Dowry, Violence and Divorce*

November 15, 2024

Parimal Bag[1]

Abstract

Dowry violence plaguing a non-negligible proportion of arranged marriages in India is a classic case of market failure under asymmetric information. Dowry exchanged at the time of marriage fails to reveal the groom's hidden type, because social norm builds into expectation that a groom will ask for a dowry. Brides and their parents go along with it but may have to fight it out later on if the marriage turns turbulent with demands for further extortion.

By inflicting violence, a bad type groom *screens* the type of the bride and her parents—whether a 'compliant' or 'stubborn' type. Violence leaves a trail of physical evidence, so escalating violence for extortion demand not being fully met is of low marginal cost to the perpetrator if the bride and her parents are of compliant type. Expected extortion is increasing in dowries. High dowry creates a status-quo bias in preserving marriage.

Dowry sorts the marriage market assortatively—matching high-value grooms with brides–parents whose combined worth are also high, leaving low-value grooms to marry low-value brides whose parents cannot compensate adequately. Equilibrium dowries are *compressed*—ask prices are depressed because brides and their parents can push the grooms down the dowry-demand path due to limited number of good available matches; dowries are also propped up because parents desperate to match their daughters with well-earning grooms would compete to the last cents (rupee) of their paying-power.

JEL Classification: D59, D82, J12, J16, K14, K42.

Key Words: Marriage market, asymmetric information, dowry, violence, extortion, divorce, social norm, money burning, screening, signalling, Dutch auction, dowry compression.

*__Work in progress.__

[1]Department of Economics, National University of Singapore, Faculty of Arts and Social Sciences, AS2 Level 6, 1 Arts Link, Singapore 117570; E-mail: ecsbpk@nus.edu.sg

1 Introduction

Dowry-related violence in India is a well-recognized social problem even now despite its anti-dowry laws and reforms.[1] Along with dowries demanded by grooms at the time of (arranged) marriage, post-marriage extortions from the brides' parents through violence and intimidation is a common occurrence among the poor as well as rich, in both villages and urban areas. One of the first papers to examine this issue using economic theory and survey data is Bloch and Rao (2002). The authors view the groom's dissatisfaction with the bride as the cause for domestic violence. Violence signals credibly the groom's dissatisfaction, asking for financial compensation failing which the groom will leave the bride and remarry. Scarcity of choice for the brides to remarry, lack of financial independence of women and the stigma of divorce, all create a power imbalance. The work is followed by an extensive empirical literature on household decision making and asymmetric power, educational investment in female child, violence and homicide, in developing as well as developed countries.[2]

Against the above backdrop, with improving education and job opportunities for women, urbanization and exposure to progressive views on women's rights, the scale of power imbalance is tilting somewhat.[3] Divorce is not as stigmatized and because of the groom's obligation to pay alimony in a marriage breakdown for which violence is one of primary triggers, the issue of dowry violence needs a fresher scrutiny with divorce as an exit option.

We model grooms to be one of two types, *good* (or non-violent) or *bad* (or violent), which is a reflection of their likely behavior post marriage. Groom's type is private. Brides' parents (and the brides) are also one of two types – *stubborn* or *compliant* – and again the type is private information. Even stubborn parents are accepting of the norm of having to pay dowry for their daughter's marriage, because it can be seen as a gift to get the new couple started on better economic footing and also it is a necessary price to pay to secure a financially better groom.

[1] The following quote is taken from the Indian Ministry of Women and Child Development website ("Dowry System," dated 10 Dec 2021) (`https://pib.gov.in/PressReleasePage.aspx?PRID=1780110#:~:text=As%20per%20information%20received%20from,7167%2C%207141%20and%206966%20respectively.`):

> "*As per information received from NCRB, the number of cases registered under the Dowry Prohibition Act, 1961 during 2018, 2019 and 2020 are 12826, 13307 and 10366 respectively. Further, the cases registered under Dowry Deaths during these years are 7167, 7141 and 6966 respectively.*"

(NCRB is an abbreviation for National Crime Records Bureau.) Another report dated 06 Dec 2023 states,

> "*As many as 13,479 cases were registered in 2022 under the Dowry Prohibition Act, 1961, according to the National Crime Records Bureau (NCRB) data that was released on Monday, December 4. At the same time, 6,450 dowry deaths were registered in 2022.*"

See `https://www.thenewsminute.com/news/more-than-6000-dowry-death-cases-registered-in-2022-ncrb-data`.

[2] Srinivasan and Bedi (2007), Aizer and Dal Bó (2009), Aizer (2010), Eswaran and Malhotra (2011), Anderson and Genicot (2015), Erten and Keskin (2018), Menon (2020), and Calvi and Keskar (2023).

[3] Tertilt et al. (2022) is an empirical study of how expansion of women's rights – economic, political, labor, and body – have been associated with economic development over the last 50 years across the world. The right to divorce and protection against domestic violence were not there even in common law countries such as the USA and the United Kingdom two centuries ago. See also an early work on the subject: Luke and Munshi (2011).

But post-marriage, they firmly oppose any form of violence and monetary extortion; any such demand will prompt them to go for the daughter's divorce. Only compliant parents, who worry about the stigma of divorce, are willing to compromise to ensure their daughter remains married and make transfers to the groom.

One of the key differences from Bloch and Rao's modelling is how we view violence: it is a costly way for a bad groom to *screen* the in-laws' type, rather than *signalling* any dissatisfaction in marriage. Violence is necessary to test the water – whether the in-laws can be pressured to make the post-marriage transfer. Of course the cost is that the stubborn in-laws will be triggered leading to divorce and the groom having to pay the alimony. We build our analysis with this narrative of dowry violence. As such there is no unhappy marriage at the start (in the sense Bloch and Rao described), nor are the grooms actively looking to remarry. Marriage is arranged via a competitive matching market under asymmetric information about the grooms' types and in-laws' types, in which dowry is the mediating price mechanism in the matching stage and violence is the sorting mechanism in post-marriage extortion negotiations.

In order to explain how violence helps screening, we need to understand that domestic violence is not a one-off phenomenon. Instead, it is a gradual pressure building tactic adopted by the groom to extort money from the in-laws. If the groom were to issue only a threat of violence without intending to carry it out, the threat loses its force and the monetary transfer from the in-laws does not materialize. To overcome this problem and to sustain violence in equilibrium, we formulate it as a one-off costly *money burning* decision: the torture of the bride with a trail of physical evidence that, if produced before the court, would facilitate divorce and make the groom pay the alimony. While compliant parents do not want the divorce, they do not want to make the monetary transfer either demanded by the groom. But once the groom has already inflicted violence on the bride, any additional violence in the event of the 'promised' (or expected) transfer unheeded is not costly to the groom because the threat of taking the groom to the court and implementing divorce is still intact for the original violence committed. Thus, refusal by compliant in-laws to make the full monetary transfer at one go is not rational: why subject the daughter to further violence? One strike is enough to overcome the problem of non-commitment of repeated extortion. This is a key result, summarized in Proposition 1, where our paper starts to depart fundamentally from Bloch and Rao (2002).

While Bloch and Rao motivates us to undertake this study, our model is much richer and comprehensive.[4] It is not just about dowry violence. The bride can divorce the groom and seek compensation (alimony) which introduces a different dynamic to the groom's violence decision.[5]

[4]The model is less rich in one sense – we do not analyze intra-household bargaining for resource allocation between husband and wife.

[5]In today's India dowry violence is not just limited to rural villages but also a concern for urban families, and independent working women are not shy of divorce. Bringing in divorce as a choice for women alters the interaction between grooms and brides. Our modelling is thus a natural adaptation of changing times. Note that the option of divorce does not make the analysis any less applicable to village households as we allow for compliant brides–parents who concede to extortion demands because of social shame of divorce as well as lesser

And preceding the violence stage, we build a fully fleshed out competitive marriage market with asymmetric information about the two sides' private types.[6] Arranged marriages with no prior information discovery stage are a leap in the dark, especially for the brides and their parents. So studying how a price (dowry) mechanism facilitates matching is a very relevant question to ask. Does price mitigate information asymmetry? With the grooms' and brides' visible human capital and the (brides') parents' observable wealth, price is best placed to harmonize the observable characteristics. But can dowry also mitigate the risks of a bad marriage, the bride being paired with a violent groom? In a way, the additional threat of divorce should act as a restraint on violence. But at the start, shouldn't asking too much dowry partly reveal the groom's character? And if that works, could limited price variability jeopardize perfect synchronization of bride's and groom's matching according to their human capital? We seek to address all these questions using an extensive form *marriage-violence-divorce* game.

The introduction of the marriage market explicitly is the second important difference.[7] In Bloch and Rao, the groom is allowed to remarry which is entered as an exogenous parameter that influences groom's dowry bargaining with the bride's parents. This short-cut was necessary as modelling multilateral bargaining in a market with multiple prospective brides and grooms for marriage and groom's marriage after divorce poses a difficult technical hurdle. How is dowry to be determined in the extensive game formulation? True to the spirit of a competitive market,[8] instead we are going to determine equilibrium dowries when heterogeneous grooms and brides–parents decide on their preferred match from multiple alternatives. With extensive ongoing empirical works by researchers in the field, enriching the theory of marriage market with dowry has the potential to deliver a better understanding of dowry violence.

■ **Results.** Applying backwards induction, we first study the post-marriage continuation game. Our main result here offers a different rationalization of violence (as discussed earlier): it's a screening mechanism to determine if the bride's parents can be pressured for the extortion money (Proposition 1). In the case where bride's parents are of compliant type, we show a positive relationship between the level of dowry exchanged at the time of marriage and subsequent extortions (Proposition 2). The intuition is that a bigger dowry, by generating more utility for the couple, creates a status-quo bias in preserving an abusive marriage. This incentivizes in-laws

average human capital of the brides, the latter due to inadequate investments by parents in girls and a preference for inheritance of parental homes and agricultural lands being given to sons.

[6] In Bloch and Rao's formulation, a groom and a bride negotiates dowry with only the groom having an outside option of remarriage that is also taken to be exogenous. Considering the marriage market explicitly allows all prospective brides and grooms to weigh their available options that, in turn, will give rise to equilibrium pairing of brides and grooms and a vector of dowries.

[7] Studying marriage market is not new, as we will review a related work by Anderson and Bidner (2015). But analyzing marriage market with dowry violence is new.

[8] Considering a competitive market for arranged marriages is not unrealistic with newspaper ads and internet portals dedicated towards marriage (e.g., https://www.shaadi.com/) for bringing together two sides of the alliance. Even in villages where marriages might be confined within a given caste, the set of brides and grooms at any point of time is usually small and can be considered to be common knowledge through the word-of-mouth of relatives or by mediation of the *Ghataks* (Majumdar, 2004).

to accede to higher extortion demands from an abusive groom.

Stepping back to the marriage proposal stage, our first result is that in posting dowry demands the grooms cannot be too greedy: violent types must ask for dowries that are no different from that demanded by non-violent, good type grooms (Proposition 3).[9] The pooling equilibrium result squashes any hope of the grooms' types being revealed at the dowry exchange stage. In the process, there will be Stiglitz and Weiss (1981) type *upwards-stickiness of dowries*. Moreover, for some ranges of dowries stubborn brides may decline a groom's proposal (Corollary 1). This creates an additional downward pressure on dowries.

A second non-revelation result is about the brides' parents. They cannot signal their stubbornness at the marriage proposal stage for lack of credible means of communication (Proposition 4). While the parents only have the option of $\{\text{Accept}, \text{Reject}\}$ choices over the grooms' dowry proposals, endowing them with any other cheap-talk messages will be ineffective as claiming other than *"I am a stubborn type"* will likely increase the chances of a proposal from a violent groom which is undesirable to both stubborn and compliant type parents.

Our final two results concern how the equilibrium market clearing dowries are determined. Much of the construction relies on a careful partitioning of the two sides of the marriage market. First, the grooms are ranked in equivalence classes according to their observable worth. Then the brides and the parents are grouped in the order of their joint worths (bride's human capital plus parents' wealth). Starting from the class of highest-value grooms going down the hierarchy, bride–parents groups are collated or split (by subtracting some pairs) in a decreasing hierarchy in order to exactly match the number of grooms from the highest economic class (of grooms) and lower down successively, with the following restriction: the *maximum* combined worth of brides and parents in a hierarchy must not exceed the *minimum* combined worth of brides and parents one hierarchy above. Finally, each groom from an economic class (i.e., hierarchy) make one-to-one proposal of $\big(\textbf{marriage}, \textbf{dowry}\big)$ to one bride belonging to the same hierarchy as his own and to a second bride one hierarchy below who will have the maximum (bride–parents) combined worth for that lower hierarchy. That is, we restrict each groom's proposals to only a pair of brides, and the proposals take the form of dowry offers with an Accept/Reject choice by the brides and their parents. The dowry offers are made with the groom pushing the bride and parents in the lower hierarchy to their maximal worth, who will have no better option than to accept the proposal. This, in turn, drives the bride and parents from the groom's same hierarchy to accept a dowry proposal that combined with the bride's human capital equals the combined worth of the competing bride and parents from the lower-down hierarchy.[10] Any dowry proposal

[9] Any upward deviation through higher dowry demands would lead to the groom being shunned by prospective brides due to a punishing off-equilibrium belief, that the groom must be of violent type. Such belief might be considered reasonable because violent types have more to gain from higher dowries due to follow-on extortions; this satisfies the D1 refinement of Cho and Kreps (1987). There is no gain, and it is strictly a loss, also from downward deviation so long as at the pooling dowry the proposal is accepted.

[10] This is a different kind of "bidding of the wall," to borrow a terminology from the common-value auction literature (Vincent, 1995); the bride–parents from the lower hierarchy serves as an additional option for the

that exceeds (in at least one coordinate) the pair of dowries derived thus will be believed to be coming from a violent type groom. In effect, we have constructed a one groom selling his candidacy for marriage to two prospective brides as in a one seller–two buyers Dutch auction. The equilibrium of this game will involve both bride–parents pairs accepting the proposal, the groom then honoring the acceptance of the bride and parents from his own hierarchy and rejecting the bride–parents from the lower hierarchy. All grooms paired this way in parallel Dutch auctions end up marrying one bride each, in *assortative matching* (Proposition 5).

Note that having the option of marrying the alternative bride from the competing bride–parents pair in the lower hierarchy serves to prop up equilibrium dowries that otherwise could be in a free-fall due to punishing beliefs. We thus have a result of *dowry compression* – a unique equilibrium dowry for each groom according to his own worth and the worth of the bride he is going to marry, given by the equation (34) (or (35)). Dowry cannot go up or come down.

The marriage mechanism can be decentralized further by allowing random matching between prospective grooms and brides over a finite period of time. By applying a variant of the decentralized trading mechanism of Rubinstein and Wolinsky (1990) with no discounting, we show that the assortative matching outcome with the corresponding dowries in Proposition 5 can be implemented (Proposition 6). The mechanism is closer to an iterative search for a partner through proposal/no-proposal and accept/reject decisions in a market setting, which is a more realistic description of the marriage market.[11] Basically, in each round every groom is paired exclusively with one bride and vice versa. Either of them may choose not to proceed to marriage with the groom not making a proposal or the bride not agreeing to the proposal. Pairs culminating in marriages are permanently removed from the set of participants for future matching. Also, any mismatch is excluded from the set of possible matches in future rounds, although the individuals themselves return to the pool of candidates for matching. This process converges to the equilibrium outcome of Proposition 5.

■ **Literature review.** We bring together two very specific literatures that relate predominantly to India: *dowry in marriages* and *dowry violence*. Both literatures are well-subscribed, with the latter seeing renewed interests of late from economists. The former studies the role of economic transactions between two families, the bride's and the groom's, to facilitate marriage. While Becker (1981) had originally noted dowry for its economic role in marriages, the empirical significance of the sustained growth of dowry in marriages in Indian villages roughly during the period 1950–1990 was underpinned by Rao (1993) offering a "marriage squeeze" explanation (due

groom although the option is never exercised in equilibrium.

[11] Without the dowry, the search for a partner is the non-cooperative version of the classic matching problem as exemplified in a book by Richter and Rubinstein (2024) (see Ch. 1), with preferences (over partners) incompletely specified due to lack of knowledge over partner's type. So unlike the book's title suggests, our modelling of marriage is quite the opposite with *prices* and *games* rather than *no prices, no games*. And the preference basis for marriage is not intangible love but money (i.e., partners' human capital), greed and violence (as means for monetary extortion) and divorce. Finally, dowry can be explained only by societal norms (Ch. 2 of Richter and Rubinstein); most societies don't have dowries despite the factors determining marriage preferences being not that dissimilar.

to a greater number of younger cohorts of women than men with growing population).[12] The general issues of dowry are well-studied.[13] On dowry violence, Rao (1997), and Bloch and Rao (2002) are two key contributions drawing economists' attention that had previously been the focus of sociologists and anthropologists. Some of the follow-on and recent works include Sekhri and Storeygard (2014), Anderson and Genicot (2015), Bhalotra et al. (2020), Calvi and Keskar (2023), and Bag and Sikdar (2024).[14]

In the theoretical literature on marriage with dowry, of direct relevance is Anderson and Bidner (2015). The authors develop a property rights theory of dowry: (i) how parents allocate resources between their own consumption and children's consumption (e.g., bride's parents choosing between investment in daughter's human capital and marriage payment) depends on the differential returns to human capital for males and females and the distribution of bargaining power in marriage;[15,16] (ii) dowry is given predominantly as grooms money, called marriage payment, rather than as bequest to the daughter (to which the daughter would have had better claims), mainly to attract more wealthy grooms. Our work is different in several respects: (i) with two-sided asymmetric information and the post-marriage violence and divorce possibilities in the background, the analysis of marriage market brings a different challenge, but we do not have the richness of pre-marriage parental investment decisions influencing dowries;[17] (ii) while both settings consider marriages as the outcome of price-mediated market interactions, ours is a finite population model and auction is a natural mechanism to look at whereas Anderson and Bidner's model assumes many atomistic families as in perfect competition, treats dowry as a given function of bride's and groom's human capital, $t(w_f, w_m)$, and then finds a self-fulfilling linear dowry function that arises through the endogenous allocation of parental resources and clearing of marriage market; (iii) a key difference thus comes down to the mechanism of dowry determination: our marriage equilibrium is the result of a Dutch auction where a bride's worth plus the dowry paid equals the maximum joint worth of a competing aspirant family wanting to

[12] In an unpublished dissertation, Dasgupta (1991) had similarly studied, using ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) data of South Indian villages over a ten year period (1975/76–84/85), alternative theories of dowries.

