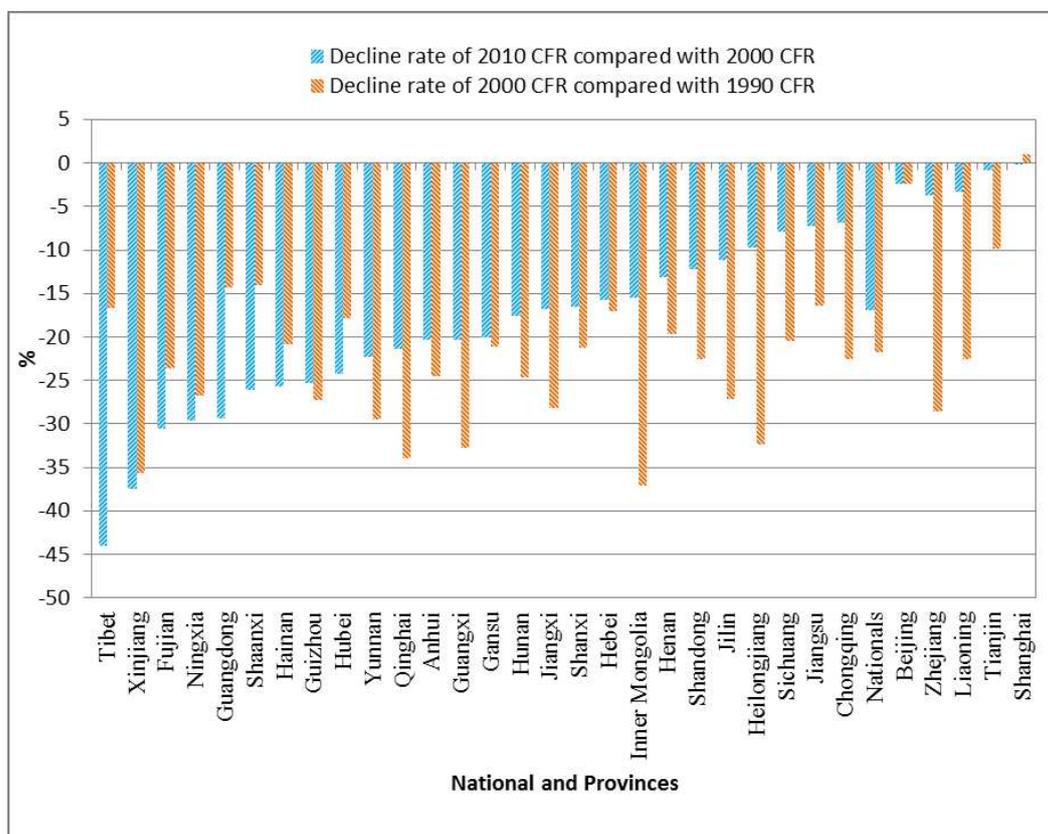
Figure 3. Comparisons of the Completed Fertility Rates between 2010 and 2000 Among Provinces



Source: Summary based on 1‰ sample data from the 2010 national population census and 2000 national population census.

Note: Blue bar is the completed fertility rate in 2010, while the red bar is the Completed Fertility Rates in 2000 estimated by adjustment of the average number of children ever born at age 35 up to age 49.

Figure 4: Comparisons between the 1990 and 2000 population censuses, and the 2000 and 2010 population censuses among provinces



Sources: These fertility comparisons are calculated from a 1‰ sample of the 1990 (the fourth) population census, a 1‰ sample of the 2000 (the fifth) population census, and 1‰ sample of the 2010 (the sixth) population census. Data of Chongqing city are included in Sichuan province in the 1990 population census because of China's administrative divisions at that time.

Note: The blue bar is the percent decline in the completed fertility rate (estimated by adjustment of the average number of children ever born at age 35 up to age 49) from the 2000 census to the 2010 census. The red bar is the percent decline in the completed fertility rate (estimated by adjustment of the average number of children ever born at age 35 up to age 49) from the 1990 census to the 2000 census.

