Are China's "Leftover Women" really leftover?: An investigation of marriage market penalties in modern-day China

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Abstract

In the U.S., college-educated women, despite their tendency to delay marriage, have ultimately been marrying at the same or even greater rates than their less-educated female counterparts since the mid-1970s. In contrast, a recent trend in Korea, Japan, Taiwan, and Singapore sees college-graduate women marrying not only later, but also at a lower rate. This latter phenomenon has garnered so much attention that, in 2007, the Chinese Central Government set overcoming China's domestic "leftover women trap" as one of its primary goals to "upgrade population quality (suzhi)." Focussing on urban women, however, this paper finds that marital outcomes for highly educated Chinese women are in fact closer to US than to East Asian pattern: highly educated women delay marriage but do not ultimately marry at lower rates relative to their less-educated female counterparts in recent years. Using a classic Choo-Siow estimator of marital gains, we find that average marriage gains fell continuously over the period 1990 and 2009 for both men and women, and that marital gains to education have also fallen. However, the penalty to delaying marriage for has decreased over time and education beyond high school still raises the average return a woman can expect to receive from marriage in all years. Using a recently developed dynamic estimator of marriage gains (Choo (2016)), we can also extend our analysis to explore the likely evolution of marriage rates in coming years as the gender ratio continues to evolve in favor of women.

1 Introduction

From the Chinese Central Government's recent announcements and media publications, China's current marriage market has two ostensibly simultaneous problems: a "leftover men crisis" and a "leftover women trap." With both men and women being "leftover" at the same time, China's current marriage market situation constitutes an economic puzzle of sorts.

China's "leftover men crisis" is a relatively straight-forward mechanical problem. China's one-child policy (enforced from 1979 to 2015 for easier family planning), coupled with a long-standing preference for sons, has lead China to have one of the most skewed birth gender ratios in the world (Loh and Remick, 2015). Despite having prohibited gender-based abortion since 1995, China's age 1-4 infant gender ratio is approximately 123 (infant boys for every 100 infant girls) at the national level — a figure that rises to greater than 130 in various provinces as of January, 2010, according to the US Congressional-Executive Commission on China. This gender imbalance is so severe that the Chinese Academy of Social Sciences predicts that 1 in every 5 men will not be able to find a wife in China by 2020, and that China will have 30-40 million boys under the age of 20 *in excess* of girls. At the same time, the Government of China is concerned that a portion of (already scarce) Chinese women are increasingly remaining unmarried. China's Ministry of Education officially defines "leftover women" broadly — as any unmarried woman over the age of 27 — and added the term to the national lexicon in 2007.

In terms of economic significance, while the magnitude of the "leftover men crisis" is acknowledged by the Chinese Central Government in a 2007 edict as a major "threat to social stability", there is minimal recourse available due to the pure dearth of Chinese girls. On the other hand, the Central Government believes that resolving the "leftover women trap" is integral to "upgrading population quality (suzhi)" and announces it as one of its primary goals. The National Bureau of Statistics of China (hereafter, NBS) remarks on both phenomena in its 2012 release of Facts & Figures. Drawing upon the results of its Sixth National Population Census (2010), NBS groups the population of individuals aged 15 and above by educational attainment and calculates the percent unmarried for each group. In particular, NBS contrasts percent unmarried for primary education or less (2.5% for women and 11.1% for men) with that of post-graduate education (49.2% for women and 39.1% for men). From these figures, NBS purports that, "under the influence of the traditional notion that the husband should excel his wife in a marriage, many outstanding women and less advantaged men are having difficulty in finding their spouse." The All-China Women's Federation, appointed by the Chinese Central Government to resolve the "leftover women trap," also advocates the importance of marrying early, arguing: "the tragedy is, women do not realize that, as they age, they are worth less and less. So by the time they get their MA or PhD, they are already old like yellowed pearls," (March, 2011). These official statements suggest two main facets to the government's concern regarding "leftover women": (1) that there may be a "success penalty" disadvantaging high-achieving women in marriage markets where traditional attitudes prevail; and (2) there is an "age penalty" due to the depreciation of reproductive capital over time for women who delay marriage.

Internationally, economists have found conflicting evidence for the existence of a marriage market "success penalty" for women of higher educational attainment. In the United States, for example, this penalty no longer exists as the gap between marriage rates of college-graduate women and their less-educated female counterparts first closed and then reversed since the mid-1970s (Rose (2003), Schwartz and Mare (2005), Stevenson and Wolfers (2007)). This is to say, despite highly educated American women's tendency to delay marriage into their late twenties and thirties, their *ultimate* marriage rate catches up to and eventually overtakes those of women with lower educational attainment. High educated couples also face much lower divorce rates. In striking contrast, many developed East Asian nations have seen *declining* marriage rates for college-educated women in recent years. Kawaguchi and Lee (2012), for example, study the growing prevalence of cross-border marriages in Korea, Japan, Singapore, and Taiwan (and also expect similar circumstances in Hong Kong). As these nations' highly educated women increasingly opt to remain single, Kawaguchi and Lee find that native men are turning to importing brides from less developed Asian nations, such as Vietnam, the Philippines, and China, despite their preference for a native wife. The authors note that although this phenomenon barely existed in the early 1990s, imported brides now comprise 4 to 35 percent of newlywed marriages among the nations studied. Focusing on Korea and Japan, Hwang (2016) finds that in recent years, the marriage rate gap between college and non-college is actually widening. These highly educated women are not merely delaying marriage; they are marrying less altogether. This is occurring despite the fact that cohabitation is stigmatized[1], which presumably augments the opportunity cost of single-hood in Asia relative to Western nations. The situation is arguably even more stringent in China, as non-marital conjugal cohabitation is illegal, and it is virtually impossible for a mother to secure citizenship rights for an infant born out of wedlock.

We might therefore expect that the Chinese experience mirrors that of the other Asian Tiger countries more closely than the experience of the US. This paper explores the issue for urban Chinese women in the context of a transferable utility model, using static and dynamic versions of the Choo-Siow framework developed by Choo et al. (2006) and Choo (2016). By comparing net gains to marriage, not only across couples of varying educational attainment and first marriage age but also over time, this paper seeks to further explore two main marriage market penalties: (1) a "success penalty" for highly educated women; and (2) a cost to delaying marriage. Our main finding is that highly-educated women delay marriage similarly to US women, but they ultimately marry at the same, and in our most recent sample slightly higher, rates as their less educated counterparts. When looking at marriage gains, however, we find that the average marriage market returns to eduction, particularly university degrees, have fallen over time for both men and women. A woman's university degree reduces the surplus she can hope to achieve from marrying unless she marries a man with a university degree. By contrast, we find that both per-capita and female-specific marital surplus has increased over time for women who marry after 30, while declining for younger brides, and that this is true across the education spectrum. Since high educated women marry later on average, their returns in the marriage market are still higher on average than women with only high school or equivalent. The results the qualitatively similar whether we use the static gains estimator of Choo and Siow (2006a) or the dynamic estimator developed recently by Choo (2016), which accounts explicitly for the opportunity cost of marriage in the form of participating in future marriage markets, but the decline in the value of early marriages over our 20 year interval

[1] As a proxy for cohabitation (as it may not be frankly reported, due to social stigma), Hwang (2016) looks at out-of-wedlock childbirth and finds that it amounts to only less than 2% of total births in Korea and Japan.

is much more pronounced using the latter estimator.

Even if high educated women (and men) are still opting for marriage, government concern for delayed marriages leading to the depreciation of women's reproductive capital still remains, which may become increasingly a concern given the recent relaxation of one-child policies. Moreover, as children are traditionally the most important component of marital output for most marriages (Brandt et al., 2008), the social and private returns marriage may be diminished if there is increased likelihood of childlessness or if high educated couples finding childbearing relatively unattractive. In fact, we do find evidence that married women's completed fertility is declining and that the decline is modestly larger for high educated women in recent years. Also, recent cohorts of women who marry later may be those who opt to forego childbearing.

The remainder of the paper proceeds as follows. Section 2 provides an overview of the economic and sociological literature on marriage markets in Asia, with a focus on the possibility of a marriage market penalty for older or higher educated women in China and other rapidly growing East Asian countries. Much of the theoretical literature on marriage has been based on non-transferable models of utility, which we discuss in the context of discussing our own choice to study marriage in the context of transferable utility. In section 3 we introduce and briefly describe the models we use to assess the gains to marriage: the classic Choo-Siow (2006) and a dynamic extension, the Choo (2016) estimator. In section 4 we introduce our data sets and explain how we deal with various issues of compatibility and cleaning. In section 5 we present our main results. Section 5.1 describes results using the Choo-Siow estimator and section 5.2 presents results using the Choo (2016) estimators. Under the assumption of perfect foresight about future marriage markets, the latter estimator requires us to extrapolate marriage markets into the future under evolving gender ratios, which, under the assumption that fundamental gains to marriage remain constant, also allows us to explore how marriage rates across age and education are likely to evolve in the future. Section 5.3 discusses evidence on assortative mating and its contributions to returns in the marriage market. Section 6 concludes.

2 Literature review: marriage and education in the East and West

A large literature in economics has examined the interplay between women's education and their marital outcomes. While this literature has traditionally focussed on Western women, a more recent set of papers explores women's marital outcomes in the developing countries of East Asia. At first glance, the current "leftover women" phenomenon in several "Asian tiger" nations may appear similar to the marriage market dynamics of America and other nations in the 1940s-60s, when women first began graduating from college. However, the historical context is quite different. Before the mid-1960s in America, for example, time endowment constraints were binding for many U.S. college-graduate women, which mandated a trade-off between family and career. Goldin (2004) notes that, among American women who opted to establish their career, a significant portion would remain unmarried or childless after marriage well into their late 30s and early 40s. Goldin attributes this to the lack of contraceptive methods, market substitutes for household production, time-saving household appliances, etc. — technological advancements that are easily accessible to women in developed Asia today — but made long-term career investments impracticable alongside family life for women in pre-1970 America.

The general consensus in the literature is that the current phenomenon in East Asia, on the other hand, has been brought about by a combination of two things: (1) unprecedented economic growth within a relatively short period of time, and (2) a failure of the marriage market's gender attitudes to keep up with this rapid modernization of labour markets. Hwang (2016) notes that the Asian nations experiencing declining marriage rates for women of high educational attainment are also the East Asian "tiger economies" that transformed rapidly into developed nations in less than 50 years' time. While this led to surges in higher educational attainment and female labour force participation amongst the younger generation, Kawaguchi and Lee (2012) point out that the evolution of cultural norms determining net gains to marriage have remained relatively stagnant. As expected gains to marriage fail to catch up with the growth of outside options in the labour market, a natural consequence is that highly educated and financially independent women are increasingly choosing to remain single over entering marriages where they are expected to take on the traditionally female role of home production.

There are three main road-blocks that remain in the path of the adjustment of social norms such that the domestic marriage market can clear. First, in what Hwang describes as the inter-generational transmission of gender attitudes, gender norms require time to shift from generation to generation. Since most men grow up accustomed to seeing women from their mother's generation in the role of housewives, they may have a tendency to adopt 'traditional' values and prefer marrying women who are willing to take on the brunt of home production. Second, parents-in-law have great say over the distribution of net gains to marriage. So even if a highly educated 'modern' woman were to be able to find herself a similarly 'modern' man who is open to the idea of partaking in household chores, the parents-in-law may not be able to tolerate their son taking on traditionally female household roles and veto the marriage bargaining altogether. Third, even if search frictions are successfully overcome and there is no exogenous breakdown in marital bargaining, there may still be a problem of limited commitment in marriage (Lundberg and Pollak (2007)). While both parties may be happy with their bargaining outcome, we must keep in mind that it is not possible to write a binding contract holding either spouse to their word to prevent shirking after marriage.

In our case, a woman will not enter into marriage with a man if *her expectation* of the gains is less than that of single-hood. To see this, suppose that highly educated women generally prefer remaining single to marrying less educated men, unless the less educated man agrees to do all of the housework. Additionally, suppose that there exist less educated men with parents who are accepting of his taking over the home production after marriage. In spite of this, a highly educated woman may still decide not to enter into the marriage if she estimates the likelihood of the man reneging after marriage to be sufficiently large, especially if divorce is costly. In further evidence against traditional gender attitudes in Korea and Japan's domestic marriage market, Hwang points out that college-educated Korean and Japanese women *in America* marry at the same rate as non-college women.

