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Surplus Chinese Men: Demographic Determinants of the Sex Ratio at Marriageable Ages in China

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Introduction

Since 1979, the Chinese government through its one-child policy has limited the number of children most citizens can have. This policy slowed the growth of China's population but resulted in many unintended consequences. One such consequence is an unbalanced sex ratio at birth, with many more boys born in each generation than girls. China recently announced that the National Population and Family Planning Commission would maintain its one-child policy (*Xinhua News* 2013), despite criticism by some experts who maintain that the policy is unnecessary and contributes to population aging and unbalanced sex ratios (*The Economist* 2013). Regardless, our projections show that any change in policy, even if enacted immediately, would come too late to ameliorate the problems caused by China's unbalanced sex ratio at birth. The children born immediately after the initiation of the one-child policy are now reaching marriageable ages and inheriting the consequences of the skewed sex ratio at birth. Poston and Glover (2005) estimated that in 2020 23.5 million single men in China would be looking for women to marry. In this article we explore the relationship between demographic factors and China's unbalanced sex ratio at marriageable ages and ask what population policies could most effectively address the problem in the future. What demographic changes would result in the largest decrease in the sex ratio at marriageable ages? How long will the effects of the unbalanced sex ratio persist in China? Could new family planning or marriage policies reverse or lessen this problem?

To answer these questions, we first develop a stable population model of the sex ratio at marriageable ages. We develop formulas to show how altering the sex ratio at birth, population growth, and the age gap between marriage partners would influence the sex ratio at marriageable ages in a stable population. These formulas can be used to gauge the long-run effects that future policies would have on an existing population. Second, we compare population projections with alternative underlying assumptions about the sex ratio at birth, population growth, and the age gap at marriage. Although many researchers have studied the projected number of men in excess of women in China's marriage market, we extend this research by modeling the number of men unlikely to marry given simulated marriage market conditions. This provides a more realistic assessment of the scope of the problem for China in the near future. Sex ratio at birth in China China's sex ratio at birth (SRB) has been unbalanced since around 1980. A sex ratio of about 105 males per 100 females at birth is considered biologically normal. Males tend to have higher mortality than females during younger ages, resulting in a sex ratio of approximately 1.00 by marriageable age (Rowland 2003). Since 1980, China's SRB exceeded 1.07 and peaked around 1.21 in 2000–05 before trending downward to about 1.13 by 2012. Poston and Glover (2005) forecast that China's unbalanced SRB would continue at least until 2020 if not beyond.

China began experimenting with fertility policy almost 30 years before it introduced the one-child policy (Tien et al. 1992), motivated by concern that economic growth would be negated by unconstrained population growth. Interrupted during the period of Maoist radicalism, the birth control campaign was reenergized in the 1970s under the slogan *wan, xi, shao* (“later, longer, fewer”) and was specifically targeted at rural areas. From 1971 to 1979 the total fertility rate (TFR) fell from almost 6 children per woman to only 2 (ibid.). Despite this steep fertility decline, by 1979 the Chinese government became convinced that more extreme measures would have to be taken to curtail population growth (Greenhalgh 1990). The one-child policy resulted in a further drop in fertility. Since the early years the policy has been relaxed for some groups, including ethnic minorities and some families in rural areas. Notably, the city of Yicheng in Hubei province was exempted from the one-child policy in 1985 and has biologically normal sex ratios at birth in addition to low fertility rates (Das Gupta, Ebenstein, and Sharygin 2010). In 2013, the National People’s Congress of China announced that the National Population and Family Planning Commission would be merged with the existing Ministry of Health. However, Chinese official Wang Feng was quick to clarify that there would be no other changes in the one-child policy (*Xinhua News* 2013). Regardless, experts on China speculated that scrutiny of the one-child policy is increasing and that this restructuring may precede elimination of the policy altogether (*The Economist* 2013). Researchers attribute China’s unbalanced sex ratio at birth to three factors: rapidly falling fertility, a preference for sons, and technology revealing the sex of the fetus (Gu and Xu 1994). The government policy limiting most couples to one child and a strong preference for sons appear to have driven the large sex imbalance at birth. The Chinese prefer sons to daughters for several reasons: to carry on a family name, to provide support for aging parents, and to assist parents in household production (Bhattacharjya et al. 2008; Gu and Roy 1995; Kim 1997; Park and Cho 1995; Poston et al. 1997).

