China's New Demographic Reality: Learning from the 2010 Census
Author(s): Yong Cai
Source: *Population and Development Review*, Vol. 39, No. 3 (SEPTEMBER 2013), pp. 371-396
Published by: Population Council
Stable URL: https://www.jstor.org/stable/23655331
Accessed: 05-10-2019 13:08 UTC

China's New Demographic Reality: Learning from the 2010 Census

YONG CAI

CHINA CARRIED OUT its sixth modern population census in 2010. It was a massive operation, mobilizing over 6 million enumerators to visit more than 400 million households, recording a total of 1.34 billion people. Enough census data are available to provide a panoramic view of the country's demographic situation in the first decade of the twenty-first century. That is my aim in this article.

In brief, the census confirms that China has firmly entered the era of demographic modernity and depicts the continuing vast transformation the country is undergoing in its regional and rural–urban distribution. China's population has grown since the last census (2000) at an annual average rate of 5.7 per 1000, down from 11.0 in 1990–2000 and 14.4 in 1980–90.[1] Life expectancy has improved by 3–4 years during the decade to levels around 74 and 77 years for males and females. Fertility remains well below replacement level—probably as low as 1.5 births per woman—and there is still a significantly elevated sex ratio at birth. Low fertility and falling old-age mortality make for continued and rapid population aging, with proportions aged 60 and over rising 3 percentage points in the decade to 13 percent in 2010. Internal migration maintains its pattern of strongly favoring major coastal regions and to a lesser degree the far west. Shanghai and Beijing grew by some 40 percent over the decade. In contrast, a number of inland provinces, notably Sichuan, Hubei, and Chongqing, have recorded actual population decline—a trend likely to persist and perhaps extend to other provinces. And China has reached an overall urban proportion of 50 percent.

I start with a discussion of enumeration procedures adopted in the census, then proceed to more detailed analysis of the population age structure, mortality, fertility, the sex ratio, and regional distribution. For the most part, the discussion is restricted to the national level. As with all censuses, problems of underenumeration and other data quality issues arise, complicating the analysis and often calling for adjustments to estimates derived from the raw data. How best to make such adjustments can be a lively source of controversy.

Challenges in enumerating an increasingly mobile population

Adding to the challenge of enumerating more than one billion people is the increasing mobility and diversity of the Chinese population. Three decades ago, population data from China were praised for their overall quality (Coale 1984), a result of China's then relatively immobile society, tightly controlled by a rigid household registration (*hukou*) system and the widespread use of lunar and astrological dating of births that facilitated reliable age counting. Subsequent economic liberalization and relaxation of migration controls facilitated population mobility. The *hukou* system is the backbone of China's population statistics, including censuses and household surveys. With more and more people, particularly peasants previously bound to farms, leaving their registered home areas to live and work in other locations, the *hukou* system became less capable of providing timely information concerning people's whereabouts. People on the move are more likely to be missed or misclassified. Data quality, especially the possibility of large-scale underenumeration, has been a major concern of researchers in the field of Chinese demography over the past two decades (e.g., Feeney and Yuan 1994; Goodkind 2011).

The implementation of the one-child policy since 1980 has further increased the problem of underenumeration (Goodkind 2004; Merli and Raftery 2000; Zeng et al. 1993). The government has relied heavily on the *hukou* system to implement the one-child policy (Wang 2005; Gu et al. 2007). Not only does the system provide the basis of assigning a family's qualification for birth quotas, it is also used to punish families with children born outside of official quotas. Such children are routinely denied registration and thus denied access to many government benefits and social services, including public education and health care. The monitoring and punishment associated with the one-child policy also give both families and local government strong incentives to hide so-called out-of-plan births (Merli 1998; Scharping 2003, 2007). Analyses have shown that a substantial proportion of births and children were missed by the 1990 and 2000 censuses (Cai and Lavely 2003; Goodkind 2011; Zhang and Cui 2002).

China's 2010 census took three major steps to address the problem of underenumeration. First, unlike the previous ones, the 2010 census registered both *de jure* and *de facto* populations: everyone was recorded at the place he/she was on the evening of October 31, 2010, regardless of the person's household registration locale, and everyone was also recorded at his/her household registration place no matter where he/she was that night. A computer algorithm was then used to determine where a person should be counted as a resident. This new method was designed to minimize underenumeration of migrants who live in a place different from their official *hukou*—a major problem encountered in previous censuses, especially in 2000 (Zhang and Cui 2002). In

the period leading up to enumeration in all previous censuses, census-takers had to carefully check everyone's status to determine who should be counted. More specifically, census-takers had to first judge whether to include a person based on the person's *hukou* status and how long ago he/she had left his/her registration place to ensure that each person was counted only once. Those assessments were time consuming and subject to error, often undercounting (Lavely 2001). Mandating *de facto* and *de jure* counts greatly diminished the chance of underreporting. Of course, this new method increases the risk of double counting.

Second, families with children born outside the quota were provided opportunities to register in the *hukou* system before the census. According to a report by China's official English-language newspaper *China Daily*, quoting Gu Yanzhou, deputy director of the Beijing Statistics Bureau, "People who violated family planning policies can apply for household registration by taking the opportunities of the census." This was in fact a nationwide measure mandated by the Ministry of Public Security, the government agency in charge of the *hukou* system. Although the measure was not an amnesty for out-of-plan births, since birth control departments could still levy fines, it should have encouraged families to get their children registered in the system.[2]

Third, the census put special emphasis on enumerating everyone, with or without *hukou*. In the census manual, census-takers were reminded to check and register all out-of-plan births without *hukou*. The census also promised confidentiality in stating that it would not pass on such information to birth control organizations as a basis for fines. According to Ma Jiantang, Commissioner of the National Bureau of Statistics (NBS), the 2010 census enumerated 13 million people with a pending household registration, a majority of whom were out-of-plan births.[3] In comparison, the number of people in the 2000 census with "pending household registration" was 8 million.

In addition to these specific measures to improve census quality, some institutional arrangements favored accurate enumeration. The implementation of the census was led by the NBS under the aegis of the Leading Group for the 6th Population Census, a special office established within the State Council that involved 25 government agencies to coordinate the census. The group was headed by Vice Prime Minister Li Keqiang. Similar offices were also established at lower levels of government. The massive bureaucratic system that penetrates every layer of Chinese society, in combination with an all-out mobilization campaign, encouraged full participation in the census.

Moreover, the use of new technology facilitated data gathering and cross-validation. Advances in information technology have greatly reduced the costs of gathering and managing administrative data such as school enrollment, medical, and travel records, and has enhanced the control of data by the central government, which has long struggled with local authorities to acquire accurate information. Secondary and administrative data give the

central government new tools with which to cross-validate population information collected from the census.

The new approaches and new technology have given the Chinese government high confidence about the quality of the 2010 census data. Answering a question at the press conference on the release of the *Communiqué on Major Figures of the 2010 Population Census*, Zhang Weimin, NBS Deputy Commissioner, responded that "it's a top-quality census." He further explained, without giving details, that this assessment was based on two lines of evidence. First, the postenumeration survey estimated a 0.12 percent net underenumeration rate, far lower than the estimated 2000 rate of 1.81 percent. Second, internal examination suggested that the census data are consistent with administrative statistics collected from other sources, such as "household registration data, education statistics, birth data provided by the birth control authority, and mortality data provided by the civil affairs authority." Without further details on the postenumeration survey and these consistency checks, however, statements about census data quality should be regarded with caution.

Population totals and age structure

The release of census data followed a protocol similar to the one established by the previous three censuses, in 1982, 1990, and 2000. The first data release of the 2010 census came in the form of the aforementioned *Communiqué*. In June 2012, NBS released a three-volume compendium titled *Tabulation on the 2010 Population Census of the People's Republic of China*, including a digital version made available online at the NBS website. Provincial- and county-level tabulations are gradually being released.

