Terms of Engagement: Migration, Dowry, and Love in Indian Marriages

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Abstract

The Indian marriage market is characterized by extensive female migration, sizable dowries, and the widespread practice of arranged marriage. We develop and estimate a dynamic, general equilibrium, two-sided search and matching model to recover women's and men's preferences over spousal characteristics (such as age and education) and features of their marriage (including migration upon marriage, dowry payments, and women's involvement in the choice of their spouse). In counterfactual simulations, we study how changes in sex-ratios, women's education, and the practice of dowry, arranged marriage, and child marriage affect the equilibrium match and welfare in the marriage market.

Keywords: Matching; Marriage; Migration; India; Dowry; Arranged Marriage; Child Marriage.

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1 Introduction

With its large young population, more marriages take place annually in India than anywhere else in the world.[1] For an Indian family, there is often no greater event than a wedding, dramatically evoking social obligations, kinship bonds, traditional values, and economic resources. For an individual, marriage is a critical life-milestone, typically marking the transition from childhood to adulthood. Despite recent demographic and economic changes, the social cost of being unmarried in India remains high. To avoid remaining single, prospective brides and grooms (or their families) may trade-off features of their ideal marriage with the probability of finding a match. While other aspects of the Indian marriage market have been previously investigated, the scope of such trade-offs and their consequences for women's and men's welfare in the marriage market remain unknown.

To better understand this issue, we develop and estimate a dynamic, general equilibrium, two-sided matching model of the Indian marriage market. Our focus is on recovering the different preferences of men and women (or their families) over spousal characteristics and other specific features of their marriage.[2] Recovering the preferences underlying both sides of the marriage market allows us to understand how women and men trade-off various traits and features they find desirable, and how their chances of matching may affect these trade-offs. It also allows us to shed light on how recent demographic and social trends and policies (increasingly biased sex-ratios, the expansion of female education, the decline of arranged marriages, or the legal attempts to eliminate dowries and child marriage) may impact who marries whom, when, and on what terms.

Our model is built around equilibrium match terms, which we call the *terms of engagement*, and *spousal characteristics*, such as age and education. What distinguishes spousal characteristics from terms of engagement is that an individual searching for a match typically cannot change his or her own traits but can look for better terms (an action which is more likely when competition in the marriage market is low). In other words, a term is a feature of the match rather than of either partner.

We focus on three terms of engagement. Since most of India practice some form of patrilocal village exogamy (whereby women marry outside of their natal village and join their husband's family in his village), the first term of engagement we consider is a woman's distance from her natal family upon marriage. While the spatial distances are not always significant, the average travel time for the bride at the time of marriage to her natal village is non-trivial.[3] Consistent with dowries (wealth transfers from the bride's family to the groom or his family at the time of marriage) being nearly universal and quite sizable in India (Rao, 1993a,b; Anderson, 2007; Chiplunkar and

[1] Calculations from the Indian Census show that there were between 8.9 and 9.9 million women who married for the first time in 2001. Since then, the population of women of marriageable age has increased. Remarriage after widowhood and divorce add to this number, although the Census provides no easy way of calculating these totals. India is followed by China. The United Nations Population Division lists the number of Chinese marriages in 2005 and 2006 between 8.2 and 9.5 million (see World Marriage Data, 2008, which omits India).

[2] We are not able to disentangle perspective spouses' preferences from their parents'. So, in what follows, men's and women's preferences are intended as a combination of spouses' and parental preferences. This does not mean that parents and their children have the same preferences; only that we can only recover their combination.

[3] Average travel times are about three hours on marriage using the India Human Development Survey of Desai et al. (2012). Rosenzweig and Stark (1989) suggest one motive for female marriage migration may be consumption smoothing in the presence of geographically diverse shocks. Fulford (2013) finds limited evidence of such transfers and suggests that a model of the marriage search is necessary to rationalize the regional differences in migration.

Weaver, 2019), the second term we consider pertains to the size of marital transfers. The third term captures a woman's involvement in the choice of her spouse.[4] As a significant share of Indian marriages are arranged by the parents (Rubio, 2014; Anukriti and Dasgupta, 2017), understanding preferences over this traditional practice is of primary interest.

In our model, search is entirely directed in a given period (with men and women being able to target their search on both spousal characteristics and terms of engagement) and modeled as a dynamic matching game. Individuals who do not match in one period can search again in future periods (provided that they are young enough). The matching process is essentially a production function, which takes as inputs the number of searching men and women in each market and generates as output the number of matches in each market.[5] By determining the number of men and women searching in a specific market, the search probabilities impact the matching probabilities. But the search probabilities depend in turn on the matching probabilities, which enter the value function for women's and men's optimal search decisions. So, equilibrium in our model is obtained as the fixed point of the probabilities of searching in all the distinct marriage markets in all periods. The main idea behind identification is that we should observe marriages characterized by what men want when they face less competition; conversely, when men outnumber women, the observed matches would align more with women's preferences.

Our theoretical framework contributes to previous work modeling marital matching in several ways. First, existing models of two-sided marriage markets are often static.[6] But the marriage problem is inherently dynamic. So, abstracting from the dynamic nature of the problem necessarily reduces the substitution patterns available to the prospective brides and grooms and limits their choices in ways that may distort the inferences researchers can draw regarding preferences and marital gains. Instead, we allow for inter-temporal substitution by combining results from the dynamic discrete-choice literature with a two-sided marriage matching problem. Second, by working in a non-transferable utility framework with partner selection, we can identify individual preferences and not only the joint gains from marriage even when transfers between spouses are not perfectly observed. In our model, uncertainty about matching serves to coordinate agents' decisions and to clear the market, instead of freely transferring utility (as in transferable utility models; Choo and Siow (2006)).[7] We also allow for additional trade-offs between spouses through the *terms of engagement* (i.e., specific characteristics of the match rather than of either spouse). Third, we explicitly consider the existence of search frictions. Such frictions, which are typically ignored but prove to be critical in our setting, may arise from costly information acquisition about potential matches. Fourth, we account for the existence of unobserved spousal traits, which turn out to be important

[4]Our focus on women's (rather than men's) involvement in the choice of their spouse is driven by data availability (see Section 4.1 for details).

[5]As described in more details in Section 3, a marriage market is defined by the cross-product of spousal characteristics and terms of engagement within a specific geographic area.

[6]While other work has acknowledged the role that aging plays in marriage market dynamics (see Choo (2015) and Shephard (2019)), integrating the dynamic two-sided matching problem into an endogenous equilibrium has received less attention. See Gayle (2019) for one of the few dynamic approaches in a frictionless setting.

[7]As we will discuss at length later on, the interpretation of dowries as market clearing prices in the Indian setting is problematic. On one hand, societal norms may restrict the nature and size of these transfers; on the other hand, both sides of the market may favor higher dowries due to societal expectations, reputation and other considerations. Other types of transfers between spouses (via private consumption and leisure for instance) may also be constrained in traditional societies with rigid gender roles (Chiappori, 2017; Chiappori and Salanié, 2021). Here search (i.e., time and effort) is essentially the market clearing mechanism; see Galichon and Hsieh (2017).

to understand substitution patterns in counterfactual simulations.[8]

To estimate the model, we combine survey data from the 2011-2012 India Human Development Survey with district-level population counts from the 2001 Census of India. The set of parameters to be estimated include women's and men's (or their families') utility values for spousal characteristics and terms of engagement, their terminal values (i.e., their (dis)utility from not matching), and the matching function parameters.

We estimate that women favor husbands who have completed primary school and are of the same age. By contrast, men do not value their wives' education and actively substitute away from highly educated women. They also favor younger brides. Both men and women have a strong preference for living not too far away from the woman's natal family and for higher dowries. While perhaps surprising, the latter finding is consistent with the high social costs associated with insufficient dowry payments (Jayachandran, 2015), the documented negative effect of low dowries on women's post-marital well-being (Bloch and Rao, 2002; Calvi and Keskar, 2020a,b), and the use of dowry as an early bequest to daughters (Botticini and Siow, 2003). With regard to preferences for arranged marriages, we find a large degree of heterogeneity among women: a majority of women (or their parents) prefer arranged marriages, but a sizable minority favor love-marriages (especially at older ages). By contrast, men are largely indifferent about women's involvement in the choice of their husbands. Importantly, we estimate a substantial disutility from remaining unmatched for both women and men, suggesting that the prospect of remaining single is affecting how individuals trade-off desired spousal and union characteristics. Finally, the estimated matching parameters support the existence of search frictions in the marriage market, which may emerge due to the cost of acquiring information about potential partners.[9] We do not detect any meaningful differences across castes. We also show that our results are not driven by regions with outlying sex-ratios or rates of labor migration.

Using the estimated model, we simulate the effects of several policy-relevant counterfactual experiments. The growing shortage of women caused by son-preference, sex-selective abortion, and excess female mortality at various ages (Sen, 1990; Bhalotra and Cochrane, 2010; Anderson and Ray, 2010, 2012) is bound to dramatically change competition in the Indian marriage market. So, our first experiment simulates the impact of a decrease in the sex-ratio (i.e., a decrease in the number of women relative to men) on search behavior, matching rates, and welfare in equilibrium. We find that a decrease in the sex-ratio would boost the women's match rate and decrease it for men. It would also generate sizable changes in the age gap at marriage, largely driven by increases in matching rates among men aged 25-29. We predict a slight increase in arranged marriages and dowry payments, but larger decreases in migration as fewer women compete against each other. This result follows from women's stronger preference for shorter migration distances relative to men. A lower sex-ratio would also lead women to match with more educated husbands, and to an overall increase in women's welfare and decrease in men's welfare in the marriage market.

In a second experiment, we study the marriage market effects of an increase in female edu-

[8] In a transferable utility framework, Chiappori et al. (2019) simulate a non-separable model with, showing limited bias from ignoring it. Parallel work by Anderberg et al. (2020) also develops a marriage market model where individuals can match on a latent ability.

[9] See Chade et al. (2017) who highlight the importance of search in rationalizing real-world matching problems were identity matters to individuals.

cation. As several programs have been implemented throughout India to encourage girls' school attendance and learning (see, e.g., Chin (2005) and Muralidharan and Prakash (2017)), understanding their marriage market implications is critical. Our analysis indicates that granting universal primary education to all women would yield lower match rates at younger ages, increasing the average age at marriage and narrowing the spousal age gap. Consistent with men's preferences against women's education, we predict a reduction in welfare for both men and women in the marriage market (although it may, of course, increase in other domains).

Our third experiment simulates the consequences of an increase in women's participation in the decisions on whom to marry, which we interpret as an increase in love (as opposed to arranged) marriages. Rubio (2014) documents that arranged marriages are disappearing in most countries. While this practice is deep-rooted in South Asia, urban areas in India have also started the transition from arranged to love marriages. On average, we find that banning arranged marriage would shift matches towards older ages and would lead to reductions in welfare from marrying on both sides of the market. As women differ substantially in their preferences along both observed and unobserved dimensions, however, we estimate significant heterogeneity in the impact of this counterfactual policy on welfare.

Our fourth experiment simulates the impact of a policy that limits transfers of wealth between families upon marriage (Alfano, 2017; Calvi and Keskar, 2020b). Our counterfactual experiments show that reducing the bride's family's wealth contribution relative to the groom's family (which we interpret as a reduction in dowry) would increase the age at marriage for both men and women, boost marriage migration, and reduce the likelihood of arranged marriages. Our analysis also suggests that limiting dowries would increase women's search for older husbands. As both men and women (or their families) prefer higher dowries, we estimate a reduction in welfare in the marriage market when dowries are low.[10]

Our fifth and last experiment focuses on the issue of child marriage. Despite efforts to reduce marriage at early ages both at the national and state levels, more than one in four Indian women aged 20-24 in 2016 was married before age 18 (Jejeebhoy, 2019). By restricting the possibility for girls to marry in their teenage years, we apply our model to simulate how an effective ban on early marriage could impact marriage market outcomes. We find that, by reducing the competition for older women (i.e., 20 and above), an early marriage ban would yield welfare gains for older women and losses for all men and young women (whose choice sets are essentially shrunken by the ban).

Taken together, our counterfactual analysis shows that key dimensions of substitution in partner choice are sensitive to changes in the underlying market conditions and marital norms. Accounting for general equilibrium effects and preferences over spousal traits and terms of engagement is critical in this context. This is because women and men (or their families) do substitute across such features and their probability of matching. The estimated welfare losses (which admittedly only account for marriage market consequences, not total welfare) may help explain the slow pace of change of traditional customs in the Indian marriage market.

[10] A broad body of work has identified the benefits of anti-dowry laws (Alfano, 2017; Bhalotra et al., 2020). We wish to stress that we are definitely not advocating in favor of dowries, but hope our work can guide the design of policies to limit the possible unintended welfare effects of such laws in the marriage market.

Related Literature. Our modeling approach extends previous work by Arcidiacono et al. (2016), who build a static equilibrium discrete-types model in the spirit of Choo and Siow (2006) to study teen relationships and sexual behaviors in the United States. The principal difference of Arcidiacono et al. (2016) from Choo and Siow (2006) is to pursue an identification strategy that exploits the observation of multiple matching markets and a non-transferable utility framework to recover the distinct preferences of women and men.[11] Arcidiacono et al. (2016)'s framework also allows for preferences over relationship outcomes (or terms) in addition to preferences over partner characteristics. To shed light on preferences and trade-offs in Indian marriages, we extend their model to incorporate the full dynamic marriage problem on both sides of the market, endogenously modeling the distribution of singles and marriages over time. We also expand their framework to incorporate unobserved heterogeneity. The original work of Choo and Siow (2006) and Arcidiacono et al. (2016) builds upon discrete-choice models of individual decision making. So, extending the model to include dynamics and unobserved heterogeneity represents a natural application of the literature on dynamic discrete choice models (Aguirregabiria and Mira, 2010; Arcidiacono and Miller, 2011; Keane et al., 2011). This is, however, an important modeling contribution since most two-sided marriage studies treat the problem as static in nature, necessarily abstracting away from inter-temporal substitution, which we instead find to be critical in our application.

While previous works have developed models to explain various features of the Indian marriage market, including the prevalence of dowries, arranged marriages, or marriage migration (Rosenzweig and Stark, 1989; Edlund, 2006; Munshi and Rosenzweig, 2009; Banerjee et al., 2013; Fulford, 2013; Keskar, 2021), and to take into account sex-ratios (Rao, 1993b; Anderson, 2003, 2007; Edlund, 1999, 2000; Foster and Rosenzweig, 2001; Bhaskar, 2011, 2019; Borker et al., 2017), ours is the first to do so comprehensively in a general equilibrium framework.Not accounting for equilibrium forces may lead to wrong conclusions: it would be easy just by looking at the decisions made by individuals to mistake indifference between choice sets for indifference over individual characteristics. For example, all women may prefer men with more education, but, in equilibrium, some women will have to marry men with less education. What do the women who marry the better-educated men give up to do so? Our framework sheds light on these complex, multi-dimensional trade-offs that are inevitable in a two-sided matching market with frictions.

Understanding the Indian marriage market is crucial to shed light on both the causes and consequences of the growing scarcity of women in India (Sen, 1990, 1992; Bongaarts and Guilmoto, 2015). Indian women are *missing* for several reasons. First, the growing prevalence of sex-selective abortion and excess female mortality during childhood due to son-preference play important roles. While the reasons are complex, the widespread preference for sons is partly related to the fact that

[11] In a transferable utility framework, typically only joint gains can be identified unless tranfers are perfectly observed. So, if the occurrence of a particular outcome is affected by the sex-ratio, it is unclear how utilities are affected because individuals may be making transfers not observed by the researcher. Applications of one-to-one opposite-sex transferable utility model to empirically study marriage markets has seen an uptake over the last decade, but mostly focused on developed countries (see e.g. Choo and Siow (2006); Chiappori et al. (2009, 2012); Dupuy and Galichon (2014); Chiappori et al. (2017b); Eika et al. (2019); Chiappori et al. (2020b,a,c); Ciscato and Weber (2020); Low (2023). Recent applications to less developed contexts include Chiappori et al. (2017a) (China), Hoehn-Velasco and Penglase (2021) (Mexico), Keskar (2021) (India) and Ashraf et al. (2020) (Zambia and Indonesia). Studying polygamous marriages in sub-saharan Africa, Reynoso (2019) models a marriage market with polygamy (many-to-one) and hierarchy of wives (complementarities). Ciscato et al. (2020) develop an equilibrium model of the same-sex marriage market. Both papers consider matching models with transferable utility. See Chiappori and Salanié (2016), Galichon and Salanié (2020), and Chiappori and Salanié (2021) for detailed reviews of the literature.

women join their husband's family upon marriage, and so investments in them are more difficult to justify (DasGupta, 2005; Bhat and Zavier, 2007; Jayachandran, 2015). Since marriage is the intermediate event which imposes costs on girls' parents through dowries and moves a bride away from her natal household, understanding the preferences over marriage transfers and migration is crucial to address skewed sex-ratios in early life.[12] Second, a substantial fraction of Indian missing women die in adulthood (Anderson and Ray, 2010, 2012), partly because of their limited bargaining power within the household (Calvi, 2020). Since the terms set at marriage impact women's post-marital status, understanding how these terms are determined might provide greater insight into women's outcomes later in life.[13]

Finally, marriage (especially early marriage) is closely linked to education in South Asia: women get married at very young ages, which significantly limits their chances to obtain higher levels of education (Field and Ambrus, 2008). Moreover, since women's labor force participation in India is low,[14] the returns to education in the marriage (rather than the labor) market are particularly salient for parents' decisions to invest in their daughters' human capital (Adams-Prassl and Andrew, 2019). While we do not model human capital investment decisions, we estimate men's preferences over their future wives' age at marriage and education, providing insight on the marriage market returns to female education in India.

The rest of the paper is organized as follows. Section 2 provides an overview of the institution of marriage in India, including the customs of dowry and arranged marriage, and the marriage migration phenomenon. Section 3 presents our theoretical model. Section 4 describes our data sources and estimation strategy. The estimation results, including an assessment of the model's within-sample fit, are presented in Section 5, while counterfactual policy experiments are discussed in Section 6. In Section 7, we present a few robustness checks. In our concluding section, we discuss some limitations of our analysis and pathways for future work. Proofs and additional material are in an online Appendix.

2 Marriage in India

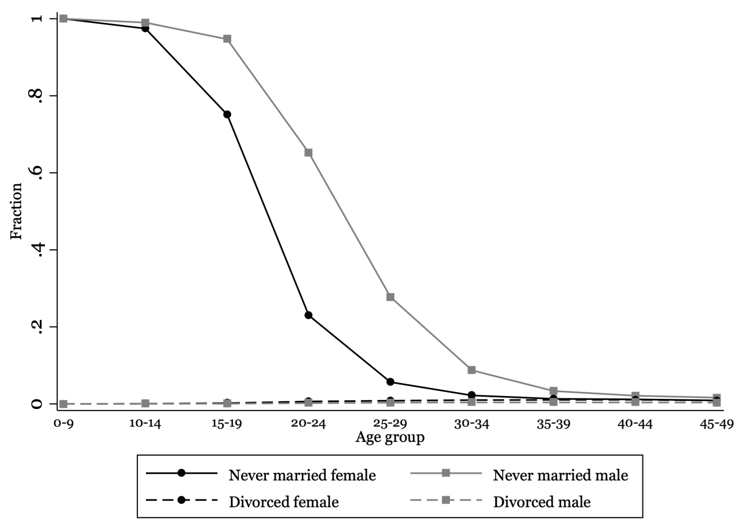
Marriage in India is mostly universal. Based on data both from the 2001 Census of India and the 2011-2012 India Human Development Survey or IHDS (the two data sources we later use in our empirical analysis), Figure 1 summarizes the marriage and divorce rates for women and men by age (Panel A) and the distribution of women's and men's age at marriage (Panel B). Indian women start marrying early: the peak marriage ages are between 15 and 19, with both the average and the median age at marriage in the IHDS being equal to 17; more than 80 percent of women have married by age 25. Men marry later (both the average and the median spousal age gap at marriage is five years), but by the time they have reached their thirties, more than 80 percent of men have

[12] Recent studies have also shown that the expectation of a future dowry payment substantially changes parents' saving behavior (Anukriti et al., 2022b) and that Indian parents delay their daughters' marriage as a strategy to cope with income volatility and avoid the payment of a dowry, at least in the short-run (Corno et al., 2020).

[13] Recent works directly study how equilibrium in the marriage market determines intra-household bargaining power (e.g., Chiappori et al. (2015); Cherchye et al. (forthcoming); Gayle and Shephard (2019)).

[14] According to World Bank data (2019), India's female labor force participation is only slightly above 20 percent.

Figure 1: Marriage and Divorce by Age in India



(A) Marriage and Divorce Rates by Age

(B) Age at Marriage

NOTES: Data in Panel A are from the Census of India 2001 (Table C-2 "Marital Status by Age and Sex"); data for Panel B are from the 2011-2012 India Human Development Survey and refers to age at first marriage.

married at least once. Marital dissolution, either in the form of legal divorce or informal separation, is extremely uncommon and often riddled with stigma. According to the Indian census, 1.36 million individuals in India are divorced, amounting only to 0.24 percent of the married population and 0.11 percent of the total population; the population that is separated, while almost thrice as large, is still minimal, with 0.61 percent of the married population and 0.29 percent of the total population reported as separated (Jacob and Chattopadhyay, 2016). For these reasons, we do not consider divorce in our theoretical framework and empirical analysis.

In this paper, we focus on three central features of Indian marriages: women's migration upon marriage (or patrilocal village exogamy), dowries (wealth transfers from the bride's family to the groom or his family upon marriage), and the practice of arranged marriage.[15] Below, we provide an overview of these customs and discuss some descriptive statistics.

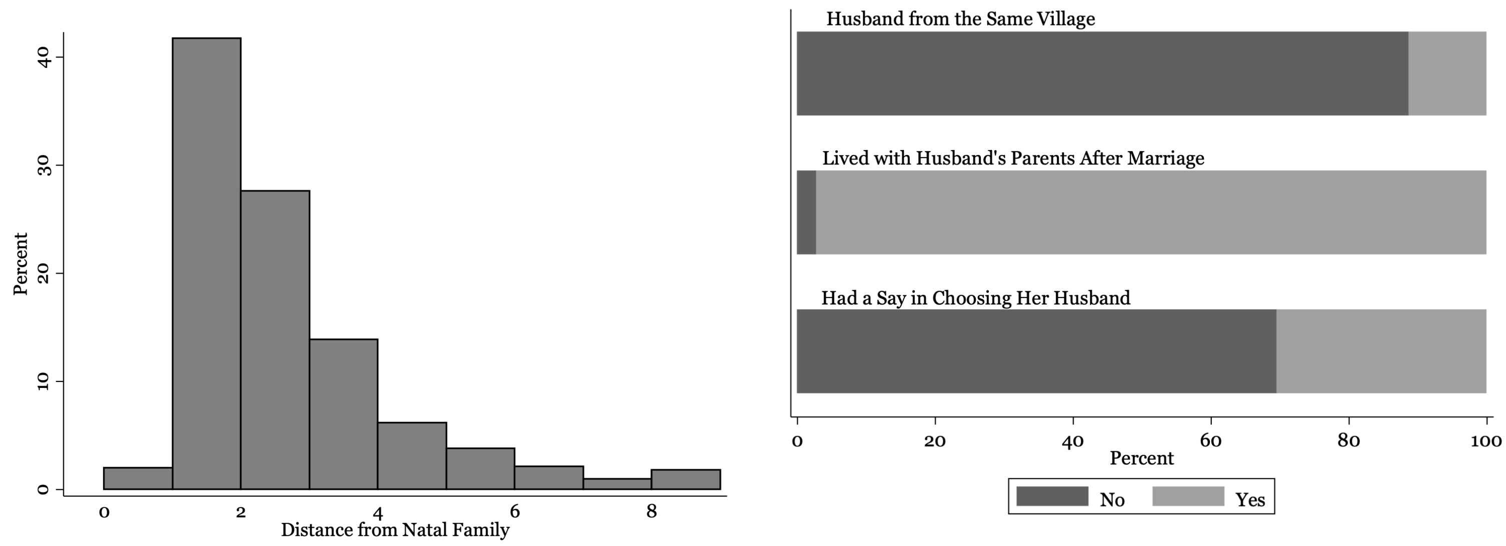
Marriage Migration. Patrilocal village exogamy (whereby a woman moves out of her village to join her husband's family in his village or town) is a practice that is widespread throughout most of India.[16] Table A1 in the Appendix shows descriptive statistics about individual migration from the place of birth by origin and reason for migrating (based on the 2008 National Sample Survey of Employment/Unemployment). Overall, only 24 percent of women aged 25 and older still live where they were born, while 85 percent of men do. While this gender distinction holds in urban areas, it appears to be more prevalent in rural areas. Women move almost entirely (87 percent) for marriage. While marriage migration is pervasive among Indian women, the vast majority of women (73 percent) remain within their birth district.[17]

[15]Another important aspect of marriages in India is caste endogamy (whereby women and men typically marry within their caste): 95 percent of IHDS respondents report marrying a man from their same caste. Banerjee et al. (2013) show that, while caste is highly valued in terms of preferences, it does not require a very high price in equilibrium, which is consistent with assuming that preferences are relatively horizontal rather than vertical and individuals not marrying across caste. Since virtually anyone marries within caste, there is no scope of substitution patterns along this feature. We discuss some results related to caste endogamy in Section 7.1.