Before China underwent its rapid fertility decline in the early 1970s, the birth rate was very high and the chance of a family having at least one son was correspondingly high (Pison 2004). When a woman has six children, the probability that at least one of them will be male is greater than 98 percent. In 1984, the Chinese government eased the one-child policy for rural couples, allowing them to have two children. In a sense, this relaxation of policy institutionalized a cultural value of son preference. Greenhalgh and Li (1995, pp. 626–627) noted that “son preference moved from being a peasant value (deeply embedded, of course, in social institutions) to becoming a component of informal reproductive policy in the villages, to being incorporated into the formal population policy of the province.” The preference for sons drives the imbalance in sex ratios at birth (Poston 2001) and is maintained by practices such as sex-selective abortion. China has banned this practice since 1994 (Shang, Li, and Feldman 2010). Although the degree to which sex-selective abortions are practiced is debated (Eberstadt 2000; Chu 2001; Banister 2002), scholars agree that it probably occurs in China as well as many other East Asian countries with a son preference (Hull 1990; Johansson and Nygren 1991; Chu 2001; Banister 2002).

Sex ratio at marriageable age in a stable population

China’s unbalanced sex ratio at birth leads to an unbalanced sex ratio at marriageable ages and to unmarried men at older ages. While sex imbalances at birth remain with cohorts as they age, several other demographic factors influence the sex ratio at marriageable age and may therefore reduce or, in some circumstances, exacerbate the influence of an unbalanced sex ratio at birth. This is evident in stable population models. In a stable population growing at rate r where men aged x at time t ($PM(t, x)$) marry women at age y ($PF(t, y)$), the sex ratio at marriageable age (SRM) at time t is:

$$SRM = P M(t, x) / P F(t, y). \quad (1)$$

In turn, the population aged x is the product of the number of births x years earlier, $B(t-x) = B(t)e^{-rx}$, and the probability of survival to age x , $l(x)$. Thus, for men aged x :

$$P M(t, x) = B M(t) e^{-rx} l M(x)$$

and for women aged y :

$$P F(t, y) = B F(t) e^{-ry} l F(y).$$

When these expressions are substituted into (1):

$$SRM = SRB e^{r(y-x)} l M(x) / l F(y). \quad (2)$$

Thus the sex ratio at marriageable age is a function of the sex ratio at birth (SRB), population growth (r), the age gap of spouses ($y - x$), and the sex ratio in survival to the age of marriage. We elaborate on each factor below. Specifically, we describe their typical ranges across world populations and their current levels in China. Then, to assess the sensitivity of SRM to each factor, we use (2) to simulate for a stable population how much SRM could change given an adjustment in each of the factors across their normally observed ranges.

The *sex ratio at birth* (SRB) lies in the range from about 1.04 to 1.06 in the absence of deliberate sex selection, but currently ranges from 1.01 (Lichtenstein) to 1.13 (China) among countries today (CIA 2011). It exceeds 1.10 in Albania, Armenia, Azerbaijan, China, Georgia, India, and Pakistan, all places with strong son preference. The SRB is closely associated with the SRM when the growth rate, age gap between marriage partners, and mortality ratio are held constant at their current levels in China. From (2), under these assumptions, an increase in SRB from normal levels (1.05) to current Chinese levels (1.13) is associated with an increase in SRM from 1.04 to 1.12, or 8 more single men per 100 women at marriageable ages.

The *population growth rate* (r) affects the sex ratio at marriageable age because it shapes age structure. Population growth rates vary considerably across world regions from a low of -0.2 percent per year in Eastern Europe to a high of 2.7 percent in Eastern Africa. The rate is currently 0.5 percent in China. China's population is projected to peak and start to decline in the near future because of its below-replacement fertility rate. The Population Reference Bureau (2012) projects that China's annual population growth rate will drop to -0.3 percent between 2025 and 2050.

In growing populations, younger cohorts are generally larger than older cohorts. Since men tend to marry younger women, a youthful age structure helps to offset the effects of an unbalanced SRB. That is, if there were excess men because of a high SRB, men may still be able to find spouses among the larger cohorts of younger women. In shrinking populations, younger cohorts are smaller than older cohorts, which compounds the problem of an unbalanced SRB. In a stable population where the age gap between spouses is 2 years and the SRB and mortality gap are set at current Chinese levels, an increase in population growth from the lowest level observed (-0.2 percent) to the highest (2.7 percent) is

associated with a .07 decrease in SRM (from 1.14 to 1.07). If we consider a narrower range of population growth rates that could be realistically expected for China, a decline from the current rate (0.5 percent) to the projected rate (−0.3 percent) is associated with a .02 increase in SRM (from 1.12 to 1.14). This suggests that, if Chinese men continue to marry younger women, the projected population decline and shifting age structure are likely to exacerbate the problem of marriage for Chinese men.

The *age gap* ($y - x$) between spouses also influences the SRM. The spousal age gap varies considerably across countries and contexts. Casterline, Williams, and McDonald (1986) analyzed the age difference between spouses across 28 developing countries in the 1970s and 1980s, and found median gaps as high as 9.8 years in Mauritania and 9.7 years in Nigeria, and gaps as low as 3 years in Costa Rica and Mexico, and 2.5 years in the Philippines.