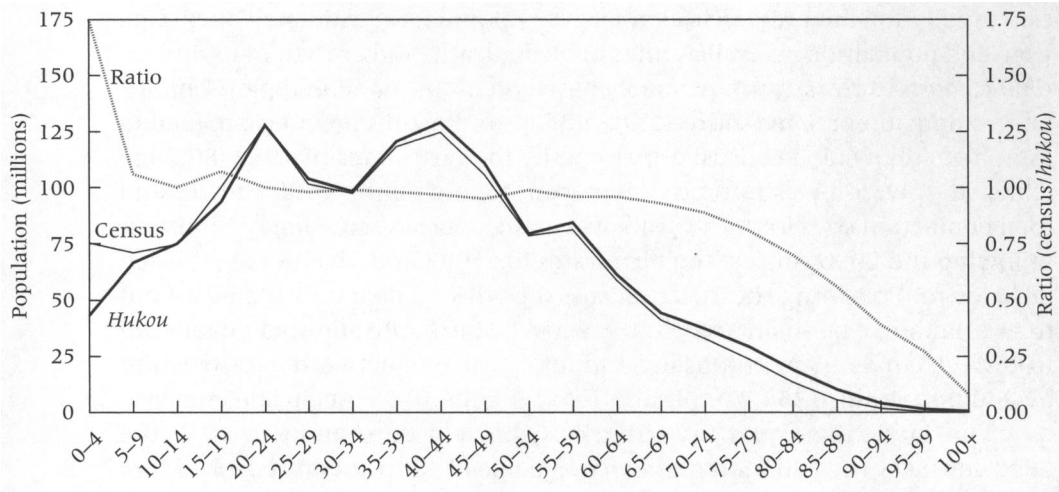
There are small but important discrepancies between the *Communiqué* and the *Tabulation*, as the *Communiqué* was based on the so-called quick aggregation—a summary of enumeration totals aggregated and submitted by local census organizations—and the *Tabulation* was based on a full computer tabulation of all returns. The total population for whom tabulation details were provided (1,335.1 million) is 4.6 million or 0.34 percent below the number released in the *Communiqué* (1,339.7 million). Examination of the population by region reveals that the two sets are virtually identical, except that the *Communiqué* includes 4.6 million "population with permanent residence difficult to define." Similar discrepancies have also appeared in previous censuses. For example, in the 2000 census, the total population enumerated (1,265.8 million) was 20.7 million more than the published tabulations (1,245.1 million, including 2.5 million in military service). Judging from that discrepancy, the 2010 census appears to be of better quality than the 2000 census. The analysis below uses the combined age and sex structure of the "National Population" and "Military Personnel"[4] and makes no adjustment for the 4.6 million.

The total population enumerated in the 2010 census is consistent with previous estimates provided by NBS. The NBS routinely provides the latest (usually for the previous calendar year) population estimates, including year-end population, as well as rates of birth, death, and growth in its annual *China Statistical Yearbook*, presumably based on its annual Population Change Survey and other related sources. The NBS also adjusts its previous population estimates following a census. For example, the birth rates of 1982–89 were adjusted upward by as much as 18 percent following the 1990 census; and total population sizes for those years were also adjusted accordingly. Similarly, following the 2000 census, the birth rates for 1998 and 1999 were adjusted downward. Following the 2010 census, the NBS made a minor adjustment to its estimate of population for 2009, with the birth rate adjusted downward from 12.13 to 11.95 per thousand and total year-end population downward by 240,000 (from 1,334.7 million to 1,334.5 million)—a negligible change.

One factor that could have contributed to a more accurate count in the 2010 census is the adoption and expanded use of China's National Resident ID system, particularly the introduction of the Second-generation Resident ID system. China introduced its National Resident ID system in 1984. Chinese citizens who are aged 16 or older can apply for their Resident ID card at their *hukou* place. The system started with some major design and implementation problems, such as a non-unique ID number and easy forgery. In 2003, China introduced a newer, machine-readable Second-generation Resident ID card with an embedded IC-chip. The new ID card uses a revised coding system to avoid the problem of non-unique numbers. With the IC-chip, along with other anti-counterfeiting measures, the newer card is more difficult to forge. The Resident ID card is now widely used and is often the only acceptable legal document for social, governmental, and commercial services, such as marriage, employment, banking, passing security checkpoints at airports, and buying train tickets. The National Resident ID system has made it much easier to maintain and update China's *hukou* system, which itself has undergone digitization over the past decade. With an improved information infrastructure, the Ministry of Public Security has established a National Citizen ID Information System (NCIIS) that allows for real-time identity checking.

The population age structure from the 2010 census closely matches that from the *hukou* system. Figure 1 compares the age structure recorded in the *hukou* system with that enumerated in the census. The household registration data are from the Ministry of Public Security's NCIIS database with a standard time of June 30, before it completed its system-wide "rectification" prior to the 2010 census.[5] The "rectification" was designed to clean and update the *hukou* system in preparation for the census, similar to what was done in previous censuses (Lavely 2001). Overall, the two data sources display great consistency, especially in the middle part of the age distribution. The disparities for young and old ages are substantial but not

FIGURE 1 Comparison of China's population age structure in 2010, census vs. *hukou*



NOTE: The standard time for the census data is 1 November 2010. The standard time for the *hukou* data is 1 July 2010. No adjustment is made to synchronize the comparison cohorts.
DATA SOURCES: Census data: NBS 2002, 2012; *hukou* data: National Citizen ID Information System (NCIIS).

unexpected. For the age group 0–4, the count in the census is 75 percent larger than registered in the *hukou* system. For the population aged 60 and above, consistency levels drop as age increases. For example, for ages 60–64, the census count is 96 percent of the registered population; for ages 80–84, the ratio declines to 70 percent, and for ages 90–94, to 39 percent. The reason behind such an age pattern is rather simple: the *hukou* system is usually slow to register newborns and young children, and slow to purge the dead, both of which require administrative paperwork and bureaucratic action.

The consistency between the census and the *hukou* system, as shown above, inspires confidence in the census data. The good quality of Chinese census work has always depended on public security systems (namely the *hukou*, administered by the police). The growing sophistication of the Chinese security state (with ID cards and real-time identity checking) is further increasing census accuracy. However, because the census and *hukou* system are not entirely independent of each other, the consistency between them is not a sufficient measure of census validity. The intercensal survival analysis conducted below allows a further examination of the 2010 age structure and the trends in mortality and population aging revealed by the census.

Intercensal survival, mortality, and population aging

Because Chinese censuses also collect information on deaths in the year prior to the census, intercensal survival analysis, in combination with mortality

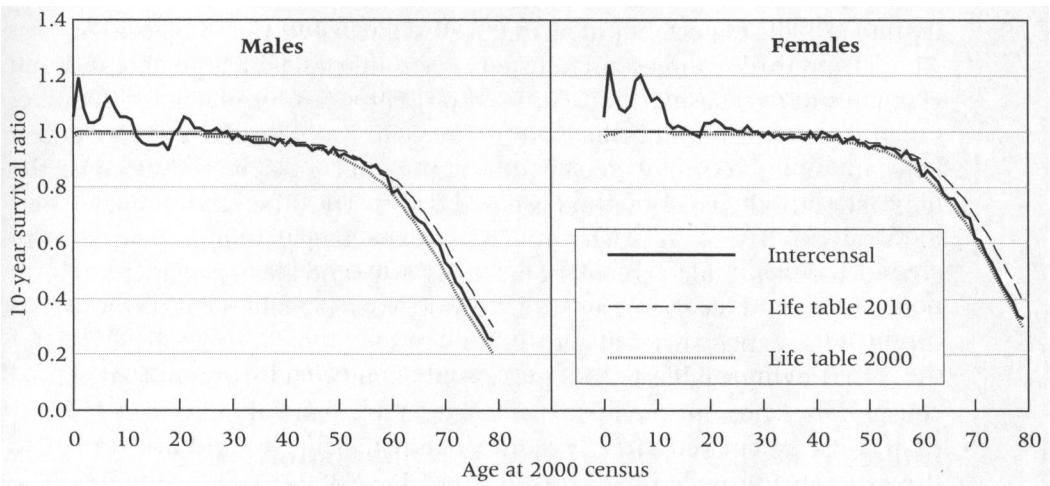
analysis, provides both a check of the completeness of population enumeration and an assessment of mortality reporting. Previous studies have shown that population data from China are of reasonable quality at adult ages (e.g., Banister and Hill 2004; Coale 1984; Coale and Banister 1994).

Figure 2 presents an intercensal analysis between 2000 and 2010, together with ten-year life-table survival ratios based on unadjusted mortality rates from the 2000 and 2010 censuses. The life expectancies at age 0 (e_0) using unadjusted census mortality rates are 70.7 and 74.3 years for males and females born in 2000 and 75.6 and 80.4 years for males and females born in 2010. Several observations can be made based on Figure 2.

First, for both males and females, survival ratios beyond age 40 accord closely with life-table age patterns. For males, the survival ratio line falls between the two life-table lines, suggesting consistency between age-structure data and mortality data from these two censuses. For females, the survival ratio line is much closer to the 2000 census life-table line than to the 2010 life-table line, suggesting that mortality for females is likely underreported in the 2010 census. Because this analysis is based on single-year age data without smoothing, the remarkable consistency once again confirms the good quality of Chinese age reporting.

