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China's New Demographic Reality: Learning from the 2010 Census¹

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Abstract

The paper provides an examination of China's 2010 census data to evaluate its quality and to assess China's demographic situation. The demographic trends revealed by the new census data suggest that China has entered a new demographic era characterized by prolonged low fertility, elevated sex ratios, rapid aging, fast urbanization and major geographic redistribution. How China responds to these demographic challenges will have profound implications for its social and economic future.

China carried out its 6th modern population census in 2010. It is another enumeration in grand scale. The census mobilized over 6 million enumerators ² who visited over 400 million households, and registered a total of 1.34 billion people. The census provides timely information for updating our understanding of demographic trends in China.

Data from the 2010 census indicates that China has entered a new demographic era. China's population grew at a pace significantly slower than that had been anticipated by the Chinese government, averaging 5.7 per thousand over the 10-year period since the 2000 census, significantly below the 8–9 per thousand in the official projections for the same time period. ³ Such a growth rate was also drastically lower than that in the preceding two decades, when it was 14.4 and 11.0. This slower growth rate was primary a result of steady low fertility. Meanwhile, urbanization and geographic redistribution happened at an astonishing speed – population in urban centers like Shanghai and Beijing grew as much as 40 percent in one decade, whereas six inland provinces recorded negative population growth for the first time since the end of the Great Leap Forward famine. The census also shows that China's population has undergone rapid aging – population aged 60 and above accounted for 13.3

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²Two different numbers have been given for the number of enumerators. In its public *Thank-You Letter* published on Nov 15, 2010, China's National Bureau of Statistics (NBS) thanked "over 6 million enumerators and supervisors." [http://www.stats.gov.cn/tjdt/gtjjdt/t20101116_402683510.htm]. The *Communiqué on Major Figures of the 2010 Population Census* put the total number of census workers at "about 10 million."

³China's official 10th 5-year plan, which covers the period of 2000–2005, projected China's population to grow at an annual rate of 9 per thousand; the 11th 5-year plan, which covers the period of 2006–2010, projected China's population to grow at an annual rate of 8 per thousand.

percent of the total population in 2010, up by 2.9 percentage points as compared with that from the 2000 census. All in all, the demographic situation in China is vastly different from the decade before.

This paper presents an overview of China demographic situations based on an examination of 2010 census data, mostly at the national level. The paper starts with a general discussion of census data quality. It then turns to detailed demographic analyses to evaluate major demographic indices, including mortality, fertility, sex ratio and regional distribution. It concludes with a discussion of the social and policy implications of China's new demographic reality.

1. Challenges in Enumerating an Increasingly Mobile Population

Enumerating more than one billion people is not an easy task (Li 1984). Adding to this great challenge 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), result of China's still relatively immobile society, tightly controlled by a rigid household registration (*hukou*) system, and the widespread use of lunar and astrological dating of birth that facilitated reliable age counting. Subsequent economic liberalization and relaxation of migration controls unleashed population mobility. With more and more people, particularly peasants previously bound to the farmland, leaving their registration home to live and work in other locations, the *hukou* system became less capable of providing timely information about people's whereabouts. Because the *hukou* system is the backbone of China's population statistics system, including the censuses and surveys, people on the move are more likely to be missed or misclassified. Data quality, especially possible 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 1996; Goodkind 2011).

The implementation of the one-child policy since 1980 has further exacerbated the problem of underenumeration (Goodkind 2004; Merli and Raftery 2000; Zeng et al. 1996). The Chinese government has relied heavily on the *hukou* system to implement the one-child policy (Wang 2005; Gu et al. 2007). Not only does the *hukou* provide the basis of assigning family's qualification for birth quotas, it is also used as a measure to punish families with children born without official quotas; those children are routinely denied registration and thus denied access to many government and social services, such as education, health care, and more. The evaluation and punishment associated with the one-child policy also give both families and local government strong incentives to hide the 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 Lavelly 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 counted at where he/she was in the evening of October 31, 2010, regardless of the person's household registration locale, and everyone was also counted at his/her household registration place no matter where he/she was that night. A computer

algorithm was used to determine whether 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 the previous censuses, especially in the 2000 census (Zhang and Cui 2002). In all previous censuses, in the period leading up to the census, the census takers had to carefully check everyone's status to determine whom to be counted, and whom to be left out. More specifically, census-takers had to first judge whether to include a person based on the person's *hukou* status and how long s/he has left his/her registration place to make sure that each person was only counted once. Those assessments were time consuming, and prone to error, often underenumeration, as migrants and people without *hukou* were often missed (Lavelly 2001). In contrast, the 2010 census enumerated everyone, sometimes twice, and then used a computer algorithm to differentiate residents from visitors. Mandating de facto and de jure counts greatly diminished the chance of underreporting. Using a computer algorithm that checks qualification of "residency" should also provide both better accuracy and better consistency. Of course, this new method increases the risk of double counting.

Second, families with children born without quota were provided opportunities to get registered in the *hukou* system before the census. According to a report by China's official English-language newspaper *China Daily*, "People who violated family planning policies can apply for household registration by taking the opportunities of the census," quoting Gu Yanzhou, deputy director of the Beijing Statistic Bureau. This was in fact a nation-wide measure mandated by the Ministry of Public Security (MPS), the government agency in charge of the *hukou* system. Although the measure was far from 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.⁴

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 that it would not pass on such information to birth control organizations as a basis for fines. According to Ma Jiantang, the Commissioner of NBS, the 2010 census enumerated a total of 13 million people with a pending household registration, a majority of whom were out-of-plan births.⁵ In comparison, the number with "pending household registration" was 8 million in the 2000 census.

In addition to the above-mentioned specific measures to improve census quality, some institutional and organizational setups favored for a good enumeration. The implementation of the census was led by the National Bureau of Statistics of China (NBS) under the aegis of the Leading Group for the 6th Population Census, a special office established within the State Council that involved 25 different 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 the government. The massive bureaucratic system that penetrates every

⁴<http://www.unhcr.org/refworld/country,,,CHN,,4c2b5e2926,0.html>

⁵http://www.stats.gov.cn/tjdt/gjtjdt/t20110429_402722652.htm

layer of Chinese society in combination of with an all-out mobilization campaign encourages a full participation in the census.