The story outlined above is consistent with non-transferable utility models of the household, where individuals' socio-economic status and marriage pay-off are exogenously determined (see Smith

(2006)) in a two-sided matching framework. Kawaguchi and Lee, for example, tailor this model to their East Asian "tiger economies" data to illustrate the types of "leftover" men and women in fixed matching equilibrium when marriage markets fail to clear. Their model can rationalize the evidence of highly educated women being systematically "leftover" in Korea, Japan, Taiwan, and Singapore, as men prefer marrying women whose educational attainment does not exceed their own while highly educated women prefer to remain single than to marry men with "traditional" values. It also, at first glance, constitutes a plausible explanation for the Chinese Central Government's concern regarding China's own high-achieving women. However, so far there has been little systematic research to confirm this. As China's 2010 Population Census is only slowly becoming available to researchers, the existing literature on "leftover women" in China is mostly qualitative. To (2013), for example, categorizes 50 high-achieving "leftover" Chinese women by their attitude towards marriage into four main types[2] and speculates on the likelihood of future marriage for each type, conditional on whether they are still-unmarried by choice[3]. In contrast, Fincher (2014) suggests that urban women in big cities may be *more likely* to marry quickly in an attempt to escape the "leftover women trap". After conducting a series of in-depth qualitative interviews with both men and women mostly of higher education in China's big cities, Fincher finds that many urban women are rushing into marriages[4], sacrificing individual happiness and/or marital compatibility[5], in an attempt to avoid being branded a "leftover woman" and/or out of societal / parental pressure to marry[6]. In terms of quantitative analysis, the National Bureau of Statistics of China's note on "leftover" men and women in the aforementioned 2012 Facts & Figures report seems to closely follow the general

[2]Specifically, To (2013) studies high-achieving unmarried women's partner choices subject to two interactional constraints — "filial constraints" (imposed by parents who are found to have considerable influence over their daughter's marital choices) and "gendered constraints" (imposed by male romantic partners) — which constitute China's "patriarchal" environment. From these observed choices, To gleans information on the women's personality and attitudes toward marriage and uses this to categorize the women into four main types — "traditionalists" (analogous to Kawaguchi and Lee's 'traditional' high-type), "maximizers" (who try to evade patriarchal discrimination by dating foreign men), "satisicers" (who "settle" for lower-type men), and "innovators" (analogous to Kawaguchi and Lee's 'modern' high-type).

[3]In seeking to understand why highly educated Chinese women are increasingly delaying marriage, To argues that while a subset of these women remain still-unmarried due to being "picky," some are "leftover" due to binding interactional constraints.

[4]Fincher (2014) finds that many women tend to "marry quickly — often within several months of meeting a man — specifically to avoid being designated 'leftover'."

[5]See Fincher (2014) for a series of individual accounts.

[6]According to Fincher, educated women are "constantly told by their families, friends, and the State media that they will be ostracized if they do not find a husband quickly."

theory of the literature outlined above — grouping marriage market participants by gender and education and finding that "many outstanding [high-type] women and less advantaged [low-type] men are having difficulty in finding their spouse under the influence of the traditional notion that the husband should excel his wife in a marriage."[7]

In fact, as we will detail in this paper, at least among the urban-with-urban-hukou population[8], we find that Chinese women with higher education (college or more) actually have the *lowest* unmarried rates (and therefore, the highest marriage rates) by their late 30s, compared to female counterparts of lower educational attainment in 2009. Amongst recently emerging quantitative studies, this appears to be a new result. Qian and Qian (2014) are the first to update previous studies on assortative mating by age and education to account for recent trends in urban China. In apparent consistency with the Chinese government, Qian and Qian find likelihood of marriage to *decrease* with respect to education for women. However, their results are based on grouping marriage market individuals into three age categories ('early' (20-24), 'normal' (25-29), and 'late' (30-49))[9]. Looking at first marriages over the period 2000-2008 in the Chinese General Social Survey (CGSS), Qian and Qian find that while marriage rates for highly educated men catch up to other types in 'late' marriages, highly educated women marry at lower rates than other types across all three age categories. Perhaps due to this last 'late' age category being too broad and confounding marriage delayers with never-marriers, this result is inconsistent with our findings based on the Urban Household Survey, which display that, for higher education types, marriage is delayed by Chinese men and women alike. In much the same vein as NBS' 2012 Facts & Figures report, You et al. (2016) find "declining marriage rates" as well as a "marital college discount" (success penalty) for women with higher education. However, it is important to note that their marriage rates are *not* ultimate marriage rates, but the NBS age-15-and-above currently-single rates by education, which

[7] See also Ong et al. (2016) which looks at competition intensity, marriage probability, and post-marriage household bargaining power of Chinese urban women by income in the context of reference-dependent preferences and using data from a Chinese online data site. Their model predicts that high-earning women will be worse off in the marriage market as men become wealthier or more plentiful since it will increase competition from lower-earning women.

[8] As the highly educated constitute less than 10% of the total population and are concentrated in urban areas, excluding rural areas from the analysis is consistent with the literature on "leftover women" in China. See Section 4 for a discussion on why focusing on urban hukou holders is not intended or expected to affect results in any meaningful way.

[9] Qian and Qian (2014) use broad categorization as opposed to a finer age grid owing to the small sample size of the Chinese General Social Survey (CGSS).

disadvantage marriage-delaying types by construction, as discussed above. You et al. also estimate likelihood of marriage for a pool of women aged 27 to 60 by regressing income over education and marital status, among various individual, household, and province controls. After obtaining the resulting coefficient estimates, You et al. re-arrange their regression equation to predict likelihood of marriage, given education and income and information on the other controls. Again, this age range of 27-60 conflates marriage delayers with ultimate non-marriers as the unmarried rates are not ultimate unmarried rates but, rather, currently-single rates.

Although the results of our paper suggests that the domestic Chinese marriage market is clearing, this finding is not meant to be presented as evidence overturning the non-transferable utility model. The non-transferable utility model does seem to fit the story of these other East Asian developed nations and is even capable of producing fixed matching equilibria of no leftover women if we alter preference ranking assumptions or simply suppose the share of 'modern' high-type men to be sufficiently large. However, there are sufficient ways in which China's domestic marriage market differs from that of the other developed East Asian nations to warrant its own separate analysis. In terms of high and rising age of first marriage for women — 29 in Japan and Korea, 28 in Taiwan, 30 in Hong Kong, and 28 in Singapore (Jones and Gubhaju, 2009) — You et al. (2016) find mainland China's urban figure to be substantially lower at 25 (though, as we find, rising). In fact, Ji (2015) notes that, even after more than 3 decades of rapid socioeconomic development, marriage in China remains not only relatively early, but also near universal, which we also find to be true in our data even as late as 2009.[10]. There is also direct evidence for transferable utility in China with respect to spousal transfers. While the existence of transfers in and of themselves may simply be a product of traditional gender expectations and not necessarily proof of transferable utility, Shang-Jin Wei (2011)'s findings suggest that these husband-wife transfers are responsive to changes in the sex ratio. This constitutes a case for marital bargaining, which predicts transfers to increase with the

[10]The arguments of To (2013) and Fincher (2014) lend insight into the near-universal marriage of Chinese women. In what To terms "filial constraints," Chinese women's marriage decisions are found to be considerably influenced by their parents, and that "even those who chose highly alternative or non-traditional paths had to negotiate more or less to appease their parents." And, despite the fact that parents generally wish for their daughter to find a suitable spouse, Fincher notes that Chinese parents' first order priority is still to see their daughter married suitably early (with a pervasive fear that being "picky" will lead to being "leftover" and unable to marry) and then to see to the birth of their grandchild soon thereafter. The failure of a daughter to fulfill these wishes is considered unfilial.

erosion of male bargaining power. Specifically, Shang-Jin Wei finds that China's rising sex ratio contributes substantially to the upsurge in competitive household savings rates between 1990 and 2009, as parents of sons attempt to improve their son's relative attractiveness in the marriage market in terms of ability to make large family investment purchases such as a house and car. Huang and Zhou (tted) also attempt to provide new evidence for transferable utility by arguing that China's One-child Policy induces not only a higher unmarried rate among the (Chinese Han) population but also increased instances of inter-ethnic marriages. If we believe in a setup of transferable utility, children would constitute important marital outputs. By this logic, the setting of a limit on the number of children that a Han couple can have necessarily constrains the net gains to marriage to intra-ethnic Han couples. These depressed martial gains would then effectively explain the Han population's rising unmarried rates and increasing substitution towards specific ethnic minorities not subject to the one-child constraint. And, while spousal transfers cannot be observed in the 2000 and 2005 Census data, Huang and Zhou use spouse education as a proxy and find that increases in fertility fines (for breaching the One-Child Policy) lead to larger transfer payments from Han to ethnic minority spouses not subject to the one-child constraint. Therefore, in the specific case of China, a transferable utility model seems to be appropriate.

3 Model: Static and dynamic Choo-Siow models

3.1 Choo-Siow (2006)

The classic Choo-Siow matching function (and its extensions) has emerged as one of the core tools by which economists and demographers explore marriage market outcomes. Briefly, suppose there are I types of men and J types of women. Let i denote i-type men and j denote j-type women. At any point in time t, a marriage market has a population vector of available men M with types $i = 1, ..., I$ and typical element m_i, and a population vector of available women F with types $j = 1, ..., J$ and typical element f_j. A marriage matching function $\mu(M, F; \Pi)$ predicts changes in marriage distribution μ due to changes in population vectors M and F or changes in the parameters governing the gains to marriage Π. Effectively, μ is an $(I+1)\times(J+1)$ matrix, where each element μ_{ij} represents the number of couples of that specific $\{i,j\}$ type combination, with μ_{i0} and μ_{0j} giving the number of unmarried men and women of type i and j respectively. Accounting requires:

$$\begin{cases} \mu_{i0} + \sum_{j=1}^{J} \mu_{ij} = m_i & \forall i \\ \mu_{0j} + \sum_{i=1}^{I} \mu_{ij} = f_j & \forall j \\ \mu_{i0}, \mu_{0j}, \mu_{ij} \geq 0 & \forall i, j \end{cases}$$

Under the assumption of perfectly transferable utility, an $I \times J$ set of (possibly negative) transfers τ_{ij} from men i to woman j will emerge that function as the prices that clear the marriage market. The marriage market clears when, given equilibrium transfers $\{\tau_{ij}\}$ demand is equal to supply for all $\{i,j\}$ combinations. An i-type man g who marries a j-type woman obtains net utility V_{ijg}. If he remains unmarried he receives net utility V_{i0g}. These are given by:

$$V_{ijg} = \widetilde{\alpha}_{ij} - \tau_{ij} + \varepsilon_{ijg} \tag{1}$$

$$V_{i0g} = \widetilde{\alpha}_{i0} + \varepsilon_{i0g} \tag{2}$$

If man g marries a j-type woman, he obtains gross systematic return $\widetilde{\alpha}_{ij}$, pays equilibrium income transfer τ_{ij} to his spouse, and gains an additional individual-specific random component ε_{ijg} that is independent and identically distributed according to the type I Extreme Value distribution (McFadden (1973)). The systematic payoff from marriage common to all i-type men who marry j-type women is characterized by $\widetilde{\alpha}_{ij} - \tau_{ij}$, and the individual man g-specific payoff deviation from this systematic component is given by ε_{ijg}. Alternatively, if i-type man g remains unmarried (denote this with $j = 0$), he receives a systematic payoff to single-hood $\widetilde{\alpha}_{i0}$ as well as an individual-specific component ε_{i0g}, which is also an i.i.d. random variable with type I Extreme Value distribution. Man g will therefore choose according to $V_{ig} = \max_j \{V_{i0g}, ..., V_{ijg}, ..., V_{iJg}\}$.

For each sub-market $\{i,j\}$, McFadden (1973) shows (a proof is also provided in Choo and Siow (2006a)) that the quasi-demand equation is given by:

$$\ln \mu_{ij}^d = \ln \mu_{i0}^d + \alpha_{ij} - \tau_{ij} \tag{3}$$

where μ_{ij}^d is the number of j-type spouses demanded by i-type men, μ_{i0}^d is the number of unmarried i-type men, and $\alpha_{ij} = \widetilde{\alpha}_{ij} - \widetilde{\alpha}_{i0}$ represents the systematic gross return of marriage relative to remaining single for i-type men. The women's problem is symmetric and yields a corresponding quasi-supply equation for woman j to man i:

$$\ln \mu_{ij}^s = \ln \mu_{0j}^s + \gamma_{ij} + \tau_{ij} \tag{4}$$

where $\ln \mu_{ij}^s$ is the supply of j-type women for i-type men and $\ln \mu_{0j}^s$ is the number of unmarried j-type women. ("Demand" and "supply" can be easily transposed across genders.)

Imposing equilibrium, $\ln \mu_{ij}^d = \ln \mu_{ij}^s$ and rearranging gives gives the Choo and Siow (2006b) marriage matching function:

$$\pi_{ij} = \ln \left(\frac{\mu_{ij}}{\sqrt{\mu_{i0} \cdot \mu_{0j}}} \right) \tag{5}$$

where $\pi_{ij} \equiv \frac{\alpha_{ij}+\gamma_{ij}}{2}$ quantifies the per-capita systematic net gains to marriage for a couple consisting of an i-type man and j-type woman in any given marriage market year. Mathematically, π_{ij} is the natural log of the ratio of the total number of newly-wed $\{i, j\}$-type couples to the geometric average of single i-type men and j-type women in any given marriage market year. Choo and Siow show that this ratio of observable marriage market outcomes is a sufficient statistic for quantifying the quality of marriage matches. Intuitively, more marriages of a $\{i, j\}$ match type (that is, higher μ_{ij}) indicates greater match desirability on average, holding constant the total number of marriageable people of this type, m_i and f_j. To capture desirability and separate it from abundance, we therefore scale μ_{ij} by the number of unmarrieds of these types, i.e. those who could have formed an $\{i, j\}$ marriage but opted to reject the match. Conversely, the Choo-Siow statistic tells us that *for a given number of marriages*, the more scarce the types involved (lower μ_{i0} and μ_{0j}) , the more desirable is, i.e. the higher average returns are to, the match.