Second, in line with conventional wisdom that young children are more likely to be underreported in China's current population statistics, Figure 2 suggests there was significant underreporting of children in the 2000 census and that the underreporting is more substantial for females than males. For females, underreporting is as high as 25 percent (at age 1 in 2000), with an average of 13 percent for ages 0–9 in 2000; for males,

FIGURE 2 Intercensal survival ratio by sex and birth cohort, China 2000–2010



DATA SOURCES: Intercensal survival ratios are calculated from two censuses using data taken from census tabulations (including population in military service). Life-table survival ratios are calculated from unadjusted life tables using mortality rates from the census tabulations.

maximum underreporting is about 20 percent (at age 1 in 2000), with an average of 8 percent for ages 0–9 in 2000. While levels of underreporting differ, male and female underreporting have parallel age patterns. Both the level and age patterns of underreporting are similar to what was observed in comparing the 1990 and 2000 censuses (Cai and Lavely 2003; Zhang and Cui 2002).

Finally, there are some large mismatches between the two censuses in the age range 10–39 (in 2000), especially around age 20. For males, the survival ratio dips below life-table lines for most of the teenage years, but stays above life-table lines in the 20s and drops below them in the 30s. For females, the mismatches are similar but less substantial across these three age groups. The mismatches could be caused by enumeration problems in one or both censuses; it is not possible to identify the underlying causes without a third set of data. Nevertheless, one may speculate that these mismatches are likely due to some systematic problems, given their strong age patterns. I will return to this issue in the later discussion of sex ratios.

Building on visual examination of Figure 2, I apply the general growth balance (GGB) method developed by Hill (1987) for both data assessment and mortality estimation. Banister and Hill (2004) demonstrated that this method is well suited for Chinese data. In light of concerns about data quality for persons below age 40 in 2000, this application uses data for ages 40–79, instead of ages 15–69 as suggested by Banister and Hill. The application shows that the two censuses have comparable coverage for both males and females in population enumeration.[6] Death registration is more complete for males than females, in accord with Figure 2.[7] The GGB method estimates life expectancy at birth of 72.5 for males and 76.1 for females for the 2000–2010 intercensal period.

Table 1 compares three sets of key life-table measures: the infant mortality rate (q_0), life expectancy at birth (e_0), and life expectancy at age 40 (e_{40}) for China from three sources: unadjusted census figures, NBS adjustments,[8] and estimates derived using the GGB method. The GGB estimates for 2000 are taken from Banister and Hill (2004). The GGB estimates for 2010 assume a constant rate of mortality decline during the intercensal period. Because the application of the GGB method is based on the presumed more reliable part of the census data, that is, ages 40–79, life expectancies at age 40 are shown. Also included in Table 1are infant mortality rates and life expectancies at birth matched from Coale–Demeny (1983) Model West life tables with corresponding GGB life expectancies at age 40.

As shown in Table 1, NBS makes only a minor adjustment to the 2000 census data. The adjusted life expectancies at birth are about one year lower than those calculated directly from unadjusted figures and are similar to the estimates provided by Banister and Hill's (2004) GGB estimates. The high female infant mortality rate is one noticeable discrepancy between the

TABLE 1 Comparison of infant mortality rates and life expectancy at birth and at age 40, by sex: China 2000 and 2010

		Males		Females	
Rate	**Source of estimate**	**2000**	**2010**	**2000**	**2010**
q_0	Unadjusted census data	20.5	4.3	28.4	4.4
	NBS adjustment	23.9	13.6	33.8	14.3
	GGB	22.7	8.4	33.5	12.5
	MW-GGB	26.5	11.8	16.0	7.3
e_0	Unadjusted census data	70.7	75.6	74.3	80.4
	NBS adjustment	69.6	72.4	73.3	77.4
	GGB	69.7	74.1	72.8	77.4
	MW-GGB	69.8	74.6	74.8	78.4
e_{40}	Unadjusted census data	34.6	38.0	38.5	41.6
	GGB	33.9	36.5	37.2	39.5

NBS: Adjusted estimates provided by the National Bureau of Statistics (NBS 2012).
MW-GGB: Matched values from Coale–Demeny (1983) Regional Model West life tables with the general growth balance(GGB) estimates of e_{40}.
DATA SOURCES: Unadjusted census data, NBS 2003, 2012.

mortality estimates from China and Coale–Demeny Model West, reflecting unfavorable female mortality attributable to a cultural bias against female infants (Cai and Lavely 2007). Although NBS provides no technical details on its adjustments, it is likely that the Bureau made its adjustment based on data from other sources such as mortality data from the Ministry of Health. It is also possible that NBS used demographic tools such as the GGB method to derive its estimates.

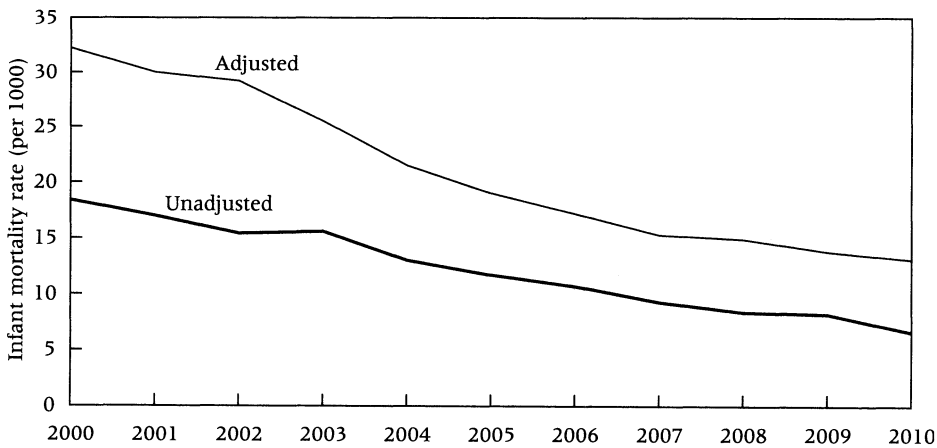
For the 2010 census, however, the NBS adjustments are much larger. The reported infant mortality rates from the 2010 census are only 4.3 per thousand for males and 4.4 per thousand for females, much lower than the corresponding numbers from the 2000 census. If those low rates are accurate, China would be among the countries with the lowest infant mortality in the world. Infant mortality from Coale–Demeny Model West matched with corresponding GGB e_{40} values suggests that underreporting could be substantial. NBS adjusted the infant mortality rates upward to about three times the census figures and adjusted life expectancies downward by about three years. The NBS adjustments are generally in line with GGB-based estimates, with the exception of life expectancy at birth for males, which is more than three years lower than the unadjusted figure and about two years lower than the GGB and GGB matched Model West estimates, suggesting that NBS might have over-adjusted for male mortality underreporting.

The NBS-adjusted infant mortality rates are very close to estimates provided by the Ministry of Health. The China Maternal and Child Health Surveillance Office (MCHSCN) under the Ministry of Health collects infant

mortality data through the National Maternal and Child Health Surveillance Network. It publishes selected unadjusted data in its bi-monthly newsletter and adjusted numbers in the *China Health Statistical Yearbook*. Figure 3 presents infant mortality data from the Ministry of Health for the years between 2000 and 2010. For 2010, the infant mortality rate derived from the MOH's surveillance network is 6.6 per thousand for both sexes. MCHSCN (2011) judged that this rate was too low and adjusted infant mortality upward by nearly 100 percent to 13.1 per thousand. Figure 3 shows a steady infant mortality decline from 2000 to 2010: from 18.4 to 6.6 with unadjusted statistics, and from 32.2 to 13.1 with adjusted numbers. The close concordance between the MOH adjustment and the NBS adjustment is probably not a coincidence.

