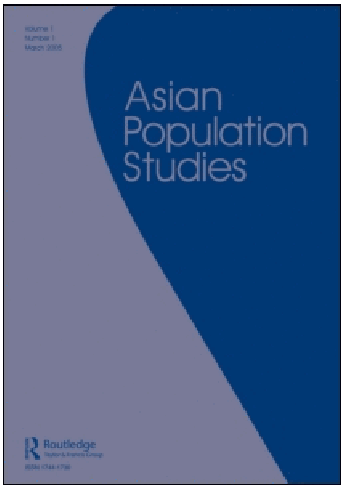

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LONGER-TERM DISRUPTIONS TO DEMOGRAPHIC STRUCTURES IN CHINA AND INDIA RESULTING FROM SKEWED SEX RATIOS AT BIRTH

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LONGER-TERM DISRUPTIONS TO DEMOGRAPHIC STRUCTURES IN CHINA AND INDIA RESULTING FROM SKEWED SEX RATIOS AT BIRTH

Christophe Z. Guilmoto

This paper presents population forecasts for China and India till 2100. The rise in sex ratios at birth in these countries has been observed to be the longest-running and most pronounced in Asia. The paper is based on different hypotheses on the future evolution of birth masculinity in each of these countries. These hypotheses are derived from an examination of present trends across Asia. The population forecasts allow us to explore the influence of various trajectories of sex ratio at birth on the demographic structures of both countries till 2100. In particular, the specific impact of skewed sex ratios on the adult population in which gender imbalances may translate into a major marriage squeeze in the future will be examined.

KEYWORDS: China; India; sex ratio; age structures; sex ratio at birth; forecasts

Introduction

Research on the demographic future of countries after rapid fertility decline has stressed the importance of the 'population waves' sweeping across the continent's age structures under the impact of fast declining fertility and extended life expectancy (Pool *et al*. 2006). These studies have, in particular, highlighted the variegated social and economic merits of demographic dividends when the proportion of the working age population reaches its historical maximum at the turn of the century. Similarly, this research has also identified the emergence of an acceleration in population ageing that will soon follow the 'demographic window of opportunity'. However, Asia's population structures are concurrently undergoing an entirely different process of demographic change, which is likely to result in waves of excess male cohorts.

Several Asian countries today are characterized by a gradual masculinization process in which the proportion of male births during the last 20 years has reached unusually high levels. The sex ratio at birth (SRB) has, in many places, increased above the standard range of 104–106, reaching at times over 110 or 120 male births per 100 female births.[1] Countries affected include China and India. In fact, the two Asian billionaires are jointly responsible for today's masculine sex ratio of 101.6 on a planetary scale. This is in spite of the rest of the world having a somewhat reasonable overall sex ratio of 98.3.[2] However, many other countries, from South Caucasus to South Asia and East Asia, have also witnessed a significant rise in their SRB levels.[3] The extent of future distortions in the age and sex

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distributions among Asian countries will be closely related to the intensity and schedule of this demographic masculinization over the next decades.

This paper will present population forecasts for China and India—countries where the rise in birth masculinity has been the longest-running and most pronounced in Asia. Moreover, as these two countries are the most populous in the world, their overall influence on Asian and world demographics is bound to be formidable. The paper starts with a discussion of the most recently available population data to project their demographic compositions. Using different hypotheses for the future evolution of the SRB in each country, the influence of various SRB trajectories on the demographic structures of both countries till 2100 will then be examined. The last part of the paper examines the specific impact of skewed sex ratio on the adult population in which gender imbalances may translate into a major marriage squeeze.

Skewed SRB and Population Projections

Progressive masculinization of birth cohorts dates back to the 1980s in South Korea, India and China.[4] As is well-established, the cause for this change lies in the growing use of ultrasound or amniocentesis technology to abort female foetuses. Low fertility and preference for sons are other factors at the core of the growing aversion for daughters.[5] The intensity of sex selection in various Asian countries results from this unique combination of new technological capacity, pressure caused by low fertility and higher risk of remaining sonless, and the inherited preference for male progeny. Sex selection of births was initially limited to small sections of the population with access to the new technology, including the urban population and the wealthiest classes. However, as fertility decline accelerated and prenatal testing became more accessible, sex selection spread to the rest of society.

The long-term impact that the current excess of male births will have on future demographic pyramids has already spurred several attempts at simulating population growth in China.[6] In this paper, the analysis will be extended to India where the SRB has now reached over 113. Moreover, 2005 will now be used as the baseline year as recent demographic estimates already contradict more optimistic scenarios of SRB reduction. Contrary to previous studies, the projection period has also been extended from 2050 till 2100 as demographic consequences will, in fact, be felt over this longer period. Finally, the forecasts are based on three alternative scenarios of future SRB change so that the consequences of various possible evolutions in birth masculinity can be explored.

Demographic Hypotheses

Key demographic assumptions for these projections, such as mortality and fertility (Table 1), have been kept simple. Where possible, demographic parameters follow the United Nations' forecasts for the period 2005–2050 at the national level (medium variant, United Nations 2007). Furthermore, the projection procedure assumes no occurrence of international migration. Sex differentials in childhood mortality, which contribute to sex ratio imbalances in adulthood, particularly in China, are incorporated in the mortality patterns used.

TABLE 1
Parameters used for demographic projections, 2005–2100.

	China				India			
	2005	**2030**	**2050**	**2100**	**2005**	**2030**	**2050**	**2100**
Baseline age and sex distribution for 2005	**Corrected 2005 distribution[a]**				**United Nations 2005 estimates**			
Total fertility	1.60[a]	1.74[a]	1.85	2.10[b]	2.96	1.92	1.85	1.85[b]
Life expectancy								
Male	70.9	75.1	78.0[b]	82.0[a]	62.4	69.9	74.0[a]	82.0[a]
Female	74.2	79.0	82.0[b]	86.0[a]	65.3	74.2	78.0[a]	86.0[a]
	2005	**2020**	**2050**	**2100**	**2005**	**2020**	**2050**	**2100**
Three SRB scenarios								
Late transition	120	130	105	105	113	125	105	105
No transition	120	120	120	120	113	113	113	113
Rapid transition	120	105	105	105	113	105	105	105

[a]Estimates by the author (see Appendix for details).
[b]Adapted from the United Nations and IIASA parameters (Lutz *et al*. 2008; United Nations 2004).
Units: Fertility in children per woman; life expectancy at birth in years, SRB in male births per 100 female births.
Note: All other mortality and fertility parameters are from the 2006 population forecasts by the Population Division (United Nations 2007).

Several adjustments had to be introduced though. China's age and sex distribution, and population total are taken from the one per cent sample survey of 2005. It is believed that Chinese census data, as compared to estimates from the United Nations, reflects more accurately the intricate nature of China's age pyramids as shaped by numerous demographic episodes—famine, baby boom and baby bust—over the last 60 years. While age statement is reliable in Chinese censuses, selective under-enumeration with respect to urban residence or family policies is a distinct possibility. Some age-specific sex ratios that appear to be widely underestimated had to be corrected (see the Appendix). Moreover, the total fertility rate (TFR) level in China is one of the most disputed demographic estimates in the world. The fertility level postulated by the United Nations at 1.71 children per woman for 2005 appears to be slightly too high and contradicts China's age distribution below the age of five. On the contrary, the census-based TFR figures (1.22 in 2000 and 1.33 in 2005) are underestimates. Therefore, a medium value of 1.6, which is very close to the figures proposed recently by Lutz *et al*. (2007), Retherford *et al*. (2005) and Zeng (2007), was adopted.