Moreover, the use of information technology facilitated data gathering and cross-validation. At the same time as increased population mobility makes it more difficult to track an individual's whereabouts, movement also creates more opportunities to gather secondary and administrative data such as school enrollment, medical, and travel records. The revolution in information technology has greatly reduced the costs of gathering and managing such records, and has enhanced the control of data by the central government, which has long struggled with local agents to acquire accurate information. Secondary and administrative data provide the central authorities new tools to cross-validate population information collected from the census.

Combined, the new approaches and new technology lend the Chinese government high confidence about the 2010 census's data quality. Answering a question at the press conference on the release of the *Communiqué on Major Figures of the 2010 Population Census*, Zhang Weimin, Deputy Commissioner of NBS 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 post enumeration survey revealed a 0.12% net underenumeration rate, far lower than that of 2000, at 1.81%. 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 either the post enumeration survey or the consistency checks, however, census data quality should be regarded with caution.

2. Census Data Quality, First Look

The release of census data followed a similar protocol established by the previous three censuses, in 1982, 1990, and 2000. The first data release of the 2010 census came in the form of *Communiqué on Major Figures of the 2010 Population Census* (referred as *Communiqué* below). In June 2012, NBS released a three-volume compendium entitled *Tabulation on the 2010 Population Census of the People's Republic of China* (referred as *Tabulation* below), including a digital version made available online at NBS's website. Provincial level and county level tabulations are gradually coming out.

There are small, but important discrepancies between the *Communiqué* and the *Tabulation*, as the *Communiqué* was based on the so-called "quick aggregation" -- summary of enumeration totals aggregated and submitted by local census organizations, and the *Tabulation* was based on a full computer tabulation based on individual level. The total population provided with tabulation details (1,335.1 million) is about 4.6 million or 0.34% fewer than the number released in the *Communiqué* (1,339.7 million). Examination of 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, for 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, the 2010 census appears to have better quality than the 2000 census. The analysis below uses the combined sex age structure of the “National Population” and “Military Personnel”⁶ and makes no adjustment for the 4.6 million “population with permanent residence difficult to define.”

The total population enumerated in the 2010 census is consistent with previous estimates provided by NBS. It is conventional that the NBS provides the latest (usually for the previous calendar year) population estimates, including year-end population, as well as birth, death and growth rates in its annual publication of *China Statistical Yearbook*, presumably based on its annual Population Change Survey and other related sources. It is also conventional that the NBS adjusts its previous population estimates following a census. For example, the birth rates of 1982–1989 were adjusted upward following the 1990 census, by as much as 18 percent; 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 downwards. Following the 2010 census, the NBS made a minor tweak to its estimate of population for 2009, with birth rate adjusted downwards from 12.13 to 11.95 (per 1000), and total year-end population downwards by 240,000 (from 1,334.7 million to 1,334.5 million) – a negligible amount for such a large population.

One factor that could have contributed to a better count in the 2010 census is the adoption and expanded use of China’s National Resident ID system, particularly the introduction of so-called Second-generation Resident ID system. China introduced its National Resident ID system in 1984. Chinese citizens who are 16 years 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 non-unique ID number (number collisions), and easy forgery. In 2003, China introduced a newer, machine-readable, so-called Second-generation Resident ID card with an embedded IC-chip. The new ID card uses a new coding system to avoid the problem of number collision. 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 often the only acceptable legal document for social, governmental as well as 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 to update China’s *hukou* system, which itself has undergone digitization over the past decade. With a better 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 matches up well with 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 30th, before it completed its system-wide “rectification” prior to the 2010 census.⁷ The “rectification” was designed to clean and update the *hukou* system in preparation for the census, similar to what was done in previous

⁶The *Tabulation* provides only limited information on military service personnel, including age structure, nationality, and education.

⁷The rectification to update the household registration system took place between January and September 2010.

censuses (Lavelly 2001). Overall, the two data sources display great consistency, especially in the middle part of the age distribution. The disparities for young ages and old ages are substantial, but not unexpected. For the age group 0–4, the count in the census is 75% larger than registered in the *hukou* system. For population aged 60 and above, consistency level drops as age goes up. For example, for 60–64, the census count is 96% of the registered; for 80–84, the ratio declines to 70%, and for 90–94, the ratio further declines to 39%. 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 record checking/keeping.

The consistency between the census and the *hukou* system, as shown above, lends some 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). Now the growing sophistication of the Chinese security state (with ID cards and real time identity checking) is taking census accuracy to new heights. However, because the census and *hukou* system are not entirely independent of each other, the consistency between them is not a sufficient measure of the census validity. In the next section, intercensal survival analysis will be applied to further examine the 2010 sex-age structure and to study the mortality and aging pattern revealed by the census.

3. Data Quality, Mortality and Population Aging

Because Chinese censuses also collect death information in the year prior to the census, intercensal survival analysis, in combination with mortality analysis, provides not only a check of the completeness of population enumeration, but also an assessment of mortality reporting. It has been shown by previous studies that population data from China are of reasonable quality in adult ages (e.g. Banister and Hill 2004; Coale 1985; Coale and Banister 1994).

Figure 2 presents the intercensal analysis between 2000 and 2010, together with 10-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: $e_0^{m,2000}=70.7$, $e_0^{f,2000}=74.3$, $e_0^{m,2010}=75.6$, $e_0^{f,2010}=80.4$. 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 right between the two life table lines, suggesting a good 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 any smoothing, the remarkable consistency once again confirms the good quality of Chinese aging reporting.

Second, if the conventional wisdom holds that young children is more likely to be underreported under China's current population statistical system, Figure 2 suggests that there was significant underreporting of children in the 2000 census, and the underreporting

is more substantial for females than males. For females, underreporting is as much as 25% (at age 1 in 2000) with an average of about 13% for ages 0–9 in 2000; for males, underreporting tops at about 20% (at age 1 in 2000) with an average of about 8% for ages 0–9 in 2000. While at somewhat different levels, male and female underreporting have parallel age patterns. Both the level and age patterns of underreporting are similar to what was observed in the comparison between 1990 and 2000 censuses (Cai and Lavelly 2003; Zhang and Cui 2002).

Third, there are some large mismatches between the two censuses in the age range of 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 age 20s, and drops below in age 30s. For females, the mismatches are similar across those three age groups, but less dramatic. The mismatches could be caused by enumeration problems in either census, or both, thus it is not possible to identify the underlying causes without a third set of data. Nevertheless, it is safe to speculate that these mismatches are likely due to some systematic problems given their strong age patterns. This issue will be re-examined in the section on sex ratio below.

