Gender imbalance in China: Dynamics and new trends

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Abstract: Given high population sex ratio for 60 years since China's first population census in 1953 and skewed sex ratio at birth for 30 years, we review the determinants and expose the new patterns of gender imbalance in China. Using censuses data from 1982 to 2010, we adopt demographic method to decompose the population sex ratio into three factors --- population age structure, sex differential in mortality, sex ratio at birth. The results indicate that sex differential in mortality had little influence on high population sex ratio and started to decline the population sex ratio by 0.65 since 2000. The rapid aging of population age structure takes the main effect on declining population sex ratio, competing with the skewed sex ratio at birth which becomes the leverage to raise the population sex ratio in contemporary China. We also evaluate the quality of census data by comparing models with and without the effects of sex-selective underreporting, the under-enumerate of girls in census data is confirmed. Finally, we focus on the new trend of sex ratio at birth --- shifting pattern of sex-selection at birth, and approve that the decline in sex-selection at second birth fully offset by the increase in sex-selection at first birth, given the sex ratio at birth rising from 116.9 in 2000 to117.9 in 2010.

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Introduction

Gender imbalance has been existed throughout Chinese history as well as in contemporary China, for men's dominant status in property inheritance, residential arrangement, family succession, family power structure and women's lower status in family and society. Therefore, it is not surprising to observe a high population sex ratio of 107.6 since the first population census of China in 1953. The population sex ratio then varied between 105 and 107 in the next 60 years (105.2 in 2010).

Figure 1 About Here

But causes and patterns of the high ratios have been shifting significantly, given the population sex ratio hovering at high level. Adult female mortality levels initiated to decline and become lower than those of males since 1960s. Sex ratios of child-age mortality (male/female) started to exceed 1 since 2000s, so that sex differential in mortality had little influence on high population sex ratio at present.

Figure 2 is About Here

The rapid aging of population age structure started in the late of 1990s takes the main effect on declining population sex ratio, competing with the skewed sex ratio at birth which becomes the leverage to raise the population sex ratio in contemporary China.

Figure 3 and 4 About Here

Not only the population sex ratio, but also patterns of sex ratio at birth are also shifting. According to recent population census in 2010, there has been a sharp reduction in sex-selection at second birth and a sharp rise at first birth, given the overall sex ratio at birth rising from 116.9 in 2000 to117.9 in 2010.

Figure 5 About Here

In this paper, we aim to reveal the new shifting patterns under the two high sex ratio --- population sex ratio and sex ratio at birth. For the population sex ratio, we adopt demographic method to decompose the population sex ratio into three factors --- population age structure, sex differential in mortality, sex ratio at birth and examine how much the shift of the sex ratio could be explained by each factor. We also evaluate the quality of census data by comparing models with and without the effects of sex-selective underreporting. For the sex ratio at birth, we calculate how the difference of the overall sex ratio at birth is offset by the shift in the pattern of sex-selection between 2000 and 2010 (increase in sex-selection in first births, reduction for second births, flat for third births).

Data and methods

The data we used here is from population census data in 1982, 1990, 2000 and 2010. Censuses in 1953, 1964 do not contain the death section, so we start our analysis from 1982 census.

A decomposition approach is used to model the effects of population age structure, sex differential in mortality, sex ratio at birth on population sex ratio change and also sex-selective underreporting. Following Das Gupta (1991)[1], the analysis decomposes population sex ratio into four components to estimate the separate effects of each component on population sex ratio. For the reader's convenience, the mathematical expression is recapitulated as below.

Assuming the population is closed to migration, the population sex ratio at time t can be estimated with the following identity[2]:

$$SR(\cdot,t) = \sum_x\big(SR(x,t) * C^F(x,t)\big) = \sum_x\left(SRB_{t-x} * C^F(x,t) * \frac{P_c^M(x,t-x)}{P_c^F(x,t-x)} * V_{t-x}\right) \quad (1)$$

Where $SR(\cdot,t)$= sex ratio of the population at time t, $C^F(x,t)$= proportionate age structure of the female population at time t, $SR(x,t)$= age-specific sex ratio at time t, SRB= sex ratio at birth, $P_c^M(x,t-x)$ and $P_c^F(x,t-x)$= male and female probability of surviving from birth to age x in the cohort born at time t-x (i.e., aged x at time t), and V_{t-x} is the correction factor for sex-selective underreporting in the cohort born at time t-x.

