Demography (2012) 49:77–100
DOI 10.1007/s13524-011-0083-7

Skewed Sex Ratios at Birth and Future Marriage Squeeze in China and India, 2005–2100

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Published online: 17 December 2011

Abstract I examine the potential impact of the anticipated future marriage squeeze on nuptiality patterns in China and India during the twenty-first century. I use population projections from 2005 to 2100 based on three different scenarios for the sex ratio at birth (SRB). To counteract the limitations of cross-sectional methods commonly used to assess the severity of marriage squeezes, I use a two-sex cohort-based procedure to simulate marriage patterns over the twenty-first century based on the female dominance model. I also examine two more-flexible marriage functions to illustrate the potential impact of changes in marriage schedules as a response to the marriage squeeze. Longitudinal indicators of marriage squeeze indicate that the number of prospective grooms in both countries will exceed that of prospective brides by more 50% for three decades in the most favorable scenario. Rates of male bachelorhood will not peak before 2050, and the squeeze conditions will be felt several decades thereafter, even among cohorts unaffected by adverse SRB. If the SRB is allowed to return to normalcy by 2020, the proportion of men unmarried at age 50 is expected to rise to 15% in China by 2055 and to 10% in India by 2065. India suffers from the additional impact of a delayed fertility transition on its age structures.

Keywords China · India · Sex ratio at birth · Marriage simulation · Marriage squeeze

Introduction

The proportion of male birth cohorts has reached unusually high levels over the last 20 years in several Asian countries.[1] In many countries, the sex ratio at birth

[1]The literature on the sex ratio issues in Asia is now abundant and describes in particular determinants of gender discrimination. On the diversity of situations across Asia, see Croll (2000), Miller (2001), Attané and Guilmoto (2007), and UNFPA-sponsored case studies (UNFPA 2007).

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(hereafter SRB) has increased above the standard range of 104–106 male births per 100 female births, reaching values above 110 or even 120. This process of demographic masculinization stems mostly from the increasing frequency of sex-selective abortions across Asia, from the Caucasus to South and East Asia. While discrimination against unborn girls today is a dismal reflection of the status of women, sex imbalances may also lead tomorrow to the potential disruption of marriage systems set off by the unavoidable shortage in prospective brides.

In this article, I aim to evaluate the potential severity of the marriage crisis and to explore the potential responses of nuptiality systems to future changes in China and India. I selected these two countries because of their demographic weight in the world and their early rise in SRB over the last two decades. For this article, compared with previous studies, demographic parameters have been updated and the study period extended from the conventional year 2050 to 2100 in view of the especially long-term impact of SRB imbalances on marriage patterns. But the most important difference from previous research is the use of a longitudinal simulation procedure to simulate future male and female marriages rather than relying on cross-sectional indicators of sex ratio imbalances.

The article starts with a presentation of the data and models used to simulate future marriage patterns. Taking 2005 as baseline year, my simulations rely on various population projections based on three scenarios of change in SRB over the coming decades. I also describe the different marriage models used in the simulations. Next, I present results from the simulations, starting with new estimates of the extent of the marriage squeeze and the analysis of the respective contribution to it of changes in age structures and in birth masculinity. Two additional simulations illustrate the extent to which mere changes in marriage timing could reduce the intensity of the marriage squeeze. The article concludes with a synthesis of the results and a review of some of the implications of my findings.

Data and Models for Marriage Simulations

The simulation of marriage patterns in China and India requires first a set of population projections based on different SRB scenarios for the future. Since other long-term trends in age structures may also affect the marriage-sex ratio, I also develop a set of projections without rise in SRB levels. I examine two dimensions of population change in the first sections and describe the parameters used in the population projections. I then discuss the limitations of the cross-sectional sex ratio indicators of marriage squeeze and present a more realistic indicator of marriage squeeze based on longitudinal marriage simulations. These simulations are based on specific parameters for projecting female marriage patterns in the future. At the end of this section, I also explore what other responses of male nuptiality to the increasing marriage squeeze conditions could be by presenting two alternative marriage functions.

Impact of Population Structures on Sex Imbalances

Since men usually marry younger women, the birth cohorts of future husbands tend to be older (Esteve and Cabré 2005; McDonald 1995). But the size of these birth cohorts stems also from long-term trends: the number of annual births tends to increase during the first phase of the demographic transition but decreases later after prolonged fertility decline. India's case is probably emblematic of this situation because the number of births recorded a regular increment until 1990. For instance, the annual increase in the birth cohort size reached 1.5% during the 1970s. This means that there were, on average, 7.7% more prospective wives born during this decade than husbands born five years earlier (five years being the current age difference at marriage), and this imbalance affected the marriage market 20 years later.[2] Incidentally, this disequilibrium in the past is often associated with the concomitant rise in dowry observed in India after independence (Mari Bhat and Halli 1999). But with decreases in fertility and further changes in age structures, the number of births started declining in the 1990s, and, according to my population projections, this reduction in the size of birth cohorts is expected to accelerate in the future. For instance, by 2025, an average birth cohort in a given year would be 7% larger than the cohort born five years later. Without any rise in the SRB, male adults would therefore become more numerous than their prospective brides.

China presents an undoubtedly more complicated picture because of the irregular size of its birth cohorts since the 1950s. While the number of births has, on the whole, decreased since the 1980s, this decline is less rapid than in India and also is disturbed by the regular ups and downs that are a legacy of China's volatile demographic past. Short-term fluctuations therefore have a marked effect on age and sex distributions in China and will directly influence the sex ratio of adults—a point highlighted by Goodkind (2006) and Rallu (2006). But the decline in the number of births will also be pronounced in China, especially during 2020–2035.[3] As a result, the impact of skewed SRBs in China and India on adult sex ratios is likely to be compounded by future age-structural transformations. I therefore insert a separate projection set designed to assess the potential influences of changes in age structures on marriage imbalances.

Birth Imbalances in the Future

My demographic projections for China and India will start from 2005 and extend to 2100. They are based on the most recent demographic estimates as well as on assumptions that are different from previous attempts.[4] Parameters for these projections have mostly been borrowed from the 2006 prospects by the United Nations Population Division, but several adjustments and corrections have been made (see Appendix A).

SRB levels for the future decades are also essential to my projections. SRB started to increase above normal values 20 years ago in China and India (for China,

[2] Data used in this section are based on United Nations estimates for 1950–2005 complemented by projection results for the period beyond 2005.

[3] According to my projections, the overall yearly decline in birth cohort size during the 2005–2100 period is 0.25% in China and 0.4% in India (rapid transition scenario).

[4] No projection exists for India. Forecasts of China's future sex imbalances (Attané 2006; Tuljapurkar et al. 1995) are based on 1990 or 2000 census data and on fixed fertility and mortality assumptions. Estimates provided by Jiang et al. (2007) follow a more realistic demographic scenario. An alternative method based on nuptiality tables has also been proposed by Jiang (2011).

see, e.g., Banister (2004), Li et al. (2007), and Zeng et al. (1993); for India, see Mari Bhat (2002a, b) and Patel (2006)). As available data indicate, SRB has risen to a level of above 115 in many Asian countries, from Armenia to China, and seems to have leveled off since 2000. There are, in fact, reasons to believe that SRB levels will not increase indefinitely and may ultimately decline. Both China and India during the last decade have introduced or strengthened comprehensive programmes to tackle sex-selective abortions (Joseph and Center for Youth Development and Activities (CYDA) 2007; Li et al. 2007). Moreover, recent trends indicate that in several areas, the SRB may be about to level off or to decline. For instance, data for China based on the 2000 census (long form) and on the 2005 1% sample survey reflects a near stagnation of the national average, from 119.9 in 2000 to 120.5 in 2005, which has already been interpreted as the beginning of a turnaround, with a significant decline in birth masculinity being observed in southeastern provinces such as Guangdong or Guangxi. There has also been a perceptible shift in SRB since 2002 in several states of northwest India, such as Haryana, Delhi, and Punjab.[5] In addition to these concordant traces of moderate decrease, the remarkable experience of South Korea—where SRB first rose to 116 in 1990 and then gradually declined to 106 in 2008—suggests that SRB may follow typical transitional patterns, with an initial rise followed by a later decline (Guilmoto 2009).

