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## A note on marriage market clearing<sup>☆</sup>

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### ABSTRACT

We provide a formula for marriage sex ratios based on birth sex ratios and dynamic factors like the marriage age gap and gender-specific mortality. We show that ignoring dynamic considerations can lead to faulty conclusions about scarcity in marriage markets.

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### 1. Introduction

The ratio of men and women at marriage age, or the *marriage sex ratio*, is a useful measure of scarcity in the marriage market. It has long been recognized that the marriage sex ratio is not necessarily equal to the sex ratio at birth or the population sex ratio, and empirical measures of marriage sex ratios have been constructed for different marriage markets (Akers, 1967; Schoen, 1983; Angrist, 2002). However, constrained by data availability, many empirical papers use the population sex ratio as a proxy for marriage market conditions (Chun and Lee, 2001; Gould and Paserman, 2003). Moreover, even the most careful measurement cannot take into account that the marriage age may adjust in response to marriage market conditions. Similarly, the current birth sex ratio is often used to predict future marriage market

imbalances (Ullman and Fidell, 1989; Park, 1995; Junhong, 2001). Finally, theoretical models often construct marriage sex ratios based on simplifying assumptions like a birth sex ratio that equals one (Anderson, 2007) or a matching technology where only agents of the same age meet (Aiyagari et al., 2000; Caucutt et al., 2002).

We demonstrate that such simplifications may have misleading implications. We suggest a simple correction that constructs the expected sex ratio at marriage using a limited number of dynamic factors. We show that this formula is a much better predictor of the marriage sex ratio than the sex ratio at birth or the population sex ratio. We therefore believe that our simple correction formula will be useful for both theory and measurement.

Our point of departure is the standard, static, marriage market clearing condition used in Becker's seminal work on marriage.<sup>1</sup>

$$n(1-s_m)M = (1-s_w)W. \quad (1)$$

Here  $M$  and  $W$  denote the number of men and women and  $s_m$  and  $s_w$  the fraction of each who never marry. Allowing for polygamy,  $n$  is the number of wives per man.

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<sup>1</sup> See Becker (1973, p.837) and Becker (1993, p.83). See also Bergstrom (1996).

1.1. Two puzzles

1.1.1. Polygyny

Does widespread polygyny ( $n > 1$ ) imply that a large fraction of men never marry? In Senegal, about 40% of married men have more than one wife (Bankole and Singh, 1998). The average number of wives per husband is 1.5. There are 1.03 women for every man. In 1997, 99.9% of women in Senegal had been married by age 49.<sup>2</sup> Setting  $\frac{W}{M} = 1.03$ , Eq. (1) would imply that 31.2% of Senegalese men never marry. This is not true; data shows that only 1.9% never marry. What explains this discrepancy?

1.1.2. Dowries and shortage of women

In India, women often pay a large dowry at marriage. Dowries concern scientists and the media because they are seen as the cause for female infanticide and selective abortions (Croll, 2000). Economic logic suggests that scarcity of husbands drives women to compete for men, which leads to the existence of dowries. However, men are not scarce in India. For every 100 men, there are currently only 95 women in the overall population. Even taking gender differences in marriage rates into account (98.4% of men and 99.2% of women marry), there are only 95.7 women per 100 men. It seems puzzling that dowries exist despite the scarcity of women.

2. Dynamic marriage market accounting

Eq. (1) is clearly at odds with the data. We argue that it is crucial to take several dynamic considerations into account. A key observation is that men typically marry younger women.<sup>3</sup> The mean age at first marriage in Senegal is 20 for women and 29 for men, giving an average age gap of 9 years for first marriages. The spousal age gap varies widely across countries and is important because it can adjust to clear the market (Foster and Khan, 2000; Edlund, 1999). For example, Tertilt (2005) shows that a large fraction of men can be polygynous despite a balanced sex ratio as long as men marry substantially younger wives and the population grows fast.

A second important factor is gender variation in mortality. Mortality is typically higher for men, which means that the ratio of men to women at marriage age is smaller than at birth. This effect is larger the later men marry and the larger the age gap. On the other hand, gender differences in the impact of disease may lead to higher adult mortality rates for women. Anderson and Ray (2008) show that this has led to a large number of missing women in India, China, and sub-Saharan Africa.