For its part, India's age distribution is much smoother than China's as the country has experienced no brutal demographic change over the last 50 years. However, it is significantly distorted by age mis-statement, especially among children. The age pyramids derived from the 2001 Census and from the latest fertility survey[7] present a somewhat vertical aspect at its basis, with the population aged 0–4, 5–9 and 10–14 years in almost equal proportion, and the next 15–19 age group smaller by 20 per cent. The smoothed United Nations age distribution for 2005 is therefore retained as the baseline for projections. To avoid any inconsistency in age distribution, the United Nations TFR estimate of 2.96 for 2005 had also to be retained, although more recent data from the 2005–2006 National Family Health Survey (NFHS-3) put the TFR at a lower level of 2.68 in 2003–2005.

Other demographic parameters for the period 2005–2100 were derived from the United Nations' medium forecasts up to 2050. Beyond 2050, demographic parameters were derived from the two major studies by the International Institute for Applied Systems Analysis (IIASA) team and the United Nations Population Division.[8] Fertility is held constant at 1.85 in India, while it is allowed to rise to 2.1 children in China. The course of fertility in China may, however, be entirely different, motivating the introduction, in a later section of this paper, of a radically different set of parameters based on lowest-low fertility levels during the twenty-first century. Life expectancies are assumed to rise continuously in both countries from 2050 to 2100, to 82 and 86 years of age respectively for men and women. These figures are similar to the maximum levels projected for more prosperous Asian countries such as Singapore.

SRB Trends in Asia

The SRB has risen to a level of over 115 in many Asian countries since the 1980s.[9] However, there is a large heterogeneity in national or regional situations as far as SRB levels and trends are concerned. To start with, South Korea was amongst the earliest of those with widespread sex selection. The rise in the SRB in this country started to reverse in the 1990s though. In fact, annual SRB estimates in South Korea followed a bell-shaped curve; it rose initially, plateaued at its peak level for a few years in the early 1990s and began its descent immediately thereafter. The latest estimate of 106 for 2007 suggests that the SRB has now returned to normal levels in the country. Interestingly, the length and shape of the rise in SRB (first stage) and its decline (second stage) are symmetrical. South Korea provides the only case of a series in which the SRB has been consistently decreasing over the last decade, and it remains the sole country in which the 'sex ratio transition' may be over.

In other countries, trends in birth masculinity have long seemed to be dominated by a constant rise to new record levels. This is especially visible in the few countries where detailed annual SRB series are available such as Azerbaijan, Georgia and China. The rise, since the 1980s in China and since the early 1990s in Caucasian countries, has been constant. Less detailed data for India suggest a similar rise since the 1980s. However, since 2000, several signs of stagnation or even decline in the proportions of male births are at times discernible. In several countries, the SRB still seems in fact to be plateauing. This is, for instance, the case for all three affected Caucasian countries; after a rapid rise during the last decade of the twentieth century, their SRBs have stopped rising or even declined slightly during the last five years. China's case is more ambiguous; its last SRB estimate of 120 from the 2005 survey indicates an end to the rise observed earlier at the national level, but not real decline. The SRB is, however, falling in specific areas such as the important province of Guangdong. In India, there are traces of recent stagnation and slow decline in the most affected north-western part of the country (Das Gupta *et al*. 2009). This is, for instance, visible in the case of Delhi, for annual civil registration data available.

There are also areas where further rise in birth masculinity is the most probable hypothesis. This is particularly the case for many Chinese and Indian regions that have been spared so far; large segments of these countries—South and East India, and West China—may in fact be affected in the future by higher SRB levels. Similarly, birth masculinity may continue to rise in the near future in countries with a more recent history of birth masculinization dating from the 1990s or later, such as Viet Nam and Pakistan.

Future Scenarios

The trends observed across Asia have encouraged me to envisage different SRB trajectories for the projections, which are crucial for an assessment of the demographic consequences of current gender imbalances at birth. In a way reminiscent of what has been observed for the demographic transition (Chesnais 1992), the overall impact of SRB imbalances in terms of missing women or surplus men is in fact the combined product of both their duration and overall intensity. Therefore, three distinct SRB scenarios, in which duration and intensity vary, are utilized (see Figure 1). The most straightforward scenario is a no transition scenario. This assumes that in the coming decades, SRB will remain at its current level as if it had reached some kind of equilibrium threshold. According to such a 'business-as-usual' scenario, high SRB is sustainable in the long run, and the general social, technological and political environment that initially gave rise to the gradual masculinization of births will remain the same in the future.

If prolonged sex imbalances turn out to be demographically unsustainable—a hypothesis that projections in this paper plan to substantiate—parents may discover the nefarious effect of relative surpluses of young men on male marriage rates after two decades. The SRB would then be likely to undergo a gradual transition back to normal values, as has been observed in South Korea (Guilmoto 2009). This would mean that the SRB would reach its apex in a given period and later recede to 105 male births per 100

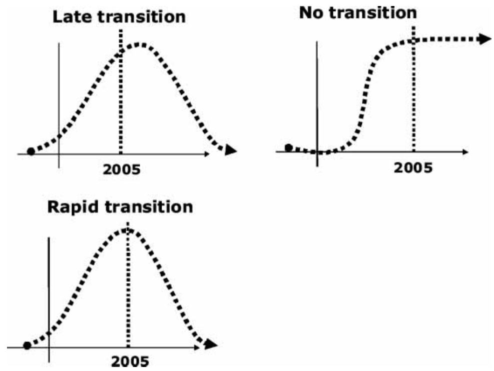

FIGURE 1
Three scenarios of the future evolution of SRB after 2005.

female births. Two distinct scenarios of fast or slow return to normal are put forward. According to the first such scenario, transition is assumed to occur immediately and be over by 2020. The rapid transition scenario is admittedly the most optimistic scenario at hand, and may sound somewhat improbable. It will, however, serve as a benchmark to assess the minimal impact that current SRB distortions will have on future population structures.

Another possible SRB trajectory is the scenario of late transition. This scenario would correspond with the aggravating role of factors such as continuing fertility decline or the increased availability of sex selection technology in the future, both of which may cause a further rise in sex-selective abortion. We would first observe a further degradation in the proportion of female births until the SRB reaches a maximum value in 2020, at the end of the first stage. In each country, the peak value for 2020 will be borrowed from the highest SRB level presently observed on a regional scale.[10] Once this maximum level is reached, the SRB is then allowed to return to a normal level of 105 during the next 30 years.

SRB levels corresponding to each of these scenarios are given in Table 1 and intermediary levels have been interpolated.[11] There are admittedly more possible scenarios, including a worst-case scenario encompassing a further rise in SRB with no subsequent transition, but attempts were made to use the various trajectories observed in Asia.