In order to explore the possible consequences of future gender imbalances, it seems crucial to consider several different SRB scenarios. First, according to a *no-transition scenario*, SRB will remain at its current level until 2100; the SRB would therefore stay at 120 in China and at 113 in India during the entire twenty-first century. Second, according to a *rapid-transition scenario*, the SRB starts decreasing immediately after 2005 and declines to a normal 105 level in 15 years—at a pace slightly faster than that observed in South Korea after 1990. This is admittedly a rather optimistic transitional scenario in which birth imbalances would have vanished by 2020. Both scenarios are deliberately extreme. The first, "business-as-usual" scenario implies, for instance, that a high SRB would remain sustainable, in demographic and social terms, during the entire century, a proposition that seems rather implausible in view of the implications of abnormal sex ratios in the long run. In contrast, the second, transitional scenario would require a complete change in gender attitudes in 15 years, something that government interventions or spontaneous social change may not be able to achieve. But taken together, these first two scenarios may reasonably be seen as the upper and lower limits for simulating sex-transitional change in China and India.

I have also included an entirely different scenario based on the hypothesis of the absence of any sex ratio imbalance since 1980. This third baseline scenario of *normal SRB* posits a constant SRB of 105 and will serve to highlight the specific impact on marriage imbalances of age-structural changes caused in particular by the process of fertility decline in China and India (see Appendix A for details).

[5] Kulkarni (2010) analyzed the recent SRB downturn in India; see also Sharma and Haub (2008). Chinese trends are described in Das Gupta et al. (2009) and Guilmoto and Ren (2011). Preliminary data from the Chinese 2010 census put the sex ratio at birth at 118, confirming the slight downturn. Original data are found in the reports of the 2000 census and of the 2005 1% sample survey for China, while Indian data are from the annual reports of the Sample Registration System.

Measuring Marriage Squeeze

Adult sex ratios weighted by marriage rates provide the usual index to assess the intensity of demographic disequilibria in the marriage market. This indicator allows the incorporation of both the size of specific cohorts and the effects of age-specific nuptiality rates in my computations. However, it presents serious limitations for the appraisal of the actual impact of sustained sex imbalances. The major issue related to strictly synchronic indicators, such as weighted sex ratios, is that they do not take the potential effects of the past nuptiality experience of each cohort into consideration. When surplus male bachelors fail to marry in a given year, they will unavoidably inflate the pool of potential grooms in the following year, and if the sex disequilibrium does not reduce rapidly, unmarried bachelors will accumulate in the marriage market and further aggravate the squeeze conditions. This is a direct application of a basic law in queuing theory according to which the number of people in a system (here the marriage market) is a function not only of arrival rates (cohort size) but also of the queuing time (number of years unmarried).[6] But usual cross-sectional sex ratio indicators fail to reflect the cumulative impact of the marriage squeeze in the previous periods.

A more appropriate solution to this conundrum is the two-sex cohort-based simulation of marriages. In this approach, I compute the number of first unions by using the estimated number of single men and women during each five-year period starting from 2005. In so doing, I deduce the size of the unmarried population at the end of each period and use it to simulate marriages taking place during the next period. This approach is longitudinal as we follow individual cohorts and their nuptiality over the years. It also makes it possible to estimate the mean age at marriage and the proportion of people unmarried at age 50. To assess the intensity of the future marriage squeeze, I use a cohort-based ratio of expected first male marriages to expected first female marriages, which I refer to here as the *marriage squeeze indicator* (MSI). In addition to the specific effect of cohort sizes (also captured by the weighted sex ratio), the MSI is influenced by the population who did not marry during the previous periods. This simulation technique is based on first-marriage tables by age, sex, and period. But while weighted sex ratios are computed from first-marriage rates applied to the projected population, the cohort-based method uses marriage probabilities (ratio of marriages to single population by age and sex) and is therefore affected by any backlog of unmarried men or women.

A key component in the simulations is the adjustment function used to quantify the number of marriages occurring in case of marriage squeeze, when the expected numbers of male and female marriages differ. The main marriage function used in the simulations is a modified female dominance (FD) model, which is applicable when there is a deficit of women. In the original FD model, the number of marriages is determined only by female marriage rates.[7] Since not all men are able to marry, their nuptiality rates must be adjusted downward. The FD model presupposes that female marriage rates will follow a fixed trajectory and that they will not be affected by variations in the number of unmarried men as long as there is a male surplus. I

[6] Little's law states that the average number in a given stable system is equal to the rate of new arrivals in the system multiplied by their average time in the system (Tijms 2003:50–52).

[7] See Keyfitz and Caswell (2005) and Iannelli et al. (2005) for a broader discussion of marriage models.

have, however, added a constraint to this model: the age difference at marriage between men and women is assumed to remain the same. In other words, women are not only able to marry at the chosen age but are also able to select husbands with a constant age difference. This model offers surplus men no flexibility, such as delaying marriage. Because this model depends almost exclusively on female nuptiality behavior, it is crucial to delineate appropriately the most likely course of female marriage patterns over the coming decades.

Simulating Female Nuptiality in Asia

It would be rather unrealistic to assume that current female nuptiality patterns will remain unchanged in China and India until 2100. On the contrary, Asian marriage systems are today characterized by rapid and deep transformations: under the impact of various factors such as prolonged education, urbanization, access to formal employment, and increasing social autonomy, women have delayed their marriages in many East Asian countries and metropolitan areas.[8] New phenomena, such as the end of universal marriage or, to a lesser extent, cohabitation, have even emerged over the last 15 years.

In India, women still marry rather early—19.8 years is the latest estimated average age at first marriage (see Appendix B). Such a low figure may appear at first sight to reflect the permanence of traditional matrimonial arrangements privileging early female union soon after menarche. Until the 1930s, the country was indeed characterized by very early marriages, with a large proportion of women betrothed before reaching physiological maturity. But the pace of change observed in India has been remarkable, and age at first marriage has regularly increased ever since: it increased from 13 to 15 years in 1951, reaching 18.3 in 1981 and 20.2 in 2001 (census-based estimates). The progress in female age at first marriage—one additional year per decade since 1931—has, in fact, been strictly linear in India. Moreover, recent NFHS data (IIPS 2007) indicate that age at marriage in today's India is also closely correlated to education levels as well as to urban residence and socioeconomic status. With such covariates of late female marriage, current trends in rapidly modernizing India suggest further gains in mean age at marriage in the future. A plausible hypothesis for India thus consists in positing a gradual rise in female age at first marriage in India, reaching 23.5 years at the middle of the century, at a level similar to what is observed today in China.[9] I have also posited a gradual leveling of remarriage rates between men and women in 2005–2050.[10]

In 2005, Chinese women married on average at the age of 23.5 years, a value significantly above the legal age at union (20 years), but with only 2% of women still unmarried in the 30- to 34-year age group. The proportion single at 50 was as low as 0.2%. Female age at first marriage was 22.4 years at the time of the 1982

[8] Jones (2007) provides the most recent comprehensive synthesis of nuptiality in East Asia. Detailed statistics and case studies are also available in Jones and Ramdas (2004) and Xenos et al. (2006), as well as in United Nations (1990) for trends prior to the 1990s. See also Retherford et al. (2001) on Japan, and Kwon (2007) on South Korea.