Building on visual examination of Figure 2, the General Growth Balance (GGB) method developed by Hill (1987) is applied for both data assessment and mortality estimates. Banister and Hill (2004) demonstrate that this method is well suited for Chinese data. In light of concerning data quality for those below age 40 in 2000, as having been observed in Figure 2, this application uses data from ages 40–79, instead of ages 15–69 as suggested by Banister and Hill (2004). The application shows that the two censuses have comparable coverage for both males and females in population enumeration.⁸ Death registration is more complete for males than females, in accord with what has been revealed in Figure 2.⁹ The GGB method estimates life expectancy at birth of 72.5 for males, and of 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 adjustments¹⁰, 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 proportional mortality decline during the intercensal period. Because the application of the GGB method is based on the more “reliable” part of the census data, i.e. ages 40–79, as suggested in the data examination presented in Figure 2, life expectancies at age 40 are included. Also included are infant mortality rates and life expectancies at birth matched from Coale-Demeny’s Model West (1983) with corresponding GGB life expectancies at age 40.

As shown in Table 1, for the 2000 census data, NBS only makes minor tweaks. The adjusted life expectancies at birth are about one year lower than those calculated directly from unadjusted figures, and similar to the estimates provided by Banister and Hill’s (2004) GGB

⁸The measures of relatively population enumeration completeness k_1/k_2 are .9946 and .9920, for males and females respectively.

⁹The measures of completeness of death reporting (k_3) are .9566 and .9002 for males and females respectively.

¹⁰http://www.stats.gov.cn/tjgb/rkpcgb/qgrkpcgb/t20120921_402838652.htm

estimates. High female infant mortality rate is one noticeable discrepancy between the mortality estimates from China and Coale-Demeny Model West, reflecting unfavorable female mortality due to a cultural bias against female infants (Cai and Lavelly 2007). Although NBS provides no technical details on its adjustments, it is likely that NBS made its adjustment based on data from other sources such as mortality data from the Ministry of Health. It is also possible that demographic tools such as GGB were used by the NBS to derive its estimates.

For the 2010 census, however, NBS's adjustments are much more substantial. The reported infant mortality rates from the 2010 census are only 4.16 per thousand for males and 4.37 per thousand for females, much lower than the corresponding numbers from the 2000 census. If those low numbers were real, China would stand in the ranks of countries with the lowest infant mortality in the world. Infant mortality from Coale and Demeny's Model West matched with corresponding GGB e_{40} values suggests underreporting could be substantial. NBS adjusted the infant mortality rates upwards to about three times of the census figures and life expectancies downwards by about three years. NBS's adjustments are generally in line with GGB-based estimates, with the exception of life expectancy at birth for males, which is more than 3 years lower than the unadjusted figure and about 2 years lower than the GGB and GGB matched Model West estimates, suggesting that NBS might have over-adjusted for male mortality underreporting.

The NBS's adjusted infant mortality rates are very close to estimates provided by the Ministry of Health. The Office of China Maternal and Child Health Surveillance (MCHSCN) under the Ministry of Health of China collects infant mortality information through the National Maternal and Child Health Surveillance Network. It publishes selected raw 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 between 2000 and 2010. For 2010, the infant mortality rate gathered by the MOH's surveillance network is 6.6 per thousand for both sexes. MCHSCN (2010) judged that this 6.6-per-thousand number was too low, and adjusted infant mortality upwards by nearly 100% to 13.1 per thousand. Figure 3 shows a clear trend of steady infant mortality decline from 2000 to 2010: from 18.4 per thousand to 6.6 per thousand with raw statistics, and from 32.2 per thousand to 13.1 per thousand 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 age- and cause-specific mortality data gathered from a group of selected regions. For example, the 2010 data include 10 major cities, 9 regional cities, and 34 counties. Figure 4 contrasts the mortality age pattern in the MOH data with that from the 2010 census using the ratio of the two sets.¹¹ A ratio of 1 suggests perfect consistency between the two sources; and above 1 indicates a relatively lower mortality rate reported in the census. Figure 4 shows that the main difference between the two is in infant and child

¹¹MOH publishes mortality data separately for rural and urban. Population age structure by rural and urban from the 2010 census is used as weights to create the national mortality age profile.

mortality. For example, mortality rates for ages 5–9 and 10–14 reported by MOH is only about 75 percent and 50 percent, respectively, of those reported in the census, but for age 1–4 males, the rate is double in the MOH data than in the census. For age 15 and above, the two sources have a reasonable consistency, while displaying some small gender difference. The difference between the two sources can be attributed not only to how death is recorded, but also how the at-risk population is calculated. Because the MOH publishes its 2010 mortality data before the release of the 2010 census, it must have used data from the 2000 census or *hukou* registration as the base population – as discussed previously, accurately counting infants and children has been 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 the life expectancy at birth calculated from the two sources is only about 0.5 year.

The comparison of three sets of mortality measures: those taken directly from the census, those based on intercensal analysis, and those from MOH's reporting, on one hand reveals problems in China's mortality and population data, especially the counting of infants and children, on the other hand confirms China's mortality age pattern and continued improvement in health. Those data suggest that mortality reduction was substantial between the 2000 and 2010 censuses. Before adjusting for mortality underreporting, the census raw data show a jump in life expectancy of 5.0 years for males and 6.1 years for females in the decade between the 2000 and 2010 censuses. NBS's adjustment cuts the increase to 2.8 and 4.0 years for males and female, respectively. Data comparison suggests 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 decades (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 a rapid economic growth for the entire decade under this study, it also implemented a major reform of its health care system that has greatly expanded its coverage. Both could have had very positive effects on population health and in mortality reduction. Moreover, such a speedy decline in mortality has also been observed in other countries. For example, between 1980 and 2010, South Korea's life expectancy at birth increased from 65.8 to 80.8, averaging 5.0 years per decade; the increase was 3.8 years per decade for Indonesia, and 3.3 years per decade for India (World Bank 2012)¹².