[13] Anderson (2003; 2007a; 2007b), Anderson and Bidner (2015), Zhang and Chan (1999), Edlund (2006), Maertens and Chari (2020), Anukriti et al. (2022), and Chiplunkar and Weaver (2023).

[14] The literature on marriage but without the mediation of a price (or dowry) is too vast, so to contextualize we mention only early papers that observed a pattern of matching common with ours: Becker (1973; 1974) had shown *positive assortative* mating in a full information marriage market model; a similar assortative marriage equilibrium was derived by Burdett and Coles (1997) in a dynamic model.

[15] Human capital w_f, w_m depend linearly on parental investment: $w_k = \theta_k \cdot e$, $\theta_m > \theta_f$.

[16] Botticini and Siow (2003) considered an asset allocation problem by parents between a son and a daughter where the transfer to the daughter takes primarily the form of a dowry whereas the son receives it as bequest.

[17] Our model can be viewed as a reduced-form version of Anderson and Bidner with asymmetric parental investments in male and female child having already distorted the distribution of human capital overall in favor of the grooms. We may thus consider dowry as grooms money rather than brides money without assuming an unbalanced sex-ratio in marriage-age brides and grooms. While asymmetric investments can be a driving force, the gender norm that couples want to avoid a situation where the wife earns more than the husband (Bertrand et al., 2015) also leads to grooms marrying brides of lesser human capital and dowry partly bridges this gap. We do not, however, assume this type of preference but simply assume grooms money as the convention (or norm) of arranged marriages in India dominated by patriarchal system.

marry up their daughter (Proposition 5), whereas in Anderson and Bidner an equal number of "male" and "female" families choose (as in a competitive demand-supply story) the same ideal human capital pairs (w_f, w_m) for their children's marriage.[18] In both settings, competition for desirable grooms is in play through different instruments under different timings; in Anderson and Bidner, dowry is almost an end-result whereas in ours dowry happens at the start with uncertainties regarding violence, extortions and divorce yet to be resolved.

The majority of the theoretical and empirical research on dowries adopt the Nash-bargaining approach. This is done with resource allocation between the spouses being the main focus. Instead, we assume equal sharing of resources in a functioning marriage even if the marriage might not be perfect, and only when the marriage breaks down and leads to divorce the bride and the groom consume their respective inalienable human capital and the groom appropriates the dowry but has to pay the alimony.[19] Our simplification is to tackle the complexity of the extensive form involving the two stages – the marriage and the violence.

The literature on marriage market with asymmetric information is sparse. Only exceptions are Bergstrom and Bagnoli (1993), and Angelucci and Bennett (2017) and (2021). These authors consider how timing of marriage, delay specifically, can help grooms with positive characteristics (income potential, or being free from HIV) to reveal their type. Delaying marriage in our context cannot resolve problems of asymmetric information.

Finally, a gap in research on dowry violence calls for more work. Empirical research has been based on village level surveys because there is no official documentation of dowries due to its illegal nature and domestic violence is largely unreported. Any formal study of dowry violence in cities and rural towns is lacking. How dowry violence has evolved over time, not just in Indian villages but also in urban areas, should be a worthwhile subject for policy enforcement.

Starting with a detailed description of the model and a quick overview of the groom's and bride–parents' strategies in the next two sections, the core analysis of the violence, marriage and dowry are contained in Sections 4–6.

[18] This is a strong result that derives from an ancillary result where (equilibrium) marriage payment function $t(w_f, w_m)$ adjusts to (w_f, w_m) in a way that both male and female families only care about the *total expenditure* they spend on their children and not their precise breakdown between investment in human capital and dowry (in the case of bride's parents). This indifference leaves a lot of freedom to manipulate the measure of desirable grooms and measure of desirable brides, for any (w_f, w_m), to be equated. Our model is very different in that given an exogenous budget for the daughter's marriage, parents are prepared to spend it all in dowry if that could buy them a groom of a higher human capital so long as the higher dowry demanded doesn't increase the posterior of the groom's type to be 'violent' relative to the pre-marriage prior (see Assumption 6).

[19] The groom's appropriation of dowry in the event of marriage breakdown makes dowry as the grooms money rather than a bequest to the daughter from parents. This is a plausible description in the context of Indian marriages. See a similar treatment in Bloch and Rao (2002) and Calvi and Keskar (2023).

2 Model

■ **Worth of prospective match.** There are $n > 1$ number of grooms, and n bride–parents pairs. That is, the marriage market is 'balanced'.

The grooms, and brides and their parents, alternatively referred as in-laws, have two characteristics – discounted present value of income streams reflecting human capital, ω_m and ω_w for grooms and brides respectively, and in-laws' wealth ω_p,[20] and private 'types' of grooms and bride–parents pairs. We will start with the former, postponing the discussion of types for later.

Formally, let ω_m be (strictly) positive reals drawn from $\mathbf{\Omega}_m = \{\omega_{m1}, \omega_{m2}, ..., \omega_{mk}\}$, with an increasing order $\omega_{mi} < \omega_{m\,i+1}$. Similarly, ω_w is drawn from $\mathbf{\Omega}_w = \{\omega_{w1}, \omega_{w2}, ..., \omega_{wk'}\}$, where $\omega_{wj} < \omega_{w\,j+1}$. And ω_p is drawn from $\mathbf{\Omega}_p = \{\omega_{p1}, \omega_{p2}, ..., \omega_{pk''}\}$, where $\omega_{pj'} < \omega_{p\,j'+1}$.

All three ω_m, ω_w and ω_p are observable and common knowledge before marriage.

Define the combined values of a typical bride and her parental wealth by $\omega_{wp} = \omega_w + \omega_p$, with the set of its all potential values denoted by

$$\mathbf{\Omega}_{wp} = \{\omega_{wp1}, \omega_{wp2}, ..., \omega_{wpI}\},$$

where $I = k' \times k''$.

Denote the realized frequency distributions with positive frequencies by

$$\Big\{f_m(\omega_{mi}), f_w(\omega_{wj}), f_p(\omega_{pj'}), f_{wp}(\omega_{wpx})\Big\},$$

where $\sum f_m(\omega_{mi}) = \sum f_w(\omega_{wj}) = \sum f_p(\omega_{pj'}) = \sum f_{wp}(\omega_{wpx}) = n \quad \text{and } x \in \{1, ..., I\}.$

Rank the grooms' <u>realized</u> values in a decreasing order

$$\omega_{m(1)} > \omega_{m(2)} > ... > \omega_{m(\eta)}, \tag{1}$$

and the combined <u>realized</u> values of brides and parental wealths as

$$\omega_{wp(1)} > \omega_{wp(2)} > ... > \omega_{wp(\zeta)}, \tag{2}$$

where $\eta \leq k$ and $\zeta \leq I$.

■ **Dowry and post-marriage violence.** The marriage is facilitated by the payment of a dowry from the bride's side to the groom. Dowry, a groom's price, is a social norm as is the case in India. The bride's parents compete to secure financially attractive grooms. But they are also aware that the amount of dowry paid could be a double-edged sword. After marriage the

[20]Parental wealths are in liquid assets (cash, bank balance, valuable stock of golds) that is easily disposable. Gold ornaments are ostentatious wealth that families reveal during social events such as festive periods, marriage, birthday celebrations, and so on. That bride's parental wealth enters into groom's utility function is quite standard in the marriage market literature, e.g., Rao (1993).

groom's type – good (or non-violent) or bad (violent) – becomes known to the bride and her parents. A bad groom may inflict violence on the bride to extort further monetary transfer from the bride's parents. The dowry paid can potentially signal the groom's type and what kind of post-marriage interaction might follow.

The violence inflicted is no guarantee, however, that the bride's parents would agree to make the monetary transfer. If the in-laws are of stubborn type, they would initiate a divorce rather than tolerating abuse.[21,22] On the other hand if the in-laws are of compliant type, they may be willing to make the transfer demanded rather than go for divorce and inflict upon themselves the perceived social shame of divorce. In our formulation, not every bride and her parents consider divorce to be shameful; only the compliant types do.

■ **Timing.** The extensive form involves a natural ordering – marriage using dowry, and post-marriage violence; see Fig. 1. The actions are chosen sequentially in four sub-stages:

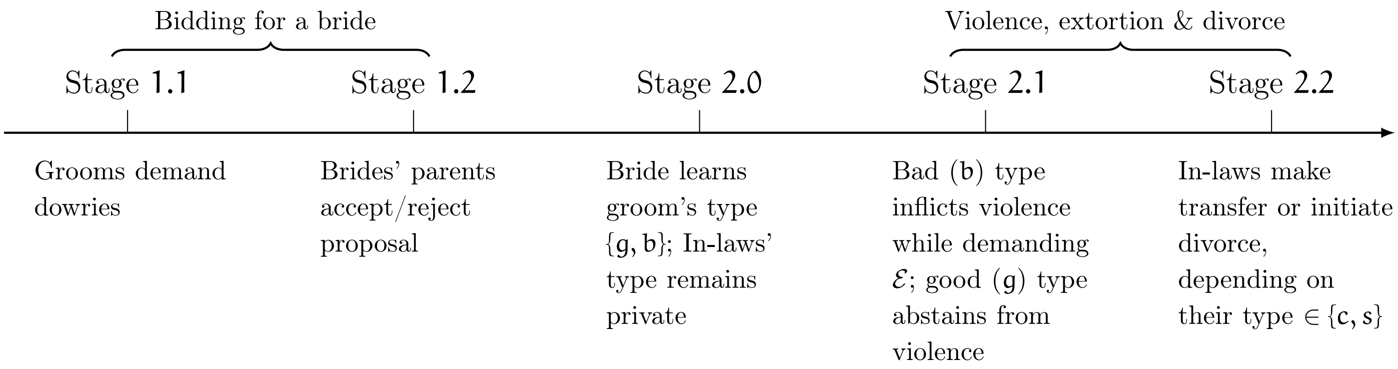

Figure 1: Time line

Stages 1.1, 1.2, 2.1, and 2.2. Stages 1.1 and 1.2 form the initial *marriage* stage, and stages 2.1 and 2.2 form the *violence* (and extortion) stage. The analysis will apply backward induction, solving the sequential violence and extortion game first, then solve the dowry and marriage decisions. The solution concept is *Perfect Bayesian Equilibrium* (in short, PBE).

■ **Type distribution of grooms, and brides-parents.** The type of the groom $\tau_m \in \{g, b\}$ is drawn with probability $q = \Pr(\tau_m = b)$, $0 < q < 1$. Type g is the non-violent good groom who never demands extortionary money after marriage, whereas type b is the bad groom

[21]Divorce as an outside option in intrahousehold bargaining in marriage was studied by Manser and Brown (1980), and McElroy and Horney (1981).

[22]While in this paper divorce and the payment of alimony follows domestic violence as a natural sequencing, in Islamic law divorce can happen even without violence if the husband pronounces "Talaq" three times (https://static.mygov.in/indiancc/2021/08/mygov-10000000001305919284.pdf). But the divorced wife can still bring a charge of domestic violence and demand alimony according to the *'Protection of Women From Domestic Violence Act, 2005'*, making the money burning power of domestic violence salient. See Bombay High Court's ruling, "Hubby cannot be absolved of domestic violence charges even after divorce: HC", dated June 15, 2023; http://timesofindia.indiatimes.com/articleshow/101006172.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst. See also, https://www.indiatoday.in/law/story/divorced-wife-entitled-to-maintenance-under-domestic-violence-act-says-bombay-hc-2331066-2023-02-06.

who may not hesitate to inflict violence on the wife after marriage if this helps to advance his personal utility.[23] The non-violent groom has no aversion to taking dowry, however, when given voluntarily by the bride's parents at the time of marriage; it helps lift the newly formed family's assets that contributes to the family's joint utility as well as personal utility of the groom. While ω_m is observable before marriage, τ_m is private information.

The types of bride–parents pairs, denoted by $\tau_p \equiv \tau_w \in \{s, c\}$, are drawn with probability $\pi = \Pr(\tau_w = c)$, $0 < \pi < 1$. We impose this realistic assumption that the bride inherits parental traits (Hamilton, 1964; Cavalli-Sforza and Feldman, 1973; Bisin and Verdier, 2001).

Type-s parents, whom we call strong/stubborn parents, would never consent to demands for additional monetary extortion in the post-marriage phase. Any violence inflicted on the daughter strengthens this (s) type of parent's resolve further. Type c, i.e., soft/compliant parents, on the other hand, would be willing to concede to any monetary extortion in response to violence or any threat of its escalation in the future if the cost-benefit analysis justifies so.

■ **Bad groom's utility.** At the time of marriage a bad groom takes into account what he hopes to extort, through violence, from bride's parents post marriage. His expected utility is:

$$U_{m|b} \equiv \pi \left[u_m\left(\frac{\Pi}{2} + \mathcal{E}\right) + \delta\right] + (1-\pi)u_m\big(\omega_m + d - \mathcal{A}(\omega_m)\big), \tag{3}$$

where $\Pi = \omega_m + \omega_w + d$ is the combined value of a married couple aided by dowry d given at the time of marriage;[24] $u_m(.)$ is a strictly increasing, strictly concave real-valued function: $u'_m(.) > 0$, $u''_m(.) < 0$;[25] $\delta \geq 0$, and $\mathcal{E} \geq 0$ is the monetary extortion by inflicting violence and creating a credible threat of inflicting further violence in the future (i.e., second period of a two-period violence-extortion game) in case extortion demand is not met;[26] $\mathcal{A}(\omega_m)$ is the alimony to be paid following separation when the violence is not tolerated and a divorce is granted to the wife whose parents are of strong type s. We assume the extorted money $\mathcal{E}$ goes towards the groom's enjoyment exclusively; see footnote 23. The term δ reflects the perverse gratification due to male dominance in the unbalanced power structure within the household (Tauchen et al., 1991; Jayachandran, 2015), which is over and above the monetary gain $\mathcal{E}$. In

[23] Personal utility derives from habits not congruent with wife's welfare such as addiction to gambling, drinking, philandering etc. Or it could be simply to satisfy the demands of groom's parents to extort more money from the in-laws, with the parents then diverting it onto their other children. In joint families in India with husband and wife living under the same roof as the groom's parents and siblings, within household transfers is known to be a major cause of spousal conflicts.

[24] Symbol Π should not be confused with π, the notation for probability introduced above.

[25] The combined worth of the groom and the bride along with dowry contributing to husband's utility (and wife's utility, which will be specified later) also appeared in Anderson and Bidner (2015). But their formulation used a linear weighted property rights division of the aggregate worth: $c_k = a_k w_f + b_k[w_m + t(w_f + w_m)]$ where $0 < a_m < b_m$ and $0 < b_f < a_f$. We assume $a_k = b_k = 1/2$ so long as the couple stays together in marriage.

[26] As modelled in Section 4 (see Fig. 2), we allow for repeated violence but only one-time transfer of money from the bride's parents to the groom; domestic violence is rarely a one-off event. Bag and Sikdar (2024) analyze a related model capturing the interaction between reporting and violence escalation driven by different penalties for varied intensities of violence.

most of the analysis we will work with a simpler formulation, by setting $\delta = 0$. Finally, we assume $0 < \mathcal{A}(\omega_m) = k\omega_m$, $k \leq \frac{1}{4}$. That is, the groom pays at most 25% of his net earnings in alimony.[27] Finally, in the event of divorce the groom gets to keep the dowry, in accordance with an understanding of dowry as a transfer of property rights from the bride's family to the groom, or what is generally known as *marriage payments* (Becker, 1991; Rao, 1993; Anderson, 2003, 2007b; Anderson and Bidner, 2015). Interpretation of dowry as *bequest* to the daughter works well when the marriage is intact so both husband and wife share the benefit of it, but in the case of marriage dissolution the marriage payment interpretation kicks in.

Assumption 1 (Marriage dominates) *A bad-type groom of any worth ω_m strictly prefers to marry a bride of any worth ω_w even if not given a dowry and without violence and extortion rather than remaining unmarried:* $U_{m|b}(\delta = 0, \mathcal{E} = 0) = u_m(\frac{\omega_m+\omega_w}{2}) > u_m(\omega_m|\textit{unmarried})$.