[9] This figure is slightly above that of Kerala women today but still distinctly below that of Sri Lankan women (Caldwell 2005).

[10] Higher remarriage rates among men than women represent a rather untenable hypothesis in view of the mounting surplus of unmarried men. On remarriage in India, see Mari Bhat and Halli (1999) and Chen (2000).

census, and it has only marginally increased since then. Jones (2007:466) attributed these features to both institutional and structural factors. Among men, the average age at first marriage was 25.1 years and has remained constant over the last two decades. However, because the experience of neighboring countries, such as South Korea and Japan, suggests that female age at marriage may rise in the future, I have also postulated a gradual increase in age at marriage among Chinese women up to 26.5 years in 2050, a pace of change comparable to that hypothesized for India.[11] It may be observed that the projected female age at first marriage for China in 2050 remains significantly below the current figures for Japan and South Korea, where women today marry, on average, at age 29.

Alternative Marriage Models

The modified FD model corresponds to a reasonable scenario of future marriages based on both nuptiality changes among Asian women and a strictly parallel rise in male nuptiality. Yet, this system allows for almost no flexibility in marriage patterns since both female and male marriage schedules are fixed. In this section, I relax some of these assumptions and explore two alternative ways in which the marriage market may adjust to gender imbalances, mostly through a gradual increase in the age difference between spouses caused either by earlier female marriages or by delayed male marriages (methods and parameters are in Appendix B).

One possible change corresponds to symmetrical changes in male and female marriage schedules. This is the harmonic mean (HM) model, which is probably the most commonly used marriage matching function (Schoen 1981; see also Okun 2001; Qian and Preston 1993; and Raymo and Iwasawa 2005). This method provides the basis for a self-regulatory marriage system in the case of imbalances, such that the surplus sex is assumed to temporarily defer marriage while the deficit sex is expected to marry earlier. At the same time, the average age at first marriage of the combined male and female cohorts remains the same. The HM model implies that the deficit sex takes advantage of the relative surplus of the opposite sex by marrying earlier because its pool of prospective spouses has momentarily expanded. In other words, union is regarded as partly constrained by the number of suitable partners, and marriage probabilities are expected to rise when the relative size of the unmarried population of the opposite sex increases. Because union has long been nearly universal among women in China and India, there is no pool of available unmarried women, and the application of the HM model entails a reduction in female age at marriage. Such an adjustment may be conceivable if current constraints on marriage—such as intense dowry negotiations in India or prohibition of early marriage in China—were relaxed. Similarly, the abundance of marriageable men could also improve the probability of women finding suitable partners by shortening the search period.[12]

I also use a different model that combines features from the FD model (rising female age at marriage) and the HM model (rising age difference). In this hybrid model based on delayed male marriage (DMM), I posit a regular increase in female

[11] I am grateful to the suggestion of an anonymous reviewer on this point.

[12] Better marriage opportunities for women and lower dowry costs in high sex-ratio societies are among the hypotheses put forward by Guttentag and Secord (1983).

age at marriage as in the FD model, but also a two-year increase in the age gap between men and women. This DMM model presupposes that women would accept marriage to older men more than they did in the past, suggesting that social status or accumulated assets of older men compensate the growing age difference. This could also be interpreted as a lengthened search period among unmarried men caused by the diminishing number of prospective brides.

Results

My simulations rely on three different population projections based on SRB parameters —namely, the no-transition scenario, the rapid-transition scenario, and the normal-SRB scenario. Based on these projected populations, I examine in the first section the extent of the marriage squeezes as measured by cross-sectional and longitudinal indicators. Since the SRB may be overestimated in China, I include the results of a sensitivity analysis based on lower SRB levels for this country (Appendix C).

The results of marriage simulations presented in the following section are based first on the FD model, which assumes a nuptiality regime determined by the future course of female nuptiality. The outcomes of these simulations are given in terms of marriage tempo (age at marriage) and intensity (unmarried men at age 50). Finally, I use the two additional alternative marriage functions (HM and DMM models) to illustrate different ways in which male and female nuptiality may adjust to the marriage crunch.

A New Look at the Marriage Squeeze

I start with the usual index of marriage squeeze computed as weighted sex ratios. As Fig. 1 indicates, the rise in the weighted adult ratio in China is rather abrupt after 2010 in both SRB scenarios, and the sex ratio reaches 122 in 2025. Results based on the normal SRB scenario show that the imbalance was bound to increase to 108 in 2020 because of past fluctuations in birth cohort size in China (Goodkind 2006). Following the transitional scenario, the adult sex ratio will record an equally rapid fall after 2025 and will oscillate around 104 during the second part of the century. As expected, the difference between the normal and rapid-transition scenarios declines gradually, and both series are similar in 2050, when the impact of surplus male births before 2020 disappears. In contrast, the no-transition scenario suggests that the weighted adult sex ratio in China would not return to normal levels and would instead oscillate after 2025 around a high level of 119. My results agree with findings already found in the literature on China suggesting that the marriage squeeze will peak in 2030 (Jiang et al. 2007).

When measured through marriage simulations, the marriage squeeze in the future appears rather different from the preceding picture (Fig. 1 and Table 1). As previously explained, the MSI is computed as the sex ratio of expected first marriages based on the single populations estimated during the previous period, while the weighted sex ratio is based on projected age and sex distributions. Both indicators would be similar if the observed proportions unmarried in each period were identical to that of the corresponding marriage tables. But the gradual accumulation of unmarried men in several cohorts tends to enlarge the number of expected marriages, leading to MSI levels far higher than projected weighted sex ratios.

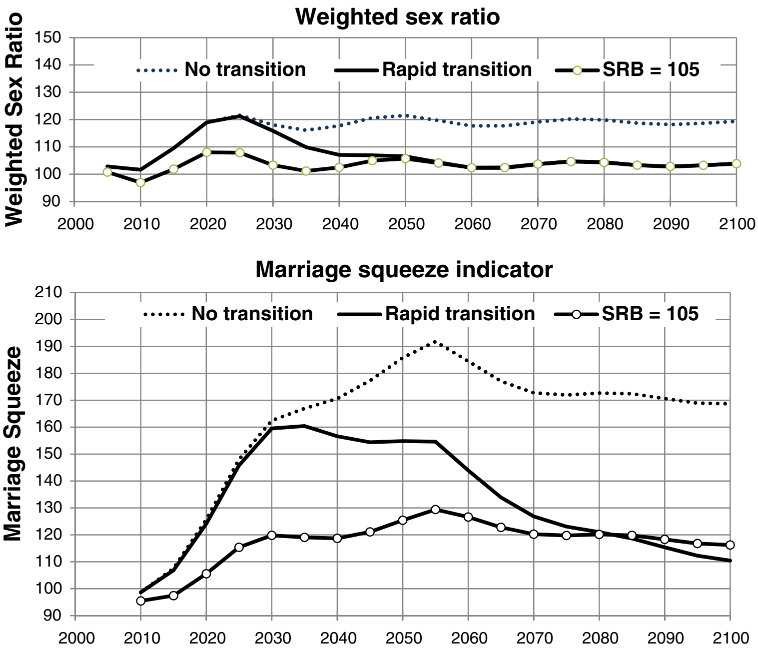

Fig. 1 Two indicators of marriage squeeze according to three SRB scenarios, China: 2005–2100. See the text for details on SRB scenarios and the indicators used

In the more favorable rapid-transition scenario, marriage squeeze peaks at 160 in 2035 and does not decline substantially before 2060. A level of 160 means that in 2030, 60% more single men than single women are expected to marry within the next five years according to the corresponding nuptiality table. A large part of this 60% comes from the lower-than-expected marriage rates observed during the previous 20 years and the associated backlog of unmarried men. The indicator stagnates at a high level after 2035 as new cohorts born in 2020—with normal SRB levels—enter the marriage market. But the real decline takes place after 2055, when the cohorts most affected by birth imbalances reach 50 years.