To simplify the formula, we use the following capitals to make a replacement,

$$A = SRB_{t-x}, \quad B = C^F(x,t), \quad C = \frac{P_c^M(x,t-x)}{P_c^F(x,t-x)}, \quad D = V_{t-x}$$

It follows that the change in the population sex ratio is,

$$\Delta SR(\cdot,t) = SR(\cdot,t_1) - SR(\cdot,t_2) = \sum_x\big(\Delta A * (\bar{B} * \overline{CD} + \bar{C} * \overline{BD} + \bar{D} * \overline{BC})\big) +$$

$$\sum_x\big(\Delta B * (\bar{A} * \overline{CD} + \bar{C} * \overline{AD} + \bar{D} * \overline{AC})\big) + \sum_x\big(\Delta C * (\bar{A} * \overline{BD} + \bar{B} * \overline{AD} + \bar{D} *$$

$$\overline{AB})\big) + \sum_x\big(\Delta D * (\bar{A} * \overline{BC} + \bar{B} * \overline{AC} + \bar{C} * \overline{AB})\big) \quad (2)$$

Where the symbol Δ denotes change, and bar on the capital like $\bar{A}$ are average values over the period, and $\overline{CD} = \bar{C} * \bar{D}$. The first of the four principal terms on the right hand side of Eq. 2 denotes the contribution to change in population sex ratio from changes of SRB. The second term denotes the contribution from changes population age structure. The third term denotes the contribution from changes in sex differential in mortality. The last term denotes the contribution from changes in

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[1] Das Gupta, P. (1991). Decomposition of the difference between two rates and its consistency when more than two populations are involved. Mathematical Population Studies, 3(2), 105–125.

[2] This identity is a revised edition based on Michel Guillot's research. Michel Guillot. (2002). Dynamics of the population sex ratio in India, 1971-96. Population studies, 56(1), 51–63.

sex-selective underreporting.

Reconstruction of population sex ratios in 1982, 1990, 2000 and 2010

In order to examine the data quality for sex ratio in census data, we reconstruct the trend in the population sex ratio of China in 1982, 1990, 2000 and 2010 via Eq. 1.

Table 1 About Here

The results indicate that the population sex ratio should be lower than the adjust-reported data by the National Bureau of Statistics of China (NBS) based on the six population census data in 1982, 1990, and 2000. This implies that females were underreported in census year but an over-adjustment was made based on the sixth census by NBS. However, the reconstructed population sex ratio in 2010 is higher than the reported level. This is consistent with previous censuses that females are underreported again in 2010 census.

Dynamics of population sex ratio in China: Shifting determinants

Table 2 presents the change in population sex ratio, which is decomposed into three components. The first component represents changes in population age structure (AS), the second component represents changes in sex differential in mortality (MD), and the third component represents changes in sex ratio at birth (SRB). Here, we assume no sex-selective underreporting, so that V=0. The results show a 1.99 increase in China's population sex ratio between 1982 and 2010. The change of population age structure and sex differential mortality contributed to decline 2.50 and 0.33 of population sex ratio, which could not offset the increasing effect of 4.81 by the rapid rising sex ratio at birth since 1980.

Table 2 About Here

From 1982 to 1990 and 1990 to 2000, both changes in sex differential mortality and sex ratio at birth led to a growth in population sex ratio. During this period, the mortality of females, especially at child age, is still higher than males. The age structure started to balance the population sex ratio, but not significant. From 2000 to 2010, the population sex ratio only increasing 0.1, but effects from population age structure and sex differential mortality offset almost all the effect of rising sex ratio at birth, and the change of sex differential mortality turned to decline population sex ratio first time which indicate a sign of the improved gender balance.