■ **Good groom's utility.** The utility function of good grooms is given by

$$U_{m|g} \equiv u_m\Big(\frac{\Pi}{2}\Big) + \Delta, \tag{4}$$

where $\Delta \geq 0$ is the additional utility from a stable relationship free of domestic violence.[28] In fact, a good groom would never engage in violence and extortion even in the absence of any threat of divorce so that

$$u_m\Big(\frac{\Pi}{2}\Big) + \Delta > u_m\Big(\frac{\Pi}{2}, \mathcal{E}\Big), \quad \text{for all monetary extortions } \ \mathcal{E} > 0. \tag{5}$$

Note that $u_m\big(\frac{\Pi}{2}, \mathcal{E}\big)$ is different from the function $u_m\big(\frac{\Pi}{2}\big)$; $\mathcal{E}$ is added as a separate argument in good-type groom's utility function instead of adding to monetary wealth. Inequality (5) is reflection of a moralistic stand by good grooms against violence and extortion.

■ **Bride's utility.** The *ex post* (or experienced) utility to the bride of type τ_w, after marriage, will of course depend on the quality of the match. If matched with a good groom, the utility is uniform for either type of bride:

$$U_w\big(\text{good match}\big) \equiv u_w\Big(\frac{\Pi}{2}\Big) + \Delta, \quad \text{with } \ u_w'(.) > 0, \ \ u_w''(.) < 0. \tag{6}$$

The common Δ for a good-type groom and his spouse is a reflection of the public good benefit of a violence-free stable marriage.

[27] Alimony rule does not set a fixed payout but depends on the spouse's earning ability. For alimony paid periodically, "As per the Supreme Court of India, the husband has to pay 25% of his net salary to his estranged wife, but there is no hard and fast rule for the alimony calculator to calculate the actual amount taking in consideration that it depends on the judgement." Source: https://www.adityabirlacapital.com/abc-of-money/how-is-alimony-calculated-in-india.

[28] The importance of Δ can be better understood from the incentive compatibility condition (ICg) that comes up later in Section 5.1.

But if matched with a violent groom, we consider situations where the compliant parents would concede to the groom's extortion of money and let the daughter continue in the fractious relationship. Denote the utility of the bride and her parents, combined, by

$$\begin{aligned} U_{w|c}(\text{bad match, compliance}) &\equiv u_w\left(\frac{\Pi}{2}\right) - \delta_c - \underbrace{\left[u_p(w_p - d) - u_p(w_p - d - \mathcal{E})\right]}_{\text{parent's utility loss from extortion}} \\ &\approx u_w\left(\frac{\Pi}{2}\right) - \delta_c - \nu(\mathcal{E}), \end{aligned} \tag{7}$$

where $\delta_c > 0$ denotes the utility loss of compliance,[29] and $\nu(0) = 0$, $\nu'(\mathcal{E}) > 0$ and $\nu''(\mathcal{E}) < 0$.[30] We choose $\nu(.)$ to be free of $w_p - d$ for two reasons: (1) by omitting $w_p - d$ we ignore the "income effect" that is going to be of second-order importance for our main economic logic of equilibrium extortion;[31] (2) the assumption $\nu''(\mathcal{E}) < 0$ already captures the principle of diminishing marginal utility of money.

The basis for (7) is that at least in the limit $\mathcal{E} = 0$,

$$u_w\left(\frac{\Pi}{2}\right) - \delta_c > u_w\big(\omega_w + \mathcal{A}(\omega_m)\big) - \delta_{cf}, \tag{8}$$

where δ_{cf} is the social costs of shame of divorce (or failed marriage). That is, with minimal/zero extortion but violence inflicted the compliant bride strictly prefers compliance over divorce.

Assumption 2 (Compliant bride's preference) *Condition* (8) *holds.*

So there exists a unique $\mathcal{E} > 0$ such that the utilities from compliance and the option of divorce are equal:

$$[\text{Bad match: stability of compliance}] \qquad u_w\left(\frac{\Pi}{2}\right) - \delta_c - \nu(\mathcal{E}) = u_w\big(\omega_w + \mathcal{A}(\omega_m) + \mathcal{E}\big) - \delta_{cf}. \tag{9}$$

$\mathcal{E}$ satisfying (9) is the maximal extortion that the parents would tolerate in a compliant relationship; for any higher extortion demand, divorce is a better option.

It is reasonable to assume the following:

Assumption 3 (Social shame of divorce) $\delta_{cf} > \delta_c$.

That is, divorce is socially more costly for the compliant bride than staying in an abusive relationship that is not public.

[29] This is over and above the loss of Δ that the bride would have enjoyed when matched with a good groom.

[30] Like in footnote 25, even in a bad marriage the compliant wife enjoys the same per-capita consumption as her husband (except the extortion money). The disutility of bad marriage due to violence and extortion are instead reflected in the two negative terms in (7); in Anderson and Bidner (2015), similar disutility would have been accounted for in a lower bargained consumption for the wife.

[31] As one might expect, a groom will extort more from parents with a higher $w_p - d$. This will be true even with the simpler specification of $\nu(\mathcal{E})$.

On the other hand, the utility of the bride (and her parents) after divorcing the violent groom when the parents are of 'strong' type is:[32]

$$U_{w|s}(\text{bad match, divorce}) \equiv u_w\big(\omega_w + \mathcal{A}(\omega_m)\big) - \delta_s, \tag{10}$$

where $\delta_s \geq 0$ is the utility loss from a failed marriage. But a strong bride, by definition, would rather divorce even in the absence of alimony than stay in an abusive relationship:

$$[\text{Divorce dominates: strong type}] \qquad u_w(\omega_w) - \delta_s > u_w\Big(\frac{\Pi}{2}\Big) - \delta_{sc}, \tag{11}$$

where $\delta_{sc} > 0$ is the private indignation (or loss of pride) of putting up with the abusive husband and thus be compliant. Any alimony makes this divorce incentive only stronger:

$$u_w\big(\omega_w + \mathcal{A}(\omega_m)\big) - \delta_s > u_w\Big(\frac{\Pi}{2}\Big) - \delta_{sc}.$$

We assume that the strong bride will feel less social shame from divorce than a compliant bride, and feel a sense of indignation in complying with an abusive partner:

Assumption 4 *1.* $\delta_s < \delta_{cf}$*; 2.* $\delta_{sc} \gg \delta_s$*.*

Notice the difference between (9) and (10)/(11). In the former, we add $\mathcal{E}$ when considering the compliant bride's divorce option, as parents offer the divorce-trigger extortion money as support to their daughter should they choose the marital dissolution. In the latter, the very idea of staying with an abusive spouse is abhorrent, so the bride doesn't need to get financial support to divorce; here the amount $\mathcal{E}$ cannot be determined as the trigger amount for divorce.

Finally, we impose the following assumption:

Assumption 5 (Avoid bad grooms) *A bride of either type, compliant or stubborn, would rather remain unmarried than knowingly marry a bad-type groom.*

Notice the contrast between Assumption 1 and Assumption 5. The former makes any prospective groom to be well-behaved in marriage, if such commitment were possible, even if intrinsically he might be a bad type to simply ensure marriage. The latter makes prospective brides skeptical in agreeing to a marriage proposal; there has to be good enough a chance that the groom is a good type for the bride to be willing to say *'yes'* to a marriage proposal. That is, desperate grooms must persuade skeptical brides.

■ **Parental preference over dowries.**

Assumption 6 (Benevolent parents) *Parents are benevolent in that they are prepared to exhaust all their wealth in dowry payment if it comes down to securing a groom that they consider*

[32] Here we are assuming the bride inherits her parent's values.

of the highest human capital ω_m *achievable at a starting prior below a cut-off,* $q < q^c << 1$*, that the groom is violent type.*

Such an assumption can be justified in the context of arranged marriages in India where parents get into heavy debts to pay dowries to get a well-to-do groom with good job/business and family assets. This behavior is also driven by a form of social contest among relatives and friends.

3 Strategies: Preliminary specifications

In this short brief, we give a quick exposition of how we view the marriage market operates. It is a finite game involving the two sides, the grooms and the bride–parents, and differs from a textbook competitive market in the following aspects:

(i) There is no single commodity to be traded. Instead, grooms and brides-parents (in place of buyers and sellers) have their individual characteristics that determine their match potential, just like in any matching market.

(ii) Some characteristics are hidden that we earlier called types, whereas other characteristics such as grooms' worth and the worth of the brides and the wealth of their parents are common knowledge.

(iii) The *matching*, which occurs in *stage 1*, will be executed in three sub-stages.

In *stage 1.1*, the grooms will simultaneously make two marriage proposals indicating (bride, dowry ask) – one within their own hierarchy, and a second one 1-step below their hierarchy.[33] The hierarchies are constructed, first, in declining order of visible worths for the grooms, and the combined values of brides' worth and their parents' wealth, and next by equating the number of brides-parents pairs who will have a realistic shot at their best group of grooms for one-to-one matching. Precise details will be written formally later on.

In *stage 1.2*, the two pairs of brides and parents proposed to simultaneously announce their acceptance/rejection decisions.

In case both proposals are accepted, in *stage 1.3* the groom finalizes which of the two accepted proposals to settle for.

After marriage, each pair of groom and bride starts interacting in a second round that we call the *extortion* phase or *stage 2*. The groom makes an extortion demand and decides whether to inflict violence or not; the bride then decides whether to comply or fight and divorce.

[33]Restriction to only two proposals avoids having to specify complex strategies that serves no real purpose, especially given that important variables at the time of marriage proposals, such as grooms' and bride–parents' worth and wealth, are assumed to be common knowledge.

Somewhat formally, a groom's strategy is a pair $(d_m, \mathcal{E}_m)$ defined as follows:

$$\begin{aligned} &\text{Stage 1} \qquad d_m : (\omega_m, \omega_w, \omega_p) \times \{g, b\} \to R_+\,, \\ &\text{Stage 2} \qquad \mathcal{E}_m : (\omega_m, \omega_w, \omega_p, d_m) \times \{g, b\} \to R_+ \times \{\nu, n\nu\}\,. \end{aligned} \tag{12}$$

A bride's (and her parent's) strategy involves giving consent to the marriage proposal in the first stage and choosing to comply or not with the violence, if any, in the second stage:

$$\begin{aligned} &\text{Stage 1} \qquad \mathcal{C}_w : (\omega_m, \omega_w, \omega_p) \times \{c, s\} \times d_m \to \{\text{Yes, No}\}\,, \\ &\text{Stage 2} \qquad \mathcal{F}_w : (\omega_m, \omega_w, \omega_p, d_m) \times \{c, s\} \times \mathcal{E}_m \to \{\text{comply, divorce}\}\,. \end{aligned} \tag{13}$$

Besides strategies, we also need to specify the *beliefs* about the groom's type given the dowry demanded. This we will address when we analyze the marriage market equilibrium in Section 5.

4 Violence and Divorce

The interaction between the groom and the bride and her parents in the post-marriage phase is a key component in solving the full game of two-sided matching and dowry in marriage. Bloch and Rao (2002) formulate it as a static game where the groom inflicts violence to signal his type, described as dissatisfaction in the marriage, and in response the in-laws make a transfer so that the groom finds it incentive compatible to stay in the marriage.

In this section, we solve the second stage of the game – violence and extortion decisions. We model violence in two phases – one when demanding a transfer from the bride's parents and a second time if the demand is not met. Besides improving the realism of dowry violence, we will see how the two-stage formulation will help us offer a rationalization of violence fundamentally different from Bloch and Rao's explanation. Along with this modification, we also abstract away from incomplete information about the groom's type in the post-marriage subgame. Instead, we assume that the bride learns the groom's type even within a short span of time after marriage. After all, it is hard to hide one's greediness from the partner in day-to-day interactions. So when a bad-type groom is thinking of inflicting violence, the bride and her parents know precisely the groom's intent and the character behind it. The crucial difference lies in the fact that the *groom does not know the type of the in-laws*: stubborn or compliant.

The demand for additional transfer of money is a reflection of the groom's character and the in-laws can foresee the greediness and the associated violence playing out in the long-term of the relationship. The compliant and stubborn in-laws react differently to violence. Specifically,

(i) if the initial violence on the bride with a specific demand for transfer is not met with immediate resistance, the in-laws reveal themselves to be of 'compliant' type and hence the amount of extortion can be pushed to a maximal level so that the bride and the in-laws will be indifferent between (1) not meeting the demanded transfer and instead opting for divorce, and (2) meeting the demanded transfer and avoid the stigma of divorce;

(ii) if the initial violence is retributed, the in-laws reveal themselves to be the 'stubborn' type and the groom has no chance to drag the violence further to extort any money and ends up in the costly divorce process.

This post-marriage interaction is captured in an extensive form in Fig. 2. It is a more elaborate presentation of the last two stages in Fig. 1. Below we describe its special structure and the underlying logic.

The post-marriage interaction starts with the groom choosing a (violence/no violence, demand) pair. The key to starting a divorce process is that the groom inflicts violence. In the absence of violence (the left-hand side of the tree), the bride's side will only need to decide how much, if at all, to accommodate the extortion demand; after this the groom will have a second turn at violence. The right-hand side of the tree starts with violence, so the bride's side may end the game by choosing the option of divorce in which case they do not accommodate the groom's extortion demand. The alterative choice of not divorcing induces the concomitant decision of how much of the extortion demand to accommodate. And finally, the groom again has a final shot at violence.

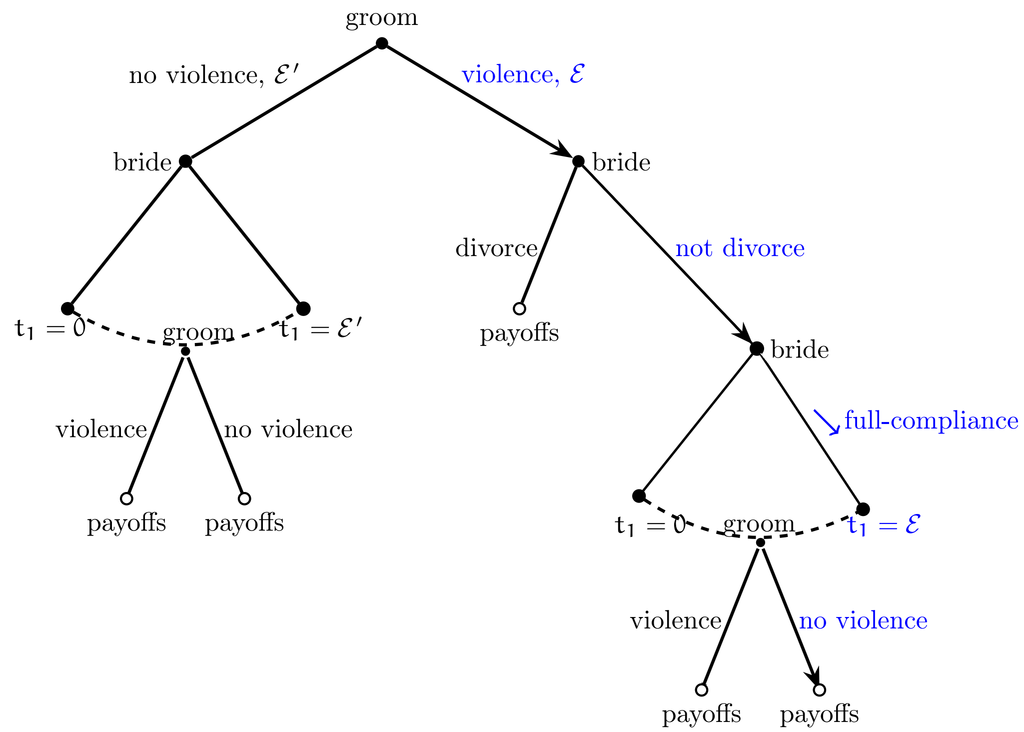

Figure 2: Two-period post-marriage repeated violence game with demand for extortion, divorce/no divorce, and transfers. Inflicting violence exposes the groom to the possibility of divorce. The equilibrium path is indicated by a combination of downarrows (↘) and blue-colored choices of strategies by a bad groom/compliant bride pair.

Notice that we have abstracted away from an indefinite repetition of the (violence, extortion) narrative. Nor do we consider extortion in the second round. The latter is primarily because without the threat of a retribution for non-payment, just asking for another round of monetary transfer will not have any meaningful bite. We consider infinite/indefinite repetition as a mere technicality for the main message of this paper.[34] Instead, what is important is that we allow the groom to start the proceedings with violence and end it with violence. As we will see in the formal argument, exercising violence at the final leg for non-payment can be used as a credible threat against the compliant-type in-laws to make them pay the transfer demand in the earlier round. And this is possible because the already inflicted violence at the start has exposed the groom to costly divorce which the in-laws chose not to avail. The fact that the groom has already been exposed for his early action (i.e., *costly money burning*), makes the second violence of little adverse consequence to himself but with the upside of making the bride's parents pay. This obviates the credibility problem noted in the chain-store paradox of Selten (1978).

The following proposition reports an important role of dowry violence.