If the sex ratio were, on the contrary, to remain stable at 120 (the no-transition scenario), the MSI would grow to 190 and stabilize in later decades to 170. But it is interesting to observe the sizable impact of mere changes in age structures, with an MSI reaching 130 in 2055 according to the normal-SRB scenario. In other words, the rapid shrinking of age structures appears to have a sizable independent effect on the future marriage squeeze. Thanks to this set of estimates, the MSI for each SRB scenario may be broken into two components: the age-structural component, summarized in the baseline 105 curve, and the additional effect of past SRB disturbances.[13] In China, the age-structural effects appear to account for more than half of the marriage squeeze after 2050.

India's weighted sex ratios (Fig. 2 and Table 1) have a smoother profile because of the country's far more regular age distributions and do not reach 110 in the transitional scenario. However, the analysis is more accurate when it is based on the longitudinal

[13] For simplicity, the effects of birth imbalances and age-structural change on the marriage squeeze are assumed to be additive.

Table 1 Marriage indicators according to three SRB scenarios, China and India: 2010–2100

	No SRB Transition				Rapid SRB Transition				Normal SRB			
	Marriage Squeeze Indicator	Mean Age at Marriage		% Single Men at Age 50	Marriage Squeeze Indicator	Mean Age at Marriage		% Single Men at Age 50	Marriage Squeeze Indicator	Mean Age at Marriage		% Single Men at Age 50
		Male	Female			Male	Female			Male	Female	
China												
2010	98.6	25.6	23.3	3.3	98.6	25.6	23.3	3.3	95.4	25.6	23.2	3.3
2020	125.7	26.0	24.2	3.3	124.1	26.0	24.2	3.2	105.5	25.9	24.2	3.0
2030	162.5	27.4	24.7	4.3	159.5	27.6	24.7	4.1	119.8	27.2	24.6	2.6
2040	170.6	27.6	25.1	10.0	156.6	28.0	25.0	9.3	118.7	27.3	25.0	4.2
2050	185.8	28.3	26.1	16.7	154.8	28.6	26.0	14.5	125.4	28.2	26.0	6.0
2060	184.5	28.7	26.5	19.7	143.9	28.8	26.5	14.6	126.6	28.8	26.4	6.8
2070	172.7	28.5	26.5	21.4	126.8	28.5	26.4	12.8	120.2	28.6	26.4	7.8
2080	172.7	28.7	26.7	20.4	121.0	28.7	26.7	9.6	120.2	28.8	26.7	7.6
2090	170.6	28.7	26.6	18.9	115.4	28.8	26.5	7.2	118.3	28.8	26.5	7.1
2100	168.7	28.7	26.5	18.5	110.4	28.8	26.5	6.0	116.2	28.7	26.5	6.8
India												
2010	104.0	24.3	19.5	1.1	104.0	24.3	19.5	1.1	101.5	24.3	19.5	1.1
2020	126.9	25.0	20.2	1.3	125.1	25.0	20.2	1.3	111.3	24.9	20.2	1.2
2030	149.9	26.1	21.2	2.5	144.9	26.2	21.1	2.4	118.2	26.0	21.1	1.6
2040	172.0	27.2	22.1	5.4	157.7	27.3	22.1	5.0	125.0	27.0	22.1	2.7
2050	189.0	28.1	23.1	9.3	163.6	28.1	23.0	8.0	130.8	28.0	23.0	4.1
2060	191.4	28.7	23.5	12.9	156.8	28.6	23.5	10.0	132.0	28.7	23.5	5.6
2070	183.4	28.7	23.6	14.9	141.2	28.5	23.6	10.2	128.8	28.7	23.6	6.7
2080	182.6	28.6	23.7	14.9	134.0	28.5	23.6	8.6	130.1	28.7	23.6	7.0
2090	183.2	28.7	23.6	14.3	129.2	28.6	23.6	7.2	131.8	28.7	23.6	6.9
2100	183.6	28.6	23.6	14.2	125.3	28.7	23.6	6.5	133.3	28.6	23.6	7.1

Notes: For the marriage squeeze indicator, the sex ratio of expected first marriages is computed on simulated single populations (per 100; see the text for details). Mean age at marriage is computed on simulated marriages (female dominance model) during the five preceding years. SRB scenarios and the marriage simulation procedure are described in the text and in Appendices A and B.

MSI. In the rapid-transition scenario, the index rises gradually to 165 in 2055, in spite of the sex ratio transition completed in 2020. This rise has obviously been aggravated by shrinking birth cohorts as the MSI in the normal-SRB scenario reaches 130 in 2050 and stays at this level until the end of the century. Changes in age structures account for more than half of the rise in weighted sex ratios from the 2030s, and the marriage squeeze in this scenario does not decrease during the second half of the century because of the lower fertility and larger spousal age difference in India. The more pessimistic scenario of high SRB results in a continuous rise in marriage imbalances until 2055, after which the indicator remains above 180 during the following decades.

Measurements based on marriage simulations in China and India correct the lower and shorter trends suggested by the weighted sex ratios. In particular, because of the queuing effect, the marriage squeeze captured by the cohort-based simulations is likely to be more intense than usually predicted and might not decline before 2060. Even in the more optimistic SRB scenario, the number

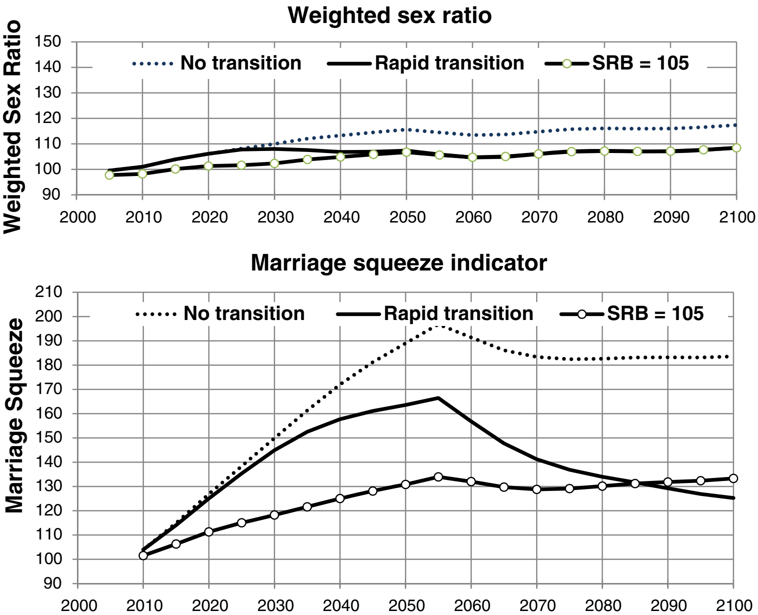

Fig. 2 Two indicators of marriage squeeze according to three SRB scenarios, India: 2005–2100. See the text for details on SRB scenarios and the indicators used

of prospective grooms exceeds that of brides by more than half for three decades in a row in both countries. These results also contradict the somewhat reassuring picture for India, where the weighted sex ratio remains below 110 in the rapid-transition scenario. Even with the SRB back to normalcy in 2020 and the last affected birth cohorts above 40 years by 2060, the marriage squeeze remains elevated in India until the end of the century as a result of India's late fertility decline. This is why India's marriage squeeze takes place later (2055) and at a higher level (165) than China's.