Furthermore, solving the Choo-Siow model also gives the spouse-specific as well as the total net gains to marriage, i.e. husband-specific systematic net gains $\pi_{ij}^m \equiv \alpha_{ij} - \tau_{ij}$ and wife-specific systematic net gains $\pi_{ij}^f \equiv \gamma_{ij} + \tau_{ij}$:

$$\pi_{ij}^m = \ln\left(\frac{\mu_{ij}}{\mu_{i0}}\right) \tag{6}$$

$$\pi_{ij}^f = \ln\left(\frac{\mu_{ij}}{\mu_{0j}}\right) \tag{7}$$

These expressions capture the fact that the type-specific gains resulting from such a match depend on the relative scarcity of the husband's and wife's types. Relative scarcity of type translates to increased bargaining power and therefore a greater type-specific share of the marriage's total systematic net gains. By 2009, for example, rapid growth of Chinese women's educational attainment from China's higher education enrollment expansion project (implemented in 1999) reduced the scarcity of high-type women. In general, if average absolute attractiveness or output $(\widetilde{\alpha}_{ij} + \widetilde{\gamma}_{ij})$ of marriages in which the wife is high-educated have remained constant over time, then the denominator of (7) will rise and high educated women's bargaining power (reflected in τ) and average private returns from marriage will fall. (In fact, as shown in tables 4 and 13, the rise in the educational attainments of men and women in urban areas have tracked each other fairly closely, suggesting that the marriage market returns to high education for men should also be falling relative to medium- and low-educated men.) This outcome could be mitigated if, for instance, the fundamental returns $\widetilde{\alpha}_{ij} + \widetilde{\gamma}_{ij}$ to high-educated partners were rising over time due, for example to increasing utility from assortative mating or increasing tolerance toward non-traditional (working) wives, or if the gains from marriage were becoming more concentrated around ages when the high educated were more free to marry, i.e. after completing a degree.

The Choo and Siow (2006b) framework has many nice properties; in particular it allows for unrestricted substitution effects across types of marriages when population vectors change. It is static in the sense that, while it controls for changes in population vectors, any cultural, social, or policy changes affecting marriage distributions will be reflected in changes to the systematic net gains of marriage over time, but anticipated changes to these gains, or to the population vectors, will not affect the behavior of individuals in a given marriage market. As well, payoff to remaining single at a point in time (hence the estimated gains to marriage, which are calculated relative to singlehood) will implicitly capture the option value of participating in future marriage markets, but this is captured purely in reduced-form. We treat this model as our benchmark in examining the systematic net gains to marriage by educational attainment and first marriage age in recent years — both before and after the Chinese Central Government's 2007 media announcements, and using 1990 as a baseline year for comparison.

3.2 The Choo (2016) framework

In a recent extension to the classic Choo-Siow framework, Choo (2016) develops a matching function that explicitly accounts for the fact that the returns to a particular match in a given marriage market represent a present discounted surplus and that that committing to a marriage requires paying the opportunity cost of participating in subsequent marriage markets. This is likely to be especially important if the fundamentals of the marriage market – the gains to marriage types and the set of available partners – are changing over time and if agents are aware of these changes. Choo (2016) makes use of the same basic utility function as Choo and Siow (2006a) with Type 1 Extreme Value matching function and male-to-female transfers $\tau_{i,j}$. In Choo (2016), the τs are up-front transfers (like bride prices or dowries) made at the time of marriage.

We consider a very simple version of Choo's dynamic model, extended to multi-dimensional types (age and education categories), in which there is no risk of divorce and in which the terminal age for participating in the marriage market, or gaining utility from a marriage, is $T = 44$ for both genders. Under these two assumptions, dynamic marriage gains to an $\{i, j\}$ marriage, $\Pi_{i,j}$ are given by

$$2\Pi_{i,j} = \ln\left(\frac{\mu_{i,j}}{m_i}\right) - \sum_{k=0}^{T_i-1} \ln\left(\frac{\mu_{i'(i,k),0}}{m_{i'(i,k)}}\right)^{\beta^k} + \ln\left(\frac{\mu_{i,j}}{f_j}\right) - \sum_{k=0}^{T_j-1} \ln\left(\frac{\mu_{0,j'(j,k)}}{m_{j'(j,k)}}\right)^{\beta^k} \tag{8}$$

where $i = \{age, educ\}$, $j = \{age, educ\}$, $T_i = T - age_i + 1$ and $T_j = T - age_j + 1$. The first two terms on the rhs give the dynamic analog of π^m and the next two terms give the dynamic analog of π^f. $i'(i,k)$ is a function relating how state i changes with time k. If age is the only characteristic on which people sort, as in Choo (2016), then $i' = i + k$, which is the functional form given in Choo (2016). In the case where the two characteristics making up a type are age (grouping) and education, then age increases one for one with k while education remains constant with both time and age. For now, we omit marriage market (or, interchangeably, cohort) subscripts t from (8) as we did for (5), which assumes that the marriage market is in steady state. In principle, however, the πs, Πs, and μs can change over time as well as across types. Note that if $T_i = T_j = 1$ then (8 reduces to

$$2\Pi_{i,j} = \ln\left(\frac{\mu_{i,j}}{m_i}\right) - \ln\left(\frac{\mu_{i,0}}{m_i}\right) + \ln\left(\frac{\mu_{i,j}}{f_j}\right) - \ln\left(\frac{\mu_{0,j}}{m_j}\right) = 2\pi \quad (9)$$

and π is the classic static Choo-Siow estimator. That is, the dynamic Choo-Siow estimator takes into account the fact that if a man (say) opts to remain single in the current marriage market (at any age before the terminal age T), he will have the opportunity to participate in next period's marriage market, with new state vector $i'(i,1)$ and then in subsequent markets if he does marry next period, receiving new i.i.d. draws of the vector $\boldsymbol{\epsilon}$ at each k. The present discounted value of participation in future marriage markets enters the expression for Π negatively to reflect the fact that it is the opportunity cost of marrying in the present. Note, however, that the closer $\mu_{i'}$ is to $m_{i'}$ in subsequent marriage markets, the closer this opportunity cost gets to zero, since the likelihood that male i will be able to marry in the future when he is in state i' also goes to zero and so also the marital surplus he can hope to gain by waiting to participate in that marriage market. The identical arguments hold for women j.

As in the classic static case, Π measures net marital gains, or marital surplus: specifically the difference between gross output or utility from the marriage and the gross output or utility received from remaining single for the duration of the marriage. In appendix B we show the derivation of (8) for our simplified model without divorce. The derivation the more general estimator (with one-dimensional types) in which individuals are subject to divorce shocks and expect with some probability to re-enter the marriage market at a later date, is of course provided in Choo (2016).

3.3 Application to China

We explore the systematic net gains to marriage in the marriage markets for which we have data — namely, years $t = \{1990, 2000, 2005, 2008/9\}$ (see Section 4). Within a marriage market t, let us define individual types across two dimensions {age, education}. Consistent with the Choo and Siow (2006b) and Choo (2016) setups, let i denote i-type men and j denote j-type women. The vectors I and J are the same for both genders, and we will call it N.

For each marriage market year t, we observe both singles and newly-weds; in both the Choo and Choo-Siow frameworks, previously wed individuals have exited the marriage market, make no further decisions, and receive no further payoffs. The N-dimensional population vectors $\mathbf{m}$ and $\mathbf{f}$ therefore consist of singles and those who have just made the decision to marry (newlyweds). Let μ_{ij} denote the number of newly-wed couples with i-type husband and j-type wife. Let μ_{i0} denote the number of single i-type men and μ_{0j} the number of single j-type women. There are (potentially) N^2 types of recent marriages in each marriage market year t. The marriage matching distribution μ is an $N \times N$ matrix with typical element μ_{ij}. This paper then employs equations (5) - (7) and (8) to translate these marriage market outcomes into average, husband-specific, and wife-specific static systematic net gains and dynamic systematic net gains to marriage. To calculate the dynamic net gains, we will consider two cases: one in which marriage market participants are myopic in the sense that they assume the marriage market to be in steady state even though it is not, and one in which marriage market participants are forward looking and anticipate changes in population vectors and average systematic surplus Π over time that will influence their decisions today. In the former case, each year of data is sufficient to estimate the type-specific marital gains for the national urban marriage market in that year. In the latter case, data on subsequent marriage markets at $t + k$ are necessary to estimate the Πs in the marriage market at t. We will discuss these data requirements in more detail in section 5.2.

4 Data

To analyze marriage market trends, we employ four nationally-representative datasets: two NBS National Population Censuses {1990, 2000} (1% samples), the 2005 NBS Population Survey (a .2% sample), and the combined 2008 and 2009 waves of the annual NBS Urban Household Surveys (UHS), the most recent dataset available with sufficient size to construct measures of the gains to marriage along the lines laid out in the previous section.[11] The NBS UHS samples individuals residing in urban areas and focuses almost exclusively on individuals with urban hukou[12]. This focus on urban hukou holders should not detract from the analysis of "leftover women" in any meaningful way. In fact, You et al. (2016) find in their 2008-2011 sample of the Chinese General Social Survey (CGSS) that college-educated women with urban hukou are *more* likely to be never-married after age 27 compared to their rural hukou peers while the difference is insignificantly different using the 2010-2012 CFPS. Furthermore, within urban areas, the marriage markets for (local) urban hukou holders and (rural-urban migrant) rural hukou holders are largely segregated, especially for individuals with higher educational attainment. While Han et al. (2015) finds rural-urban marriages to be slowly increasing since a 1998 change in hukou law which allows children to adopt either parent's hukou status, the increase in rural-urban marriages is almost entirely restricted to lower educational types. For these reasons, we think the UHS' focus on urban hukou holders is not restrictive. For comparability between all years of data, all census and population survey samples are made consistent with the 2008/2009 UHS in that only urban areas of the same set of provinces (16 in total) for which we have UHS data are retained, and we consider only couples in which *both* spouses have urban hukou.

[11] Because the 2010 NBS Population Census is only slowly being made available to researchers, popular (and accessible) alternatives include the China Family Panel Studies (CFPS) and Chinese General Social Survey (CGSS) household surveys. However, despite the in-depth detail of the CFPS variables, the 2012 CFPS dataset is less than a third the size of the combined 2008 and 2009 NBS UHS in total observation count. Furthermore, CFPS covers individuals living in both urban and rural areas making the urban coverage of the CFPS is more than halved yet again. The CGSS is even smaller at about a third the size of the CFPS.

[12] 94.7% of the 2009 UHS respondents have urban hukou registration.

4.1 Data issues

In terms of calculating systematic gains to marriage, the methodology employed by this paper is as follows. In the main analysis, each dataset {1990, 2000, 2005, 2008/9} is an observational marriage market year. In each of these years, we obtain a snapshot of the currently-single individuals in the marriage market. In an ideal world, we would collect newly-wed data for the few years immediately proceeding each marriage market snapshot[13]. In lieu of that, we exploit the fact that the 2000 and 2005 census samples contain data on historical first marriage years. To obtain four "marriage markets" worth of couples data, we identify newly-wed couples who married in the three years leading up to and including each snapshot of the singles market using retrospective data (see Table 1).

Table 1: SETUP: systematic gains to marriage construction

Singles	Newly-weds
1990	1988-1990
2000	1998-2000
2005	2003-2005
2008/9	2006/7-2008/9

We are primarily interested in looking at marital payoffs by spouses' education levels and the age at marriage so as to explore whether there is a marriage penalty associated with delaying marriage or with attending university, particularly for women. An obvious issue with our approach is that average educational attainment has increased very rapidly between 1990 and 2009 (see table 4). These changes, which are plausibly exogenous to the marriage market, have implications for marriage expectations in a dynamic context; more generally, changing supplies imply that the average quality of spouse associated with each education level may also be changing over time. We therefore define our education categories "low", "medium" and "high" in two ways. First, our "fixed" education categories assign low education to those with less than high school, medium education to those who have completed high school or equivalent vocational / technical training, and high education to those with post-high school education, which can mean either junior college

[13] Indeed, Choo and Siow (2006b) does exactly this; they use the US Censuses to quantify marriage market singles and then look at the Vital Statistics of the proceeding two years to quantify newly-wed couples.

or university. These categories do not change over time. Second, our "moving" education categories reassign education levels so that the shares of "high", "medium" and "low" remain roughly constant over the 20 years of data with the "fixed" 2000 shares as the benchmark. In 2008/9 this means that only university-educated individuals are classified as "high educated". In order to have large enough cells in all four samples, we focus on the the age-of-first-marriage range 18-38 in three-year intervals (18-20 up to 36-38). This range is natural because 20 is the earliest age at which men are legally allowed to marry in China. "Early marriages" with grooms under 20 and brides under 18 are relatively rare among urban dwellers with urban hukou. Moreover, we cannot correctly identify individuals' completed education before the age of 18 whereas individuals at 18 and above who are still in school can be classified as high educated since they have finished high school and are pursuing a subsequent degree. For the upper limit, almost all men who marry do so by age 38, and women by 35, and 38 is also approximately the age of women's completed fertility. For singles, age is measured as age at time of survey. For newly-weds, it is the age at the time of marriage.

Given this framework, there are two main data issues to deal with. First, we have to identify couples within households in all the data sets; second, we have to identify from the full set of couples the subset of *newlywed* couples: those who married within the time ranges given in table 1. This is especially challenging in the 1990 census and the 2008/9 UHS, because year of first marriage is not reported. We discuss these two data issues in turn, with further details provided in appendix A.