Table 3 About Here

When we take account the effect of sex-selective underreporting, this effect contributed to decline population sex ratio by 1.66 and made the population sex ratio at 105 in 2010.

Figure 6 About Here

To illustrate the independent effect of each component on population sex ratio change, we compared the population sex ratio with and without the each component. For instance, in Fig.4, the light blue line represents what the population sex ratio would be without skewed sex ratio at birth (counter-factual test). This figure confirms the importance of sex ratio at birth to the increase in China's population sex ratio. Without the growth of sex ratio at birth, China's population sex ratio would be much lower than it actually is. If we do not take account the effects of population age structure, sex differential mortality and sex-selective underreporting, the population sex ratio would be higher than it is now.

New trends of sex ratio at birth: Shifting pattern of sex-selection at birth

We conduct the same method to see how the new shifting pattern increase the overall sex ratio at birth by the change of birth proportion and change of sex ratio by birth order in 2000-2010.

The SRB at time t can be estimated with the following identity and we do not write down the decomposition formula here,

$$SRB(\cdot, t) = \sum_i \left(SRB(i,t) * C^F(i,t) \right)$$

$SRB(\cdot, t)$= sex ratio at birth at time t,
$SRB(i, t)$= sex ratio of birth i at time t,
$C^F(i, t)$= proportionate female birth i of the total female birth population at time t.

Table 4 About Here

The results indicate that: 1) The effect of changing birth proportion by birth order is more significant than the variation of SRB by birth order on the difference of total SRB between 2000 and 2010. 2) The drop of first birth proportion from 72.3% to 64.3% declines total SRB by 8.7, while the growth of second birth proportion from 22.8% to 30.1% increases total SRB by 10.3 between 2000 and 2010. 3) The decline in sex-selection at second birth, which decreases the total SRB by 5.7, fully offsets the increase in sex-selection at first birth which increases the total SRB by 4.5. 4) The few changes in birth proportion and SRB at 3+ births take little account of total SRB change.

Conclusions

The first implication of this reconstruction refers to levels of a sex-specific undercount in censuses. The results alone do not allow us to conclude whether the discrepancy between recorded and reconstructed sex ratios is due to an undercount of females. However, the results tell us that females were more likely to be missed than males in census data.

Secondly, the sex ratio of overall population and birth population could be kept stable at certain high levels, but it doesn't mean the mechanism of determinants and patterns not changed. In this paper, we find that sex differential in mortality had little

influence on high population sex ratio and started to decline the population sex ratio since 2000. The rapid aging of population age structure takes the main effect on declining population sex ratio, competing with the skewed sex ratio at birth which becomes the leverage to raise the population sex ratio in contemporary China. For sex ratio at birth, we find that the effect of changing birth proportion by birth order is more significant than the variation of SRB by birth order on the difference of total SRB between 2000 and 2010, given the shifting pattern of sex-selection at birth.

Finally, the public policies on the issue of high sex ratio at birth, like Care for Girl Program, should be revised according to the new trends. Government used to focus on the second birth since censuses had showed that sex ratios at first birth were close to normal but rose very sharply at the second birth. The program should be substantially intensified since the new trend of shifting sex-selection in birth order was revealed in 2010 census.

