

**‘ARRANGED’ MARRIAGE, EDUCATION, AND DOWRY: A  
CONTRACT-THEORETIC PERSPECTIVE**

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This paper propounds a contract-theoretic model that addresses the empirically observed conundrum of increased education of the groom being associated with increased dowry transactions. Unlike the human capital approach, we impart a signaling role to education whereby education signals unobservable qualities of the groom that are valuable to the bride. In ‘arranged’ marriage settings that are characterized by incomplete information in the sense that the true quality of the groom remains unobservable to the bride, and in the presence of observable traits like education that are easier for the better quality groom to achieve, education-dowry contracts can potentially serve as a screening instrument to differentiate grooms of varying qualities. In equilibrium, different types of grooms select different education-dowry contracts, with better types being associated with both higher education and higher dowry. Hence the model has interesting and important policy implications since it means that increased public expenditure on education may actually be forcing dowry levels to rise. The paper also discusses historical and narrative evidences in support of its main hypotheses.

*Keywords:* ‘Arranged’ Marriage, Dowry, Dowry Inflation, Dowry and Education, Dowry as a Screening Device, Dowry as a Signal of the Quality of the Groom

*JEL Classification:* J12, J16, D10

1. INTRODUCTION: BACKGROUND

*Dowry is characterised by asymmetry, uncertainty and unpredictability (Srinivas, 1989).*

This paper provides a framework to explore interconnections among “arranged” marriage, education, and dowry essentially in an incomplete information setting. The hypothesis is that when the quality of the groom is not directly observable, then education level of the groom as well as dowry transacted at the time of marriage, help to screen grooms of different qualities. In equilibrium, different types of grooms select different education-dowry contracts, with higher/better types being associated with both

higher education and higher dowry. Hence by imparting to education an Arrow-Spence-Stiglitz (Arrow, 1973; Spence, 1973; Stiglitz, 1975) kind of screening role, we are able to explain the perverse (positive) relation between education and dowry (which the human capital approach to education, for example, could not, see discussion below). This also has serious policy implications since greater public expenditure on education may then actually exacerbate dowry inflation instead of mitigating the problem, as expected according to the human capital approach. Before we explain the mechanism of the model, we first briefly describe the concepts of ‘arranged’ marriage, education and dowry, especially in the context of our model.

There are broadly two main types of marriage arrangements – “love” marriages that dominate Western nations such as the United States and those in Europe and “arranged” marriages which are dominant in many parts of Asia and Africa (see Penn, 2011 for example). In the former, partners are chosen by each other and relationships are sustained with notions of romantic love culminating in marriage. An arranged marriage on the other hand, is one where parents (rather than prospective spouses themselves) choose marital partners. Arranged marriages so defined remain typical for large parts of the world like India, Pakistan, and Bangladesh (see Myers *et al.*, 2005).

By the very nature of the procedure, information transmitted between the marital parties about each other is necessarily limited in an arranged marriage setting, relative to love matches where the potential spouses get to mix freely with each other.<sup>1</sup> Narayan (1993) aptly speaks of arranged marriages as follows:<sup>2</sup>

*More and more, parents entrust the lives and safety of their daughters to families they know very little about; they can gain no information or assurance from common acquaintances, and they will not be close by to look out for their daughters’ welfare. Parents experience the marriage of their daughter as “losing” her to another family....*

<sup>1</sup> For example, as Chanana (1998) writes, Punjabi women who got married around 1947 (the year of Indian independence) “did not even ‘see’ their spouses before marriage nor did their spouses see them. Quite a few were betrothed when they were just a few years old....” In fact, according to reports in the popular press, many families approach detective agencies when proceeding with a match. One agency says the following: “The family that approaches us either has a specific doubt about the other party that they need us to investigate, or ask us to do a routine check”, where a ‘routine check’ involves looking into the “family’s background, financial stability, past marriages, drinking and smoking habits, past affairs, even over-involved siblings...”. One detective said, “Money is important, but since the families can easily check that out by themselves, they come to us for things like character and reputation” (The Indian Express, 2014).

<sup>2</sup> As noted by Narayan (1993), arranged marriages are mostly same caste marriages (very few arranged marriages are likely to be intercaste). But finding same-caste partners is especially complicated in modernized settings where potential same-caste partners are scattered in distant urban areas, so that resultant marriages imply brides becoming geographically distant from natal families, and thereby losing the safety net that her nearby kins and relatives could have provided.

In the Western world, usually men and women can mix freely and date each other before selecting their partners (for instance, see Penn, 2011 for an account in Western Europe). In fact, they can even live together before marrying their partners. Hence information regarding each other is likely to be much more accurate than in many societies where such free mixing is eschewed.<sup>3</sup> In contrast to such liberal practices as in the West, stringent social norms in many other parts of the world, allow only 'arranged' marriages where families of the potential bride and the groom meet each other and the marriage.<sup>4</sup> Naturally the amount of information that can be gathered about the potential bride/groom is substantially small compared to when couples can meet each other.<sup>5</sup>

Moreover, social pressure is such that marriages are hard to break (see Pothan, 1989 for example). Hence once married the couple is expected to stay together irrespective of how the match turns out to be.<sup>6</sup> Hence a spouse, once chosen, remains a life-long partner.<sup>7</sup> With virilocality, this means the bride/bridal family makes a decision with quite limited information that is going to affect her for the rest of her life (it affects the groom as well but since the bride goes to live with her in-laws she is likely to be more concerned with the decision). Hence it is crucial for the bridal family to extract as much information as possible from observable traits of the groom before taking marriage decisions.