Figure 4 shows that compared with the decline rate of the completed fertility rate in 1990s, the decline rate of completed fertility rate in 2000s for most provinces slow down, especially the developed provinces such as the Zhejiang, Liaoning, Jiangsu, Shandong while

there are eight provinces whose rates speeded up during the two 10-year inter-census periods, such as Tibet, Xinjiang, Fujian, Ningxia, Guangdong, Shaanxi, Hainan, and Hubei. However, in the past two years, the decline rates of the completed fertility rate in Beijing, Shanghai, and Tianjin are stable and subtle, while in Xinjiang, Ningxia, Guizhou, Gansu, and Heber, the decline rates are stable but significant.

3.3 Fertility levels in different residential and registration areas

The difference between fertility levels in China's urban and rural areas is declining. The 1‰ sample data from the 2000 national population census revealed that women's average completed fertility rates were 1.34 children ever born in cities, 1.62 in towns, and 2.10 in villages. The 1‰ sample data from the 2010 national population census indicated that women's completed fertility rates in cities, towns and villages were 1.34, 1.52 and 1.70. These comparisons show that fertility continued declining in the 2000-2010 period in towns and in rural areas while fertility in cities is stable. From the perspective of the household registration system ("hukou"), data from the 2010 census showed that women's completed fertility rate for the agricultural registered population was 1.73 and for the non-agricultural registered population was 1.31. The differences between agricultural registered population and non-agricultural registered population are narrowing from 2000 to 2010.

3.4 Fertility levels among women of different levels of education

In 2000, the completed fertility rate for China's women with an educational level below primary school, which included women who "never went to school" and those who "attended literacy classes," was somewhere between 2.62 and 2.55 children ever born, whereas for women with undergraduate or higher education, the completed fertility was about 1.3, as table 5 demonstrates. Since the 1990s, the fertility level for women with college or higher education has been relatively stable, while the fertility level for women with primary school or lower education has decreased by nearly 0.4-0.7 children. Women's educational level was negatively correlated with the level of fertility in 2000 and in 2010, which is completely consistent with the basic conclusions of the field of population economics.

Evidence from 2010 census data shows that the negative relationship between women's educational level and their fertility rate still remains, but the differential has narrowed. The completed fertility rate for women who never went to school is now at a low level, and compared with women in other education levels, the disparity between them is gradually diminishing.

Table 5. Completed Fertility Rates for Women of Different Educational Levels

| Education levels for women | The completed fertility in 2010 | The completed fertility in 2000 |
|----------------------------|---------------------------------|---------------------------------|
| Never went to school | 1.91 | 2.62 |
| Attended Literacy class | 1.91 | 2.55 |
| Primary school | 1.83 | 2.22 |
| Junior middle school | 1.67 | 1.86 |
| Senior high school | 1.38 | 1.42 |
| Special secondary school | 1.38 | 1.39 |
| Junior college | 1.26 | 1.29 |
| Undergraduate | 1.21 | 1.27 |
| Postgraduate | 1.11 | 1.27 |

Note: The completed fertility rate was estimated by adjustment of the average number of children ever born at age 35 up to age 49.