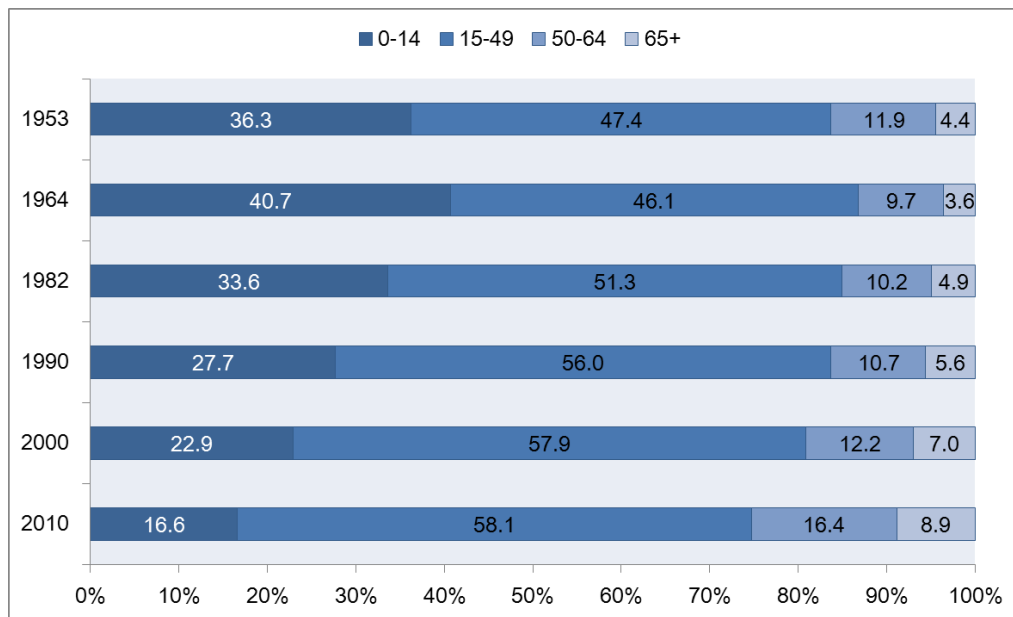**Figure 1 Trends in population sex ratios of China, 1953-2010**
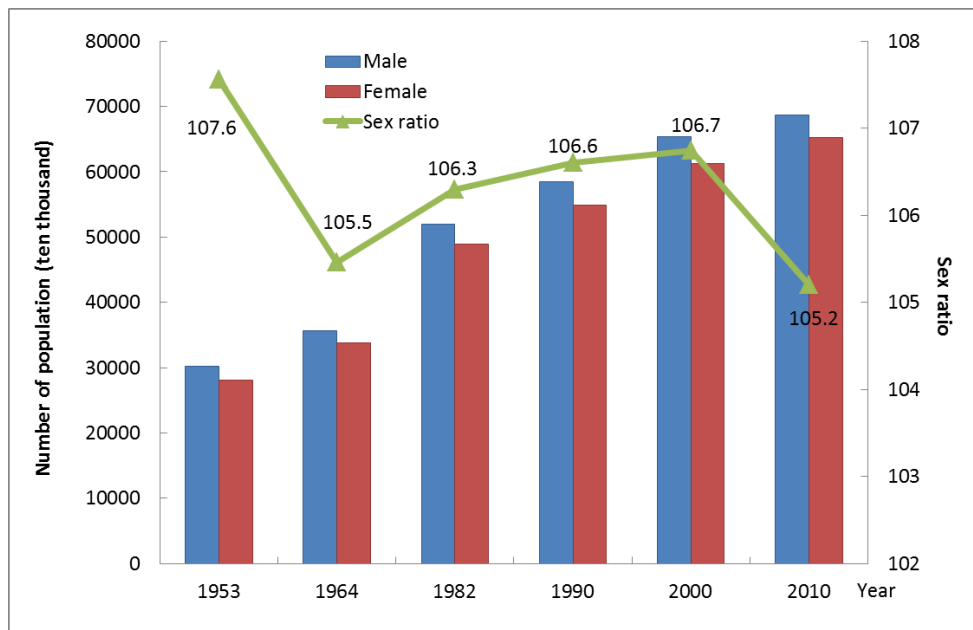
Sources: Population Censuses of China 1953, 1964, 1982, 1990, 2000, and 2010