[16]As an exception, very different practices prevail in the North-east due to the presence of matrilineal societies such as Khasis, Jaintias, and Garos.

[17]According to the 2001 Census of India, there are 549 districts divided among 29 states and seven union territories. The average district

Figure 2: Marriage Migration, Patrilocality, and Arranged Marriage



(A) Distance from Natal Family

(B) Patrilocality and Arranged Marriage

NOTES: Data are from the 2011-2012 India Human Development Survey and refers to age at first marriage. The survey is administered to ever married women aged 15 to 49. Distance from natal family is measures in travel time (hours) and excludes the top 5 percent of the distribution.

As we discuss later in Section 4.1, the India Human Development Survey contains a detailed module on marital histories for ever-married women aged 15 to 49. Based on this data, Figure 2 (Panel A) shows the empirical distribution of a woman's distance from her natal family after marriage. Specifically, respondents are asked how long (in hours) it took them to go to their natal home at the time of their marriage. While geographic distances may not always be significant, the average travel time for a bride to her natal village is about three hours. The survey also asks whether the respondent is from the same village as her husband and about their living arrangements after marriage. Consistent with widespread patrilocal village exogamy, in 89 percent of cases, women report marrying outside of their village (Panel B). Moreover, 97 percent of respondents report living with their husband's family after marriage (with the remaining 3 percent equally split between living with her own family or alone).

Arranged Marriage. Historically, arranged marriages were common in most pre-industrialized societies (Goody and Goody, 1983). While over time self-choice or *love* marriages became the norm in contemporary Western societies, family-arranged marriages continue to be the dominant form of matchmaking in Asia, Africa, and the Middle East (Anukriti and Dasgupta, 2017). Examining the trends in arranged marriages by cohort for eighteen countries, Rubio (2014) shows that approximately three-quarters or more of the marriages in East and Southeast Asia, Africa, and the Middle East at the beginning of the twentieth century were arranged, but that younger cohorts are more likely to choose their own spouses. By contrast, in South Asia (India, Pakistan, and Bangladesh), most marriages continue to be arranged by the families rather than by the groom and bride themselves.

As shown in Panel B of Figure 2, the majority of IHDS respondents report not being at all involved in the choice of their husbands. When asked directly about who chose their husbands,

has an area of 5,000 squared kilometers and a population of 1.7 million.

only 5 percent of women report choosing whom to marry independently; in 72 percent of cases, spouses were instead selected by their parents or other relatives. Even in most recent times, the majority of marriages are arranged, with only one in three IHDS respondents under 25 reporting being involved in the choice of their husbands.

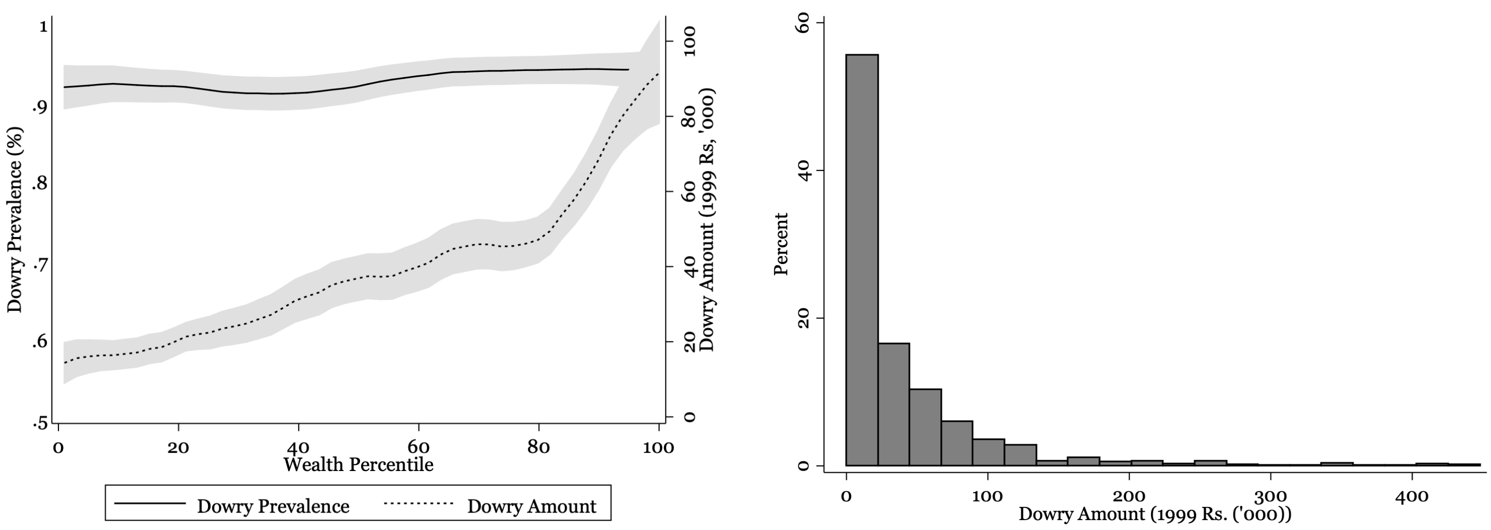
Dowry. Dowry payments are wealth transfers from the bride's family at the time of marriage.[18] In contemporary India, dowry payments are nearly universal and a woman is often unable to marry without such transfers. In a recent paper, Chiplunkar and Weaver (2019) investigate the evolution of dowries in India over the past century, documenting a rapid increase in the prevalence of dowry between 1935 and 1975. Dowry amounts increased substantially between 1945 and 1975 but then declined in real terms (and as a fraction of household income) after 1975. Despite this decline, dowries remain strikingly sizable, amounting to one to several times the average annual income of Indian households (Rao, 1993a, 2000). The total value of dowry payments is estimated to be roughly five billion dollars annually, approximately equal to the annual spending of the Indian national government on health (Chiplunkar and Weaver, 2019).

Contrary to what one might think, dowry payments in India are as prevalent in poor families as they are in rich families. Panel A of Figure 3 plots the share of marriages involving dowries by the marital family's wealth rank, while the empirical distribution of dowry amounts is displayed in Panel B. Figure 3 is based on data from the 1999 Rural Demographic and Economic Survey, one of the very few sources collecting retrospective information on marital transfers. At each point of the wealth distribution, approximately 90 percent of marriages involve the payment of a dowry. The dowry amount is higher for better-off families, with dowry payments in the top ten percent of the wealth distribution being approximately six times the dowry payments in the bottom ten percent.

In the next section, we set out a dynamic directed-search and matching model to recover preferences over the three marriage attributes discussed above (which we call *terms of engagement*) and spousal traits, such as age and education. By exploiting variation in sex-ratios among singles (and hence the level of competition faced by men and women) across different marriage markets, we can recover preferences over the terms of engagement and spousal traits separately for women and men (or their families).

[18] Traditionally, dowries served as a pre-mortem bequest to a daughter, especially in patrilocal and patrilineal societies, where the family wealth is inherited by male children and a couple typically resides with or near the husband's parents (Botticini and Siow, 2003; Anderson, 2007). The literature on the origins of dowries and their role in the Indian marriage market is extensive. A series of papers have studied the role of population growth in combination with the existence of an age gap between the bride and the groom as a cause of rising of dowries in India (the so-called *marriage squeeze*; e.g., Caldwell et al. (1983); Rao (1993b,a, 2000); Edlund (2000); Bhaskar (2011, 2019)). Anderson (2003) proposes a matching model in which dowry inflation emerges naturally during the process of modernization in a caste-based society. Botticini and Siow (2003) argue that altruistic parents in patrilocal societies may use dowries and bequests to mitigate a free-riding problem between siblings. Anderson and Bidner (2015) construct an equilibrium model of the marriage market with intra-household bargaining to study shifts in women's property rights over marital transfers. Their model formalizes the dual role of dowry as a pre-mortem bequest and a market-clearing price and predicts that women's property rights over dowry deteriorate with development. Borker et al. (2017) develop a model of assortative matching with caste-endogamous marriage markets, in which sex selection and dowry payments arise endogenously. Bau et al. (2022) propose a model where dowries can mitigate an inter-generational limited-commitment problem by providing a liquid pool of resources that a son can transfer to his parents in case of migration.

Figure 3: Dowry Prevalence and Distribution of Dowry Amounts



(A) Dowry Prevalence by Wealth

(B) Distribution of Dowry Amounts

NOTES: Statistics include both urban and rural. Data are from the 1999 Rural Demographic and Economic Survey. Family wealth is constructed using principal component analysis and a list of 35 assets owned by the household at the time of the survey.

3 Model

We now formulate a matching model of the Indian marriage market. This model helps us analyze the trade-offs among three sources of expected utility from searching for a spouse: spousal characteristics (age, education), the terms of engagement (the dowry size, the extent of marriage migration, and arranged vs. love marriage),[19] and the probability of matching. We consider a two-sided matching model with non-transferable utility and only opposite-sex one-to-one matching.

We categorize each man as a type m, where $m \in \{1, 2, \ldots, M\}$. Similarly, each woman is given a type w, where $w \in \{1, 2, \ldots, W\}$. An individual's type is defined by a set of observable characteristics, such as age or education. For men (women), there are W (M) types of mates. Let im denote the i-th member of type m.

We index the possible terms of engagement by $r \in \{1, ..., R\}$, where r is a combination of discrete marriage attributes. Note that a term characterizes a match rather than either partner. So, e.g., although it may seem at first glance that the extent of marriage migration is a characteristic of a woman, it depends on the geographic position of both individuals and we model it as a characteristic of the match (i.e., a term of engagement).

Search within this framework is completely directed: men and women can target their search on both the characteristics of the partner and the terms of the engagement. Since the majority of spouses come from the same district (see Table A1 in the Appendix), we treat the district as the primary market, in the sense that each woman (man) makes a discrete choice to search in one of $M \times R$ ($W \times R$) markets *within* her (his) district of residence. So, marriage markets are segmented, which is consistent with needing to invest in particular networks or search channels to identify a partner within a given type-term combination (e.g., a younger woman with primary

[19]Other terms could include the relative social status of the two families (e.g., whether the woman is marrying "up" or "down"), which we consider in Section 7.1.

school education, living nearby, whose parents are going to pay a high dowry and arrange her marriage). The search results in $M \times W \times R$ types of matches (each element of which we denote as $\{m, w, r\}$).

Search is modeled as a multi-stage matching game. For simplicity, we preclude the option of not searching. Given the very high marriage rates in India and the cultural preference for marriage, this assumption is reasonable. Following search, couples are formed with the probabilities of matching depending on the number of searchers on both sides of the market. Unmatched individuals who do not age out of the market participate in the market tomorrow, but they do so as older agents whose matching prospects are different. So, the decision of where to search in a given time period endogenizes the uncertainty over whether one can match today and the uncertainty over market prospects in the future, both of which are functions of the behavior of all types of men and women today and in future periods.

3.1 Individuals

A woman's expected utility from searching in a particular market in period $t = 1, ..., T$ depends upon four factors. For a w_t-type woman (whose type depends on her age, and so we denote it using a subscript t), who matches with an m-type man on terms r during period t, these four elements are: the probability of matching in period t ($P_t^{mr}(w_t)$), a deterministic portion of utility conditional on matching ($\mu^{mr}(w_t)$), an individual-specific preference term ($\epsilon_{it}^{mr}(w_t)$), and the continuation value associated with participating in the market tomorrow or, if old enough, with exiting the market following a failure to match ($V_{t+1}(w_t)$). The corresponding factors for men are denoted by $P_t^{wr}(m_t)$, $\mu^{wr}(m_t)$, $\epsilon_{it}^{wr}(m_t)$, and $V_{t+1}(m_t)$.

Note that the probability of matching and the deterministic utility from matching vary only at the type-term level rather than at the individual level. Stating it differently, all women of type w_t searching for a husband of type m and terms r in period t have the same probabilities of matching and the same deterministic components of utility. This also means the probability of matching is only affected by the individual's and partner's types and by the terms of engagement, and not by any idiosyncratic individual trait. The only individual-specific element of the expected utility is $\epsilon_{it}^{mr}(w_t)$. We assume $\epsilon_{it}^{mr}(w_t)$ is known to the individuals before making their decision over where to search, while only its distribution is known to the other participants in the market. The continuation values only vary based on an individuals' own type and are not directly influenced by the decision over where to search. So, in our framework, the sources of uncertainty from the individual's perspective are their probability of finding a match in the current period ($P_t^{mr}(w_t)$) and their continuation value, which can include participation in the marriage market tomorrow. Finally, we assume that $\mu^{mr}(w_t)$ is not a function of time *per se*. However, age will be included in the state-space, and so time does indirectly affect the utility from matching through the time-varying type w_t.

The value from searching in a particular market takes an expected utility form: it equals the probability of matching (or not) multiplied by the deterministic utility conditional on matching (or the continuation value). So, for a woman of type w_t searching for a husband of type m and terms

r in period t, it takes the following form:

$$V_{it}(w_t) = \max_{j \in \{M \times R\}} P_t^j(w_t) \cdot \mu^j(w_t) + (1 - P_t^j(w_t)) \cdot E(V_{t+1}(w_{t+1})) + \epsilon_{it}^j(w_t), \tag{1}$$

where $E(V_{t+1}(w_{t+1}))$ is the unconditional expected-value function from the search problem in the following period, when woman i's type is w_{t+1}. The value function is expressed as a function of time varying types w_t (with analogous expressions for men as a function of m_t) because individuals in our model age from one period to the next. Thus, the state transition probabilities in our model are degenerate and the rest of the type-space consists of permanent individual characteristics (such as education, which we assume to be fixed when men and women start searching for a mate).

For agents who are sufficiently old in period t, we assume a terminal value function characterizes their utility, as they will not participate in the matching market in period $t+1$. Specifically, they will receive a terminal value, which can be a function of their type, the discount factor, and the lifetime utility of reaching the post-marital ages.By contrast, for agents who are younger (and so search in a marriage market in subsequent periods), the expected value of searching again takes the following form:

$$E(V_{t+1}(w_{t+1})) = \beta \int_{\mathbf{P_{t+1}(w_{t+1})}} \int_{\varepsilon_{\mathbf{t+1}}(\mathbf{w_{t+1}})} V_{t+1}(w_{t+1}) f(d\varepsilon, dP|w_t), \tag{2}$$

where expectations are taken both with respect to the vector of unobserved utility tomorrow ($\varepsilon_{\mathbf{t+1}}(\mathbf{w_{t+1}})$) and the vector of matching probabilities for a type w_{t+1} woman ($\mathbf{P_{t+1}}(\mathbf{w_{t+1}})$), and f is the joint density of the next period unobservables and state variables conditional on the observed state today.

We assume that the idiosyncratic preference terms $\epsilon_{it}^{mr}(w_{t+1})$ are independent and identically distributed (i.i.d.) Type-I Extreme Value errors. This assumption allows for a closed-form representation of the expected value of facing the matching market tomorrow:[20]

$$E(V_{t+1}(w_{t+1})) = \beta \int_{\mathbf{P_{t+1}(w_{t+1})}} \Big(\log\Big(\sum_j e^{V_{t+1}^j(w_{t+1})} \Big) + \gamma \Big) q(dP|w_t), \tag{3}$$

where $V_{t+1}^j(w_{t+1})$ is the choice-specific value function expressed in period $t+1$, and q is the conditional density of the state variables under the assumed i.i.d. logit shocks.

We solve explicitly for the equilibrium probabilities of matching tomorrow for both sides of the market, obtaining $\mathbf{P_{t+1}}(\mathbf{w_{t+1}})$ and $\mathbf{P_{t+1}}(\mathbf{m_{t+1}})$. By imposing the assumption of rational expectations,[21] we can replace the integral in Equation (3) with the equilibrium probabilities which are consistent with decision making on both sides of the market at all time periods. Under the logit-error structure, the probability that a w_t-type woman searches for an m-type man on relationship

[20]This requires the conditional independence assumption of Rust (1987) with respect to the distribution of unobserved utility and the expectations regarding prospects of matching in the future.

[21]The dynamic problem requires an assumption on the subjective probability distribution that agents hold for future outcomes under alternative choice paths. The conventional approach assumes that agents have rational expectations. An alternative approach is to directly elicits subjective expectations (see, e.g., Dominitz and Manski (1996); Manski (2004); Delavande (2008); Wiswall and Zafar (2018)).

terms r during period t, $\phi^{mr}_{w_t}$, is as follows:

$$\Pr(m,r|w_t) = \phi^{mr}_{w_t} = \frac{\exp\left(P^{mr}_t(w_t)\cdot\mu^{mr}(w_t) + (1-P^{mr}_t(w_t))\cdot E(V_{t+1}(w_{t+1}))\right)}{\sum_j^M\sum_k^R \exp\left(P^{jk}_t(w_t)\cdot\mu^{jk}(w_t) + (1-P^{jk}_t(w_t))\cdot E(V_{t+1}(w_{t+1}))\right)}, \tag{4}$$

Note that $\phi^{mr}_{w_t}$ is a function of the current probabilities of matching as well as the future probabilities of matching (through the expected value terms). Similarly, the probability that a m_t-type man searches for an w-type woman on relationship terms r during period t, $\phi^{wr}_{m_t}$, is given by:

$$\Pr(w,r|m_t) = \phi^{wr}_{m_t} = \frac{\exp\left(P^{wr}_t(m_t)\cdot\mu^{wr}(m_t) + (1-P^{wr}_t(m_t))\cdot E(V_{t+1}(m_{t+1}))\right)}{\sum_j^W\sum_k^R \exp\left(P^{jk}_t(m_t)\cdot\mu^{jk}(m_t) + (1-P^{jk}_t(m_t))\cdot E(V_{t+1}(m_{t+1}))\right)}. \tag{5}$$

3.2 Matching

We now specify the matching process within each period. The matching process is essentially a production function, which takes as inputs the number of searching men and women in each market in each period and generates as output the number of matches in each market in each period.

We parameterize the number of matches in period t and in marriage market $\{m,w,r\}$ as depending upon the number of unmarried m_t-type men and w_t-type women searching in that market. We denote by N^m_t and N^w_t the total number of m_t-type men and w_t-type women, respectively, and by X^{mwr}_t the total number of matches in marriage market $\{m,w,r\}$. As we described above, $\phi^{wr}_{m_t}$ and $\phi^{mr}_{w_t}$ give the per-period search probabilities (that is, the probability of searching in a particular market). So, $\phi^{wr}_{m_t}N^m_t$ is the number of m_t-type men searching for a wife of type w and relationship terms r in time t. Analogously, $\phi^{mr}_{w_t}N^w_t$ is the number of w_t-type women searching for a husband of type m and terms of engagement r in time t. The number of matches in market $\{m,w,r\}$ at time t is then given by:[22]

$$\begin{aligned} X^{mwr}_t &= A^*\left[\frac{\left(\phi^{wr}_{m_t}N^m_t\right)^\rho}{2} + \frac{\left(\phi^{mr}_{w_t}N^w_t\right)^\rho}{2}\right]^{\frac{1}{\rho}} \\ &= A\left[\left(\phi^{wr}_{m_t}N^m_t\right)^\rho + \left(\phi^{mr}_{w_t}N^w_t\right)^\rho\right]^{\frac{1}{\rho}}, \end{aligned} \tag{6}$$

where ρ determines the elasticity of substitution $1/(1-\rho)$, and A can be interpreted as a measure of search frictions. When $\rho\to 0$, the CES function becomes Cobb-Douglas (in which case the sex-ratios do not affect the likelihood of observing particular matches); when $\rho\to-\infty$, the CES function becomes Leontief. Note that $X^{mwr}_t = X^{wmr}_t$ for all m, w, and r.[23]

[22]For simplicity, we assume an interior solution such that the number of matches produced is less than both the number of men and the number of women in the $\{m,w,r\}$ market at time t. In practice, we nest the CES matching function into a Leontief function to constrain the number of matches to be less than the number of searching men and women:

$$X^{mwr}_t = \min\left\{A\left[\left(\phi^{wr}_{m_t}N^m_t\right)^\rho + \left(\phi^{mr}_{w_t}N^w_t\right)^\rho\right]^{\frac{1}{\rho}}, \phi^{wr}_{m_t}N^m_t, \phi^{mr}_{w_t}N^w_t\right\}.$$

[23]The interior share parameter is normalized to be one-half. Identification of ρ and A are discussed below. It is unclear which moments in

As discussed before, all women (or men) of the same type searching in the same market in the same period have the same matching probabilities. So, for all w_t-type women searching for a husband of type m and terms of engagement r, their matching probabilities at time t are given by:

$$\begin{aligned} P_t^{mr}(w_t) &= \frac{X_t^{mwr}}{\phi_{w_t}^{mr} N_t^w} \\ &= \frac{A\left[\left(\phi_{m_t}^{wr} N_t^m\right)^\rho + \left(\phi_{w_t}^{mr} N_t^w\right)^\rho\right]^{\frac{1}{\rho}}}{\phi_{w_t}^{mr} N_t^w} \\ &= A\left[\left(\frac{\phi_{m_t}^{wr} N_t^m}{\phi_{w_t}^{mr} N_t^w}\right)^\rho + 1\right]^{\frac{1}{\rho}}. \end{aligned} \tag{7}$$

This term is embedded in the multinomial logit search probabilities defined in Equations (4) and (5), and captures the influence of the sex-ratio (i.e., the level of competition faced by future brides and grooms) on search decisions in the current period.

Given these representations of the probability of searching and matching, it is straightforward to express the flow of unmatched individuals across periods. Recall that only women and men who are young enough and remain unmatched at time t can search again at time $t+1$ (at which point they can decide to search in the same or a different marriage market). So, the numbers of women and men searching for a spouse in the next period are given by:

$$N_{t+1}^w = \sum_j^M \sum_k^R N_t^w (1 - P_t^{jk}(w_t)) \phi_{w_t}^{jk} + \widetilde{N_{t+1}^w} \tag{8}$$

$$N_{t+1}^m = \sum_j^W \sum_k^R N_t^m (1 - P_t^{jk}(m_t)) \phi_{m_t}^{jk} + \widetilde{N_{t+1}^m}, \tag{9}$$

where $\widetilde{N_{t+1}^m}$ and $\widetilde{N_{t+1}^w}$ are the next generation of individuals who enter the marriage market for the first time at $t+1$, and the first terms ($\sum_j^M \sum_k^R N_t^w (1-P_t^{jk}(w_t))\phi_{w_t}^{jk}$ and $\sum_j^W \sum_k^R N_t^m (1-P_t^{jk}(m_t))\phi_{m_t}^{jk}$) correspond to the total unmatched individuals from the marriage market at t, whose search has been unsuccessful.[24]

3.3 Equilibrium

The search probabilities (i.e., $\phi_{w_t}^{mr}$ and $\phi_{m_t}^{wr}$) provide the share of a particular set of individuals who will search in a particular market. So, the search probabilities determine the probabilities of matching (i.e., $P_t^{jk}(w_t)$ and $P_t^{jk}(m_t)$). In Equation (10) below, we make this dependence explicit. In each period, except the terminal period, the probability that a woman of type w_t searches for a

the data would identify the share parameter in our framework, so we normalize it.

[24] With this formulation, it would be straightforward to adjust the stocks of agents participating in the market in the next period (because of out-migration, mortality, widowhood and marital dissolution, for instance), by simply adding another scaling factor to N_t^w and N_t^m. For simplicity, we here abstract from these considerations.

man of type m and relationship terms r in period t takes the following form:

$$\phi_{w_t}^{mr} = \tag{10}$$
$$\frac{\exp\left(P_t^{mr}(w_t,\phi_{w_t}^{mr},\phi_{m_t}^{wr})\cdot\mu^{mr}(w_t)+(1-P_t^{mr}(w_t,\phi_{w_t}^{mr},\phi_{m_t}^{wr}))\cdot E(V_{t+1}(w_{t+1}),\mathbf{P_{t+1}}(\phi_\mathbf{t},\mathbf{P_t},\phi_\mathbf{t+1})\right)}{\sum_j^M\sum_k^R\exp\left(P_t^{jk}(w_t,\phi_{w_t}^{jk},\phi_{j_t}^{wk})\cdot\mu^{jk}(w_t)+(1-P_t^{jk}(w_t,\phi_{w_t}^{jk},\phi_{j_t}^{wk}))\cdot E(V_{t+1}(w_{t+1}),\mathbf{P_{t+1}}(\phi_\mathbf{t},\mathbf{P_t},\phi_\mathbf{t+1})\right)}.$$

Analogous equations can be derived for men of type m_t looking for a wife of type w and terms of engagement r in period t. Note that the future value of facing the marriage market in the next period depends on the expected market conditions in the next period, i.e., $\mathbf{P_{t+1}}$. So, $\mathbf{P_{t+1}}$ is a function of:

1. the current probabilities of searching: $\phi_{w_t}^{mr}, \phi_{m_t}^{wr}$,
2. the current probabilities of matching: $P_t^{mr}(w_t), P_t^{wr}(m_t)$,
3. the next-period probabilities of searching: $\phi_{w_{t+1}}^{mr}, \phi_{m_{t+1}}^{wr}$.