Such conservative societies practicing arranged marriages are also often characterized by dowry payments (described later) at the time of marriage. The co-existence of arranged marriages and dowry has been noted by other scholar as well (see Narayan, 1993; Anderson, 2007 for example) but the exact mechanism as to why

<sup>3</sup> Hence, as argued later, there is no role of such instruments like dowry as an information extracting device, since informational bottlenecks don't exist in the first place.

<sup>4</sup> See Blood (1967) for an account of such marriages in Japan, Xiaohe and Whyte (1990) for an account in China, Fox (1975) for an account in Ankara, Turkey, and Sam (2009) for an account of Nigerians in the USA, to name a few studies.

<sup>5</sup> Note that in such societies, marriage is usually considered a bonding between two families rather than two individuals (see Fox, 1975; Blood, 1967, for instance) and hence a lot of information is collected about the background of the family and so on, but not on the individual potential spouse per se. At times again, information collected about a potential partner was not communicated to the would-be affine. For example, writing about marriages among Chanana (1998) says, "Within the parameters of caste and gotra, information about the future affines and acquaintance with them, direct or indirect, was very crucial in the settling of marriage alliances." As an illustration, she further refers to a woman who "was not even told that her future spouse was a widower with a daughter."

<sup>6</sup> For example, as Pothan (1989) points out, the phenomenon of divorce actually did not exist in the Hindu institution of marriage (Hindus constitute more than 80% of the population of India and hence are a majority). According to Hinduism, husband and wife are bound to each other not only in this world but also after death in the other world.

<sup>7</sup> This is especially true in societies which are monogamous (men usually have one wife) and where divorce is rare (as in dowry-paying societies like India).

this is so is not elucidated.<sup>8</sup> This paper argues that dowry, in such societies where marriage involves considerable incomplete information, acts as a screening device.<sup>9</sup>

Education is almost universally perceived to be associated with values.<sup>10</sup> In fact, Jeffrey *et al.* (2004) elucidate as to why this might be true. In their study of Dalit (ex-untouchables) and Muslim young men of Uttar Pradesh, an Indian state, they note that the first thing that sets educated men apart from their uneducated counterparts is speech. They say,

*... educated people speak politely in clipped, rounded, and correctly punctuated Hindi, while illiterates utter sentences strewn with aggression, expletives, and inappropriate familiarity.*

Not just in speech, but also manners, and morality, education seems to imbue in young men a kind of refinement and composure that ought to be appealing. Briefly therefore, education inculcates a form of cultural distinction that is both valued and desirable. (Please see further details in Section 4.)

Higher education is also often associated with higher dowry. The most common explanation for why higher education of the groom leads to higher dowry is that competition among brides for a particular groom leads to offers of higher and higher dowries, not unlike bidding in auctions, leading to overall increase in dowry payments. Here of course, the question then is that why are more educated men more in demand than their less educated counterparts. This could be because more education is

<sup>8</sup> Narayan (1993) has observed the co-existence of arranged marriages and dowry and has in fact recommended marriages based on “romantic love” as a strategy to improve the position of women. But her contention is mainly that modernization has aggravated the plight of women under arranged marriages, and she explains this by referring to dowry and its associated problems (along with problems of nuclear families, for instance). For example, in the modern world the components of dowry has changed - while previously it consisted mainly of jewellery and cooking vessels which mainly remained the property of the bride, with modernization there is increasing demand for cash and expensive consumer durables, which impose greater costs on the bride's family. Hence, she really does not relate arranged marriage and dowry causally.

<sup>9</sup> Note that many arranged marriages are consanguineous (spouses belong to the same family) where even though the marriage is arranged in the sense of families deciding on the match, there is unlikely to be dearth of information regarding potential spouses since they belong to the same family. This theory does not apply to such situations (like in many Muslim marriages (see Fox, 1975, for example, where in fact we know dowry to be non-existent or very small). Hence, to be precise, this theory is about arranged non-consanguineous marriages.

<sup>10</sup> As Silcock and Duncan (2001) succinctly put it “values learning is, arguably, the core of formal education”. In fact, Halliday (1996) argues that this is true irrespective of the kind of education in question. He says, “Practices such as plumbing, joinery, and hairdressing are value laden as, more obviously, are other practices such as literary criticism or feminist pedagogy. ... All practices are evaluative and an induction into any practice is bound to be a form of values education.”

associated with higher earnings.<sup>11</sup> But in fact, it has been seen that dowry levels are high with high education, even if earnings are not high. This is especially true in countries like India where there is a large pool of 'educated' unemployed and underemployed young men (Jeffrey *et al.*, 2004). So it seems that what is in demand really is just education as an end in itself, not as a means.