In China, the age gap in marriage partners is even lower. In 2000, the UN estimated that the mean age at first marriage was 25.1 for men and 23.3 for women, or an average gap of 1.8 years. China's age gap at marriage has varied historically from slightly more than 3 years to around 1.8 years, independent of age at first marriage (Ebenstein and Sharygin 2009). In growing stable populations (with a young age structure), an unbalanced SRB may be offset if men marry women from much younger and larger cohorts than themselves, and this effect would increase the greater the age gap. The opposite is true in declining populations. Comparing across the normally observed range, an increase in the age gap from 2 to 10 years (husband's age minus wife's age) would result in a decline of .04 in the SRM in a growing population ($r = 0.5$ percent), and an increase of .05 in the SRM in a shrinking population ($r = -0.5$ percent). The age gap is unlikely to change to this extent in China, but if we consider a more realistic change from 2 to 4 years, the SRM would decrease by .01 in a growing population and increase by .01 in a declining population. If Chinese men began to marry women who were about the same age as themselves, this would increase the SRM by .01 in a growing population and decrease it by .01 in a declining population.

Finally, the *sex ratio in survival* ($l M(x)/l F(y)$) influences the SRM. Mortality tends to be higher for men than women. A report issued by the World Health Organization produced life tables for 191 countries (Lopez et al. 2001). We calculated the ratio of survival to age 25 for men versus women for each country. The average ratio across countries was .99, meaning that men's probability of survival is 1 percent less than women's. Thus, an uneven sex ratio at birth could possibly even out by young adulthood as a result of differential mortality. This effect is larger the later men marry and the wider the age gap between spouses.

The male-to-female ratio in survival to age 25 varies considerably, ranging from .95 in Sierra Leone to 1.07 in Botswana (ibid.), and is 1.00 in China. This means that in China, an unbalanced SRB is not offset by sex differentials in mortality. Roughly 94 percent of Chinese men and women survive to age 25, so further reductions in mortality in China are theoretically possible. If mortality declined faster for women, this could help offset the uneven SRB.

As the mortality gap between men and women shifts from the lowest (.95) to the highest (1.07) ratios observed in the world, the SRM for a stable population, with current Chinese values for the SRB, growth rate, and age gap, increases by .14 (from 1.06 to 1.20). If we consider a range that is more realistic for China, from the current ratio (1.00) to the ratio if female survival increased to the highest in the world while male survival remained constant (.95), the SRM would decrease by .06 (from 1.12 to 1.06). In sum, four demographic factors have the potential to alter the SRM.

When comparing across normally observed ranges, SRB, population growth, the age gap between spouses, and the sex ratio in survival could change SRM by as much as .08, .07, .05, and .14, respectively. If China conformed to the assumptions of the stable population model, SRM could decrease as much as .08 by reducing the SRB to normal levels, increase by .02 as a result of projected declines in population growth, decrease by .01 if men married women of the same age, and decrease by .06 if survival improved for females but not males. Of course, China's population is not stable; its fertility and mortality levels have fluctuated widely over the past several decades and its uneven age structure reflects its history. An uneven age structure can be especially problematic for men if they tend to marry younger women and if their birth cohort is larger than the cohorts born just after them, as was the case for Chinese men who were 15–19 in 2010 and who will be entering the marriage market between 2020 and 2030. In the remainder of the article, we consider whether and when these types of changes are likely to influence SRM for China given the country's current age structure and its recent history of an unbalanced SRB.

Three policy direction

While researchers agree that the sex imbalance is a problem, few address ways in which China could devise policies to address it. We produce several alternative population projections for China in which we test the effect of the three possible interventions identified in our stable population equation. These include policies that target (1) the sex ratio at birth, (2) population growth through increased fertility, and (3) the age gap between marriage partners. We do not simulate the effects of policy directions to influence migration.¹ One possible policy direction is to publicize campaigns to normalize the sex ratio at birth. The government could do this indirectly through efforts to raise the status of women in Chinese society. Additionally (or alternatively), it could adopt more punitive measures for women seeking sex-selective abortions. Finally, it could also offer incentives for couples to have female children, similar to the existing Care for Girls program (Shang, Li, and Feldman 2010).

Another policy direction is to relax fertility restrictions, a policy option apparently now strengthening. Women in China report they would prefer to have two children, a boy and a girl (Riley 2004). As this preference is accommodated by relaxing the one-child policy, it could lead to a more balanced sex ratio both at birth and at marriage. In particular, if women were allowed to have more children, they may be less likely to seek sex-selective abortions. (The example of Yicheng, mentioned earlier, offers support for that expectation.) This would have the additional effect of increasing population growth, which can reduce the SRM through modifications in age structure.