Dependencies 1 and 2 occur through the flow conditions defined in (8), while dependency 3 comes from the marriage market equilibrium in the next period. We collect these three terms into the vector $(\phi_\mathbf{t},\mathbf{P_t},\phi_\mathbf{t+1})$, whose elements respectively contain the elements of 1 through 3.

For women (men) who are sufficiently old in period t, the search probabilities $\phi_{w_t}^{mr}$ ($\phi_{m_t}^{wr}$) depend on their matching probabilities in period t and on their terminal value function (rather than their matching probabilities at time $t+1$).

Within each period, the search probabilities must sum to one for both men and women. So, equilibrium in our model is characterized by stacking the $(W\times R-1)$ and $(M\times R-1)$ search probabilities in each period and solving for the fixed point defined by the set of Equations (10) for women and the analogous set for men. Since ϕ is a continuous mapping on a compact, convex space, Brouwer's fixed point theorem guarantees that an equilibrium exists. In Appendix C, we present conditions demonstrating the equilibrium is unique in the vast majority of markets we study.[25]

Finally, if one were to recursively substitute the next-period equilibrium expressions of Equation (10) for a given cohort in the non-terminal period, the equilibrium governing the market in $t+1$ (through $\mathbf{P_{t+1}}$) will be a function of the search probabilities of the next-generation market participants. So, for example, a cohort making search decisions at $T-2$ will be influenced by the future decisions (at $T-1$) of agents who have yet to enter the market at $T-2$. Those beginning the matching process in the next period, whose populations were given by $\widetilde{N_{t+1}^w}$ and $\widetilde{N_{t+1}^m}$, would have search probabilities that are in-turn influenced by their expectations about decisions by the

[25]There is only one equilibrium where the search probabilities are positive in all markets in a static model. Diamond (1982) shows a necessary condition for multiple equilibria (with positive search probabilities) in a similar, but static, model (with endogenous search on both sides of the market) is increasing returns to scale in the matching technology. There are other equilibria of the static game that result from coordination failures where specific markets are empty. In our framework, the functional forms of the model (i.e., the logit choice probabilities and a CES matching function with $\rho<0$) provide the basis for existence of the equilibrium defined in equation (10). Namely, the continuity of the recursive equation on the closed interval $[0,1]$ guarantees existence by the fixed-point theorem. Uniqueness of equilibrium relies on establishing that the local changes to the input yields changes to the function which are small enough that an iterative sequence will converge to a unique fixed-point; that is, for a fixed point $x=f(x)$, we have $|f'(x)|<1$ on the interval. Further details are available in our online Appendix C. The Appendix also establishes a model expression with which we can verify if this sufficient condition for uniqueness holds, and demonstrates that it does in-fact hold for more than 95 percent of the fixed points we examine. Thus, while we cannot rule out multiplicity for those few markets, in practice the potential scope for multiplicity to complicate our parameter estimates is quite limited.

generation entering at T. Given that we cannot observe the entire history of matches, we impose a simplifying assumption to solve for equilibrium. Specifically, we assume the market after the next-generation proceeds in a stationary manner, such that $\mathbf{P_{t+2}} = \mathbf{P_{t+1}}$. Thus, when agents at $T-2$ look forward to equilibrium at $T-1$, they further assume that the match probabilities operating at $T-1$ will also govern equilibrium at time T. This approach allows us to avoid the explicit modeling of the decisions of the next-generation. This approach also facilitates estimation with the available data, which is essentially a retrospective cross-section (see Section 4.1 for details).

3.4 Identification

We now provide a brief description of identification. A more detailed discussion of identification can be found in Appendix B.[26] As previously mentioned, identification in our model relies on observing multiple segmented marriage markets.[27] In a slight abuse of notation and conditional on spouses' characteristics such as age and education, the probability of observing a match on term r has a sample analogue (left-hand side) and non-linear model expression (right-hand side) which can be written as:

$$\frac{N_r^{(d)}}{N_w^{(d)}} = \phi_{r,w}^{(d)} P_{r,w}^{(d)},$$

where $\frac{N_r^{(d)}}{N_w^{(d)}}$ is the share of matches observed on term r among women in district d. The right hand-side is a function of the observed sex-ratio in each district. So, with a similar equation for each term, the identification of utility parameters and the matching function parameter ρ comes through co-movement in sex-ratios and term-specific match rates. Identification of the search friction parameter A comes through co-movement of sex-ratios with non-matching rates. Preference parameters for spousal traits can also be identified using cross-market variation, though this is not required. Preferences for observed spousal characteristics in similar (i.e. logit) models are simply a mapping of observed within-market shares into utility parameters, conditional on the matching function (Choo and Siow, 2006). Turning to the parameters of the dynamic discrete choice problem, the terminal values are identified by the co-movement between term-specific match rates in the last period and period-specific sex-ratios. The discount factor is not identified and is set exogenously. Similarly, the variance of the distribution of the error terms is normalized to a fixed value.

3.5 Discussion

Our model incorporates directed search into a matching model to identify preferences for terms of engagement and spousal characteristics on both sides of the market and to reveal how individuals on both sides substitute across the terms of engagement, spousal traits, and the probability of matching.

Existing search and matching models struggle to investigate these trade-offs simultaneously.

[26] For a detailed discussion of identification of similar models, see also Hsieh (2012).

[27] As also discussed in Galichon et al. (2019), it is not possible to identify the preferences on both sides of the market in transferable and imperfectly transferable utility models unless we observe the transfers. However, in contrast with the transferable utility case, with imperfectly transferable utility, it may possible to identify the preferences on both sides of the market with multiple markets. Our identification argument is similar.

Two-sided matching models with transferable utility, for instance, often assume a frictionless environment and that partners in a match can freely transfer utility to each other. When transfers are available between spouses, they essentially allow individuals to bid for their preferred mate by reducing their own gain from the match and increasing their partner's. So, in such a framework, it is possible to identify the joint marital surplus (or gains from marriage), but not women's and men's preferences over relationship terms or spousal traits, unless transfers are perfectly observed. These models are also restrictive in how the changes in the sex-ratio affect the distribution of matches.[28] Moreover, while recent applications of these models introduce dynamic considerations, those are primarily related to household dissolution, divorce, and limited commitment, and how these may influence the allocation of marital surplus between spouses. Finally, for the most part, existing transferable utility matching models have focused on the setting in which a single characteristic is used to distinguish between individuals on each side (notable exceptions include Chiappori et al. (2012, 2018, 2020d), Dupuy and Galichon (2014), and Low (2023)). In reality, however, women and men often match on several traits.

Search models have also been widely applied to study marriage markets (see Goussé et al. (2017), for instance).[29] In these models, individuals sequentially and randomly meet one potential spouse and then decide whether to match with him/her or to continue searching. The latter option involves various costs related to discounting or the risk of never finding a better partner. If both individuals agree to match, then a negotiation begins on how the marital surplus is shared. So, while search frictions introduce a trade-off between matching now or deciding to wait for the chance of meeting another potential partner (and possibly) achieving higher surplus, search models typically maintain the assumption of transferable utility (Chiappori and Salanié, 2021). As a result, they typically do not allow one to identify women's preferences separately from men's, limiting the scope of welfare analyses.[30]

Our framework overcomes some of the limitations discussed above. First, by considering a non-transferable framework with partner selection, we can identify preferences separately for both sides of the market and not only the joint gains from marriage. Second, by allowing preferences over both partner characteristics and match terms, we can uncover how individuals trade-off across these two dimensions when the matching environment changes. The terms of engagement also allow for additional trade-offs between spouses and relax some of the constraints inherent in non-transferable utility models (Chiappori, 2017). Third, by considering the dynamic aspect of the search (i.e., that, if unmatched, an individual can keep searching in the future), we help shed light on how individuals on both sides of the market substitute across the terms of engagement, spousal traits, and the probability of matching in different periods. Fourth, in our model, uncertainty

[28] As shown by Decker et al. (2013), differentiating the number of matches in the Choo and Siow (2006) model with respect to the number of m-type men produces the same change in the number of matches as differentiating with respect to the number of w-type women, implying no shift in match terms.

[29] Search models play a crucial role in labor economics. Two of the early and seminal papers in the search literature, Mortensen (1982, 1988), explicitly referred to the marriage market as a prime application of search models. Shimer and Smith (2000) embed time-intensive partner search and transferable output in a neoclassical marriage market model (Becker, 1973), showing that the presence of search frictions results in matches that are not positively assortative.

[30] There is also a related literature in macroeconomics working with quantitative dynamic models of marriage and divorce (see e.g., Greenwood et al. (2003, 2016) and Greenwood et al. (2016). Our approach is different and allows us to delve deeper into preferences over spousal characteristics and terms.

about matching serves to coordinate agents' decisions and, therefore, to clear the market instead of transferring utility. In most transferable utility models, transfers are symmetric, but in our search model, the transfer is essentially the disutility associated with the possibility of not matching. In our specific application, we also model an observed monetary exchange (i.e., the dowry payment) as a relationship term, hence incorporating *transfers,* just in a different and more specific way. Fifth, we allow men and women to search for spouses who differ along multiple dimensions. While our empirical application focuses on age and education, our theoretical framework could accommodate a broader set of individual features, such as physical appearance (Chiappori et al., 2012, 2017a; Keskar, 2021) or personality traits (Dupuy and Galichon, 2014).

It is typically argued that, in the case of marriage, the assumption of transferable utility may be more appealing, as there is likely at least one privately consumed commodity that can be exchanged across partners (which would amount to a transfer between spouses).[31] As noted in Chiappori (2017); Chiappori and Salanié (2021), however, in societies ruled by very rigid social and gender norms, transfers may be constrained and frictions can be critical. So, while a non-transferable utility model may not apply to the study of marriage markets in developed countries or less traditional societies, it may plausible for the Indian context.[32]

Finally, the Indian marriage market sees virtually no pre-marital cohabitation, and often spouses have no opportunity to learn about match quality before marriage. So, ignoring learning seems reasonable in our context.[33]

4 Empirical Strategy

4.1 Data and Measurement

For our empirical analysis, we combine population counts by district, gender, age, and marital status from the 2001 Indian Census with individual survey data from the 2011-2012 India Human Development Survey (IHDS) collected by Desai et al. (2012).

Survey Data. We obtain data on *choices* from survey data. The IHDS is a nationally representative survey of more than 40,000 households in 375 districts across India.[34] The survey contains standard socio-economic and demographic information at the household and individual levels. It also includes a women's questionnaire asking ever-married women aged 15 to 49 a wide range of questions about marriage practices, fertility, gender relations, and social capital. Relevant for our analysis, the survey includes detailed information about respondents' marital histories.

[31] For a characterization of utility functions compatible with transferable utility, see Chiappori and Gugl (2020).

[32] Non-transferable frameworks have been previously used to study the Indian marriage market (though with different goals) in Anderson (2003) and Banerjee et al. (2013).

[33] This assumption might be questionable in other settings. Becker (1991), e.g., argued that the potential for marital instability could lead to "trial marriages." Rasul (2006) also shows that when marriage markets are characterized by search, learning about marriage quality plays an important role in determining the impact of divorce law changes. Laufer and Gemici (2011) also show that learning about partner quality is important for rationalizing non-marital cohabitation, while Svarer (2004) presents evidence from Denmark in favor of learning through cohabitation. Finally, Brien et al. (2006) develop an economic model of cohabitation, marriage, and divorce that is consistent with US data and that can rationalize cohabitation as a tool to learn about the quality of the match.

[34] Districts are the main administrative division of Indian states or territories. The survey covers 33 states and union territories of India, except for small populations living in the island states (Andaman & Nicobar and Lakshadweep).

Based on this information, we construct discrete variables for spousal traits and terms of engagement. Specifically, we categorize women and their spouses into three education groups based on whether they have no schooling or only some primary school, whether they have completed primary school, and whether they completed secondary school. Consistent with our model and with the distribution of age at marriage in India (see Sections 2 and 3), we consider women to be *young* if they are aged 15 to 19 and *old* if they are 20 to 24. To account for the fact that men generally marry later and that the spousal age gap in India is about five years on average, we classify men as young if they are of ages 20 to 24 and old if they are of ages 25 to 29.

Turning to the terms of engagement, we construct three binary variables, measuring the three features of Indian marriages discussed in Section 2. To capture marriage migration, we construct an indicator variable equal to 1 if the respondent reports having moved more than four hours away from her natal family at the time of her marriage.[35] The size of dowry payments at the time of marriage is captured by a binary variable equal to one or zero if the bride's family's wealth contribution at the time of marriage was 50 percent lower or higher than that of the groom's family.[36] Finally, we rely on survey questions regarding a woman's involvement in the choice of her husband to determine whether her marriage was arranged by her family. Specifically, we consider a marriage to be a love (as opposed to arranged) marriage if the answer to the question "Who chose your husband?" is the respondent alone or the respondent jointly with her family.[37]

Census Data. We measure *choice sets* using aggregate data from the 2001 Census of India, which collects population counts by district, gender, age, and marital status. Based on this data, we construct district-level sex-ratios (which we define as the number of women relative to men) for individuals in different age groups, who were unmarried in 2001. Figure A2 in the Appendix contains maps of India illustrating the variation across districts in total sex-ratios (Panel A) and sex-ratios among never-married individuals aged 15 to 29 (Panel B). A few observations stand out. First, sex-ratios are more balanced in Southern and Eastern districts. Notably, the state of Kerala in the South has the largest overall ratio (with 1,058 females per 1,000 males). Second, the geographic distribution of sex-ratios changes quite substantially when focusing on the never-married population aged 15 to 29. These differences may arise due to differential population growth rates, ages at marriage, and age-specific migration patterns across districts and genders. Third, there is considerable variation in sex-ratios overall and among singles across districts, which is the variation we exploit for identification.

[35] A travel time of four hour or more is likely associated with the inability to go visit the natal family and come back within the same day.

[36] Panel A of Figure A1 in the Appendix shows a scatterplot of the reported families' contributions upon marriage and illustrates how we construct this binary term. Note that the survey does not include direct questions about dowry payments at marriage, which is typical when asking questions about criminal practices (despite being widespread, dowries have been illegal in India since 1961). Instead, respondents are asked what is the amount of money usually spent by the bride's family and the groom's family at the time of marriage in their community, for a family like theirs (they report the typical upper and lower bounds of these amounts; we take the average between the two bounds). Admittedly, this is a significant limitation to our analysis that can be overcome with the collection of novel primary data (which we leave to future work). Nevertheless, to check that these reports are informative of one's own experience, we compare dowry data from IHDS and the Rural Demographic and Economic Survey (or REDS, which is the only nationally representative survey collecting the monetary value of marital transfers made or received by the respondent or his family), finding a positive and significant correlation between the two dataset (see Panel B of Figure A1 in the Appendix). Since REDS is only limited to rural areas and does not include information about whether a marriage was arranged, we cannot use it for our main analysis.

[37] Our results are robust to reasonable changes in the cutoffs used to to construct these discrete relationship types. Robustness checks in this direction are available upon request.

Note that a population breakdown by age, gender, district, marital status, *and* education level is not available in the 2001 Census of India. To overcome this limitation and achieve the required level of disaggregation in the population counts, we first estimate the probability of completing primary school or secondary school for men and women (conditional on their age, marital status, and district of residence) using IHDS data.[38] Then, we use these probabilities to estimate the number of men and women in each district by age group, education, and marital status.

To implement our model empirically, we match IHDS respondents with the aggregate population counts from the Census. The match is made possible by the fact that IHDS contains 2001 Census district identifiers. Table A2 in the Appendix contains some descriptive statistics for the overall IHDS sample and for the subsample used in estimation (women aged 15 to 24 in 2000, who married in or after 2001 and hence who where single and potentially looking for a spouse in year 2000). On average, women in the estimation sample are 30 years old at the time of the survey (18 years old in 2000), while the men whom they end up marrying are 35 years old (23 years old in 2000). Educational attainment is generally low (though higher than the overall figures, since the estimation sample is naturally skewed towards younger generations), with one in four women having no schooling at all or not completing primary school and only half of men completing secondary school. Upon marriage, one in five women relocates more than four hours away from their natal family (with 90 percent of them not living in their natal family village). In more than 50 percent of cases, the bride's family spends more than 1.5 times what the groom's family spends at the time of their marriage. Finally, only one in three women report being involved in the choice of their husbands, and the vast majority of marriages are solely arranged by parents or relatives.

4.2 Distributions of Matches and Terms of Engagement

As we discussed early on, the difference between spousal characteristics and terms of engagement is that an individual cannot change his or her own characteristics when searching for a mate, but can look for better terms of engagement when they face lower competition in the marriage market. In what follows, we first explore the distribution of matches in our sample. We then provide some preliminary evidence of the existence of trade-offs between the terms of engagement and the probability of matching.

Distribution of Realized Matches. We summarize the distribution of matches in our sample in three tables. Table 1 shows the share of marriages by women's and men's level of education. For simplicity, we focus here on the sample we use to estimate our model, i.e., 4,342 women aged 15 to 24 in 2000, who married in or after 2001. The most common matches are among individuals with the same level of education, which account for 63 percent of all matches. The three combinations of a more educated man matched with a less-educated woman also make up a large fraction of observations at approximately 24 percent. So, marriages where women have a higher education

[38] We estimate these probabilities using an ordered logit regression of our discrete education variable (which we recall takes on three values from less than primary school to secondary school completion) on indicator variables for age, single, and district of residence. We estimate education probabilities for men and women, separately.

level than their husbands are rare, amounting only to 13 percent of matches. This may result from gender-specific education distribution, preferences over spousal education, and general equilibrium effects. Table 2 displays the patterns of matching by age. As can be seen from the frequencies in the upper triangle of the table, the vast majority of matches (68 percent) occur between a younger woman and an older man. In sporadic cases, the woman is older than her husband. This is consistent with a substantial age gap between spouses, with wives being five years younger than their husbands, on average.

Table 3 presents the frequency of marriages by terms of engagement, as we defined them in Section 4.1. In one in four marriages, the bride lives less than four hours away from her natal family (though 50 percent of women live more than two hours away, which is a non-trivial distance), she is not at all involved in the choice of her husband, and her family pays a relatively high dowry (with their transfers upon marriage exceeding the groom's family by more than 50 percent). Another 26 percent of all matches are accounted for by arranged marriages involving relatively low marriage migration and low dowries. Love marriages are more prevalent in conjunction with short migration distances, with less than 7 percent of brides involved in the choice of their husbands living less than four hours away from their natal family.[39]

Terms of Engagement and Sex-ratios. We now exploit variation in sex-ratios across marriage markets to provide suggestive evidence of the existence of trade-offs between the probability of matching and the terms of engagement. Specifically, we assess how the terms of engagement (i.e., migration distance, dowry size, and women's participation in the choice of their husbands) relate to the number of single women relative to single men of marriageable age in a district.

Any unconditional correlation between marriage attributes and sex-ratios is likely to be spurious. Unobserved factors, such as traditional gender norms, are likely to influence both the terms of engagements and the gender composition of the population (through, e.g., sex-selective abortion and other forms of discrimination against women). So, we first estimate logistic regressions of the binary terms of engagement on district-level 0 to 9 sex-ratios, in an attempt to control for district-level differences in gender norms. Next, we plot the Pearson residuals for each binary term of engagement against the district-level sex-ratios among unmarried individuals aged 15 to 29 (Figure 4). While it is still not possible to attach a causal interpretation to these relationships, it is worth noting that the estimated correlations are statistically different from zero. The higher is the level of competition faced by women (that is, the higher is the sex-ratio among unmarried individuals of marriageable age), the higher is the likelihood of a low-distance marriage migration, the lower is the likelihood of the bride's family shouldering a low fraction of marriage expenses, and the higher is the likelihood of a love marriage.

When women face less competition in the marriage market, one should expect them to be able to achieve their preferred relationship terms. So, based on the correlations in Figure 4, one may be tempted to infer that women like to (or their parents prefer them to) live far away from their natal families after marriage and favor low dowries and arranged marriages. However, such

[39] Clearly, these specific matching distributions depend heavily on how we define relationship terms and individual types. Taken together, however, Tables 1, 2, and 3 document substantial variation in the realized matches.

Table 1: Distribution of Matches by Education

	Husband's Education			
Wife's Education	1(Less than Primary)	1(Primary)	1(Secondary)	Total
1(Less than Primary)	466	414	118	998
	(0.11)	(0.10)	(0.03)	(0.23)
1(Primary)	228	808	527	1,563
	(0.05)	(0.19)	(0.12)	(0.36)
1(Secondary)	29	317	1,435	1,781
	(0.01)	(0.07)	(0.33)	(0.41)
Total	723	1,539	2,080	4,342
	(0.17)	(0.35)	(0.48)	(1.00)

NOTES: Data are from the 2011-2012 India Human Development Survey. The sample includes women aged 15 to 24 in 2000, who married in or after 2001. Frequencies in parentheses.

Table 2: Distribution of Matches by Age

	Husband's Age at Marriage				
Wife's Age at Marriage	Less than 20	20-24	25-29	30 or above	Total
15-19	252	1,118	417	74	1,861
	(0.06)	(0.26)	(0.10)	(0.02)	(0.43)
20-24	7	543	1,000	382	1,932
	(0.00)	(0.13)	(0.23)	(0.09)	(0.44)
25 or above	1	6	211	331	549
	(0.00)	(0.00)	(0.05)	(0.08)	(0.13)
Total	260	1667	1628	787	4,342
	(0.06)	(0.38)	(0.37)	(0.18)	(1.00)

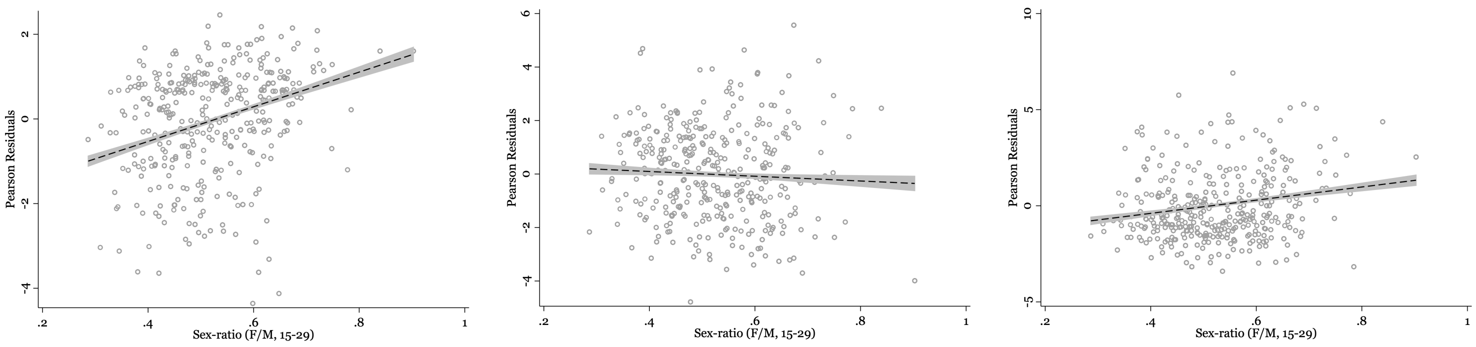
NOTES: Data are from the 2011-2012 India Human Development Survey. The sample includes women aged 15 to 24 in 2000, who married in or after 2001. Frequencies in parentheses.

Table 3: Distribution of Matches by Terms of Engagement

Terms of Engagement				
1(Low Distance)	1(Low Dowry)	1(Love Marriage)	Number of Matches	Frequency
1	0	0	1,223	28.17
1	1	0	1,169	26.92
1	0	1	562	12.94
1	1	1	528	12.16
0	1	0	303	6.98
0	0	0	273	6.29
0	0	1	146	3.36
0	1	1	138	3.18

NOTES: Data are from the 2011-2012 India Human Development Survey. The sample includes women aged 15 to 24 in 2000, who married in or after 2001. 1(Low Distance) equals one if the woman's distance from natal family upon marriage is less than four hours; 1(Low Dowry) equals one if the woman's family's contribution to marriage expenses is less than 1.5 times her husband's family's; 1(Love Marriage) equals one if the woman reports being involved in the choice of her husband.

Figure 4: Terms of Engagement and Sex-ratios



(A) $\mathbb{1}$(Low Distance) (B) $\mathbb{1}$(Low Dowry) (C) $\mathbb{1}$(Love Marriage)

conclusions may be misleading since they do not account for general equilibrium effects, especially whether there is systematic substitution between these terms collectively (e.g., women may be willing to accept living farther away in exchange for a higher dowry) and between terms and partner characteristics. Below, we apply the framework outlined in Section 3 to shed light on these issues.

4.3 Estimation

From the IHDS, we observe whether individuals were unmarried in the year 2000 and when they got married between 2001 and 2010. Based on this information and age and education details for women and their husbands, we construct the type-spaces W and M as the cross-product of categorical measures of women's age group (young or old, as we defined earlier) and education level (less than primary school, primary school or secondary school). So, in our baseline model, each type-space consists of six elements. The set of possible relationship terms, R, consists of eight elements, which arise from the cross-product of the binary indicators for low dowry, low distance, and love marriage. With six types of women (men) and eight relationship terms combinations, there are 48 marriage markets within each district that prospective brides (grooms) can search in. As described later on, in alternative specifications, we expand the number of marriage markets within each districts to account for unobserved spousal types and hypergamy.