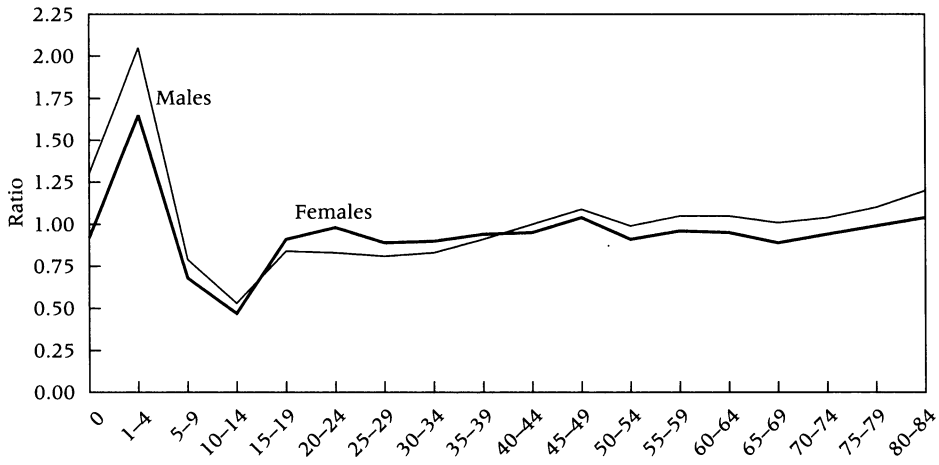
Another source that can be used to cross-validate mortality reporting in the census is the Ministry of Health's age- and cause-specific mortality data. Since 2006, the Ministry of Health has published such data gathered from selected regions. For example, the 2010 data come from ten major cities, nine regional cities, and 34 counties. Figure 4 contrasts the mortality age pattern in the MOH data with that from the 2010 census by calculating the ratio of the two sets.[9] A ratio of 1 suggests perfect consistency between the two sources; a ratio above 1 indicates a lower mortality rate reported in the census. Figure 4 shows that the main difference between the two sources is in infant and child mortality. Mortality rates for ages 5–9 and 10–14 reported by the MOH are only about 75 percent and 50 percent, respectively, of those reported in the census, but for ages 1–4 the MOH rates are far above the census rates. For age 15 and above, the two sources have a reasonable consistency, while

FIGURE 3 Infant mortality reported by the Ministry of Health, China 2000–2010



DATA SOURCES: Adjusted infant mortality rates from the *China Health Statistical Yearbook*; unadjusted rates from Newsletter of China Maternal and Child Health Surveillance Network, 2010(5) and 2011(4).

FIGURE 4 Ratio of age-specific mortality rates: Ministry of Health registry vs. census data, China 2010



DATA SOURCES: Age-specific mortality rates from *China Health Statistical Yearbook* (2011) and the 2010 census.

displaying some small difference by sex. The difference between the two sources can be attributed not only to how death is recorded, but also to how the at-risk population is calculated. Because the MOH published its 2010 mortality data before the release of the 2010 census, it must have used data from the 2000 census or from *hukou* registration as the base population; and as I noted earlier, accurately counting infants and children has posed a major challenge for China. Nevertheless, the real difference between the two sources is actually smaller than the impression given by Figure 4: the difference in life expectancy at birth calculated from the two sources is only about half a year.

The comparison of three sets of mortality measures—those taken directly from the censuses, those based on intercensal analysis, and those from the MOH's reporting—reveals problems in China's mortality and population data, especially the counting of infants and children. However, it confirms China's mortality age pattern and continued improvement in health. The data suggest that mortality reduction was substantial between the 2000 and 2010 censuses. Before adjusting for mortality underreporting, the census data show a gain in life expectancy of 5 years for males and 6 years for females in the decade between the two censuses. The NBS adjustment lowers the increase to 3 and 4 years for males and females. Data comparison suggests that the NBS might have over-adjusted for male mortality underreporting.

Even after NBS's major adjustment, life expectancies at birth in China still rose at a higher rate than the world average of about 1.5–2 years per decade (Bongaarts 2006; Oeppen and Vaupel 2002; UN 2011). Such a speedy decline of mortality, however, is not unexpected for China. Not only did

China experience rapid economic growth for the entire intercensal decade, it also implemented a major reform of its health care system that has greatly expanded its coverage. Both factors no doubt had positive effects on population health and mortality reduction. Moreover, rapid declines in mortality have also been observed in other Asian countries. For example, between 1980 and 2010, South Korea's life expectancy at birth increased from 66 to 81, averaging 5 years per decade; the corresponding increase was nearly 4 years per decade for Indonesia and over 3 years per decade for India, according to data assembled by the World Bank (2012).[10] In recognition of China's rapid mortality reduction, the UN's 2012 revision of *World Population Prospects* adjusted China's current life expectancy at birth upward by almost two years compared with the 2010 revision.

Partly as a result of this rapid improvement in life expectancy, China's population aged rapidly between the 2000 and 2010 censuses. As highlighted in the *Communiqué*, the population at age 60 and above reached 178 million, or 13.3 percent of the total population in 2010, up by 2.9 percentage points in one decade; the population at age 65 and above exceeded 120 million, or 8.9 percent of the total population, up by 1.9 percentage points as compared with the 2000 census.

Even with this rapid mortality reduction, mortality's direct contribution to aging is still relatively small in comparison to the more pronounced effect of fertility change. A simple standardization exercise which assumes that mortality remains at the level observed in the 2000 census suggests that only 6 percent of the increase in the population aged 60 and above and 8 percent of the increase at age 65 and above is the result of mortality reduction. The rest is attributable to the change in population age structure driven mostly by fertility decline. Nevertheless, continued mortality reduction will have a greater effect on population aging in the long term.

Fertility and the sex ratio

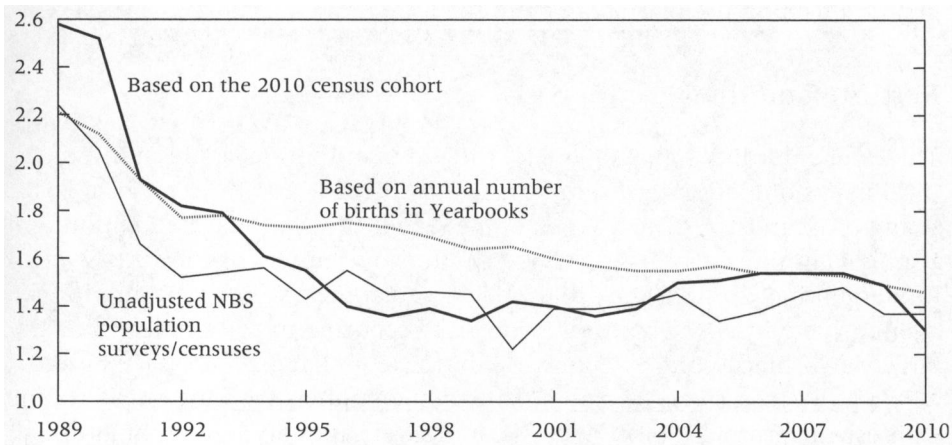
The level of fertility has been one of the most contentious issues in the study of China's population in recent decades (Guo 2011, 2013; Gu and Cai 2011; Wang, Cai, and Gu 2013). On the one hand, the National Population and Family Planning Commission (NPFPC), the government agency in charge of implementing China's one-child policy, and some experts working for the agency, have insisted that the low fertility reported in the Chinese data are largely an artifact of underreporting of births (e.g., Jiang 2006; NPDSRG 2007; NPFPC 2007); on the other hand, many demographers working outside of the Chinese government, both domestic and international, argue that although underreporting exists, China has indeed experienced a major transition to below-replacement fertility (e.g., Cai 2008; Gu and Cai 2011; Guo 2013; Morgan, Gu, and Hayford 2009; NBS and EWC 2007; Retherford et al. 2005; Zhang and Zhao 2006). In addition to the more than three decades of the

one-child policy, such a transition has unfolded in a context of widespread socioeconomic changes related to urbanization, industrialization, economic liberalization, and expansion of education. All of these transformations exert pressure on the traditional family and reproductive institutions and are thus conducive to very low levels of fertility (Cai 2010; Gu and Wang 2009; Zheng et al. 2009).

The 2010 census provides new evidence of low fertility in China over the past two decades. Figure 5 compares three estimates of the TFR. The first is a series calculated from unadjusted age-specific fertility rates from China's annual population surveys/censuses. Applying the same fertility schedule to corresponding reproductive-age women as enumerated in the 2010 census, it is possible to derive two other sets of TFR estimates: one based on the annual number of births reported in the *China Statistical Yearbooks*, and another matching the birth cohort size reported in the 2010 census. As mentioned earlier, the numbers of births reported in the *China Statistical Yearbooks* are adjusted figures based on internal evaluation by the NBS.[11]

These three estimates each indicate that fertility in China fell below replacement in the early 1990s. The paths taken thereafter were different in the three sets of estimates. The NBS estimates suggest a gradual fertility decline. The data from population surveys and censuses show small fluctuations and stabilization at a lower level for most of the 1990s and 2000s. The 2010 census cohort estimate indicates that a speedy decline continued until 1997 when the TFR dropped below 1.4, followed by a small recovery in the first decade of the new century. The sudden drop of the 2010 cohort trend line in the last