In short therefore education embodies composure, good manners in speech and deed and morality, all very valuable qualities and predictably very desirable in a potential life partner.<sup>12</sup>

Marriages in India are characterized by payments of dowries of huge amounts which broadly connotes a transfer of wealth made by the family of the bride to that of the groom at the time of marriage (see Anderson, 2007; Botticini and Siow, 2003; Caplan, 1984; Waheed, 2009 for example). In recent times, an unprecedented rise in overall dowry levels (see Rao, 1993a, 1993b; Anderson, 2003 for example) has been documented.

Several explanations have been put forward to explain the existence and inflation of dowry. Marriage payments arise in Becker's model of assortative matching (see Becker, 1973, 1974 for a seminal work on economic modelling of marriages) as a result of inflexibility in division of joint product of a marriage. Botticini and Siow (2003) explore the link between virilocality (where married daughters leave their parental homes and stay with the husband and the in-laws) and dowry. Zhang and Chan (1999) propound

<sup>11</sup> Higher education leads to greater income but the question 'why exactly' has generated a lot of debate, especially among the 'human capital' school (which said that individuals invest in human capital, such as schooling, because human capital makes a person more productive and this gain in productivity is rejected in higher incomes in future, see Machin, 2008, for example) and the proponents of the screening hypothesis (Arrow, 1973; Stiglitz, 1975). In words of Layard and Psacharopoulos (1974), the screening hypothesis says that "the earnings differentials associated with education do not mainly reflect improvements in individual productive capacity caused by education but, rather, employers' use of education to identify preexisting differences in talents." Hence, as they put it, "the question is not whether education explains earnings, but why it does". In words of Stiglitz (1975), a strong proponent of the screening theory, "the reason that the school system is the major screening institution in our society is that this information is a natural by-product of its principal activity of providing knowledge (skills) and guiding individuals into the right occupations". Hence Stiglitz concludes that "it is hard to imagine an educational system which did not obtain some information about individuals". Predictably, this generated a spate of research on the validity of the screening hypothesis. In a series of empirical papers, the screening hypothesis of education has been put to test (see Riley, 1975; Psacharopoulos, 1979; Katz and Ziderman, 1980; Albrecht, 1981; Cohn *et al.*, 1987; Grubb 1993). The conclusion appears to be mixed.

<sup>12</sup> Similar to the dilemma inherent in the screening hypothesis, one knows that higher education is associated with a demonstrably better behavior but why exactly is not quite clear - whether education inculcates good behavior or whether those with already superior dispositions earn education, remains a valid and more of an empirical question. In our model, what is important is that education implies good behavior, irrespective of the mechanism.

dowry as a premortem bequest by altruistic parents for a daughter. (See section 2 for some details of these models.) However all these models are based in a complete information setting whereas marriages (especially arranged marriages) are almost always likely to be characterized by incomplete information since ex-ante the payoff of one or more parties is likely to be uncertain. The present paper is an attempt to fill in this gap.<sup>13</sup>

This paper propounds a contract theoretic model that rationalizes the existence and in action of dowry in ‘arranged’ marriage settings and highlights its role as an information extraction device, along with the level of educational attainment of the groom. At the macro level, our marriage market follows the standard economic theory, that is, it clears through positive assortative matching between the brides and grooms. The model hypothesizes the mechanism once a bride and a groom are matched. At that individual (couple) micro level, the theory propounds a hypothesis of dowry being used as a screening instrument.

Here we model dowry as a payment in a marriage setting characterized by informational asymmetry in which the potential bride does not know the true quality of the potential groom. Marriage here is modelled as a contract under incomplete information since the (potential) bride’s utility depends on the (potential) groom’s quality which is unknown to her. However though quality is not directly observable, the groom can earn characteristics that are directly observable like education which signals quality. In equilibrium, different types of grooms select different education-dowry contracts, with higher/better types being associated with both higher education and higher dowry. Brides (bride’s families) pay more dowry to a groom who has higher education because education stands for unobservable characteristics that are valuable to the bride. In other words, observable attainments (like education) signal unobservable traits that are important and hence dowry might arise as an endogenous payment device to screen for these hidden qualities in the groom. This paper simply tries to capture this idea.

In fact, such a characterization of dowry also helps to explain dowry inflation that is of-ten associated with increasing education of the grooms. It had often been expected that with increased education, dowry levels will fall (presumably because young educated men and women will cease to make/accept monetary transfers at the time of marriage)<sup>14</sup> and ultimately cease to exist (such an outcome is consistent with the models

<sup>13</sup> There is also a huge literature outside Economics that attempt to explain dowry. See Oldenburg (1993) for a thesis about dowry having its roots in colonialism.