A major challenge to estimation is solving for the equilibrium probabilities of matching across time. We simplify the dynamic aspects of the model by assuming individuals only match during two periods which correspond to being aged 15 to 19 and 20 to 24 for women and 20 to 24 and 25 to 29 for men. This choice has a triple motivation. First, it allows us to match the structure of the Indian Census, which only releases population counts by marital status in 5-year age groups. Second, it simplifies the number of future periods, which must be explicitly solved for within each likelihood iteration. Third, it is consistent with the distribution of realized matches by age displayed in Table 2 and the fact that the overwhelming majority of matches occur between the ages of 15 and 24 for women and between the ages of 20 and 29 for men.

Rather than having separate μ's for every type-term combination,[40] we put some structure on the deterministic utility function and terminal values. Doing so helps reduce the computational

[40]We recall from Section 3 that we denote by $\mu_{mr}(w_t)$ and $\mu_{wr}(m_t)$ the deterministic portion of women's and men's utility conditional on matching.

burden. In our baseline model, we specify:

$$\begin{aligned}\mu_{w_t}^{mr} &= \alpha_1^w 1(\text{Husband 20-24}) + \alpha_2^w 1(\text{Husband Primary Educ}) + \alpha_3^w 1(\text{Husband Secondary Educ}) \\ &\quad + \alpha_4^w 1(\text{Low Dowry}) + \alpha_5^w 1(\text{Love Marriage}) + \alpha_6^w 1(\text{Low Distance}), \end{aligned} \tag{11}$$

for women; for men, we set:

$$\begin{aligned}\mu_{m_t}^{wr} &= \alpha_1^m 1(\text{Wife 15-19}) + \alpha_2^m 1(\text{Wife Primary Educ}) + \alpha_3^m 1(\text{Wife Secondary Educ}) \\ &\quad + \alpha_4^m 1(\text{Low Dowry}) + \alpha_5^m 1(\text{Love Marriage}) + \alpha_6^m 1(\text{Low Distance}). \end{aligned} \tag{12}$$

For individuals who are sufficiently old in period t, we specify their terminal values as linear functions of the sex-ratio of the next cohort entering the marriage market. So, e.g., for women aged 20-24 in period t, we set:

$$E(V_T(w_T)) = \beta \left[\tau_{w0} + \tau_w \frac{\widetilde{\widetilde{N_T^w}}}{\widetilde{\widetilde{N_T^m}} + \widetilde{\widetilde{N_T^w}}} \right], \tag{13}$$

where $\widetilde{\widetilde{N_T^w}}/(\widetilde{\widetilde{N_T^m}} + \widetilde{\widetilde{N_T^w}})$ is the share of women in the next-next generation, which we use to proxy how competitive the marriage market would be in subsequent periods.[41] So, τ_{w0} measures the terminal value for a woman who would have virtually no competition in the marriage market in the next period, but who is too old to search again for a spouse in our model. In alternative specifications, we include additional terms capturing preferences for the partner being of the same age group and heterogeneity of preferences for love marriage by age.

The parameters that need to be estimated include those of the utility functions above and the parameters of the matching function, ρ and A. We denote by θ the set of parameters to be estimated $\{\alpha^{\mathbf{w}}, \alpha^{\mathbf{m}}, \tau, \rho, A\}$, where $\alpha^{\mathbf{w}}$ and $\alpha^{\mathbf{m}}$ are the vector of preference parameters for women and men (or their families), and τ contains the terminal value parameters. The likelihood contribution for an individual who matches in a given period is the product of the search and matching probabilities; for an individual who did not match, we integrate out over the potential (unobserved) search decisions. Thus, in each period (for a woman who has never successfully matched before) we can express the likelihood function as:

$$\begin{aligned} l_{iwt}(\theta) &= \left[\prod_m \prod_r \left(\left[\phi_{w_t}^{mr}(\theta) \right] \times \left[P_{w_t}^{mr}(\theta) \right] \right)^{I(d_{iwt}=\{m,r\})} \right]^{I(y_{iwt}=1)} \\ &\quad \times \left[\prod_m \prod_r \phi_{w_t}^{mr}(\theta) \times (1 - P_{w_t}^{mr}(\theta)) \right]^{I(y_{iwt}=0)}, \end{aligned} \tag{14}$$

where y_{iwt} is a binary indicator equal to one of woman i of type w_t matches in period t, d_{iwt}

[41]To ease computation, we use the proportion of women rather than sex-ratios as our measure of marriage-market competition. Doing so does not change the interpretation of our results. The discount factor β is set at 0.82, which is consistent since our "periods" are four years in length (0.82=0.95^4). The error variance is set to four times the the scale value for a standard logit model (i.e., 1.2825). This value allows the continuation values (and utility) to not sum to such a large number that the logistic function returns extreme values of 0 or 1.

indicates which type of match she gets, $\phi^{mr}_{w_t}$ are the logit search probabilities specified in Equation (4), and θ denotes the vector of matching and utility parameters to be estimated. Each likelihood iteration involves specifying the initial vectors of matching probabilities $(\mathbf{P_t}, \mathbf{P_{t+1}})$ corresponding to $t = 2001-2005$ and $t+1 = 2006-2010$, respectively. We then proceed by explicitly solving for the fixed-point defined by Equation (10) for women and the analogous set of equations for men, iterating until the probability vectors across time, types, and district converge. More formally, the parameters of interest can be estimated by maximum likelihood as follows:

$$\hat{\theta} = \text{argmax}_{\theta}\left(\prod_t \prod_i l_{iwt}(\theta)\right), \tag{15}$$

where a fixed point in the search probabilities for men and women is solved at each iteration. That is, within each district and for each iteration of the likelihood function, we must first solve an $m \times w \times r$ fixed point in the search probabilities $(\phi^{mr}_{w_t}, \phi^{wr}_{m_t}, \phi^{mr}_{w_{t+1}}, \phi^{wr}_{m_{t+1}})$.

Unobserved Heterogeneity. Finally, we include additional heterogeneity in the form of an unobserved binary type for women. In this case, the number of markets expands from 48 to 96 for men, and the likelihood function for a type-w_t woman searching for a spouse is written conditional on the unobserved type k and the overall likelihood function is a weighted average of type-specific likelihoods:

$$L_w(\theta) = \prod_t \prod_i \left(\sum_k p(k|x_i, \theta_k) l_{iwt}(\theta_k)\right), \tag{16}$$

where $p(k|x_i, \theta_k)$ are the unobserved heterogeneity weights. We model these weights as functions of a set of observable characteristics, x_i, which essentially serve as shifters of the unobserved type and strengthen identification. As shifters, we include a woman's mother's education, the number of siblings in the woman's natal family and their gender composition, and indicator variables for whether she lives in a rural area and whether she was exposed to amendments to the Hindu Succession Act (that equalized women's inheritance rights to men's).[42] The unobserved type is assumed to be known by both men and women but unobserved to the researcher. Given the complexity of the equilibrium model, we include only one unobserved binary type, and we do so only for women.[43] Still, as shown below, accounting for unobserved hetereogeneity this way is sufficient to have the model fit the data fairly well.

[42] The Hindu Succession Act and its amendments only apply to Hindu, Buddhist, Sikh or Jain women, who were not yet married at the time of the amendment in their state. Kerala in 1976, Andhra Pradesh in 1986, Tamil Nadu in 1989, and Maharashtra and Karnataka in 1994 passed reforms making daughters coparceners. National ratification of the amendments occurred in 2005. The effect of these reforms on women's outcomes has been studied extensively. Deininger et al. (2013), for example, find evidence of an increase in women's likelihood of inheriting land following the introduction of Hindu Succession Act amendments. Roy (2015) show that the reforms increased female education, Heath and Tan (2020) argue that they increase women's labor supply, and Calvi (2020) show that they increase women's health outcomes as well as their control and access to household resources. Other related studies include Jain (2014), Anderson and Genicot (2015), Bose and Das (2015), and Bhalotra et al. (2020).

[43] Monte Carlo simulations for a male undeserved binary type suffered from weak identification. Galichon and Salanié (2020) discuss identification in similar (transferable utility) models.

5 Model Estimates and Fitness

The estimates of the model parameters, including utility, matching function, and unobserved heterogeneity parameters, are presented in Table 4. We compute standard errors from bootstrap resamples clustered at the district level. We present three versions of the model: a baseline version without unobserved heterogeneity (listed under Model (i)), an alternative model with richer preferences (Model (ii)), and a model with richer preferences and unobserved heterogeneity (Model (iii)). Model (iii) is our preferred specification, which we can reject relative to Models (i) and (ii) via a likelihood ratio test. Different from Model (i), Models (ii) and (iii) allow individuals to have preferences over partners being of their same age (age homophily) and women to have differential preferences for love marriages (as opposed to arranged marriages) by age. As discussed below, the inclusion of these additional terms and of unobserved heterogeneity in Model (iii) helps improve the model fit of our baseline model, which generally struggles to match the overall match rate and the matching statistics, especially in the second period.

Critical to disentangling men's and women's preferences given observed matches is the effect of the different sex-ratios on the individuals' search decisions. The sex-ratios manifest themselves through their impact on the probability of matching. As shown in the upper panel of Table 4, the estimates of ρ (which captures the degree to which the sex-ratio is correlated with the decision to search for a particular partner) are significant and negative, ruling out the Cobb–Douglas matching model and confirming that sex-ratios do affect the likelihood of observing particular matches. Moreover, A is estimated to be less than one in all models, suggesting the presence of search frictions.

The second and third panels of Table 4 present our estimates of the deterministic utility parameters. Focusing on spousal characteristics, men (or their families) seem to prefer younger women but dislike women's education (especially secondary education). By contrast, women prefer husbands with primary education (though they seem not to favor more highly educated men) and who are of the same age group. Turning to preferences over the terms of engagement, both men and women favor limited migration upon marriage (with positive utility values for a low distance between natal families on both sides of the market) and high dowries. While perhaps surprising, the latter finding is consistent with the high social costs associated with insufficient dowry payments and the documented negative effect of low dowries on women's post-marital well-being.[44] It is also consistent with dowries being at times used as early bequest for women rather than a groom-price (as discussed in Botticini and Siow (2003)). Whereas women (or more likely their parents) have a strong preference for arranged marriages, men seem to slightly value women's involvement in the choice of their husbands. The interactions between terms, spousal characteristics, and women's age group and the unobserved women's type ($k = 1$) are all statistically different from zero, suggesting that women's preferences are heterogeneous along several dimensions.[45] Preferences over marriage migration and younger husbands are particularly different by women's unobserved type. Since women's unobserved type is strongly correlated with their mother's education, whether they live in urban areas, and whether they have legal access to their natal family wealth, these differ-

[44] See e.g. Bloch and Rao (2002); Menon (2020); Calvi and Keskar (2020a,b).

[45] The exact set of interaction terms has been chosen to maximize the model fit.

Table 4: Structural Model Estimates

	Model (i)		Model (ii)		Model (iii)	
	Est.	St.Err.	Est.	St.Err.	Est.	St.Err.
	(1)	(2)	(3)	(4)	(5)	(6)
Matching Function (ρ, A)						
ρ	-0.298	0.079	-4.661	0.589	-7.538	2.319
A	0.848	0.010	0.855	0.005	0.830	0.008
Men's Preferences (α^{m})						
1(Wife 15-19)	9.794	0.432	8.098	0.694	17.259	0.340
1(Wife Primary Educ)	-3.050	0.390	-2.183	0.773	-5.371	0.191
1(Wife Secondary Educ)	-7.636	0.335	-6.863	0.515	-11.771	0.346
1(Low Dowry)	-6.269	0.310	-6.730	0.890	-6.254	0.459
1(Love Marriage)	-0.261	0.515	0.403	0.647	1.229	0.705
1(Low Distance)	10.496	0.594	10.188	0.681	10.095	0.423
1(Same Age)			2.944	0.728	3.000	0.585
Women's Preferences (α^{w})						
1(Husband 20-24)	2.411	0.385	-5.538	0.817	1.319	0.450
1(Husband Primary Educ)	1.131	0.545	1.974	0.389	1.584	0.438
1(Husband Secondary Educ)	-3.068	0.403	-1.424	0.496	-2.700	0.394
1(Low Dowry)	-7.424	0.654	-7.753	0.831	-7.146	0.555
1(Love Marriage)	-0.937	0.526	-1.526	0.349	-7.780	0.474
1(Low Distance)	13.429	0.476	13.836	1.496	13.914	1.023
1(Same Age)			7.611	0.996	10.020	0.683
1(Wife 20-24) × 1(Love Marriage)			-0.226	2.108	4.899	0.800
1(k=1) × 1(Love Marriage)					7.306	0.230
1(k=1) × 1(Husband 20-24)					-8.795	0.703
1(k=1) × 1(Low Dowry)					-1.274	0.460
Terminal Values (τ)						
τ_w	-26.222	0.036	-26.326	0.090	-31.647	0.112
τ_m	-60.072	0.038	-60.384	0.117	-61.688	0.017
τ_{w0}	-26.554	0.096	-26.342	0.130	-27.958	0.280
τ_{m0}	-60.666	0.076	-61.221	0.216	-60.338	0.016
1(k=1) × τ_{w0}					-21.481	0.147
Unobserved Type Shifters						
Number of Siblings					-0.045	0.184
Share of Female Siblings					-0.899	0.708
1(Hindu Succession Act)					1.699	0.833
Wife's Mother Education					2.466	0.508
1(Rural)					-1.655	0.613
Constant					4.224	0.301
-log(like)	8930.300		8929.700		8724.400	

NOTES: Maximum likelihood estimates. The sample includes women aged 15 to 24 in 2000, who married in or after 2001. The standard errors are calculated from 10 cluster-bootstrap re-samples, clustered on the district level. 1(Low Distance) equals one if the woman's distance from natal family upon marriage is less than four hours; 1(Low Dowry) equals one if the woman's family's contribution to marriage expenses is less than 1.5 times her husband's family's; 1(Love Marriage) equals one if the woman reports being involved in the choice of her husband. Mother education and number of siblings have been standardized. 1(Hindu Succession Act) equal to one if a woman is Hindu, Sikh, Jain, or Buddhist, and unmarried at the time of the Hindu Succession Act amendment in her state.

Table 5: Model Fitness: Women's Matching Probabilities

		Model (i)		Model (ii)		Model (iii)	
	Observed	Predicted	Gap	Predicted	Gap	Predicted	Gap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Period 1							
Overall	0.729	0.675	-0.054	0.697	-0.032	0.792	0.063
1(Low Distance)	0.627	0.609	-0.018	0.623	-0.004	0.715	0.088
1(Low Dowry)	0.171	0.151	-0.020	0.153	-0.018	0.184	0.012
1(Love Marriage)	0.297	0.317	0.021	0.327	0.030	0.252	-0.045
1(Husband 25-29)	0.217	0.250	0.033	0.333	0.116	0.202	-0.015
1(Husband Primary Educ)	0.275	0.300	0.025	0.300	0.026	0.374	0.099
1(Husband Secondary Educ)	0.314	0.293	-0.021	0.325	0.011	0.296	-0.018
Period 2							
Overall	0.805	0.705	-0.100	0.678	-0.127	0.817	0.013
1(Low Distance)	0.661	0.631	-0.030	0.601	-0.060	0.728	0.066
1(Low Dowry)	0.178	0.160	-0.018	0.151	-0.027	0.198	0.020
1(Love Marriage)	0.451	0.334	-0.117	0.323	-0.128	0.368	-0.083
1(Husband 25-29)	0.433	0.282	-0.151	0.428	-0.005	0.511	0.078
1(Husband Primary Educ)	0.230	0.232	0.002	0.217	-0.013	0.306	0.076
1(Husband Secondary Educ)	0.460	0.408	-0.052	0.421	-0.039	0.452	-0.007
Single in Terminal Period	0.196	0.295	0.100	0.322	0.127	0.183	-0.013

NOTE: Women's probabilities of matching. The predicted probabilities come from simulating the equilibrium model under specifications (i), (ii), or (iii). The predicted probabilities are then compared the observed fraction of matches with a given term or characteristic.

ences may reflect heterogeneity in gender-related norms, adherence to more traditional customs, and women's unobserved empowerment.[46]

The terminal values estimates in the fourth panel of Table 4 reveal that both men and women prefer to avoid not-matching, though men have a slightly stronger preference for marriage, or at least marriage before age 30. This difference may be driven by the fact that in our model the marriage window for women runs from age 15 to 24, while the marriage window for men runs from age 20 to 29, reflecting the ages where the vast majority of (but not all) men and women get married. Particularly notable is the difference in women's terminal values by their unobserved binary type.

In Table 5, we compare the predicted matching probabilities from the model with those observed in the data. The baseline Model (i) struggles to hit the overall match rate in both periods. Model (ii), which allows for limited observed heterogeneity in women's preferences, performs better, though it is still quite far from correctly predicting the probability of remaining unmatched in the terminal period. Our preferred specification (Model (iii)), which includes observed and unobserved heterogeneity, does a much better job of fitting the observed match distributions in both periods as well as the probability of remaining unmarried.

[46] Specifically, 1(k=1) women are much more likely to live in urban areas, to come from smaller natal families (with imbalanced sex-ratios among siblings, likely due to their lower fertility rates) and higher maternal education. They are also more likely to be exposed to the Hindu Succession Act Amendments, and hence to better inheritance rights over their natal family wealth.

6 Counterfactual Analysis

Given model parameters that fit the features of the terms' and characteristics' distributions fairly well (Model (iii)), we now examine a series of counterfactual environments to see how women's and men's choices and matches respond in equilibrium. First, we study how widening or shrinking sex-ratios affect matching across periods and overall welfare in equilibrium. Second, we investigate the matching and welfare consequences of a set of counterfactual policies: a ban on arranged marriages, education policies granting universal primary schooling for young women or for both women and men, a more effective enforcement of the Indian anti-dowry law, and a child-marriage ban.

The matching probabilities are computed from the model based on the women's reported matches and the observed populations of singles. Equilibrium is solved for following each policy change. Note that the matching probabilities can change because of differences in the populations of available partners or competitors, and because of prospective brides and grooms substituting away from specific characteristics or terms. Any change in the probability of searching in a given market conditional on matching would reflect these substitution effects. To compute changes in welfare, we calculate the ex-ante expected utility of facing the choice set in the first period for all respondents. Specifically, we calculate the change relative to baseline in dollar-denominated utils, using the convenient logit-consumer surplus functional form and assuming the marginal utility of wealth is 1.44,[47] and express it as a percentage of the baseline value. We then compute overall changes as a sample-weighted average of the welfare changes, using the distribution of respondents across periods as weights.

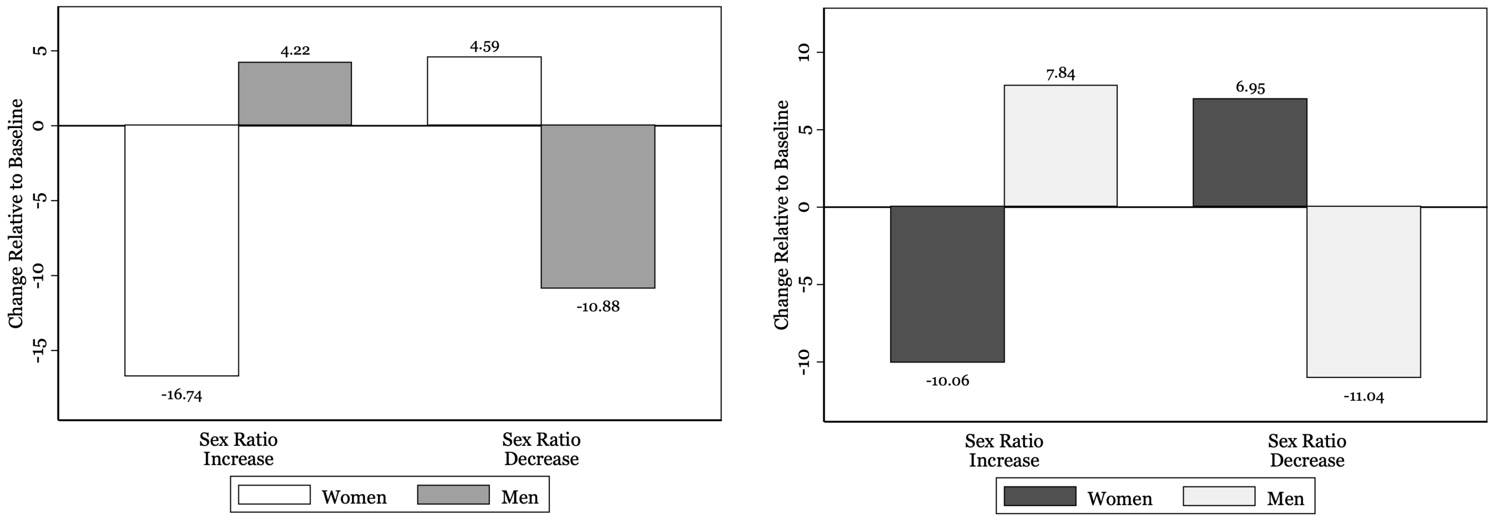
Three caveats to our counterfactual analysis deserve mention. First, as we discussed before, we are unable to disentangle spouses' preferences from their parents', which is important to keep in mind when interpreting welfare effects. Second, we take spousal traits (including human capital) as given. So, we cannot account for changes in the distribution on women's and men's education that may be induced by delaying marriage. Third, our analysis of welfare is limited to the marriage market. Since we are unable to measure how women's and men's welfare would change in other domains, we do not wish to derive definite policy implications from our analysis.

6.1 Changes in Sex-ratios

There are far more men than women in India relative to developed countries. Excess female mortality at early ages due to parental preferences for sons are essential determinants of *missing women* and biased sex-ratios (Sen, 1990; DasGupta, 2005). Technological developments permitting sex-selective abortions coupled with declining fertility have seriously aggravated this sex imbalance (Bhalotra and Cochrane, 2010; Jayachandran, 2015). Bongaarts and Guilmoto (2015) estimate that over 43 million Indian women who should have been alive in 2010 were missing. The scarcity of women of marriageable age has inevitable marriage-market consequences. To better understand these consequences, we study how equilibrium search and matching probabilities and women's and

[47] Layard et al. (2008) present a tight range of estimates for this parameter: we use their estimate for younger individuals. The logit form is $E(CS_i) = \frac{1}{\alpha_i} log\left(\sum_j^J e^{V_i^j}\right)$, where V_i^j is given in Equation (1).

Figure 5: Counterfactual Sex-ratios



(A) Match Probability

(B) Welfare

NOTE: The figure plots changes in matching probabilities and welfare for men and women following an increase or decrease in the proportion of women in each marriage market by one standard deviation (holding the population constant). Panel A reports changes in matching probabilities at the end of the second period relative to baseline (changes in the probability of remaining unmatched equal -1 times the change in the probability of matching). In Panel B, changes in welfare are calculated as the ex-ante expected utility of facing the choice set as a 15 to 19 year old woman (or a 20 to 24 year old man) in the first period or as a 20 to 24 year old woman (or a 25 to 29 year old man) in the second period. Specifically, we calculate the percentage point change in dollar-denominated utils, using the logit-consumer surplus functional form and assuming the marginal utility of wealth is 1.44.

men's welfare change following a change in sex-ratios. Specifically, in this first set of experiments, we exogenously increase or decrease the proportion of women in each age-education group within a district (by one standard deviation), while holding the overall population constant.[48]

Figure 5 plots the overall changes in the probability of finding a match (Panel A) and in women's and men's welfare (Panel B) in each counterfactual scenario relative to baseline. Note that the changes in the match probabilities shown in the figure refer to the terminal period; so, any change in probability of remaining single in the terminal period induced by the counterfactual sex-ratios simply equals the negative of the reported values. To help make sense of these overall effects and of why specific matches did or did not happen, Columns (2) and (3) of Tables A3, A4, and A5 in the Appendix provide a breakdown of the changes in matching probabilities, search probabilities, and welfare by search period, terms of engagement, and spousal traits.

A few observations emerge from this analysis. First, we can see that increasing the share of women of marriageable age in a district would reduce women's probability of matching overall and increase it for men. By contrast, increasing the relative number of men would have the opposite effects on match rates. This holds true in both periods, but particularly in the second period, with women's probability of remaining unmatched going from 18 percent to 35 percent following a one standard deviation increase in the sex-ratio and men's probability of remaining single increasing from 20 percent to 30 percent following an equivalent decline in the sex-ratio.[49] It is also the case that the decline the overall female matching rate coincides with an increased migration distance (see

[48] As discussed before, our focusing on the proportion of women rather than sex-ratios does not change the interpretation of our results, but simplifies computation by restricting the range of values that our measure of marriage-market competition can take on. In what follows, we refer to sex-ratio as the share of women in a market.

[49] An important point to note is that any increase or decrease in sex-ratios does not generate symmetric changes in the distribution of matches. This result follow from the asymmetry in terminal value estimates, but also from asymmetries in preferences for partner characteristics and terms.