Projection Results

The projection results are simultaneously presented for both countries and for the three different scenarios (see Table 2). The overall trends will be examined first. Further details on their implications in terms of age composition will be given later.[12]

Sex Ratio Trends in China and India till 2100

Overall population trends till 2100 are determined primarily by long-term mortality and fertility parameters. With fertility taken as 1.85 children per woman in 2050, populations of both China and India are bound to contract during the second half of the century.[13] However, what is noteworthy is that the evolution of SRBs do also have an

TABLE 2
Sex ratio measurements according to three SRB scenarios, China and India, 2010–2100.

	China			India		
	All	**15–49 years**	**15–49 years (W)**	**All**	**15–49 years**	**15–49 years (W)**
Late transition scenario						
2010	107	106.5	101.6	108	108.7	101.1
2020	107.8	109.9	119	109.6	108.5	106.2
2030	108.3	115.7	120.3	110.5	110.9	114.6
2040	108.6	122.8	125.4	110	114.5	123.6
2050	109.1	126.2	129.3	108.9	117	124.2
2060	109.8	124	116.5	107.8	116.7	114.2
2070	110.2	117.6	107.7	106.9	112.1	108.9
2080	110.1	110.9	104.7	106.2	107.5	107.7
2090	108.9	107	102.8	105.5	105.5	107.3
2100	107.1	106.4	103.9	104.6	105.8	108.7
No transition scenario						
2010	106.8	106.5	101.6	107.6	108.7	101.1
2020	106.9	109.9	119	107.7	108.5	106.2
2030	106.7	114.6	118.1	107.3	109.2	110.1
2040	107	119.1	117.7	106.9	109.8	113.5
2050	108.5	120.7	121.5	106.6	110.4	115.8
2060	110.6	120.6	117.7	106.4	111.1	113.7
2070	112.5	120.9	119.1	106.4	111.5	115
2080	114.2	121.1	119.9	106.7	112.1	116.3
2090	115	121.4	118.2	107.3	112.9	116.2
2100	115.7	121.6	119.3	107.9	113.8	117.6
Rapid transition scenario						
2010	106.7	106.5	101.6	107.5	108.7	101.1
2020	105.6	109.9	119	106.6	108.5	106.2
2030	104.1	113.3	115.8	105.2	108.4	108.2
2040	103	113.7	107.1	103.9	106.9	107
2050	102.9	110.8	106.5	102.9	105.3	107.6
2060	103.2	106.8	102.3	101.9	103.8	104.9
2070	103.2	105.8	103.7	101.1	103.6	106.2
2080	103	106	104.4	100.7	104.2	107.5
2090	102.4	106.2	102.8	100.5	105	107.3
2100	102.1	106.4	103.9	100.8	105.8	108.6

Note: Sex ratio as males per 100 females; 15–49 (W): sex ratio weighted by marriage rates (see text for details).
Sources: computed from projection results.

impact on the long-term trends of total populations; a high SRB reduces population growth by several millions. The reason for this outcome is not difficult to understand as the decline in the proportion of girls born contributes to a subsequent decrease in the number of women of child-bearing age. High SRBs will therefore automatically result in fewer births after 20 years. The cumulative impact of this mechanism will affect all subsequent population totals during the century.

Using the more favourable rapid transition scenario as a benchmark, the final impact of our less favourable scenarios—late transition and no transition—on 2050 estimates is a sizeable deficit, respectively of 13.3 and 7.9 million inhabitants for China, and 22.6 and 8.7 million for India. The late transition scenario has a greater impact on population growth since the SRB reaches its maximum value in this scenario. The evolution is more complex during the second half of the twenty-first century as the changing SRB works in combination with the negative natural increase observed in both countries. When measured on population totals in 2100, the cumulative impact of inordinate SRB levels appears, however, considerable. In both countries, the resulting populations will be lower by about 60 million than in the rapid transition scenario. This gap even reaches 90 million in China under the late transition scenario. These results provide an unexpected illustration of the link between fertility decline and increased SRBs observed in Asia. In particular, countries keen to promote low fertility to check population growth may read such results as a somewhat beneficial side-effect of the current process of demographic masculinization. This interpretation would, however, be wrong not only because gender discrimination undermines birth control, but also because the overall impact on birth rates would be felt only after several decades of skewed SRBs.

Of greater interest to us is the evolution of the overall population sex ratio in the twenty-first century, starting from abnormal levels of 107 in China and 108 in India. As Table 2 and Figure 2 show, the rapid transition scenario in both countries results in a gradual sex ratio decline until 2100. The decline appears also to start immediately, and not after 2030 when the SRB is supposed to return to its normal value. This indicates that inherited age structures were already deeply skewed, especially among the older population, as a result of excess female mortality in the past. It is relevant here to stress that even according to this favourable scenario, the male population would predominate up to 2100 in both countries, in spite of better female survival rates and normal SRBs from 2020 onwards. The population sex ratio of China and India would respectively be 102 and 101 in 2100. This unexpected feature of the Asian sex-structural transition results, in particular, from the increasing weight of the older cohorts—among which the sex ratio is higher than expected—due to low fertility. Beyond 2050, higher survival rates among women are apparently not sufficient to reverse the impact of a SRB of 105. Contrary to the rest of the world, Asia is therefore bound to remain a masculine continent for a very long time, and this will have a major impact on world trends.

Besides structural transformations caused by changing fertility and mortality levels, the consequences of a longer masculinization process are obvious. In the absence of a SRB transition, the sex ratio of the entire population moves gradually to a value close to the postulated SRB. In China, the overall sex ratio reaches 115 during the last decade of the twenty-first century while in India, it fluctuates around 107. More interesting features emerge though in the case of delayed transition or the late transition scenario, when the SRB peaks in 2020 only to return to a normal level in 2050. The impact on the total population is rapid in India as the overall sex ratio reaches 110 during the period 2025–2040 and declines thereafter. In China, however, the general sex ratio swells slowly and reaches its maximum value of 110 only during the period 2060–2085. Interestingly, in spite of higher SRB parameters in China, the evolution of its sex ratio proves to be slower than that in India, and can be seen to extend over a longer period with its value remaining as high as 107 at the conclusion of the period of forecast. The long-term impact of such sex ratio trends in China will therefore be more pronounced.