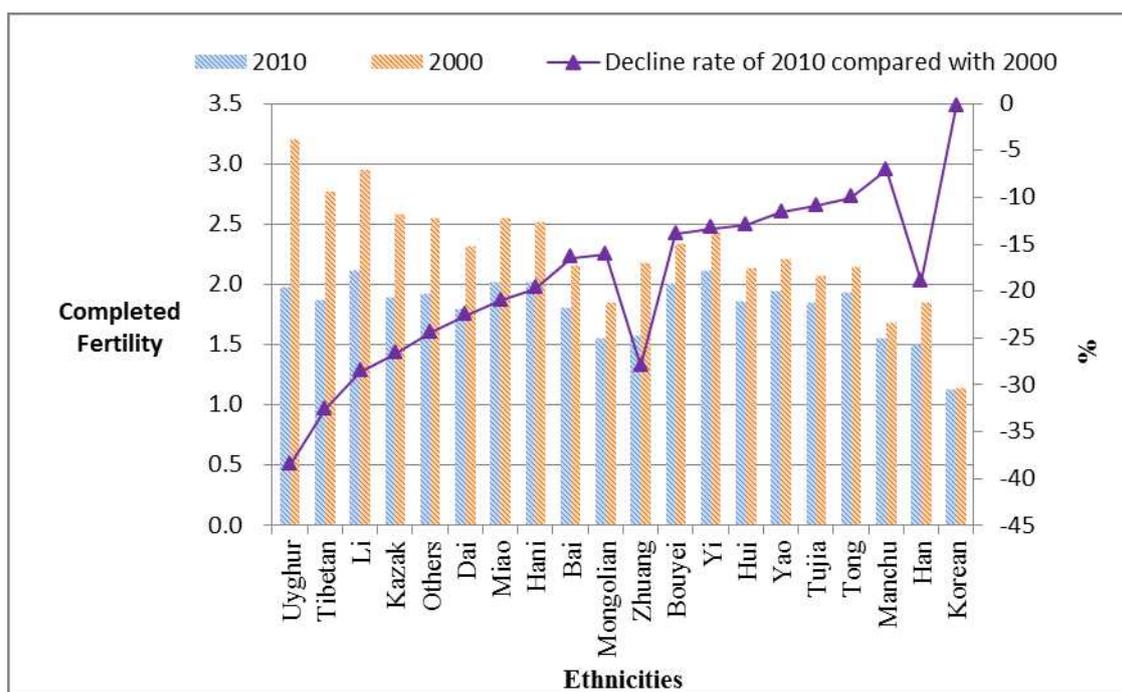
3.5 Fertility levels in different ethnic groups

The vast majority of China's population, 92%, is the Han Chinese ethnic group. The other 8% is made up of over 55 minority nationalities.

We use the average number of children ever born by women between the ages of 35 and 39 rather than merely at the age of 35 to estimate completed fertility rates for women from different ethnic groups (here we also adjusted to include births to women 40-49). The reason for using data for women aged 35-39 is that population data are too limited for some small ethnic groups, especially for 35-year-old women in a 1‰ sample of the 2000 and 2010 national population censuses; a 5-year population age group 35-39 provides data for a larger number of women in each ethnic group. Even after this measurement shift, the tiniest ethnic populations are still too small to report separately. Therefore, the populations of Lisu, the Wa and another 27 ethnic groups are grouped together as “Others” in figure 5. Women’s completed fertility rates exhibit convergence among the different ethnic groups from 2000 to 2010, declining to somewhere between 1.8 and 2.1 children ever born to women in 2010,

among which the fertility rate for the Korean ethnic group women is the lowest, followed by the Mongolian, Manchu, and Zhuang minority groups.

Figure 5. Comparisons of the Average Number of Children Ever Born by Women Aged 35-39 among Different Ethnic Groups



Source: Summary based on 1‰ sampling data from the 2010 national population census and 2000 national population census.

Note: The blue bar is the completed fertility rate estimated by the adjustment to the average number of children ever born by women aged 35-39 in 2010, the red bar is the completed fertility rate estimated by the adjustment to the average number of children ever born by women aged 35-39 in 2000, and the purple line is the percent decline in the completed fertility rate estimated by the adjustment to the number of children ever born by women aged 35-39 from 2000 to 2010, with the percent decline shown on the right vertical axis.

3.6 Fertility levels of the registered permanent resident population and the migrant population

According to question R6 of China's census questionnaire, which asks “the status of household registration,” there are two categories of the national population: one is the registered permanent resident population, which means people who live within their “hukou”

registered places or who have been gone from their permanent registration locations for less than 6 months; the other is the migrant population, which means people who have lived outside their “hukou” registered places for more than half a year. According to the scope of geographic migration, we can further divide the migrant population into three sub-categories: trans-provincial migrants, trans-county within province migrants, and trans-village within county migrants.