1. *Identifying couples within a household.* Our four NBS datasets label individuals of each household by their 'relationship to household head' which does not always uniquely identify couples within a household.[14] Only "household head" and "spouse of head" can be perfectly matched from the available information, which has led some researchers to focus only on household heads (e.g. Han et al. (2015)). For our analysis, however, omitting all but household heads and spouses is potentially problematic since, as can be seen from the first three rows of Table 2, the shares of "adult children", and "other" couples in the household (including parents, grandchildren, or siblings / siblings in law of the head) are fairly substantial, though

[14] This is different from other survey designs. The China Health and Nutrition Survey (CHNS), for example, records spouse ID number for easy matching. The CFPS, on the other hand, directly lists the spouse attributes of all individuals in the survey.

decreasing over the sample period. Further, it is likely that couples who live apart from their parents are likely to experience higher net gains to marriage than "adult children" couples living in the family home after marriage, so omitting these couples could lead to bias in the estimated returns to marriage over time. We therefore wish to include all identifiable couples in the analysis for all years. Appendix A discusses our method for matching individuals in couples within households.

A related problem is that, in the censes (1990, 2000, and 2005), even head and spouse couples can only be identified if both spouses are present in the household at the time of the survey. Rows 4 and 5 of table 2 reports the share of married household heads and other married household members for whom no spouse is identifiable in the survey. In all years but 2008/9, in which the survey takers request information about temporarily missing members, the numbers are fairly large, and in 2005 particularly, this share reaches almost 50% among urban couples under 45.[15] Because missing spouses, both of household heads/wives and other married family members, are also not likely to be random within the married population (and also because of sample size concerns), we deal with this missing data by drawing "replacement" spouses for these individuals from the age / education / hukou distribution observed among the complete couples in that year. Of course, this distribution is different for each age, education level, and gender of the spouse who appears in the census.

Finally, the 1990 dataset poses two additional challenges. First, in 1990, children in law are not given as a separate category of relations to the head, making it more difficult than the other years to identify the spouses non-head family members. The problem is more acute because, in houses with older heads, household births may predate the implementation of one child policies so that multiple married children are present. Second, the 1990 census does not provide information on the year of first marriage, preventing us from linking couples on their year of marriage or determining newlyweds from older married couples. To get around this, in our main analysis we construct our marriage market payoffs using the distribution of newly

[15] In the 2005 census, the enumerators record the number of family members living at the address which is systematically less than the enumerated members. This leads us to believe that the public file may contain information only on individuals who were physically present at the time of the initial visit.

married couples in 1990 inferred from the 2000 census (couples who report having married between 1987 and 1990) rather than from the 1990 census, from which we merely take the corresponding distribution of singles.

2. *Identifying newlyweds.* For the 2000 and 2005 censes, we identify newlyweds directly using retrospective data on year of first marriage. As discussed above, we also use the 2000 census to compute the distribution of newlyweds for 1990 which is then used for the main analysis in section 5. However, year of first marriage is not reported in the 2009 UHS. For 2009, therefore, we back out predicted age of first marriage by using data on fertility, which fortunately is feasible given the lack of "missing" individuals within families in the UHS relative to the censes (see the final column of table 2). We use the 2005 data combined with a 50% sample of the 2000 data to construct the distributions of marriage tenure for couples by age of the head, education of the spouses and age of the oldest child: 0-1 years, 2-3 years,4-10 years and 11-18 years, and missing (childless couples).[16] The older ages are included because some of the marriages could be second marriages following divorce or death of a spouse. The maintained assumption is that this distribution of *time from marriage to first childbirth* or more specifically, the relationship between marital tenure and oldest child in the household, has not changed meaningfully between 2005 and 2009, conditional on age and education levels of the head and spouse.[17] Since, as shown in row 6 of table 2, a fairly substantial number of children are missing in 2005 (that is, the mother reports having surviving children but they are not enumerated in the household), we use only households in which both spouses are enumerated and assume that any missing child in this subset of complete couples was born two years after the marriage started.

[16]For this exercise, we weight the data so that the sum of the weights of the 2005 observations is three times larger than the (larger) 50% 2000 sample, which is included so as to span the distribution of marriages. This is important because, as shown in row 7 of table 2 and later in figure 5, the time between marriage and childbirth seems to have increased between 2000 and 2005 especially at older first marriage ages.

[17]Note that by "age" here we mean actual age, counted in single year units, and not age (category) of first marriage.

Table 2: Couples composition: share of hh heads, adult children, and other hh couples ages 18-44

	1990	2000	2005	2009
HH head	0.690	0.740	0.746	0.866
Adult child	0.225	0.167	0.151	0.105
Others	0.085	0.093	0.103	0.029
Missing "spouse" of married head	0.118	0.114	0.480	0.014
Missing "spouse" of other family members	0.115	0.074	0.179	0.031
Missing children	0.054	0.076	0.229	0.000
Share of childless couples	0.072	0.090	0.096	0.112

4.2 Preliminary analysis

We now turn to a first-pass exploration of our main question: do highly educated women face a marriage market penalty in urban China? This penalty could take the form either of systematically less favorable marriages or a greater likelihood or not marrying at all. Moreover, we are interested in the question of whether this penalty is increasing or decreasing over time. Figure 1 plots the percentage share of currently-single women over the age range 20-40 by educational attainment for each observation year. The figures show results using our fixed education categories: "low type" individuals are defined as those with educational attainment ranging from illiterate (no schooling) to middle school (the blue lines) while medium type individuals include those with high school or technical / vocational schooling (the red dashed lines). High type individuals (the green dash-dotted lines) include all those with college, undergraduate university, or higher degrees. There are two main takeaways from these graphs. First, the horizontal distance between the blue and red, and the red and green lines represents the tendency for individuals of higher educational attainment to delay marriage.[18] The difference across education categories has been increasing over time, consistent with the findings of the literature on Chinese marriage markets. Second, unmarried rates (and thereby marriage rates) of high educated women 35-40 are noticably lower than those of less educated women in 1990 but then appear to "catch up" over the subsequent three samples.

We examine this phenomenon more formally in table 3, which reports mean non-married rates and adjusted Wald tests of the differences across education categories and time periods for women

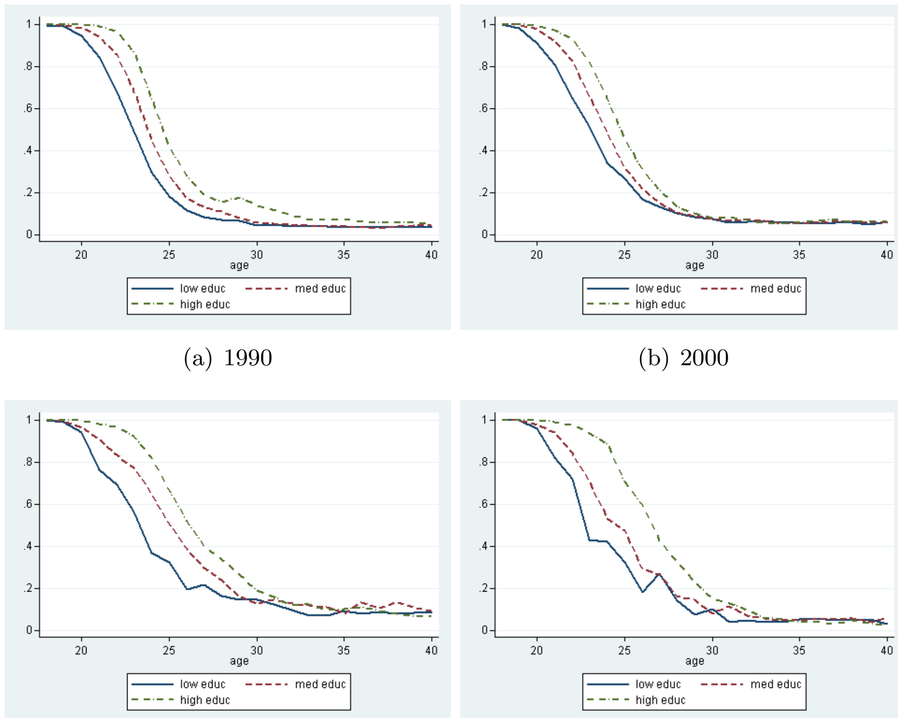
[18] Recall that we include as high types those individuals who are medium types (in terms of completed education) but also report their educational status (available in all four years) as "student", which avoids a compositional effect at younger ages.

aged 35 to 40. The first four columns report the (weighted) means and test for the differences in means between the highest educated and the pooled low and medium educated groups. In 1990 and 2000, the highest educated group is significantly less likely to be married after age 35 in line with the idea of a "success penalty" in the marriage market for highly educated women. However, in 2000, the difference, though large in percentage terms (a 12% greater likelihood of being unmarried when high-educated) is economically fairly small, with under one percentage point more of the high educated group of women unmarried. The difference across groups becomes insignificant and reverses sign in 2005 (column 3) and by 2008/9 the high educated sample is significantly *more* likely to be married between ages 35 and 40 than the low and medium educated.

An obvious possibility is that the disappearing gaps are a mechanical product of the global increase in education among urban Chinese women over the period (see table 4; table 13 in appendix C shows similar results for men), combined with the lower statistic power available in the 2005 and 2008/9 samples. To check this possibility, column 5 (labeled 2009*) reports the results using the "moving" education category for 2008/9, in which only those women with undergraduate or graduate university degrees are categorized as high educated while college degree holders are re-labeled as medium type, making the share of high educated women comparable to the share from 2000. Making this change does not affect the finding that the highest educated women are in fact more likely to be married between 35 and 40, although the difference in marriage rates across education groups is no longer statistically significant. In the last two columns of the table we report results from a test of equivalence of the unmarried rate for both education categories between 1990 and 2009. Adjusted Wald F-tests reveal that the change is due both to falling high-educated unmarried rates for 35-40 year old women (this is true using both the fixed and moving categories, though we report results using the fixed categories), and increasing unmarried rates among low and medium educated women. Overall marriage rates, however, are very high with no significant change between 1990 and 2008/9.

If we do not see a marriage penalty in terms of completed marriage rates, do we see evidence that women with more education, or later first marriage age, marry less well? Figure 2 provides some very cursory evidence on the question. The top panel shows the percentage of married women in

Figure 1: % currently-single women by age



(a) 1990

(b) 2000

(c) 2005

(d) 2008/9

Table 3: Share currently-single women

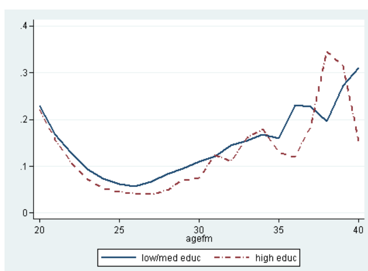
education type	1990	2000	2005	2009	2009*	High type 90 vs 09	Low type 90 vs 09
high educ	0.051	0.057	0.056	0.035	0.039		
low/med educ	0.032	0.051	0.059	0.049	0.045		
F-stat	23.360	6.239	0.535	11.344	0.976	11.64	27.586
Adj Wald (Prob > F)	0.000	0.012	0.465	0.001	0.323	0.006	0.000

Table 4: Shares of women with educ {low,medium,high} by year

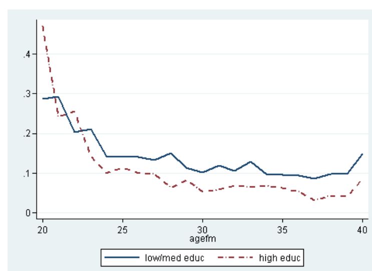
educ	1990	2000	2005	2009	2009*
Low	0.519	0.422	0.319	0.207	0.399
Medium	0.399	0.390	0.302	0.329	0.411
High	0.082	0.188	0.379	0.464	0.191

2000 (left) and 2008/9 (right) who are married to men six or more years older than themselves, disaggregated by whether they are "high" educated (the red dashed line) or less (the blue solid line) by age of marriage. The bottom panel shows the same analysis using the percentage of women by education type and first marriage age who marry less educated (low or medium type) men. In 2000, the likelihood of marrying a significantly older man increases with the bride's marriage age (although the trend may be driven by noise due to the relative small sample sizes at these later first marriage ages) but this no longer appears to be true in 2008/9. As well, high educated women in 2008/9 are less likely to marry a man six or more years older than less educated women at nearly all marriage ages. From the bottom two panels, we see no evidence that high educated women are more likely to "marry down" to lower educated men either over time or by marriage age except perhaps at very late (and rare) marriage ages in the 2000 sample. Overall, we see no immediate evidence that women are worse off in terms of their partner's observable characteristics when they marry late, and no evidence that high-educated women are doing systematically worse in the marriage market over time.