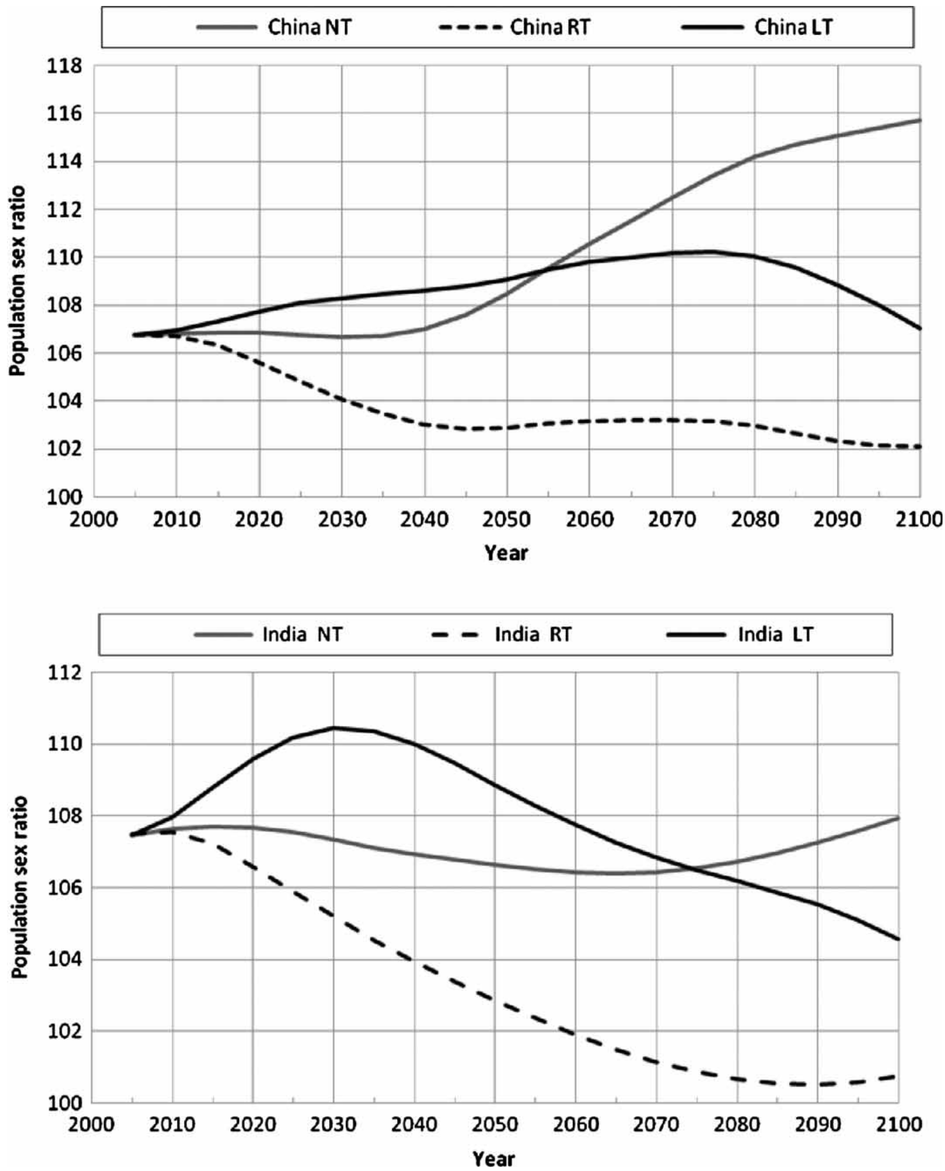

FIGURE 2
Sex ratio of the total population according to three scenarios, China and India, 2005–2100.
Note: LT, late transition; NT, no transition; RT, rapid transition.

Gender Imbalances and Age Structures

As can be seen, abnormal SRB levels can exert some indirect influence on population growth. Similarly, they also have an impact on age distribution and ultimately, the proportion of adults. However, the direct consequence on sex distributions is far more visible on specific age groups as distorted SRB levels will affect only a limited number of birth cohorts in the future, at least in the transitional SRB scenarios used here.

The case of adults is of particular importance because of the potential implications of gender imbalances on marriage patterns. Figure 3 is based on the population aged 15–49, which corresponds roughly with the marriageable age for both countries (see also Table 2). This gives a first overview of the evolution of sex ratio for adults, which appears clearly distinct from that for the overall population. In India, a rapid transition of the SRB would leave almost no trace on this broad age group, and its sex ratio would start

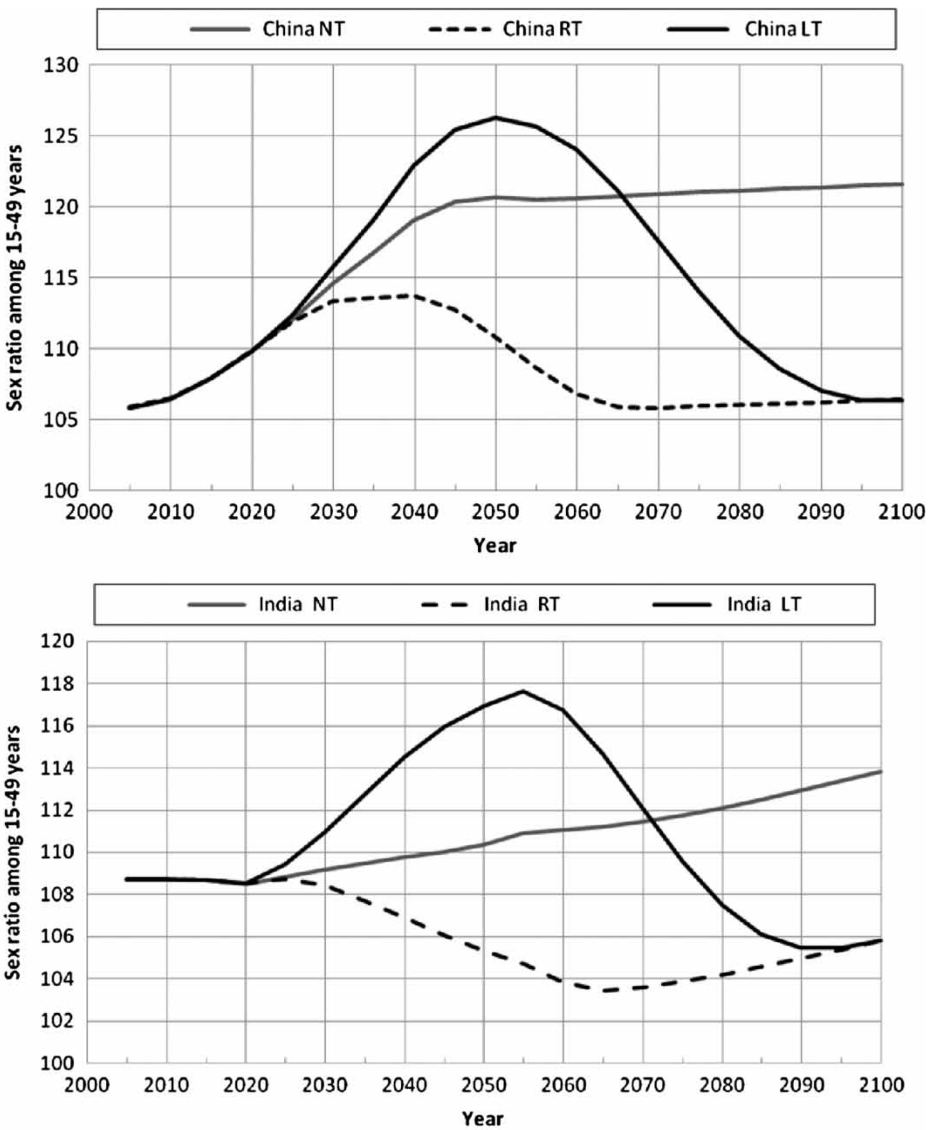

FIGURE 3
Sex ratio of the population aged 15–49 according to three scenarios, China and India, 2005–2100.
Note: LT, late transition; NT, no transition; RT, rapid transition.

declining after 2020. The picture is rather different in China. In this optimistic scenario of rapid transition, the sex ratio within the 15–49 age group increases nevertheless, from 106 today to 114 in 2040. It returns subsequently to a more normal level of 106 only by 2065.