Table A3): that is, women substitute away from competition by moving farther away to find spouses, but this substitution is incomplete, and more women remain single. Next, changes in the sex-ratio generate sizable changes in the age gap at marriage: as the sex-ratio declines, women (men) are more likely to marry at younger (older) ages, which would increase the spousal age gap; vice versa, improving sex-ratios would increase women's (men's) probability to match at older (younger) ages, consequently shrinking the age gap. Finally, the counterfactual search probabilities (presented in Table A4) suggest that search behaviors are fairly stable; so, the changes in the distribution of matches are driven mainly by general equilibrium effects rather than changes in what type of marriages women and men decide to pursue.

All the movements in relationship terms and spousal characteristics arising in the counterfactual equilibrium can be summarized by changes in expected utility (in Panel B of Figure 5 and Table A5 in the Appendix). When faced with higher competition in the marriage market (i.e., when the sex-ratio increases), women lose on average (older women in particular), while men are better off. The most significant gains in utility following an increase in the sex-ratio accrue to men aged 25 to 29. The welfare effects are also heterogeneous by education level. While educated women typically experience the largest decline in welfare following an increase in the sex-ratio, men who have completed primary or secondary school experience the most sizable gains.[50]

6.2 Counterfactual Policy Experiments

We now turn to analyze the effect of a series of counterfactual policies. The choice of these policies is motivated by recent developments in marriage practices and legislation in India, which we briefly discuss below. Figure 6 presents the predicted changes in the probabilities of matching by the terminal period (Panel A) and changes in ex-ante welfare (Panel B) relative to baseline in five counterfactual scenarios. Note that all counterfactual experiments alter the choice set available to prospective brides and grooms, either by changing the distribution of spousal characteristics (e.g., education or age) or the availability of the terms of engagement. Columns (4) to (8) in Tables A3, A4, and A5 in the Appendix provide a breakdown of the changes in matching probabilities, search probabilities, and welfare by period, terms of engagement and spousal traits.

From Arranged to Love Marriage. While in India the majority of all marriages are still arranged by the bride's and the groom's families, love-marriages are becoming increasingly popular in urban areas (Rubio, 2014). In our first experiment, we consider a counterfactual scenario of all women being involved in the choice of their husbands (which we interpret as a complete shift from arranged to love marriages). In a clear abuse of terminology, we refer to this experiment as one of *universal love marriage.*[51]

[50]As an alternative, we simulate the effect of a 4 percent reduction in the number of women relative to men. This counterfactual exercise is tightly linked to insightful works by Bhalotra and Cochrane (2010) and Anukriti et al. (2022b), who quantify the effect of ultrasound diffusion on sex-ratios in India: Bhalotra and Cochrane (2010) estimate that ultrasound technology resulted in a rise in sex-selective abortion, equivalent to 6 percent of potential female births during 1995–2005; Anukriti et al. (2022b) document a decrease in post-natal excess female mortality and show that for every three girls that went missing before birth, only one girl survived after birth who otherwise would have died. The combined estimates indicate that the introduction of ultrasound technology in India resulted in a 4 percent decrease in the number of female children under 5. The results of this alternate counterfactual are both qualitatively and quantitatively in line with those considered in this section and available upon request.

[51]To help alleviate concerns about differential preferences for love marriages in urban and rural districts, we recall that we include an

Our simulation indicates that the disappearance of arranged marriage would lead to an increase in the probability of matching, for both women and men. Women's universal involvement in the choice of their husbands would also shrink the age gap at marriage quite substantially, with a woman's probability of matching before the age of 20 and a man's probability of matching after age 25 both decreasing in the counterfactual scenario. This finding suggests that a young woman's actual preferences are not in favor of older spouses (despite the evidence in simulating counterfactual sex ratios above). In this scenario, women would be less likely to search for husbands with primary education in both periods, and so their likelihood to match with them would be lower. By contrast, men would be more likely to search for a woman with primary education in the second period, which would boost the matching rate of women with primary school aged 20 to 24.

Increasing Primary Education. In recent decades, several programs have focused on the status of education.[52] Partly as a result of such programs, school enrollment has increased substantially (reaching 96 percent since 2009), with girls making up 56 percent of new students between 2007 and 2013. To better understand the marriage-market effects of increasing men's and women's education, we consider two counterfactual experiments. In our first experiment, we simulate the impact of granting universal primary education to everyone (men and women of all marriageable ages). Consistent with several policies focusing on female education in particular (Chin, 2005; Muralidharan and Prakash, 2017), our second experiment studies the impact of granting universal primary education to all girls aged 15 to 19.

Both policies induce substantial changes in the probability of finding a partner. For men, the probability of finding a match increases in both experiments, while women's likelihood to remain single increases in the first but decreases in the second experiment. This is driven both by changes in the distribution of spousal traits and by changes in search behaviors (seen in Table A4). When all young women are granted primary education, they are 10 percentage points more likely to search for more educated husbands in both periods. The increase in the supply of more educated women would lead more men to search for an educated wife, hence trading-off their preferred spousal trait for a higher probability of matching.

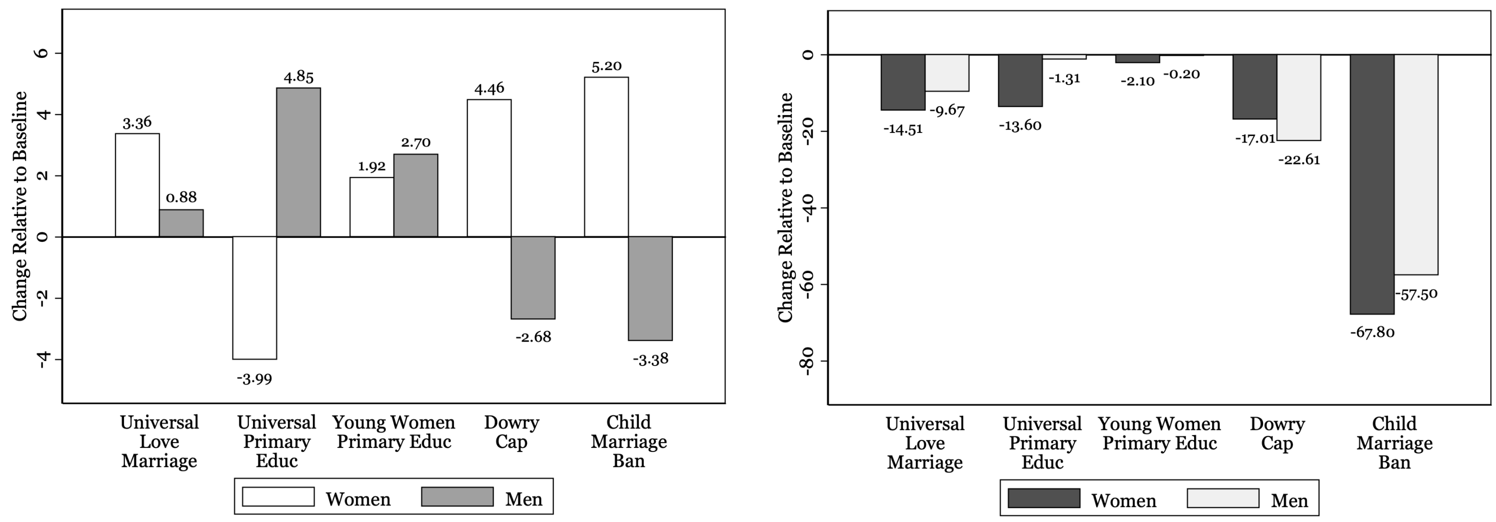
Limiting Dowries. The custom of dowry in India has been associated with parents' desire to have sons instead of daughters, leading to sex-selective abortion, and the missing women phenomenon. It has also been linked to the occurrence of violence against women, including dowry deaths and bride burning. In an attempt to curb the prevalence of dowries, the government of India enacted the Dowry Prohibition Act in 1961, prohibiting both the giving or receiving of a dowry. The provisions of the act, however, were not strong enough and its attempt to reduce dowries proved mostly unsuccessful (Chiplunkar and Weaver, 2019).[53] So, in our fourth experiment, we assess the

indicator variable for rural areas in the unobserved heterogeneity function.

[52]For example, the District Primary Education Program has been financed since the 1990s by the World Bank to facilitate India's efforts to achieve universal primary education. To enhance school enrollment and attendance and simultaneously improve nutritional levels among children, the National Programme of Nutritional Support to Primary Education was launched in 1995. In 2001, the program evolved into a Midday Meal Scheme (MDMS), under which every child in every government and government-aided primary school was to be served a prepared meal with a minimum content of 300 calories and 8-12 grams of protein per day for a minimum of 200 days.

[53]Between 1985 and 1986, the Indian government took a series of steps towards tightening the existing anti-dowry legislation. While these amendments were effective at reducing the prevalence of dowries (Alfano, 2017; Calvi and Keskar, 2020b), they failed to eliminate them (see

Figure 6: Counterfactual Policy Experiments



(A) Match Probability

(B) Welfare

NOTE: The figure plots changes in matching probabilities and welfare for men and women following each of the policy experiments. Panel A reports changes in matching probabilities at the end of the second period relative to baseline (changes in the probability of remaining unmatched equal -1 times the change in the probability of matching). In Panel B, changes in welfare are calculated as the ex-ante expected utility of facing the choice set as a 15 to 19 year old woman (or a 20 to 24 year old man) in the first period or as a 20 to 24 year old woman (or a 25 to 29 year old man) in the second period. Specifically, we calculate the percentage point change in dollar-denominated utils, using the logit-consumer surplus functional form and assuming the marginal utility of wealth is 1.44.

impact of enforcing a *dowry cap,* which essentially limits the dowry amount that can be exchanged upon marriage.[54]

Our analysis indicates that such a policy would cause overall match rates to plummet for men but to increase for women. This increase is entirely driven by increased matching for women in the second period. As a result, introducing a dowry cap could tighten the spousal age gap at marriage. When dowries are low, women are less likely to search for husbands with primary education or of the same age, while men are more likely to look for educated wives, pointing to the existence important substitution patterns. As both women and men favor high dowries, this policy would induce welfare losses for both. The estimated preferences for low dowries are fairly similar across men and women, so relatively larger welfare losses from men are being driven by marrying older women and entering the terminal period unmatched at a higher rate.

Banning Early Marriage. Our last counterfactual experiment focuses on early marriage. Specifically, we simulate the effect of an effective *child-marriage ban* by forcing women 15-19 to wait until age 20 to search for a spouse. In India, child marriage was outlawed in 1929, setting the legal minimum age of marriage at 14 for girls and 18 for boys. In 1978, the legal age for marriage was increased to 18 for women and 21 for men, respectively. Despite several efforts by the Indian government to expand the legislation on this issues,[55] one in three women who married between

Section 2 for details).

[54]Given the data limitations discussed in Section 4.1, our dowry measure is not perfect. In this simulation, we set 1(Low Dowry) to one for everyone. This means that in all marriages the bride's family's contribution does not exceed the groom's family's contribution by more than 50 percent.

[55]For example, several national policies, including the 2001 National Population Policy and, most relevant, the 2006 Prohibition of Child Marriage Act have advocated special attention to helping young women delay marriage and to enforcing existing laws against child marriage. In addition, several national flagship programs, including the Beti Bachao Beti Padhao scheme, the Scheme for Adolescent Girls, the Rashtriya Kishor Swasthya Karyakram (adolescent health) program, various national- and state-level conditional cash transfer programs for girls, as well as numerous civil society initiatives have been implemented to prevent child marriage (Jejeebhoy, 2019).

1997 and 2001 did so before their eighteenth birthday (Census of India).

We find that imposing a ban on early marriage benefits older women at the expense of men and younger women. Since they face lower competition in the marriage market, older women are more likely to look for husbands with primary education, whom they favor. To avoid remaining unmatched, men pursue more educated women, whom they do not favor. The ban generates welfare gains for older women by limiting the choice set for men (there are no younger brides to search for). Essentially, in this counterfactual experiment, women searches and matches are compressed into a single five-year time frame, improving the welfare and terms that women obtain in that 20 to 24 year old matching window, without a meaningful increases in the number of women unmarried at age 25. Younger women lose out in welfare terms since they (or their families) value matching in the 15-19 window.

As a final remark, it is interesting to note that (with few exceptions) women's and men's welfare in the marriage market is overall reduced in our experiments (though these effects are highly heterogeneous, as shown in Table A5 in the Appendix). The gender asymmetry in the welfare reductions is also striking, with women bearing a larger welfare loss in four out of five experiments. Taken together, the results of our counterfactual analysis suggest that well-intended policies may hurt women in the marriage market, although they clearly may benefit them in other domains. Our analysis also highlights possible reasons (i.e., welfare penalties) for the slow pace of change of marital customs in India (e.g., dowry and arranged marriage).

7 Robustness Checks

7.1 The Role of Caste

As mentioned in Section 2, most marriages in India happen within caste or *jati*.[56] Caste endogamy is so prevalent in India that matrimonial advertisements in Indian newspapers are often classified under caste headings to make it immediately apparent where prospective brides or grooms can find someone from their caste. Banerjee et al. (2013) study the strength of caste preferences in Indian marriages using a specialized data-set collected based on interviews with families who placed newspaper matrimonial ads in a major newspaper in West Bengal, finding strong evidence for own caste preferences (relative to, e.g., education and female beauty). Anderson (2003) also notes that within each caste, prospective brides may strive to marry wealthier husbands (hypergamy), a phenomenon that is more likely as wealth dispersion within a caste increases with modernization. While we cannot fully incorporate caste endogamy and hypergamy in our main analysis due to the data limitations discussed below, we now present some additional findings in these directions.

One critical constraint we face when trying to incorporate caste endogamy in our analysis is that the Indian Census does not provide population aggregates by caste. So, we cannot measure the choice set faced by potential brides and grooms in each marriage market.[57] Nevertheless, for

[56]There are more than 3,000 jatis in India, and it is not possible to rank them in order of status across India. Yet, in each local area, jati ranking exists. Each jati traditionally has some specific job, but today not everyone in the jati performs it.

[57]This limitation means that the sex-ratios we use in our primary analysis are noisy measures of competition in the marriage market, which

a subset of states,[58] the Indian Census separately reports population aggregates by district, marital status, age group, and sex for two broad demographic groups: Scheduled Castes (SC) and Scheduled Tribes (ST).[59] While there are several jatis within these broad categories (and even more so in the non-SC and non-ST group), we assess the sensitivity of our results to estimating our model separately for SC, ST, and non-SC/non-ST demographic groups. Columns (1) to (6) of Table A7 in the Appendix report the estimated parameters in the three subsamples. Except for the estimated utility value of women for a husband's primary education and of men for a wife of the same age, there is no meaningful difference across subsamples.

Next, we estimate an extended version of Model (iii), featuring an additional term of engagement for hypergamy. We call this specification Model (iv). Besides being faced with choosing a dowry amount, the scope of marriage migration, and whether to go for an arranged or love marriage, spouses can now decide to search for a spouse with a particular socio-economic status (relative to theirs). Specifically, we introduce a fourth binary term of engagement, which equals one if the wife's family socio-economic status at the time of marriage was higher than the husband's and zero if it was lower or the same (hence increasing the number of markets to 192 for men and 96 for women).[60] In addition, we include a caste indicator as an additional shifter of women's unobserved type.

Columns (7) and (8) of Table A7 in the Appendix present the estimation results. The estimated matching function parameters, women's and men's preferences over traits and their terminal values, and women's preferences over relationship terms are largely in line with our estimates of Model (iii) in Table 4. Men's estimated utility parameter for love marriages as opposed to arranged marriages is significantly higher when the hypergamy term is included, suggesting a likely negative correlation between the two terms. According to Model (iv) estimates, men favor love marriages and prefer not to marry a woman of a lower socio-economic status. Women (or their parents) also prefer to match with a man with a similar socio-economic status, possibly capturing a strong preferences for marrying within the same caste (as documented in Banerjee et al. (2013)). A preference against hypergamy is also consistent with the fact that women's post-marital well-being may be influenced by the relative status of the two families upon marriage (a wealthier groom may be able to command higher decision-making power after marriage, an outcome that women or their parents may want to avoid. However, we cannot rule out that this finding is driven by mismeasurement or misreporting (see footnote 60).

Finally, we conduct counterfactual experiments based on this alternative model. The counterfactual analysis based on Model (iv) rather than Model (iii) estimates delivers similar results, which are all available upon request. In summary, while we are constrained in our ability to incorporate

would likely attenuate the estimates of the matching parameters.

[58] All states and union territories except for Haryana, Delhi, Punjab, Chandigarh, Nagaland, Sikkim, Mizoram, and Pondicherry.

[59] Scheduled Castes are defined as such by provisions contained in Article 341 of the Constitution. They often suffer from extreme social, educational, and economic backwardness arising out of the age-old practice of untouchability and hence deserving special treatment because of the traditional discrimination practiced against them. Like Scheduled Castes, Scheduled Tribes are social groups recognized by the Indian Constitution as specially marked by poverty, powerlessness, and social stigma. Article 366 of the Constitution of India defines Scheduled Tribes as "such tribes or tribal communities or parts of or groups within such tribes or tribal communities as are deemed under Article 342 to be Scheduled Tribes for the purposes of this constitution."

[60] We construct this indicator variable based on the answers to the following question from IHDS: "At the time of your marriage, if you compared the economic status of your natal family with your husband's family, would you say your natal family was same, natal better off, natal worse off?".

detailed caste-related consideration in our framework due to data limitations, we do not find these limitations to be biasing our conclusions in any meaningful way.

7.2 An Alternative Way of Modeling Dowries

So far, we have modeled dowries as a term of engagement. As such, they are chosen endogenously by the two spouses or their families at the time of the marital search but there is no bargaining over them after the match occurs. This approach departs from the standard one in the literature, which treats marital transfers as a price that helps clear the marriage market (Becker, 1991). As we have argued, however, interpreting dowries as market clearing prices in the Indian setting may be problematic: on one hand, societal norms may restrict the nature and size of these transfers; on the other hand, both sides of the market may favor higher dowries due to societal expectations, reputation and other considerations.

For completeness, we test the sensitivity of the results to our specific modeling choice regarding dowries. Instead of modeling dowries as a term of engagement, we now include them as an additional shifter of the women's unobserved type. So, perspective grooms or their families do not target dowries directly, but can search for a specific type of bride who, among other traits, may be able to a provide lower or higher dowry for reasons that remain unobserved to the researcher. These may include differences in wealth and bargaining power between families, unobserved bride's quality as well as societal expectations or norms regarding marital transfers. We call this specification Model (v). In Table A7 in the Appendix, we present the estimation results: Columns (1) and (2) present point estimates and standard errors when the relative marriage contribution (our proxy for dowry and wedding expenses as discussed in Section 4.1) is included linearly as a shifter of the women's unobserved type; Columns (3) and (4) include an additional quadratic term. Relative to our baseline specification, the estimated parameters for the matching function change slightly in magnitude, but the preference parameters remain fairly stable for both men and women. Notably, the estimated coefficients on relative marriage contribution are not highly significant, suggesting that it is not strongly correlated with the woman's unobserved type.

7.3 Excluding Outliers

As an additional robustness check, we assess the sensitivity of our results to restrictions of the estimation sample. Specifically, we wish to rule out that our findings are driven by outliers.

We start by restricting the sample to districts that may have unusually conservative gender norms. Although the cohorts we examine in our empirical application were born before the widespread diffusion of sex-selective abortion,[61] there is still concern that sex-ratios might be excessively skewed in places were marital norms are also systematically different or evolving more quickly or slowly relative to other parts of the country. Accordingly, we drop from the sample districts above the 90th percentile or below the 10th percentile of the distribution of age-specific sex ratios among children

[61] Anukriti et al. (2022a) define 1973-1984 as the pre-ultrasound period, 1985-1994 as the early diffusion period, and 1995-2005 as the late diffusion period when ultrasound supply and use became widespread. Our sample consists of women who were 15 to 24 in 2000, hence born before 1985.

aged 0 to 9 in 2001 (Columns (3) and (4) of Table A9).

Additional variation in sex-ratios may come from gender-specific labor migration patterns. According to the Indian Census, four states recorded the highest declines in the share of rural population between 2001 and 2011: Kerala (by 26 percent), Goa (19 percent), Nagaland (15 percent) and Sikkim (5 percent); the top three states for increase in urban population were Sikkim, Kerala, Tripura. While other explanations are possible, labor migration from rural to urban areas may be driving these trends. Importantly for our analysis, the rates of inter-district migration for employment or education-related reasons may be not trivial and highly gendered (see Table A1 in the Appendix). To verify that these outlying movements in migration across districts are not driving our results, we re-estimate the model dropping all districts from the five states listed above (Columns (5) and (6) of Table A9). We cannot detect any substantial differences across subsamples.

7.4 Ignoring Dynamics

As a final check, we collapse our dynamic model into a static model, essentially shutting down any intertemporal dimension of substitution. Specifically, we estimate a static version of the model where the timing of a marriage, in either period one or period two, is treated as a term (distinct from partner age). We include separate preferences for men and women matching in the later period, and zero out all terminal value and dynamic parameters. This exercise allows us to answer the following questions: How critical is it to consider a dynamic formulation? What biases may arise from estimating a static model instead?

Table A9 in the Appendix provides some answers to these questions. First, a simpler static model would dramatically overestimates men's preference for younger brides. It would also overestimate women's preferences for love marriages at older ages, underestimate men's preferences for nearby matches, and suggest a slight preference by men for arranged marriages. In the static model, some women (with unobserved type equal one) also appear to slightly prefer lower dowries, possibly confounding preferences over terms with dynamic trade-offs. Second, the matching parameters estimated from a static model would yield remarkably different conclusions regarding the technology of matching: in a static model, the matching function is much closer to Leontieff and search frictions are limited (with a much lower estimated ρ and a A closer to one).

To sum up, ignoring dynamics in our setting matters and doing so may alter the conclusions of any counterfactual analysis based on the model estimates. On one hand, it can introduce significant biases in the estimated preferences that men and women have for their spouse's characteristics as well as the terms of the union; on the other hand, the matching parameter estimates obtained when dynamics are considered indicate that sex ratios may matter in ways that a static model is unable to detect.

8 Conclusion

We propose a new empirical model that can deal with dynamic sorting in the marriage market while separating the preferences of spouses for each other's (multiple) traits and those of the union. We do so by segmenting the marriage market and endogenizing sex ratios in these sub-markets as prospective spouses choose which market to join in each period. Identification exploits the fact that the vast majority of marriages in India occur within a district (the administrative unit below the state).

The model estimates reveal strong preferences for living not too far (less than four hours) from the bride's native family, not only for women but also for men. We also find that both women and men favor larger dowries, challenging the notion of dowry as a market-clearing price in the Indian context. We estimate that men have a slight preference for love marriages, while women (or more likely their parents) prefer marriages to be arranged. Notably, preferences vary substantially across women, an aspect we are able to uncover by including unobserved heterogeneity in our model. Finally, we estimate that men do not value the education of their wives and actively substitute away from highly educated women. In our counterfactual simulations, this finding translates directly into welfare losses among women following increases in female education. Our counterfactual experiments also reveal that the gradual deterioration of sex-ratios in India can have important marriage-market consequences, such as sizable changes in the spousal age gap.

There are some caveats to our analysis that deserve mention and suggest future direction for research. The most important is the hidden nature of household decisions. While we make some progress by incorporating arranged vs. love marriage as an endogenous term of engagement, it is likely the case that parental preferences are being jointly measured with the preferences of the perspective spouses. But parents and future spouses may differ substantially in what they value in the marriage market. Understanding women's preferences separately from their parents' may be especially important in India, where women's intra-household bargaining is limited (Calvi, 2020). Future work should focus on this issue. Second, while our framework accounts for the dynamic nature of marriage search and allows for inter-temporal substitution patterns, we do not explicitly model decisions about human capital investment in future brides and grooms. This is a limitation; since education and marriage decisions are tightly related at certain points in the life-cycle, future work should extend the model in this direction. Third, due to data availability, our measure of dowry is likely imprecise, which compounds problems in recovering preferences over marital transfers. Future efforts should focus on collecting detailed dowry data at the individual (rather than community) level. Fourth, Census data by sub-caste or *jati* are not available, which may mean that the sex-ratios we use in our analysis are noisy measures of competition in the marriage market. This would likely attenuate the estimates of the matching parameters. Fifth, our analysis inevitably relies on some structural assumptions about individual behavior and the environment (e.g., preference stability across markets and perfect segmentation). Future work should aim at relaxing some of these assumptions while relying on possibly richer data.

The approach we have developed can be applied to alternative settings. The data requirements for estimating a dynamic two-sided matching model as we do in this paper are modest, as it only requires survey data and aggregate population data on singles. Especially notable is the extent to which our approach can help disentangle women's and men's preferences over characteristics of their spouse and features of their marriage. A better understanding of such preferences can provide insight on the drivers of human capital investment and the persistence of traditional marriage practices in developing countries, and may help guide the design of policies aimed at improving individual welfare in many such contexts.