<sup>14</sup> This result may follow for example, from the human capital explanation of education. A very general model capturing the basic idea might be as follows (I am indebted to Indraneel Dasgupta for providing me with the succinct expression of this thought): Consider a population of brides with measure unity, where bride  $i$  has an idiosyncratic willingness to pay  $w_i$  for an educated groom, but 0 for an uneducated groom. The distribution of  $w$  is given by some continuous distribution function  $F(w)$ , with support  $[0; W]$ . For high ( $H$ ) type grooms, whose proportion in the population is  $h$ , the cost of acquiring education is  $c < W$ ,

of Anderson (2003) or Botticini and Siow (2003), for example, see the discussion below). It has therefore, unfortunately, been a puzzle that increased education (especially of the groom) has conspicuously come to be associated with increased dowry transactions.<sup>15</sup>

Our model can explain this since higher education signals better quality and educational levels are rising (with governmental policies, for example). As such there is upward pressure on dowry since education and dowry have to move concomitantly in our model, to make screening possible (see Proposition 3).

The rest of the paper is organized as follows: in Section 2 some related literature is discussed; in Section 3, the theoretical model is provided; in Section 4, the model and

but for low ( $L$ ) type grooms, it is  $C > W$ . Notice that grooms are demarcated purely by their efficiency in acquiring education, and brides are assumed to value education for intrinsic reasons (e.g. greater earning potential), not because of any signaling function. Then, the demand for educated grooms at any dowry rate  $d$  is given by  $1 - F(d)$ . Let  $d^*$  be the dowry rate at which  $[1 - F(d^*) = h]$ , and suppose  $c < d^*$ . The unique equilibrium in a competitive marriage would involve a dowry  $d^*$  for educated grooms and 0 dowry for uneducated grooms. All  $H$  grooms will be educated and receive  $d^*$ , while all  $L$  grooms will be uneducated and receive 0 dowry. Brides with values of  $w$  between  $W$  and  $d$  will marry educated grooms, pay  $d$  and be strictly better off by doing so, compared to their marrying uneducated grooms and paying no dowry. The opposite is true for brides with willingness to pay between 0 and  $d^*$ . Now suppose that increased public expenditure on schools reduces the private cost of schooling to 0 for ALL boys, irrespective of their ability. Then the new equilibrium must involve ALL grooms acquiring education and (consequently) the dowry rate for educated grooms dropping to 0. Thus, dowry disappears with education.

<sup>15</sup> This dilemma between more education and more dowry is well brought out in the following words of Mahatma Gandhi. He wrote in *Young India* (1928) “Any young man who makes dowry a condition of marriage discredits his education and his country and dishonours womankind”. In the same year, Mahatma Gandhi explicitly wrote that change could only be brought about by the educated youth. Hence implicitly, the Mahatma must have believed that the remedy for the social malady dowry, lies in better education for all. Reality has proven to be quite the contrary. As far as women's education is concerned, research shows that monetary transfers from brides and their families to grooms and their families are not decreasing in bride's schooling (see Dalmia, 2004 and Dalmia and Lawrence, 2005). It seems counter-intuitive that women with more education have to pay a larger net dowry. One possible explanation could be that education of a bride serves as a good proxy of her household wealth, and hence both higher education and higher dowry are effects of household wealth, without necessarily being causally related to one another. And wealthier fathers pay higher dowries. So it seems that higher education of the brides means higher dowry. Hence dowry seems to increase with the education of both the bride and the groom. Dasgupta *et al.* (2011) provide an interesting alternative explanation - parents have incentives to make their married sons stay with them, chances of which dwindle the more educated the daughters-in-law are. Hence higher dowries arise to compensate for future separation of sons (and his family) from their parent's home. Moreover in arranged marriages, parents might actually want to choose less educated brides for their sons to safeguard against possible future partitioning of the household into nuclear families.

its implications are discussed; in Section 5, historical and narrative evidences are explored; Section 6 concludes.

## 2. RELATED LITERATURE

The paper broadly falls within the genre of theoretical economics literature that explores dowry. The model is specifically related to the literature on signaling/screening models, while the implications of the model draw support from several socio-anthropological and historical accounts.

Most of the literature on marriage payments in economics is built on the seminal work of Becker (1973, 1974) (see Anderson, 2007 for a discussion), where an efficient marriage market exhibits positive assortative mating (high-quality men are matched with high-quality women, and low-quality men are matched with low-quality women). If the rule of division of output within the marriage is inflexible,<sup>16</sup> so that the share of income of each spouse is not the same as under the market solution, then an up-front compensatory transfer will be made between the spouses (or the respective households) and efficiency will be restored. Thus, if the wife's share of family income is below her shadow price in the marriage market, then a brideprice will be paid by the groom's family to the bride or her family, and this transfer in reverse is a dowry. Rajaraman (1998) argues in a similar vein and in a more India-specific context that dowry reflects the economic worth of a woman and came into being when her economic contributions decreased.

Dowry is also often viewed as a pre-mortem inheritance to the daughter, which formally remains her property after marriage (Goody, 1973, 2000). Botticini and Siow (2003) models this idea. Their model starts with the observation that dowries occur primarily in virilocal societies (that is where married daughters leave their parental home and married sons do not). In this case, altruistic parents transfer dowries to daughters and bequests to sons to solve a free-riding problem between siblings.