The late transition scenarios in both countries result in similar bell-shaped trends peaking in 2050 at 126 in China—as opposed to 117 in India—with a return to standard levels no earlier than 2090. Once again, the impact of high SRBs, as predicted for the period 2005–2050 using the two transitional scenarios, is felt long after the gender proportion of births has resumed its normal course. However, the late transition scenario causes the sex ratio among adults to reach record levels by the middle of the century. Such high sex ratios among adults are found in Asia, but only in places such as cities affected by the heavy, temporary migration of male workers.

Impact of Population Trends and Fluctuations on the Marriage Market

The previous section sums up the growing deficit of adult women that emerges from contemporary sex imbalances in births. To examine the implications of demographic imbalances on marriage patterns though, it is necessary to use more sophisticated sex ratio measurements. We will stress here the specific impact of the change in size of the birth cohort, i.e. the consequence of structural demographic change driven by fertility decline and resulting fluctuations in the annual number of births.

As men usually marry younger women in Asia, the sex ratio among adults of marriageable age is inevitably affected by structural demographic factors such as fertility decline, change in population growth or, to a lesser extent, increased longevity (Esteve & Cabré 2005; McDonald 1995). An illustration of this is evident from annual changes in the number of births in relation to the gap in age at marriage between men and women. Leaving aside the consequences of SRBs and sex differentials in survival rates up to adulthood, secular and cyclical variations in annual births will automatically affect the relative size of male and female cohorts among young adults. For instance, when the annual number of births increases significantly over the years, the sex ratio among adults of marriageable age will decrease because of the difference in ages at first marriage between men and women (about two and five years, respectively, in China and India).[14]

In India's case, the absence of any major demographic crisis since Independence means that the annual birth rate has mostly been determined by secular trends. Until the early 1990s, the number of births has shown a regular increase, at a rate varying between 1.2 per cent and 1.6 per cent. With an age difference at marriage of about five years between men and women, the rapidly increasing number of births annually meant that on average, birth cohorts of brides were larger than those of grooms by more than six per cent in the period 1950–1990. This imbalance was partly offset by a preponderance of males at birth, but it did bring about a long-term excess of brides in India over the course of the previous century (Bhat & Halli 1999). However, India's changing demographic pattern in the twenty-first century signifies a gradual reduction in births annually from the late 1990s onwards. This decrease will amplify and may reach a rate of less than negative one per year in the period 2020–2035; during this period, the difference in cohort size would be 4.4 per cent in favour of men belonging to earlier, bigger cohorts. Adding the biological advantage of the SRB to this value brings the male cohort surplus to close to 10 per cent during the second half of the century, a surplus only marginally reduced by higher male mortality. The global change in demographic structures, if it does indeed translate into reduced birth cohorts, is the portent of an irreversible erosion of men's demographic advantage in India. Indian men have indeed benefited from a 'demographic bonus' during decades of swelling birth cohorts, and the paucity of marriageable boys has often been interpreted as the cause of rising dowry in late twentieth century's India. However, anticipated changes in demographic structures brought about by diminishing birth cohorts will lead to a rapid decline of men's demographic advantages in India.

China is characterized by more irregular changes in the annual number of births because of fluctuations due to a host of factors that are a legacy of China's volatile demographic past. A brutal contraction of birth cohorts during a period of famine around 1960 followed by a sustained baby boom in the 1960s and rapid fertility decline over the next decade all contribute to the subsequent demographic 'echoes' of these cohorts as they reached child-bearing age. As such, China's age structure cannot easily be situated within decadal trends. Sudden fluctuations in the cohort size are reflected by irregular age groups such as the unusually large 1985–1995 birth cohorts, which is itself a repercussion of the post-crisis surge in births after 1960. Short-term fluctuations therefore have more clear-cut effects in China than the secular variations observed in India, and they will have a direct impact on the sex ratio of adults—a point highlighted by Goodkind (2006). However, demographic forecasts used here suggest that the decline in number of births will also peak in China during the decade 2025–2035 at a rate of −1.4 per cent per year. Even in the absence of SRB distortion, this trend will lead to a structural surplus of men relative to women born a few years later.

Male Surplus at the Age of Marriage

In addition to the structural effects described later, the rise in the proportion of male births in Asia since the 1980s is going to directly affect the relative gender equilibrium among young adults. Skewed sex ratios in specific cohorts are likely to disturb marriage patterns in direct relation to the age-specific propensity of men and women. It is therefore possible to improve on the sex ratio of the adult population aged 15–49 by using available information on marriage patterns. A better measurement of gender imbalances consists of weighing age groups by marriage rates for each sex (Jiang *et al.* 2007). This allows for building a fictitious cohort of men and women expected to marry at each period by using projected age distributions and age-specific marriage rates.

In the absence of detailed civil registration data on marriage, age distributions by marital status are relied upon to reconstruct first marriage patterns. Marriage probabilities along a birth cohort are computed by using successive age distributions by marital status. For China, the series comes from the 2000 Census and the 2005 sample survey. For India, results from the 2001 Census, the NFHS-3 survey and the District-Level Household Survey (DHLS-2)[15] have been averaged. The median age at marriage for women obtained is respectively 23.5 and 19.5 years in China and India. It is respectively 25.7 and 24.5 years for men. The corresponding nuptiality tables are derived from five-year probabilities of first marriage among single men and women.

The ratio of male and female populations, weighted by the respective age-specific first marriage rates for men and women, provides a reasonably good index of the potential for marriage squeeze.[16] It reflects better gender imbalances than unweighted sex ratios as it responds more accurately to compositional changes in adult populations. With 2005 as a baseline for marriage patterns, the ratio starts from levels equal to 100.[17]

Figure 4 displays this index (see also Table 2), and patterns significantly different from those based on the broader 15–49 age group can immediately be observed. This is especially the case for the Chinese series as a result of profound fluctuations in the size of its birth cohorts in the past. The impact of the large cohorts born in 1985–1995 is, in particular, recognizable after 2025, when the weighted sex ratio decreases for all scenarios. The estimates for India are comparatively much smoother. However, in both countries, the rise in SRBs observed since the 1980s causes a rapid increase in the excess of men of