Partly due to this rapid improvement in life expectancy, China's aging process between the 2000 and 2010 censuses was faster than expected. As highlighted in the *Communiqué*, population at age 60 and above reached a total of 178 million, or 13.26 percent of the total population in 2010, up by 2.93 percentage points in just one decade; the population at age 65 and above reached over 120 million, or 8.87 percent of the total population, up by 1.91 percentage points as compared with the 2000 census. In comparison, China's 11th 5-year plan projected that the population at 60 and above would reach 174 million by 2010, or 12.78 percent of the total population; and the 2010 revision of the *World Population Prospects* by UN's (2011) estimates the number at 60 and above at only 169.4 million, or

¹²<http://tinyurl.com/aawjd8f>

12.6 percent of the total population.¹³ One factor behind those low estimates is the underestimation of life expectancy. In recognition of rapid mortality reduction, UN's 2012 revision of *World Population Prospects* adjusted China's current and future life expectancies at birth by almost 2 years.

Even with this rapid mortality reduction, mortality's direct contribution to aging is still relatively small in comparison to the more dramatic effect of fertility change. A simple standardization exercise that assumes mortality stays at the same level as observed in the 2000 census suggests that only 6.3 percent of increase at age 60 and above, and 7.8 percent of increase at age 65 and above, is from mortality reduction. The rest is from the change in population age structure driven mostly by fertility change. However, the rapid progress in mortality reduction is going to have a much greater impact in the longer term.

4. Fertility and Sex Ratio

Fertility has been one of the most contentious issues in the study of Chinese population in recent decades (Guo 2011, 2013; Gu and Cai 2011; Wang et al. 2013). On 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 mostly an artifact of underreporting (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 to certain degree, China has indeed experienced a major transition to a below replacement-level regime (e.g. Cai 2008; Gu and Cai 2011; Guo 2013; Morgan et al. 2009; NBS and EWC 2007; Retherford et al. 2005; Zhang and Zhao 2006). In addition to the three-decade long one-child policy, such a transition has unfolded in a context of drastic socioeconomic changes over the last few decades, i.e. urbanization, industrialization, liberalization, and expansion of education. All these transformations exert pressure on the traditional family and reproductive institutions and are thus conducive to very low fertility level (Cai 2010; Gu and Wang 2009; Zheng et al. 2009).

The 2010 census provides new evidence of the prevailing low fertility in China over the past two decades. Figure 5 compares three different 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's possible to derive two other sets of TFR estimates: a second based on the annual number of births reported in the *China Statistical Yearbooks*, and a third matching the cohort size reported in the 2010 census. Be reminded that the numbers of births reported in the *China Statistical Yearbooks* are adjusted figures based on the NBS's internal evaluation.¹⁴

¹³China's 5-year plan uses year-end figures; no adjustment was made. UN's projection uses July 1st as standard time; intrapolation is used to estimate the population of Nov 1st, 2010.

¹⁴No 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.

These three lines all confirm that fertility in China dropped to below replacement-level at the beginning of the 1990s. The process afterwards was somewhat different in the three sets of estimates. The NBS's estimated birth numbers portray 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 size indicates that a speedy decline continued until 1997 when TFR dropped to below 1.4, followed by a small recovery in the first decade of new century. The sudden drop of cohort 2010 is likely to be a repeat of underenumeration of infants, which has been seen in previous censuses. All three confirm that the fertility level in China by the time of the 2010 census was around 1.5 or lower.¹⁵

Examination of the fertility age pattern data suggests that the very low fertility observed in the late 1990s and the small reversal of fertility in the first decade of the 21st century could be partially attributed to a tempo distortion. Figure 6 presents the proportion of births by mother's age and the mean age at childbearing from 1989 to 2009. The mean age at childbearing has risen to over 28 years: it started with a gradual rise with fluctuation up to 2005, followed with a major jump and a leveling off. In parallel, the distribution of mother's age at childbearing shows a similar trend. At the end of the 1980s, 50 percent births were born to mothers of 24 or younger. This proportion declined rapidly over the past two decades. By 2010, it had declined to less than 35 percent. At the same time, the proportion of births born to mothers age 30 and above increased steadily, rising from around 15 percent in the early 1990s to about 20 percent in 2005, and reaching 30 percent in 2009. The small increase of fertility in the first decade of the 21 century, as compared with very low fertility in late 1990s, can be attributed to this change of fertility age pattern: after a decade-long delay, many women eventually had their births in ages that would be regarded as late not too long ago: in 2010, the mean ages of parities 1, 2 and 3+ were at 26.7, 30.8, and 33.4, respectively.

Related to the debate on fertility level and underreporting is the increased sex imbalance of the population (South and Trend 2010; UNFPA 2012). China's sex ratio at birth has been above the normal level of 103–106 since the early 1980s. While its causes are generally agreed upon (strong son preference made manifest by constrained low fertility), as is the main mechanism (sex selective abortion), its real scale is still inconclusive due to the possibility of sex-selective underreporting (Zeng et al. 1993; Gu and Roy 1995; Poston et al. 2010). Cross-examination of the 1990 and 2000 censuses data show that over a quarter of all the missing girls in the 1990 census were hidden in the population and they reappeared in the 2000 census (Cai and Lavelly 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 total population sex ratio. The population sex ratio increased in the three previous censuses: 106.3 (1982), 106.6 (1990) and 106.7 (2000), but dropped to 105.20 in the 2010 census. This sudden drop is indicative

¹⁵The large discrepancy in 1994–2003 is likely a result of Chinese government overreacting to the underreporting problem: the Chinese 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 population of 2005 (NBS 2007), breaking away from the National Population and Family Planning Commission's insistence on TFR at the 1.8 level.

of a potential data problem, because while it is expected that an aging population would tip more towards females because females tend to live longer, it is extremely unlikely to have such a dramatic shift in the sex balance, given the continued high sex ratio at birth.¹⁶

Close data examination suggests that the problem exists mainly in the enumeration of cohorts born in recent decades, especially those 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” that were hidden in the population, assuming the sex differential in survival ratio is mainly caused by differential underreporting in the 2000 census. Table 2 provides both cohort sizes and sex ratios for cohorts born between 1970 and 2010 reported in the 2000 and 2010 censuses, and from the 2010 *hukou* data. In total, the 2010 census enumerated about 13.9 million more girls for cohorts born between 1971 and 2000, before taking into account the mortality effect. In comparison, the 2010 census only enumerated about 4.6 million more boys in those same cohorts. It appears that the 2010 census could have recovered as many as close to 10 million “missing girls” previously hidden in the population for cohorts born between 1981 and 2000. However, the sex ratio for those born in 1981–1985 and 1986–1990 are too low to be true: 102.2 and 102.5. Assuming a normal sex ratio at birth of 105 (boys per 100 girls), the expected sex ratio in ages 20 to 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 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 reason is that the 2010 census under-enumerated male population born in 1981–1990, i.e. males in their 20s at the 2010 census. This is suggested not only by an unusual sex ratio in this age group, but also the relatively very low survival ratios compared with their surrounding cohorts. It is also consistent with the fact that male population in this age group are of the highest mobility, thus most likely to be undercounted by a census. Table 2 compares population sizes and sex ratios for those born after 1971 from three sources: the 2000 and 2010 censuses and 2010 *hukou* data. For those born in the 1980s, there is a better consistency between the 2000 census and the 2010 *hukou* data. In other words, the lower sex ratio, especially for those of 1981–1990 cohorts in the 2010 census, could be a data artifact.