The fertility level of the migrant population is lower than that of the non-migrant population. Table 6 indicates that completed fertility rates of registered permanent-residential women and migrant women aged 35-39 are significantly different. Population flow is not only conducive to effective allocation of labour resources but also conducive to the stability of low fertility rates. China is entering the era of accelerated urbanization and the urban (defined as cities plus towns) proportion of the total population will reach approximately 60% by 2020, with 15 million migrants transferring from rural areas to urban areas each year.

Table 6 Comparisons of the completed fertility rate between the migrant population and the registered permanent resident population

| Age | trans-provincial migrant population | | trans-county within province migrants | | Trans-village within county migrants | | Total number of migrant population | | Registered residential population | |
|--------------|-------------------------------------|------|---------------------------------------|------|--------------------------------------|------|------------------------------------|------|-----------------------------------|------|
| | 2000 | 2010 | 2000 | 2010 | 2000 | 2010 | 2000 | 2010 | 2000 | 2010 |
| 35 | 1.68 | 1.49 | 1.55 | 1.37 | 1.36 | 1.39 | 1.48 | 1.38 | 1.80 | 1.54 |
| 36 | 1.75 | 1.52 | 1.68 | 1.46 | 1.34 | 1.35 | 1.51 | 1.39 | 1.85 | 1.56 |
| 37 | 1.76 | 1.53 | 1.72 | 1.49 | 1.37 | 1.38 | 1.53 | 1.40 | 1.90 | 1.58 |
| 38 | 1.90 | 1.58 | 1.84 | 1.53 | 1.43 | 1.38 | 1.61 | 1.41 | 2.00 | 1.61 |
| 39 | 1.98 | 1.62 | 1.84 | 1.51 | 1.49 | 1.42 | 1.65 | 1.43 | 2.03 | 1.62 |
| 35-39 | 1.78 | 1.54 | 1.70 | 1.47 | 1.39 | 1.39 | 1.54 | 1.40 | 1.90 | 1.58 |

Sources: these data are based on the 1‰ sample data of the 2000 and 2010 population censuses.

Note: the completed fertility rate estimated by the adjustment to the average number of children ever born by women aged 35-39 .

4. Conclusion

We have analyzed fertility levels and trends for China's population in the 1990s and the current century, demonstrating that the national level of fertility declined in the 1990s to about 1.52 births per woman in the years 1997-2002, an astonishingly low fertility rate for a developing country. China is now among the countries with low fertility well below replacement level. In 2003-4 there may have been a slight drop in period fertility, then a rebound to a period total fertility rate of around 1.52 again in 2005. From 2005 to 2010, China's fertility rate apparently continued a slow decline. The fertility levels and trends for China since 2010 are still unclear, though recent relaxation of strict limits on births beyond one per couple may cause stabilization or even a slight rise in China's fertility. We have shown that China's pattern of fertility decline in recent decades has been characterized by continuing fertility decline among almost all groups and places, but steeper fertility decline in those groups who started with higher birth rates, resulting in convergence of fertility rates. The gap is narrowing between various groups including: different geographic regions, urban and rural areas, different educational levels, various occupations, different ethnic groups, and between the migrant population and the registered permanent population.

The derivation of these robust results on China's fertility levels has relied heavily on data from the 2010 population census of China, as well as the 2000 population census and to a lesser extent the 1990 census. Census data utilized in the analysis included the population counts by single years of age and sex, the mortality data by single years of age and 5-year age groups, fertility data on children ever born by age of women, data on births by age of women in the year before the census, and children ever born to women age 35 and at other ages by province, educational level, ethnic group, residence and migration category, and urban compared to rural areas.

The incredible usefulness of data from China's decennial censuses highlights the importance of making the data readily available to scholars throughout China and the world. Fortunately, China's National Bureau of Statistics has released data and statistics in myriad forms from the 1982, 1990, and 2000 censuses, including electronic data from the census tables and microdata available for scholarly analysis worldwide through IPUMS (Integrated Public Use Microdata Series) International, based at the Minnesota Population Center at the University of Minnesota, USA. Unfortunately, China's Statistical Bureau has not yet released such microdata from the 2010 census to IPUMS, and other forms of data from the 2010 census are also hard to get, even for analysts in China and especially for analysts abroad. We were able to get the use of electronic microdata from China's 2010 census only because of our personal direct access to our colleagues at the National Statistical Bureau in Beijing. Few other Chinese or foreign scholars can get such access to 2010 census data or other

important data compilations for years since 2000, thus hampering domestic and global understanding of the demography of China in this century.