References

ADAMS-PRASSL, A. AND A. ANDREW (2019): "Preferences and beliefs in the marriage market for young brides," . [6]

AGUIRREGABIRIA, V. AND P. MIRA (2010): "Dynamic discrete choice structural models: A survey," *Journal of Econometrics*, 156, 38–67. [5]

ALFANO, M. (2017): "Daughters, dowries, deliveries: The effect of marital payments on fertility choices in India," *Journal of Development Economics*, 125, 89–104. [4], [32]

ANDERBERG, D., J. BAGGER, V. BHASKAR, AND T. WILSON (2020): "Marriage Market Equilibrium with Matching on Latent Ability: Identification using a Compulsory Schooling Expansion," *Unpublished Manuscript*. [3]

ANDERSON, S. (2003): "Why Dowry Payments Declined with Modernization in Europe but Are Rising in India," *Journal of Political Economy*, 111, pp. 269–310. [5], [9], [18], [34]

——— (2007): "The Economics of Dowry and Brideprice," *The Journal of Economic Perspectives*, 151–174. [1], [5], [9]

ANDERSON, S. AND C. BIDNER (2015): "Property Rights Over Marital Transfers," *The Quarterly Journal of Economics*, 130, 1421–1484. [9]

ANDERSON, S. AND G. GENICOT (2015): "Suicide and Property Rights in India," *Journal of Development Economics*, 114, 64 – 78. [25]

ANDERSON, S. AND D. RAY (2010): "Missing Women: Age and Disease," *The Review of Economic Studies*, 77, 1262–1300. [3], [6]

——— (2012): "The age distribution of missing women in India," *Economic and Political Weekly*, 47, 87–95. [3], [6]

ANUKRITI, S., S. BHALOTRA, AND E. H. TAM (2022a): "On the Quantity and Quality of Girls: Fertility, Parental Investments and Mortality," *The Economic Journal*, 132, 1–36. [36]

ANUKRITI, S. AND S. DASGUPTA (2017): "Marriage markets in developing countries," in *The Oxford Handbook of Women and the Economy*. [2], [8]

ANUKRITI, S., S. KWON, AND N. PRAKASH (2022b): "Saving for dowry: Evidence from rural India," *Journal of Development Economics*, 154, 102750. [6], [31]

ARCIDIACONO, P., A. BEAUCHAMP, AND M. MCELROY (2016): "Terms of endearment: An equilibrium model of sex and matching," *Quantitative Economics*, 7, 117–156. [5]

ARCIDIACONO, P. AND R. A. MILLER (2011): "Conditional choice probability estimation of dynamic discrete choice models with unobserved heterogeneity," *Econometrica*, 79, 1823–1867. [5]

ASHRAF, N., N. BAU, N. NUNN, AND A. VOENA (2020): "Bride price and female education," *Journal of Political Economy*, 128, 591–641. [5]

BANERJEE, A., E. DUFLO, M. GHATAK, AND J. LAFORTUNE (2013): "Marry for What? Caste and Mate Selection in Modern India," *American Economic Journal: Microeconomics*, 5, 33–72. [5], [7], [18], [34], [35]

BAU, N., G. KHANNA, C. LOW, AND A. VOENA (2022): "Traditional Institutions in Modern Times: Dowries as Pensions When Sons Migrate," . [9]

BECKER, G. S. (1973): "A theory of marriage: Part I," *Journal of Political economy*, 81, 813–846. [17]

——— (1991): *A Treatise on the Family*, Harvard University Press. [18], [36]

BHALOTRA, S., R. BRULÉ, AND S. ROY (2020): "Women's inheritance rights reform and the preference for sons in India," *Journal of Development Economics*, 146, 102275. [4], [25]

BHALOTRA, S. R. AND T. COCHRANE (2010): "Where have all the young girls gone? Identification of sex selection in India," . [3], [29], [31]

BHASKAR, V. (2011): "Sex selection and gender balance," *American Economic Journal: Microeconomics*, 3, 214–44. [5], [9]

——— (2019): "The demographic transition and the position of women: A marriage market perspective," *The Economic Journal*, 129, 2999–3024. [5], [9]

BHAT, P. N. AND A. J. F. ZAVIER (2007): "Factors Influencing the Use of Prenatal Diagnostic Techniques and Sex Ratio at Birth in India," *Watering the Neighbour's Garden: The Growing Demographic Female Deficit in Asia*, 109–130. [6]

BLOCH, F. AND V. RAO (2002): "Terror as a Bargaining Instrument: A Case Study of Dowry Violence in Rural India," *American Economic Review*, 92, 1029–1043. [3], [26]

BONGAARTS, J. AND C. Z. GUILMOTO (2015): "How Many More Missing Women? Excess Female Mortality and Prenatal Sex Selection, 1970–2050," *Population and Development Review*, 41, 241–269. [5], [29]

BORKER, G., J. EECKHOUT, N. LUKE, S. MINZ, K. MUNSHI, AND S. SWAMINATHAN (2017): "Wealth, marriage, and sex selection," Tech. rep., Technical report, Working Paper, Cambridge University. [5], [9]

BOSE, N. AND S. DAS (2015): "Women's Inheritance Rights, Household Allocation and Gender Bias," *Unpublished*. [25]

BOTTICINI, M. AND A. SIOW (2003): "Why Dowries?" *American Economic Review*, 93, 1385–1398. [3], [9], [26]

BRIEN, M. J., L. A. LILLARD, AND S. STERN (2006): "Cohabitation, marriage, and divorce in a model of match quality," *International Economic Review*, 47, 451–494. [18]

CACHON, G. P. AND S. NETESSINE (2006): "Game theory in supply chain analysis," *Models, methods, and applications for innovative decision making*, 200–233. [59]

CALDWELL, J. C., P. H. REDDY, AND P. CALDWELL (1983): "The causes of marriage change in South India," *Population studies*, 37, 343–361. [9]

CALVI, R. (2020): "Why are older women missing in India? The age profile of bargaining power and poverty," *Journal of Political Economy*, 128, 2453–2501. [6], [25], [38]

CALVI, R. AND A. KESKAR (2020a): "Dowries, Resource Allocation, and Poverty," *Unpublished Manuscript*. [3], [26]

——— (2020b): "'Til Dowry Do Us Part: Bargaining and Violence in Indian Families," *Unpublished Manuscript*. [3], [4], [26], [32]

CHADE, H., J. EECKHOUT, AND L. SMITH (2017): "Sorting through Search and Matching Models in Economics," *Journal of Economic Literature*, 55, 493–544. [3]

CHERCHYE, L., T. DEMUYNCK, B. DE ROCK, AND F. VERMEULEN (forthcoming): "Household Consumption When the Marriage is Stable," *American Economic Review*. [6]

CHIAPPORI, P.-A. (2017): *Matching with transfers: The economics of love and marriage*, Princeton University Press. [2], [17], [18]

CHIAPPORI, P.-A., E. CISCATO, C. GUERRIERO, ET AL. (2020a): "Analyzing matching patterns in marriage: theory and application to Italian data," Tech. rep. [5]

CHIAPPORI, P.-A., M. COSTA-DIAS, S. CROSSMAN, AND C. MEGHIR (2020b): "Changes in assortative matching and inequality in income: Evidence for the uk," *Fiscal Studies*, 41, 39–63. [5]

CHIAPPORI, P.-A., M. C. DIAS, AND C. MEGHIR (2015): "The Marriage Market, Labor Supply and Education Choice," Tech. rep., National Bureau of Economic Research. [6]

——— (2020c): "Changes in assortative matching: Theory and evidence for the us," Tech. rep., National Bureau of Economic Research. [5]

CHIAPPORI, P.-A. AND E. GUGL (2020): "Transferable utility and demand functions," *Theoretical Economics*, 15, 1307–1333. [18]

CHIAPPORI, P.-A., M. IYIGUN, AND Y. WEISS (2009): "Investment in schooling and the marriage market," *American Economic Review*, 99, 1689–1713. [5]

CHIAPPORI, P.-A., R. MCCANN, AND B. PASS (2020d): “Multidimensional matching: theory and empirics,” Tech. rep., Working Paper. [17]

CHIAPPORI, P.-A., D. L. NGUYEN, AND B. SALANIÉ (2019): “Matching with random components: Simulations.”,” *Work. Pap., Columbia Univ., New York Google Scholar Article Location*. [3]

CHIAPPORI, P.-A., D. ONG, Y. YANG, AND J. ZHANG (2017a): “Marrying up: Trading off spousal income and height,” Tech. rep., Working Paper. [5], [18]

CHIAPPORI, P.-A., S. OREFFICE, AND C. QUINTANA-DOMEQUE (2012): “Fatter Attraction: Anthropometric and Socioeconomic Matching on the Marriage Market,” *Journal of Political Economy*, 120, 659 – 695. [5], [17], [18]

——— (2018): “Bidimensional matching with heterogeneous preferences: education and smoking in the marriage market,” *Journal of the European Economic Association*, 16, 161–198. [17]

CHIAPPORI, P.-A. AND B. SALANIÉ (2016): “The econometrics of matching models,” *Journal of Economic Literature*, 54, 832–61. [5]

——— (2021): “Mating Markets,” Tech. rep. [2], [5], [17], [18]

CHIAPPORI, P.-A., B. SALANIÉ, AND Y. WEISS (2017b): “Partner choice, investment in children, and the marital college premium,” *American Economic Review*, 107, 2109–67. [5]

CHIN, A. (2005): “Can redistributing teachers across schools raise educational attainment? Evidence from Operation Blackboard in India,” *Journal of Development Economics*, 78, 384–405. [4], [32]

CHIPLUNKAR, G. AND J. WEAVER (2019): “Marriage markets and the rise of dowry in India,” *Unpublished Manuscript*. [1], [9], [32]

CHOO, E. (2015): “Dynamic Marriage Matching: An Empirical Framework,” *Econometrica*, 83, 1373–1423. [2]

CHOO, E. AND A. SIOW (2006): “Who Marries Whom and Why,” *Journal of Political Economy*, 114, pp. 175–201. [2], [5], [16], [17]

CISCATO, E., A. GALICHON, AND M. GOUSSÉ (2020): “Like attract like? A structural comparison of homogamy across same-sex and different-sex households,” *Journal of Political Economy*, 128, 740–781. [5]

CISCATO, E. AND S. WEBER (2020): “The role of evolving marital preferences in growing income inequality,” *Journal of Population Economics*, 33, 307–347. [5]

CORNO, L., N. HILDEBRANDT, AND A. VOENA (2020): “Age of marriage, weather shocks, and the direction of marriage payments,” *Econometrica*, 88, 879–915. [6]

DASGUPTA, M. (2005): "Explaining Asia's "Missing Women": A New Look at the Data," *Population and Development Review*, 31, 529–535. [6], [29]

DECKER, C., E. H. LIEB, R. J. MCCANN, AND B. K. STEPHENS (2013): "Unique equilibria and substitution effects in a stochastic model of the marriage market," *Journal of Economic Theory*, 148, 778–792. [17]

DEININGER, K., A. GOYAL, AND H. NAGARAJAN (2013): "Women's Inheritance Rights and Intergenerational Transmission of Resources in India," *Journal of Human Resources*, 48, 114–141. [25]

DELAVANDE, A. (2008): "Pill, patch, or shot? Subjective expectations and birth control choice," *International Economic Review*, 49, 999–1042. [12]

DESAI, S., R. VANNEMAN, AND NATIONAL COUNCIL OF APPLIED ECONOMIC RESEARCH (2012): "India Human Development Survey (IHDS 2005, 2011-2012)," Inter-university Consortium for Political and Social Research (ICPSR). [1], [18]

DIAMOND, P. A. (1982): "Aggregate Demand Management in Search Equilibrium," *Journal of Political Economy*, 90, pp. 881–894. [15]

DOMINITZ, J. AND C. F. MANSKI (1996): "Eliciting student expectations of the returns to schooling," *Journal of Human resources*, 1–26. [12]

DUPUY, A. AND A. GALICHON (2014): "Personality traits and the marriage market," *Journal of Political Economy*, 122, 1271–1319. [5], [17], [18]

EDLUND, L. (1999): "Son preference, sex ratios, and marriage patterns," *Journal of political Economy*, 107, 1275–1304. [5]

——— (2000): "The marriage squeeze interpretation of dowry inflation: A comment," *Journal of political Economy*, 108, 1327–1333. [5], [9]

——— (2006): "The Price of Marriage: Net vs. Gross Flows and the South Asian Dowry Debate," *Journal of the European Economic Association*, 4, pp. 542–551. [5]

EIKA, L., M. MOGSTAD, AND B. ZAFAR (2019): "Educational assortative mating and household income inequality," *Journal of Political Economy*, 127, 2795–2835. [5]

FIELD, E. AND A. AMBRUS (2008): "Early marriage, age of menarche, and female schooling attainment in Bangladesh," *Journal of political Economy*, 116, 881–930. [6]

FOSTER, A. AND M. ROSENZWEIG (2001): "Missing women, the marriage market and economic growth," *Unpublished Manuscript*. [5]

FULFORD, S. (2013): "The Puzzle of Marriage Migration in India," Working Paper 820, Boston College. [1], [5]

GALICHON, A. AND Y.-W. HSIEH (2017): "A Theory of Decentralized Matching Markets without Transfers, with an Application to Surge Pricing," Usc-inet research paper no. 17-03. [2]

GALICHON, A., S. D. KOMINERS, AND S. WEBER (2019): "Costly concessions: An empirical framework for matching with imperfectly transferable utility," *Journal of Political Economy*, 127, 2875–2925. [16]

GALICHON, A. AND B. SALANIÉ (2020): "Structural Estimation of Matching Markets with Transferable Utility," *Unpubloshed Manuscript*. [5], [25]

GAYLE, G.-L. (2019): "Dynamic frictionless marriage matching: commitment and household behaviour," Tech. rep. [2]

GAYLE, G.-L. AND A. SHEPHARD (2019): "Optimal taxation, marriage, home production, and family labor supply," *Econometrica*, 87, 291–326. [6]

GOODY, J. AND J. R. GOODY (1983): *The development of the family and marriage in Europe*, Cambridge University Press. [8]

GOUSSÉ, M., N. JACQUEMET, AND J.-M. ROBIN (2017): "Marriage, labor supply, and home production," *Econometrica*, 85, 1873–1919. [17]

GREENWOOD, J., N. GUNER, AND J. A. KNOWLES (2003): "More on marriage, fertility, and the distribution of income," *International Economic Review*, 44, 827–862. [17]

GREENWOOD, J., N. GUNER, G. KOCHARKOV, AND C. SANTOS (2016): "Technology and the changing family: A unified model of marriage, divorce, educational attainment, and married female labor-force participation," *American Economic Journal: Macroeconomics*, 8, 1–41. [17]

HEATH, R. AND X. TAN (2020): "Intrahousehold bargaining, female autonomy, and labor supply: Theory and evidence from India," *Journal of the European Economic Association*, 18, 1928–1968. [25]

HOEHN-VELASCO, L. AND J. PENGLASE (2021): "Changes in Assortative Matching and Educational Inequality: Evidence from Marriage and Birth Records in Mexico," *Available at SSRN 3844840*. [5]

HSIEH, Y. (2012): "Understanding Mate Preferences from Two-Sided Matching Markets: Identification, Estimation and Policy Analysis," Working paper, University of Southern California. [16]

JACOB, S. AND S. CHATTOPADHYAY (2016): "Marriage dissolution in India," *Economic & Political Weekly*, 51, 25. [7]

JAIN, T. (2014): "Where There Is a Will Fertility Behavior and Sex Bias in Large Families," *Journal of Human Resources*, 49, 393–423. [25]

JAYACHANDRAN, S. (2015): "The roots of gender inequality in developing countries," *economics*, 7, 63–88. [3], [6], [29] Jejeebhoy, S. (2019): "Ending Child Marriage in India, Drivers and Strategies," Tech. rep. [4], [33]

Keane, M. P., P. E. Todd, and K. I. Wolpin (2011): "The structural estimation of behavioral models: Discrete choice dynamic programming methods and applications," in *Handbook of labor economics*, Elsevier, vol. 4, 331–461. [5]

Keskar, A. (2021): "Marital Sorting on Height in India," *Unpublished Manuscript*. [5], [18]

Laufer, S. and A. Gemici (2011): "Marriage and Cohabitation," 2011 Meeting Papers 1152, Society for Economic Dynamics. [18]

Layard, R., G. Mayraz, and S. Nickell (2008): "The marginal utility of income," *Journal of Public Economics*, 92, 1846–1857. [29], [52]

Low, C. (2023): "The Human Capital-Reproductive Capital Tradeoff in Marriage Market Matching," *Journal of Political Economy*. [5], [17]

Manski, C. F. (2004): "Measuring expectations," *Econometrica*, 72, 1329–1376. [12]

Menon, S. (2020): "The effect of marital endowments on domestic violence in India," *Journal of Development Economics*, 143, 102389. [26]

Mortensen, D. T. (1982): "Property rights and efficiency in mating, racing, and related games," *The American Economic Review*, 72, 968–979. [17]

——— (1988): "Matching: Finding a partner for life or otherwise," *American journal of sociology*, 94, S215–S240. [17]

Munshi, K. and M. Rosenzweig (2009): "Why is mobility in India so low? Social insurance, inequality, and growth," Tech. rep., National Bureau of Economic Research. [5]

Muralidharan, K. and N. Prakash (2017): "Cycling to school: Increasing secondary school enrollment for girls in India," *American Economic Journal: Applied Economics*, 9, 321–50. [4], [32]

Rao, V. (1993a): "Dowry 'inflation' din rural India: A statistical investigation," *Population Studies*, 47, 283–293. [1], [9]

——— (1993b): "The rising price of husbands: A hedonic analysis of dowry increases in rural India," *Journal of political Economy*, 101, 666–677. [1], [5], [9]

——— (2000): "The marriage squeeze interpretation of dowry inflation: response," *Journal of Political Economy*, 108, 1334–1335. [9]

Rasul, I. (2006): "Marriage Markets and Divorce Laws," *Journal of Law, Economics and Organization*, 22, 30–69. [18]

REYNOSO, A. (2019): "Polygamy, co-wives' complementarities, and intra-household inequality," *Work. Pap, Univ. Mich., Ann Arbor*. [5]

ROSENZWEIG, M. R. AND O. STARK (1989): "Consumption Smoothing, Migration, and Marriage: Evidence from Rural India," *Journal of Political Economy*, 97, pp. 905–926. [1], [5]

ROY, S. (2015): "Empowering women? Inheritance rights, female education and dowry payments in India," *Journal of Development Economics*, 114, 233–251. [25]

RUBIO, G. (2014): "How Love Conquered Marriage: Theory and Evidence on the Disappearance of Arranged Marriages," Manuscript. [2], [4], [8], [31]

RUST, J. (1987): "Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurcher," *Econometrica*, 55, 999–1033. [12]

SEN, A. (1990): "More Than 100 Million Women Are Missing," *New York Review of Books*, pp. 61–66. [3], [5], [29]

——— (1992): "Missing women." *Bmj*, 304, 587–588. [5]

SHEPHARD, A. (2019): "Marriage Market Dynamics, Gender, and the Age Gap," Pier working paper no. 19-003. [2]

SHIMER, R. AND L. SMITH (2000): "Assortative matching and search," *Econometrica*, 68, 343–369. [17]

SVARER, M. (2004): "Is Your Love in Vain? Another Look at Premarital Cohabitation and Divorce," *The Journal of Human Resources*, 39, pp. 523–535. [18]

WISWALL, M. AND B. ZAFAR (2018): "Preference for the workplace, investment in human capital, and gender," *The Quarterly Journal of Economics*, 133, 457–507. [12]

Online Appendix (Not for Publication)

A Additional Figures and Tables

Table A1: Adult Migration in India by Origin and Reason

Migration by Origin (%)				
	Women			Men
	All	Rural	Urban	
Never moved	24.0	20.8	32.5	85.0
Moved to same district	49.1	57.2	27.4	5.2
Moved to same state (different district)	16.2	17.1	14.0	2.9
Moved to another state/country	10.8	5.0	26.2	6.9
Living in same district	73.1	78.0	59.9	90.2
Reason for Migration if Migrated (%)				
	Women			Men
	All	Same District	Different District	
Employment	1.2	0.7	2.1	60.8
Education	0.1	0.0	0.1	1.8
Displaced	0.4	0.4	0.5	2.9
Marriage	87.3	91.7	79.3	5.8
Accompany parents/family	8.6	4.9	15.2	10.8
Other	2.4	2.2	2.8	18.0

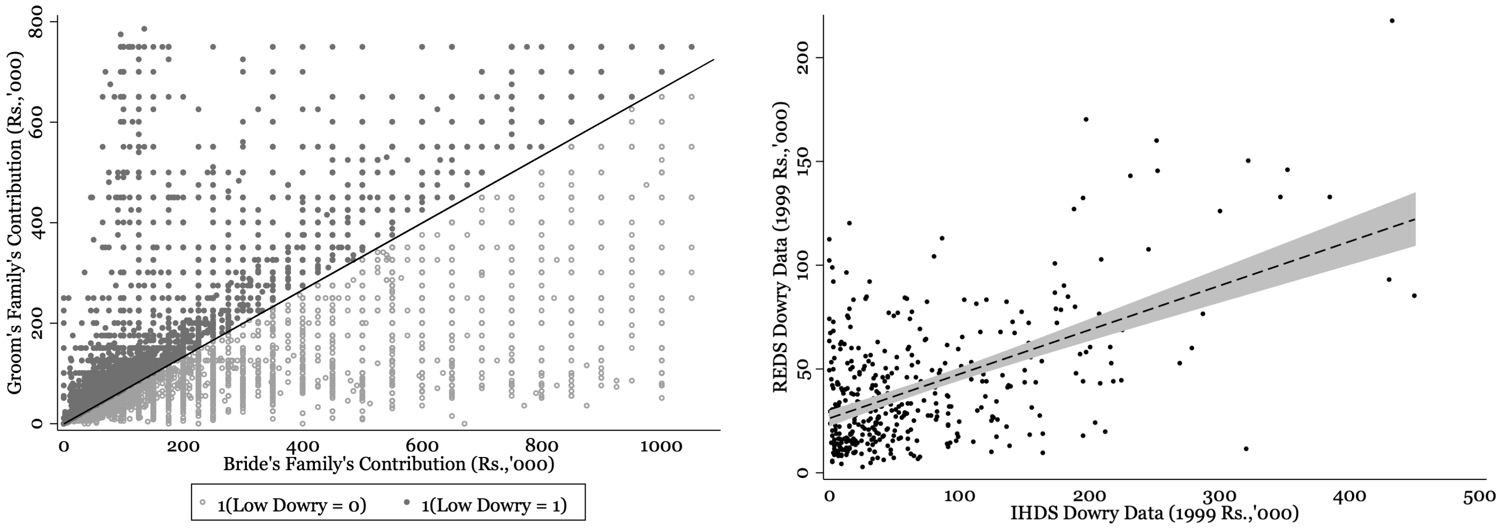
NOTES: Data are from the 64th round of the NSS Employment/Unemployment survey of 2008.

Table A2: Descriptive Statistics: India Human Development Survey

	Mean	St.Dev.	Median	Min.	Max.
Overall Sample (Obs. 27,086)					
Woman's Age at Survey	35.280	7.775	35.000	15.000	49.000
Woman's Age in 2000	23.382	7.771	23.000	4.000	38.000
Woman's Age at Marriage	18.037	3.317	18.000	5.000	42.000
Man's Age at Survey	40.602	8.692	40.000	18.000	75.000
Man's Age in 2000	28.704	8.674	28.000	6.000	63.000
Man's Age at Marriage	23.359	4.663	23.000	15.000	64.000
1(Woman No Primary Educ)	0.445	0.497	0.000	0.000	1.000
1(Woman Primary Educ)	0.329	0.470	0.000	0.000	1.000
1(Man Secondary Educ)	0.227	0.419	0.000	0.000	1.000
1(Man No Primary Educ)	0.294	0.456	0.000	0.000	1.000
1(Man Primary Educ)	0.366	0.482	0.000	0.000	1.000
1(Man Secondary Educ)	0.340	0.474	0.000	0.000	1.000
1(Low Distance)	0.792	0.406	1.000	0.000	1.000
1(Low Dowry)	0.505	0.500	1.000	0.000	1.000
1(Love Marriage)	0.271	0.444	0.000	0.000	1.000
Number of Woman's Brothers	1.982	1.296	2.000	0.000	10.000
Number of Woman's Sisters	1.893	1.477	2.000	0.000	9.000
1(Rural)	0.657	0.475	1.000	0.000	1.000
Woman's Mother's Educ	1.523	3.074	0.000	0.000	16.000
Estimation Sample (Obs. 4,342)					
Woman's Age at Survey	29.687	2.392	29.000	26.000	36.000
Woman's Age in 2000	17.759	2.363	17.000	15.000	24.000
Woman's Age at Marriage	20.545	3.194	20.000	15.000	34.000
Man's Age at Survey	34.756	4.169	35.000	22.000	65.000
Man's Age in 2000	22.828	4.133	23.000	10.000	54.000
Man's Age at Marriage	25.614	4.614	25.000	15.000	64.000
1(Woman No Primary Educ)	0.230	0.421	0.000	0.000	1.000
1(Woman Primary Educ)	0.360	0.480	0.000	0.000	1.000
1(Man Secondary Educ)	0.410	0.492	0.000	0.000	1.000
1(Man No Primary Educ)	0.167	0.373	0.000	0.000	1.000
1(Man Primary Educ)	0.354	0.478	0.000	0.000	1.000
1(Man Secondary Educ)	0.479	0.500	0.000	0.000	1.000
1(Low Distance)	0.802	0.399	1.000	0.000	1.000
1(Low Dowry)	0.492	0.500	0.000	0.000	1.000
1(Love Marriage)	0.316	0.465	0.000	0.000	1.000
Number of Woman's Brothers	1.803	1.197	2.000	0.000	10.000
Number of Woman's Sisters	1.741	1.442	1.000	0.000	9.000
1(Rural)	0.592	0.492	1.000	0.000	1.000
Woman's Mother's Educ	2.622	3.910	0.000	0.000	16.000

NOTES: Data are from the 2011-2012 India Human Development Survey. The overall sample includes ever-married women aged 15 to 49 at the time of the survey. The estimation sample includes women aged 15 to 24 in 2000, who married in or after 2001. 1(Low Distance) equals one if the woman's distance from natal family upon marriage is less than four hours; 1(Low Dowry) equals one if the woman's family's contribution to marriage expenses is less than 1.5 times her husband's family's; 1(Love Marriage) equals one if the woman reports being involved in the choice of her husband.