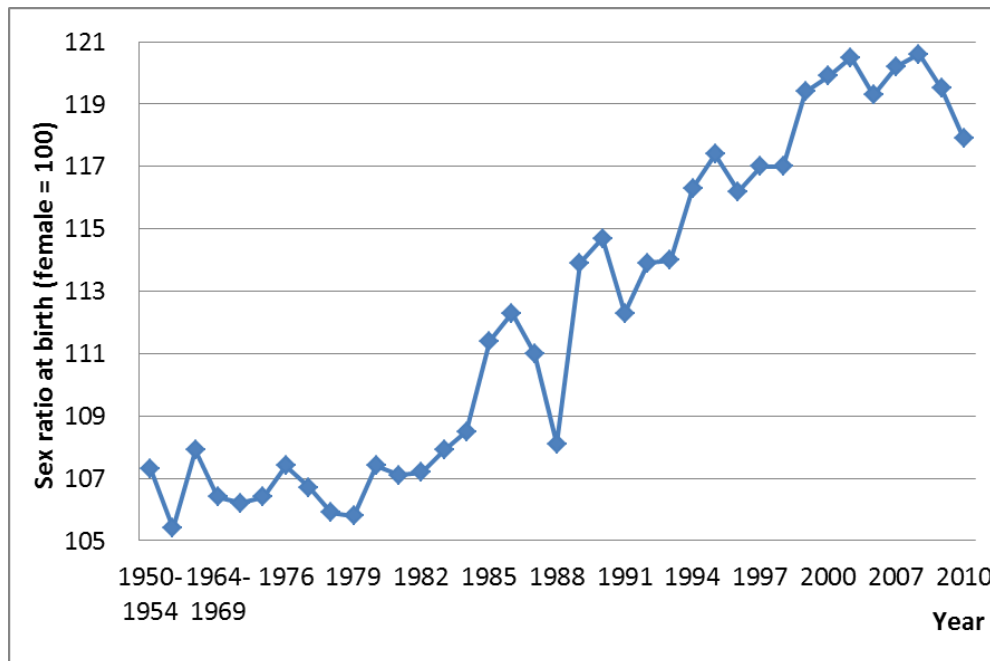**Figure 2 Trends in sex ratios of mortality of China, 1982-2010**
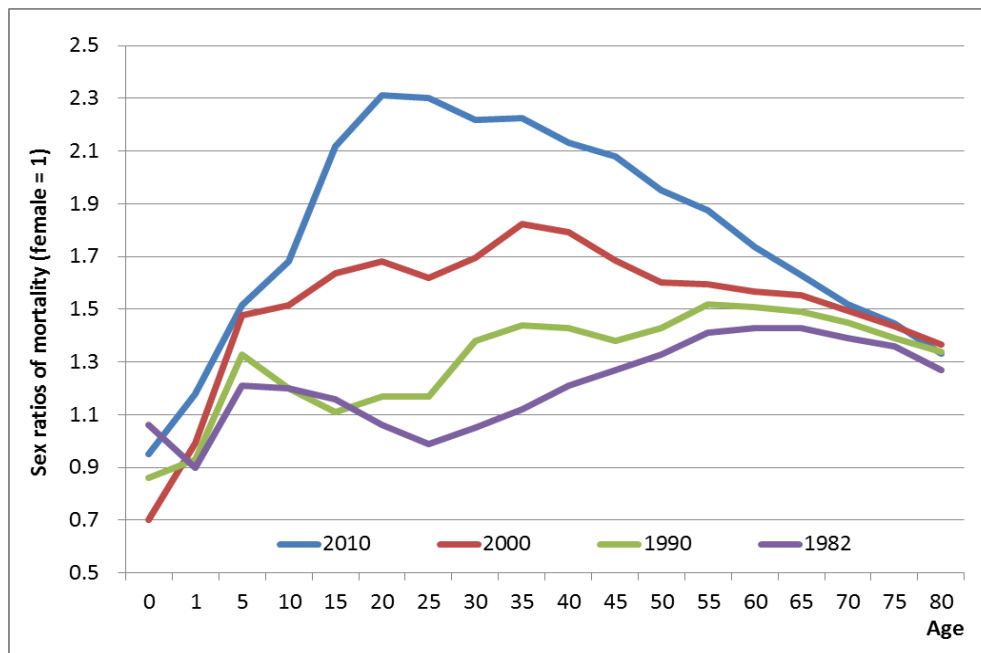
Sources: Population Censuses of China 1982, 1990, 2000, and 2010