We have shown that scholars who argue for the usefulness of China's decennial census data for estimating China's fertility levels and trends are indeed correct. However, the censuses are taken only every 10 years. In addition, census data are imperfect, as shown by the necessity to adjust the count of children age 9 for undercounting in every census. The completeness of the counts of younger children, and of births in the year before the census, are even more underreported.

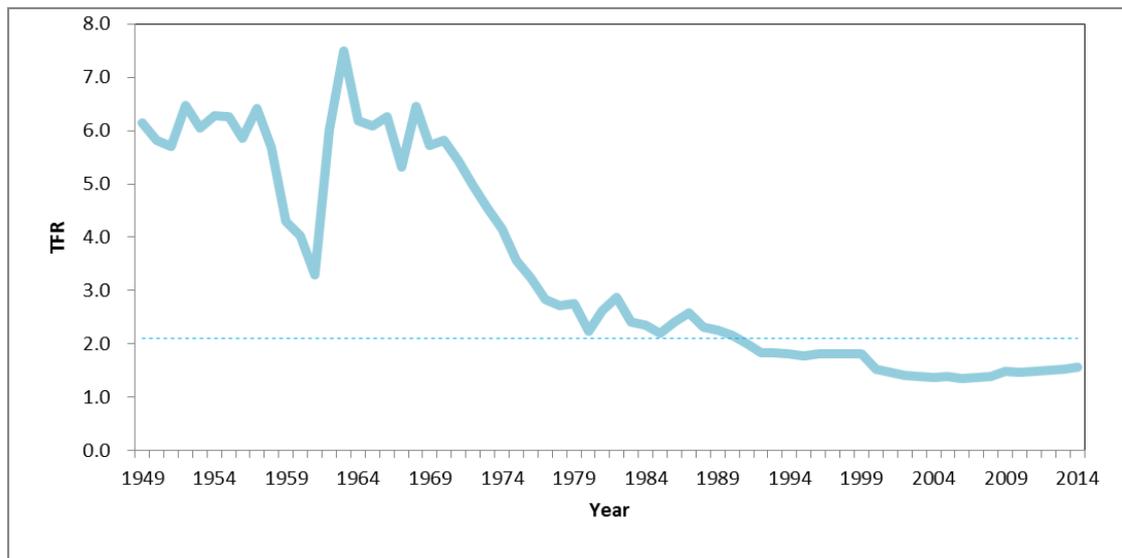
Therefore, we have demonstrated that some annually collected and reported data can also be used to estimate fertility in China, even though they are systematically either underreported or overreported or overadjusted. By comparing the data sources one with another, we can tease out the best fertility estimates from the available data. For example, we used Ministry of Education primary school enrollment data of children age 9 and discovered, by comparison with the adjusted census count of children age 9, that the annual enrollment data are a slight overcount of China's children age 9. However, after a small correction, the enrollment data are very useful for deriving levels and trends of China's fertility 9 years earlier when the children were born. This analysis confirms the conviction of those scholars who support the use of Ministry of Education enrollment data for estimating China's fertility, with the caveat that a minor adjustment is needed for overreporting of the number of children age 9 each year.

In addition, we have seen that the official annual fertility data for China collected from all provinces and adjusted by the National Bureau of Statistics are useful for showing macroscopic general fertility trends in China. This series could be made much more accurate and useful if the NBS reassessed the amount of upward adjustment it makes to the annually collected fertility numbers. Numerous Chinese and foreign scholars have undertaken and published excellent analyses of fertility levels and trends in China, thus providing for NBS the basis for fine tuning historical and current figures for China's actual birth rates and total fertility rates.