A third possible policy direction is to encourage men to marry same-aged or older women. China's population is projected to decline in the coming decades, and younger cohorts will be smaller than older cohorts. As demonstrated above for stable populations, an unbalanced

¹Recruiting foreign women to immigrate to China is unlikely to alleviate the sex ratio imbalance, for three reasons. First, other countries in East Asia are experiencing a similar excess of males in their population. Vietnam and India, which together contribute almost half of China's migrants (Connor and Tucker 2011), have sex ratios at birth of 1.12 and 1.10 respectively (CIA 2011). South Korea, another migrant-sending country, has only recently recorded a decline in the sex ratio at birth. Importing women from these populations into the Chinese marriage market would only create more problems in their country of origin. Second, the men most likely to remain unmarried are the *guanggun* ("bare sticks") (Hudson and den Boer 2004; Das Gupta, Ebenstein, and Sharygin 2010; Greenhalgh 2012), who are poor and reside in rural areas. These men are the least likely to be able to attract foreign women for marriage (Eberstadt 2000; Das Gupta, Ebenstein, and Sharygin 2010). Finally, the sheer number of bachelors in China's population makes international migration an unlikely solution (Das Gupta, Ebenstein, and Sharygin 2010). Internal migration is an option, but research by the World Bank indicates that migration, whether internal or international, is a solution only for the most privileged and wealthiest Chinese men (ibid.). Future research might assess the degree to which variations in the sex ratio at birth across China's provinces produce variations in marriage inequality, and the degree to which internal migration might even out marriage markets.

SRM would become closer to 1.00 if men married older women. While it would be far fetched to imagine the Chinese government would become involved in match making, it could increase the legal age of marriage for women. A current law prohibits women from marrying until they are 20 years old, although illegal marriages are not uncommon, especially in rural areas (Croll 1994). Additionally, research shows that the age at first marriage can vary as people adjust to changes in the marriage market (Foster and Kahn 2000; Ebenstein and Sharygin 2009). Thus, marriage age patterns might change by themselves as the marriage squeeze worsens.

Population projections

We used a cohort-component projection method to examine the combined effects of the SRB, the age gap of marriage partners, and fertility rates on the sex ratio and percentage of single Chinese in marriageable ages (focusing on the 25–39 age group) from 2010 to 2060. The cohort-component method begins with a “baseline” population broken down by age and sex. A sex ratio at birth and a set of age-specific fertility, mortality, and migration rates are applied to this population to determine the expected number of births and deaths and the level of migration occurring each year for each age and sex group. To simplify the projection, we assumed a closed population where migration was zero. The population is then projected forward 5 years at a time by adding the expected births, subtracting the expected deaths, and aging the surviving population. We then applied a “marriage algorithm” (described below) to determine the maximum possible number of married men and women for each age group. The resulting population represents the baseline population for the next five-year projection period.

To project the population forward from 2010 to 2060, we repeated these steps ten times. As with all population projections, our projections rest on several assumptions. They are described below.

Baseline population

The Chinese population was estimated to be 1.3 billion in 2010 (US Census Bureau International Database). This was broken down by age, sex, and marital status (married versus not married) using the distribution based on 2010 data.

Fertility

We used the most recently available (2008) adjusted age-specific fertility rates, produced by China’s National Bureau of Statistics. The total fertility rate was 1.47, and the highest fertility rates were for 25–29-year-old women, followed closely by 20–24-year-old women (see Table 1).

Mortality

We assumed that the Chinese population had the same sex and age-specific mortality rates as China in 1999, the latest year for which data were available. This makes the projection insensitive to changes in mortality. In the absence of a widespread lethal epidemic or natural disaster, mortality rates tend not to increase substantially from year to year. Thus, our projection conservatively removes slightly more men from the population than an improved mortality rate. Additionally, we assume the sex- and age-specific mortality rates are the same for married and unmarried individuals. Although mortality rates vary by marital status (Manzoli, Villari, and Boccia 2007), we are unaware of an accurate, up-to-date Chinese life table by marital status. In any case, we do not believe that the results would differ appreciably if we had applied marital-status-specific mortality rates. The chief reason is that we are primarily interested in projecting the number and percentage of single men aged 25–

39, an age group with very low mortality risks. Additionally, women in China are almost universally married by age 40 (99.8 percent; UN 2000), so mortality risks may not vary significantly among them.