We now modify Eq. (1) to allow for dynamic concerns: spousal age gaps, gender-specific mortality, and population growth. We construct a marriage market clearing condition for a cohort of men born at time  $t$ . Assume that all men in this cohort who marry do so at age  $k$ . A fraction  $s_m$  of men never marry. Let  $M_t^k$  be the number of men born at time  $t$  and alive at time  $t+k$  (i.e. the number of men of age  $k$  in year  $t+k$ ). Assuming a constant age gap,  $g$ , they marry women born at time  $t+g$ ,  $s_w$  of whom never marry. If each man takes  $n$  wives, the marriage market clearing condition for cohort  $t$  men is  $n(1-s_m)M_t^k = (1-s_w)W_{t+g}^{k-g}$ . The left hand side is demand for brides and the right hand side the supply. This equation highlights the importance of the marriage sex ratio,  $W_{t+g}^{k-g}/M_t^k$ .

Note that our formulation abstracts from divorce and remarriage. As long as divorcees remarry among themselves this is an innocuous assumption. However, if remarriage differs by gender, then our formulation needs to be modified. We focus on the simpler case because of the lack of data on remarriage.

Next, suppose that the annual mortality rate for men is  $\pi_m$ . If  $M_t^0$  men are born in period  $t$ , then  $(1-\pi_m)^k M_t^0$  will survive to age  $k$ , the age at which they marry. They will be matched with women of cohort  $t+g$ . Assuming a constant population growth rate,  $\gamma$ , the number of women

**Table 1**  
Marriage statistics for women (W) and men (M)

Data	Senegal	India	China	Source
Overall sex ratio (W/M)	1.0331	0.9506	0.9470	United Nations (2005)
Sex ratio at birth (W/M)	0.9709	0.9524	0.9091	United Nations (2005)
Population growth rate (%)	2.37	1.43	0.60	The World Bank (2006)
Age at first marriage (M)	29	24.9	25.1	United Nations (1997, 2003)
Age at first marriage (W)	20	19.9	23.3	United Nations (1997, 2003)
Wives per married man	1.50	1.05 <sup>a</sup>	1.00	United Nations (1990)
Marriage rate (M)	0.981	0.984	0.960	United Nations (1990)
Marriage rate (W)	0.999	0.992	0.998	United Nations (2003)
Annual survival rate <sup>b</sup> (M)	0.9903	0.9936	0.9961	The World Bank (2006)
Annual survival rate (W)	0.9920	0.9953	0.9974	The World Bank (2006)

<sup>a</sup> 5% of Hindus in India are in polygynous unions. Assuming they have 2 wives leads to  $n = 1.05$ . The numbers are slightly higher for other religions.

<sup>b</sup> All annual survival probabilities are calculated using only adult mortality and are hence an approximation. While infant mortality rates are available by sex, we are not aware of any data source for the mortality of 5–15 year olds by sex.

in cohort  $t+g$  is  $(1+\gamma)^g W_t^0$ . Taking female mortality into account, the number of brides available to cohort  $t$  men is  $(1-\pi_w)^{k-g} (1+\gamma)^g W_t^0$ . Therefore, the marriage market clearing condition for cohort  $t$  can be written as:

$$n(1-s_m)(1-\pi_m)^k M_t^0 = (1-s_w)(1-\pi_w)^{k-g} (1+\gamma)^g W_t^0. \tag{2}$$

If  $g=0$  and  $\pi_w = \pi_m$ , Eq. (2) reduces to Eq. (1).<sup>4</sup> However, if age gaps or mortality differences are large, then Eq. (1) will have misleading implications. It should also be emphasized that Eq. (2) describes a market clearing condition rather than a full behavioral model of the marriage market. Any behavioral model of the marriage market will include some version of this equation.

The age gap that ensures marriage market clearing (given marriage, population growth, and mortality rates) can be derived from Eq. (2):

$$g = \frac{\ln \left( n \left( \frac{1-s_m}{1-s_w} \right) \left( \frac{1-\pi_m}{1-\pi_w} \right)^k \frac{M_t^0}{W_t^0} \right)}{\ln \left( \frac{1+\gamma}{1-\pi_w} \right)}. \tag{3}$$

Finally, the marriage sex ratio can be expressed as a function of the sex ratio at birth, gender differences in mortality, the population growth rate, and the age gap:

$$\frac{W_{t+g}^{k-g}}{M_t^k} = (1+\gamma)^g \frac{(1-\pi_w)^{k-g} W_t^0}{(1-\pi_m)^k M_t^0}. \tag{4}$$

Note that population growth is particularly important if the age gap is large.

2.1. Puzzles reconsidered

Table 1 reports the data needed to compute both demand and supply of brides as defined by Eq. (2), which, in theory, should be equal. This will not be exactly true because an economy may not be in a steady state with constant  $g$ ,  $k$  and  $\gamma$ .<sup>5</sup> We find, however, that the dynamic formulation (Eq. (2)) does much better than Eq. (1), which illustrates the general point that dynamic considerations are important.