Proposition 1 (Screening) *The bad-type groom will resort to a one-off violence and screening. Screening occurs in one of the following forms:*

(i) He learns that the in-laws are of the stubborn type in which case there will be no extortion and he ends up paying the alimony in divorce settlement;

(ii) He learns that the in-laws are of the compliant type in which case he can stay on course of continued violence credibly until the demanded transfer has been fully paid.

In the latter case, the equilibrium will involve the compliant-type in-laws immediately paying the transfer in full and thereby avoiding their daughter being subjected to additional violence.

Given Proposition 1, we suppress an analysis of the extensive-form game and instead use the reduced normal form where the bad-type groom inflicts violence on the bride when demanding extortion money.

■ **Determination of $\mathcal{E}$.** In the post-marriage subgame with the dowry exchanged, $d \geq 0$, sunk, the extorted money will depend on $(\omega_m, \omega_w, \omega_p) \equiv \boldsymbol{\omega}$. It is set at the maximal level so that the bride's compliant parents are indifferent between their daughter staying in the relationship

[34]Elsewhere, Baliga and Ely (2016) has pointed out the problem of extracting valuable information from an agent, a suspected terrorist, when the principal, an interrogating officer, cannot commit not to ratchet up torture once the agent has divulged some information relating to a potential terror attack. An extension of our model to possibilities of extortion by the groom over many rounds will run into the same type of problem.

by paying the money, and divorcing and suffering social shame:

$$
\begin{aligned}
& u_w\Big(\frac{\omega_m + \omega_w + d}{2}\Big) - \delta_c - \nu(\mathcal{E}) = u_w\big(\omega_w + \mathcal{A}(\omega_m) + \mathcal{E}\big) - \delta_{cf} \\
\text{or, } \; & \underbrace{u_w\big(\omega_w + \mathcal{A}(\omega_m) + \mathcal{E}\big) + \nu(\mathcal{E})}_{\equiv \Psi(\mathcal{E})} = u_w\Big(\frac{\omega_m + \omega_w + d}{2}\Big) + \delta_{cf} - \delta_c \qquad (14) \\
\text{or, } \; & \Psi(\mathcal{E}) = u_w\Big(\frac{\omega_m + \omega_w + d}{2}\Big) + \delta_{cf} - \delta_c, \qquad (15)
\end{aligned}
$$

where $\Psi'(\mathcal{E}) > 0$ and $\Psi''(\mathcal{E}) < 0$. We have kept the notation $\Psi(.)$ clean, although it is clear that it depends on the parameters (ω_w, ω_m) as well.

The $\mathcal{E}$ satisfying (15) is the limit of how much extortion the compliant parents are willing to tolerate, if they are not financially constrained. This limit is called ***no-divorce extortion***, denoted by $\mathcal{E}_{\text{no-divorce}}$; any higher demand will tilt the decision in favor of divorce. The actual extortion, as the following result shows, will be less than the limit extortion when the (bride's) parent's ***financial constraint***, $\omega_p - d$, binds. But often $\mathcal{E}_{\text{no-divorce}} < \omega_p - d$, so then the no-deviation to divorce constraint overrides the financial constraint.

Proposition 2 (Post-marriage extortion) *Suppose Assumptions 2 and 3 hold. Consider a groom with wealth ω_m who marries a bride with wealth ω_w whose parents have the wealth ω_p. The dowry exchanged is d. Then in the violence equilibrium in the post-marriage subgame involving a bad-type groom,*

1. *The extortion by the groom from compliant-type in-laws equals*

$$
\mathcal{E} = \max\Big\{0, \min\{\mathcal{E}_{\textit{no-divorce}}, \omega_p - d\}\Big\}, \qquad (16)
$$

where, by rewriting (15),

$$
\mathcal{E}_{\textit{no-divorce}} \equiv \Psi^{-1}\left(u_w\Big(\frac{\omega_m + \omega_w + d}{2}\Big) + [\delta_{cf} - \delta_c]\right) \qquad (17)
$$

which is illustrated in Fig. 3 and Table 1.

2. *The extortion $\mathcal{E}$ is*

(i) an increasing function of d, the dowry given at the time of marriage when the parent's residual wealth $\omega_p - d$ exceeds (17) (blue-colored curve in Fig. 4 and the numerical illustration in Fig. 6);

(ii) a decreasing function of d, when the financial constraint $\omega_p - d$ binds (16) (red-colored curve in Fig. 4 and the numerical illustration in Fig. 6);

(iii) the higher the $\delta_{cf} - \delta_c$ (costly social shame of divorce relative to the troubles of a compromise marriage), the more the extortion post dowry-violence.

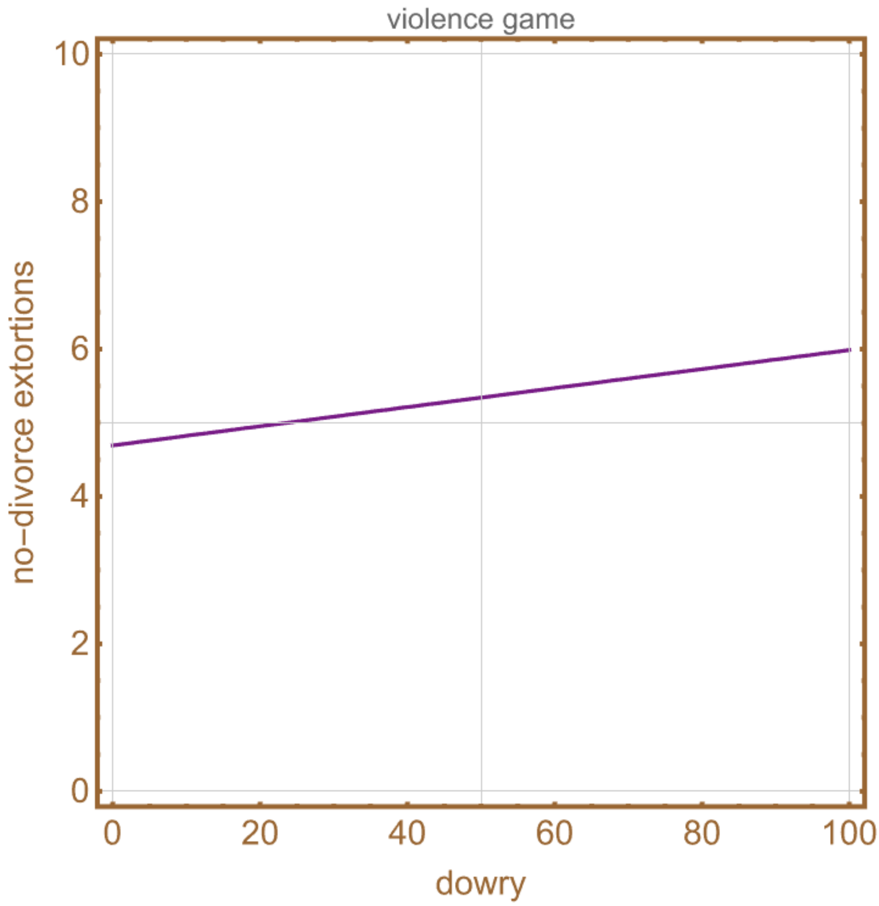

Figure 3: Extortions $\mathcal{E}_{\text{no-divorce}}$

Derivation of $\mathcal{E}_{no\text{-}divorce}$: Illustration 1. Fix ω_w and ω_m. Recall the limit condition of indifference between divorce and no divorce, (14):

$$\underbrace{u_w\big(\omega_w + \mathcal{A}(\omega_m) + \mathcal{E}\big) + v(\mathcal{E})}_{\equiv \Psi(\mathcal{E})} = u_w\Big(\frac{\omega_m + \omega_w + d}{2}\Big) + \delta_{cf} - \delta_c.$$

Let $u_w(x) = \ln x$, $\mathcal{A}(\omega_m) = 0.25\omega_m$, $v(\mathcal{E}) = \ln \mathcal{E}$, $\delta_{cf} = \rho\delta_c$ where $\rho > 1$.

We can derive the maximal possible extortions $\mathcal{E}_{\text{no-divorce}}$ as a function of the dowry paid at marriage (see (17)) in Fig. 3, after setting $\omega_w = 100$, $\omega_m = 250$ and $\delta_{cf} - \delta_c = 5(1.3 - 1)$.

Note that the example is carefully calibrated to yield a solution to the above indifference condition. Sometimes an explicit precise solution may not obtain in which case numerical approximation will be necessary, which we demonstrate next in Illustration 2. $\|$

Derivation of $\mathcal{E}_{no\text{-}divorce}$: Illustration 2. Fix $\omega_w = 1000$ and $\omega_m = 10,000$, $\delta_{cf} - \delta_c = 5$. Suppose $u_w(x) = x^{1/2}$ so that the utility is strictly concave. Again, by applying the indifference condition (15), we can solve for $\mathcal{E}_{\text{no-divorce}}$ to obtain the numbers reported in Table 1. The numbers translate into an upward-sloping no-divorce extortion curve. $\|$

Table 1: No-divorce extortions

	Dowry	$\mathcal{E}_{\text{no-divorce}}$
1.	500	352.07
2.	600	356.83
3.	625	361.60
3.	650	366.39
5.	700	371.19
6.	750	376
7.	800	380.84
8.	850	385.68
9.	900	390.54
10.	950	395.41
11.	1000	400.29

Formally, that $\mathcal{E}_{\text{no-divorce}}(.)$ function is increasing in d follows from (15), given $\Psi'(.) > 0$.

Let us define, after setting $d = 0$ in (17),

$$\underline{\mathcal{E}} \equiv \Psi^{-1}\left(u_w\left(\frac{\omega_m + \omega_w}{2}\right) + [\delta_{cf} - \delta_c]\right). \tag{18}$$

From (8) it follows that $\underline{\mathcal{E}} > 0$.

So paying less dowry means the compliant type will pay less post-marriage extortion money (Fig. 4). In the extreme, if $d = 0$, the extortion money $\mathcal{E}$ will be (locally) minimal.

Discussion of intuitions behind Proposition 2 and Fig. 4. Intuition for why $\mathcal{E}(d)$ is increasing in d in the non-binding wealth constraint part: With a high d already committed during marriage (financial help in buying an apartment), the couple's stay-in-marriage (although fractious it is) utility is already high. The higher the dowry d, the higher is this status-quo utility. So the upper limit to extortion the bad-type groom can extract (beyond which even compliant in-laws would deviate to their daughter's divorce) will rise with the dowry d. It is the bad commitment of dowry—a hold-up problem—that exposes the wife to husband's extortions. Another rationale for the increasing extortion is as follows. Consider two bride-parents pairs such that the combined worth of the bride's human capital and parent's wealth are the same but one of the brides possess less human capital than the other. In a result to be shown later in Proposition 5, we will have $\omega_{h_1(\ell)} + d_{h_1(\ell)} = \omega_{h_2(\ell)} + d_{h_2(\ell)}$ (see (34)). That is, the parents of the bride with lesser human capital (say parents 1) will pay a higher dowry to make up for the shortfall of the daughter's human capital. Assuming both sets of parents are of compliant type, parents 1 will end up paying higher extortion money because their daughter's fall-back option in the event of marriage breakdown will be lower and hence the bargaining position will be weaker. This again

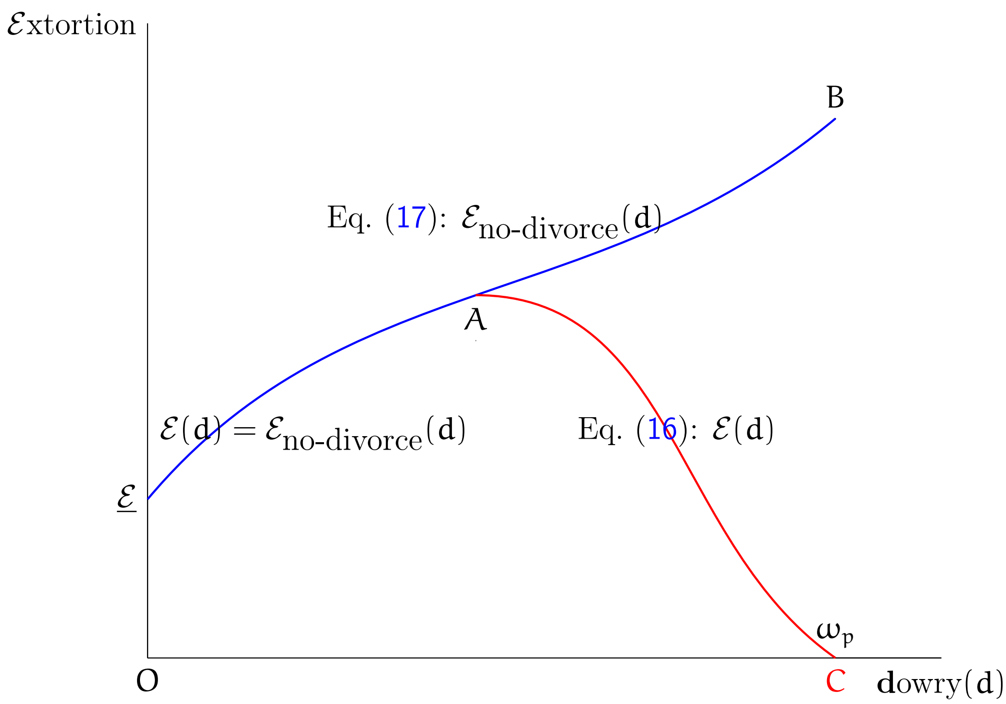

Figure 4: Post-marriage extortion from compliant in-laws, fixing ω_w, ω_p, ω_m, δ_{cf}, δ_c, and the utility function: the curve $\underline{\mathcal{E}}AC$. The red segment is when financial constraint is binding: $\mathcal{E}_{\text{no-divorce}} > \omega_p - d$. In the non-binding part in-laws retain $\omega_p - \mathcal{E}$, because any higher extortion ($\mathcal{E} > \mathcal{E}_{\text{no-divorce}}(d)$) would prompt the compliant bride to report violence and initiate divorce.

translates into a positive relationship between dowry and extortion.

But when the wealth constraint binds, the higher the dowry d, the less wealth the in-laws will have left post-dowry for extortion. Hence the declining part AC of the $\mathcal{E}(d)$ curve in Fig. 4.

Differentiating (17) w.r.t. $\delta_{cf} - \delta_c$, obtain:

$$\frac{d\mathcal{E}_{\text{no-divorce}}}{d[\delta_{cf} - \delta_c]} = \frac{1}{\Psi'(\mathcal{E})} > 0.$$

The intuition is simple: As the social shame of divorce (Assumption 3) increases, the bride and her parents become more vulnerable to exploitation by the violent groom. So more money can be extorted.

5 Marriage and Dowry

We will start with the important question, who should match with whom. In an environment without dowry and violence the answer is relatively straightforward – each side should like to avail the best possible match out there, best ω_w for any ω_m and vice versa. Market merely facilitates matching between the correct pairs. There is no meaning to good and bad grooms, and strong and compliant brides/in-laws.

But as soon as we admit dowry and violence, the equilibrium must sort out the question of the dowry pattern for incentive compatible pairs of (ω_m, ω_w) matching influenced by the brides' parental wealths ω_p. This we do by fixing for any potential match the Bayesian Nash equilibrium to follow in the post-marriage violence subgame.

5.1 Incentive compatibility of marriage

■ **Bride's incentive compatibility.** Bride's parents, given their types, simply respond to the dowry demands posted by the grooms in the pre-marriage stage by accepting or rejecting the proposal.[35]

A **strong** bride's expected utility from a match is

$$q(d)\big[u_w\big(\omega_w + \mathcal{A}(\omega_m)\big) - \delta_s\big] + (1 - q(d))\big[u_w(\frac{\Pi}{2}) + \Delta\big], \tag{19}$$

where $q(d)$ is the posterior that the groom asking for a dowry d is a bad type. This posterior will be calculated once we have a full description of the *marriage market equilibrium.*

The same person's utility from not agreeing to the particular match (with wealth ω_m and asking for dowry d) and remaining single is

$$u_w\big(\omega_w + d\big) + \phi, \tag{20}$$

where $\phi > 0$ is a measure of resilience/independence of a strong unmarried woman, and d is the transfer that the parents can make to their daughter in the future should she remain single; this reflects that the higher the dowry demanded, the bride's incentive to marry the particular groom tends to weaken because the dowry is an opportunity cost of foregone consumption.