Marriage

We elaborated the basic cohort-component method by taking in to account marriage dynamics. At the end of each five-year period, we used a marriage algorithm to determine the maximum expected number of married men and women by age and sex. An alternative approach might have been to model entry into and exit from marital status on the basis of multi-state marital status life tables. We chose the marriage algorithm because we were most interested in obtaining “best-case-scenario” (i.e., minimum) estimates of the number and percentage of single men, rather than the expected number and percentage based on current marital status transition probabilities. In other words, men’s marital status is the key output of our projections, and is therefore not treated as an input. The algorithm uses a set of rules to randomly assign single men to marry eligible single women within a “preferred” age range. Given the low divorce rate in China (UN 2000), marriages are assumed to last until the death of one of the spouses, after which the surviving spouse becomes eligible for marriage again. Because we estimate the maximum number and percentage of married men, the simulation allows as many men as possible to marry, that is, until the pool of eligible single women is depleted. Thus the number and percentage of married men are limited primarily by the number of eligible single women in their preferred age range. The marriage algorithm specifically assumes the following:

1. Everyone becomes eligible for marriage at age 20.
2. The maximum number of women eligible to marry at each age is capped at the observed percentage single in China’s population in 2010. This ensures that the simulation takes into account the fact that a small proportion of women never marry. Once a woman in the simulated population marries, she exits the pool and the number of eligible single women decreases by one.
3. Single men are simulated to marry eligible single women in their preferred age range, which is determined by the assumption about the age gap of marriage partners. For example, if men are assumed to marry women who are on average 2 years younger than themselves, then single men at ages 25–29 would be simulated to marry women at ages 23–27.
4. When a single person dies, the pool of single adults decreases by one.
5. When a married person dies, his or her spouse becomes single. Accordingly, the number of married people decreases by two and the pool of single adults increases by one. For a portion of cases (i.e., the product of the five-year probability of death for the spouses), both spouses are predicted to die in the same five-year period.
6. The marriage algorithm is iterative and operates in the following manner. It first assigns a “preference score,” a random number drawn from a uniform distribution, to each single man. It then selects the person with the highest preference score to get married, assuming there remain eligible single women in his preferred age range. These steps are repeated until all single men are married or the pool of eligible single women is depleted.

The population projection and marriage assignments were conducted in Stata. Details are available from the authors on request.

Results

We present two outcome measures for our projections: the number of single men aged 25–39 and the percent single among men aged 25–39. The first is the number of single men projected to remain unmarried; the second is the fraction of the male population projected to remain unmarried. We ran projections in which we altered our assumptions for the SRB, fertility, and the age gap between marriage partners and compared the results of each with those produced by a steady-state projection in which all inputs were held at their 2010 levels. To test the effects of altering these three demographic inputs, we made two sets of projections, one in which the changes occur instantly and another in which they occur gradually over the 50-year projection period.

Tables 2, 3, and 4 present results of projections that simulate changes in SRB, fertility, and the age gap, respectively, while holding the other two demographic factors at their 2010 levels. Figure 1 illustrates the steady-state projection in a population pyramid. Figures 2 and 3 present projections that simulate, respectively, instantaneous and gradual changes in combinations of the demographic factors.

Steady-state projection

The steady-state numbers are included in all tables and figures to serve as the comparison group. Our steady-state projection suggests that if mortality, fertility, and age patterns in China remained at their current levels, the number of single men would increase sharply from almost 19 million to 30.9 million between 2010 and 2040. The percentage of single men would increase from 11.4 percent in 2010 to 25.5 percent by 2060. In 2060, more than one quarter of men of marriageable age (approximately 24 million) would remain single and be unable to find partners.

SRB

Table 2 shows the results of the two projections that simulate a decline in the SRB from 1.130 to 1.048 instantly (SRB -instant) and at one percent per year over the projection period (SRB -gradual). An instant reduction in the SRB results in fewer single men of marriageable ages, but is not projected to occur until at least 2040. A gradual reduction in the SRB also results in fewer single men; however, we find a substantive difference only in 2060. This is a consequence of the existing sex ratio among the population getting married in the next 30 years. An instant reduction in the SRB would result in a peak in the number of single men at 29 million in 2030 and a steady decrease to 18.5 million in 2060. Additionally, 19.6 percent of men aged 25–39 would be single in 2030, with a peak of just below a quarter of marriageable men single in 2040 (23.3 percent). A gradual decrease in the SRB would also improve the sex imbalance at marriage, though not as quickly as an instant decrease would. The projection simulating gradual change in the SRB differs little from the steady-state model. The results demonstrate that several decades are required for changes in the SRB to alter the SRM. The men who will marry in the next 30 years have already been born in to disadvantaged cohorts. Thus, even if the SRB were reduced to 1.048 immediately, China's population would still face several decades of sex imbalances at marriageable ages.²

²In fact, a gradual decline in SRB actually slightly increases the number of single men in 2020 and the percentage of single men in 2020, 2040, and 2050 relative to the baseline projection. This stems from irregularities of the sizes of birth cohorts and the fact that the simulations assume men marry women from younger birth cohorts. In other words, for some cohorts and time periods, a more unbalanced sex ratio is actually advantageous to men.