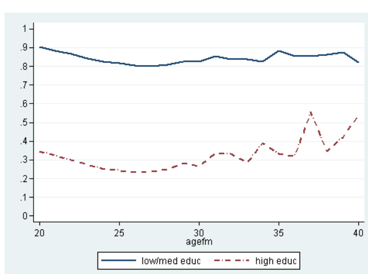
Figure 2: Preliminary evidence: do high educated or late marrying women "marry down"



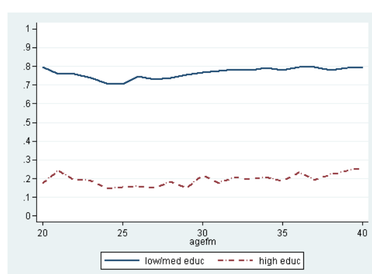
(a) 2000: older husband



(b) 2009: older husband



(c) 2000: less educated husband



(d) 2009: less educated husband

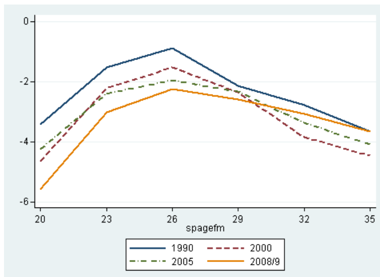
5 Returns to marriage 1990-2009

In this section we more formally examine the gains to marriage for newlywed men and women between 1990 and 2008/9. Again, we are mainly interested in whether the data provide evidence of a "success penalty" for women who attend university. In section 5.1, we study the average payoffs from different marriages using the classic Choo-Siow (2006) framework. In this framework, the distribution of newly formed marriages and the share of singles (those who opted not to marry) across individuals of different age-education types tells us the relative average discounted gains to each potential marriage of a type i man with a type j woman, where a "type", for both men and women, is differentiated by age and education. By comparing across our four "marriage markets", we can observe how these average gains change over time as well as across individual types. If there is a "success penalty" for high educated women, we should expect to see women of high education less well off in terms of marriage market outcomes than women of medium education; if this is a new or worsening phenomenon we should see this penalty increasing as we move closer to the present. Similarly, if there is a cost to delaying marriage (often associated with time spent in school), we should calculate lower marriage gains for women with older first marriage ages. In section 5.2, we explore returns in a dynamic context using the extension recently developed by Choo (2016). Because population vectors are not constant, but are changing over time (a secular increase in educational attainment as well as a gradual increase in the male to female gender ratio) implementing the Choo estimator requires us to make assumptions about individuals' expectations about the characteristics of marriage markets they will encounter in future years, as well as about the likelihood of divorce. We close the section in 5.3 by examining associated changes in assortative mating on education over the period of interest.

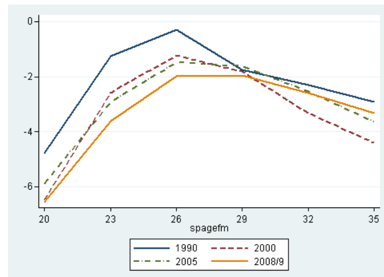
5.1 Gains to marriage in the Choo-Siow [2006] framework

Figures 3 and 4 show the calculated values of π and π^f (the total deterministic and female-specific deterministic gains) respectively for women between the (wife's marriage) age categories of 18-20 and 33-35 for all four years for which we have data. The upper panels show the deterministic gains using our fixed education categories and the lower panels show the gains when using our moving or constant-shares education categories. In appendix C we show corresponding figures for medium- and high-educated men between the age groupings 21-23 and 36-38, in terms of π and π^m, also by (husband's) age of first marriage.

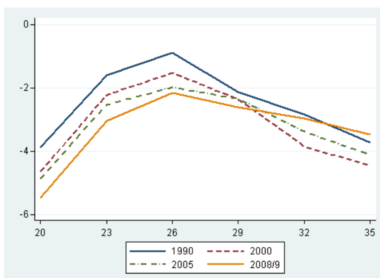
Figure 3: π by age for medium and high-educated women



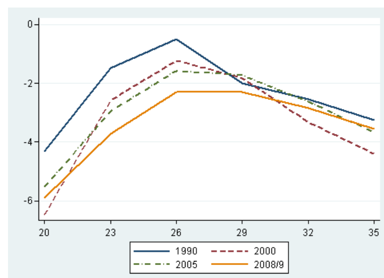
(a) Medium-educated women: fixed education



(b) High-educated women: fixed education



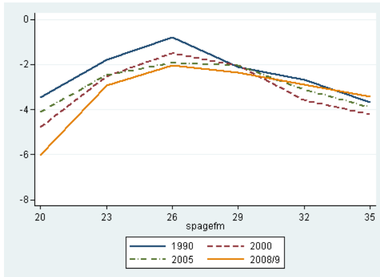
(c) Medium-educated women: moving education



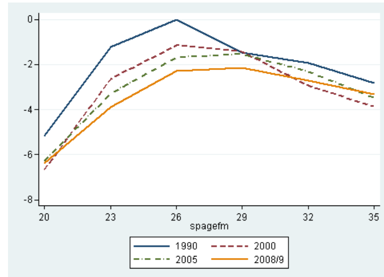
(d) High-educated women: moving education

We begin by noting that the estimated πs are everywhere negative, that is for every age and education level and in every year, which is a common feature of CS models. In any marriage market (even over our three-year interval and given the very high completed marriage rates in China), most individuals opt to remain single, so the average or deterministic gains are likely to be low, and only those individuals who draw very high values of the idiosyncratic utility of marrying their preferred spouse type actually marry and thereby exit the marriage market. We also note that the gains to marrying first rise and then fall in the bride's age. (In appendix C we show that the same holds for men with respect to groom's age, though the peak age is later, as we would expect.) This pattern holds in every year. Third, marriage surplus is in general highest for the men and women with the highest education, although this fact is actually more pronounced when

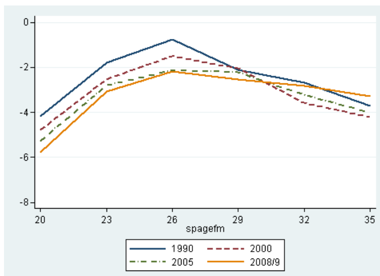
Figure 4: π^f by age for medium and high-educated women



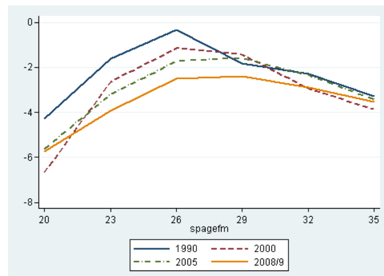
(a) Medium-educated women: fixed education



(b) High-educated women: fixed education



(c) Medium-educated women: moving education



(d) High-educated women: moving education

we use the fixed rather than the moving education categories, which suggests that marriage gains to education are not concentrated at the very top of the education distribution.

Comparing across the years, we see that on average marriage gains have been decreasing: they are highest in 1990 and at younger ages fall monotonically across time. At later ages, however, this monotonicity breaks down: in general, for women who marry after age 30, gains are largest, or second largest after the 1990 gains, in the 2008/9 sample. Combined with the lower returns to marrying at earlier ages, the age-profile of marriage gains has clearly been flattening over time. The picture is almost identical for the female-specific gains π^f as the joint per-capita returns π, though it is not the case that π^f is on average higher for high-educated women. The pattern also does not appear to be education-specific; indeed, though we omit the low-type graphs for space, the same flattening holds for low as well as for medium and high educated women, although the lowest-educated women also have also on average the lowest πs. Overall, we see no evidence of a specific marriage market penalty to high educated women. There is a penalty to delayed marriage (which is linked to more education) but it appears to be decreasing rather than increasing with time.

To study the question of delay-based penalties more directly, table 5 displays the results of four regressions, each in a separate column. The dependent variables are average per-capita gains π (columns 1 and 3) and wife-specific gains π^f (columns 2 and 4), respectively for our fixed and moving education categories. These are regressed against our main variables of interest: husband and wife indicators for high-type education and their interactions with year dummies for 2000, 2005, and 2009 (1990 is the omitted category). The sample of couples is the same as used to make the graphs and includes medium- and high-type married individuals of first marriage ages 15-17 up to 39-41, in three year intervals. Year dummies (again with 1990 as the reference group) control for any secular trends that affect everybody in the urban Chinese marriage market. Finally, both first marriage age and its square for both spouses are added as controls to extract any average age effects out of the education effects we are trying to capture. Although the πs have an intuitive interpretation, coefficients capturing changes in π with type and year are less directly interpretable in terms of units. We therefore normalize the π so that the coefficients represent standard deviations from the sample mean π taken across all the years.

Compared to the graphs, what table 5 tells us is that, once we control for husband's education and marriage ages of both partners, the wife's education has a null effect on total marriage gains: -1.6% (12.8% -14.4%) of a standard deviation in 2008/9. Using the moving education categories, the direct effect of the wife's education on marriage gains is actually negative, reducing gains by a small but statistically significant 18% of a standard deviation in 2008/9. The greater average gains to high-educated women seen in the graphs (40% of a standard deviation averaged across high vs. medium educated women in 2008/9) are therefore driven not by the returns to education itself but by more beneficial matches among this group. The same patter holds, to a lesser extent, for husband's education, for which the direct returns in terms of marital surplus have also fallen over time.

The second column confirms this sorting story. π^f is strongly increasing over time in *husband's*

Table 5: Marriage gains and education

VARIABLES	(1) π: fixed	(2) π^f: fixed	(3) π: moving	(4) π^f: moving
high ed husband	0.418***	-0.124***	0.436***	-0.00520
	(0.0170)	(0.0201)	(0.0176)	(0.0206)
high ed husband x 2000	-0.226***	0.157***	-0.252***	0.0299
	(0.0262)	(0.0310)	(0.0268)	(0.0314)
high ed husband x 2005	-0.181***	0.577***	-0.246***	0.0874**
	(0.0325)	(0.0385)	(0.0313)	(0.0367)
high ed husband x 2009	-0.0653***	0.832***	-0.461***	-0.239***
	(0.0190)	(0.0226)	(0.0192)	(0.0226)
high ed wife	0.128***	0.700***	-0.0108	0.343***
	(0.0190)	(0.0225)	(0.0185)	(0.0218)
high ed wife x 2000	-0.179***	-0.558***	-0.0451	-0.203***
	(0.0277)	(0.0329)	(0.0277)	(0.0325)
high ed wife x 2005	-0.158***	-1.095***	0.0496	-0.239***
	(0.0329)	(0.0390)	(0.0318)	(0.0374)
high ed wife x 2009	-0.144***	-1.310***	-0.167***	-0.446***
	(0.0207)	(0.0245)	(0.0202)	(0.0238)
Observations	56,435	56,435	57,995	57,995
R-squared	0.495	0.573	0.455	0.556
Year FE	YES	YES	YES	YES
FMA Quad Effects	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

education but decreasing in own education (using the fixed categories). The opposite is true for π^m which is the difference between 2π and π^f. With reference to the fixed education categories, this result should not be too surprising. The secular increase in education for both genders means that high educated mates are becoming less scarce while the average quality within an education category (in terms, say, of earning potential) is likely to be falling. Higher educated men and women are thus less valuable per se but benefit from their ability to marry good quality mates. This finding is a bit different for the moving education categories since, in this case, we are controlling at least in part for changes in supply, of both own and partner types. π^f is now falling in both own and husband's education as of 2008/9 though more in own education (which also slightly reduces π) and conditional on first marriage age. This does suggest that the marriage market may be shifting against the highest quintile of educated women, perhaps due to sticky gender norms.

To summarize our findings, tables 6 (for the fixed education categories) and 7 (for the moving education categories) report the average gains to marriage in each of the four years (after year effects are removed) for wife-husband couples of medium-medium, medium-high, high-medium, and high-high type. Again, the numbers give standard deviations, but this time relative to the year-specific means. Once again, we see that gains are highest under positive sorting, and highest for the most educated couples in all years, though the difference between high-high and medium-medium couples is decreasing over time, especially for the moving education categories. However, the female-specific cost of marrying down is smaller for the more elite group of women, likely because of the declining value of *men*'s elite education in the marriage market seen in table 5.

5.1.1 Is there a cost to delaying marriage?

We now address our second question: do women pay a penalty for delaying marriage conditional on education? Table 8 regresses the same dependent variables π and π^f against indicators for husband's and wife's age of first marriage interacted with year dummies, while controlling for year fixed effects and educational attainment of both spouses (using the fixed categories in columns 1 and 2, and the moving in columns 3 and 4), for the same sample of medium and high-type married

Table 6: Average systematic gains by year: fixed education

Year	$\pi_{avg}\{medium, medium\}$	$\pi_{avg}\{high, medium\}$	$\pi_{avg}\{medium, high\}$	$\pi_{avg}\{high, high\}$
1990	-0.110	-0.948	-0.080	0.664
2000	0.010	-0.994	-0.302	0.464
2005	0.052	-1.166	-0.543	0.359
2009	-0.007	-1.146	-0.561	0.360
Year	$\pi^f_{avg}\{medium, medium\}$	$\pi^f_{avg}\{high, medium\}$	$\pi^f_{avg}\{medium, high\}$	$\pi^f_{avg}\{high, high\}$
1990	-0.047	-0.446	-0.524	0.694
2000	0.042	-0.746	-0.486	0.533
2005	0.128	-1.416	-0.361	0.271
2009	0.123	-1.562	-0.261	0.195

Table 7: Average systematic gains by year: moving education

Year	$\pi_{avg}\{medium, medium\}$	$\pi_{avg}\{high, medium\}$	$\pi_{avg}\{medium, high\}$	$\pi_{avg}\{high, high\}$
1990	-0.060	-1.047	-0.122	0.484
2000	0.010	-0.994	-0.302	0.464
2005	-0.006	-0.737	-0.501	0.494
2009	0.208	-1.103	-0.593	0.317
Year	$\pi^f_{avg}\{medium, medium\}$	$\pi^f_{avg}\{high, medium\}$	$\pi^f_{avg}\{medium, high\}$	$\pi^f_{avg}\{high, high\}$
1990	0.026	-0.683	-0.441	0.475
2000	0.042	-0.746	-0.486	0.533
2005	-0.019	-0.684	-0.694	0.430
2009	0.100	-1.073	-0.996	0.156

individuals. We consider newlyweds as “young” if they marry before 25 (women) or 27 (men), and “old” if they marry after 30 (women) and 32 (men). The omitted category are those who marry in their mid to late 20s (25-29 for women, 27-31 for men).