Even for the 1991–1995 birth cohorts, the drop of sex ratio from 115.4 in the 2000 census to 108.7 in the 2010 census appears too steep. Most in this cohort should be in primary school by 2003 – primary school students in China enroll at age 6 or 7. According to China’s education enrollment statistics, the sex ratio of primary school students was 112.4 in 2003 (Table 3), same as the sex ratio of the 1991–1995 cohort recorded in the 2010 *hukou* data (Table 2). Although there is a known cultural bias against females that puts girls at a higher risk of not enrolling or of dropping out, given that primary school education is now mostly

¹⁶If the decline of mortality was the main reason for such a reversal, it would mean a major change in male/female mortality pattern: it would require a life expectancy (at age 0) gap of around 7–8 years.

paid by the government, and close to universal, the sex ratio of primary school students should not be too much higher than that of the general population of primary school age. Using average age of primary school student to gauge sex ratio at birth, the result suggests that rising sex ratio was an ongoing phenomenon at least up 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 all three external sources: that of the 2000 census, that of the 2010 *hukou* data and that of enrollment statistics. This indicates that while the 2010 census did recover some “hidden missing girls”, e.g. about a quarter of distorted sex ratio for the 1996–2000 cohort can be attributed to “hidden girls”.

In sum, the 2010 census once again confirms that the skewed sex imbalance is not a statistical artifact, but a reality. The total of “missing girls” in China has jumped from about 8.5 million revealed by the 2000 census (Cai and Lavelly 2003) to more than 20 million (Cai 2013). Facing this epic challenge, the Chinese government has deployed a wide array of measures to reverse the gender imbalance, such as banning the use of pre-natal sex determination technology, and launching a “*Care for Girls*” campaign. Unfortunately, these policies have not been very effective in dealing with the problem (Greenhalgh 2013; Li 2007). Sex selective abortion, albeit illegal, is not difficult to obtain. The “Care for Girls” program, though it could have improved girls status within the family, has yet to change people’s desire to have a son. The roots of the problem are deep and 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 et al 2011). The sex ratio of those born after the 2000 census is still at an alarmingly high level of 118 and above. While there are some positive signs, such as a decline in the sex ratio of higher parities, it is still too early to declare that China has turned the corner on sex discrimination.

5. Internal Migration, Rapid Urbanization, and Geographic Redistribution

Internal migration and resulting rapid urbanization are the main driving forces behind population’s geographic change within China. In contrast to the overall slow population growth (averaging annual rate of 0.57 percent between 2000 and 2010) is the enormous regional variation across Chinese provinces. Map 1 categorizes Chinese provinces by intercensal population growth in four groups: a) rapid growth with population growth at an annual rate of 1% or higher, b) modest growth with an annual rate between 0.5% and 1%, c) slow growth with an annual rate between 0 and 0.5%, and d) negative growth with population loss. The map shows that rapid growth is observed both on the more developed east coast, and ethnic minority-concentrated western frontiers. In the middle of the country, negative population growth emerged.

A total of 8 provinces recorded population growth at an average annual rate of 1% or higher (Map 1 and Table 4). The three fastest growth regions are three urban municipalities: Beijing, Shanghai, and Tianjin. Both Beijing and Tianjin added about 6 million to its population in just 10 years, at an average annual growth rate of more than 3%. At this rate, a

population would double in just 20 years. The next two high growth provinces are Guangdong and Zhejiang, two 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 the population of these five provincial level units account for only 13.7 percent of China's total population in 2000 and 16.0 percent in 2010, its share of China's population growth during the decade is more than half of the total at 54.9 percent. Three minority-concentrated provinces in the western frontiers, Tibet (Xizang), Xinjiang and Ningxia also recorded rapid growth in the ten-year period. Because of their small base populations, the total growth in these three provinces only accounts for 6 percent of the national total.

Table 4 also decomposes population growth in each province using the population balance equation based on annual birth rate and death rates for each province drawn from the *China Statistical Yearbook*. The difference between total population growth and natural growth (births minus deaths) is the contribution from migration. Results shown in Table 4 portray a sharp contrast between the coastal and the western frontier provinces in their sources of population growth. For Beijing, Shanghai, and Tianjin, the three municipalities that recorded the fastest population growth, their source is almost entirely from migration. For Guangdong and Zhejiang, although in-migration's contribution is not as large as in Beijing or Shanghai, it is still the dominant force, an outcome of economic opportunities that attracted migrants from hinterland provinces. On the other hand, the main source of population growth in the three minority-concentrated western frontier provinces is natural growth, 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 the Han majority population from other provinces, they are far from being inundated with Han migrants as some have contended.

The true surprise for China is a new demographic phenomenon, in the form of negative growth. Between 2000 and 2010, six Chinese provinces recorded population loss, 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 6 provinces recording population loss, natural population change is still in the positive territory. The losses are therefore entirely due to out-migration. Sichuan alone lost 5.5 million to out-migration. The loss is expected to expand from those six provinces to their neighbors, where population growth rates have already been below the national average. Should this migration pattern continue, and as negative population growth momentum accumulated over the last few decades is set in motion, the middle part of China will continue to lose population.

China's drastic population redistribution in the first decade of the twenty-first century is an outcome of rapid urbanization. The 2010 census counted 49.7 percent of Chinese population as urban, suggesting that China has reached at historical turning point in its urbanization process. Moving from rural to urban, from farming to manufacturing to service, marks fundamental changes in social organization and individual life, with profound implication for the country's socioeconomic future. It will also have implication for other demographic issues such as childbearing behavior, gender preference, etc.