The parents of a strong bride would agree to pay the dowry d and marry their daughter provided

$$q(d)\big[u_w\big(\omega_w + \mathcal{A}(\omega_m)\big) - \delta_s\big] + (1 - q(d))\big[u_w(\frac{\Pi}{2}) + \Delta\big] - \big[u_w\big(\omega_w + d\big) + \phi\big] \geq 0. \tag{ICs}$$

A **compliant** bride's expected utility from a match is

$$q(d)\big[u_w(\frac{\Pi}{2}) - \delta_c - \nu(\mathcal{E})\big] + (1 - q(d))\big[u_w(\frac{\Pi}{2}) + \Delta\big]. \tag{21}$$

The utility to the bride from not agreeing to any match and remaining single is

$$u_w\big(\omega_w + d\big). \tag{22}$$

A compliant bride would agree to marry provided

$$q(d)\big[u_w(\frac{\Pi}{2}) - \delta_c - \nu(\mathcal{E})\big] + (1 - q(d))\big[u_w(\frac{\Pi}{2}) + \Delta\big] - u_w\big(\omega_w + d\big) \geq 0. \tag{ICc}$$

It follows that

[35] Parent's and bride's type (compliant or stubborn) will come into play more directly in the post-marriage extortion game.

$$
\begin{aligned}
&\text{LHS of (ICs)} - \text{LHS of (ICc)}\\
&= q(d)\left[u_w(\omega_w + \mathcal{A}(\omega_m)) - \delta_s - u_w\left(\frac{\Pi}{2}\right) + \delta_c + v(\mathcal{E})\right] - \phi\\
&= q(d)\left[u_w(\omega_w + \mathcal{A}(\omega_m)) - \delta_s - u_w\left(\omega_w + \mathcal{A}(\omega_m) + \mathcal{E}\right) + \delta_{cf}\right] - \phi \quad \text{(using (9))}\\
&= q(d)\left[\underbrace{u_w(\omega_w + \mathcal{A}(\omega_m)) - u_w\left(\omega_w + \mathcal{A}(\omega_m) + \mathcal{E}\right)}_{<0} + \underbrace{\delta_{cf} - \delta_s}_{>0}\right] - \phi\\
&< 0,
\end{aligned}
$$

if $q(d)\left[\delta_{cf} - \delta_s\right] - \phi \leq 0$.

Corollary 1 (Marriage participation) *For some ranges of dowries the strong type brides may refuse to marry when otherwise identical but compliant brides would agree to the proposal.*

As $\delta_{cf} \uparrow$, it leads to $\mathcal{E} \uparrow$ that in turn implies LHS of (ICs) − LHS of (ICc) can either $\uparrow$ or $\downarrow$. Thus, the overall impact of an increase in δ_{cf} on the preferences of the two types of brides becomes *uncertain*.

Note from both (ICs) and (ICc) that the higher the dowry d demanded, the weaker could be the incentive on the parent's part to agree to their daughter's marriage: the daughter's utility of the option of remaining unmarried increases. A positive influence of a higher dowry is through Π that increases the couple's joint wealth that can be enjoyed only when the marriage does not end in dissolution. This positive influence is one interpretation of dowry as a 'gift' for the newly-wed.

■ **Groom's incentive compatibility.** If the groom is of type $\tau_m = g$, his payoff gain from the match rather than remaining single must be positive:

$$u_m\left(\frac{\omega_m + \omega_w + d}{2}\right) + \Delta - u_m(\omega_m|\text{unmarried}) \geq 0.$$

In fact, Assumption 1 combined with (4) yields a stronger version of the above condition:

$$u_m\left(\frac{\omega_m + \underline{\omega}}{2}\right) + \Delta > u_m(\omega_m|\text{unmarried}), \tag{ICg}$$

for all ω_m. That is, a good-type groom would prefer to match with a bride of least human capital even without any dowry than remaining single.[36] While marrying a bride of not enough individual worth dilutes utility from personal consumption, the value of a stable relationship (Δ) makes up for it.

If the groom is of type $\tau_m = b$, his payoff gain from the match and then inflicting violence relative to not inflicting violence is positive provided extortion money and enjoyment of violence

[36] Remember, we are considering males and females outside the dating pool so that the alternative to marrying the female of worst human capital is to remain single.

are sufficiently high relative to the cost of divorce:

$$U_{m|b}(\nu) - U_{m|b}(n\nu) \equiv \pi(d)\,\big[u_m\big(\frac{\omega_m + \omega_w + d}{2} + \mathcal{E}\big) + \delta\big] + (1 - \pi(d))u_m\big(\omega_m + d - \mathcal{A}(\omega_m)\big) - u_m\big(\frac{\omega_m + \omega_w + d}{2}\big) \geq 0, \tag{ICviolence}$$

where $\pi(d)$ is the posterior that the in-laws who accept a dowry demand d is of compliant type. $\pi(d)$ will be calculated fixing a *marriage market equilibrium*.

5.2 A finite marriage market and determination of dowries

■ Examples of dowry equilibrium.

Example 1. Suppose there are 5 grooms all with $\omega_m = 5$, 3 bride–parents pairs with $\omega_w = 4$ and $\omega_p = 4$ and 2 bride–parents pairs with $\omega_w = 3$ and $\omega_p = 4$. Then the equilibrium dowry is $d = 0$ and posteriors of grooms' types equal the prior $0 < q < 1$. The parents do not need to accept a positive dowry bid to win one of the grooms. The grooms, all homogeneous, are in 'abundant supply'. If all other grooms are posting $d_m = 0$, the fifth groom holding out for a positive dowry is believed to be of a bad type with probability 1 while other grooms' type is non-revealing with posterior equal to prior q. So no bride will agree to the marriage proposal by the fifth groom, which is strictly worse than posting zero bid that would result in a utility-improving match. More details about how the marriage market is organized will be presented later on. ||

Example 2. Suppose there are 5 grooms all with $\omega_m = 5$, another 5 grooms all with $\omega_m = 4.5$, 6 bride–parents pairs with $\omega_w = 4$ and $\omega_p = 4$ and 4 bride–parents pairs with $\omega_w = 3$ and $\omega_p = 4$. Then the equilibrium dowry demanded by the wealthiest grooms is $d(\omega_m = 5) = 4$ and the accompanying beliefs about their types are pooling. The dowry demand will be acceptable to the 6 bride–parents pairs with $(\omega_w = 4, \omega_p = 4)$ but only 5 of the brides will marry the 5 grooms; the sixth bride will be paired with the next group of grooms with equilibrium dowry $d(\omega_m = 4.5) = 0$ and once again beliefs about the grooms' types will be pooling. (In fact, the grooms with $\omega_m = 4.5$ may want to bid for the lone bride with $\omega_w = 4$ who fails to match up with any of the high-value grooms.) ||

The working assumption behind Example 2 and any other example is that the brides' parents are *benevolent* (Assumption 6) in that they are willing to fork out their entire budget to secure a groom of better human capital, of ϵ higher worth, sacrificing their own future personal consumption. This is essentially a bidding for the satisfaction of securing a well-to-do son-in-law. But the same parents won't put in an extra penny as gift in their daughter's marriage if the groom can be secured without the extra penny. This formulation can be considered as a budget-constrained bidding to secure an object. It can be justified given that in India where arranged marriages are the norm, most parents set aside savings, a target amount of money, with the specific purpose of getting their daughter(s) married off. The savings often include selling of assets and/or borrowing loans from employers (drawing down on gratuity/retirement funds). See Gupta (2002), Kodoth (2005), Anukriti et al. (2022).

These examples indicate that the equilibrium pattern of matching and dowries will depend on relative supplies of, and demands for, grooms and brides (and their parents) of heterogeneous characteristics. As it should be clear, equilibrium dowries may exhibit discontinuities/big jumps with "small changes" in the characteristics of the two sides of the marriage market, in a sense to be clarified in later analysis.

■ **Partitioning the marriage market and dowry equilibrium.**

The second stage of the dowry-and-violence game has already been solved in the previous section. To solve for the first stage, we are going to partition the two sides of the marriage market in decreasing order of worths/values of the grooms and bride–parents pairs and then hold parallel (i.e., simultaneous) Dutch auctions where each groom is going to post a dowry demand to two prospective brides, one from the same rank as his own group and another from one rank lower. Along with dowry demands there will be beliefs by the brides and their parents about the grooms' types. The beliefs will be derived using Bayes' rule on the equilibrium path. We are going to focus on a market-clearing pooling PBE with off-equilibrium beliefs, following deviation from posited equilibrium dowries, assigning probability 1 that the groom must be of a violent type. The indicated alliances are *coordinated* so that there will be no duplication of compatible agreements between multiple groom-bride pairs and the equilibrium match will be one-to-one. Below we present the formal details.

Enumeration. Below we write an algorithm to determine whether one group of bride–parents pairs is on the short side (S) or long side (L) or it's balanced (B) vis-à-vis their target group of grooms. Visualization of the algorithm would be easier if one also keeps Fig. 5 in the background; Fig. 5 is more detailed as it also lists equilibrium dowries that come up later in Proposition 5.

Step 1. Start with the bride–parents group $wp(1)$ as defined in (2). Compared with the target group of grooms $m(1)$ defined in (1), let the relative position of the group $wp(1)$ be

$$\mu\big(wp(1), m(1)\big) = \begin{cases} S \\ L \\ B \end{cases}$$

if, respectively,

$$f_{wp(1)} < f_{m(1)},$$
$$f_{wp(1)} > f_{m(1)},$$
$$f_{wp(1)} = f_{m(1)}.$$

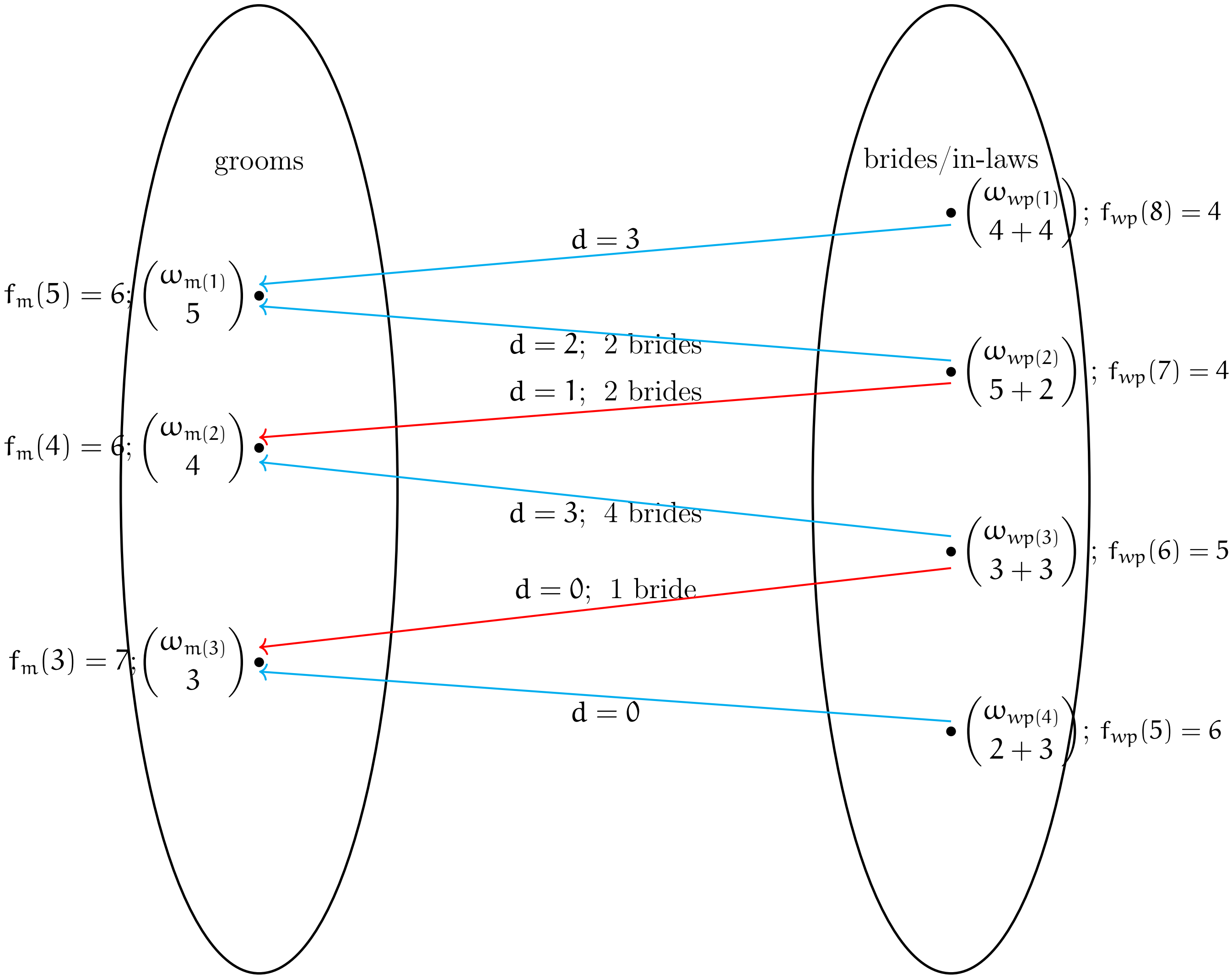

Figure 5: Marriage market and dowries: (i) Top brides-parents group $\{wp(1)\}$ is on the short side vis-à-vis top grooms $\{m(1)\}$; so, form $\mathcal{M}_1 := \{wp(1)\} \cup \{\text{only two bride–parents from } \{wp(2)\}\}$. (ii) Two residual brides-parents from second-top group $\{wp(2)\}$ are on the short side vis-à-vis second-top grooms $\{\omega_{m(2)}\}$; so, form $\mathcal{M}_2 := \{\{\text{two residual bride–parents from } \{wp(2)\} \cup \{\text{four bride–parents from } \{wp(3)\}\}$. And and so on.

Now the best value any bride–parents from $\{wp(2)\}$ can bring to table for grooms in $\{m(1)\}$ is $5+2=7$. So, the grooms when demanding dowry from $\{wp(1)\}$ are able to obtain combined value of $\omega_w + \text{dowry} = 4+3$; any higher dowry ask will be declined, and any lower dowry will be outbid by the residual members of $\{wp(2)\}$.

Step 2. If $wp(1)$'s position is balanced, then let

$$\mathcal{M}_1 := wp(1) \tag{23}$$

denote the group of bride–parents who are designated contenders for the grooms $m(1)$.

If it is a long position, let us carve out a subset of $wp(1)$ (by dropping some members of

$wp(1)$), of equal size as that of $m(1)$ (call it $WP(1)$), who are designated contenders for $m(1)$:[37]

$$\mathcal{M}_1 := WP(1). \tag{24}$$

The residual members of $wp(1)$ are denoted as

$$R(wp(1)) := \{wp(1)\} \setminus \{WP(1)\}, \tag{25}$$

who will be considered for the next group of bride–parents pairs for potential matching with $m(2)$ grooms.

If $wp(1)$ is on the short side, include $wp(2)$ and let

$$\mu\big(wp(1) \cup wp(2), m(1)\big) = \begin{cases} S \\ L \\ B \end{cases}$$

be the relative position of the groups $wp(1) \cup wp(2)$ vis-à-vis $m(1)$ if, respectively,

$$f_{wp(12)} < f_{m(1)},$$
$$f_{wp(12)} > f_{m(1)},$$
$$f_{wp(12)} = f_{m(1)}.$$

Iterate in this manner until the adjusted wp-group, call it $wp(12...\kappa)$, is balanced or on the long side vis-à-vis the grooms $m(1)$ for the first time. As should be clear, the iterative process may stop at $\kappa = 2$.

Now if $wp(12...\kappa)$ is balanced vis-à-vis $m(1)$ (where $\kappa < I$), then define like before

$$\mathcal{M}_1 := wp(12...\kappa) \tag{26}$$

to be the contenders for grooms $m(1)$.

If $wp(12...\kappa)$ is on the long side vis-à-vis $m(1)$, define $\mathcal{M}_1 := WP(12...\kappa)$ much the same way as (24) after carving out a subset of $wp(12...\kappa)$ (by dropping some members of $wp(\kappa)$) so that the cardinality of the reduced set equals that of $\{m(1)\}$. And then construct the residual members of $wp(12...\kappa)$ denoted as

$$R(wp(12...\kappa)) := \{wp(12...\kappa)\} \setminus \{WP(12...\kappa)\} \subset wp(\kappa), \tag{27}$$

[37] The specificity of $WP(1)$ is not important for the arguments to follow. In actual implementation, the subset can be chosen at random because there are more suitable bride–parents pairs than the eligible grooms. What is important is that $WP(1)$ is known to all before dowry demands are communicated.

who will be part of the next group of bride–parents pairs for potential matching with $\mathfrak{m}(2)$ grooms.

Step 3. Starting from each of the four definitions of $\mathcal{M}_1$ in (23), (24), (26), and $\mathcal{M}_1 := \mathsf{WP}(12...\kappa)$ (see above, following (26)), let us build the next group of contenders of grooms $\mathfrak{m}(2)$, to be denoted by $\mathcal{M}_2$.

Case 1. Suppose $\mathcal{M}_1 := w\mathfrak{p}(1)$ (i.e., definition (23)). To determine $\mathcal{M}_2$, consider the group $w\mathfrak{p}(2)$ vis-à-vis $\mathfrak{m}(2)$. If it is in a balanced position, let

$$\mathcal{M}_2 := w\mathfrak{p}(2). \tag{28}$$

If $w\mathfrak{p}(2)$ is in a long position, consider a strict subset of it, $\mathsf{WP}(2)$, that is of equal size as that of $\mathfrak{m}(2)$, so

$$\mathcal{M}_2 := \mathsf{WP}(2), \tag{29}$$

and set aside the residual members, like (27), for the next tier of matching with $\mathfrak{m}(3)$ grooms.

If $w\mathfrak{p}(2)$ is in a short position, expand it by adding to it a group (or groups) down the ranking until the enlarged group $w\mathfrak{p}(23...\kappa')$ (where $3 \leq \kappa' < I$) is either balanced or in a long position vis-à-vis $\mathfrak{m}(2)$. Then construct $\mathcal{M}_2$ much the same way $\mathcal{M}_1$ was constructed in (26) (if $w\mathfrak{p}(23...\kappa')$ is balanced vis-à-vis $\mathfrak{m}(2)$) or appropriately trimming the set $w\mathfrak{p}(23...\kappa')$ if it is in a long position.