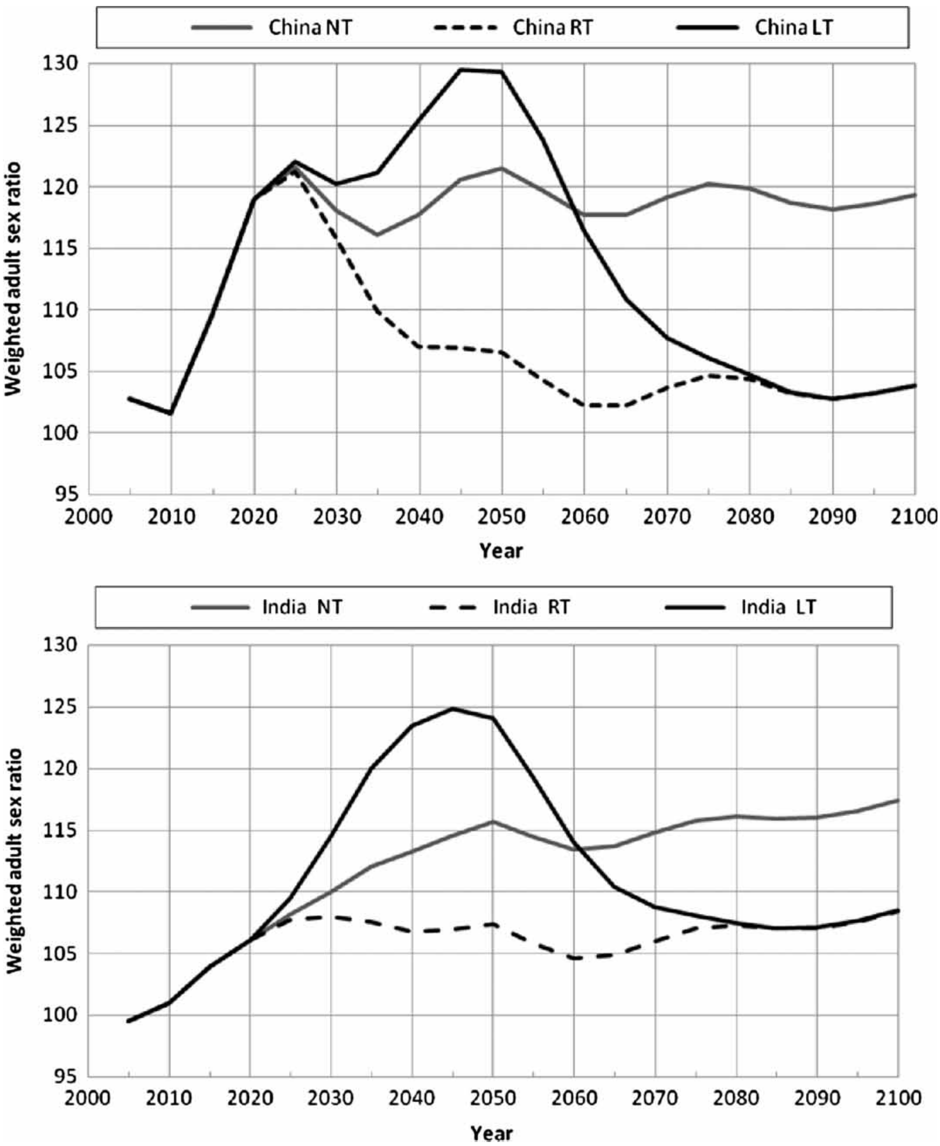

FIGURE 4
Sex ratio of the population aged 15–49 weighted by marriage rates according to three scenarios, China and India, 2005–2100.
Note: LT, late transition; NT, no transition; RT, rapid transition.

marriageable age till 2025. The deterioration is less pronounced in India as the weighted sex ratio remains below 110 against 123 in China.

According to the most optimistic scenario of rapid transition, the intensity of the potential squeeze as measured by the index will decrease after 2025. The decrease from 123 in 2025 to 107, 15 years later, is rather abrupt in China, but this is partly a result of its turbulent age structure. In both countries, the weighted adult sex ratio tends to stabilize at 105 over the next decades and does not decrease any further. This illustrates the consequences of a structural excess of men caused by the declining size of birth cohorts. In this scenario, the sizeable gap between potential brides and grooms in China appears to be limited to only two decades around 2025. It is therefore probable that adjustments in marriage patterns, such as delayed marriage among men or increased female remarriage, will be able to alleviate this tension and reduce the proportion of men that may have to forego marriage altogether. In India, gender imbalances under this scenario of rapid transition would be moderate and may be offset, at the national level, by changes in marriage patterns.

If, however, the sex ratio transition is delayed (late transition scenario), the peak will reach higher figures in 2045–2050: almost 130 for China and 122 for India. This suggests that more than 20 per cent of the male cohorts would find themselves *de trop* during that period compared to female cohorts. When translated into actual population figures over a decade, this surplus amounts to about 15.2 and 22.6 million men of marriageable age in China and India. In spite of its lower SRB, the result is of greater magnitude in India because of lower fertility levels and other compositional factors. It is, however, important to emphasize, at this point, that the actual size of this men-to-women gap is of unusual demographic magnitude and is thus, unlikely to be corrected only by migrations.

The duration of the gender disequilibrium will also last significantly longer if the transition takes a long time to set in. The weighted sex ratio will indeed be above 110 for four decades in India and five decades in China. In the late transition scenario, the length of the crisis is longer than the usual age range of marriage among men of about 35 years. This will make it impossible for men to simply delay marriages; the continuous arrival of new cohorts of younger, single men means that the number of unmarried men will dramatically accumulate over the years. Within a closed marriage market, the only solution left to a large proportion of men will be to remain unmarried.

The 'business-as-usual' scenario, in which the SRB would remain at the same level from 2005 onwards in both countries, leads to somewhat implausible results. The nuptiality-weighted sex ratio used here would stabilize or oscillate for more than 70 years at a high level at 110–115 in India and 120 in China. From a strictly quantitative viewpoint, men will be severely disadvantaged in terms of the number of years of married life among adults below the age of 50, even allowing for intense female remarriage. The effects of such a long-term disequilibrium on marriage patterns seem too remote from current sociological conditions to be worth examining at length here.

The Additional Impact of Low Fertility on Gender Imbalances: The Case of China

As was already mentioned when discussing the demographic parameters for the projection exercise, fertility estimates in China remain disputed, and it may be said that the issue of future fertility trends is even more problematic. In our previous projections, fertility is assumed to increase regularly to 2.1 children per woman in 2100, in keeping with other projection scenarios. Yet, the historical process of fertility decline in China may not be reversible and an alternative scenario of constant low fertility is thus worth considering.[18] Findings from a different set of projections based on the same parameters as shown in Table 1, except for fertility, will be presented in this section. In this alternative scenario, TFR in China is now assumed to reach 1.2 in 2050 and to remain at this level till 2100. While this 'lowest-low fertility' level may seem extreme, it will illustrate more clearly the role of changing age structures on gender imbalances.

As might be anticipated, the major outcome of the low fertility regime postulated in this section is the rapid reduction of China's population over the present century. According to these new forecasts, China would have less than 500 million inhabitants by 2100 as compared to about 0.9 billion with the previous set of projection parameters. However, of greater interest to us here is the specific impact of low fertility on Chinese age and sex distributions. Below-replacement fertility would in fact generate a severe contraction of the Chinese age pyramids during the next decades and a parallel acceleration of ageing processes. The exact repercussions of such age-structural transformations are illustrated by the findings described in the next two paragraphs.

Low fertility in China would bring about a slight reduction in the overall sex ratio of the population by about two to three per 100 in 2100. This result is somewhat predictable for both the no transition and the rapid transition scenarios examined here. Low fertility would first lead to a dramatic ageing of the Chinese population during the course of the century, which would in turn swell the relative share of the older age groups in the population. As the sex ratio tends to decrease with age due to sex differentials in mortality, structural ageing tends to reduce the population sex ratio.

However, the sex ratio among adults weighted by marriage rates remains of greater relevance to our analysis of gender imbalances than the overall sex ratio. This indicator of marriage imbalance among adults reacts very differently to the hypothesis of lowest-low fertility during the twenty-first century. Applying the same nuptiality schedule to projected age distributions indicates that low fertility would tend to aggravate gender imbalances seriously. Figure 5 reproduces results already presented in Figure 4, i.e. the weighted adult sex ratios according to two SRB scenarios in China, to which are added results obtained under the new low fertility hypothesis. Projection results do not diverge before 2030 as low fertility has yet to affect the adult population. However, from this date onwards, the entry of new, smaller birth cohorts into the marriage market causes a further increase in the sex ratio of adults of marriageable age.