Another major factor behind China's drastic population redistribution is regional economic inequality. The more developed coast areas and urban centers attracted migrants from other provinces, as indicated by a whopping 261.4 million of Chinese living at a place different from their place of household registration. Although the Chinese government has made efforts to change regional economic imbalance by investing heavily in the central and western parts of the country through its "Western Development Strategy," the hierarchical nature of the state planning has a tendency to favor the more developed areas.

Population redistribution, itself a result of economic imbalance, is likely to further exaggerate regional inequality. For example, the selective nature of population migration makes Shanghai, despite its extremely low fertility, demographically better prepared for aging society because it can attract migrants from other provinces. Meanwhile, the "negative growth" areas will not only have a smaller population but also likely be more aging and feminized as well as in more shortage of young people.

6. Discussion and Conclusion

Analyses of preliminary census data in this paper show that the 2010 census is of reasonable quality, but at the same time contains possible defects that require careful scrutiny. For example, while the age structure displays great consistency with previous censuses, again attesting the high quality of age reporting, there are considerable discrepancies especially for younger age groups. Extremely low infant mortality also suggests problems in death counting. Nevertheless, with due caution, the 2010 census data are sufficient to present a panoramic picture of demographic changes for China during the first decade of the twenty-first century.¹⁷

China's 2010 census provides a timely update of the demographic situation in China, and indicates the direction of future change. The 2010 census leaves no ambiguity that China's fertility is indeed well below replacement (Guo 2013; Cui et al. 2013; Wang and Ge 2013). In fact, more recent data from China suggests that China might have experienced another round of fertility decline: the unadjusted TFR dropped four years in a row, to an unprecedented 1.04 in 2011 (NBS 2012). It suggests that China might be following its more developed neighbors in falling into the "low fertility trap." (Lutz et al. 2006;) On the mortality side, even after discounting for underreporting, China's improvement in life expectancy is faster than expected. This has already contributed to China's rapid aging process, but its longer term impact is going to be more substantial. Despite considerable attention devoted to correcting the problem of sex imbalance, the new census data offer no sign of relief. Another important new trend is that internal migration is the single most important factor and agent behind the rapid population redistribution in China. Mass population movement across this vast country not only alters population composition, but also brings and stimulates social, economic, and cultural changes.

¹⁷More inconsistencies, mismatches, and errors are certainly 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 strong physical features distinguishing them from the Han majority, many minority migrants were counted as Hans.

China's 2010 census marks another milestone in documenting China's profound demographic change in the first decade of the twenty-first century. The new census data confirm and reveal that China has entered a new demographic era, featured by prolonged low fertility, persistently elevated sex ratios, rapid aging, massive urbanization and major geographic redistribution. These changes have taken place during China's historical decade of economic boom, 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 products of fertility decline. Unfortunately, China has been slow to acknowledge these problems, and insists to continue controversial one-child policy. How China responds these demographic challenges will have profound implications for China's, as well as the world's, social and economic future.

References

- Banister, Judith; Hill, Kenneth. Mortality in China 1964–2000. *Population Studies*. 2004; 58:55–75. [PubMed: 15204262]
- Bongaarts, John. How Long Will We Live? *Population and Development Review*. 2006; 32(4):605–628.
- Cai, Yong; Lavelly, William. China's Missing Girls: Numerical Estimates and Effects on Population Growth. *The China Review*. 2003; 3:13–29.
- Cai, Yong. Assessing fertility levels in China using variable-r method. *Demography*. 2008; 45(2):371–81.
- Cai, Yong. Social Forces behind China's below Replacement Fertility: Government Policy or Socioeconomic Development. *Population and Development Review*. 2010; 36(3):419–440. [PubMed: 20882701]
- Cai, Yong. China's Demographic Challenges: Gender Imbalance. Paper presented at the "China's Challenges: the Road Ahead" conference at the Center for the Study of Contemporary China; April 25–26, 2013; University of Pennsylvania; 2013.
- Coale, Ansley. Committee on Population and Demography, Report No. 27. Washington, D.C: National Academy Press; 1984. Rapid Population Change in China, 1952–1982.
- Coale, Ansley; Banister, Judith. Five decades of missing females in China. *Demography*. 1994; 31(3): 459–479. [PubMed: 7828766]
- Coale, Ansley; Demeny, Paul George; Vaughan, Barbara. Regional Model Life Tables and Stable Populations. 2. New York: Academic Press; 1983.
- Cui, Hongyan; Lan, Xu; Rui, Li. An Evaluation of Data Accuracy of the 2010 Population Census of China. *Population Research*. 2013; 37(1):10–21. In Chinese.
- Feeney, Griffith; Yuan, Jianhua. Below replacement fertility in China? A close look at recent evidence. *Population Studies*. 1994; 48:381–394.
- Goodkind, Daniel. China's missing children: The 2000 census underreporting surprise. *Population Studies*. 2004; 58:281–295. [PubMed: 15513284]
- Goodkind, Daniel. Child Underreporting, Fertility, and Sex Ratio Imbalance in China. *Demography*. 2011; 48(1):291–316. [PubMed: 21336689]
- Greenhalgh, Susan. Patriarchal Demographics? China's Sex Ratio Reconsidered. *Population and Development Review*. 2013; 38:130–149.
- Gu, Baochang; Feng, Wang, editors. An Experiment of Eight Million People--reports from areas with two-child policy. Beijing: China Social Sciences Academic Press; 2009.
- Gu, Baochang; Cai, Yong. Expert Paper No. 2011/14. Department of Economic and Social Affairs Population Division, the United Nations; 2011. Fertility Prospects in China.
- Gu, Baochang; Roy, Krishna. Sex ratio at birth in China, with reference to other areas in East Asia: what we know. *Asia-Pacific Population Journal/United Nations*. 1995; 10(3):17–42. [PubMed: 12290692]