The total fertility rate in China has decreased rapidly since the 1970s because of the Family Planning Policy. It decreased to replacement level in the 1980s, and to below replacement level in the 1990s and continued to decline to less than 1.5 births per woman in recent years (figure 6). Zeng (1992), Zhu (1989) and Zha (1996) have analysed the process of population transformation according to population birth rates, total fertility rates and childbearing policies. For western industrialized countries to complete their demographic transition took seventy to eighty years and in some cases even one hundred, whereas in

China, it took only about thirty years to realize rapid and wide-ranging population transition. Freedman (1995) argues that apart from famine, plague and war, there has never been such a rapid decline in fertility levels in human history as in China.

Figure 6 The Change of Women’s Period Total Fertility Rate Since 1949



Sources: Combination of the national fertility sample surveys and our estimation.

Note: the solid line is the annual period total fertility rate since 1949, and the dashed line is the replacement value of total fertility rate.

The primary reasons for the rapid decline in China's fertility level are very complex and have been the focus of much research in academia. The development and modernization of the economy and society as well as the long-term family and birth planning policies may have worked together to help cause China's low fertility rate. In China, the effect of family planning work has had a close relationship with economic growth, history, national characteristics, local customs and so forth. The improving quality of the population and the development of the family economy have made family planning policy effective in China. With the continuous diffusion of economic and social development, urbanization, television, the internet and other information technology to the western regions and to impoverished

areas, there has been considerable convergence in fertility levels between urban and rural areas and among different ethnic groups as well as among all the geographic regions.

We have explored only the main factors that could possibly affect fertility levels. To precisely understand what and to what extent each factor influences the fertility level, we should consider confounding and extraneous variables by employing multi-statistical methodologies, based on microdata that could be made widely available to experts at home and abroad.

According to “the decision of the Central Committee of the Communist Party of China on major issues concerning family planning reform” issued in 2013, a couple was allowed to have two children if one of them is the single child of his or her parents. Policies on the adjustment and improvement of family planning proposed by the State Council suggest that we should have solid and safe adjustment and perfection for fertility policies, as well as moderately stable and low fertility level, in order to ensure the goal of total population control. In October 2015, the eighteenth National Congress of the Communist Party of China fifth plenary communique has proposed the full implementation of the “two children” policy. Table 7 shows that it is estimated that after the full implementation of two children policy, the total fertility rate will increase to around 2.1. However, childbearing behaviour in China is facing uncertainties. In a period of time, Chinese government needs to establish population monitoring and early warning mechanisms, strengthen surveys on the demographic transition, improve information reporting systems on births, and facilitate access to databases of basic information on the national population, in order to realize information sharing among marriage, childbearing and household registration statistical systems.

Table 7. The Period Total Fertility Rate Projected Under Various Scenarios

| Year | Policy Without Change | Full Implementation of Two-child policy | | |
|------|-----------------------|---|--------------------------|-----------------------|
| | | Radical Scenario | Moderate Scenario | Conservative Scenario |
| 2017 | 1.66 | 2.05 | 1.97 | 1.89 |
| 2018 | 1.65 | 2.19 | 2.09 | 1.99 |
| 2019 | 1.65 | 2.14 | 2.04 | 1.95 |
| 2020 | 1.61 | 2.07 | 1.96 | 1.87 |

| | | | | |
|------|------|------|-------------|------|
| 2021 | 1.61 | 1.83 | 1.77 | 1.72 |
|------|------|------|-------------|------|

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References

- Banister, J., and Hill, K. (2004). Mortality in China 1964-2000. *Population Studies*, 58(1): 55-75.
- Cai, Y. (2009). Do Enrolment Statistics Provide a Gold Standard for Chinese Fertility Estimates? *Population Research*, 4: 22-23.
- Cai, Y. (2010). China's Below-Replacement Fertility: Government Policy or Socioeconomic Development? *Population and Development Review*, 36(3): 419-440.
- Cai, Y. (2013). China's New Demographic Reality: Learning from the 2010 Census. *Population and Development Review*, 39(3): 371-396.
- Chen, W. (2014). China's Fertility in 2010: An Indirect Estimation Using Brass P/F Ratio Method. *Population Research*, 6:16-24.