Figure 3 Population proportion by age-group of China, 1953-2010 (%)

| Year	0-14	15-49	50-64	65+
1953	36.3	47.4	11.9	4.4
1964	40.7	46.1	9.7	3.6
1982	33.6	51.3	10.2	4.9
1990	27.7	56.0	10.7	5.6
2000	22.9	57.9	12.2	7.0
2010	16.6	58.1	16.4	8.9

Sources: Population Censuses of China 1953, 1964, 1982, 1990, 2000, and 2010

**Figure 4 Trends in sex ratios at birth of China, 1950-2010**

Sources: Population Censuses of China 1953, 1964, 1982, 1990, 2000, and 2010, 1 per 1000 fertility Survey of China in 1988 and 1992, and 1 per 100 population sample survey, 2011

Figure 5:   Trends in Sex Ratio at Birth by Birth Order of China, 1982-2010
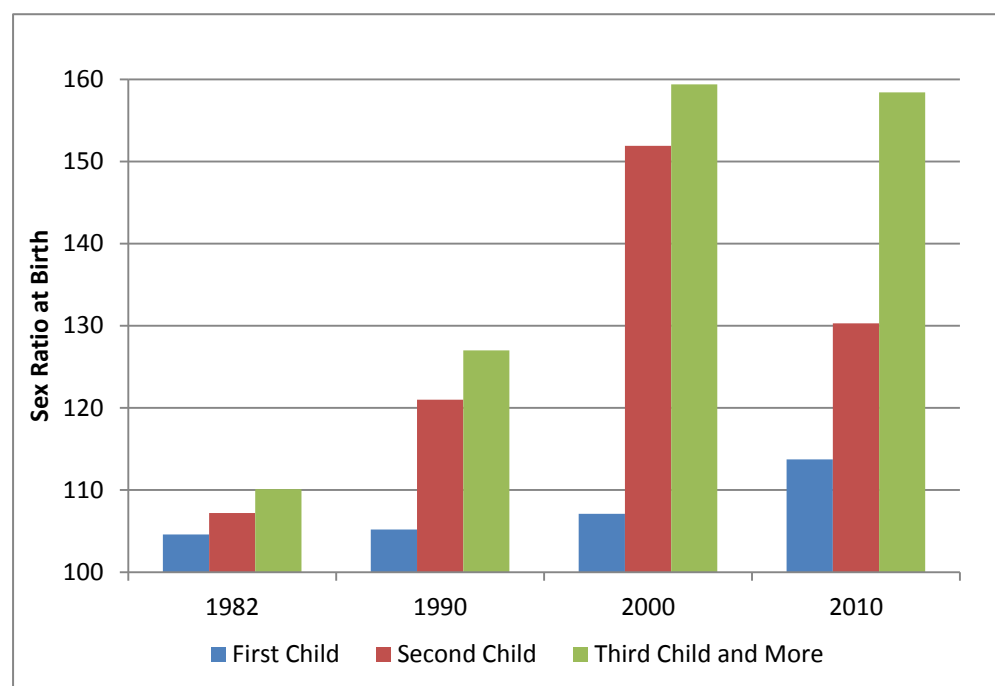
Source: Census of China 1982, 1990 2000 and 2010