- Gu, Baochang; Feng, Wang; Guo, Zhigang; Erli, Zhang. China's Local and National Fertility Policy at the Twentieth Century. *Population and Development Review*. 2007; 33(1):129–147.
- Guilmoto, Christophe. The Sex Ratio Transition in Asia. *Population and Development Review*. 2009; 35(3):519–549.
- Guilmoto, Christophe. Skewed Sex Ratios at Birth and Future Marriage Squeeze in China and India, 2005–2100. *Demography*. 2012 Feb 1; 49(1):77–100.10.2307/41408220 [PubMed: 22180130]
- Guo, Zhigang; Chen, Wei. Below replacement fertility in mainland China. In: Zhao, Zhongwei; Guo, Fei, editors. *Transition and Challenge: China's Population at the Turn of the Twenty-First Century*. Oxford University Press; 2007. p. 54–70.
- Guo, Zhigang. 2010 Population Census Data Indicates Serious Mismatch in Past Population Estimation and Projection. *Chinese Journal of Population Science*. 2011; 2011(1):2–13.
- Guo, Zhigang. The Low Fertility Rate is the Major Demographic Risk in China. *China Economic Journal*. 2013.10.1080/17538963.2012.761834
- Huang, Rongqing; Zeng, Xianxin. Infant Mortality Reported in the 2010 Census: Bias and Adjustment. *Population Research*. 2013; 37(2):3–16.
- Jiang, Zhenghua. Thinking Ahead of Population Policies in the New Era. *Chinese Journal of Population Science*. 2006; 6:2–5. (In Chinese).
- Lavelle, William. First impressions from the 2000 Census of China. *Population and Development Review*. 2001; 24(4):755–69.
- Li, Chengrui, editor. *A census of one billion people: papers for the International Seminar on China's 1982 Population Census*. Beijing: 1984.
- Li, Shuzhuo. Imbalanced sex ratio at birth and comprehensive intervention in China. Paper presented at 4th Asia Pacific Conference on reproductive and Sexual Health and rights; 29–31 October; Hyderabad, India. New York: UNFPA; 2007.
- Lutz, Wolfgang Lutz; Skirbekk, Vegard; Testa, Maria Rita. *Vienna Yearbook of Population Research*. Vienna: Austrian Academy of Sciences Press; 2006. The Low Fertility Trap Hypothesis.
- MCHSCN. Newsletter of China Maternal and Child Health Surveillance Network, 2010(5) & 2011(4). 2010/2011.
- Merli, M Giovanna; Raftery, Adrian E. Are Births Underreported in Rural China? Manipulation of Statistical Records in Response to China's Population Policies. *Demography*. 2000; 37:109–126. [PubMed: 10748993]
- Merli, M Giovanna. Underreporting of Births and Infant Deaths in Rural China: Evidence from Field Research in One County of Northern China. *The China Quarterly*. 1998:637–655.
- Ministry of Education, China (MOE). *China Education Statistical Yearbook*. Beijing: People's Education Press; 2003–2010.
- Ministry of Health, China (MOH). *China Health Statistical Yearbook*. Beijing: Peking Union Medical College Press; 2000–2012.
- Morgan, Philip; Guo, Zhigang; Hayford. China's Below-Replacement Fertility: Recent Trends and Future Prospects. *Population and Development Review*. 2009; 35(3):605–629. [PubMed: 20376285]
- Murphy, Rachel; Tao, Ran; Lu, Xi. Son Preference in Rural China: Patrilineal Families and Socioeconomic Change. *Population and Development Review*. 2011; 37(4):665–90. [PubMed: 22319769]
- National Bureau of Statistics of China (NBS). *China Population Statistical Yearbook (1990–2012)*. 1990–2012. In Chinese
- National Bureau of Statistics of China (NBS). *The Complete Collection of National and Provincial Population Census Data Assembly*. University of Michigan China Data Center; 2003. Electronic version CDC-S-2003-201
- National Bureau of Statistics of China (NBS). *Major Figures on 2010 Population Census of China*. Beijing: China Statistical Press; 2011.
- National Bureau of Statistics of China (NBS). *Tabulation on the 2010 Population Census of the People's Republic of China*. Beijing: China Statistical Press; 2012.

- National Bureau of Statistics of China and East-West Center (NBS and EWC). Fertility Estimates for Provinces of China, 1975–2000. Beijing: China Statistics Press; 2007.
- National Population and Family Planning Commission of China (NPFPC). Report on the National Strategy of Population Development. 2007. http://www.gov.cn/gzdt/2007-01/11/content_493677.htm. (In Chinese)
- National Population and Family Planning Commission of China (NPFPC). Data Handbook for Population and Family Planning 2006. Beijing: China Population Press; 2007. (In Chinese)
- National Population Development Strategy Research Group (NPDSRG). National Population Development Strategy Research Report. Beijing: China Population Press; 2007. (In Chinese)
- Oeppen, Jim; Vaupel, James W. Broken Limits to Life Expectancy. *Science*. 2002; 296(5570):1029–1031. [PubMed: 12004104]
- Office of China Maternal and Child Health Surveillance (MCHSCN). Newsletter of China Maternal and Child Health Surveillance Network. 2010/11. <http://www.mchscn.org>
- Preston, Dudley L.; Conde, Eugenia; DeSalvo, Bethany. China's unbalanced sex ratio at birth, millions of excess bachelors and societal implications. *Vulnerable Children and Youth Studies*. 2011; 6(4): 314–320.
- Retherford, Robert; Choe, Minja K.; Chen, Jiajian; Xiru, Li; Cui, Hongyan. How Far Has Fertility in China Really Declined? *Population and Development Review*. 2005; 31:57–84.
- Scharping, Thomas. Birth control in China, 1949–2000: population policy and demographic development. London/New York: Routledge; 2003.
- Scharping, Thomas. The Politics of Numbers: Fertility Data in Recent Decades. In: Zhao, Zhongwei; Guo, Fei, editors. *Transition and Challenge: China's Population at the Turn of the Twenty-First Century*. Oxford University Press; 2007. p. 34–53.
- South, Scott J.; Trent, Katherine. Imbalanced Sex Ratios, Men's Sexual Behavior, and Risk of Sexually Transmitted Infection in China. *Journal of Health and Social Behavior*. 2010 Dec 1; 51(4):376–390.10.2307/20798301 [PubMed: 21131616]
- UNFPA. Sex Imbalances at Birth: Current Trends, consequences and policy implications. UNFPA Asia and the Pacific Regional Office; Bangkok, Thailand: 2012.
- United Nations. World Population Prospects, the 2010/2012 Revision. Department of Economic and Social Affairs, Population Division; New York: United Nations Publication; 2011/2013.
- Wang, Fei-Ling. Organizing Through Division and Exclusion: China's Hukou system. Stanford, California: Stanford University Press; 2005.
- Wang, Feng; Cai, Yong; Gu, Baochang. Population, Policy, and Politics: How Will History Judge China's One-Child Policy? *Population and Development Review*. 2013; 38(Supplement):115–129.
- Wang, Jinying; Yanxia, GE. Assessment of 2010 Census Data Quality and Past Population Changes. *Population Research*. 2013; 37(1):22–33.
- Zeng, Yi; Ping, Tu; Baochang, Gu; Yi, Xu; Bohua, Li; Yongping, Li. Causes and Implications of the Recent Increase in the Reported Sex Ratio at Birth in China. *Population and Development Review*. 1993; 19:283–302.
- Zeng, Yi. Is fertility level in China in 1991–1992 far below the replacement level? *Population Studies*. 1996; 50:27–34.
- Zhang, Guangyu; Zhao, Zhongwei. Reexamining China's fertility puzzle: Data collection and quality over the last two decades. *Population and Development Review*. 2006; 32(2):293–321.
- Zhang, Weimin; Hongyan, Cui. Preliminary Assessments of 2000 Census Data. *Population Research*. 2002; 2002(4):25–35. In Chinese.
- Zhang, Weiqing. Seeking a Path with Chinese Characteristics for Better Coordination in Solving Population Problems. *Population Research*. 2007; 31(3):1–6. (In Chinese).
- Zhao, Baige. News Conference December 9th, 2009 in Copenhagen, reported in "Population control called key to deal" by China Daily; December 10th, 2010; 2009.
- Zhao, Zhongwei; Chen, Wei. China's far below-replacement fertility and its long-term impact: Comments on the preliminary results of the 2010 census. *Demographic Research*. 2011; 26(25)
- Zheng, Zhenzhen; Cai, Yong; Feng, Wang; Gu, Baochang. Below-Replacement Fertility and Childbearing Intention in Jiangsu Province, China. *Asian Population Studies*. 2009; 5(3):329, 347.