Rao (1993) adapts Rosen's implicit market model and studies the determinants of dowry in South India. He finds that 'marriage-squeeze' (caused by population growth and hence causing a surplus of younger women) significantly leads to dowry increases. Again, Bloch and Rao (2002), study dowry-related violence but dowry in their model means not only the payment from the groom's side to the bride at the time of marriage but also transfers that the husband may demand from time to time after marriage (not fulfilling which may result in violence). The only variable that significantly affects dowry given at the time of marriage in their data is the 'marriage-squeeze' ratio.

Bloch *et al.* (2004) build a model where dowry is used to 'signal' the social status of

<sup>16</sup> This is likely to be the case since household commodities like housing and children, which are jointly consumed, are difficult to divide. Also legal restrictions, social norms, or an implicit imbalance of power within the household could restrict the efficient division of surplus.



the groom's family (and hence enhanced status of the bride's family by virtue to tying marital link with a good family) in the bride's village. They find that dowry payments increase significantly with land and schooling of the husband (whereas those of the bride are not that significant) which presumably indicate good quality of the groom. Hence they conclude that

*...brides' families signal their new social status by "displaying" high-quality husbands from other villages with more expensive celebrations.*

However, though their idea behind dowry seems to be one of signaling, the theoretical model underlying it is one of complete information and hence not quite compatible with the conclusions drawn from it. In fact their concluding remark aptly points at this shortcoming:

*...existing marriage market models based upon the assumption of complete information need to be extended to allow for imperfect and incomplete information that could result in different and empirically important prediction.*

The current paper can be seen to be filling in this gap. Here dowry is a payment for the unobserved qualities of the groom, based on observable traits like education.

Anderson (2003) links dowry inflation to castes. In this model, even if the modernization and the associated market shocks have caused a high caste groom to become poorer, it will have only minimal effect on the dowry that a lower caste bride is willing to give him, since hypergamy (marrying into higher castes) is very desirable. On one hand therefore, these payments act as a lower bound on the groom's dowry receipt. On the other hand, the high-income, high-caste grooms must see a relative increase in their payments. Thus average dowry payments increase. However the theoretical model that captures this intuition is based on complete information.

For example, in her theoretical model, quality of the groom as perceived by the bride is assumed to be a deterministic function of the caste difference between that of the groom and the bride and the earning of the groom. Moreover the function is increasing in both the arguments, which means (other than its implications about inter-caste marriages) that higher earning grooms are considered to be better quality, a possibility necessarily based on incomplete information but largely probable since higher earning must signal desirable post-marital living - either the comfort of material benefits or the psychological benefits of having a good husband, or both. (See Section 4 for more discussion.)

In general, most theories are quite agnostic as to causes of rising dowries (except for Anderson's model (2003) of hypergamy). Botticini and Siow (2003), for example, say, that though their model of virilocality and dowries which predict a decline of dowry with modernization does not contradict the case of India, they are agnostic as to what the correct model in case of India would be. They think that dowry in India is rising instead of falling perhaps because of the slow pace of urbanization.

The model proposed here is more contract theoretic in nature, where education and dowry together help to screen grooms of different qualities in arranged marriage setting.

### 3. THE MODEL

The model is essentially one of monopolistic screening.<sup>17</sup> Consider the following model: A potential bride and a potential groom are facing each other to tie possible marital alliance. The (would-be) groom can potentially be of two types (qualities), high,  $\theta_H$  or low,  $\theta_L$ . The (would-be) bride is willing to pay an amount of dowry  $d_H$  to a high-quality groom and an amount  $d_L$  to a low-quality groom, if type was known. But type is unobservable.

The groom can choose a level of education  $e \in [0, \infty]$  which is observable. Assume that the disutility incurred by the groom to acquire education depends on his type. Specifically, if he is type  $\theta_H$ , he is more suitable for acquiring education in which case his disutility associated with more education is less. If he is type  $\theta_L$  there is relatively greater disutility to acquire more education.

The bride's benefit function  $b(e, \theta)$  gives the amount of benefit she derives from being married to a type  $\theta$  groom with education level  $e$  (excluding dowry payments). Assume that  $b(\theta_H, e) \geq b(\theta_L, e)$ , and  $b_e(\theta, 0) = 0, b_e = (\theta, e) >$  and  $b_{ee}(\theta, 0) < 0, \forall e$ . Her net utility from marrying a type- $\theta$  person having  $e$  level of education and paying  $d$  amount of dowry is given by

$$u_b(d, e, \theta) = b(\theta, e) - d.$$

The groom is an expected utility maximizer with von Neumann-Morgenstern utility function  $u_g$  over dowry, education given type and we assume it has the following form (which is also widely used in the literature, see Mas-colell *et al.*, 1995 for example)

$$u_g(d, e, \theta) = v(d - g(e, \theta)).$$

The groom is assumed to be strictly risk-averse<sup>18</sup> with  $v''(\cdot) < 0$ . The function

<sup>17</sup> Following Akerlof's seminal work on the theory of lemons (1970), models of both competitive screening and monopolistic screening have been widely used in the analysis of different kinds of markets characterized by incomplete information. For example, competitive screening and signaling have been analyzed in markets like labor market (Spence, 1973; Arrow, 1973), insurance market (Rothschild and Stiglitz, 1976), discrimination (Arrow, 1972; Phelps, 1972), product markets (Salop, 1977). However, to the best of my knowledge such techniques have not yet been applied to the marriage market.