Female Dominance and the Rise in Male Nonmarriage

The next set of results translates the sex imbalances in the marriage market into proportions of men remaining single at age 50 (Fig. 3). Starting with China, notice that the sex disequilibrium is not felt before 2030 in spite of the SRB rise observed since 1990. This suggests that older birth cohorts reaching age 50 before 2030 are not affected. My simulation, however, demonstrates the suddenness of changes after this date: the proportion of men never married reaches almost 10% in both scenarios during the 10 following years. Irrespective of the scenario, the impact of gender imbalances at birth appears considerable during the 2030–2050 period. The proportion of 50-year-old unmarried men rises from 3% before 2030 to 17% in 2050 and reaches 20% in 2060 in the no-transition scenario, an overall increase that parallels the long-term 120 SRB level assumed in this pessimistic scenario. As Fig. 3 also illustrates, a rapid SRB decline in China will not invert trends in male singlehood before 2055. Note that the estimated proportion of bachelors at age 50 will rise by only 12% (from 3% to 15%). Although the proportion decreases after

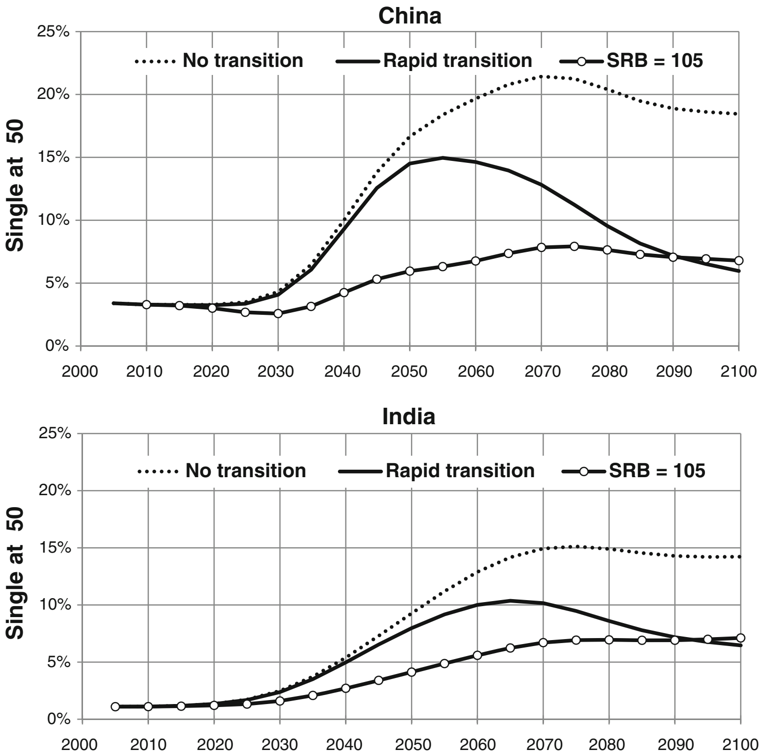

Fig. 3 Proportion of single men at age 50 according to three SRB scenarios, China and India: 2005–2100

2055, the curve is skewed toward the right, and the decline is slower than the initial rise because of the lingering marriage squeeze conditions.

The results for India are, on the whole, parallel to China, although they are more favorable during the first half of the century. In the absence of SRB transition, the share of never-married men at age 50 increases from 2030 onward to reach 15% by 2070. But in the rapid-transition scenario, this proportion of unmarried men would on the contrary reach only 10% in 2060. The subsequent decline in the male proportion remaining single is, however, much slower than in China. In fact, the net increase in the proportion remaining single—computed from the low proportion of 1% observed today—becomes larger in India than in China after 2070. This peculiar situation of India is linked to the effects of age-structural change as underlined in the previous section. In contrast to China, India's age structures have not undergone a rapid transformation during the late twentieth century, and its TFR is not expected to reach replacement level before 2025, causing a sizable delay in its age-structural transformations and a parallel delay in the rise of its marriage squeeze and of male singlehood.

The Alleviating Effects of Changing Marriage Patterns

I run another set of simulations according to these two alternative scenarios of nuptiality adjustment. The results shown in Table 2 and Fig. 4 also include results from the standard FD simulations discussed in the previous section. For simplicity, I restrict the discussion to the rapid-transition scenario.

Table 2 Marriage indicators according to two alternative marriage models, China and India: 2010–2100

	Harmonic Mean Model				Delayed Male Marriage			
	Marriage Squeeze Indicator	Mean Age at Marriage		% Single Men at Age 50	Marriage Squeeze Indicator	Mean Age at Marriage		% Single Men at Age 50
		Male	Female			Male	Female	
China								
2010	98.6	25.6	23.3	3.3	98.6	25.6	23.3	3.3
2020	117.2	25.8	24.0	3.3	117.0	26.2	24.2	3.1
2030	157.5	26.6	22.7	3.7	148.0	28.2	24.7	3.2
2040	156.3	26.7	22.4	5.9	144.1	29.1	25.0	6.9
2050	162.6	27.1	22.6	8.9	144.9	30.2	26.0	10.6
2060	157.2	27.0	22.3	9.6	139.6	30.9	26.5	11.1
2070	144.4	26.6	22.6	9.8	124.1	30.5	26.4	10.8
2080	145.8	26.7	22.7	9.0	122.0	30.6	26.7	8.8
2090	139.9	26.5	22.6	8.1	117.7	30.8	26.5	7.4
2100	135.8	26.4	22.8	7.8	112.5	30.7	26.5	6.6
India								
2010	104.6	24.3	19.5	1.1	104.0	24.3	19.5	1.1
2020	112.3	24.9	19.6	1.4	111.5	25.2	20.2	1.3
2030	123.5	25.6	19.4	1.9	118.4	26.7	21.1	1.7
2040	134.3	26.4	19.2	3.0	121.9	28.3	22.1	3.0
2050	145.1	27.0	19.1	4.4	122.5	29.7	23.0	4.5
2060	150.2	27.4	18.8	6.1	120.5	30.5	23.5	5.7
2070	156.9	27.4	18.8	7.5	115.8	30.5	23.6	6.4
2080	169.7	27.6	18.6	8.6	117.1	30.5	23.6	6.3
2090	177.4	27.8	18.5	9.7	118.8	30.7	23.6	6.4
2100	184.7	27.9	18.4	10.9	119.3	30.8	23.6	6.7

Notes: For the marriage squeeze indicator, the sex ratio of expected first marriages is computed on simulated single populations (per 100; see the text for details). Mean age at marriage is computed on simulated marriages during the five preceding years. A rapid transition scenario is used in these simulations. The harmonic mean model involves symmetrical adjustment of male and female marriage rates (see the text and Appendix B). Delayed male marriage indicates a gradual increase by two years in the male-female age difference at marriage by 2050 (see the text and Appendix B).

The DMM model is the easiest to interpret because the difference with the FD model is limited to the delayed male nuptiality. In China, with the male age at first marriage rising by an extra two years in 2050, this increase in spousal age difference would cause a significant decline in the number of men unable to marry. The gain is already perceptible in 2030 but swells during the next two decades. It peaks in 2050, when the male singlehood rate reaches 10.6%, against 14.5% predicted in the standard model. In India, the gain in male nuptiality is also considerable but tends to peak later on: in 2070, the DMM model entails a decline of 4% in the male singlehood rate at age 50. In both countries, higher age at marriage among men also reduces the marriage squeeze (Table 2). This strategic trade-off between tempo and intensity of male nuptiality is only temporary and gradually dissipates during the second half of the century.