To understand the factors behind this additional sex ratio deterioration, we need to remember the structural processes already mentioned and their relationship to the marriage market. Since the weighted adult sex ratio reflects the tendency of men to marry later, rapidly reducing number of annual births put male cohorts at a great disadvantage, given that they are condemned to outnumber female cohorts by the sheer effect of earlier births (age at marriage factor) and SRBs. It may be observed that the difference caused by the low fertility hypothesis is substantial as the weighted sex ratio would correspondingly increase in both scenarios by five per 100. The specific impact of low fertility levels remains visible for the most optimistic transitional scenario in which the SRB returns to normal by 2020. This demonstrates the major role played by age structures in gender imbalances in the long run. This exercise emphasizes therefore that irrespective of the future trends in birth masculinity, the sex disequilibrium in China and India during the second half of the

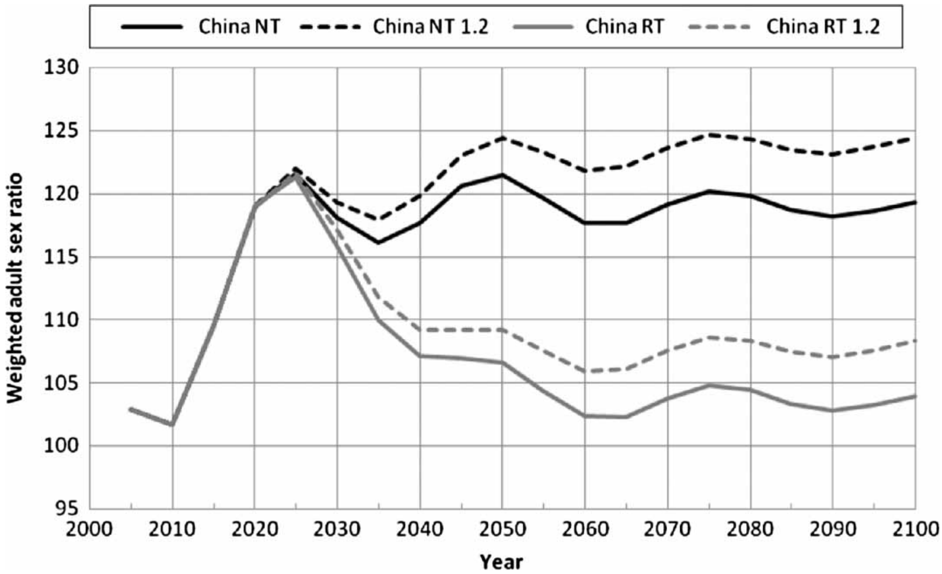

FIGURE 5

Sex ratio of the population aged 15–49 weighted by marriage rates according to two SRB scenarios and two TFR parameters, China, 2005–2100.

Note: NT, no transition; RT, rapid transition; 1.2, low fertility hypothesis.

century will, to a significant extent, be shaped by fertility levels and the changing size of birth cohorts.

Conclusion and Discussion

The projections in this paper rely on a set of parameters that may not capture the future demographic trajectories of China and India perfectly. However, most hypotheses such as future mortality and fertility levels have a limited bearing on the sex ratio indicators computed here. The analysis is in fact much more sensitive to anticipated changes in SRB levels. Scenarios used here are derived from the analysis of recent trends in various countries, and the transitional assumption, according to which the proportion of male births would ultimately return to normal, appears far more plausible than a permanent excess of male births. The results of the forecasts tend to reinforce the transitional scenario, i.e. the gender imbalances that are likely to emerge in the future seem unsustainable, and the social impact of the mounting male surplus is likely to precipitate a downturn in birth masculinity after two or three decades even if this had not already occurred spontaneously.

There are, however, two other hypotheses that need clarification in light of our findings. The first hypothesis is the absence of international migration in our projections. China and India are the biggest providers of international migrants in the world today, and the assumption of a closed population may therefore sound somewhat inadequate in a rapidly globalizing world. Migration would obviously present a potential solution for unmarried men, who often predominate among international migrants, and would therefore contribute to easing marriage conditions in both countries. Men on out-migration may locally deflate the marriage squeeze, but the analysis based on populations of whole countries indicates that mere inter-regional redistribution does not present a durable solution. Large-scale emigration would be an effective solution to the gender gap only on the condition that Chinese and Indian men be allowed to settle durably outside Asia, and to get married there. However, in 2030, an average cohort of prospective grooms will outnumber prospective brides by about 1.1–1.2 million per year in either China or India. This is far beyond current estimates of net out-migrants in both countries according to the United Nations estimates, which also include a large proportion of women. A reverse flow of foreign brides towards China and India—a trend that has already been observed in more advanced countries such as South Korea and Taiwan (Kim 2008)—may only fill a small part of the gap in view of the magnitude of the female deficit.

Another hypothesis that needs further examination lies in marriage systems. It has been postulated that the propensity to marry would remain the same for men and women in the future. This is an obviously conservative supposition in view of rapid changes taking place all over Asia towards late female age at marriage (Jones 2007). Any delay in age at marriage among women, especially in India, would tend to further exacerbate gender imbalances among young adults. Retreat from marriage, as observed today among Japanese women (Retherford *et al*. 2001), would have an additional negative impact on the sex disequilibrium. Such changes in marriage patterns have not been factored in our indicator of weighted adult sex ratio, and it is obvious that doing so would have resulted in even less favourable levels for prospective grooms. While it seems unlikely that women would marry younger to accommodate surplus men, the rise of male age at marriage, and of male singlehood rates, is a predictable outcome.

Finally, it may be said that weighted adult sex ratios remain imperfect indicators of potential marriage squeeze. Their limitation lies in the strictly synchronic approach encompassed by procedures based on period measurements such as annual age and sex distributions. Cross-sectional sex ratio indicators do not take into consideration events of preceding periods. When conditions for marriage squeeze extend over a long time, the marriage market is, however, bound to be affected much more severely than mere cohort sizes suggest. Surplus male bachelors who fail to marry for several years will inflate the pool of potential grooms in the following years. This results from a typical queuing process in which the proportion of unmarried men will grow rapidly. The squeeze resulting from many years of male surplus is consequently bound to be more severe than is suggested by the period-based sex ratios used here.

The comparison of China and India also shows that in both countries, a rapid decline in SRBs is unlikely to obliterate the effects of past gender imbalances observed for more than 20 years. The demographic repercussions will be more acute in China due to a host of factors such as the magnitude of past birth imbalances, and the structural effects of its peculiar age distribution inherited from its troubled past. Our late transition scenario has produced more worrying results in terms of distorted sex ratios and surplus men among adults. It may be added that in both countries, there are wide regional and social variations in SRB levels, and the SRB has already crossed the 130 threshold by 2000 in parts of both countries (Guilmoto & Oliveau 2007). As a result, projections conducted at a regional level would yield even more pronounced imbalances in several Chinese and Indian provinces. Likewise, specific social groups are likely to be much more affected than others because gender disequilibria are more acute among them.