Increased fertility

Table 3 shows the results of projections in which the total fertility rate is simulated to increase from 1.47 to 1.60 (Fertility 1) or from 1.47 to 1.80 (Fertility 2) while maintaining 2010 age patterns in fertility. Although population growth is inversely related to the sex ratio at marriageable age in a stable population, in the case of China with its irregular age structure, an increase in fertility would result in a greater number of single men, but all of the fertility simulations project a percentage of single men in 2050 and 2060 similar to that in the steady-state projection. However, China's uneven baseline age structure means that some cohorts would be more advantaged in finding a marriage partner during the middle of the projection period if fertility increased instantly. This is a result of the existing age gap in marriage, where men marry women younger than themselves. As with changes in the SRB, several decades would be required before changes in fertility would affect the sex ratio at marriageable age, largely because the children born as a result of an increase in fertility would not be eligible to marry until much later in the projection period, and any beneficial effect of higher fertility would be highly erratic and short-lived (i.e., confined to 2040) because of the highly irregular age structure of China's population.

This evidence suggests that changes in fertility are unlikely to be effective at alleviating the uneven sex ratio at marriageable age in China in the absence of other policy initiatives. Of course, these simulations do not consider the effects of fertility on the sex ratio at birth. If China relaxed the one-child policy, the proportion of couples who use sex-selective abortion might be reduced as well. Thus, increasing fertility is also likely to decrease the sex ratio at birth. We simulate this interaction below.

Reduced age-gap

Next, we consider whether and how quickly changes in age patterns of marriage could alleviate the marriage squeeze. The results of the age-gap projections are shown in Table 4. In the short run, elimination of an age gap between spouses tends to decrease the sex ratio imbalance at marriageable ages. If men married women their own age instantly (Age gap-instant), this would reduce the number of single men by more than 3 million and the percentage of single men by 1.6 percentage points as early as 2020, compared with the steady-state model. Closer inspection of China's age composition suggests that if reductions in the age gap of marriage partners occurred instantly, the 15–19 male cohort would become more advantaged because they would be projected to marry relatively larger same-aged female cohorts rather than younger and smaller female cohorts. In contrast, other cohorts such as 25–29-year-old men would face a relatively less privileged marriage market, because they would be marrying into the smaller 25–29-year-old female cohort. This demonstrates that changes in the age gap at marriage have the potential to affect the marriage market much more quickly than changes in SRB or fertility. However, the impact depends on the age structure of men and women of marriageable ages.

In the middle of the projection period (2030–40), if men began marrying women of the same age (Age gap -instant), the percentage of single men would range between 13 and 15 percent (compared with a range between 20 and 25 percent in the steady-state model). By the end of the projection period, eliminating the age gap between spouses would reduce the percent of single men by almost half, from 25.5 percent in the steady-state model to about 13 percent in the reduced age gap models. When changes in the age gap were applied gradually over the period, the number and percentage of single men do not differ substantially from the steady-state scenario except in 2060, when they drop to levels projected for the simulation assuming an instant decline in the age gap at marriage.

Combination models

Last, we consider the combined effects of the three simulations. Figure 2 presents the scenarios where the interventions occur instantly and in combination with one another. In the short run (2010), scenarios that reduce the age gap in marriage partners actually increase the percentage of single men. In the longer run (2030 or later) the combined interventions would reduce the percentage of single men more than each intervention alone and the steady-state simulation. However, they have differing effects. Interaction 1 (SRB -instant, Fertility 2 -instant) does not differ from the steady-state projection until 2040, and then levels off around 17percent for the remainder of the projection period. This is because reducing the sex ratio at birth and increasing fertility can only affect future marriage prospects once those cohorts have reached marriageable age.

These scenarios further show that, because of China's negative growth rate and aging population structure, a balanced SRB is not sufficient to balance SRM. The age gap in marriage partners must also change. This is demonstrated by the fact that interactions 3 and 4 show the greatest reduction in the percentage of single men. Both of these interactions include a normal sex ratio at birth and no age gap between spouses.

Interaction 4 also includes an increase in the fertility rate. In these simulations, the percent of single men remains steady around 10 percent after 2040. Nevertheless, in this interaction, the percentage of single men in China is still projected to reach almost 18 percent in 2040 before declining to near-normal levels (about 10 percent in 2050 and 2060). Thus, even with these most optimistic interventions, China still faces a significant proportion of single men in the future.

Figure 3 presents the most likely scenarios that China could face in the future. These simulations include the assumed rise in fertility (to 1.6), a gradual decline in the sex ratio at birth similar to the one South Korea has experienced (Das Gupta, Chung, and Li 2009), and a reduced age gap (men marrying women who are the same age). The figure illustrates how the existing population conditions create an inescapable demographic future for China. The only scenarios that eventually result in a reduction in the percentage of single men are those in which the age gap narrows (Interactions 2, 3, and 4), and this is projected to occur only after 2050. None of the interactions differs more than one percent from the steady-state projection until 2040.