FIGURE 5 Total fertility rate by year, China 1989–2010



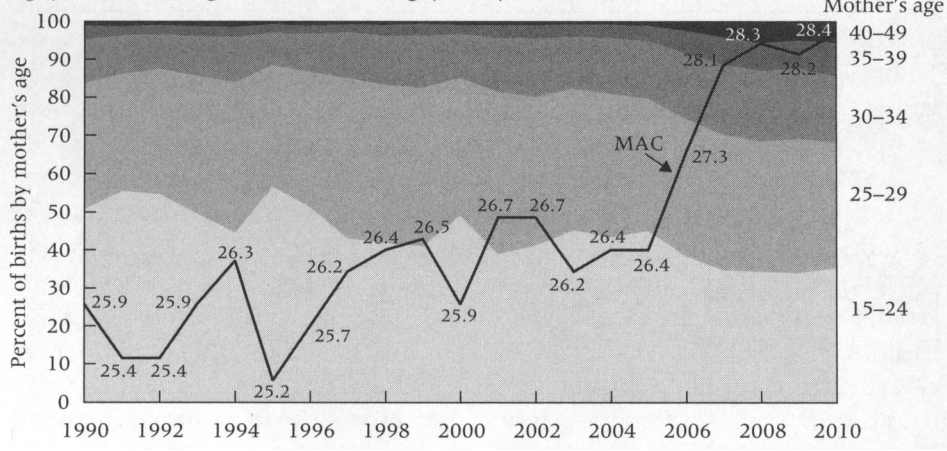
DATA SOURCES: TFR based on unadjusted NBS population surveys/censuses calculated from age-specific fertility rates published in the *China Population Statistical Yearbook*. TFR based on annual number of births derived from annual births in the *China Statistical Yearbook* using women's age structure from the 2010 census. TFR based on 2010 census cohort derived from cohort size enumerated in the 2010 census using women's age structure from the 2010 census.

year likely indicates a repetition of the underenumeration of infants, which has been seen in previous censuses. All three estimates agree that fertility in China by the time of the 2010 census was around 1.5 or lower.[12]

Examination of the data on the age pattern of fertility suggests that the very low fertility observed in the late 1990s and the small reversal of fertility in the first decade of the twenty-first century could be partially attributed to a tempo distortion. Figure 6 indicates the percent of births by mother's age and the mean age at childbearing from 1990 to 2010. The mean age at childbearing has risen to over 28 years. The increase started with a gradual rise with fluctuation up to 2005, followed with a major jump and a leveling off. The distribution of mothers' age at childbearing shows a similar trend. At the end of the 1980s, 50 percent of births were to mothers aged 24 or younger. This proportion declined steadily over the next two decades. By 2010, it had fallen to less than 35 percent. At the same time, the proportion of births to mothers aged 30 and above increased from around 15 percent in the early 1990s to about 20 percent in 2005, and reaching 30 percent in 2009. The small increase in fertility in the first decade of the twenty-first century can be attributed to this change of fertility age pattern: after a decade-long delay, many women eventually had their births at ages that would previously have been regarded as late: in 2010, the mean ages of births at parities 1, 2, and 3+ were 26.7, 30.8, and 33.4.

Related to the debate on fertility level and underreporting is the increased sex imbalance of the population (South and Trent 2010; UNFPA 2012). China's sex ratio at birth has been above the normal level of around

FIGURE 6 Age pattern of fertility (percent distribution by mother's age) and mean age at childbearing (MAC), China 1990–2010



DATA SOURCES: Calculated using age-specific fertility data published in the *China Population Statistical Yearbook*.

105 males per hundred females since the early 1980s. While both the causes of the elevated level (strong son preference made manifest by constrained low fertility) and the main means of achieving it (sex-selective abortion) are generally agreed upon, its real scale is still inconclusive owing to the possibility of sex-selective underreporting of births (Zeng et al. 1993; Gu and Roy 1995; Poston et al. 2010). Comparison of data from the 1990 and 2000 censuses shows that over a quarter of all "missing" girls in the 1990 census were hidden in the population and reappeared in the 2000 census (Cai and Lavely 2003). It is possible the same sex-selective phenomenon could have been repeated between the time of the 2000 and 2010 censuses.

One major surprise in the 2010 census was a drop in the reported sex ratio of the total population. The population sex ratio increased from 106.3 in the 1982 census to 106.6 in 1990 and 106.7 in 2000, but fell back to 105.2 in the 2010 census. This drop is indicative of a potential data problem: while the sex ratio at older ages would be expected to decline because females tend to live longer, it is extremely unlikely to have caused such a pronounced shift in the sex balance, given the continued high sex ratio at birth.[13]

Closer examination suggests that the problem exists mainly in the enumeration of cohorts born in recent decades, especially in the 1980s. The intercensal survival analysis, shown in Figure 2, suggests that females have much higher survival ratios for cohorts born after 1980. This suggests that the 2010 census recovered a large proportion of "missing" girls who were hidden in the population, assuming the sex differential in the survival ratio is mainly caused by differential underreporting in the 2000 census. Table 2 presents both cohort sizes and sex ratios for cohorts born between 1971 and 2010 reported in the 2000 and 2010 censuses and in the 2010 *hukou* data. In total, the 2010 census enumerated about 13.9 million more females for cohorts born between 1971 and 2000, before taking into account the effect of mortality. In comparison, the 2010 census enumerated only about 4.6 million more males in those same cohorts. It appears that the 2010 census could have recovered as many as 10 million "missing" girls previously hidden in the population for cohorts born between 1981 and 2000. However, the sex ratio for persons born in 1981–85 and 1986–90 are too low to be plausible: 102.2 and 102.5. Assuming a normal sex ratio at birth of 105, the expected sex ratio at ages 20–30 should not be lower than 104, assuming a normal sex ratio of mortality. Given China's high sex ratio at birth and unfavorable infant and child mortality for females, the real sex ratio for this age group is certainly higher. The observed values of 102.2 and 102.5 are clear signs of a data problem. Thus the total scale of "recovered hidden girls" is certainly smaller than the 10 million suggested above.

One possible explanation is that the 2010 census underenumerated the male population born in 1981–90, that is, males in their 20s at the 2010 census. This is suggested not only by an unusual sex ratio in this age group, but also by the relatively low survival ratios compared with the surrounding

TABLE 2 Male and female population totals and sex ratios by birth cohort, China, 2000 and 2010 censuses and 2010 *hukou* registration

	2000 census			2010 census			2010 *hukou*		
Birth cohort	Males (millions)	Females (millions)	Sex ratio (males per 100 females)	Males (millions)	Females (millions)	Sex ratio (males per 100 females)	Males (millions)	Females (millions)	Sex ratio (males per 100 females)
2006–2010				41.1	34.5	119.1			
2001–2005				38.5	32.4	118.7			
1996–2000	37.7	31.3	120.2	40.3	34.6	116.2	40.5	34.6	117.1
1991–1995	48.3	41.9	115.4	52.2	48.0	108.7	49.5	44.1	112.4
1986–1990	65.3	60.1	108.8	65.0	63.4	102.5	66.1	62.0	106.7
1981–1985	53.7	50.2	107.0	51.3	50.2	102.2	53.3	50.5	105.5
1976–1980	48.7	46.7	104.3	49.8	47.6	104.5	50.0	48.3	103.6
1971–1975	60.7	57.4	105.7	60.5	57.7	105.0	61.2	59.2	103.3

NOTE: Because the 2000 and 2010 censuses use November 1 as the reference data, birth cohorts used here refer to census year, not calendar year. For example, the 2006–10 cohorts refer to persons born between 1 November 2005 and 31 October 2010.
DATA SOURCES: Census data: NBS 2003, 2012. *Hukou* data: National Citizen ID Information System (NCIIS).

cohorts. It is also consistent with the fact that males in this age group often have the highest mobility and are thus most likely to be omitted by the census. Table 2 compares population sizes and sex ratios for those born in 1971 and thereafter from three sources: the 2000 and 2010 censuses and 2010 *hukou* data. For those born in the 1980s, there is greater consistency between the 2000 census and the 2010 *hukou* data. In other words, the lower sex ratio, especially for those in the 1981–90 cohorts in the 2010 census, could be a data artifact.

Even for the 1991–95 birth cohorts, the drop in the sex ratio from 115.4 in the 2000 census to 108.7 in the 2010 census appears too steep. Most people in this cohort should be in primary school by 2003, since primary school students in China enroll at age six or seven. According to China's enrollment statistics, the sex ratio of primary school students was 112.4 in 2003 (Table 3), the same as the sex ratio of the 1991–95 cohort recorded in the 2010 *hukou* data (Table 2). Although a cultural bias against females puts girls at higher risk of not enrolling in school or of dropping out, primary school education is now mostly paid for by the government and is nearly universal. Thus, the sex ratio of primary school students should not be much higher than that of the overall population of primary school age. Using the average age of primary school students to gauge the sex ratio at birth suggests that the sex ratio was rising at least until 2000, as the sex ratio of primary school students continued to rise from 2003 to 2010.

The sex ratio of the 1996–2000 birth cohort observed in the 2010 census is more consistent with two external sources: the 2010 *hukou* data and primary school enrollment statistics. This indicates that only about a quarter of the distorted sex ratio reported in the 2000 census for the 1996–2000 cohort can be attributed to the existence of "hidden girls." Overall, while the 2010 census did recover some "hidden missing girls," it was not at the massive scale suggested by the intercensal analysis.