- Cui, H., Xu, L., and Li, R. (2013). An Evaluation of Data Accuracy of the 2010 Population Census of China. *Population Research*, 1: 10-21.
- Feeney, G., and Yuan, J. (1994). Below Replacement Fertility in China? A Close Look at Recent Evidence. *Population Studies*, 48(3): 381-394.
- Freedman, R. (1995). Asia's recent fertility decline and prospects for future demographic change. *Asia-Pacific population research reports*, No. 1. Program on population, East-West Center.
- Guo, Z. (2002). Limitation and Improvement of Total Fertility Rate. *Population Research*, 5: 24-27.
- Guo, Z. (2004). A Further Discussion on China's Fertility in 1990s. *Population Research*, 4: 14-24.
- Guo, Z. (2010). Low Fertility Level and Other Related Population Issues in China. *Academia Bimestrics*, 1: 5-25.
- Guo, Z. (2011). 2010 Population Census Data Indicates Serious Miscount in Past Population Estimation and Projection. *Chinese Journal of Population Science*, 6: 2-13.
- Guo, Z. (2015). A Clear Understanding of the Risk of Low Fertility In China. *International Economic Review*, 2:100-109.
- Hao, J., and Qiu, C. (2011). A Comparative Analysis of the Fertility of the Urban and Rural Areas in China Since 2000. *South China Population*, 5: 27-33.
- Li, H., and Li, L. (2012). Estimating China's Fertility Level Since 2000: Based on the 6th Population Census. *Chinese Journal of Population Science*, 5: 75-83.
- Merli, M. G., and Morgan, S. P. (2011). Below Replacement Fertility Preferences in Shanghai. *Population*, 66(3): 519.
- Ministry of Education of China (2014). *Educational Statistics Yearbook of China*. Beijing: People's Education Press.
- Morgan, S. P., Guo, Z., and Hayford, S. R. (2009). China's Below-Replacement Fertility: Recent Trends and Future Prospects. *Population and Development Review*, 35(3): 605-629.
- National Statistical Bureau of China (1993). *Major Figures on 1990 population census of China*. Beijing: China Statistics Press.

National Statistical Bureau of China (2002). *Major Figures on 2000 population census of China*. Beijing: China Statistics Press.

National Statistical Bureau of China (2011). *Major Figures on 2010 population census of China*. Beijing: China Statistics Press.

Wang, F., Cai, Y., and Gu, B. (2013). Population, Policy, and Politics: How Will History Judge China's One-Child Policy? *Population and Development Review*, 38: 115-129.

Wang, F. (2015). China's Long Road toward Recognition of Below-Replacement Fertility. *Low and Lower Fertility*, 15-31.

Wang, J., and Ge, Y. (2013). Assessment of 2010 Census Data Quality and Past Population Changes. *Population Research*, 1: 22-33.

Yang, F., and Zhao, M. (2013). China's Fertility Level Since 2000: A Reestimation. *Population Research*, 2: 54-65.

Zeng, Y. (1992). *Family dynamics in china: A life table analysis*. The university of Wisconsin, 1992.

Zha, R. (1996). Reexamine the features of Fertility Transition in China. *Population & Economics*, 2: 1-11.

Zhai, Z., et al. (2015). China's Recent Total Fertility Rate: New Evidence from the Household Registration Statistics. *Population Research*, 6: 22-34.

Zhang, G., and Zhao, Z. (2006). Reexamining China's Fertility Puzzle: Data Collection and Quality over the Last Two Decades. *Population and Development Review*, 32(2): 293-321.

Zhao, Z., and Zhang, X. (2010). China's Recent Fertility Decline: Evidence from Reconstructed Fertility Statistics. *Population* (English Edition, 2002-), 65(3): 451-478.

Zhu, G. (1989). View on Demographic Transition. *Population & Economics*. 2: 31-38.

Zhu, Q. (2012). Estimation on Fertility Level in China 2000-2010: Preliminary Study Based on the 2010 Population Census. *Chinese Journal of Population Science*, 4: 68-77.