Case 2. Next suppose $\mathcal{M}_1 := \mathsf{WP}(1)$ (i.e., definition (24)). This implies we will have the residual $\mathsf{R}(w\mathfrak{p}(1))$ (see (25)) from where we can start to build $\mathcal{M}_2$. To this end, first see how $\mathsf{R}(w\mathfrak{p}(1))$ compares with $\mathfrak{m}(2)$. If it is balanced, clearly

$$\mathcal{M}_2 := \mathsf{R}(w\mathfrak{p}(1)). \tag{30}$$

If the residual $\mathsf{R}(w\mathfrak{p}(1))$ is in a long position, then trim this residual further to make the size of the truncated set, call it $\mathsf{R}[\mathsf{R}(w\mathfrak{p}(1))]$, equal to that of $\mathfrak{m}(2)$, so that

$$\mathcal{M}_2 := \mathsf{R}[\mathsf{R}(w\mathfrak{p}(1))]. \tag{31}$$

Finally, if $\mathsf{R}(w\mathfrak{p}(1))$ is in a short position, the set needs to be expanded by including $w\mathfrak{p}(2)$ or more groups down the chain until it is either balanced vis-à-vis $\mathfrak{m}(2)$ or turns into a long position, which then needs to be truncated appropriately to make the cardinalities equal and thus yield $\mathcal{M}_2$.

Case 3. This starts from when $w\mathfrak{p}(12...\kappa)$ is balanced vis-à-vis $\mathfrak{m}(1)$ (so $\mathcal{M}_1$ is given by (26)), or it is in a long position and accordingly $\mathcal{M}_1 := \mathsf{WP}(12...\kappa)$ has been defined.

For the former, the next group of contenders for grooms $\mathfrak{m}(2)$ starts from the bride–parents group $wp(\kappa+1)$. If this group is balanced vis-á-vis $m(2)$ then

$$\mathcal{M}_2 := wp(\kappa+1). \tag{32}$$

If $wp(\kappa+1)$ is in a long position, then trim it down to make its cardinality equal $m(2)$ and define $\mathcal{M}_2 := WP(\kappa+1)$. (The residual set $R(wp(\kappa+1))$ will then be next up for construction of $\mathcal{M}_3$ in the manner similar to how $R(wp(1))$ was used to build up $\mathcal{M}_2$.) If $wp(\kappa+1)$ is in a short position vis-à-vis $m(2)$, extend it by including group(s) down the chain in the same manner as the procedure discussed earlier to increase its cardinality to that of $m(2)$ and construct $\mathcal{M}_2$.

On the other hand, if $wp(12...\kappa)$ is in a long position and thus $\mathcal{M}_1 := WP(12...\kappa)$, place the residual members $R(wp(\kappa))$ vis-á-vis $m(2)$ grooms to determine if and how the residual group should be adjusted (i.e., expanded or truncated) to define $\mathcal{M}_2$.

This exhaustively completes the construction of $\mathcal{M}_2$. Step 3 ENDS.

Step 4. Given the extension of the definition of $\mathcal{M}_1$ to $\mathcal{M}_2$, suppose we have defined similarly $\mathcal{M}_i$ as contenders of grooms $m(i)$. Next we define *recursively* $\mathcal{M}_{i+1}$ who will be the contenders of grooms $m(i+1)$.

For the construction of $\mathcal{M}_{i+1}$ we adopt a similar approach as in the construction of $\mathcal{M}_2$: first consider the final group, $wp(\kappa')$ whose members, partly or wholly, were contained in $\mathcal{M}_i$. If it was partial inclusion, then the residual members $R(wp(i...\kappa')) = \{wp(i...\kappa')\}\backslash\{WP(i...\kappa')\}$ must be the first members to be included in $\mathcal{M}_{i+1}$ and then possibly be expanded by including later groups to follow down the ranking of bride–parents tier $wp(\kappa'+1))$ and others. In doing so, we have to keep track that the cardinality of the expanding group either equals the cardinality of $m(i+1)$ so that the collated group is in a balanced position, or crosses this value for the first time (i.e., the group is in a long position). For the balanced case, $\mathcal{M}_{i+1}$ is already formed; for the long position, the last added group (call it $wp(\kappa''))$ has to be trimmed appropriately to equal the cardinality of $m(i+1)$.

We have thus completed the construction of $\mathcal{M}_{i+1}$.

At the start we have already constructed $\mathcal{M}_1$ and then built on it to define $\mathcal{M}_2$. Now set $i=2$ and apply the recursion to successively construct all $\mathcal{M}_i$'s until all bride–parents down the ranking have been associated with a group of grooms. An intuitive property that the association between the two sides will have is the following: *no bride–parents pair with a lower combined value can be associated with a groom of higher worth, relative to another bride–parents pair whose combined value is strictly greater.* This possibility we eliminated because in the equilibrium to be constructed, the combined worth of a bride and her parents will dictate how high a groom, in terms of worth, they can achieve. And the ambition to achieve as high value a groom as possible by spending the last dollar of parental wealth preserves the (above) hierarchy.

With the above definitions of $\mathcal{M}_i$'s, we are able to associate η groups of brides and parents with η groups of grooms. ||

■ **The proposal mechanism $\mathcal{F}$.** The matching will be conducted under a specific proposal mechanism, as follows. First, fix the $\mathcal{M}_i$'s constructed above. Consider the associations

$$\begin{aligned}\{m(1)\} &\longleftrightarrow \mathcal{M}_1\\ \{m(2)\} &\longleftrightarrow \mathcal{M}_2\\ &\\ \{m(\eta)\} &\longleftrightarrow \mathcal{M}_\eta\end{aligned} \tag{33}$$

The grooms in $\{m(i)\}$, $i < \eta$ will propose to <u>two</u> brides, one in their own hierarchy $\mathcal{M}_i$ and a second one in $\mathcal{M}_{i+1}$, just one hierarchy below, whose (bride) worth plus parental wealth is the *highest* within that hierarchy, and ask for dowries from their parents.[38] Let $\mathcal{M}_{i+1}^{\max}$ be this subset of $\mathcal{M}_{i+1}$ containing bride–parents pair(s) whose combined worth are among the highest. The grooms in $\{m(\eta)\}$ propose to only <u>one</u> bride in $\mathcal{M}_\eta$.

No two grooms from a hierarchy will make proposals to the same bride within their own hierarchy, although there can be duplication of proposals in the lower hierarchy $\mathcal{M}_{i+1}$, i.e., a bride may be shown multiple interests. The bride and parents from the group $\mathcal{M}_{i+1}$ with the highest combined worth serves as a threshold, back-up option much like in a contestable market.

Define a composite of a bijective function (i.e., one-to-one correspondence or invertible function) and a function, $h := (h_1, h_2)$, as follows:

$$\begin{aligned} h_1 &: \{m(i)\} \twoheadrightarrow \mathcal{M}_i,\\ h_2 &: \{m(i)\} \rightarrow \mathcal{M}_{i+1}^{\max} \quad \text{whenever } \ i < \eta. \end{aligned}$$

This mapping associates each groom in $\{m(i)\}$ to a unique bride–parents pair in $\mathcal{M}_i$ and vice-versa. In addition, each groom is also associated with at most one bride–parents pair in $\mathcal{M}_{i+1}^{\max}$. $\quad\|$

The mechanism imposes a discipline on the grooms' behavior by restricting the number of proposals to two, the minimal necessary to generate an intuitively plausible marriage equilibrium without undue strategic complexity. As we will argue, allowing an arbitrary number of proposals will not alter the equilibrium analysis.

We start with a result that would simplify the analysis of the marriage market significantly, and the result does not depend on the proposal protocol $\mathcal{F}$.

Proposition 3 (Inscrutable grooms) *In any pure strategy perfect Bayesian equilibrium, when it exists, the dowry demands must be* <u>pooling</u>*.*

Proof. If the equilibrium were separating, the bad-type groom will reveal his type for the prospective match in which case the marriage proposal will be declined because a bride of either

[38]There can be multiple such brides belonging to hierarchy $\mathcal{M}_{i+1}$. Also, note that the combined worth of bride and parental wealth need not be uniform within $\mathcal{M}_{i+1}$.

type would rather remain unmarried than knowingly marry a bad-type groom (Assumption 5). This is undesirable for the bad-type groom as he will be left without a match (by Assumption 1). Hence, a bad-type groom will always mimic the good-type's dowry ask and the equilibrium must be *pooling*. **Q.E.D.**

Proposition 4 (No-signalling by brides' parents) *Brides' parents cannot signal their types, stubborn or compliant, in the decentralized market at the business end of marriage, without of course declining the marriage proposal.*

The reason for no-signalling is simple: Parents do not have a credible action to convey their types at the dowry/proposal stage and not until violence has been inflicted when it is too late. If, however, dowry is too high and the bride's participation constraint is violated (Corollary 1), a bride may refuse to marry. But in that case signalling doesn't serve any purpose.

The following is our central result on marriage and dowry, one that leads to assortative matching.

Proposition 5 (Dowry & Dutch auction) *Fix the proposal mechanism $\digamma$. In addition, consider the following strategies and beliefs in the first stage of the marriage–violence game:*

(i) *Any groom $\ell \in \{m(i)\}$, $i < \eta$ demand dowries for the prospective bride $h_1(\ell) \in \mathcal{M}_i$ from her parents $p(h_1(\ell))$, and for a second prospective bride $h_2(\ell) \in \mathcal{M}_{i+1}^{\max}$ from her parents $p(h_2(\ell))$, that satisfy*

$$\textit{\textbf{[Dutch auction-}}\text{I}\textit{\textbf{]}} \qquad \omega_{h_1(\ell)} + d_{h_1(\ell)} = \omega_{h_2(\ell)} + d_{h_2(\ell)} = \omega_{h_2(\ell)} + \omega_{p(h_2(\ell))}\,; \tag{34}$$

(ii) *Any groom $\ell' \in \{m(\eta)\}$ demand dowries for the prospective bride $h_1(\ell') \in \mathcal{M}_\eta$ from her parents $p(h_1(\ell'))$ that satisfy*

$$\textit{\textbf{[Dutch auction-}}\text{II}\textit{\textbf{]}} \qquad \omega_{h_1(\ell')} + d_{h_1(\ell')} = \omega_{h_1(\hat{\ell})} + \omega_{p(h_1(\hat{\ell}))}\,, \tag{35}$$

where $\hat{\ell} = \arg\min_{\ell \in \{m(\eta)\}} \omega_{wp(h_1(\ell))}$*;*

(iii) *The brides will accept the marriage proposals provided conditions (ICs) (for strong brides) and (ICc) (for compliant brides) are satisfied; otherwise they decline the proposals.*

(iv) *If the dowry demands are in excess of those specified above, the respective grooms are believed to be of 'bad' type with probability 1. Otherwise beliefs about grooms' types are formed applying Bayes' rule to the dowry strategies* **(i)** *and* **(ii)***.*

The equilibrium of the marriage–violence game can be characterized as follows:

1. *For any profile of dowries and marriages (i.e., proposal accetance/rejection decisions) in Stage 1 and the associated (posterior) beliefs about the grooms' types, consider any* PBE

in the post-marriage violence continuation game in Stage 2 as summarized in Propositions 1 and 2. Now fold the game backwards. In the resulting reduced game, dowry demands in **(i)** *and* **(ii)***, together with beliefs* **(iv)***, form a pooling* PBE *in the marriage stage (Stage 1), provided the brides' participation conditions stated in* **(iii)** *are satisfied.*

2. *The grooms marry the brides from within their hierarchy but decline the brides from the lower hierarchy.*

3. *The beliefs are fulfilled along the equilibrium path, while for dowry demands off-the equilibrium path (i.e., in excess of those satisfying* (34) *and* (35)*) the brides' parents will decline the marriage proposal.*

4. *Finally, the above results continue to hold for a more decentralized proposal protocol that allows grooms to make any number of proposals to brides from any hierarchy.*

Proof. By construction, the bride–parents group $\mathcal{M}_i$ is balanced: the number of brides in $\mathcal{M}_i$ equals the number of grooms in $\{m(i)\}$. Each groom in $\{m(i)\}$ proposes to one bride in $\mathcal{M}_i$ and another bride in $\mathcal{M}_{i+1}^{\max}$ (if $i < \eta$)), and no bride in $\mathcal{M}_i$ receive multiple proposals from the group $\{m(i)\}$, although one may receive a proposal from one or more grooms from the higher tier of grooms $\{m(i-1)\}$ if $i \geq 2$. If $i = 1$, each bride in $\mathcal{M}_1$ receives only one proposal from one of the grooms in $\{m(1)\}$.

Case 1. Suppose first $i < \eta$, and consider a groom ℓ in $\{m(i)\}$. Consider his proposal to $h_2(\ell) \in \mathcal{M}_{i+1}^{\max}$. Suppose then the groom asks for a dowry $d_{h_2(\ell)} = \omega_{p(h_2(\ell))}$, so that $\omega_{h_2(\ell)} + d_{h_2(\ell)} = \omega_{h_2(\ell)} + \omega_{p(h_2(\ell))}$ as in (34). The groom with the best human capital the parents $p(h_2(\ell))$ can hope to achieve is a groom from $\{m(i)\}$, for whom they are prepared to exhaust their entire wealth in dowry payment under the pooling belief about the groom's type established in Proposition 3 (Assumption 6), assuming the strong and compliant brides' participation conditions (ICs) and (ICc) are also satisfied. So, the groom's dowry demand will be met. This induces a waiting game by the parents of bride $h_1(\ell)$, as in a Dutch auction, until the dowry ask has come down to $d_{h_1(\ell)} = \omega_{h_2(\ell)} + d_{h_2(\ell)} - \omega_{h_1(\ell)}$ (thus satisfying the LHS equality of (34)) so that the groom is indifferent between the two acceptances. We then ***break the tie*** with the grooms from $\{m(i)\}$ marrying brides from the same hierarchy as their own. This tie-breaker is not innocuous, given that the parents of the bride from the same hierarchy will likely have surplus money left after paying the dowry, whereas the parents of the bride from the lower hierarchy will have exhausted their wealth in dowry payment; this allows the bad type groom to go for post-marriage violence for further monetary extortion if he marries within own hierarchy.[39] Here we invoke the social norm of marginal preference for *not marrying down* (in terms of financial status of the in-laws).[40]

[39] So one may apply a punishing skeptical belief about the groom's type for agreeing to marry within the same hierarchy. But we allow no retraction by the bride and her parents of their acceptance of the groom's proposal.

[40] It is possible that the combined worth of the bride–parents involved in the lower tier is same as that of the

These dowry demands are the result of how bids are determined in a Dutch auction. The dowries translate into the *next best* combined value that the grooms in $\{m(i)\}$ can receive from any bride–parents pair in $\mathcal{M}_{i+1}^{\max}$, who are trying to achieve just above their reach-groom. The brides and their parents in $\mathcal{M}_i$ are able to hold out until dowries have been pushed down to hit the maximal dowry-giving capacity of the next hierarchy of parents. $\|$

Case 2. Suppose $i = \eta$. Now the grooms in $\{m(\eta)\}$ can only propose to brides from the group $\mathcal{M}_\eta$, as there is no lower hierarchy. And recall, by construction the two sides are balanced, i.e., there is no excess supply of brides nor is there any shortage. But recall within $\mathcal{M}_\eta$, the combined worth of the brides and their parents, $\omega_{wp(h_1(\ell))}$, need not be uniform. So let us pick $\hat{\ell} \in \{m(\eta)\}$ and the corresponding bride $h_1(\hat{\ell})$ such that the combined worth $\omega_{wp(h_1(\hat{\ell}))}$ is the <u>lowest</u> in the hierarchy $\mathcal{M}_\eta$.

The above $\omega_{wp(h_1(\hat{\ell}))}$ serves as the upper bound to how much a groom can ask for dowry from the prospective in-laws. That is, any groom ℓ' can ask at most a dowry $d_{h_1(\ell')}$ so that $\omega_{h_1(\ell')} + d_{h_1(\ell')} = \omega_{wp(h_1(\hat{\ell}))}$. Any higher dowry ask $d > d_{h_1(\ell')}$ will be considered to be coming from a 'bad' type groom (off-equilibrium belief), and this skeptical belief will relegate the groom to be left with no marriage prospect. (Note that this belief satisfies the D1 refinement of Cho and Kreps (1987): A violent groom stands to benefit more than a good-type groom because the former gets to keep the entire additional dowry $d - d_{h_1(\ell')}$ and consume it away in the event the in-laws turns out to be of stubborn type leading to divorce, whereas if the groom were a good type he enjoys only $(d - d_{h_1(\ell')})/2$ (see (5) and (ICviolence)); moreover, violent types have more to gain from higher dowries due to follow-on extortions.) Hence, all grooms in $\{m(\eta)\}$ will ask for dowries satisfying (35). Making this dowry proposal and agreeing to the proposal are incentive compatible to both the groom and the bride–parents, assuming the dowries satisfy the strong and compliant brides' participation conditions (ICs) and (ICc).