TABLE 3 Primary school students by sex, sex ratio, and average age, China 2003–2010

Year	Males (millions)	Females (millions)	Sex ratio (males per 100 females)	Average age (years)
2003	61.9	55.0	112.4	9.7
2004	59.7	52.8	113.0	9.7
2005	57.8	50.9	113.6	9.6
2006	57.1	50.0	114.3	9.6
2007	56.5	49.1	115.0	9.5
2008	55.4	47.9	115.6	9.4
2009	54.1	46.6	116.1	9.4
2010	53.5	46.0	116.3	9.3

NOTE: Education data use 1 September as the standard time.
DATA SOURCES: *China Education Statistical Yearbook* 2003–2010.

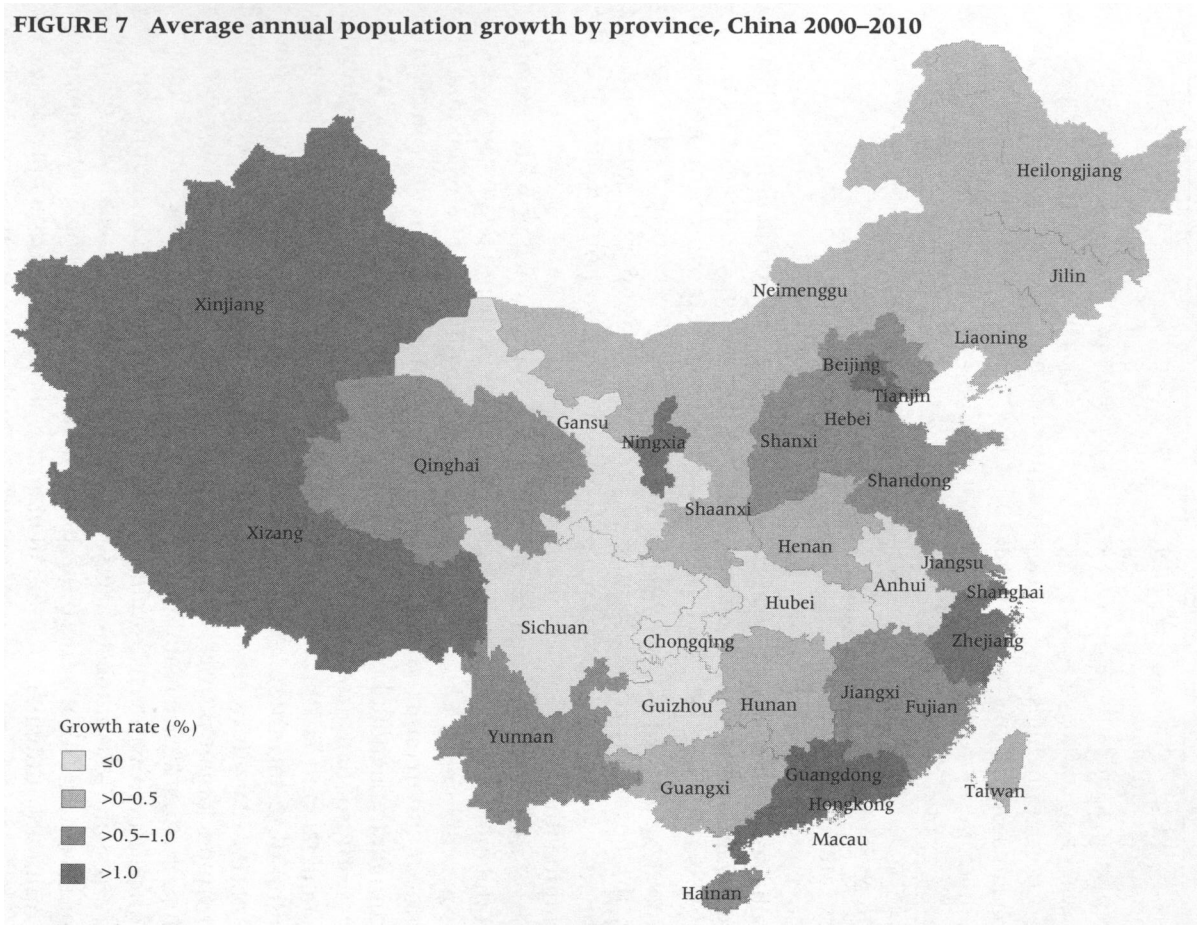
In sum, the 2010 census again confirms that the recorded sex imbalance is not a statistical artifact, but a reality. The total number of "missing" girls in China has risen from about 8.5 million revealed by the 2000 census (Cai and Lavely 2003) to more than 20 million (Cai 2013). Facing this substantial problem, the Chinese government has deployed a number of measures to correct the imbalance, such as banning the use of prenatal sex-determination technology and launching a "Care for Girls" campaign. To date, however, these policies have not been very effective (Greenhalgh 2013; Li 2007). Sex-selective abortion, though illegal, is not difficult to obtain. The Care for Girls program, though it might have improved girls' status within the family, has yet to change people's desire to have a son. The roots of the problem are entrenched in the social institutions of the patrilineal family system. Fertility decline, urbanization, and improvement in education are slowly changing these institutions, but son preference remains strong in rural China (Murphy, Tao, and Lu 2011). The sex ratio of persons born after the 2000 census is still at high levels of 118 and above. While there are some positive signs, such as a decline in the sex ratio of higher-parity births, China has clearly not eliminated sex discrimination within the family and society.

Internal migration, rapid urbanization, and geographic redistribution

Internal migration and the resulting rapid urbanization are the main driving forces behind the geographic redistribution of China's population. In contrast to the overall slow population growth there is enormous regional variation in growth rates across Chinese provinces. Figure 7 categorizes Chinese provinces by intercensal population growth in four groups: rapid growth at an annual rate higher than 1 percent, modest growth with an annual rate equal to or lower than 1 percent and higher than 0.5 percent, slow growth with an annual rate equal to or lower than 0.5 percent and higher than 0 percent, and zero or negative population growth. The figure shows that rapid growth is observed both in the more developed east coast and in western frontier provinces largely populated by ethnic minorities. Negative population growth characterizes large portions of the middle of the country.

Eight provinces or province-level units recorded population growth at an average annual rate higher than 1 percent (Figure 7 and Table 4). The three fastest-growth regions are the urban municipalities of Beijing, Shanghai, and Tianjin. Both Beijing and Shanghai added about 6 million people in just ten years, at an average annual growth rate of more than 3 percent. At this rate, a population would double in 20 years. The next two highest-growth provinces are Guangdong and Zhejiang, both of them powerhouses of China's economic growth. Guangdong added about 18 million to its population, making it the most populous province for the first time. Although these five provincial-level

FIGURE 7 Average annual population growth by province, China 2000–2010



DATA SOURCES: Calculated from population by province in the 2000 and 2010 censuses.

TABLE 4 Decomposition of population growth in the eight fastest-growing province-level units, China 2000–2010

	Population (millions)		Population change (millions)	Average annual rate (%)	Natural increase (millions)	Net migration (millions)	Migration's share of change (%)
	2000	2010					
Beijing	13.82	19.61	5.79	3.5	0.29	5.50	95
Shanghai	16.74	23.02	6.28	3.2	0.20	6.08	97
Tianjin	10.01	12.94	2.93	2.6	0.19	2.73	93
Guangdong	86.42	104.30	17.88	1.9	6.74	11.15	62
Zhejiang	46.77	54.43	7.66	1.5	2.16	5.50	72
Xizang (Tibet)	2.62	3.00	0.38	1.4	0.31	0.07	19
Xinjiang	19.25	21.81	2.56	1.3	2.21	0.35	14
Ningxia	5.62	6.30	0.68	1.1	0.63	0.05	8

NOTE: Decomposition is calculated based on census data and annual birth and death rates provided in *China Statistical Yearbook* 2001–2011.
DATA SOURCES: Census data by province from NBS 2003, 2012.

units accounted for only 14 percent of China's total population in 2000 and 16 percent in 2010, their share of China's population growth during the decade was 55 percent. Three minority-concentrated provinces in the western frontier, Tibet (Xizang), Xinjiang, and Ningxia, also recorded rapid growth in the ten-year period. Because of their small base populations, however, the total growth in these three provinces accounts for only 6 percent of the national total.