<sup>18</sup> Marriages have often been conceptualized as risky decisions, since, if the marriage materializes, the groom will have to bear the consequences of the alliance, practically forever, especially in conservative societies where break-ups are not usually an option.

$g(e, \theta)$  measures the disutility of acquiring education in monetary units and it satisfies the following properties:  $g(0, \theta) = 0, \forall \theta$ ;  $g_e(e, \theta) > 0, \forall e > 0, g_{ee}(e, \theta) > 0, \forall e$ ;  $g_\theta(e, \theta) < 0, \forall e > 0$ ;  $g_{e\theta}(e, \theta) < 0, \forall e > 0$ . These imply that both the total and the marginal cost of education is lower for high quality groom than it is for a lower quality groom. Graphically, the conditions imply that the indifference curves of the groom in the education-dowry plane exhibit single-crossing property.

If negotiations break down and marriage does not materialize then the groom gets utility  $\bar{u}$  (his reservation utility by not marrying for the moment).

Here we assume functional forms of the cost and benefit functions to derive closed-form solutions of the education and dowry levels. Let the benefit function of the bride, for any given  $\theta$  be  $b(e, \theta) = \theta(1 + \mu e)$  and hence the utility function of the bride is

$$u_b = \theta(1 + \mu e) - d.$$

Let the cost function of the groom for any given  $\theta$  be  $g(e, \theta) = e^2/e\theta$  and hence the utility function of the groom will be  $u_g = d - e^2/2\theta$ .

Let  $\lambda$  be the probability that the groom is good type,  $\theta_H$ . Hence he is type  $\theta_L$  with the remaining probability,  $1 - \lambda$ . (Proofs of all the propositions are relegated to the appendix.)

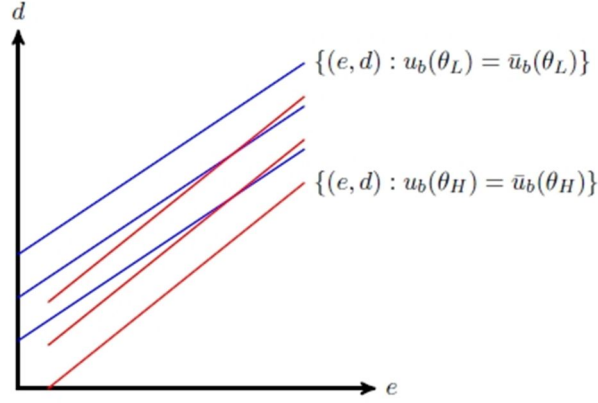
If the groom's type is observable, then for any given  $\theta$ , the bride solves the following problem.

$$\max_{e \geq 0, d \geq 0} \theta(1 + \mu e) - d, \quad \text{subject to} \quad d - e^2/2\theta \geq \bar{u}. \quad (1)$$

That is, the bride maximizes utility subject to non-negativity constraints on the amounts of dowry and education and the participation constraint (PC) of the groom. At the optimal, PC binds, and no groom will be given more than his reservation level. Hence FOC yields the following condition for every  $\theta$ .

$$e = \mu\theta^2. \quad (2)$$

The education and dowry levels in the first-best (full-observability) case are as summarized in the following proposition:



**Figure1.** Indifference Curves of the Bride

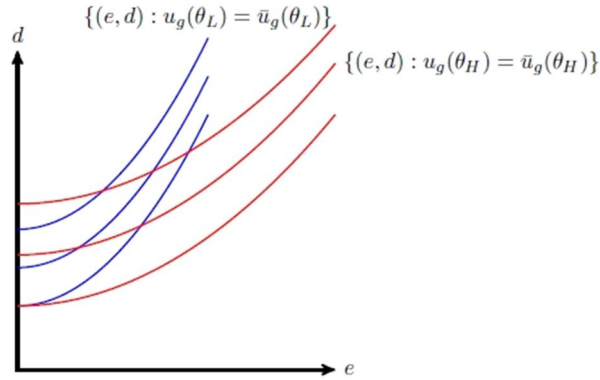
*Proposition 1:* When  $\theta$  is observable, the optimal marital contract  $[(e_H^*, d_H^*); (e_L^*, d_L^*)]$  takes the following form:  $e_H^* = \mu\theta_H^2$ ;  $d_H^* = \bar{u} + \mu^2\theta_H^3/2$ ;  $e_L^* = \mu\theta_L^2$ ;  $d_L^* = \bar{u} + \mu^2\theta_L^3/2$ . Moreover at these values, we have the following:  $e_L^* < e_H^*$ ;  $d_L^* < d_H^*$ ;  $u_g^*(\theta_H) = u_g^*(\theta_L)$  and  $u_b^* = \lambda\theta_H + (1 - \lambda) - \bar{u} + \lambda\mu^2\theta_H^3/2 + (1 - \lambda)\mu^2\theta_L^3/2$ .