After that, Interaction 1 (SRB -gradual, Fertility 1 -gradual) remains similar to the steady-state projection until 2060. Furthermore, only small difference exist between the interaction of a declining sex ratio at birth and age gap at marriage (Interaction 3: SRB -gradual, Age gap -gradual) and the three-way interaction including a rise in fertility (Interaction 4: SRB -gradual, Fertility 1 -gradual, Age gap -gradual). This demonstrates that even with changes in the demographic components, the only important change to the proportion of single men is likely to come through changes in the age gap at marriage, whether in response to the tightening marriage market or policy.

Discussion

Our cohort-component projection method together with an algorithm to simulate changes in marriage markets projects a large excess of single men in China's population even given policy intervention by the Chinese government. The SRB and age-gap policy interventions had some ameliorating effect on the number of single men, particularly when enacted in combination. In the long run, reductions in the sex ratio at birth alone are surprisingly ineffective at balancing marriage markets. This largely stems from the fact that China's population is aging; unlike growing populations where men benefit from marrying younger

women, in aging populations SRM is more balanced when men marry same-aged women, even when SRB is maintained at a biologically normal level of 1.05. Although reductions in SRB would be helpful if they occurred in combination with reductions in the age gap, such changes would not begin to resolve the problem for several decades. Even in simulations involving instant declines in both SRB and the age gap at marriage, the percentage of single men does not decline to 10 percent until 2050. In the short run, however, narrowing the age gap is the only change that could temporarily mitigate the problem. Overall, these two policies in combination with each other result in the most hopeful future for single Chinese men.

Of the various simulations, the one projecting gradual increases in SRB, gradual increases in TFR to 1.6, and elimination of the age gap between marriage partners (the final scenario in Figure 3) seems the most attainable. First, while we expect fertility to increase, we think that an increase in the TFR to 1.8 is unlikely. China's National Population and Family Planning Commission recently responded to critics of the one-child policy, indicating that it has no intention of repealing it completely (Wong 2012), a point echoed again in its recent press announcements about changes in its organizational structure (*Xinhua News* 2013). Poor families, who cannot afford to pay the fine to have a second child, are sometimes coerced into having abortions. Furthermore, Chinese demographers, such as He Yafu, agree that even abolishing the one-child policy might not increase fertility up to a "healthy" level (ibid.). Second, policies such as the Care for Girls campaign have already reduced the sex ratio at birth from its peak in the mid-2000s (Shang, Li, and Feldman 2010; Li 2007; Das Gupta, Chung, and Li 2009), so a continued steady decline in the sex ratio at birth seems realistic.³ Finally, while the age gap between spouses could have a substantial impact, we are also aware of the strength of cultural norms.

Because marriages between younger women and older men are the norm in most places, including China, the most hopeful adjustment we can anticipate is for men and women of the same age to marry each other. In the most realistic scenario, the number of single men would still peak in 2030 at almost 30 million, and the percentage of single men would reach almost 25 percent. Even under the most drastic scenarios involving both instantaneous declines in SRB and changes in the age gap of marriage partners, the percentage of single men would still reach about 17 percent in 2040 because of China's existing demographic structure, history of son preference, and use of sex-selective abortion. Moreover, it may be difficult for China to develop the specific policies necessary to bring about these changes quickly. What will become of Chinese men who remain single? Scholars such as Poston and Glover (2005) suggested that some men who remain bachelors will turn to commercial sex, resulting in a spread of HIV/AIDS. Similarly, Tucker et al. (2005) speculated that the population of single men could serve as a new transmission path of HIV/AIDS from high-risk to low-risk populations.

South and Trent (2010) reported that men who faced shortages of women in their marriage market were more likely to engage in intercourse with commercial sex workers and contract sexually transmitted infections, including HIV/AIDS. Other research suggests single rural men are more likely to live in poverty and are least likely to be able to save for retirement.

³The Care for Girls model, designed to reduce infant and child mortality, particularly among girls, can contribute to alleviating the sex imbalances. Our stable population models showed that a significant portion of the imbalance at marriageable ages is a result of equal levels of mortality among Chinese men and women. This is unusual because mortality is higher for males than females in most countries. South Korea's success in decreasing both the sex ratio at birth and female infant mortality has resulted from economic development as well as government intervention aimed at increasing the status of women in society (Chung and Das Gupta 2007). Another possible policy initiative suggested by Bhattacharjya et al. (2008) is a survey of the perceived value of male and female children in China. If variables can be identified that increase the value of female children, such as pension payments to families whose only child is a daughter, these can also be the target of further government interventions.

Controlling for education, province of residence, and minority status, these unmarried men also have lower income and savings (Das Gupta, Ebenstein, and Sharygin 2010). Taken together, this means that these rural men could face the double burden of contracting HIV/AIDS and living alone in poverty (Liu, Li, and Feldman 2012).