In 1990, there is a significant across-the-board cost to delaying marriage for both men and women, with a larger penalty for men. The coefficients of first marriage age interacted with later year dummies represent the change in this cost with time after 1990. In general, this penalty worsens in 2000 and then begins to mitigate for both genders. It is easy to see that by 2008/9, more than half of the original (1990) penalty associated with husbands' delayed marriage, and nearly half of the original penalty for wives, has disappeared. According to the estimates, delaying marriage to after 30 actually increases wife-specific gains π^f by 2008/9 when we control for educational attainment using our constant shares categories (recall that in 2008/9 this means including a dummy for having attended university), although total average per-capita gains are still lower by 37% of a standard deviation relative to the omitted category of younger bride. Since these older brides marry older grooms on average, the results suggest that women who delay marriage become relatively scarce which drives up their personal returns from marriage. It also suggests that the overall higher gains for (fixed category) high-educated women are driven mainly by the fact that these women marry at more favorable ages.

5.1.2 Fertility rates

Overall, we see some limited evidence of a marriage market penalty to high educated women, but not one large enough to encourage women to forego marriage. Moreover, the traditional penalty to delayed marriage appears to be decreasing over time for both men and women who increasingly marry at older ages. This being said, the Chinese government may have other reasons for trying to warn women off delaying marriage. For example, policy makers may be concerned with declining fertility rates associated with delayed marriage.

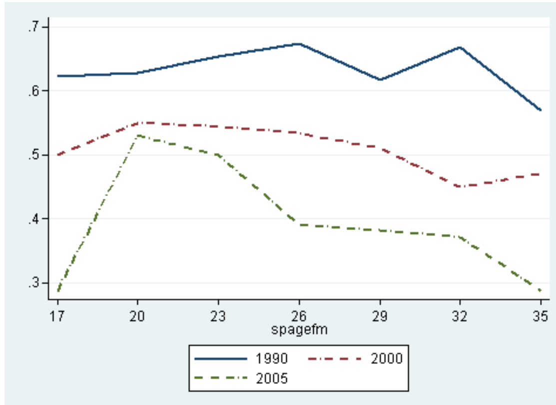
Figure 5 displays prevalence of child birth amongst newly-weds by first marriage age over time. First, it is important to note that, given the nature of the setup, the figure cannot be interpreted

Table 8: Gains to marriage by spouses' age of marriage

VARIABLES	(1) π: fixed	(2) π^f: fixed	(3) π: moving	(4) π^f: moving
young husband	0.797***	0.963***	0.682***	0.760***
	(0.0241)	(0.0253)	(0.0220)	(0.0201)
young husband x 2000	-0.811***	-0.679***	-0.722***	-0.584***
	(0.0348)	(0.0365)	(0.0308)	(0.0282)
young husband x 2005	-0.991***	-0.916***	-0.876***	-0.749***
	(0.0409)	(0.0429)	(0.0359)	(0.0329)
young husband x 2009	-1.042***	-1.040***	-0.919***	-0.825***
	(0.0263)	(0.0276)	(0.0235)	(0.0215)
young wife	-1.141***	-1.638***	-1.101***	-1.380***
	(0.0207)	(0.0217)	(0.0185)	(0.0170)
young wife x 2000	0.153***	0.164***	0.204***	0.247***
	(0.0317)	(0.0333)	(0.0278)	(0.0255)
young wife x 2005	0.0851**	0.291***	0.119***	0.256***
	(0.0387)	(0.0406)	(0.0338)	(0.0309)
young wife x 2009	-0.0610***	0.246***	0.0491**	0.292***
	(0.0236)	(0.0247)	(0.0209)	(0.0191)
mature husband	-0.957***	-1.602***	-0.853***	-1.239***
	(0.0330)	(0.0346)	(0.0299)	(0.0274)
mature husband x 2000	-0.215***	-0.0239	-0.150***	-0.00824
	(0.0526)	(0.0552)	(0.0463)	(0.0424)
mature husband x 2005	0.256***	0.555***	0.259***	0.441***
	(0.0531)	(0.0557)	(0.0467)	(0.0428)
mature husband x 2009	0.639***	0.705***	0.611***	0.552***
	(0.0351)	(0.0368)	(0.0314)	(0.0287)
mature wife	-0.864***	-0.377***	-0.757***	-0.305***
	(0.0367)	(0.0385)	(0.0328)	(0.0300)
mature wife x 2000	-0.687***	-0.573***	-0.571***	-0.453***
	(0.0803)	(0.0843)	(0.0699)	(0.0639)
mature wife x 2005	-0.0711	-0.0134	-0.00767	0.0406
	(0.0733)	(0.0770)	(0.0639)	(0.0584)
mature wife x 2009	0.324***	0.337***	0.388***	0.394***
	(0.0401)	(0.0421)	(0.0353)	(0.0323)
Observations	56,435	56,435	57,995	57,995
R-squared	0.454	0.496	0.405	0.495
Year FE	YES	YES	YES	YES
Education dummies	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5: Rate of first child birth by 1st marriage age



using the standard definition of "fertility". Since our data simply look at newly-weds who have been married three years or less before the time of the survey, Figure 5 actually plots the percentage of newly-wed couples whose first child is born between the time of their marriage and the time of the survey. We include only couples for whom neither the spouse nor a child is clearly absent (recall table 2). We also exclude the 2008/9 newlyweds since we use evidence on the timing of fertility within marriage from 2005 (and a subsample of 2000) to impute first marriage age, so the 2009 fertility profile will be mechanically similar to the 2005 profile.

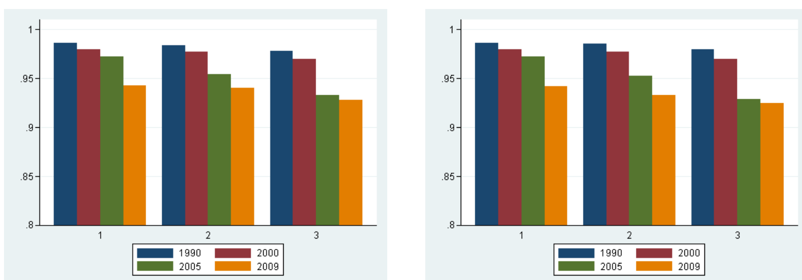
Figure 5 indicates that newlywed fertility is falling over time, suggesting that newlyweds increasingly delay child-bearing after marriage. More interestingly, in 2005, but not before, we see a decline in newlywed fertility with the age of the wife at marriage. Since women who marry older have less option to delay pregnancy, the pattern may suggest that some women (couples) are simply opting not to have children. However, we note that this graph in particular should be interpreted with caution due to the large number of missing household members in 2005.[19]

Figure 6 examines near-complete fertility rates for women between 33 and 36 for 1990, 2000, 2005, and 2008/9. For this graph we are able to make use of the census questions on surviving children and therefore keep all married women in the census and bring in the 2008/9 results. The age range

[19] Another possibility is that in 2005 we are observing more second marriages at later ages so any births would not be the first birth experienced by the woman. Reported rates of second marriages are still quite low however, at about 2.6% of reported marital statuses and remains constant between 2000 and 2005, the only years we can observe this information.

33-36 is chosen so that women will be near their completed fertility but still likely to have their children present in the household, at least part of the year, which is necessary to identify them in the 2008/9 UHS. Here we see some evidence that fertility has fallen over the period under study, and this decline has been concentrated among the educated, a trend that is slightly more evident based on our moving education categories (right panel): (near) complete fertility rates fall among the highest educated 20% of women from 97.5% to 92% between 1990 and 2008/9, while for the lowest 40% the fall is more modest: from 98% to 94.5%. If high type women are opting to delay or even forego childbearing, even if their gains to marriage or ability to make good matches is not falling over time, the Chinese government may see calling for earlier marriages, especially among high-type women, as a means of "upgrading population quality (suzhi)."

Figure 6: Near-complete fertility rates by year and education: Categories 1 (low) to 3 (high)



(a) Fixed education categories (b) Moving education categories

5.2 Dynamic returns: the Choo (2016) model

Next, we examine how our estimates differ when we turn to the explicitly dynamic context of Choo (2016). To implement the estimator, we assume that a new marriage market is formed every three years (that is, the old marriage market clears and all individuals remaining in the market enter the next age category) and that the triannual discount rate is $\beta = .94$. In the benchmark analysis, we assume there is no divorce or mortality before the terminal age of 44 and that individuals cease to receive utility from marriage after age 41 (specifically age category 39-41). Whereas Choo imposes demographic accounting constraints so that the number of single and married individuals updates endogenously, we instead impose exogenous changes over time in the gender-specific education shares and also in the gender ratio so that population vectors **m** and **f** change over time.

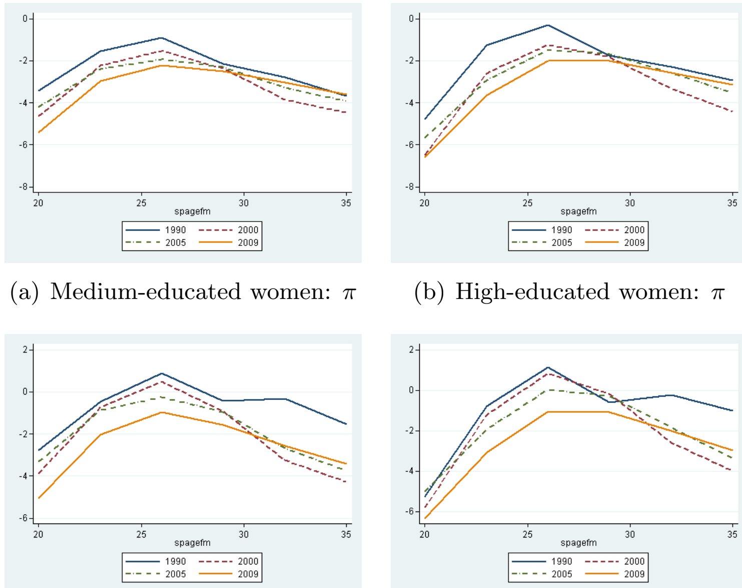
Because the economy is not stationary, we of course require more than a single cross-section to estimate the gains for any marriage market since these gains depend on expectations about future marriage markets. As well, we need to take a stand on the nature of individuals' expectations. We consider two extreme assumptions. Under our first approach, all agents are myopic and assume that the marriage market in the current year is a stationary equilibrium. This is a typical assumption in the marriage matching literature because it allows marriage market equilibria to estimated from single cross-sections of data (typically censes) and greatly simplifies the analysis when dealing with cohorts who have the option to participate in marriage markets that have not formed yet.

The results from our "myopic" dynamic estimator are shown in figure 7. The estimated gains should be interpreted as time-specific cross-sectional rather than cohort-specific gains: that is, we are estimating the deterministic gain to marrying for at a given age in a given marriage market (e.g. 36-38 year olds in the 1989-90 marriage market.) Figure 7 show how these cross-sectional gains are changing over time for women marrying in the age groups 18/20-33/35. The top panel shows the static πs estimated in the previous section while the lower panel shows the corresponding estimates of Π in the myopic agent case. The first thing to notice is the scales of the graphs: the Πs are in general higher than the πs, and become positive at the most advantageous marriage ages, 24-26, in 1990 and 2000. This result echoes Choo 2016's findings based on U.S. census data. The reason is that the Πs are interpreted as the gains to being married to a given spouse relative to being single *over the expected duration of the match*, rather than only in the given period.

Second, the fall in the average Π across the years for women under about 27 is much more pronounced in the dynamic than in the static case. This is because, over the years, the highest systematic payoffs from marriage occur at later and later ages, which young agents discount at an annual rate of approximately 2%. The further in the future are the greatest gains associated to waiting, the lower the benefits of marriage in the current period needed to induce a share of singles to marry now.

Under our second approach, we assume that agents in every cohort are forward looking: they

Figure 7: π and Π by age for medium and high-educated women (fixed education categories)



(a) Medium-educated women: π

(b) High-educated women: π

(c) Medium-educated women: Π

(d) High-educated women: Π

are informed about the marriage markets they will encounter in the future at older ages, which depend on the parameters Π and on the population vectors $\mathbf{m}$ and $\mathbf{f}$, all of which evolve over time. While this assumption of forward-looking agents is a more traditional approach in economic modeling, in our case it introduces some complications. The 1990 marriage market is complete in the data since 17 (20) year old women (men) in 1990 are 36 (39) in 2009, and therefore have completed their marital history under our assumptions. The remaining three marriage markets are not completely represented in the data, however, since the choices that 20 year olds make in 2000 (and hence the estimated payoffs they receive from marrying in the current marriage market) depend on their expected payoffs they would receive in subsequent marriage markets up to 2018. Therefore, estimating these payoffs under rational expectations requires simulation. Up to 2008/9, the time-varying, exogenous (to the marriage market) population vectors and the μs can be taken straight from our data sources, the 1990, 2000, and 2005 census files and the 2008/9 UHS. For the intermediate marriage markets, we can simply interpolate the population shares agents expect to face. These serve as simulation targets. For future marriage markets, we make use of the fact that the CS (and by extension the Choo) estimators allow us to construct the elements of μ that individuals expect to characterize future marriage markets. Specifically, we use the fact that (from Choo's equations 3.33 and 3.34 applied to our out-of-steady-state model):

$$
\begin{aligned}
m_{i,t} - \mu_{i,0,t} - \sum_{i=1}^{N} \widetilde{\Pi}_{i,j,t} \sqrt{m_{i,t} f_{j,t}} \prod_{k=0}^{T_i-1} \left(\frac{\mu_{i'(i,k),0,t+k}}{m_{i'(i,k),t+k}}\right)^{.5\beta^k} \prod_{k=0}^{T_j-1} \left(\frac{\mu_{0,j'(j,k),t+k}}{f_{j'(j,k),t+k}}\right)^{.5\beta^k} &= 0 \\
f_{j,t} - \mu_{0,j,t} - \sum_{j=1}^{N} \widetilde{\Pi}_{i,j,t} \sqrt{m_{i,t} f_{j,t}} \prod_{k=0}^{T_i-1} \left(\frac{\mu_{i'(i,k),0,t+k}}{m_{i'(i,k),t+k}}\right)^{.5\beta^k} \prod_{k=0}^{T_j-1} \left(\frac{\mu_{0,j'(j,k),t+k}}{f_{j'(j,k),t+k}}\right)^{.5\beta^k} &= 0 \qquad (10)
\end{aligned}
$$

where t indexes the marriage market in question, T_i and T_j give the amount of time a man in state i and a woman in state j have left in the marriage market (see section 3), and, as before, N is the number of types, which is symmetric across men and women in our model. The only new parameter is $\widetilde{\Pi} = \exp(\Pi)$. If we take the vector Π as given this system generates a system of $2 \times 8 \times 3$ (gender $\times$ age categories $\times$ education levels) equations and unknowns for each marriage market.[20] It is then easy to calculate the $\Pi_{i,j,t}$ using equation 3.1 in Choo (2016). To identify the system, we make the following two assumptions: (1) the education shares within each gender remain constant at their 2009 levels (which are reasonably close to U.S. education shares in urban areas); and (2) the fundamental payoffs to each type of marriage Π also remain constant after 2009. This latter assumption is questionable given the trajectory of Π shown in figure 7, and it can be relaxed to some extent so long as we assume that Π evolves after 2009 in a deterministic way. By contrast, we assume that the gender ratio continues to evolve reaching an equilibrium in 2020 after which all population shares $\mathbf{m}$ and $\mathbf{f}$ are constant. We use data on the distribution of children under 20 in 2009 to set $\mathbf{m}_t$ and $\mathbf{f}_t$ for $t > 2009$.