The above proposition lays down the contract if the groom's type would be observable to the bride. Both education and dowry levels are higher the better the type of the groom is. As expected, the bride would be better off if the groom would be good type, even if dowry payable is higher. Since the type is not known, the bride receives an expected utility as given by  $u_b^*$ . The groom is equally well-off (at the reservation level) irrespective of his type. We have relegated the algebraic proof to the appendix but a graphical depiction of the situation will be helpful and is as follows.

The indifference curves of the bride (refer to Figure 1) are straight lines (each  $\bar{u}_b$ -level curve being given by the equation  $d = \theta(1 + \mu e) - \bar{u}_b$ ) with slope  $\theta\mu$  and hence are steeper (slope is higher) for  $\theta_H$  relative to the slope for  $\theta_L$  as shown in Figure 1 (the color scheme is such that all curves in blue pertain to those when state is  $\theta_L$  while those in red pertain to the state  $\theta_H$ ). The preference direction in each state is to the south-east corresponding to higher education and lower dowry.

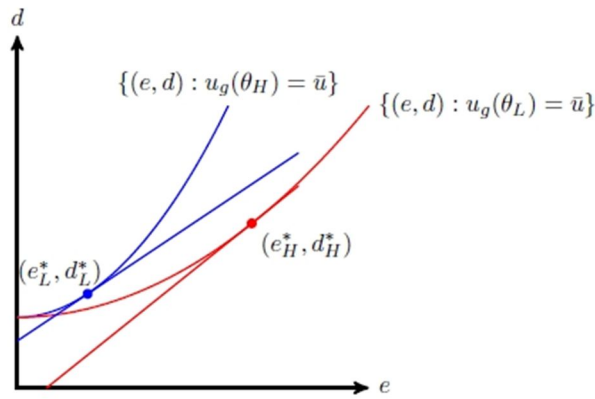
The indifference curves for the groom (refer to Figure 2) are parabolas with the slope of the parabola being higher (the parabola is steeper) for  $\theta_L$  relative to the slope for  $\theta_H$  as shown in Figure 2. The preference direction of either type is to the north-west corresponding to lower education and higher dowry.

When  $\theta$  is observable, the bride offers the optimal  $(e, d)$  contract corresponding to that particular state which occurs at the point of tangency between the straight line objective function of the bride and the parabola constraint of the groom corresponding to the reservation utility level, for that particular state. These yield  $(e_L^*, d_L^*)$  as the optimal



**Figure 2.** Indifference Curves of the Groom

contract in  $\theta_L$  state (the blue point) and  $(e_H^*, d_H^*)$  in the  $\theta_H$  state (the red point), as shown in Figure 3. It can also be verified that the bride is better off in the  $\theta_H$  state. The above levels lay down the first-best outcomes corresponding to full-observability. In reality however, the state is unobservable and we turn to the problem of the bride in that case next.



**Figure 3.** Equilibrium when  $\theta$  is Observable

When  $\theta$  is unobservable, we invoke the revelation principle by which we restrict attention to  $(e, d)$  pairs corresponding to announcements of low and high type by the groom. Hence when the bride cannot observe the type of the groom, her problem becomes the following:

$$\max_{e_H \geq 0, d_H \geq 0, e_L \geq 0, d_L \geq 0} \lambda(\theta_H(1 + \mu e_H) - d_H) + (1 - \lambda)(\theta_L(1 + \mu e_L) - d_L), \quad (3)$$

subject to

$$d_H - e_H^2/2\theta_H \geq \bar{u} \quad (PC_H),$$

$$d_L - e_L^2/2\theta_L \geq \bar{u} \quad (PC_L),$$

$$d_H - e_H^2/2\theta_H \geq d_L - e_L^2/2\theta_H \quad (IC_H),$$

$$d_H - e_L^2/2\theta_L \geq d_H - e_H^2/2\theta_L \quad (IC_L),$$

where  $PC_H$  (respectively  $PC_L$ ) gives the participation constraint of the groom when he is type  $\theta_H$  (respectively  $\theta_L$ ), while  $IC_H$  (respectively  $IC_L$ ) gives the incentive compatibility constraint of the groom when he is type  $\theta_H$  (respectively  $\theta_L$ ). The following proposition summarizes the solution to the above problem.