2.1.1. Senegal

The static condition (Eq. (1)) implies that only 69% of Senegalese men marry (or 65%, if we use the sex ratio at birth). Eq. (2), on the

<sup>4</sup> Alternatively, if  $g > 0$ , Eq. (2) reduces to Eq. (1) as long as  $\gamma = \pi_w = \pi_m = 0$ .

<sup>5</sup> The steady state assumption would not be necessary if one had cohort-specific information on mortality, marriage age, etc. Due to lack of data, we focus on the latest year for which data is available and assume that the economies are in a steady state.

<sup>2</sup> We assume that not being married by age 49 is a good proxy for never marrying.  
<sup>3</sup> Bergstrom and Bagnoli (1993) analyze why women tend to marry older men.

other hand, implies that 90% of men marry, which is much closer to the data. About two-thirds of the difference is due to population growth, which together with a nine-year age gap allows an additional 16% of men to find a wife. Another third is due to the fact that, by the time they reach the average marriage age of 29, some men will have died (many more so than their 20-year-old brides), which allows an additional 9% of the surviving men to marry.

Note also that the age at first marriage is the wrong measure for computing the average age gap in a polygynous society. Bankole and Singh (1998) compute the median age difference between a husband and all his wives for a sample of 789 Senegalese couples and find a gap of 12.2 years. This number is on the high side as it would imply that 99.8% men get married. Using Eq. (3), we find an implied market clearing age gap of 11.7 years, which lies between the two reported gaps of 9 and 12.2 years.

### 2.1.2. India

Taking dynamics into account, we find that women are in fact not scarce in the Indian marriage market. While the sex ratio at birth is only 95 women per 100 men, using Eq. (4) we find that the marriage sex ratio is 109 women per 100 men. The discrepancy is due in equal part to high population growth rates and significant mortality rates, each interacting with a large age gap. On average men marry women who are 5 years younger, which together with the annual population growth rate of 1.43% “adds” seven women per 100 men at the time of marriage. Mortality further increases the number of available women because men marry later and hence more of them die before marriage. This too “adds” seven women per 100 men. Together, these two channels lead to a marriage sex ratio of 1.09, in other words, a bride surplus of about 9%. Seen in this light, the existence of dowries is no longer surprising.<sup>6</sup>

### 2.1.3. China

Another interesting example is the case of China, where a one-child policy and a preference for boys has led to widespread sex-selective abortions. The current sex ratio at birth is about 110 boys for every 100 girls. Researchers report that families in China “anticipate the shortage of marriageable women” (Junhong, 2001) and estimate 30 million “surplus males” by 2020 (Hudson and Boer, 2002). Will the skewed sex ratio necessarily lead to a large number of “eternal bachelors” in China?

While the sex ratio at birth is only 90 women per 100 men in China (Table 1), the marriage sex ratio, calculated using Eq. (4), is much higher: 95 women per 100 men. Most of the difference is due to the mortality correction, which “adds” four potential brides by the time the average man wants to marry. One additional bride is due to population growth. Together, these two channels lead to a marriage sex ratio of 0.954, leaving only 4.6% of Chinese men without wives, which is a mere 0.6 percentage points higher than the current percentage of single men. Moreover, men not able to find wives may choose to marry younger women. Using Eq. (3) we find that the necessary age gap to sustain current marriage rates is about 3 years. Hence, as long as the age gap increases, there will be no “surplus males” in China. While unequal birth rates may be a concern in themselves, they do not necessarily imply large numbers of unmarried males.

## 3. Conclusion

The examples in this paper illustrate that ignoring dynamic considerations can lead to naive predictions about the marriage

market. In particular, they demonstrate that static population or birth sex ratios are overly simplistic measures of supply and demand in the marriage market. We construct a simple, dynamic derivation of the marriage sex ratio that can resolve several puzzles.

Our formulation assumes that people are identical and that the marriage market is in a steady state with constant age gaps and population growth rates. It also abstracts from divorce and remarriage. While it is possible to include more complex marriage patterns and to allow for transitional dynamics, the examples above show that these are of secondary importance.

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<sup>6</sup> Rao (1993) informally suggests that an increase in the population growth rate combined with the marriage age gap caused an increase in dowries in India. Anderson (2007) demonstrates that, on the contrary, these forces would cause dowries to decrease. An alternative explanation for dowry in India, put forward by Anderson (2003), is gender-specific restrictions on inter-caste marriage, which leads to a relative scarcity of marriageable men.