[Results TBA]

[20] The age groups are 15/17 - 36/38 for women and 18/20 - 39/41 for men. We assume nobody can marry after these ages so that $\mu_{i,0,t} = m_{i,t}$ and/or $\mu_{0,j,t} = f_{j,t} \forall t$ at these ages. Individuals receive utility α and γ from their marriage or from singlehood until the terminal age category 42/44.

5.3 Assortative mating

From section 5.1, we see evidence that the returns that high educated women reap in the marriage market come largely from their ability to make better matches. Education beyond high school is only valuable in the marriage market when it is paired with a husband's college or more education. It is therefore of interest to understand trends in assortative mating over time. Tables 9 and 10 report summary statistics using our fixed education categories: specifically, the shares of medium and high educated women married to low (column 1), medium (column 2), and high (column 3) educated men in each of our four sample periods. The trend toward higher education of both genders is clear in the tables, as is the prevalence of positive assortative mating on education. In all four years, high educated women are more likely than the medium educated to have a high-educated spouse and less likely than medium educated women to have a low or medium-educated spouse.

Table 9: % Medium type women married to each husband educ type

husband type:	*low*	*medium*	*high*
1990	0.316	0.528	0.156
2000	0.207	0.515	0.278
2005	0.199	0.515	0.287
2008/9	0.123	0.540	0.337

Table 10: % High type women married to each husband educ type

husband type:	*low*	*medium*	*high*
1990	0.097	0.219	0.684
2000	0.042	0.200	0.758
2005	0.040	0.146	0.814
2008/9	0.019	0.155	0.826

Next, we use two techniques, borrowed from Greenwood et al. (2014), to look more formally at the extent of positive assortative mating after controlling for changes in supply. Table 11 shows how the wife's predicted education changes with husband's education over time.

Column (1) is a basic regression of wife's education level (1 for "low", 2 for "medium", 3 for "high") on husband's education interacted with year dummies and controlling for province fixed effects, but not controlling for year fixed effects. Since our regressors are indices, there is no intuitive interpretation in terms of units and we focus on signs and relative magnitudes. The

Table 11: Assortative mating on education 1990-2009

	(1) wife's education level	(2) wife's education level
husband's educ level	0.491***	0.422***
	(0.002)	(0.003)
husband's educ level × 2000	0.049***	0.133***
	(0.001)	(0.003)
husband's educ level × 2005	0.099***	0.222***
	(0.002)	(0.006)
husband's educ level × 2008/9	0.155***	0.248***
	(0.001)	(0.003)
Year FE		YES
Prov FE	YES	YES
Observations	428715	428715

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

interpretation of coefficients is similar to the regressions in section 5.1 in that the coefficient on husband's education represents the relationship in 1990 and the coefficients on the subsequent terms represent the change between 1990 and the year indicated. The basic regression in column 1 suggests that positive assortative mating on education increased significantly over the course of the two decades and that husband's education is a better predictor of wife's education in 2009 than it was in 1990. Without controlling for year fixed effects, however, we will confound changes in assortativeness with the secular rise in education levels for the younger married population. Once we control for year fixed effects in column (2), we see that the time trend in positive assortative mating is actually steeper. High-educated men (who under standard theory of marriage markets have the best opportunity to marry whomever they like) do not appear to be opting to "marry down" at higher rates, leaving a pool of high-educated women without high-educated partners, as suggested in the context of the "Asian Tiger" economies by, for example, Kawaguchi and Lee (2012).

The second method we consider compares the pattern of actual matches to what would occur under random matching. Table 12 shows the actual couple shares in 1990, 2000, and 2008/9 by education types (the left entries) vs the shares that would arise if couples were randomly assigned within provinces (the right entries). The diagonal entries of each panel are bolded where husband and wife have the same education level. We can then compute a statistic δ as the ratio of the sum of the diagonal for actual vs randomized bolded values. The consistent $\delta > 1$ indicates persistent positive assortative mating (the bottom row of each panel). δ increases from 1990 to 2000 and then falls to 2008/9 due to the large rise in education for both genders. When we consider, in the bottommost panel, the 2008/09 "moving" education categories which adjust for this secular rise in education, we see that assortative mating in fact rose between 2000 (for which the fixed and moving education categories are the same) and 2008/9.

Table 12: Assortative vs random matching: 1990-2009

			1990			
	Wife					
Husband	Low		Medium		High	
Low	**0.357**	**0.179**	0.129	0.193	0.027	0.088
Medium	0.131	0.240	**0.219**	**0.148**	0.065	0.043
High	0.007	0.076	0.016	0.023	**0.050**	**0.010**
			$\delta = \mathbf{1.85}$			
			2000			
	Wife					
Husband	Low		Medium		High	
Low	**0.272**	**0.073**	0.137	0.144	0.032	0.131
Medium	0.078	0.157	**0.194**	**0.150**	0.104	0.089
High	0.008	0.127	0.037	0.073	**0.139**	**0.056**
			$\delta = \mathbf{2.16}$			
			2008/9			
	Wife					
Husband	Low		Medium		High	
Low	**0.126**	**0.013**	0.078	0.077	0.023	0.113
Medium	0.042	0.038	**0.187**	**0.126**	0.116	0.140
High	0.008	0.126	0.066	0.128	**0.352**	**0.239**
			$\delta = \mathbf{1.76}$			
			2008/9: Moving education categories			
	Wife					
Husband	Low		Medium		High	
Low	**0.302**	**0.073**	0.102	0.184	0.020	0.091
Medium	0.079	0.166	**0.242**	**0.144**	0.094	0.095
High	0.008	0.148	0.040	0.055	**0.116**	**0.043**
			$\delta = \mathbf{2.53}$			

6 Conclusion

In conclusion, unlike Korea, Japan, Taiwan, and Singapore, we do not see evidence up to 2009 that China's domestic marriage market is experiencing declining marriage rates among women, overall or among those with the highest educational attainment. In fact, Chinese women with college or more education have completed marriage rates (by ages 35-40) that are comparable to, or even slightly higher than, their less-educated female counterparts. We find somewhat mixed evidence as to whether women of higher education suffer a "success penalty" in marriage markets. The systematic marriage market returns to education, particularly in the top quintile of the education distribution, appear to be falling for both men and women. Because of strong positive assortative mating, however, high educated women still attain higher surplus on average than medium educated women in the last year for which we have sufficient data, 2008/9. With respect to the cost of delaying marriage, this paper finds evidence of an initial significant penalty that dissipates over time as the marriage gains profile becomes flatter in age for more recent marriage markets. This result holds whether we consider a classic Choo-Siow estimator of marital gains or the dynamic estimator recently proposed by Choo (2016), and also despite evidence of a gradual secular decline in returns to marriage for all individuals. Falling returns to young marriage may be related to falling fertility, especially among high educated women, whose fertility rates are lowest and have fallen the most over the sample period. Of course, we require data from more recent years to know whether these trends will continue, particularly as China's population becomes increasingly educated, rural-urban migration becomes easier, and the population ratio of marriage-aged individuals becomes increasingly favorable to women.

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A Details on identifying couples in the censes and UHS

First, in terms of preliminary data cleaning, note that there are two types of households {familial, collective}. For unique couple matching using ‘relationship to household head’ labels, we drop collective households and only look at individuals of familial household types. Households with more than one household head or spouse of household head are dropped. We also pair up ‘child’ with ‘child-in-law’, ‘parent’ with ‘parent-in-law’, as well as those with the same label as their spouse (‘grandparent’, ‘grandchild’, ‘sibling’, and ‘other relative’), who are listed as living together in the same household, of opposite sex, and married at the same point in time. Where there is ambiguity because more than one set of is possible (for example there are two children and two children in law in the household) we match people on reported marriage tenure where available (2000 and 2005) and on age (minimizing the sum of the age differences over the couples) where it is not (1990 and 2009, though in the latter case the number of ambiguities is negligible). Each matched couple is then assigned their unique couple ID. With regards to calculating marriage πs, we maintain consistency between our single and married samples by only retaining couples wherein both husband and wife have urban hukou.

Additionally, since the 2008/9 NBS UHS is an exclusively urban sample from select provinces, we likewise restrict the sample of our censuses to urban-with-urban-hukou individuals of the same set of provinces. Specifically, for urban hukou, we look at non-agricultural hukou holders. To identify urban areas, the China Statistical Yearbook lists, for each historical year, the percentage of the national population residing in urban areas. We employ each year-specific value as an ‘urban cutoff’ by ranking county codes from most to least urban (using the prevalence of urban hukou holders as a percentage of all county dwellers as a proxy) and retaining the higher-ranking county codes to the left of the cutoff as ‘urban’ (i.e. each county code has a population that constitutes a percentage of the national total; from these percentages and using the order of our urban ranking, we can construct a county code population CDF of sorts, for which the Statistical Yearbook provides a cutoff value — all county codes to the left of this year-specific cutoff we consider as ‘urban’, dropping the rest as ‘rural’).

In some survey years more than others, there are married-but-unmatched individuals. These are individuals who are listed as having a marital status of 'married' but whose spouse, for unknown reasons, is missing from the survey. To combat the costly drainage of missing spouses on our sample of matched couples, we generate, for each survey year, hypothetical spouse attributes for married-but-unmatched individuals based on the observable match type combinations of couples where both spouses are surveyed. We do this simulation separately for men and women of first marriage ages 17-41 and educational attainment {low, medium, high}. Recall that first marriage age and educational attainment constitute the two dimensions of our 'type' classification. For each survey year, we start with obtaining the empirical PDF distribution over spouse types observed for each type of a given gender from observable matched couples. For example, type i men can marry any of the J types of women. From our sample of successfully matched couples, the percentage of type i men observed to be married to each type of the J types of women forms the empirical PDF over wife types for type i men. Empirical PDFs over wife types can be obtained for all I types of men. Repeating this process, empirical PDFs over husband types can be obtained for all J types of women. It follows that hypothetical spouse types can be assigned probabilistically to married-but-unmatched individuals according to these empirical PDFs.

B Derivation of the Choo (2016) estimator

To derive the estimator (8), we follow the exposition in Choo (2016) very closely, as our estimator is simply a special case of his with no divorce, a two-dimensional type space for agents, and without the assumption that the marriage market is in dynamic steady state. The underlying framework is essentially the same as in the classic static model. A man g in state i who participates in the marriage market at t has a payoff given by:

$$\begin{aligned} v_{g,i,t}(a_g) &= \alpha_{0,i,t} + \epsilon_{0,g,i,t} && \text{if } a_g = 0 \\ &= \boldsymbol{\alpha}_{i,j,t} - \tau_{i,j,t} + \epsilon_{j,g,i,t} && \text{if } a_g \in \{1, N\} \end{aligned} \tag{11}$$

A woman h in state j who participates in the marriage market at t has corresponding utility

$$\begin{aligned} w_{h,j,t}(a_h) &= \gamma_{0,j,t} + \epsilon_{0,h,j,t} & \text{if } a_h = 0 \\ &= \boldsymbol{\gamma}_{i,j,t} + \tau_{i,j,t} + \epsilon_{i,h,j,t} & \text{if } a_h \in \{1, N\} \end{aligned} \tag{12}$$

In both cases a is the action taken by the individual in the period given an idiosyncratic preference draw $\boldsymbol{\epsilon}_{g,t}$, which is an $N+1$ dimensional vector of idiosyncratic preferences for each of the N types of agent in the marriage market (assumed symmetric by gender) and to staying single. The ϵs are uncorrelated across time and partner type and are drawn from the Type 1 Extreme Value distribution. Focussing on men, the action can be to take a spouse of type j, $a_g = j$ or to remain single $a_g = 0$. α_{0_t} is the average payoff to remaining single at age i in marriage market t. $\tau_{i,j}$ is an upfront transfer man i must make to woman j in order to marry her.