Figure 1. Comparison of Population 2010 Age Structure, Census vs. *Hukou*

Data sources: Census data: NBS 2002, 2012; *Hukou* data: National Citizen ID Information System (NCIS).

Note: The standard time for the census data is November 1st, 2010. The standard time for the *Hukou* data is July 1st, 2010. No adjustment is made to synchronize the comparison cohorts.

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 directly taken from the census tabulations.

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 infant mortality rates from *Newsletter of China Maternal and Child Health Surveillance Network*, 2010(5) & 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.

Figure 5. Total Fertility by Year, China 1989–2010

Data sources: Unadjusted NBS Population Surveys/Censuses TFRs are calculated from age specific fertility rates published in the *China Population Statistical Yearbook*. Annual numbers of births TFRs are derived from annual birth size found in the *China Statistical Yearbook* with women's age structure from the 2010 census. The "2010 Census Cohort Size" TFRs are derived from cohort size enumerated in the 2010 census using women's age structure from the 2010 census.

Figure 6. Change in the Age Pattern of Fertility and Mean Age at Childbearing, China 1990–2010

Data sources: Calculated using age specific fertility data published in the *China Population Statistical Yearbook*.

Figure 7. Map 1. Average Annual Population Growth by Province, China 2000–2010

Data sources: Calculated from population by province in the 2000 and 2010 censuses

Table 1

Comparison of Infant Mortality Rates, Life Expectancies, China 2000–2010

		Male		Female	
		2000	2010	2000	2010
q_0	Census Raw 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	Census Raw 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}	Census Raw Data	34.6	38.0	38.5	41.6
	GGB	33.9	36.5	37.2	39.5

Data sources:

Census: Census raw data, NBS 2003, 2012.

NBS: Adjusted estimates provided the National Bureau of Statistics (NBS 2012).

MW-GGB: Matched values from Coale and Demeny (1966:83) Regional Model Life Tables West with the GGB estimates of e_{40} .

Table 2

Sex Ratio by Birth Cohort, China 2000 vs. 2010

Birth Cohorts	2000 Census			2010 Census			2010 Hukou		
	Male (millions)	Female (millions)	Sex Ratio (per 100)	Male (millions)	Female (millions)	Sex Ratio (per 100)	Male (millions)	Female (millions)	Sex Ratio (per 100)
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

Data sources: Census data: NBS 2003, 2012. Hukou data: National Citizen ID Information System (NCIIS).

Note: Because the 2000 and 2010 censuses use November 1 as the reference date, birth cohorts used here reference to “census year”, not calendar year. For example, the 2006–2010 cohorts refer to those born between Nov 1, 2005 and October 31, 2010.

Table 3

Primary School Students by Sex, China 2003–2009

Year	Males (millions)	Females (millions)	Sex Ratio (per 100)	Average Age
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

Data sources: *China Education Statistical Yearbook* 2003–2010.Note: Education data use September 1st as the standard time.

Table 4

Decomposition of Population Growth in the Eight Fastest Growing Provincial Level Units, China 2000–2010

Region	Pop 2000 (Millions)	Pop 2010 (Millions)	Pop Change (Millions)	Ave Ann Change Rate (%)	Natural Increase (Millions)	Net Migration (Millions)	Mig's Share of Change (%)
Beijing	13.82	19.61	5.79	3.50	0.29	5.50	95
Shanghai	16.74	23.02	6.28	3.19	0.20	6.08	97
Tianjin	10.01	12.94	2.93	2.57	0.19	2.73	93
Guangdong	86.42	104.30	17.88	1.88	6.74	11.15	62
Zhejiang	46.77	54.43	7.66	1.52	2.16	5.50	72
Xizang(Tibet)	2.62	3.00	0.38	1.36	0.31	0.07	19
Xinjiang	19.25	21.81	2.56	1.25	2.21	0.35	14
Ningxia	5.62	6.30	0.68	1.14	0.63	0.05	8

Data sources: Census data by province is from NBS 2003, 2012.

Decomposition is calculated based on the census data and annual birth and death rates provided in *China Statistical Yearbook* 2001–2011.

Table 5

Negative Population Growth in Six Provincial Level Units, China 2000–2010

Province	Pop 2000 (Millions)	Pop 2010 (Millions)	Pop Change (Millions)	Ave Ann Change 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

Data sources: Census data by province is from NBS 2002, 2012.

Decomposition is calculated based on the census data and annual birth and death rates provided in the *China Statistical Yearbook* 2001–2011.