Table 4 also decomposes population growth in each province using the population balance equation based on annual birth and death rates for each province from the *China Statistical Yearbook*. The difference between total population growth and natural increase (births minus deaths) is the contribution from migration. Table 4 shows a sharp contrast between the coastal and the western frontier provinces in their sources of population growth. In Beijing, Shanghai, and Tianjin, more than 90 percent of population growth was the result of in-migration. Although the contribution of in-migration is not as large in Guangdong and Zhejiang, it is still the dominant force, an outcome of economic opportunities that attract migrants from hinterland provinces. On the other hand, the main source of population growth in the three minority-concentrated western frontier provinces is natural increase, not surprising given that China imposes a less restrictive version of the birth control policy in these areas. While these three provinces did have an inflow of migrants, presumably drawn from the Han majority population in other provinces, the number of Han migrants is not nearly as high as some have contended.

The real surprise for China is a new demographic phenomenon in the form of negative growth. Between 2000 and 2010, six Chinese provinces recorded population loss for the first time since the end of the Great Leap Forward famine. Similar to the decomposition analysis for population growth

in other parts of China, one can compare the relative scale of natural change and change due to migration. Table 5 shows that in all six provinces recording population loss, natural increase is still positive. The losses are therefore entirely the result of out-migration. Sichuan alone lost 5.5 million people to out-migration. The region experiencing population loss is expected to expand from those six provinces to their neighbors, where population growth rates are already below the national average. This ongoing out-migration, in conjunction with the momentum of negative population growth accumulated over the last few decades, ensures that large areas of central China will continue to lose population.

China's widespread population redistribution in the first decade of the twenty-first century is an outcome of rapid urbanization. The 2010 census recorded 49.7 percent of the country's population as urban, suggesting that China has reached a historical turning point in its urbanization process (Peng 2011). The transition from rural to urban, and from farming to manufacturing to services, marks fundamental changes in social organization and individual life, with profound implications for the country's socioeconomic future. Such a transformation will also have implications for other demographic areas such as childbearing behavior and sex preference.

Another major factor behind China's population redistribution is regional economic inequality. The more developed coastal areas and urban centers attract migrants from other provinces, attested to by the 261 million Chinese recorded as living at a place different from their place of household registration. Although the Chinese government has sought to alleviate regional economic imbalances by investing heavily in the central and western parts of the country through its Western Development Strategy, the entrenched nature of state planning has a tendency to favor the already more developed areas.

TABLE 5 Negative population growth in six provinces, China 2000–2010

Province	Population (millions) 2000	2010	Population change (millions)	Average annual rate (%)	Natural increase (millions)	Net migration (millions)
Gansu	25.6	25.6	–.04	–0.2	1.7	–1.7
Anhui	59.9	59.5	–.36	–0.6	3.9	–4.3
Guizhou	35.3	34.8	–.50	–1.4	3.1	–3.6
Sichuan	83.3	80.4	–2.87	–3.4	2.6	–5.5
Hubei	60.8	57.2	–3.04	–5.0	1.7	–4.7
Chongqing	30.9	28.9	–2.05	–6.6	1.0	–3.0

NOTE: Decomposition is calculated based on census data and annual birth and death rates provided in the *China Statistical Yearbook* 2001–11.
DATA SOURCES: Census data by province from NBS 2003, 2012.

Population redistribution, itself a result of economic imbalance, is likely to further exaggerate regional inequalities. For example, the selective nature of population migration makes Shanghai, despite its extremely low fertility, demographically better prepared for an aging society because it attracts young migrants from other provinces. Meanwhile, the areas characterized by declining population will not only have a smaller population but will also likely be older and have greater shortages of men and women at marriageable ages.

Discussion and conclusion

The preceding analysis of preliminary data from China's 2010 census demonstrates that the census is of reasonable quality, but at the same time contains possible defects that require careful scrutiny. For example, while the age structure exhibits great consistency with previous censuses, attesting to the high quality of age reporting, there are considerable discrepancies especially for younger age groups. Extremely low estimates of infant mortality also suggests problems in recording deaths. Nevertheless, with adequate caution, the 2010 census data are sufficient to present an overall picture of demographic changes for China during the first decade of the twenty-first century.[14]

The census leaves no doubt that China's fertility is indeed well below replacement (Guo 2013; Cui, Xu, and Li 2013; Peng 2011; Wang and Ge 2013). In fact, more recent data from China suggest that the country might have experienced further fertility decline: the unadjusted TFR dropped four years in a row, to an unprecedented 1.04 in 2011 (NBS 2012). This suggests that China might be following its more developed neighbors in falling into a "low fertility trap" (Lutz, Skirbekk, and Testa 2006). On the mortality side, even after discounting for underreporting, China's gains in life expectancy are substantial. This has contributed to China's rapid population aging, and will do so more in the future. Despite considerable attention devoted to alleviating the sex imbalance of the population, the census data offer few signs of change. Internal migration has emerged as the single most important factor behind the rapid population redistribution in China. Mass population movement across the country not only alters population composition, but also stimulates social, economic, and cultural changes.

China's 2010 census confirms that the country is in a new demographic era, characterized by prolonged low fertility, persistently elevated sex ratios, rapid aging, massive urbanization, and widespread geographic redistribution. These changes have taken place during a period of rapid economic growth and within a broad context of rising global competition, economic inequality, and political tension. The demographic challenges China now faces, such as rapid aging, skewed sex ratios, and labor shortages, are in considerable part products of fertility decline. China has been slow to acknowledge these problems—a resistance epitomized by its dogged retention of the one-child

policy. How China responds to these demographic challenges will have profound implications for China's and the world's social and economic future.

Notes

I thank Guo Zhigang, William Lavely, and Wang Feng for their insightful comments, and acknowledge support from the MacArthur Foundation, the Population Research Infrastructure Program awarded to the Carolina Population Center (R24 HD050924) by the Eunice Kennedy Shriver National Institute of Child Health and Human Development, and from the National Science Foundation of China (71273059/G030602).

1 The growth rate was lower than expected. China's official 10th 5-Year Plan, which covers the period 2000–05, projected that China's population would grow at an annual rate of 9 per thousand; the 11th 5-Year Plan, which covers 2006–10, projected an annual rate of 8 per thousand.

2 «http: //www.unhcr.org/refworld/country,,,,CHN,,4c2b5e2926,0.html».

3 «http: //www.stats.gov.cn/tjdt/gjtjjdt/t20110429_402722652.htm».

4 The *Tabulation* provides only limited information on military service personnel, including age structure, nationality, and education.

5 The rectification to update the household registration system took place between January and September 2010.

6 The measures of relative completeness of the two censuses, k_1/k_2, are .9946 and .9920 for males and females respectively. (k_1 and k_2 denote the completeness of enumeration of the 2000 and 2010 censuses, respectively.)

7 The measures of completeness of death reporting (k_3) are .9566 and .9002 for males and females respectively.

8 «http: //www.stats.gov.cn/tjgb/rkpcgb/qgrkpcgb/t20120921_402838652.htm»

9 MOH publishes mortality data separately for rural and urban areas. Population age structure by rural and urban areas from the 2010 census is used as weights to create the national mortality age profile.

10 «http: //tinyurl.com/aawjd8f».

11 No public document is available on how such an adjustment was done. A personal conversation with a retired government official who was involved in such work in the 1990s reveals that it was a coordinated effort between the National Bureau of Statistics and the National Population and Family Planning Commission.

12 The large discrepancy in 1994–2003 is likely a result of the Chinese government overreacting to the underreporting problem. The government deemed the low fertility numbers from its own surveys too low to be true; it thus inflated the number of births in its annual statistical report. The convergence of the two lines after 2004 reflected the NBS's recognition of low fertility. The NBS publicly acknowledged China's fertility to be around 1.6 in its assessment of the 2005 population (NBS 2007), departing from the National Population and Family Planning Commission's insistence on a TFR of 1.8.

13 If the decline of mortality was the main reason for such a reversal, it would mean a major change in the male/female mortality pattern: it would require a life expectancy gap (at age 0) of around 7–8 years.

14 Further inconsistencies, mismatches, and errors are certain to be detected. For example, the 2010 census shows that 13 ethnic minorities had a population decline between 2000 and 2010, but careful data examination suggests this is mostly due to loss of population in migration-prone age groups, presumably because without distinct physical features distinguishing them from the Han majority, many minority migrants were counted as Han.

References

Banister, Judith and Kenneth Hill. 2004. "Mortality in China 1964–2000," *Population Studies* 58: 55–75.

Bongaarts, John. 2006. "How long will we live?" *Population and Development Review* 32(4): 605–628.

Cai, Yong. 2008. "Assessing fertility levels in China using variable-r method," *Demography* 45(2): 371–381.

———. 2010. "China's below-replacement fertility: Government policy or socioeconomic development?" *Population and Development Review* 36(3): 419–440.

———. 2013. "China's demographic challenges: Gender imbalance," paper presented at the China's Challenges: the Road Ahead conference, Center for the Study of Contemporary China, University of Pennsylvania, 25–26 April.