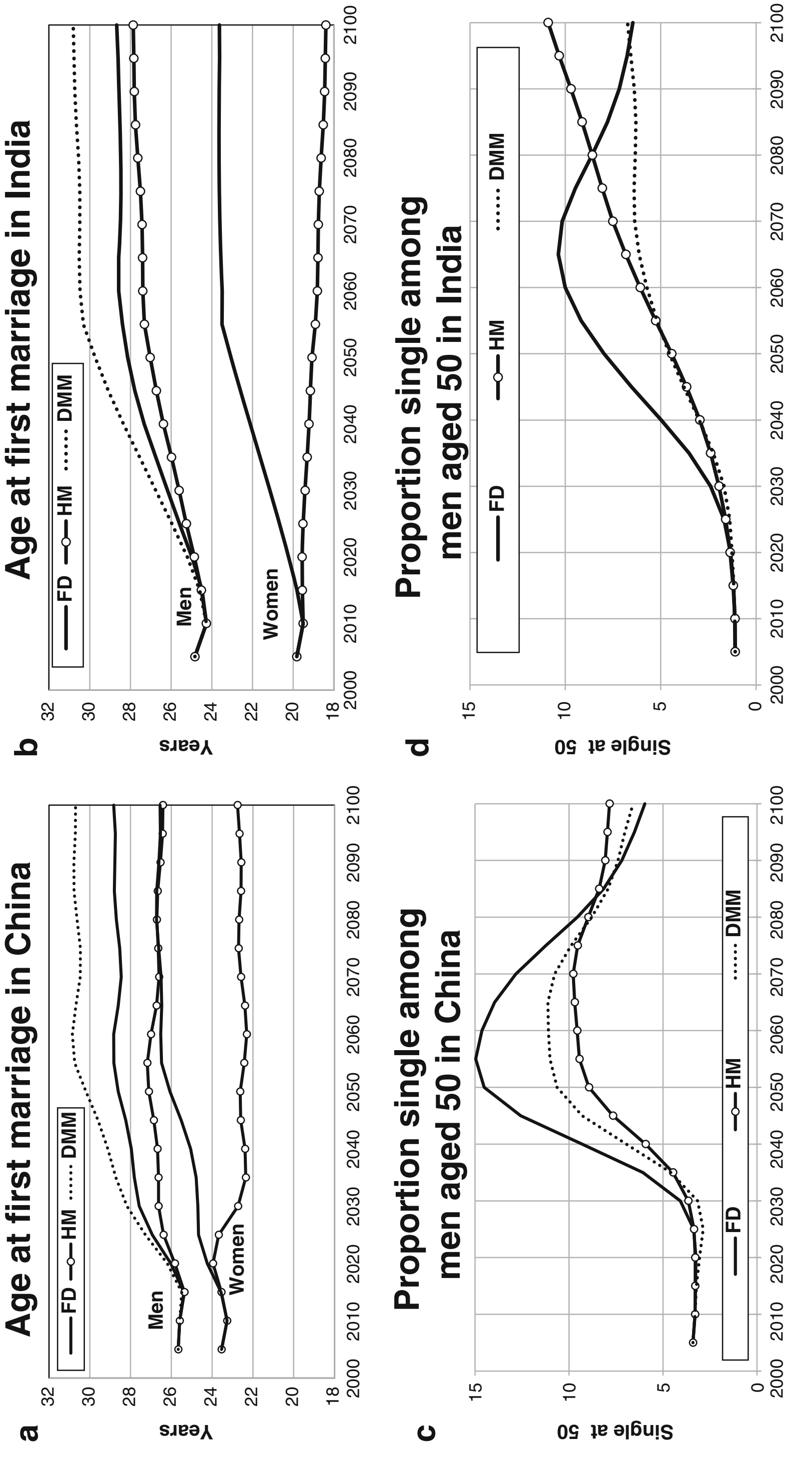

Fig. 4 Average age at first marriage and proportion single among men aged 50 according to three marriage models, China and India: 2005–2100 (rapid transition scenario). FD = Female dominance model; HM = harmonic mean model; DMM = delayed male marriage model (see the text for details)

The basic harmonic mean model illustrates a more complex readjustment process since it affects both men and women. In particular, the results confirm that higher marriage probabilities among women would substantially slow down the overall impact of the forthcoming male surplus in the marriage market. In China, the HM model corresponds to a slower increase in male age at marriage, reaching 27 years in 2060; in contrast, the average age at first marriage among women falls after 2020 to 22.5 years and oscillates around this value during the following decades. The age gap between spouses would rise to four years. In terms of male nuptiality intensity, the impact in China appears considerable since the singlehood rate at age 50 remains below 10% during the entire century, at levels that are 5% below our standard simulations in 2060. But during the last quarter of the century, the HM model leads to rather disappointing results as the male singlehood rate fails to decline significantly. In fact, the elevated age difference caused by the HM assumptions becomes detrimental to men and yields a higher proportion of unmarried men at the end of the century than the standard FD model. Results of the application of the HM model to India similarly point to a reduction of the sex ratio crisis, as in the DMM model. After 2060, the HM model leads, however, to an unstable system in which singlehood rates continue to rise in spite of the rapid disappearance of the original sex imbalance at birth. In the meantime, the age gap between men and women is also allowed to rise progressively to almost 10 years, resulting in a severe structural disequilibrium between cohorts of prospective brides and grooms.

One may conclude at this point that the HM method is probably not the appropriate technique for simulating the response of nuptiality systems to long-term sex imbalances. For all its algebraic elegance, the HM model does not appear to be sociologically plausible. Symmetrical short-term adjustments in nuptiality patterns remain in theory possible, but mounting sex imbalances are unlikely to lead to a durable reduction in the female average age at first marriage. For instance, a female age at marriage below 19 in India appears highly inconsistent with the nuptiality trends documented in a previous section. There are therefore strong reasons to believe that the HM model—and possibly other homeostatic models based on symmetrical marriage flexibility—is not applicable in the current case.[14]

Synthesis of the Results

I believe that the results of these simulations shed new light on the current masculinity crisis in Asia by translating demographic projections of skewed population structures into specific outcomes of future nuptiality change. Based on a new set of population projections, I favor here a cohort-based procedure to simulate marriage patterns in twenty-first-century Asia. In addition, although China is usually the center of attention, the inclusion of India in this exercise demonstrates the seriousness of gender imbalances in this country and the potential contribution of age-structural changes in the forthcoming deficit of marriageable women.

[14] For critical discussion of the HM model, see Iannelli et al. (2005:38–41). See also Hinaba's observations (2000:395). A long-term study of nuptiality patterns in Spain using the HM model concluded that most changes were driven more by behavioral factors than by age-sex compositional changes (Esteve et al. 2009).

While straightforward projections suggest the inevitability and the magnitude of future gender imbalances, the simulation approach yields better estimates of the potential timing and the final impact on marriage patterns than usual cross-sectional measurements. In particular, it shows that even cohorts born after a rapid decline in birth masculinity may be affected by substantial disruptions in nuptiality patterns and that the surplus of men is likely to affect both countries during the second part of the century. Using the normal-SRB projections, I can evaluate the consequences related to long-term changes in age structures and demonstrate that differences between China and India are not reducible to their current difference in SRB levels.

Beyond methodological issues, the first lesson of these simulations is the extent of the impact of skewed sex ratios at birth on demographic structures and the additional influence of fertility decline and the ensuing age-structural changes. The number of men unable to find a spouse will rise in only 20 years, but the increase would probably be abrupt in the absence of a change in the marriage schedule among them. My estimates for China point to a jump of the proportion single at age 50 from 3% now to 15%–21% in 2060, depending on the date of an eventual SRB decline. Marriage simulations show that even if the SRB is allowed to return to 105 by 2020, which is a rather optimistic assumption, gender imbalances will severely affect the marriage market and the nuptiality patterns of male cohorts during the second half of the century. A rapid transitional scenario corresponds to about 15% of China's male population born during the first decade of the century remaining single. Lower SRB levels observed today in India tend to suggest a better situation, with singlehood rates remaining below 10% if the birth masculinity were to decrease within the next 15 years, but the future reduction in birth cohort size would slow down the recovery after 2050.