Figure 6:   Counter-factual test on Sex Ratio at Birth of China, 1982-2010
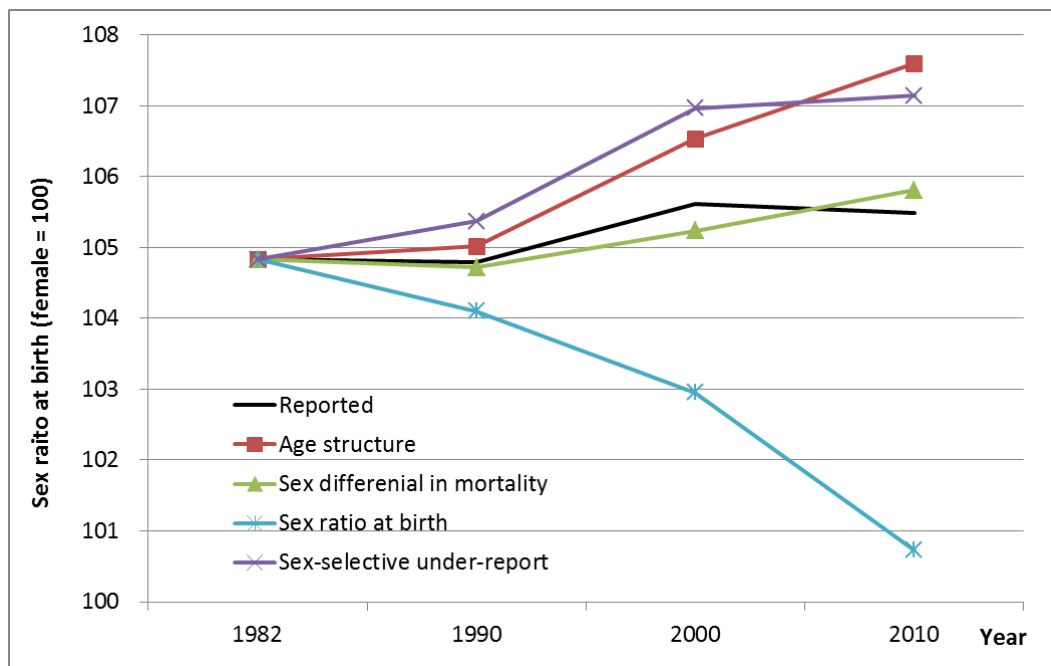
Source: Census of China 1982, 1990 2000 and 2010

Table 1 Population sex ratio according to census and projected

	1982	1990	2000	2010
Adjusted data by CBS based on the sixth population census in 2010	106.30	106.60	106.74	105.20
Report data from each population census	105.45	106.04	106.30	105.20
Projected (V=0)	104.83	105.36	106.72	106.82
Projected	104.83	104.79	105.62	105.48

Table 2 Decomposition of the Changes in Population sex ratio in China: 1982–2008

Period	Population sex ratio (Per 100)			Absolute change (Per 100)			
	Start	End	Change	AS	MD	SRB	V
1982-1990	104.83	105.36	-0.53	0.25	-0.08	-0.70	0
1990-2000	105.36	106.72	-1.36	0.92	-0.34	-1.94	0
2000-2010	106.72	106.82	-0.10	1.31	0.65	-2.06	0
1982-2010	104.83	106.82	-1.99	2.50	0.33	-4.81	0

Table 3 Decomposition of the Changes in Population sex ratio in China: 1982–2008

Period	Population sex ratio (Per 100)			Absolute change (Per 100)			
	Start	End	Change	AS	MD	SRB	V
1982-1990	104.83	104.79	0.03	0.22	-0.07	-0.69	0.58
1990-2000	104.79	105.62	-0.82	0.66	-0.34	-1.89	0.75
2000-2010	105.62	105.48	0.14	1.04	0.64	-2.01	0.47
1982-2010	104.83	105.48	-0.65	2.11	0.33	-4.75	1.66

Table 4 Standardization and decomposition of the national SRB by birth proportion and sex ratio by birth order, China, 2000-2010

			Standardized SRB		Decomposition
	2000	2010	2000	2010	Difference (effects)
Birth proportion					
1st	72.3%	64.3%	125.32	116.59	8.73
2nd	22.8%	30.1%	115.91	126.19	-10.28
3rd+	5.0%	5.6%	120.42	121.41	-0.98
SRB by birth order					
1st	107.12	113.73	118.70	123.21	-4.51
2nd	151.92	130.29	123.90	118.19	5.71
3rd+	159.36	158.41	120.94	120.89	0.05
SRB total	119.92	121.21			-1.29