Cai, Yong and William Lavely. 2003. "China's missing girls: Numerical estimates and effects on population growth," *The China Review* 3: 13–29.

——— 2007. "Child sex ratios and their regional variation," in Zhongwei Zhao and Fei Guo (eds.), *Transition and Challenge—China's Population at the Beginning of the 21st Century*. Oxford University Press, pp. 108–123.

Coale, Ansley J. 1984. *Rapid Population Change in China, 1952–1982*. Committee on Population and Demography, Report No. 27. Washington, DC: National Academy Press.

Coale, Ansley J. and Judith Banister. 1994. "Five decades of missing females in China," *Demography* 31 (3): 459–479.

Coale, Ansley J., and Paul Demeny. 1983. *Regional Model Life Tables and Stable Populations*. 2nd ed. New York: Academic Press.

Cui, Hongyan, Lan Xu, and Rui Li. 2013. "An evaluation of data accuracy of the 2010 population census of China," *Population Research* 37(1): 10–21. In Chinese.

Feeney, Griffith and Jianhua Yuan. 1994. "Below replacement fertility in China? A close look at recent evidence," *Population Studies* 48: 381–394.

Goodkind, Daniel. 2004. "China's missing children: The 2000 census underreporting surprise," *Population Studies* 58: 281–295.

———. 2011. "Child underreporting, fertility, and sex ratio imbalance in China," *Demography* 48(1): 291–316.

Greenhalgh, Susan. 2013. "Patriarchal demographics? China's sex ratio reconsidered," *Population and Development Review* 38(Supp.): 130–149.

Gu, Baochang and Yong Cai. 2011. "*Fertility Prospects in China*," Expert Paper No. 2011/14, Department of Economic and Social Affairs Population Division, the United Nations.

Gu, Baochang and Wang Feng (eds.) 2009. *An Experiment of Eight Million People—Reports from Areas with Two-Child Policy*. Beijing: China Social Sciences Academic Press. In Chinese.

Gu, Baochang, Wang Feng, Zhigang Guo, and Erli Zhang. 2007. "China's local and national fertility policies at the end of the twentieth century," *Population and Development Review* 33(1): 129–147.

Gu, Baochang, and Krishna Roy. 1995. "Sex ratio at birth in China, with reference to other areas in East Asia: What we know," *Asia-Pacific Population Journal* / United Nations 10(3): 17–42.

Guo, Zhigang. 2011. "The 2010 population census data indicates serious miscount in past population estimation and projection," *Chinese Journal of Population Science* 2011(1): 2–13.

———. 2013. "The low fertility rate is the major demographic risk in China," *China Economic Journal*. DOI: 10.1080/17538963.2012.761834.

Hill, Kenneth. 1987. "Estimating census and death registration completeness," *Asian and Pacific Population Forum* 1(3): 8–13, 23–24.

Jiang, Zhenghua. 2006. "Thinking ahead of population policies in the new era," *Chinese Journal of Population Science* 6: 2–5. In Chinese.

Lavely, William. 2001. "First impressions from the 2000 census of China," *Population and Development Review* 24(4): 755–769.

Li, Shuzhuo. 2007. "Imbalanced sex ratio at birth and comprehensive intervention in China," paper presented at 4th Asia Pacific Conference on reproductive and sexual health and rights, Hyderabad, India, 29–31 October. New York: UNFPA.

Lutz, Wolfgang Lutz, Vegard Skirbekk, and Maria Rita Testa. 2006. "The low-fertility trap hypothesis: Forces that may lead to further postponement and fewer births in Europe," *Vienna Yearbook of Population Research* 4: 167–192.

MCHSCN. 2010/11. *Newsletter of China Maternal and Child Health Surveillance Network* 2010(5) and 2011(4). «http: //www.mchscn.org».

Merli, M. Giovanna. 1998. "Underreporting of births and infant deaths in rural China: Evidence from field research in one county of northern China," *The China Quarterly* 637–655.

Merli, M. Giovanna and Adrian E. Raftery. 2000. "Are births underreported in rural China? Manipulation of statistical records in response to China's population policies," *Demography* 37: 109–126.

Ministry of Health, China (MOH). 2000–2012. *China Health Statistical Yearbook*. Beijing: Peking Union Medical College Press.

Morgan, S. Philip, Zhigang Guo, and Sarah R. Hayford. 2009. "China's below-replacement fertility: Recent trends and future prospects," *Population and Development Review* 35(3): 605–629.

Murphy, Rachel, Ran Tao, and Xi Lu. 2011. "Son preference in rural China: Patrilineal families and socioeconomic change," *Population and Development Review* 37(4): 665–690.

National Bureau of Statistics of China (NBS). 1990–2012. *China Population Statistical Yearbook* (1990–2012). In Chinese.

———. 2003. *The Complete Collection of National and Provincial Population Census Data Assembly*. Electronic version. University of Michigan China Data Center, CDC-S-2003–201.

———. 2012. *Tabulation on the 2010 Population Census of the People's Republic of China*. Beijing: China Statistical Press. In Chinese.

National Bureau of Statistics of China and East-West Center (NBS and EWC). 2007. *Fertility Estimates for Provinces of China, 1975–2000*. Beijing: China Statistics Press.

National Population and Family Planning Commission of China (NPFPC). 2007. *Report on the National Strategy of Population Development*. «http: //www.gov.cn/gzdt/2007–01/11/content_493677.htm». In Chinese.

———. 2007. *Data Handbook for Population and Family Planning 2006*. Beijing: China Population Press. In Chinese.

National Population Development Strategy Research Group (NPDSRG). 2007. *National Population Development Strategy Research Report*. Beijing: China Population Press. In Chinese.

Oeppen, Jim and James W. Vaupel. 2002. "Broken limits to life expectancy," *Science* 296(5570): 1029–1031.

Peng, Xizhe. 2011. "China's demographic history and future challenges," *Science* 333(6042): 581–587.

Poston, Dudley L., Jr., Eugenia Conde, and Bethany DeSalvo. 2011. "China's unbalanced sex ratio at birth, millions of excess bachelors and societal implications," *Vulnerable Children and Youth Studies* 6(4): 314–320.

Retherford, Robert D., Minja Kim Choe, Jiajian Chen, Xiru Li, and Hongyan Cui. 2005. "How far has fertility in China really declined?" *Population and Development Review* 31: 57–84.

Scharping, Thomas. 2003. *Birth Control in China, 1949–2000: Population Policy and Demographic Development*. London/New York: Routledge.

———. 2007. "The politics of numbers: Fertility data in recent decades," in Zhongwei Zhao and Fei Guo (eds.), *Transition and Challenge: China's Population at the Turn of the Twenty-First Century*. Oxford University Press, pp. 34–53.

South, Scott J., and Katherine Trent. 2010. "Imbalanced sex ratios, men's sexual behavior, and risk of sexually transmitted infection in China," *Journal of Health and Social Behavior* 51 (4) (December 1): 376–390. doi: 10.2307/20798301.

UNFPA. 2012. *Sex Imbalances at Birth: Current Trends, Consequences and Policy Implications*. UNFPA Asia and the Pacific Regional Office, Bangkok, Thailand.

United Nations. 2011/2013. *World Population Prospects, the 2010/2012 Revision*. Department of Economic and Social Affairs, Population Division. New York.

Wang, Fei-Ling. 2005. *Organizing Through Division and Exclusion: China's Hukou System*. Stanford, CA: Stanford University Press.

Wang, Feng, Yong Cai, and Baochang Gu. 2013. "Population, policy, and politics: How will history judge China's one-child policy?" *Population and Development Review* 38 (Supp.): 115–129.

Wang, Jinying and Yanxia Ge. 2013. Assessment of 2010 census data quality and past population changes," *Population Research* 37(1): 22–33. In Chinese.

World Bank. 2012. *World Development Indicators*. «http://data.worldbank.org/».

Zeng, Yi, Ping Tu, Baochang Gu, Yi Xu, Bohua Li, and Yongping Li. 1993. "Causes and implications of the recent increase in the reported sex ratio at birth in China," *Population and Development Review* 19: 283–302.

Zhang, Guangyu and Zhongwei Zhao. 2006. "Reexamining China's fertility puzzle: Data collection and quality over the last two decades," *Population and Development Review* 32(2): 293–321.

Zhang, Weimin and Hongyan Cui. 2002. "Preliminary assessments of 2000 census data," *Population Research* 2002(4): 25–35. In Chinese.

Zheng, Zhenzhen, Yong Cai, Wang Feng, and Baochang Gu. 2009. "Below-replacement fertility and childbearing intention in Jiangsu Province, China," *Asian Population Studies* 5(3): 329–347.