Once again, the equilibrium dowries in (35) are derived as in a Dutch auction. The implicit threat of punishing belief noted above helps coordinate the grooms to play the Dutch auction. $\|$

Finally, the above arguments continue to hold if the proposal mechanism $\mathcal{F}$ is relaxed to allow grooms to make other forms of proposal, for example, proposal to any number of brides and from any hierarchy. Given that the equilibrium matching is assortative, $\{m(i)\} \leftrightarrow \mathcal{M}_i$, under a more decentralized proposal protocol the grooms make no gains by proposing to brides more than one level below their own hierarchy. Nor would brides be able to secure a proposal from grooms more than one level up. **Q.E.D.**

A quick way to see how equilibrium dowries are determined, one can go back to Fig. 5. There the two sides of the marriage market are segmented and ignoring the aspect of extortion in the violence continuation game the dowries are listed if one applies just the Dutch auction rule. The following example completes the picture by also listing equilibrium extortions.

bride–parents in the upper tier, in which case the concept of marrying down does not apply. But there is also no reason to prefer the bride from the "lower tier" either.

An Example of dowries and extortions. Suppose there are five grooms, all of equal worth $\omega_m = 25$. Consider the profiles of brides and their parents as in Fig. 6. By applying the logic of Propositions 2 and 5 and assuming the brides' participation constraints are satisfied (so there is no rejection of proposals at the proposed dowries), the equilibrium dowries satisfying (34) and extortions satisfying (16) are reported in the second and fifth columns of Fig. 6.

$$\begin{array}{c} \\ w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \end{array} \begin{array}{c} \begin{array}{ccccc} \omega_w & d^* & \omega_p & \omega_p - d^* & \mathcal{E} \end{array} \\ \begin{pmatrix} 10 & 0 & 15 & 15 & \min\{15, \mathcal{E}_{\text{no-divorce}}(10, 25)\} \\ 7 & 3 & 15 & 12 & \min\{12, \mathcal{E}_{\text{no-divorce}}(7, 25)\} \\ 4 & 6 & 15 & 9 & \min\{9, \mathcal{E}_{\text{no-divorce}}(4, 25)\} \\ 0 & 10 & 15 & 5 & \min\{5, \mathcal{E}_{\text{no-divorce}}(0, 25)\} \\ 10 & 0 & 0 & 0 & \min\{0, \mathcal{E}_{\text{no-divorce}}(10, 25)\} \end{pmatrix} \end{array}$$

Figure 6: Equilibrium dowries and extortions. The extortions $\mathcal{E}$, i.e. the $\min\{.,.\}$ functions, will depend on the utility function and δ_{cf}, δ_c, as earlier shown in the two illustrations.

The dowries derived thus also confirm a well-known cold "truth" – a fait accompli – that brides' parents must confront, summarized in Corollary 2.

Corollary 2 (Compensating differential) *The lesser the quality of the bride, as in low ω_w, the higher the dowry needed to compensate for her to be matched with a desirable groom, i.e., ω_m-maximizing groom. See Fig. 7.*

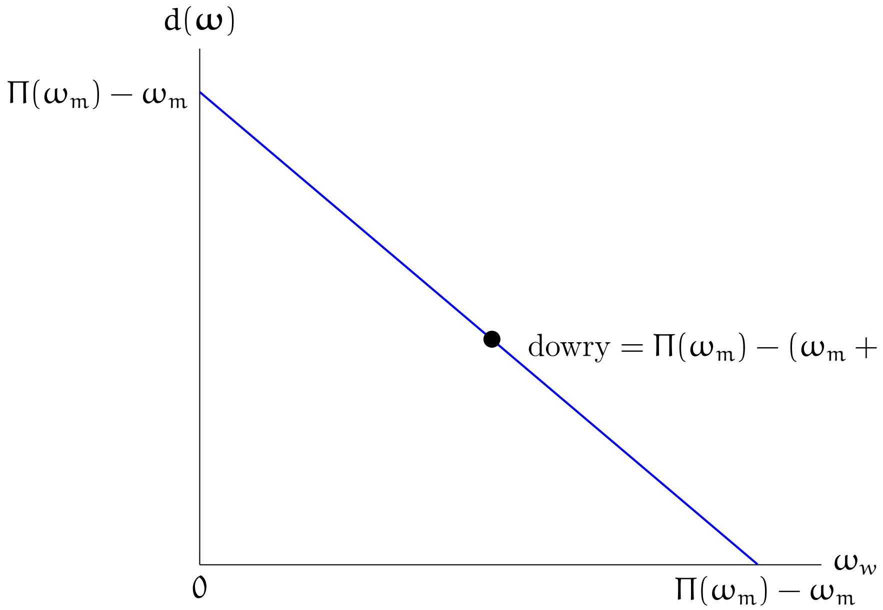

Figure 7: Bride quality and dowry as substitutes

■ **Discussion of Proposition 5 and Corollary 2.** The result (Proposition 5) is a formalization of "hedonic prices" of differentiated products first analyzed by Rosen (1974), and subsequently noted for its relevance in the marriage market by Rao (1993, p. 668). Rao discusses the application of Rosen's hedonic pricing idea for groom (and bride) prices as follows: "It gives the minimum (maximum) transfers available in the market, for each package of **W-H**, to bride (groom) households. If there are enough participants in the marriage market, potential partners waiting in the wings (e.g., widowers and migrants) would force this price function to be given exogenously. No bargaining would occur because negotiated dowries that differed from the competitive price would always be bid to a competitive level by another potential partner."[41] It is Rao's discussion and analysis that helped connect our equilibrium dowry result in Proposition 5 to Rosen's framework. Note, however, that Rao does not solve explicitly the market equilibrium dowry function but using an intuitive form estimates it econometrically. Our contribution is to formally derive the market equilibrium dowry equation using auction theory in a more extensive model of marriage, violence and divorce. A particularly notable feature of the equilibrium is *dowry compression*: dowry bid is pushed down as any groom would know that his intended partner's parents do not have to offer a dowry any higher than ensuring their daughter's worth plus the dowry only match the maximum combined worth of the bride and parents from one hierarchy lower. Any higher dowry demand will be perceived poorly as a reflection of the groom being of a violent type and thus forcing pooling by the groom's types. Note, however, that at the posited equilibrium dowry there is surplus cash left on the table for a bad-type groom to inflict violence for extortion in the post-marriage phase if he marries the bride from the same hierarchy. If the equilibrium dowry is at the lower range of Fig. 4 (see the part $\underline{\mathcal{E}}A$), then the extortion curve is upward sloping, implying any higher dowry demand could be coming from a violent groom. Thus the punishing off-equilibrium belief can be justified.

A number of authors have previously applied auction theory (transfers) for allocation of heterogeneous goods among buyers, jobs among workers, and matching between men and women (Crawford and Knoer, 1981; Demanage and Gale, 1985; Demange et al., 1986). The parties, for example buyers who want to buy at most one item and women who want to marry to be in a monogamous relationship, privately assign monetary values over goods and men. Similarly, sellers have reservation values. The two sides then announce their demand and supply functions, and a Walrasian equilibrium (not necessarily unique) mediated by a "referee" or auctioneer, sometimes through iterative/dynamic adjustments, clears the market. Our setting differs from these models in one critical aspect: the brides cannot rank the grooms in a meaningful manner; knowledge of grooms' human capital is not enough, their private types (violent or good groom) can alter brides' ranking drastically as even the bride with the least human capital will refuse to marry a groom with the highest human capital if he is known to be violent. What works, however, is the fact that the brides can rank the grooms according to observable characteristic, the human capital. Full decentralization is also workable from a practical point of view for arranged marriages because both the grooms' and brides' side would know the historical distribution of

[41]"It" at the start of the quoted paragraph refers to a dowry function **D(W-H;R)** in Rao that "maps differences in the traits of potential brides and grooms to a transfer value."

each other's worths from past experience, including the type of marriages that happen. Brides from low income parents tend to get married to grooms of worth that are from a comparable hierarchy. So when proposals are made, the initiating side, the grooms in our construction, need not look at the entire distribution of brides but consider only a comparable range of brides. Therefore, while one-to-one proposals within the same hierarchy may seem like an abstraction, the mechanism has much realism to it with the main actors driven by wealth rankings guiding their marriage alliances. Any data collection of arranged marriages is likely to confirm the assortative nature predicted in our analysis. In a brief extension in the next section, we consider a decentralized mechanism of random matching and dowry bids.

Corollary 2 may sound similar to the familiar result of dowry as compensating marriage payments where parents underinvest in girl child so that the economywide distribution of grooms' worth dominates brides' worth (Anderson and Bidner, 2015). But as discussed earlier, a system of dowry as grooms money can persist due also to social norm (footnote 17). Here compensating differential is not necessarily to compensate for the lesser quality of the bride relative to the groom's quality, but relative to qualities of other competing brides.

■ **Violation of participation constraints.** As indicated earlier, the bride's participation conditions (ICs) and (ICc) must be satisfied to sustain the equilibrium in Proposition 5. It is possible, however, that the dowries satisfying (34) and (35) fail the constraint (ICs).[42] In that case, with probability $1-\pi$ the marriage proposal will be rejected. If $1-\pi$ exceeds the cutoff for grooms' risk-tolerance, the grooms should like to lower their dowry demands just enough to bind the constraint (ICs). Put differently, *the lower the grooms' risk-tolerance of* $1-\pi$*, the lower will be the equilibrium dowries.* A related intuitive comparative statics should also be easy to check: *the lower the* π *and thus the higher the proportion of stubborn brides and parents in the population, the lower will be the average dowries paid in marriage.*

■ **Why not bride's price?** The way the marriage market has been framed in this paper can be re-cast as grooms bidding positive transfers for brides of high human capital. Why dowry and why not bride's price is a worthwhile question independent of the issue of violence and adequate answers have already been provided by other authors (e.g., Rao, 1993; Anderson, 2007a) – explanation in terms of an imbalance in marriage age for men and women, specifically due to the latter having a smaller window for the purpose of childbearing. Our analysis of dowry and marriage market should be viewed with the key objective of understanding dowry violence; bride's price does not connect well with dowry violence. Any policy intervention in curbing dowry violence will have implications for marriage, divorce and investment in girl child, a rich topic for future research. Anderson and Bidner's work (2015) will also be relevant for this agenda.

■ **Final summary.** To approximate the prevalent mode of arranged marriages in India, we relied on a quasi-decentralized matching market that functions through the posting of only

[42]By Corollary 1, strong bride's participation constraint is more demanding.

dowry bids. Most such marriages are through newspaper advertisements, and online marriage platforms such as https://www.shaadi.com/matrimony/india-matrimony and https://www.bharatmatrimony.com/, where at any point of time the two sides can view all the available prospective brides and grooms. The prediction that dowries reveal no information about the grooms' violent traits is quite striking and may not be too different from people's actual experiences. Of course it is not an absolute observation, as bride's families may make thorough enquiries about the prospective groom's past history, including any previous marriage and what could be the reason for breakdown. Our modelling cannot capture these additional information gathering exercise. Instead, assuming a typical market setting our analysis has revealed four important features of arranged marriages: (i) very little of the groom's private type can be found out at the time of marriage proposals, (ii) the dowry (price) is a natural outcome of a competitive bidding mechanism, a version of the Dutch auction for heterogeneous goods, (iii) the dowries are the *minimal* transfers (bid down as in a contestable market) that the parents make to secure the "best" grooms in terms of observable monetary worth, and (iv) dowries are the result of social norms without assuming an excess supply of marriage-age women.

6 Decentralized Matching à la Rubinstein and Wolinsky

The Dutch auction mechanism studied in the previous section requires a disinterested mediator who segments the market, especially the bride–parents pairs. It could be that the lowest combined bride–parents worth in one tier equals the highest combined worth in the tier below. This was necessary to make the number of brides in a tier equal the number of grooms in the corresponding tier. Moreover, one-to-one proposal calls for perfect coordination among the grooms within a tier. Our objective in this section is to decentralize this coordination.

One way to decentralize would be random matching. But we do not want to randomize matching over the entire population of grooms and brides. Instead, it is sufficient to let the grooms of tier j match randomly with all the brides in tier j and all brides with the maximum combined worth in the lower tier $j+1$; only in the lowest tier η, the grooms randomly match with the brides from tier η. This restricted randomization is realistic because in arranged marriages both sides are aware of the expected hierarchical sorting given their objectives as well as social norm/convention.

■ **Matching mechanism.** The mechanism presented below is a variant of the pairwise matching and bargaining protocol in Rubinstein and Wolinsky (1990), but extended to a game of incomplete information.[43] Incomplete information substantially complicates the game. Analyzing equilibrium of this game involves specifying continuation strategies and beliefs for each history that unfolds over time.

[43] See also Rubninstein and Wolinsky (1985), Binmore and Herrero (1985), and Gale (1987). In our case, Dutch auction takes the place of bargaining. In contrast to our incomplete information setting, these authors studied complete information games.

Time is discrete $t = 0, 1, 2, ..., \infty$. There is no discounting of the future, as search for a marriage partner occurs in quick succession over a short interval of time.

Consider any period t and a generic groom $m \in \{m(j,t)\}$ in tier j (where $\{m(j,t)\} \subseteq \{m(j)\}$) who is still in the game. Only the married couples in the earlier rounds have exited the game. For potential matching with m, let $\mathcal{M}_j(t) \subseteq \mathcal{M}_j$ be the set of bride–parents pairs from tier j who have not exited the game yet by the time t-th period starts. Construct an extended set of bride–parents for groom m by adding pairs with the highest combined worth from one tier below who are still in the game:

$$\mathcal{M}_j^{\text{ext}}(t) \equiv \mathcal{M}_j(t) \cup \{\overline{wp}(j+1,t) \in \arg\max \omega_{wp(j+1,t)}\}, \tag{36}$$

where $wp(j+1,t) \subseteq wp(j+1)$.

Starting at $t = 0$, we conduct $\#\{m(j,t)\}$ number of random pairwise matchings between grooms in $\{m(j,t)\}$ and brides in $\mathcal{M}_j^{\text{ext}}(t)$, $j = 1, ..., \eta$, where any combination of $\#\{m(j,t)\}$ pairs of groom and bride is likely to be drawn with an equal probability of $\#\{m(j,t)\}/(\#\{m(j,t)\} \times \#\mathcal{M}_j^{\text{ext}}(t))$. As matching rounds progress, the number of random matchings will shrink with the married couples exiting the matching game. At the start of period t, the number of brides in any hierarchy that remain unmatched equals $\#\mathcal{M}_j^{\text{ext}}(t) - \#\{m(j,t)\}$ for $j < \eta$.[44] The unmatched brides still play a role in grooms' decision making at any time t as they form the outside options in future periods, together with brides who fail to marry in the current period.

A bride may belong to both $\mathcal{M}_j^{\text{ext}}(t)$ and $\mathcal{M}_{j-1}^{\text{ext}}(t)$, and thus may be matched with a groom each from $\{m(j,t)\}$ and $\{m(j-1,t)\}$. This means at any period t, a bride may consider simultaneously two proposals but a groom always makes only one proposal. See footnote 46.

In a typical pair drawn (m, w), the groom proposes to the bride (or not), the latter responds by accepting or rejecting when there is a marriage proposal,[45] and the game evolves over time with yet unmarried grooms and brides as in the game tree in Fig. 8.

At any point of time the candidates for matching are the left-overs from previous rounds. Some of them might be holding out for a better match where match quality depends on the candidates' individual worths and the dowry demanded.

At the start of any period t, the information available to a candidate consists of three pieces of data:

$$\Big(\text{time } t, \text{set of candidates yet to exit the game}, \text{candidate's personal history up to } t\Big).$$

Call this dynamic matching game $\boldsymbol{\mu}$. ||

Proposition 6 (Decentralized search) *The dynamic random matching mechanism* $\boldsymbol{\mu}$ *with*

[44] For $j = \eta$, $\mathcal{M}_\eta^{\text{ext}}(t) \equiv \mathcal{M}_\eta(t)$ and hence $\#\mathcal{M}_\eta^{\text{ext}}(t) = \#\{m(\eta,t)\}$.

[45] A bride may not accept more than one proposal.

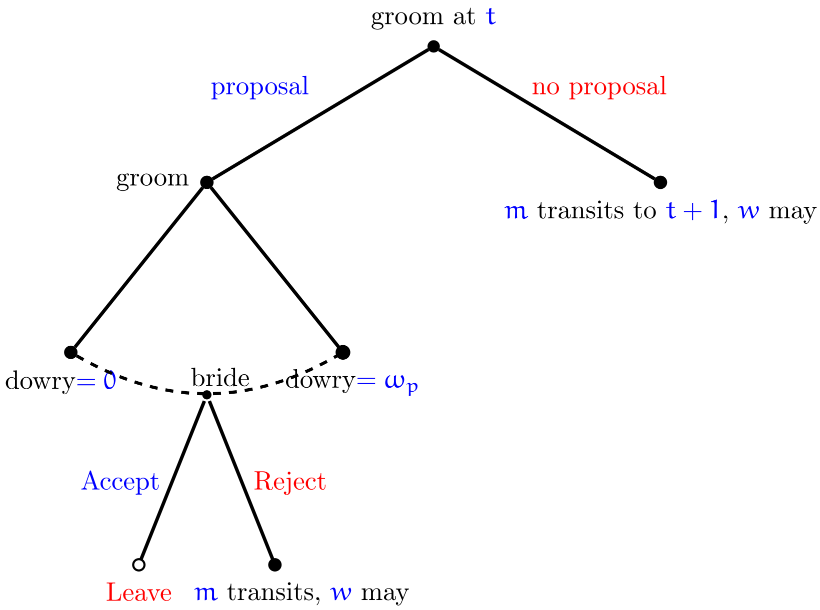

Figure 8: Game between m and w after matching in period t. Proposal and Accept/Reject decisions in period t and transition to period $t+1$. Acceptance of a proposal means the couples marry and leave the market permanently. Rejection of a proposal and 'no proposal' means at least the groom, if not the bride as well (who may be considering simultaneously two proposals at time t), will transit to the next period to be randomly matched afresh.

appropriate strategies and beliefs (to be outlined below) will implement the assortative marriage and dowry outcomes of Proposition 5 in a unique sequential equilibrium. The iterative process will terminate almost surely after a sufficiently large, finite number of rounds T.