We have refrained from describing the potential social consequences of such gender imbalances due to the lack of empirical observations on affected local systems. Nevertheless, there is already a somewhat speculative literature on this subject.[19] However, more field studies, such as those conducted by Blanchet (2005), Kaur (2008) and Le Bach *et al*. (2007), are needed to understand the responses of local social systems to mounting gender imbalances for prospective grooms.

The macro-level demographic picture offered here is obviously insufficient in shedding light on the complex social processes that inordinate gender distributions will trigger at the micro- or meso-level of households and communities across Asia. It may, however, be easily surmised that the role of men and women within the family will be greatly affected. Female deficit may also be linked to increased instances of gender-based violence such as forced marriage, rape and trafficking. Several basic tenets of traditional gender arrangements will also be shaken, especially if the ability of sons in patrilineal families to find a wife is not guaranteed. Ironically, it is the patriarchal system, which lies at the root of son preference in Asia, that is likely to be among the ultimate victims of the gender imbalances it generated.

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NOTES

1. On the diversity of situations across Asia, see Attané and Guilmoto (2007), Croll (2000), Miller (2001), and United Nations Population Fund (UNFPA)-sponsored case studies of four countries (UNFPA 2007).
2. Figures used here are based on the 2006 estimates by the United Nations Population Division (United Nations 2007).
3. We may include Albania, Azerbaijan, Armenia, Georgia, Pakistan, South Korea, Singapore, Taiwan and Viet Nam in this list.
4. On China, see, for instance, Banister (2004), Chu (2003) and Li *et al*. (2007). On India, see Arnold *et al*. (2002), Bhat (2002a, 2002b) and Patel (2006). On Korea, see Kim (2004). On Viet Nam, see Guilmoto *et al*. (2009).
5. Fertility decline *per se* is not the ultimate determinant of rising birth masculinity. Similar SRB levels close to 125 can indeed be observed both in East China and in North-West India—regions where fertility varies from less than 1.5 to three children per woman. These variations demonstrate the independence of the other two factors, namely, gender bias and access to sex selection technology.
6. Recent estimates include Attané (2006), Cai and Lavely (2003), Goodkind (2006), and Poston and Glover (2005). More detailed computations can be found in Jiang *et al*. (2007) and Zeng (2007). No such computations are available for India or other Asian countries.
7. The third nationwide National Family and Health Survey (NFHS-3) was conducted in the period 2005–2006 (International Institute for Population Sciences 2007).

8. See Lutz *et al*. (2008) and United Nations (2004). These projections beyond 2050 postulate, however, a significantly lower fertility in high-density countries, such as India, than in China during the second half of the twenty-first century. On China, see Lutz *et al*. (2007).

9. Data used in this section are from various sources: Guilmoto (2009), national statistical offices, and mortality database of the World Health Organization.

10. The maximum value used for China is 130, as this is the level observed in 2005 in the inner provinces of Anhui and Shaanxi. For India, the value of 120 is used. This value corresponds with the value in the western states of Punjab, Haryana, Rajasthan and Gujarat, where the SRB was at its highest in 2001.

11. Instead of using strictly linear trends, annual SRB values for these last two scenarios have been fitted with a polynomial function to retain the inverted-U shape typical of transitional trends.

12. Detailed tables with results are available from the author.

13. The most sophisticated long-term projections and analysis for Asia can be found in Lutz *et al*. (2008).

14. Sources for these figures are discussed later in this paper.

15. The latest District-Level Household Survey (DHLS-2) provides estimates for 2002–2004 based on 600,000 households (International Institute for Population Sciences 2006). Estimates of median age at marriage from the census, NFHS-3 and DHLS-2 are, respectively, 19.9, 18.3 and 20.1 years for women, and 24.5, 23.7 and 25.5 years for men.

16. More sophisticated indicators have been devised to incorporate the impact of widowhood, divorce and remarriage (Jiang *et al*. 2007).

17. Note that the baseline year itself may have been affected by distortions in the marriage market. The weighted sex ratio should therefore be taken as a reflection of relative variation over time rather than as an absolute index of gender imbalance.

18. I owe this suggestion of alternative fertility change in China to an anonymous reviewer. Due to obvious space limitations, this paper cannot, however, claim to explore the combination of all SRB and fertility scenarios. Results presented here are restricted to China and to the two scenarios of rapid transition and no transition. However, the impact of a low fertility trajectory would be almost identical in India's case.

19. See, for instance, Hudson and Den Boer (2004), and Poston and Glover (2005).

20. I thank Ren Qiang for his comments on this issue.

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Appendix: Age Distribution in China in 2005

As has been stated, the low overall sex ratio of 102.2, according to the 2005 sample data for China, has been corrected such that the official value stands at 106.3. Harmonizing the 2005 figures to this higher population sex ratio requires a specific analysis of age-specific sex ratio levels according to the full 2000 Census and the 2005 sample.

Age-specific sex ratios for 2000 and 2005 are presented in Figure A1. The gap between these two sources is most remarkable among the population aged 20–59. In fact, the 2005 sex ratio curve displays a rather implausible sex ratio pattern abruptly declining after the age of 15; the sex ratio among the 20–24 age group, for instance, fell to 93. These low sex ratio levels tend then to increase rather than decrease with age up to the age of 60. Such figures probably reflect a marked under-enumeration of male adults in the 2005 sample—a feature, which is, to some extent, related to China's sizeable floating populations residing in urban areas.[20] This resulting underestimation of the male adult population, if left uncorrected, would tend to artificially deflate the actual magnitude of sex imbalances over several decades.

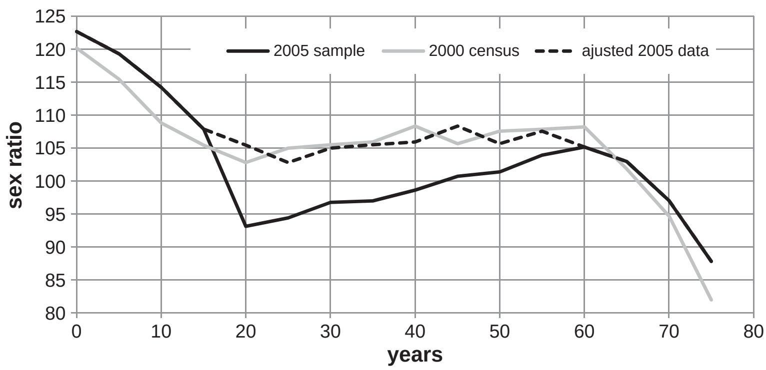

FIGURE A1
Age-specific sex ratios in China, 2000 and 2005.

In comparison, age-specific sex ratios from the 2000 Census appear much more regular. It has therefore been decided that the 2000 age-specific sex ratio be applied to all cohorts aged 20–59 in 2005; for instance, the sex ratio among the 30–34 age group in 2005 is assumed to be similar to that of the 25–29 age group in 2000. Sex ratio estimates are shown in Figure 5. The female population enumerated in 2005 and the corrected age-specific sex ratios are then used to estimate revised male populations. This procedure increases the overall sex ratio from 102.2 to 106.8—a value that is much closer to the official estimate. The corrected age and sex distributions are finally applied to the official population total of 1306.28 million to yield the 2005 baseline population used in the projections.

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