When converted to population figures, the current SRB crisis in China corresponds to an extra 8.1 million single men reaching age 50 during the 2050 decade. The cumulative number of these additional bachelors over the 2020–2080 period should exceed 32 million. In India, the situation would be hardly more favorable, since Indian population cohorts will be significantly larger than China's.[15] As a result, the cumulative number of additional men remaining single during 2020–2080 could be closer to 40 million in India, according to my simulations. In addition, if a significant proportion of women in China and India were to renounce marriage—as seen today in Japan or South Korea—or to opt for younger rather than older partners, the proportion of men remaining single would obviously rise even further than suggested here. In this respect, these simulations represent a somewhat conservative scenario of female nuptiality in the future. This observation also suggests that future female nuptiality in Asia will hold the key to gender imbalances during the twenty-first century.

Implications

The social consequences of sex imbalances on marriage patterns remain unpredictable for several reasons. First, no such massive surplus of adult males has been recorded in

[15] These estimates are derived from the difference between the proportion single as of 2005 and the simulated figure in the rapid-transition scenario (FD model).

the recent past. An additional difficulty in envisioning the consequences of current masculinization processes stems from our limited understanding of Asian family systems' capacity to cope with the forthcoming marriage squeeze. Among the potential adjustments within the current marriage system, late union among men is a more plausible response than early female marriage. If being older is perceived as an additional advantage for men in the marriage market because of its correlation with personal assets and earning capacity, a much larger proportion of men than before may end up marrying after age 35. It has recently been observed that sex ratio imbalances may generate a subsequent increase in saving rates as a response to the increasing competition among men in the marriage market (Wei and Zhang 2009). The decrease in male singlehood attributable to later marriage can be computed from my simulations: a one-year increase in male age at marriage would reduce singlehood rates at age 50 by nearly 2% (by 1.7% in China and 2.3% in India). This result is by no means negligible in view of the number of years affected and the average cohort size: the reduction of the marriage squeeze caused by delayed male nuptiality illustrated by the DMM model would indeed reduce the cumulative numbers of unmarried men at 50 in China and India (computed previously) by 11 and 19 million, respectively.

Higher male age at first marriage is therefore susceptible to alleviating the marriage squeeze for several decades without being sufficient to entirely cancel its impact. There are many other ways in which nuptiality could in theory adjust to the growing gender disequilibrium—for example, through marriage migrations, female trafficking, higher rates of divorce and remarriage among women, polyandry, or same-sex unions among men. It is beyond the scope of this article to explore all the social transformations that could be generated by the masculinization of the adult population.[16] But none of these adjustments would be of sufficient magnitude to counterbalance the mounting male surplus.

It may be more important to point to some specific issues facing future research. My findings suggest that the intensity of the future marriage squeeze is seriously underestimated by cross-sectional indicators based only on population structures because of the cumulative effect of unmarried men on the marriage squeeze. This reinforces the need for appropriate marriage simulations and consequently for specific marriage functions applicable in case of marriage squeeze. Studies using more complex marriage functions—for instance, in which age patterns are allowed to change over time—may be needed to explore alternative responses to the marriage imbalances. Another promising direction for future research concerns regional simulations, focusing on areas in China and India where SRB distortions are the most pronounced. Incorporating the effects of interregional migrations would also improve simulations in the many provinces where labor outmigration is an additional factor of sex imbalances. Finally, researchers need to keep in mind that no finer modeling of nuptiality mechanisms will be possible without insights from quantitative and qualitative surveys conducted in the most affected areas of China

[16] For reports on recent changing marriage practices in Asia, see Blanchet (2005), Davin (2005), Kaur (2004), Kim (2008), Le Bach et al. (2007), and Pandey (2003). For a larger perspective, see the analysis by Hudson and den Boer (2004).

or India to better understand how local marriage systems are likely to evolve as a response to the scarcity of prospective brides.

Acknowledgments I thank my colleagues at UNFPA, CEPED, and CEDEPLAR for their suggestions on my preliminary presentations. Additional help from Isabelle Attané, Eva Lelièvre, Zoé E. Headley, Gavin Jones, and Ines G Županov on a previous version is gratefully acknowledged. Anonymous reviewers for *Demography* also provided detailed and useful comments.

Appendix A: Parameters for Population Projection

Table 3 summarizes the parameters used for the projections of China's and India's populations until 2100 (see also Guilmoto 2010). Projections were done with the cohort-component method of the software package Spectrum (DemProj model), under the assumption of no international migration during the period under examination. Population figures and demographic parameters were borrowed from the medium variant of the world projections by the United Nations (2007). For the 2005 baseline year, population and demographic parameters come from the United Nations estimates, and these parameters incorporate in particular the current level of female excess mortality among children. However, two adjustments were necessary for China. First, the sex distribution derived from the 2005 1% survey—in which male adults are severely underestimated—was corrected by using the estimated sex ratio for the entire population in 2005 and the cohort-specific sex ratio for adults aged 15–54 during the 2000 census. Second, China's fertility in 2005 was taken as 1.6 children per woman, a medium value derived from available TFR estimates by Cai (2008), Lutz et al. (2007), Retherford et al. (2005), and Zeng (2007). Values used for the 2050–2100 period were

Table 3 Parameters used for demographic projections: 2005–2100

		China				India			
		2005	2020	2050	2100	2005	2020	2050	2100
Total Fertility		1.60[a]	1.68[a]	1.85	2.1[a]	2.96	2.23	1.85	1.85[a]
Life Expectancy	Male	70.9	73.4	78.0[a]	82.0[a]	62.4	66.9	74.0[a]	82.0[a]
	Female	74.2	77.1	82.0[a]	86.0[a]	65.3	70.6	78.0[a]	86.0[a]
SRB	No transition	120	120	120	120	113	113	113	113
	Rapid transition	120	105	105	105	113	105	105	105
	Normal SRB[b]	105	105	105	105	105	105	105	105

Notes: Fertility is reported in children per woman; life expectancy at birth, in years; and sex ratio at birth (SRB), in male births per 100 female births. All intermediary values for 2005–2100 are interpolated. Baseline 2005 populations are derived from United Nations (2007) for the No transition and Rapid transition scenarios, but are reestimated from 1980 for the Normal SRB scenario (see Appendix A for details).

Sources: Mortality and fertility estimates, except those noted below, are from the United Nations (2007).

[a]Data estimated by the author or derived from Lutz et al. (2008) and United Nations (2004).

[b]The sex ratio at birth is assumed to have remained constant at 105 in 1980–2005.

derived from two different sets of long-term projections prepared by IIASA (Lutz et al. 2008) and by the United Nations (2004).

The first two SRB scenarios described in the text are used to calculate the share of male and female births in each five-year birth cohort in 2005–2100. SRB figures used for 2005 (120 for China and 113 for India) are taken from the 2005 1% survey for China and from estimates by the Sample Registration System for India. The most recent estimate by China's National Bureau of Statistics puts the SRB at 121 for 2008. It remains that SRB levels used here are only estimates in view of the possibility of underenumeration of girls in China and of sample issues in India.[17] I have not attempted here to provide an alternative set of SRB estimates, and only the next round of censuses in both countries will provide the more detailed figures required to reestimate SRB levels. But in order to account for the possibility of female underregistration in China, I have also run a set of simulations with lower SRB (see Appendix C).