Figure A1: Dowry and Wedding Expenses Data

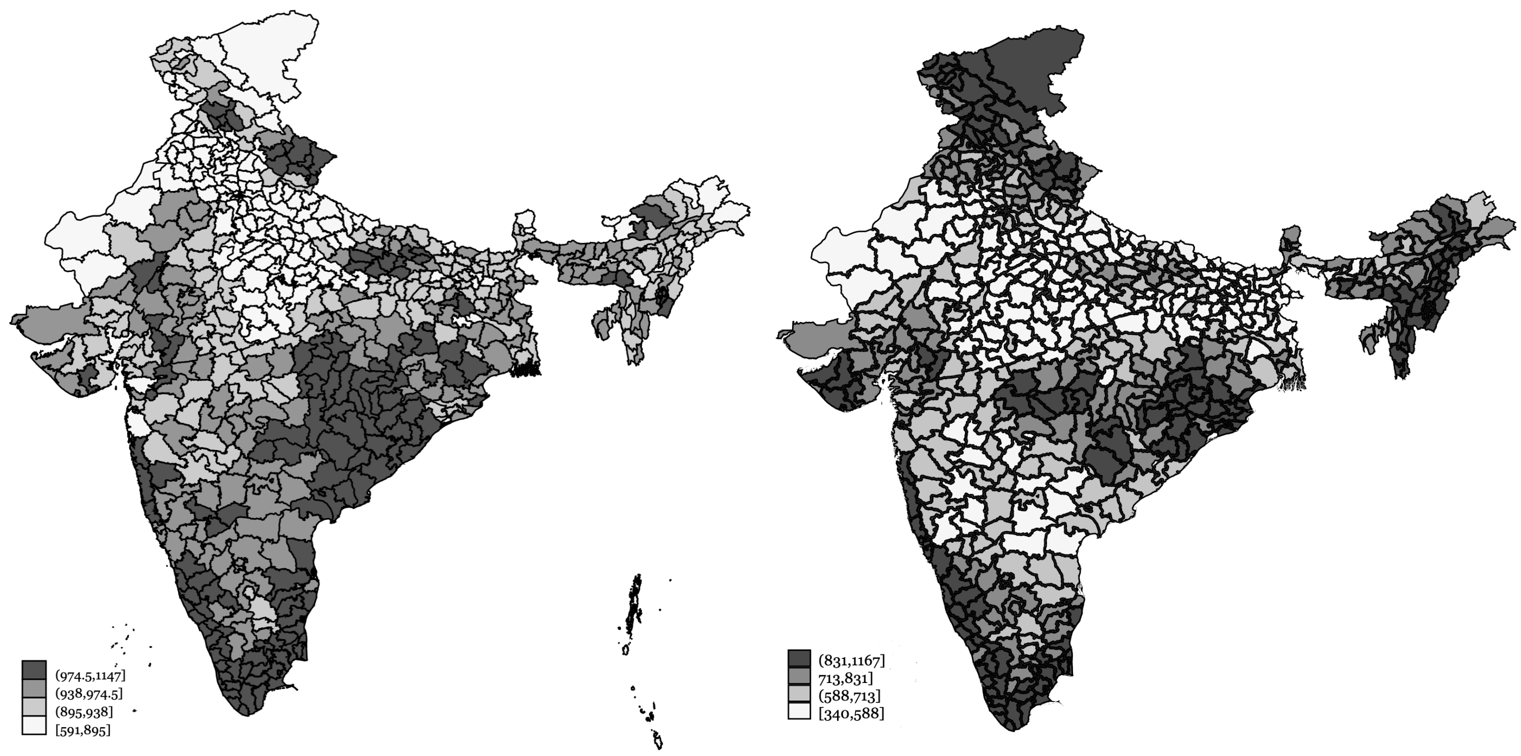


(A) Bride's and Groom's Wedding Expenses (IHDS)

(B) Average Dowry by State and Year of Marriage (REDS vs. IHDS)

NOTES: Panel A plots the reported contribution to wedding expenses by groom's and bride's families (what is typical for a family like the respondent's in his/her community). Data are from IHDS. 1(Low Dowry) is equal to 1 if the bride's contribution exceeds the groom's contribution by less than 50 percent. Panel B plots the average dowry amount by year of marriage and state in REDS vs. IHDS. The pairwise correlation is 0.55, with a p-value of 0.000.

Figure A2: District-level Sex-ratios



(A) Overall

(B) Never-married, Aged 15-29

NOTES: Data are from the Census of India 2001.

Table A3: Counterfactual Analysis: Match Probabilities

		Counterfactual Sex-ratios		Counterfactual Policy Experiments				
	Baseline	Increase ($+\sigma$)	Decrease ($-\sigma$)	Universal Love Marriage	Universal Primary Education	Young Female Primary Education	Dowry Cap	Child Marriage Ban
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Women								
Period 1								
Overall	0.792	0.733	0.835	0.602	0.765	0.774	0.591	-
1(Low Distance)	0.715	0.659	0.758	0.544	0.690	0.699	0.534	-
1(Low Dowry)	0.184	0.172	0.191	0.139	0.178	0.179	0.591	-
1(Love Marriage)	0.252	0.241	0.256	0.602	0.235	0.236	0.188	-
1(Husband 25 to 29)	0.202	0.176	0.223	0.181	0.192	0.187	0.191	-
1(Husband Primary Educ)	0.374	0.346	0.397	0.259	0.441	0.439	0.252	-
1(Husband Secondary Educ)	0.296	0.296	0.296	0.296	0.324	0.296	0.296	-
1(Wife Age 15 to 19)	0.652	0.626	0.674	0.448	0.624	0.622	0.434	-
Period 2								
Overall	0.817	0.650	0.863	0.851	0.778	0.837	0.862	0.869
1(Low Distance)	0.728	0.570	0.779	0.765	0.683	0.750	0.778	0.782
1(Low Dowry)	0.198	0.160	0.202	0.201	0.194	0.200	0.862	0.206
1(Love Marriage)	0.368	0.314	0.371	0.851	0.365	0.364	0.370	0.377
1(Husband 25 to 29)	0.511	0.384	0.607	0.582	0.383	0.549	0.634	0.675
1(Husband Primary Educ)	0.306	0.217	0.361	0.307	0.335	0.343	0.308	0.423
1(Husband Secondary Educ)	0.452	0.452	0.452	0.452	0.443	0.452	0.452	0.328
Unmatched After Period 2	0.183	0.350	0.137	0.149	0.222	0.163	0.138	0.131
Panel B: Men								
Period 1								
Overall	0.603	0.667	0.517	0.467	0.609	0.582	0.389	0.202
1(Low Distance)	0.535	0.588	0.463	0.416	0.540	0.518	0.347	0.181
1(Low Dowry)	0.137	0.155	0.113	0.104	0.139	0.131	0.389	0.044
1(Love Marriage)	0.290	0.323	0.250	0.467	0.292	0.276	0.187	0.123
1(Wife 20 to 24)	0.100	0.083	0.107	0.108	0.094	0.093	0.123	0.202
1(Wife Primary Educ)	0.252	0.296	0.204	0.195	0.307	0.292	0.161	0.060
1(Wife Secondary Educ)	0.279	0.276	0.261	0.223	0.302	0.281	0.188	0.131
1(Husband Age 20 to 24)	0.370	0.432	0.298	0.276	0.373	0.387	0.201	0.021
Period 2								
Overall	0.805	0.847	0.696	0.814	0.853	0.832	0.778	0.771
1(Low Distance)	0.711	0.743	0.623	0.719	0.747	0.732	0.690	0.681
1(Low Dowry)	0.183	0.199	0.151	0.186	0.202	0.193	0.778	0.177
1(Love Marriage)	0.414	0.430	0.370	0.814	0.432	0.423	0.403	0.455
1(Wife 20 to 24)	0.245	0.180	0.256	0.235	0.188	0.239	0.315	0.771
1(Wife Primary Educ)	0.306	0.341	0.254	0.327	0.438	0.437	0.296	0.293
1(Wife Secondary Educ)	0.395	0.362	0.370	0.380	0.415	0.395	0.400	0.401
Unmatched After Period 2	0.195	0.153	0.304	0.186	0.147	0.168	0.222	0.229

Note: The table reports the village weighted average probability of matching in a marriage with the given terms, own or partner characteristics. The simulation "+/$-\sigma$" increases (decreases) the age-education specific sex-ratio (women relative to men) by one standard deviation within each district, holding population constant. "Universal Love Marriage" eliminates arranged marriages (i.e., universal female involvement in the choice of husband). "Universal Primary Education" grants at least primary education to all women and men. "Young Female Primary Education" grants at least primary education to all women 19 and younger but leaves existing education levels for women (and men) 20 and older. "Dowry Cap" sets all dowry payments to low (i.e., the bride's family's contribution does not exceed the groom's family's contribution by more than 50 percent). "Child Marriage Ban" prevents women 15 to 19 from searching for a mate.

Table A4: Counterfactual Analysis: Search Probabilities (Conditional on Matching)

		Counterfactual Sex-ratios		Counterfactual Policy Experiments				
	Baseline	Increase $(+\sigma)$	Decrease $(-\sigma)$	Universal Love Marriage	Universal Primary Education	Young Female Primary Education	Dowry Cap	Child Marriage Ban
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Women								
Period 1								
1(Low Distance)	0.900	0.894	0.906	0.904	0.901	0.903	0.903	-
1(Low Dowry)	0.233	0.237	0.229	0.230	0.234	0.231	1.000	-
1(Love Marriage)	0.331	0.351	0.313	1.000	0.318	0.313	0.319	-
1(Husband 25 to 29)	0.267	0.267	0.271	0.268	0.261	0.244	0.290	-
1(Husband Primary Educ)	0.464	0.454	0.475	0.446	0.568	0.562	0.442	-
1(Husband Secondary Educ)	0.392	0.435	0.352	0.359	0.432	0.438	0.377	-
Period 2								
1(Low Distance)	0.888	0.871	0.901	0.898	0.876	0.895	0.902	0.899
1(Low Dowry)	0.243	0.248	0.234	0.237	0.250	0.240	1.000	0.237
1(Love Marriage)	0.456	0.500	0.432	1.000	0.477	0.439	0.431	0.435
1(Husband 25 to 29)	0.615	0.561	0.700	0.681	0.482	0.654	0.734	0.776
1(Husband Primary Educ)	0.370	0.320	0.415	0.358	0.429	0.412	0.355	0.485
1(Husband Secondary Educ)	0.560	0.635	0.503	0.546	0.571	0.588	0.554	0.380
Panel B: Men								
Period 1								
1(Low Distance)	0.892	0.883	0.901	0.896	0.890	0.895	0.899	0.901
1(Low Dowry)	0.223	0.232	0.213	0.219	0.226	0.223	1.000	0.215
1(Love Marriage)	0.475	0.480	0.473	1.000	0.473	0.469	0.457	0.585
1(Wife 20 to 24)	0.142	0.112	0.170	0.171	0.131	0.134	0.202	1.000
1(Wife Primary Educ)	0.395	0.427	0.368	0.394	0.477	0.479	0.396	0.281
1(Wife Secondary Educ)	0.504	0.446	0.549	0.516	0.523	0.511	0.514	0.676
Period 2								
1(Low Distance)	0.884	0.877	0.898	0.884	0.876	0.881	0.887	0.885
1(Low Dowry)	0.227	0.234	0.213	0.227	0.236	0.231	1.000	0.228
1(Love Marriage)	0.517	0.507	0.541	1.000	0.507	0.509	0.520	0.593
1(Wife 20 to 24)	0.323	0.219	0.414	0.301	0.227	0.299	0.425	1.000
1(Wife Primary Educ)	0.369	0.399	0.338	0.395	0.504	0.514	0.372	0.372
1(Wife Secondary Educ)	0.510	0.436	0.573	0.481	0.496	0.486	0.530	0.533

Note: The table shows the village weighted average probability of searching in a given marriage market, conditional on matching in any market. The simulation "$+/-\sigma$" increases (decreases) the age-education specific sex-ratio (women relative to men) by one standard deviation within each district, holding population constant. "Universal Love Marriage" eliminates arranged marriages (i.e., universal female involvement in the choice of husband). "Universal Primary Education" grants at least primary education to all women and men. "Young Female Primary Education" grants at least primary education to all women 19 and younger but leaves existing education levels for women (and men) 20 and older. "Dowry Cap" sets all dowry payments to low (i.e., the bride's family's contribution does not exceed the groom's family's contribution by more than 50 percent). "Child Marriage Ban" prevents women 15 to 19 from searching for a mate.

Table A5: Counterfactual Analysis: Change in Welfare (% of Baseline)

	Counterfactual Sex-ratios		Counterfactual Policy Experiments				
	Increase $(+\sigma)$	Decrease $(-\sigma)$	Universal Love Marriage	Universal Primary Education	Young Female Primary Education	Dowry Cap	Child Marriage Ban
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Women Overall	-10.061	6.948	-14.509	-13.598	-2.099	-17.011	-67.778
Women 15-19							
Overall	-3.188	1.973	-15.346	-4.941	-3.994	-16.857	-84.899
No Schooling, $k = 0$	-0.614	0.252	-19.100	-	-	-18.599	-84.914
Primary, $k = 0$	-2.057	1.292	-17.590	-2.869	-2.355	-17.625	-85.038
More than Primary, $k = 0$	-5.187	2.805	-15.468	-0.695	0.057	-16.598	-85.580
No Schooling, $k = 1$	-2.313	1.105	-4.832	-	-	-15.875	-81.725
Primary, $k = 1$	-6.680	5.151	-2.306	-1.697	2.108	-11.677	-83.063
More than Primary, $k = 1$	-7.956	11.211	-1.046	0.152	4.700	-6.741	-87.001
Women 20-24							
Overall	-72.746	52.319	-6.881	-69.989	16.226	-18.416	89.492
No Schooling, $1(k = 0)$	-5.437	2.815	-18.153	-	-8.863	-27.412	6.380
Primary, $1(k = 0)$	-16.907	9.654	-19.943	2.216	-0.830	-30.033	20.838
More than Primary, $1(k = 0)$	-139.907	99.056	4.107	11.298	38.957	-7.514	159.104
No Schooling, $1(k = 1)$	-22.539	13.813	0.177	-	3.914	-22.301	28.380
Primary, $1(k = 1)$	-126.101	95.178	35.172	31.727	31.315	9.035	200.924
More than Primary, $1(k = 1)$	65.873	-133.948	-28.540	-7.714	-10.022	-39.409	-313.057
Men Overall	7.843	-11.040	-9.671	-1.305	-0.196	-22.612	-57.478
Men 20-24							
Overall	4.652	-5.830	-7.281	-0.682	-2.250	-15.240	-33.981
No Schooling	2.816	-2.873	-9.662	-	-5.222	-18.231	-42.137
Primary	3.537	-3.863	-8.044	-2.673	-4.010	-15.941	-36.539
More than Primary	5.746	-7.722	-6.381	1.490	-0.514	-14.305	-30.940
Men 25-29							
Overall	25.236	-39.436	-22.699	-4.702	10.999	-62.790	-185.540
No Schooling	2.942	-3.915	-9.980	-	6.620	-27.829	-75.748
Primary	10.641	-15.677	-11.430	-8.290	7.192	-39.417	-120.012
More than Primary	47.435	-75.391	-38.785	-1.008	16.452	-98.165	-287.479

Note: The table reports changes in welfare as percent of baseline. Utility is measured with logit-consumer surplus calculation using 1.44 as a the marginal utility of wealth, a value estimated for younger individuals by Layard et al. (2008). The table reports the village weighted average probability of matching in a marriage with the given terms, own or partner characteristics. The simulation "$+/-\sigma$" increases (decreases) the age-education specific sex-ratio (women relative to men) by one standard deviation within each district, holding population constant. "Universal Love Marriage" eliminates arranged marriages (i.e., universal female involvement in the choice of husband). "Universal Primary Education" grants at least primary education to all women and men. "Young Female Primary Education" grants at least primary education to all women 19 and younger but leaves existing education levels for women (and men) 20 and older. "Dowry Cap" sets all dowry payments to low (i.e., the bride's family's contribution does not exceed the groom's family's contribution by more than 50 percent). "Child Marriage Ban" prevents women 15 to 19 from searching for a mate. k denotes the binary unobserved heterogeneity variable.

Table A6: Robustness Checks: The Role of Caste

	Model(iii)						Model(iv)	
	SC Only		ST Only		non-SC/ST			
	Est.	St.Err.	Est.	St.Err.	Est.	St.Err.	Est.	St.Err.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Matching Function								
ρ	-6.255	3.079	-12.749	14.053	-11.672	7.849	-7.603	2.714
A	0.857	0.019	0.871	0.040	0.838	0.023	0.837	0.008
Men's Preferences								
1(Wife 15-19)	17.030	1.046	19.501	1.863	16.540	0.367	19.001	0.209
1(Wife Primary Educ)	-4.818	1.771	-7.115	2.483	-5.485	0.651	-3.882	0.320
1(Wife Secondary Educ)	-8.933	2.876	-15.799	2.284	-12.722	0.505	-10.470	0.320
1(Same Age)	3.525	1.289	5.733	2.106	2.219	0.570	2.901	0.673
1(Low Dowry)	-7.207	1.159	-8.336	1.884	-6.604	0.659	-9.103	0.511
1(Love Marriage)	-0.905	1.928	0.724	1.616	0.343	0.608	4.722	0.395
1(Low Distance)	10.437	0.721	12.997	3.456	8.468	0.859	12.735	0.348
1(Same SES)	-	-	-	-	-	-	4.832	0.377
Women's Preferences								
1(Husband 20-24)	-1.013	3.015	1.210	2.166	1.039	0.288	1.165	0.585
1(Husband Primary Educ)	1.524	0.774	-0.194	0.900	1.855	0.653	2.792	0.286
1(Husband Secondary Educ)	-3.431	0.993	-6.791	1.853	-3.155	0.778	-0.994	0.500
1(Same Age)	12.424	3.667	12.583	1.992	9.716	0.483	10.424	0.249
1(Low Dowry)	-6.013	1.876	-4.225	1.657	-7.099	0.636	-6.969	0.466
1(Love Marriage)	-8.703	1.168	-6.754	1.611	-6.656	0.593	-7.883	0.309
1(Love Marriage) × 1(Wife 20-24)	5.846	3.036	9.012	3.564	5.016	0.329	5.814	0.425
1(Low Distance)	13.750	0.879	13.727	3.704	13.950	0.706	13.803	0.529
1(k=1) × 1(Love Marriage)	7.824	1.769	5.553	2.182	8.440	0.495	7.399	0.179
1(k=1) × 1(Husband 20-24)	-11.860	3.594	-11.401	4.344	-8.703	0.393	-9.102	0.352
1(k=1) × 1(Low Dowry)	-2.196	1.627	-2.051	3.544	-0.851	0.416	-0.859	0.479
1(Same SES)	-	-	-	-	-	-	18.322	0.441
Terminal Values								
τ_w	-31.943	0.461	-31.770	0.204	-31.689	0.029	-31.783	0.045
τ_m	-61.831	0.220	-61.870	0.188	-61.681	0.009	-61.803	0.020
τ_{w0}	-28.077	0.482	-27.825	0.474	-28.030	0.058	-27.806	0.083
τ_{m0}	-60.485	0.232	-60.588	0.238	-60.287	0.033	-60.427	0.004
1(k=1) × τ_{w0}	-22.050	0.898	-21.860	0.300	-21.541	0.043	-21.789	0.072
Unobserved Type Shifters								
Number of Siblings	-0.020	0.655	-0.689	1.157	0.450	0.428	-	-
Sibling Sex Mix	-2.068	1.950	3.450	4.725	-1.143	0.658	-0.389	0.400
1(Hindu Succession Act)	4.606	3.404	6.883	4.502	0.028	0.862	1.513	0.349
Wife's Mother Education	3.817	1.473	5.397	1.646	1.966	0.289	2.665	0.179
1(Rural)	-1.423	0.899	-1.507	2.109	-2.250	0.620	-1.519	0.474
1(non-SC or ST)	-	-	-	-	-	-	-0.064	0.313
Constant	5.127	1.722	2.824	1.891	4.827	0.719	4.318	0.323

NOTES: Maximum likelihood estimates. The standard errors are calculated from 10 cluster-bootstrap re-samples, clustered on the district level. SC stands for Scheduled Castes; ST stands for Scheduled Tribes.

Table A7: Robustness Checks: Dowry As Unobserved Type Shifter

	Model(v)			
	Linear		Quadratic	
	Est.	St.Err.	Est.	St.Err.
	(1)	(2)	(3)	(4)
Matching Function				
ρ	-3.399	0.854	-3.258	1.071
A	0.816	0.010	0.809	0.008
Men's Preferences				
1(Wife 20-24)	14.115	1.159	15.566	1.903
1(Wife Primary Educ)	-8.930	1.946	-9.983	1.091
1(Wife Secondary Educ)	-17.562	1.989	-18.736	1.303
1(Same Age)	1.491	1.097	1.589	0.851
1(Love Marriage)	-0.081	1.266	0.335	0.830
1(Low Distance)	10.420	0.938	10.712	0.929
1(Same SES)	14.943	1.714	14.843	1.628
Women's Preferences				
1(Husband 20-24)	-4.512	2.071	-4.955	1.102
1(Husband Primary Educ)	-2.509	0.976	-2.442	0.438
1(Husband Secondary Educ)	-9.405	1.18	-9.152	0.666
1(Same Age)	15.027	2.561	17.243	1.983
1(Love Marriage)	-6.636	2.225	-6.775	1.028
1(Love Marriage) × 1(Wife 20-24)	6.306	1.984	6.878	1.015
1(Low Distance)	12.974	0.910	12.832	0.916
1(Same SES)	12.263	1.782	12.683	0.725
$1\{k=1\}\times$ 1(Love Marriage)	5.895	2.122	5.577	0.907
$1\{k=1\}\times$ 1(Husband 20-24)	-11.971	3.607	-13.523	2.296
$1\{k=1\}\times$ 1(Same SES)	4.739	1.902	4.329	0.705
Terminal Values				
τ_w	-31.684	6.560	-31.760	0.076
τ_m	-61.978	12.455	-62.191	0.194
τ_{w0}	-27.270	5.413	-27.152	0.295
τ_{m0}	-60.759	11.787	-61.026	0.324
$1\{k=1\}\times\tau_{w0}$	-21.587	4.457	-21.790	0.176
Unobserved Type Shifters				
Number of Siblings	0.030	0.251	-0.002	0.666
Sibling Sex Mix	-2.518	1.651	-2.137	1.214
1(Hindu Succession Act)	5.613	2.331	5.039	0.908
Wife's Mother Education	6.138	1.403	5.695	1.187
1(Rural)	-1.922	0.938	-2.094	1.016
Relative marriage contribution	0.543	0.408	0.650	0.828
(Relative marriage contribution)^2	-	-	2.158	0.165
Constant	6.271	1.488	6.091	0.748

NOTES: Maximum likelihood estimates. The standard errors are calculated from 10 cluster-bootstrap resamples, clustered on the district level.