The gain to men from marrying a type j spouse is a discounted present value of future returns given by

$$\boldsymbol{\alpha}_{i,j,t} = \sum_{k=0}^{T_i - 1} \beta^k \alpha_{i,j,t+k}$$

and similarly for women:

$$\boldsymbol{\gamma}_{i,j,t} = \sum_{k=0}^{T_j - 1} \beta^k \gamma_{i,j,t+k}$$

where the T_i and T_j are the terminal periods for man of type i and woman of type j respectively and capture how many periods the individual has left to enjoy utility from marriage or potentially participate in the marriage market. β is the discount factor. Once an individual marries, they exit the marriage economy permanently and make no further decisions, simply receiving their payoffs each period. As well, a married individual experiences no further shocks ϵ. Therefore, the only dynamic concern in the model applies to singles who choose whether to marry their best option in the current marriage market t or wait until $t+1$ to try again with a new draw of $\boldsymbol{\epsilon}$.

Next, we define a value function for a single male g that expresses his payoffs as resulting from his optimal decision a_g in marriage market t under the usual assumption that he will always optimize in the future if faced with a choice.

$$V(i, \boldsymbol{\epsilon}_{i,g,t}, t) = \max \Big\{ \alpha_{0,i,t} + \beta \mathbb{E} V(i'(i,1), \boldsymbol{\epsilon}_{i',g,t+1}) + \epsilon_{0,g,i,t}, \\ \max_{a_g \in \{1,Z\}} \left\{ \boldsymbol{\alpha}_{i,a_g,t} - \tau_{i,a_g,t} + \epsilon_{a_g,g,i,t} \right\} \Big\} \tag{13}$$

and similarly for individual woman h:

$$W(j, \boldsymbol{\epsilon}_{j,h,t}, t) = \max \Big\{ \alpha_{0,j,t} + \beta \mathbb{E} W(j'(j,1), \boldsymbol{\epsilon}_{j',h,t+1}) + \epsilon_{0,h,j,t}, \\ \max_{a_h \in \{1,Z\}} \left\{ \boldsymbol{\gamma}_{a_h,j,t} + \tau_{a_h,j,t} + \epsilon_{a_h,h,j,t} \right\} \Big\} \tag{14}$$

Because the evolution of the vector $\boldsymbol{\epsilon}$ is i.i.d. across time and states (in Choo's formulation the evolution of the state space satisfies Conditional Independence of the systematic and idiosyncratic components, which remains the case even in the more complicated case with exogenous divorce and/or spousal mortality in which agents who marry expect to return to the marriage market at some point) the value functions can be re-written as

$$V(\cdot) = \max_{a \in \{0,N\}} \{ \tilde{v}_{i,a,t} + \epsilon_{a,i,g,t} \}$$

$$W(\cdot) = \max_{a \in \{0,N\}} \{ \tilde{w}_{j,a,t} + \epsilon_{a,i,h,t} \}$$

where $\tilde{v}$ and $\tilde{w}$ are the systematic or predictable parts of V and W (specifically, all the non-ϵ terms). This is the discreet choice problem used in logit estimation and can be solved in a method very similar to that used to derive the static Choo-Siow estimator using the facts that, under the Type 1 Extreme Value distribution of the idiosyncratic part of marriage gains, there is a closed form solution for the expected payoff from marriage in any period and for the likelihood of any particular match as a function of the systematic utility generated by that match.

Specifically, in the pivotal step of his derivation, Choo shows (see his appendix A.2), that, if we define $\mathbf{V}_{i,t} = \mathbb{E}\big(V(i, \boldsymbol{\epsilon}_{i,g,t}, t)\big) = \int V(\cdot)f(\boldsymbol{\epsilon})d\boldsymbol{\epsilon}$, then for any age up to and including the terminal age T, $\mathbf{V}_{i,t}$ takes a recursive form

$$\mathbf{V}_{i,t} = \alpha_{i,0,t} + c - \ln P_{i,0,t} + \beta \mathbf{V}_{i'(i,1),t+1} \tag{15}$$

where $P_{i,0,k}$ is the likelihood that a type-i man remains single in the marriage market at k and c is Euler's constant. For any age after T, $\mathbf{V}_{i,t} = 0 \;\forall i, t$. Similarly for women, let $\mathbf{W}_{j,t} = \mathbb{E}\big(W(j, \boldsymbol{\epsilon}_{j,h,t}, t)\big) = \int W(\cdot)f(\boldsymbol{\epsilon})d\boldsymbol{\epsilon}$, and

$$\mathbf{W}_{j,t} = \gamma_{0,j,t} + c - \ln Q_{0,j,t} + \beta \mathbf{W}_{j'(j,1),t+1} \tag{16}$$

where $Q_{0,j,k}$ is the likelihood that a type-j woman remains single in the marriage market at k.

In turn, by repeated substitution of the expected future payoffs into V and W, (15) and (16) allow us to express $\tilde{v}$ and $\tilde{w}$ as follows:

$$\begin{aligned}
\tilde{v}_{i,a>0,t} &= \boldsymbol{\alpha}_{i,a_g,t} - \tau_{i,a_g,t} \\
\tilde{v}_{i,a=0,t} &= \alpha_{0,i,t} + \sum_{k=1}^{T_i} \beta^k \big(\alpha_{i'(i,k),0,t+k} + c - \ln P_{i'(i,k),0,t+k}\big)
\end{aligned} \tag{17}$$

$$\begin{aligned}
\tilde{w}_{a>0,j,t} &= \boldsymbol{\gamma}_{a_h,j,t} - \tau_{a_h,j,t} \\
\tilde{w}_{a=0,j,t} &= \gamma_{j,0,t} + \sum_{k=1}^{T_j} \beta^k \big(\gamma_{j'(j,k),0,t+k} + c - \ln Q_{0,j'(j,k),t+k}\big)
\end{aligned} \tag{18}$$

Next, using the well known property of the Type 1 extreme value distribution that links probabilities to payoffs, we know that P is given by:

$$P_{i,j,t} = \frac{\exp(\tilde{v}_{i,j,t})}{\sum_{k=0}^{N} \exp(\tilde{v}_{i,k,t})}$$

we can derive the log-odds ratio for a type i man of forming a type $\{i, j\}$ match relative to remaining single as:

$$\begin{aligned} \ln\left(\frac{P_{i,j,t}}{P_{i,0,t}}\right) &= \tilde{v}_{i,j,t} - \tilde{v}_{i,0,t} \\ &= \boldsymbol{\alpha}_{i,j,t} - \tau_{i,j,t} - \boldsymbol{\alpha}_{0,i,t} - \sum_{k=1}^{T_i} \beta^k \big(c - \ln P_{i'(i,k),0,t+k}\big) \end{aligned} \tag{19}$$

where $\boldsymbol{\alpha}_{0,i,t} = \sum_{k=0}^{T_i} \beta^k \alpha_{i'(i,k),0,t+k}$, and similarly the log-odds ratio for a type-j woman of forming a type $\{i, j\}$ match relative to remaining single as::

$$\begin{aligned} \ln\left(\frac{Q_{i,j,t}}{Q_{0,j,t}}\right) &= \tilde{w}_{i,j,t} - \tilde{w}_{0,j,t} \\ &= \boldsymbol{\gamma}_{i,j,t} + \tau_{i,j,t} - \boldsymbol{\gamma}_{j,0,t} - \sum_{k=1}^{T_j} \beta^k \big(c - \ln Q_{0,j'(j,k),t+k}\big) \end{aligned} \tag{20}$$

Finally, to close the model, we use the fact that the (large) sample estimate of $\frac{P_{i,j,t}}{P_{i,0,t}}$ is given by $\frac{\mu_{i,j,t}}{\mu_{i,0,t}}$, of $\ln P_{i'(i,k),0,t+k}$ is given by $\frac{\mu_{i'(i,k),0,t+k}}{m_{i'(i,k),t+k}}$, of $\frac{Q_{i,j,t}}{Q_{0,j,t}}$ is given by $\frac{\mu_{i,j,t}}{\mu_{0,j,t}}$, and of $\frac{\mu_{0,j'(j,k),t+k}}{f_{j'(j,k),t+k}}$. Using these sample analogues imposes the assumption that, at marriage market equilibrium, we must have $P_{i,j,t} = Q_{i,j,t},\ \forall i > 0, j > 0, t$. Then, adding together the empirical analogues of (19) and (20),gathering the terms relating the probabilities together on the lhs, and adding and subtracting $\ln(m_{i,t})$ and $\ln(f_{j,t})$ from the lhs, we get

$$\ln\left(\frac{\mu_{i,j,t}}{m_{i,t}}\right) - \sum_{k=0}^{T_i-1} \ln\left(\frac{\mu_{i'(i,k),0,t+k}}{m_{i'(i,k),t+k}}\right)^{\beta^k} + \ln\left(\frac{\mu_{i,j,t}}{f_{j,t}}\right) - \sum_{k=0}^{T_j-1} \ln\left(\frac{\mu_{0,j'(j,k),t+k}}{m_{j'(j,k),t+k}}\right)^{\beta^k}$$
$$= \boldsymbol{\alpha}_{i,j,t} - \boldsymbol{\alpha}_{0,i,t} + \boldsymbol{\gamma}_{i,j,t} - \boldsymbol{\gamma}_{j,0,t} + \sum_{k=1}^{T_i} \beta^k c + \sum_{k=1}^{T_j} \beta^k c \equiv 2\Pi \tag{21}$$

where Π relates population vectors of singles of type i and j now and in the future to the discounted present value of entering a type $\{i, j\}$ match today relative the the discounted present value of both partners remaining single up to age T. If we further assume that the marriage market is in dynamic steady state, we can omit the t subscripts indexing the chronological order of the marriage markets, which gives us equation (8).

C Estimates for men

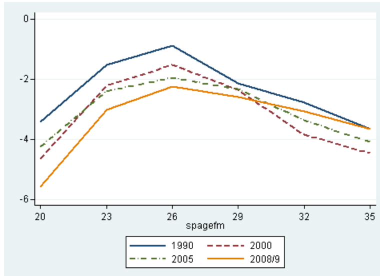
C.1 Men's education shares by census year

Table 13: Shares of men with educ {low,medium,high} by year

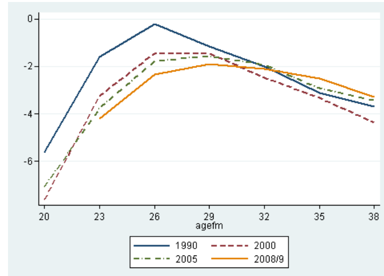
educ	1990	2000	2005	2009	2009*
Low	0.490	0.351	0.303	0.156	0.360
Medium	0.373	0.385	0.309	0.332	0.397
High	0.136	0.265	0.389	0.512	0.242

C.2 Static estimates of π and π^m by age of marriage

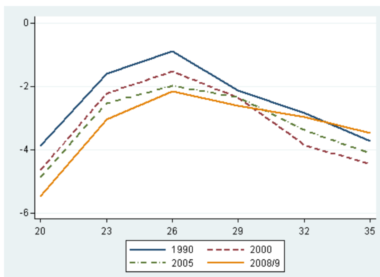
Figure 8: π by age for medium and high-educated men



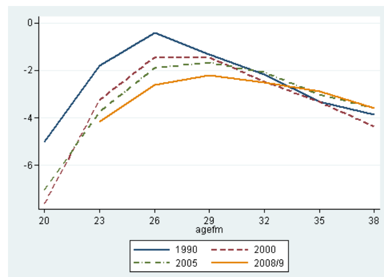
(a) Medium-educated men: fixed education



(b) High-educated men: fixed education

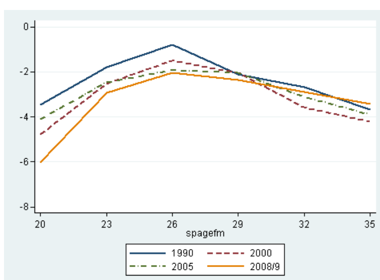


(c) Medium-educated men: moving education

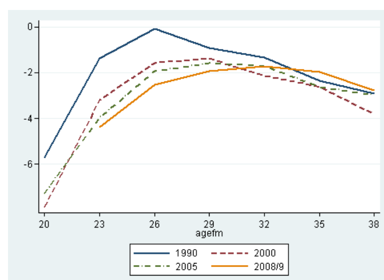


(d) High-educated men: moving education

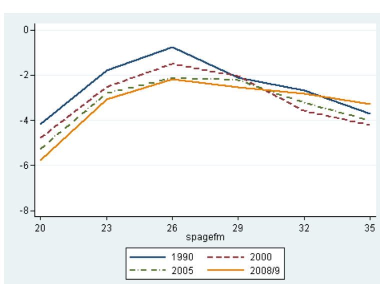
Figure 9: π^m by age for medium and high-educated men



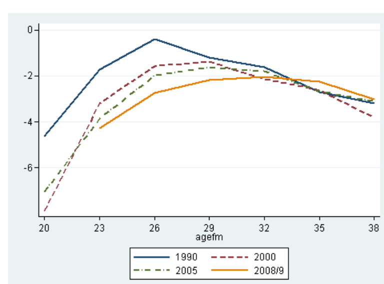
(a) Medium-educated men: fixed education



(b) High-educated men: fixed education



(c) Medium-educated men: moving education



(d) High-educated men: moving education