For the simulation based on normal SRB (with SRB constant at 105), I also corrected the 2005 baseline data for China and India because they are affected by past SRB imbalances. To do this, I modified the 2005 sex distribution of the population below 25 years in order to reflect a normal sex ratio distribution. For India, I computed correction factors for each five-year period since 1980 based on SRB estimates (see Kulkarni 2010), and I applied them to the 2005 sex ratio for all age groups below 25 years to compute the corrected sex and age distributions used in this projection. In the absence of a similar series for China, I used the average sex ratios of five-year age groups computed from United Nations estimates for the world after removing China and India.

Appendix B: Parameters and Procedure for Marriage Simulations

The nuptiality parameters are given in Table 4, starting with estimates for 2005. Because neither China nor India publishes marriage rates by age, I had to resort to indirect estimates based on successive age and sex distributions by marital status to compute the nuptiality table for 2000–2005 by five-year age group from age 15 to 50. The marriage schedules for China were computed longitudinally by combining the distributions from the 2000 census and the 2005 1% survey. Similarly, I used the two NFHS rounds of 1998–1999 and 2005–2006 (IIPS 2007) for India. The 2005 marriage rates from ages 15 to 50 have been used to compute the weighted adult sex ratio (computed on age distributions weighted by age-specific marriage rates) displayed in Figs. 1 and 2.[18]

To simulate marriages in five-year cohorts, I used the marriage probabilities derived from marriage schedules as well as a correction factor in order to account for remarriage (below age 50). This correction coefficient for remarriage was derived from two sources: the proportion remarried in the 2000 and 2005 Chinese surveys, and the proportion of remarried men and women in India according to the latest NFHS data for India. From the standard marriage schedules, I also derived other

[17] A more detailed discussion on SRB estimation issues for China and India may be found in Goodkind (2008) and Kulkarni (2010).

[18] For weighted sex ratios corrected for remarriages, see Jiang et al. (2007:357).

Table 4 Nuptiality parameters used for marriage simulations: 2005–2100

		China			India		
		Mean Age at First Marriage	Never Married at 50 (%)	Remarriage Correction (%)[a]	Mean Age at First Marriage	Never Married at 50 (%)	Remarriage Correction (%)[a]
2005	Male	25.7	3.5	103.1	24.8	1.1	108.0
	Female	23.5	0.2	103.6	19.8	0.6	102.5
Female Dominance, 2050–2100	Male	28.7	Same as in 2005		28.5	Same as in 2005	102.5
	Female	26.5	Same as in 2005		23.5	0.2	102.5
Delayed Male Marriage, 2050–2100	Male	30.7	Same as in 2005		30.5	Same as in 2005	102.5
	Female	26.5	Same as in 2005		23.5	0.2	102.5
Harmonic Mean Model, 2050–2100	Male	Same as in 2005			Same as in 2005		
	Female	Same as in 2005			Same as in 2005		

Note: All intermediary values for 2005–2050 are interpolated.

Sources: Data are derived from 2005 age distributions by marital status (see Appendix B for details).

[a]Remarriage correction = all marriages as proportion of first marriages.

marriage schedules used in the models for the second half of the twenty-first century by increasing the proportion marrying after age 25 (women) and 30 (men). The marriage simulations are limited to unions occurring before the age of 50.

The simulation process starts from the 2005 five-year age distributions by sex and marital status. The number of expected first marriages for men and women in 2005–2010 is calculated from the marriage probabilities and the single population in 2005.[19] The MSI (Figs. 1 and 2) is computed as the sex ratio of these expected first marriages after correction for remarriages. Because of the male preponderance, this ratio is usually above 100, and the final number of simulated first marriages is determined by using one of the marriage models described below. The number of men and women remaining single in 2010 is then computed for each cohort from the projected populations and the simulated numbers of first marriages during 2005–2010 according to each marriage function. With the computed 2010 distributions by age and marital status, the same procedure is then repeated successively until 2100, with specific nuptiality parameters for each five-year interval (Table 4).

This article uses the following marriage models:

1. In the *female dominance (FD) model* (Table 1), the number of simulated marriages is set by the number of expected female marriages. In the case of male surplus, male marriages are uniformly reduced across all age groups to match the available supply of brides. In this model, female nuptiality patterns are also allowed

[19] Age-specific marriage rates have to be adjusted in the FD model in order to achieve the desired age gap between men and women. The specific age distributions of unmarried men and fluctuations in cohort size (especially in China) tend to distort the observed age at first marriage among men.

to change gradually over the period 2005–2050 (rise in age at first marriage in China and India, change of remarriage coefficients in India), but the difference in age at marriage between men and women remains constant throughout.

2. The *delayed male marriage (DMM) model* (Table 2) is a variant of the previous FD model, in which the male age at marriage is made to rise faster than the female age at marriage; the spousal age difference increases by two years in China and India from 2005 to 2050 and remains constant afterward.
3. In the *harmonic mean (HM) model* (Table 2), the simulated number of marriages is the harmonic mean of male and female expected marriages (Keilman 1985). With *M* representing the expected number of male marriages and *F* representing female marriages, the actual number of marriages, μ, is computed as $\mu = (2 \times M \times W) / (M + W)$. The adjustment ratio (simulated number / expected number) is applied to expected marriage rates by age and sex. The adjusted probability of marriage is capped to one in each age group.

Appendix C: Sensitivity Analysis of Female Birth Underreporting

As indicated previously, SRB levels used here are only estimates since data for China and India are not based on exhaustive civil registration sources; my simulation exercise remains therefore potentially sensitive to the quality of the estimates. To assess the sensitivity of the model, I ran a different set of population projections and marriage simulations based on lower SRB levels. I restricted the analysis to China, where SRB is both higher and more likely to be affected by estimation issues than India. In particular, Chinese fertility is notoriously underestimated by recent surveys

Table 5 Marriage squeeze indicators and proportion of unmarried men at age 50 according to a lower SRB estimate, China: 2005–2100

	Rapid Transition		Same With Lower SRB Estimates	
	Marriage Squeeze Indicator	% Single Men at Age 50	Marriage Squeeze Indicator	% Single Men at Age 50
2010	98.6	3.3	98.6	3.3
2020	124.1	3.2	124.4	3.3
2030	159.5	4.1	157.6	4.1
2040	156.6	9.3	151.0	9.3
2050	154.8	14.5	150.8	13.9
2060	143.9	14.6	141.0	13.7
2070	126.8	12.8	125.5	12.1
2080	121.0	9.6	120.0	9.1
2090	115.4	7.2	114.5	6.9
2100	110.4	6.0	110.0	5.8

Notes: Rapid transition of SRB is postulated in both models. Rapid transition results are taken from Table 1. Lower SRB scenario is based on a 5% female excess in underreporting rates (see Appendix C for details).

and censuses, and female births might be more underreported than male births, resulting in exaggerated SRB estimates.

Based on this hypothesis, I postulate here that the real SRB is 113 in 2005, with male and female underreporting rates of 15% and 20%, respectively. This corresponds to an excess of 5% in underreporting rates for female births. Applying this rather high level of selective female underregistration will help to assess the sensitivity of the simulations. All other population and marriage parameters are kept similar to those of the rapid-transition scenario shown in Table 4.

Results in Table 5 demonstrate that a lower SRB contributes to reducing the male excess in the marriage market and to increasing the male probability to marry. However, the overall impact of lower SRB (113 in 2005) seems barely visible before the 2040s and remains modest thereafter. For instance, the MSI diminishes from 157 in 2040 to 151 according to the lower SRB scenario. The difference between the two series almost disappears after 2060. The estimated proportion of unmarried men at 50 also rises more slowly during 2050–2080 with these parameters, but the difference with the standard SRB scenario never exceeds 1%. This sensitivity analysis suggests therefore that SRB overestimation may exert but a minor effect on the simulation results.

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