Given a deterministic one-to-one pairing in Proposition 5, the random matching may not yield the exact matches but the two are payoff-equivalent *ex post* for all candidates.

Proof. At any period $t \geq 0$, consider the public history $\mathcal{H}_t$ that summarizes only the set of grooms and bride–parents pairs who are still in the game. In addition, a candidate groom or bride, $c = m, w$, will have personal history $\mathcal{H}_{c,t}$ containing information on with whom he/she was previously matched (if any) and what were the proposals and subsequent decisions; personal history leads to formation of posterior beliefs (to be specified separately later on) about other agents' types including the latest one with whom c has been matched. History $(\mathcal{H}_{t+1}, \mathcal{H}_{c,t+1})$ derives from $(\mathcal{H}_t, \mathcal{H}_{c,t})$ in an obvious manner with only the latest t-th period changes incorporated in it. Collection of all pairs $(\mathcal{H}_t, \mathcal{H}_{c,t})_{c \in \{m(j,t)\} \cup \mathcal{M}_j^{\text{ext}}(t), t \geq 0}$ define the set of histories of the long-lived pairwise matching game $\boldsymbol{\mu}$.

Fix a groom $c = m$ in tier j, and the set of prospective brides $\mathcal{M}_j^{\text{ext}}(t)$ as defined in (36). Let bride $w \in \mathcal{M}_j^{\text{ext}}(t)$ be matched with m through the random pairwise matching process.[46]

[46]The same bride w may also be matched with a groom m' in one tier above or below, i.e., tier $j-1$ or $j+1$. That is, bride w may belong to $\{\overline{wp}(j,t) \in \arg\max \omega_{wp(j,t)}\}$ and thus becomes a member of $\mathcal{M}_{j-1}^{\text{ext}}(t)$, or she originally belongs to $\mathcal{M}_{j+1}(t)$ and then is included in $\mathcal{M}_j^{\text{ext}}(t)$ by virtue of being part of $\{\overline{wp}(j+1,t) \in \arg\max \omega_{wp(j+1,t)}\}$. Given that the same bride w cannot be simultaneously a member of $\mathcal{M}_j(t)$ for multiple j-tiers, a bride can be

Below we divide the analysis into two cases.

Case A. Now first consider the case where the remaining grooms' and brides' beliefs have not changed from prior beliefs. Let the strategies and belief revision be as follows:

Strategies:

- Groom m will propose to w for her hand in marriage if and only if either (i) or (ii) below holds:

  (i) There is no $w' \in \mathcal{M}_j^{\text{ext}}(t)$ such that

  $$\omega_{w'} + \omega_{p(w')} > \min_{w_j \in \mathcal{M}_j^{\text{ext}}(t)} \omega_{w_j} + \omega_{p(w_j)}, \tag{37}$$

  whenever

  $$\omega_w + \omega_{p(w)} = \min_{w_j \in \mathcal{M}_j^{\text{ext}}(t)} \omega_{w_j} + \omega_{p(w_j)}. \tag{38}$$

  The existence of such w' that calls for no proposal to w includes the ones who might be matched, in this round t, to other grooms; or such w' might not be matched with any groom in this round who then could be a potential match with m in a future draw.[47]

  (ii) $\omega_w + \omega_{p(w)} > \min_{w_j \in \mathcal{M}_j^{\text{ext}}(t)} \omega_{w_j} + \omega_{p(w_j)}$.

- Groom m does not make a proposal to w if (38) holds and there is some $w' \in \mathcal{M}_j^{\text{ext}}(t)$ such that (37) also holds.

- When m proposes to w, he asks for a dowry satisfying the following variant of condition (34):

$$\omega_w + d_w = \min_{w_j \in \mathcal{M}_j^{\text{ext}}(t)} \omega_{w_j} + \omega_{p(w_j)}. \tag{39}$$

- The strategy of the bride and her parents is to agree to the proposal if the dowry ask is no more than the one satisfying (39), and otherwise decline the proposal.

Beliefs: Beliefs following period t decisions evolve as follows: (a) if the proposal decision and dowry ask are according to as specified above, the bride's (new) belief about the groom's

matched with at most two grooms who must belong to two adjacent tiers.

[47]At this stage an early indication of why adopt such a strategy can be seen as follows: the objective is to implement assortative matching, i.e., a groom being matched with a bride within the same bride–parents tier. The randomly drawn bride w could be coming from the lower tier $\{\overline{wp}(j+1,t) \in \arg\max \omega_{wp(j+1,t)}\}$. While such lower-tier bride serves the purpose of generating the floor to equilibrium dowries, as we will specify in (39) below, the specified strategies are ultimately geared towards ensuring within-tier matching of grooms and brides.

type remains unchanged (by applying Bayes' rule), and likewise for the groom's belief so that $\mathcal{H}_{c,t+1}$ are once again non-revealing; (b) if the groom triggers an off-equilibrium play by asking for a dowry in excess of the equilibrium dowry, the groom is believed to be a bad type with probability 1; (c) if neither (i) nor (ii) holds and yet the groom makes a proposal, the groom is believed to be a bad type with probability 1; (d) if the bride declines a proposal satisfying (39) the off-path belief about the bride's type remains the same as the prior. Moreover, the bride believes that in the other matches being played out simultaneously the strategies chosen (both by the proposers and responders) will be according to the specification above.

This last belief (about the play of other matches), which is a standard consistency requirement, serves an additional key role in our iterative matching process—should a bride remain in the game in period $t+1$ and is matched with a groom other than her past matches, her belief about the groom's type will be same as the prior belief. That is, she won't know whether the groom she is facing at time $t+1$ got there after being declined for asking in excess of the equilibrium dowry.[48]

If a groom asks for a dowry less than the equilibrium dowry in (39) and the bride declines the proposal, which is an off-equilibrium play, the groom considers the bride's type to be same as the prior. This means, should the same pair meet again in the future, the groom will propose with his last updated belief about the bride's type, i.e., the original prior.

Case B. Consider the case where among the remaining grooms and brides, some belief(s) is (are) different from prior beliefs. This means some bride believes that the matched groom is a bad type with probability 1. Let the strategies and belief revision be as follows:

- The bride will decline the groom's proposal irrespective of the dowry ask.
- The groom's belief about the bride's type remains the same as the prior.

Case A is the equilibrium specification whereas Case B is off the equilibrium path.

Finally, **sequential equilibrium** requires (1) the optimality of each proposer's move, and (2) the optimality of each bride's response given her beliefs following her matched groom's proposal and beliefs about events in the other matches. ||

[Proof to be developed further.]

7 Conclusions

We end with some related issues not addressed in the paper.

What is the value of attachment of parents to their daughter? If the daughter is married off early, there will be less attachment. Does it mean parents are less likely to be stubborn and

[48]Thus an agent knows only his/her own history and who are the remaining agents in the game, and not the complete history.

therefore more likely to concede to extortion demands? That is, are child and younger brides tortured more than more matured brides? This is an empirical question that has not been looked at by researchers.

A related question then is the issue of legal age of marriage. Is society better off to raise the legal age of marriage? One consequence of raising marriage age is that parents are compelled to invest in daughter's education that make them more independent and less malleable/gullible. But this may introduce the "problem" of a protesting bride and greater conflict in marriage. The flip side of it is that there will be more reporting that may have deterrent effect on violence. The question is worth exploring, with data on marriage age, violence and divorce.

If the legal age of marriage is raised, perhaps there won't be that much bunching of marriages at the minimal (legal) age of marriage if the legal age is high. In that case parents would choose to make their daughters more independent by investing. Investment decision can also signal the type of the bride and her parents and thus help lessen the frequency of matching between violent grooms and stubborn brides.

References

A. Aizer (2010). The Gender Wage Gap and Domestic Violence. *American Economic Review*, 100, 1847–1859.

A. Aizer and P. Dal Bó (2009). Love, Hate and Murder: Commitment Devices in Violent Relationships. *Journal of Public Economics*, 93, 412–428.

S. Anderson (2003). Why Dowry Payments Declined with Modernization in Europe but Are Rising in India. *Journal of Political Economy*, 111(2), 269–310.

S. Anderson (2007a). The Economics of Dowry and Brideprice. *Journal of Economic Perspectives*, 21(4), 151–174.

S. Anderson (2007b). Why the Marriage Squeeze cannot cause Dowry Inflation. *Journal of Economic Theory*, 137(1), 140–152.

S. Anderson and C. Bidner (2015). Property Rights over Marital Transfers. *Quarterly Journal of Economics*, 1421–1484.

S. Anderson and G. Genicot (2015). Suicide and Property Rights in India. *Journal of Development Economics*, 114, 64–78.

M. Angelucci and D. Bennett (2017). Assortative Matching under Asymmetric Information: Evidence from Malawi. *American Economic Review*, 107(5), 154–157.

M. Angelucci and D. Bennett (2021). Adverse Selection in the Marriage Market: HIV Testing and Marriage in Rural Malawi. *Review of Economic Studies*, 88, 2119–2148.

S. Anukriti, S. Kwon and N. Prakash (2022). Saving for Dowry: Evidence from Rural India. *Journal of Development Economics*, 154, 102750.

P. Bag and S. Sikdar (2024). Escalations of Domestic Violence. *Working paper.*

S. Baliga and J.C. Ely (2016). Torture and the Commitment Problem. *Review of Economic Studies*, 83, 1406–1439.

G.S. Becker (1973). A Theory of Marriage, Part I. *Journal of Political Economy*, 81(4), 813–846.

G.S. Becker (1974). A Theory of Marriage, Part II. *Journal of Political Economy*, 82(2), S11–S26.

G. Becker (1991). *A Treatise on the Family.* Cambridge, MA: Harvard University Press.

T.C. Bergstrom and M. Bagnoli (1993). Courtship as a Waiting Game. *Journal of Political Economy*, 101(1), 185-–202.

M. Bertrand, E. Kamenica and J. Pan (2015). Gender Identity and Relative Income within Households. *Quarterly Journal of Economics*, 130(2), 571–614.

S. Bhalotra, A. Chakravarty and S. Gulesci (2020). The Price of Gold: Dowry and Death in India. *Journal of Development Economics*, 143, 102413.

K. Binmore and M. Herrero (1988). Matching and Bargaining in Dynamic Markets. *Review of Economic Studies*, 55, 17–32.

A. Bisin and T. Verdier (2001). The Economics of Cultural Transmission and the Dynamics of Preferences. *Journal of Economic Theory*, 97(2), 298–319.

F. Bloch and V. Rao (2002). Terror as a Bargaining Instrument: A Case Study of Dowry Violence in Rural India. *American Economic Review*, 92, 1029–1043.

M. Botticini and A. Siow (2003). Why Dowries? *American Economic Review*, 93(4), 1385–1398.

K. Burdett and M. Coles (1997). Marriage and Class. *Quarterly Journal of Economics*, 112(1), 141–168.

R. Calvi and A. Keskar (2023). 'Til Dowry Do Us Part: Bargaining and Violence in Indian Families. Forthcoming in *Review of Economics and Statistics*.

L.L. Cavalli-Sforza and M.W. Feldman (1973). Cultural versus Biological Inheritance: Phenotypic Transmission from Parents to Children. (A Theory of the Effect of Parental Phenotypes on Children's Phenotypes). *American Journal of Human Genetics*, Nov, 25(6), 618–637.

G. Chiplunkar and J. Weaver (2023). Marriage Markets and the Rise of Dowry in India. *Journal of Development Economics*, 164, 103115.

I.-K. Cho and D.M. Kreps (1987). Signaling Games and Stable Equilibria. *Quarterly Journal of Economics*, 102(2), 179–222.

V.P. Crawford and E.M. Knoer (1981). Job Matching with Heterogeneous Firms and Workers. *Econometrica*, 49, 437–450.

V. Dasgupta (1991). The Economics of Dowry. *Ph.D. thesis, University of Southern California*, available at https://vdsa.icrisat.org/Include/theses/Thesis27.pdf.

G. Demange and D. Gale (1985). The Strategy Structure of Two-sided Matching Markets. *Econometrica*, 53, 873–883.

G. Demange, D. Gale and M. Sotomayor (1986). Multi-item Auctions. *Journal of Political Economy*, 94(4), 863–872.

L. Edlund (2006). The Price of Marriage: Net vs. Gross Flows and the South Asian Dowry Debate. *Journal of the European Economic Association*, 4(2/3), 542–551.

B. Erten and P. Keskin (2018). For Better or for Worse?: Education and the Prevalence of Domestic Violence in Turkey. *American Economic Journal: Applied Economics*, 10(1), 64–105.

M. Eswaran and N. Malhotra (2011). Domestic Violence and Women's Autonomy in Developing Countries: Theory and Evidence. *Canadian Journal of Economics*, 44(4), 1222—1263.

D. Gale (1987). Limit Theorems for Markets with Sequential Bargaining. *Journal of Economic Theory*, 43, 20-54.

J. Gupta (2002). Women Second in the Land Agenda. *Economic and Political Weekly*, 37(18), 1746–1754.

W.D. Hamilton (1964). The Genetic Theory of Social Behavior. *Journal of Theoretical Biology*, 7, 1–32.

S. Jayachandran (2015). The Roots of Gender Inequality in Developing Countries. *Annual Review of Economics*, 7, 63–88.

P. Kodoth (2005). Fostering Insecure Likelihoods: Dowry and Female Seclusion in Left Developmental Contexts in West Bengal and Kerala. *Economic and Political Weekly*, 40(30), 3278–3286.

N. Luke and K. Munshi (2011). Women as Agents of Change: Female Income and Mobility in India. *Journal of Development Economics*, 94, 1–17.

A. Maertens and A.V. Chari (2020). What's Your Child Worth? An Analysis of Expected Dowry Payments in Rural India. *World Development*,130, 104927.

R. Majumdar (2004). Looking for Brides and Grooms: Ghataks, Matrimonials, and the Marriage Market in Colonial Calcutta, circa 1875-1940. *The Journal of Asian Studies*, 63(4), 911–935.

M. Manser and M. Brown (1980). Marriage and Household Decision-Making: A Bargaining Analysis. *International Economic Review*, 21, 31–44.

M.B. McElroy and M.J. Horney (1981). Nash-Bargained Household Decisions: Toward a Generalization of the Theory of Demand. *International Economic Review*, 22, 333–349.

S. Menon (2020). The Effect of Marital Endowments on Domestic Violence in India. *Journal of Development Economics*, 143, 102389.

V. Rao (1993). The Rising Price of Husbands: A Hedonic Analysis of Dowry Increases in Rural India. *Journal of Political Economy*, 101(4), 666–677.

V. Rao (1997). Wife-beating in Rural South India: A Qualitative and Econometric Analysis. *Social Science & Medicine*, 44, 1169–1180.

M. Richter and A. Rubinstein (2024). *No Prices No Games!*. Cambridge, UK: Open Book Publishers. DOI https://doi.org/10.11647/OBP.0404.

S. Rosen (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, 82 (January/February issue), 34–55.

A. Rubinstein and A. Wolinsky (1985). Equilibrium in a Market with Sequential Bargaining. *Econometrica*, 53, 1133-1150.

A. Rubinstein and A. Wolinsky (1990). Decentralized Trading, Strategic Behaviour and the Walrasian Outcome. *Review of Economic Studies*, 57, 63-78.

S. Sekhri and A. Storeygard (2014). The Impact of Climate Variability on Crimes Against Women: Dowry Deaths in India. *Journal of Development Economics*, 111, 212–223.

R. Selten (1978). The Chain Store Paradox. *Theory and Decision*, 9, 127–159.

S. Srinivasan and A.S. Bedi (2007). Domestic Violence and Dowry: Evidence from a South Indian Village. *World Development*, 35(5), 857–880.

J.E. Stiglitz and A. Weiss (1981). Credit Rationing in Markets with Imperfect Information. *American Economic Review*, 71(3), 393–410.

H.V. Tauchen, A.D. Witte and S.K. Long (1991). Domestic Violence: A Nonrandom Affair. *International Economic Review*, 32, 491–511.

M. Tertilt, M. Doepke, A. Hannusch and L. Montenbruck (2022). The Economics of Women's Rights. *Journal of European Economic Association*, 20(6), 2271–2316.

D.R. Vincent (1995). Bidding Off the Wall: Why Reserve Prices May Be Kept Secret. *Journal of Economic Theory*, 65(2), 575–584.

J. Zhang and W. Chan (1999). Dowry and Wife's Welfare: A Theoretical and Empirical Analysis. *Journal of Political Economy*, 107, 786–808.