Table A8: Robustness Checks: Excluding Outliers

	Model(iii)					
	Baseline		Excl. 0-9 Sex-Ratio Outliers		Excl. Migration Outliers	
	Est.	St.Err.	Est.	St.Err.	Est.	St.Err.
	(1)	(2)	(3)	(4)	(5)	(6)
Matching Function						
ρ	-7.538	2.319	-7.7493	1.7276	-7.3361	2.4706
A	0.830	0.008	0.8305	0.0077	0.8355	0.0075
Men's Preferences						
1(Wife 15-19)	17.259	0.340	17.2328	0.6072	17.2552	0.9307
1(Wife Primary Educ)	-5.371	0.191	-5.3598	0.6133	-5.4063	0.8492
1(Wife Secondary Educ)	-11.771	0.346	-11.9023	0.5713	-11.6879	0.9607
1(Same Age)	3.000	0.585	2.9313	0.8576	2.979	1.1981
1(Low Dowry)	-6.254	0.459	-6.4909	1.0778	-6.2035	0.6149
1(Love Marriage)	1.229	0.705	0.8762	0.9157	1.1263	1.164
1(Low Distance)	10.095	0.423	9.9889	0.8973	10.0948	0.6897
Women's Preferences						
1(Husband 20-24)	1.319	0.450	1.0838	0.3792	1.5117	0.5164
1(Husband Primary Educ)	1.584	0.438	1.3105	0.9109	1.5992	0.8777
1(Husband Secondary Educ)	-2.700	0.394	-2.5691	0.6432	-2.8502	0.6533
1(Same Age)	10.020	0.683	9.9473	0.8517	10.2275	0.8883
1(Low Dowry)	-7.146	0.555	-7.2598	0.5918	-7.0634	0.8776
1(Love Marriage)	-7.780	0.474	-8.0007	0.682	-8.0196	0.4699
1(Love Marriage) × 1(Wife 20-24)	4.899	0.800	4.9974	1.0464	4.9391	0.7434
1(Low Distance)	13.914	1.023	13.8538	0.5668	13.7642	1.2743
1(k=1) × 1(Love Marriage)	7.306	0.230	7.1653	0.6579	7.1517	0.6093
1(k=1) × 1(Husband 20-24)	-8.795	0.703	-8.9868	1.2628	-8.6524	0.9054
1(k=1) × 1(Low Dowry)	-1.274	0.460	-1.3147	0.6682	-1.2351	0.3896
Terminal Values						
τ_w	-31.647	0.112	-31.6669	0.1288	-31.6593	0.1792
τ_m	-61.688	0.017	-61.6896	0.0403	-61.6906	0.0341
τ_{w0}	-27.958	0.280	-27.9881	0.2304	-27.9829	0.3728
τ_{m0}	-60.338	0.016	-60.3307	0.0641	-60.3394	0.0251
1(k=1) × τ_{w0}	-21.481	0.147	-21.5126	0.2026	-21.4983	0.2700
Unobserved Type Shifters						
Number of Siblings	-0.045	0.184	0.2177	0.3279	-0.031	0.2466
Share of Female Siblings	-0.899	0.708	-0.8894	0.7295	-0.8833	0.5657
1(Hindu Succession Act)	1.699	0.833	1.5528	0.5798	1.7627	0.8685
Wife's Mother Education	2.466	0.508	2.5511	0.5884	2.504	0.4497
1(Rural)	-1.655	0.613	-1.7571	1.0939	-1.7227	0.5965
Constant	4.224	0.301	4.1386	1.006	4.1846	0.4898
Districts	292		241		277	

NOTES: Maximum likelihood estimates. The standard errors are calculated from 10 cluster-bootstrap re-samples, clustered on the district level. In Columns (3) and (4), the model is estimated using a subsample that excludes districts in the top and bottom 10 percent of the 0-9 sex-ratio distribution. In Columns (5) and (6), the model is estimated using a subsample that excludes Kerala, Goa, Nagaland, Sikkim, and Tripura.

Table A9: Robustness Checks: Ignoring Dynamics

	Model(iii)			
	Dynamic (Baseline)		Static	
	Est.	St.Err.	Est.	St.Err.
	(1)	(2)	(3)	(4)
Matching Function				
ρ	-7.538	2.319	-97.232	91.016
A	0.830	0.008	0.972	0.013
Men's Preferences				
1(Wife 15-19)	17.259	0.340	54.034	0.065
1(Wife Primary Educ)	-5.371	0.191	-4.126	0.384
1(Wife Secondary Educ)	-11.771	0.346	-10.623	0.526
1(Same Age)	3.000	0.585	3.768	0.657
1(Low Dowry)	-6.254	0.459	-5.593	0.363
1(Love Marriage)	1.229	0.705	-1.593	0.595
1(Low Distance)	10.095	0.423	7.989	0.242
1(Marry in Period 2)	-	-	-2.433	0.419
Women's Preferences				
1(Husband 20-24)	1.319	0.450	3.953	0.401
1(Husband Primary Educ)	1.584	0.438	2.120	0.744
1(Husband Secondary Educ)	-2.700	0.394	0.175	0.739
1(Same Age)	10.020	0.683	8.508	0.481
1(Low Dowry)	-7.146	0.555	-8.340	0.320
1(Love Marriage)	-7.780	0.474	-8.833	0.381
1(Love Marriage) × 1(Wife 20-24)	4.899	0.800	10.046	0.315
1(Low Distance)	13.914	1.023	12.388	0.919
1(k=1) × 1(Love Marriage)	7.306	0.230	8.607	0.196
1(k=1) × 1(Husband 20-24)	-8.795	0.703	-8.732	0.617
1(k=1) × 1(Low Dowry)	-1.274	0.460	2.042	0.610
1(Marry in Period 2)	-	-	-6.217	0.323
Terminal Values				
τ_w	-31.647	0.112	-	-
τ_m	-61.688	0.017	-	-
τ_{w0}	-27.958	0.280	-	-
τ_{m0}	-60.338	0.016	-	-
1(k=1) × τ_{w0}	-21.481	0.147	-	-
Unobserved Type Shifters				
Number of Siblings	-0.045	0.184	-0.412	0.219
Share of Female Siblings	-0.899	0.708	0.133	0.041
1(Hindu Succession Act)	1.699	0.833	4.955	0.001
Wife's Mother Educ	2.466	0.508	1.364	0.060
1(Rural)	-1.655	0.613	-2.768	0.076
Constant	4.224	0.301	11.241	0.113
Districts	292	-	292	

NOTES: Maximum likelihood estimates. The standard errors are calculated from 10 cluster-bootstrap re-samples, clustered on the district level. In Columns (3) and (4), we estimate a static version of the model where the timing of a marriage, in either period one or period two, is treated as a relationship term (distinct from partner age). We include separate preferences for men and women matching in the later period, and zero out all terminal value and dynamic parameters.

B Identification

We here focus on the identification of the parameters of interest under the linear utility case presented in Section 4.3. Identification in our context revolves around a three equation system observed across districts. For the purpose of discussing identification of the key parameters, we abstract away from observable male and female characteristics, as what follows can be considered conditional on each (i, j)-characteristic match. Examining the simplified case with two terms a and b is also sufficient to see how parameters are identified. In each district (d), we observe the following:

$$\frac{N_a^{(d)}}{N_w^{(d)}} = Q_a = \phi_{a,w} P_{a,w} = \frac{e^{\mu_w P^*_{a,w}}}{1+e^{\mu_w P^*_{a,w}}} \cdot A \cdot \Big[1 + \Big(\frac{e^{\mu_m P^*_{a,m}}/(1+e^{\mu_m P^*_{a,m}})N_m^{(d)}}{e^{\mu_f P^*_{a,w}}/(1+e^{\mu_w P^*_{a,w}})N_w^{(d)}}\Big)^{\rho}\Big]^{1/\rho} \tag{B1}$$

$$\frac{N_b^{(d)}}{N_w^{(d)}} = Q_b = \phi_{b,w} P_{b,w} = \frac{1}{1+e^{\mu_w P^*_{a,w}}} \cdot A \cdot \Big[1 + \Big(\frac{1/(1+e^{\mu_m P^*_{a,m}})N_m^{(d)}}{1/(1+e^{\mu_w P^*_{a,w}})N_w^{(d)}}\Big)^{\rho}\Big]^{1/\rho} \tag{B2}$$

$$1 - \frac{N_a^{(d)}}{N_w^{(d)}} - \frac{N_b^{(d)}}{N_w^{(d)}} = 1 - Q_a - Q_b = \phi_{a,w}(1-P_{a,w}) + \phi_{b,w}(1-P_{b,w}). \tag{B3}$$

Here Q_a, Q_b represent the probability of observing a woman in district d matched on terms a and b respectively and equation (B3) is the probability of remaining unmatched. P^* represents the equilibrium probabilities of matching within the share function ϕ. At an equilibrium, permutations in parameters which formally enter the recursive definition of P need not be considered.[62] Drawing from a sample of matches (and unmatched women) across districts, the left-hand side of the equations above can be viewed as observed, and the right hand-side constitutes a set of non-linear equations, the inversion of which will implicitly define the parameters (μ_w, μ_m, A, ρ) as functions of the sex-ratio $N_w^{(d)}/N_m^{(d)}$ and term specific match rates $N_a^{(d)}/N_w^{(d)}$ and $N_b^{(d)}/N_w^{(d)}$. Monotonicity in the right-hand side functions is sufficient to prove identification, subject to the constraint that there are enough districts to identify the of parameters. Clearly, the system is invertible in A. It is important to note, however, that since A drops out as an additive constant in the log-likelihood estimation, it is only identified through equation (B3) (that is, how non-matching rates vary across districts). For the remaining parameters, we have:

Proposition 1. *Monotonicity of Q-functions. Both Q_a and Q_b are monotonic in the parameters μ_f, μ_m and ρ.*

Proof. See Appendix D.

So long as the underlying share functions and matching functions (in composition) are monotonic, the equations can be inverted. We must also have enough districts across which to observe these equations. For example, a linear model with four terms could create six term-specific param-

[62]Three analogous equations can be expressed for men if the researcher had double reporting on matching terms from both sides of the market. Our focus here though is identifying the model from aggregate data and a sample of women reporting on their marriage terms, so we focus only on the female match rates. These three equations only constitute two independent observations on match rates under the assumption that all agents search.

eters (with one parameter normalized for each sex) in addition to the matching parameters ρ and A, meaning at least four districts would be required at a minimum. While in principle using characteristics data to subdivide each district into multiple matching markets would aid in identification, in practice it would run the risk of confusing term- and characteristic-specific preference parameters. Whereas preference parameters over characteristics could in principle be identified for every (i, j)-combination (subject to discrete choice normalizations and the need to identify matching parameters from the same system), identifying term-specific preferences is more limited. Generally, for k binary terms the number of terms parameters that could be identified in a linear model would be $2^k - 2$; with two matching function parameters this means the number of districts $N_{(d)}$ must be greater than $2^k/2$. In practice we keep the number of parameters to identify far below this threshold.

Including Parameters of the Dynamic Discrete Choice Problem. Identification for the dynamic version of the choice can be formulated along the same lines. In the dynamic model, we parameterize the continuation value as a function of the terminal value parameters τ_w. Thus, in the final period matching problem, we have the following expression for the women's search probability:

$$\phi^T(\mu_w, \tau_w) = \frac{e^{\mu_w P_w^* + (1-P_w^*)\beta\tau_w}}{1 + e^{\mu_w P_w^* + (1-P_w^*)\beta\tau_w}}; \tag{B4}$$

and in all but the final period we have:

$$\phi^t(\mu_w, \tau_w) = \frac{e^{\mu_f P_w^* + (1-P_w^*)\beta EV_w^{t+1}}}{1 + e^{\mu_w P_w^* + (1-P_w^*)\beta EV_w^{t+1}}}, \tag{B5}$$

where β is the discount factor and EV_w^{t+1} is the expected value function of facing the marriage search problem in the subsequent period. This expression is a non-linear function of observed cohorts entering the search problem in $t+1$,[63] those agents unmatched from time period t, and model parameters μ_w, μ_m, ρ, A and τ.[64] For the purposes of identification, we note the monotonicity of Q_a, Q_b with respect to (μ_w, μ_m) will also apply to the τ-parameters in the terminal period, so they are identified by (i) assuming other preference parameters are stable across time and (ii) the co-movement between T-period term-specific match rates and period-specific sex-ratios. Again, given reliance on the same match rate expressions the identification requires multiple markets, and the dynamic model parameters (similar to term-preference parameters) increases the number of districts needed for identifying the model by two (for the two terminal value parameters τ_f, τ_m).

Other Comments. For the purposes of estimation, we do not observe aggregate counts of terms, and instead rely on a representative sample ofwomen for whom we observe the probabilities of search conditional on matching and the instance of non-matching. We do see observable characteristic-specific sex-ratios, which enter the right-hand side of the equations above. From these

[63]This is under the assumption of a rational expectations model where agents forecast ahead future entry by cohorts aging into the market

[64]With a long-enough panel, the discount factor β could in principle be identified since sex-ratios of future cohorts change the expected value function, without directly affecting utility. However, the sex-ratios of future cohorts will also influence the other agents search choices today, so such variation isn't ideal since works through the endogenous decisions to influence current equilibrium probabilities P_f^*. We set the discount factor in all estimations given this complexity.

two data sources, we can identify the preference parameters within the ϕ functions for both terms and characteristics, along with the matching function parameters. Identifying gender differences in preferences relies on cross-district variation as described above. The set of assumptions necessary for identification are as follows:

- All agents search.
- Preferences for terms and spousal characteristics are stable across marriage markets and over time.
- The parameters of the matching function are stable over time in the dynamic model.
- There is no selection on unobservables into matching, so that a sample of matches can identify the probability of search conditional on match.
- Agents follow rational expectations in the dynamic search problem.

C Existence and Uniqueness of Equilibrium

To study the existence and uniqueness of the equilibrium in the probability of matching, it will suffice to use the same simplified example with two terms a and b from Appendix B. We apply a local version of the contraction mapping argument. The recursive definition for a probabillity of matching for a women on term a is given by:

$$P_{a,w} = A\Big[1+\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}\Big]^{1/\rho} \tag{C1}$$

which makes explicit the functional dependence of the ϕ-choice probabilities on the P-match probabilities. We note that $P_{a,w}$ being continuous on the closed interval $[0,1]$ guarantees existence of at least one equilibria by the fixed point theorem, so long as $\rho<0$ and markets are populated so the number of searchers on each side is greater than unity. To demonstrate when this equation constitutes a contraction mapping, we start by taking the derivative with respect to the number of women searching for relationship terms a:

$$\frac{\partial P_{a,w}}{\partial(\phi_{a,w}N_w)} = \frac{A}{\rho}\Big[1+\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}\Big]^{1/\rho-1}\rho\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho-1}\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{(\phi_{a,w}(P_{a,w})N_w)^2}\Big)$$

which can be further simplified to:

$$\frac{\partial P_{a,w}}{\partial(\phi_{a,w}N_w)} = A\Big[1+\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}\Big]^{1/\rho-1}\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}\Big(\frac{1}{\phi_{a,w}(P_{a,w})N_w}\Big). \tag{C2}$$

For a function $x=f(x)$ on a local interval to converge to a unique fixed point, it is enough to verify that locally we have $|f'(x)|<1$ (Cachon and Netessine, 2006). The natural interval in this setting is $[0,1]$; so here we have the following:

$$\frac{\partial P_{a,w}}{\partial(\phi_{a,w}N_w)} = A\underbrace{\Big[1+\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}\Big]^{1/\rho-1}\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}}_{<1}\underbrace{\Big(\frac{1}{\phi_{a,w}(P_{a,w})N_w}\Big)}_{<1}. \tag{C3}$$

Where A is less than one by parameterization, and the final term because each market we consider is populated, so $(\phi_{a,w}N_w) > 1$. To see why the middle term is less than one we refer the interested reader to Proposition 2 below.

Proposition 2. *If $\rho < 0$ and a market is populated, so that*

$$S = \frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w} > 0$$

then we have:

$$\Big|\Big[1+\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}\Big]^{1/\rho-1}\Big(\frac{\phi_{a,m}(P_{a,m})N_m}{\phi_{a,w}(P_{a,w})N_w}\Big)^{\rho}\Big| < 1.$$

Proof. See Appendix D.

This result follows from the CES structure of the matching function. Given this result, we have $|\partial P_{a,w}/\partial(\phi_{a,w}N_w)| < 1$, that is (C3) means that as the number of searchers changes, how much match probabilities can move is limited by the nature of the matching function. What remains is to link this with how changes in the matching probabilities affects the number of searchers.

Using the iterative approach we have, for a sequence of $\{P^{(1)}_{a,w}, P^{(2)}_{a,w}, \ldots, P^{(l)}_{a,w}, \ldots\}$ where $P^{(l)}_{a,w} = f\left(P^{(l-1)}_{a,w}\right)$ and f is given by the right-hand side of (C2). We note

$$\frac{\partial f}{\partial P^{(l-1)}_{a,w}} = \frac{\partial f}{\partial(\phi_{a,w}N_w)} \cdot \frac{\partial(\phi_{a,w}N_w)}{\partial P^{(l-1)}_{a,w}}. \tag{C4}$$

We have already demonstrated that the first term is less than one. Recall that in a simplified model we have

$$\phi_{a,w} = \frac{e^{\mu_{a,w}P_{a,w}+(1-P_{a,w})EV_w}}{1+e^{\mu_{a,w}P_{a,w}+(1-P_{a,w})EV_w}} \tag{C5}$$

where EV is the expected value of facing the search problem in the subsequent period. The second term is less than one in absolute value when the following condition is satisfied:

$$\left|\frac{\partial(\phi_{a,w}N_w)}{\partial P^{(l-1)}_{a,w}}\right| = \left|(EV_w - \mu_{a,w})(\phi^2_{a,w} - \phi_{a,w})N_w\right| < 1. \tag{C6}$$

When this is true, any change in P is forced through the logistic function and scaled by the difference between flow utility and the continuation value, and therefore cannot yield changes greater than one (though they may be positive or negative depending on preferences). In this model the combination of choice probability and a CES-matching function usually provide a smooth enough surface which allows for a unique equilibrium. Analogous results hold for male match-probabilities. While this condition is not obviously true, we verify the full-model version of it after estimation and find that 96.1% of the matching markets satisfy this condition.[65]

While admittedly this approach involves ignoring potential multiple equilibria to verify uniqueness, the derived conditions indicate that while we may be facing multiple equilibria in some markets, the issue of multiplicity of equilibria is not a first-order concern in interpreting the estimated models. We also note that technically this argument holds fixed the male match probabilities, which in practice we update jointly with women's search probabilities.[66]

D Proofs

Proof of Proposition 1: First we show the probability of matching is monotonic in ρ. Let P be a function of parameters (A, ρ) and the ratio of searching agents on either side of a market

$$P = A\Big[1 + \Big(\frac{NSW}{NSM}\Big)^{\rho}\Big]^{\frac{1}{\rho}} \tag{D1}$$

Substituting $S = \frac{NSW}{NSM}$ and taking the derivative with respect to ρ, we have

$$\frac{\partial P}{\partial \rho} = A[\frac{1}{\rho}\log(S)S^{\rho}(S^{\rho}+1)^{\frac{1}{\rho}-1} - \frac{1}{\rho^2}\log(S^{\rho}+1)(S^{\rho}+1)^{\frac{1}{\rho}}]. \tag{D2}$$

The expression yields two cases: (a) $\log(S) > 0$ and (b) $\log(S) < 0$ ignoring for the moment the knife-edge case where $S = 1$. When case (a) holds the expression is everywhere negative since $\rho < 0$. When case (b) holds we have the following condition for the expression to be negative:

$$\frac{1}{\rho^2}\log(S^{\rho}+1)(S^{\rho}+1)^{\frac{1}{\rho}} > \frac{1}{\rho}\log(S)S^{\rho}(S^{\rho}+1)$$

To prove monotonicity of the composite functions Q_a, Q_b in (μ_w, μ_m), let $\phi(\mu_w) = \frac{e^{\mu_w P_w^*}}{1+e^{\mu_w P_w^*}}$ so that:

$$Q_a(\rho, A, \mu_w, \mu_m | N_m, N_w) = \phi(\mu_w)\cdot A\cdot\Big[1 + \Big(\frac{\phi(\mu_m)N_m}{\phi(\mu_w)N_w}\Big)^{\rho}\Big]^{\frac{1}{\rho}}$$

$$Q_b(\rho, A, \mu_w, \mu_m | N_m, N_w) = (1-\phi(\mu_w))\cdot A\cdot\Big[1 + \Big(\frac{(1-\phi(\mu_m))N_m}{(1-\phi(\mu_w))N_w}\Big)^{\rho}\Big]^{\frac{1}{\rho}}$$

[65] We calculate the fraction of matching markets across districts for both men and women since $P_{a,w} \neq P_{a,m}$. In Model (iii) in the paper, we have 12 types of women, 6 types of men, 16 terms and 292 districts and two time periods, which yields 672,768 markets, 96.1% of which showed condition (C6) to be true. The fully dynamic model version of this condition allows the change in match probability to affect the expected future values since unmatched younger individuals will re-enter the matching market, so we have:

$$\Big|\frac{\partial(\phi_{a,w}N_w)}{\partial P_{a,w}^{(l-1)}}\Big| = \Big|\Big(\frac{\partial EV_w}{\partial P_{a,w}^{(l-1)}} * P_{a,w}^{(l-1)} + EV_w - \mu_{a,w}\Big)(\phi_{a,w}^2 - \phi_{a,w})N_w\Big| < 1. \tag{C7}$$

The equation for the continuation value is:

$$\frac{\partial EV_w}{\partial P_{a,w}} = \phi'_{a,w}(\mu'_{a,w} - TV)f'(-N_w\phi_{a,w}) \tag{C8}$$

where prime denotes the next period value, TV is the terminal value, and f' is the right hand side of (C3) in the subsequent period. Incorporating this into the check we see 96.47% of terminal-period markets had unique solutions, and 95.73% of first period markets had unique solutions.

[66] Computational concerns exist getting stuck in local extrema when one follows a complete updating of one sex followed by the other. We also update the f function with convex combination of the old match probabilities so: $P^{(t)} = \alpha f(P^{(t-1)}) + (1-\alpha)P^{(t-1)}$ with $\alpha = .10$. In practice, we initiate every iterative approach from the same starting values.

Here N_w, N_m are the observed numbers of men and women, and (P_w^*, P_m^*) are the equilibrium probabilities of matching within the share function ϕ. At an equilibrium, permutations in μ which formally enter the recursive definition of (P_w, P_m) are not considered.[67] Under such conditions we $\partial\phi/\partial\mu_w > 0$ since

$$\frac{\partial\phi}{\partial\mu_w} = P_w^* e^{\mu_w P_w^*}\Big(1+e^{\mu_w P_w^*}\Big)^{-1} - P_w^*(e^{\mu_w P_w^*})^2\Big(1+e^{\mu_w P_w^*}\Big)^{-2}$$

which is always positive since

$$\frac{e^{\mu_w P_w^*}}{1+e^{\mu_w P_w^*}} > \Big(\frac{e^{\mu_w P_w^*}}{1+e^{\mu_w P_w^*}}\Big)^2. \tag{D3}$$

We can re-write the system by factoring out the $\phi(\mu_w)$ expressions so that we have

$$Q_a = \frac{1}{N_w}\cdot A\cdot\Big[(\phi(\mu_w)N_w)^\rho + (\phi(\mu_m)N_m)^\rho\Big]^{\frac{1}{\rho}}$$

$$Q_b = \frac{1}{N_w}\cdot A\cdot\Big[((1-\phi(\mu_w))N_w)^\rho + (1-\phi(\mu_m))N_m)^\rho\Big]^{\frac{1}{\rho}}$$

These expressions are monotonic in (μ_w, μ_m) since:

$$\frac{Q_a}{\partial\mu_w} = \frac{1}{N_w}\cdot A\cdot\frac{1}{\rho}\Big[(\phi(\mu_w)N_w)^\rho + (\phi(\mu_m)N_m)^\rho\Big]^{\frac{1}{\rho}-1}\cdot\rho\cdot(\phi(\mu_w)N_w)^{\rho-1}\cdot\frac{\partial\phi}{\partial\mu_w} > 0$$

$$\frac{Q_b}{\partial\mu_m} = \frac{1}{N_w}\cdot A\cdot\frac{1}{\rho}\Big[((1-\phi(\mu_w))N_w)^\rho + (1-\phi(\mu_m))N_m)^\rho\Big]^{\frac{1}{\rho}-1}\cdot\rho\cdot((1-\phi(\mu_m))N_w)^{\rho-1}\cdot\Big(-\frac{\partial\phi}{\partial\mu_m}\Big) < 0.$$

Proof of Proposition 2: Let $R = S^\rho$, so the condition requires:

$$\Big[1+R\Big]^{(1-\rho)/\rho} < \frac{1}{R}.$$

Taking the log of both sides and multiplying by $-\rho$ the required condition becomes:

$$(\rho-1)\log(1+R) < \rho\log(R)$$

Case 1: $R > 1$. Since $\rho < 0$ it must be the case that $|\rho-1| > |\rho|$, Since $R > 1$ we have:

$$\log(1+R) > \log(R)$$

which multiplying through by ρ becomes

$$\rho\log(1+R) < \rho\log(R)$$

[67] Considering the equilibrium probability as a function of μ_w changes the sign but does not change monotonicity since $\partial P_w/\partial\mu_w < 0$.

but since $\rho - 1$ is a more negative number than ρ we have:

$$(\rho - 1)\log(1+R) < \rho\log(1+R) < \rho\log(R).$$

Case 2: $R < 1$. Here we have

$$\underbrace{(\rho - 1)}_{-}\underbrace{\log(1+R)}_{+} < \underbrace{\rho}_{-}\underbrace{\log(R)}_{-},$$

so the right hand side is always positive as long as $\rho < 0$ and the condition is always satisfied.