Another concern is an increase in crime and warfare in China. Previous publications indicate that men who never marry are more likely to commit crimes (Mazur and Michalek 1998; Horney, Osgood, and Marshall 1995; Sampson and Laub 1990). Therefore, there is the potential for increased levels of criminality in China (Edlund et al. 2010). Research also shows that societies with single men are more prone to “banditry, violence and revolutions” (Hudson and den Boer 2004). Hudson and den Boer also postulate the “diversionary war theory,” in which a government confronting significant domestic problems strikes out at an external enemy.

Our results indicate that, even with substantial changes to population policy, the sex imbalance at marriageable age in China will not be undone in the near future. Our projections show that the most critical policy change China can make is to encourage changes in cultural norms of older men marrying younger women, and, to a lesser extent, encourage a balanced sex ratio. Unlike our scenarios, in which the age gap at marriage and sex ratio at birth changed in a five-year period, these changes will likely take many years. Chinese women already report they would prefer two children instead of one, so increasing fertility rates would probably not be difficult (Riley 2004) if the government were to relax the one-child policy, a prospect that seems more likely given the recent restructuring of the National Population and Family Planning Commission. Relaxation of the one-child policy could reduce pressure on families to seek sex-selection technologies. But to make longer-lasting change, China needs to continue to raise the status of women. This includes an emphasis on the importance and value of female infants as well as more equitable conditions for adult women. All of these policy options notwithstanding, the presence of large numbers of single men is China’s demographic destiny and will be a part of China’s social, political, and economic future until 2060 if not longer.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Steady State Projection of China's Population, 2010 – 2060

Figure 2.
Projected Effects of Instant Interactions in the Sex Ratio at Birth (SRB), Fertility and Age Gap on the Percentage of Single Males Ages 25–39

Figure 3.
Projected Effects of Gradual Interactions in the Sex Ratio at Birth (SRB), Fertility and Age Gap on the Percentage of Single Males Ages 25–39

Table 1

Age-Specific Fertility Rates in China

	2008
15–19	0.005
20–24	0.095
25–29	0.101
30–34	0.054
35–39	0.022
40–44	0.010
45–49	0.007
TFR	1.47

Source: China's National Bureau of Statistics

Table 2

Projected Effects of Changes in the Sex Ratio at Birth (SRB) on the Number and Percentage of Single Males Ages 25–39

	2010	2020	2030	2040	2050	2060
Single Males Aged 25–39 (thousands)						
Steady State: SRB = 1.16	18,990	18,200	29,520	30,870	28,970	24,050
SRB - Instant	18,990	17,800	29,070	28,500	21,940	18,510
SRB - Gradual	18,990	18,340	29,190	30,590	28,730	22,370
Percentage of single males ages 25–39						
Steady State: SRB = 1.16	11.4	10.6	19.7	25.2	25.1	25.5
SRB - Instant	11.4	10.9	19.6	23.3	20.5	19.5
SRB - Gradual	11.4	11.0	19.6	25.5	25.6	24.4

Table 3

Projected Effects of Changes in Fertility on the Number and Percentage of Single Males Ages 25–39

	2010	2020	2030	2040	2050	2060
Single Males Aged 25–39 (thousands)						
Steady State: Fertility = 1.47	18,990	18,200	29,520	30,870	28,970	24,050
Fertility 1 - Instant	18,990	17,960	29,640	31,260	37,100	30,570
Fertility 2 - Instant	18,990	18,050	29,460	31,590	41,720	34,780
Fertility 1 - Gradual	18,990	17,870	29,060	30,520	30,700	27,320
Fertility 2 - Gradual	18,990	18,010	29,280	30,890	32,960	29,690
Percentage of single males ages 25–39						
Steady State: Fertility = 1.47	11.4	10.6	19.7	25.2	25.1	25.5
Fertility 1 - Instant	11.4	11.1	19.7	24.7	26.5	24.6
Fertility 2 - Instant	11.4	10.7	19.8	23.2	24.5	23.8
Fertility 1 - Gradual	11.4	11.0	19.6	25.4	25.6	25.4
Fertility 2 - Gradual	11.4	11.0	19.7	24.6	25.6	25.0

Table 4

Projected Effects of Changes in the Age Gap on the Number and Percentage of Single Males Ages 25–39

	2010	2020	2030	2040	2050	2060
Single Males Aged 25–39 (thousands)						
Steady State: Age Gap = -2	18,990	18,200	29,520	30,870	28,970	24,050
Age Gap 1 - Instant	18,990	14,970	19,980	18,520	14,780	12,240
Age Gap 1 - Gradual	18,990	17,900	29,870	27,790	28,860	12,240
Percentage of single males ages 25–39						
Steady State: Age Gap = -2	11.4	10.6	19.7	25.2	25.1	25.5
Age Gap 1 - Instant	11.4	9.0	13.3	15.4	13.0	12.9
Age Gap 1 - Gradual	11.4	10.8	19.7	24.2	25.4	12.9