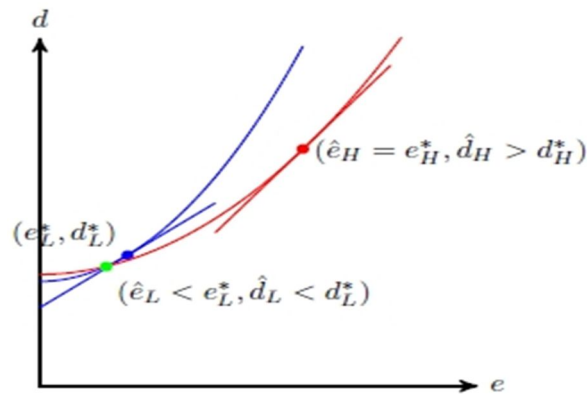
*Proposition 2. When  $\theta$  is unobservable, the optimal marital contract takes the following form:  $\hat{e}_H = \mu\theta_H^2$ ;  $\hat{d}_H = \bar{u} + \mu^2\theta_H^3/2 + \mu^2\theta_L^3\theta_H(1-\lambda)^2(\theta_H - \theta_L)/2(\theta_H - \lambda\theta_L)$ ;  $\hat{e}_L = \mu\theta_L^2[(\theta_H - \lambda\theta_H)/(\theta_H - \lambda\theta_L)]$ ;  $\hat{d}_L = \bar{u} + \mu^2\theta_L^3/2[(\theta_H - \lambda\theta_H)/(\theta_H - \lambda\theta_L)]^2$ . Moreover at these values, we have the following:  $\hat{e}_L < e_L^*$ ;  $\hat{d}_L < d_L^*$ ;  $\hat{e}_H = e_H^*$ ;  $\hat{d}_H > d_H^*$ ;  $\hat{u}_g(\theta_L) = u_g^*(\theta_L)$ ;  $\hat{u}_g(\theta_H) > u_g^*(\theta_H)$ , and  $\hat{u}_b = u_b^* - \mu^2\theta_L^3\lambda(1-\lambda)(\theta_H - \theta_L)/2(\theta_H - \lambda\theta_L)$ .*

Hence we see that compared to the case when type is observable, education choice by the high type remains the same but dowry payable rises. If the type is low, both education choice and dowry level fall. The groom is better off if he is high type (since dowry rises education remaining the same) but is equally well off if his type is actually low, as compared to his utility if his type would be observable to the bride. The bride is worse off for all groom types, and hence her expected utility falls from the first-best level.

Graphically we can represent the situation as in Figure 4. Notice first that the first-best contract  $[(e_H^*, d_H^*); (e_L^*, d_L^*)]$  cannot be offered since the high-type will want to announce the low state in order to get higher utility (when the state is  $\theta_H$ , the red parabola indifference curve through  $(e_L^*, d_L^*)$  gives higher utility to the groom than the first-best level  $\bar{u}$ ). In fact, the optimal contract involves a strictly lower  $e$  in the low-state, holding the groom at his reservation level in that state, which involves a lower dowry as well. In the high-state, the choice of  $e$  is at the first-best level, dowry is higher, and the groom gets more than his reservation level. In either state the indifference curve of the bride is lower and hence her expected utility falls from first-best levels. In Figure 4, the green point denotes such a contract if the low-state is announced while the red point denotes the contract in the high state (refer to MWG (1995) for details of a graphical analysis).

The above analysis shows how dowry is positively related to the education of the

groom and hence clarifies a dilemma that has been historically present in thoughts of great thinkers (like Mahatma Gandhi) as well as unanswered in the theoretical literature on dowry so far. Notice that with increasing education, such a positive correlation has only been strengthening.



**Figure 4.** Equilibrium when  $\theta$  is Unobservable

Hence next we show how in the above model, with increasing upward pressure on levels of minimum education (possibly due to governmental policy), this positive relation is further exacerbated.

Modernization has often witnessed large increases in education. The government, especially in developing countries like India, takes concerted measures to spread the reach of education to the nook and corner of the country.<sup>19</sup> Criticism about the efficiency of such programs abound, but that such programs have effectively reduced illiteracy, especially of the male child, is quite unambiguous. Commensurate with such spread, in our theoretical model, we just assume that government sets minimum education level at  $\bar{e}$ .

<sup>19</sup> Both primary education and higher education have tremendously increased in India. In the context of primary education, Rao et al. (2003) note that “enrolment rose from 19.3 million children in 1951 to 109 million primary school aged children in 610,763 primary schools in 1997... The number of schools and the enrolment ratio in India have steadily increased over the last five decades... Literacy rates in India climbed from 18 per cent in 1951 to 65 per cent in 2001 (GOI 2001).” Regarding higher education, Tilak and Varghese (1991) note that by the end of the 1980s, higher education in India has become one of the largest systems in the world, with about 10 million students enrolled in 188 universities and about 14 thousand colleges and with 400 thousand teachers. About 0.9% of GNP is invested in higher education every year. Nearly one-third of the total education budget goes for higher education with about one-twentieth of the total student population in the country.

Now if this  $\bar{e}$  is quite low, in particular, lower than  $\bar{e}_L$ , then the constraint is not binding for all practical purposes. Hence to make things interesting, let us assume that  $\bar{e} > \bar{e}_L$ , the equilibrium education choice of the groom when he is low type. Hence the problem of the bride becomes the following:

$$\max_{e_H \geq \bar{e}, d_H \geq 0, e_L \geq \bar{e}, d_L \geq 0} \lambda(\theta_H(1 + \mu e_H) - d_H) + (1 - \lambda)(\theta_L(1 + \mu e_L) - d_L), \quad (4)$$

subject to

$$d_H - e_H^2/2\theta_H \geq \bar{u} \quad (PC_H),$$

$$d_L - e_L^2/2\theta_L \geq \bar{u} \quad (PC_L),$$

$$d_H - e_H^2/2\theta_H \geq d_L - e_L^2/2\theta_L \quad (IC_H),$$

$$d_H - e_L^2/2\theta_L \geq d_H - e_H^2/2\theta_H \quad (IC_L).$$

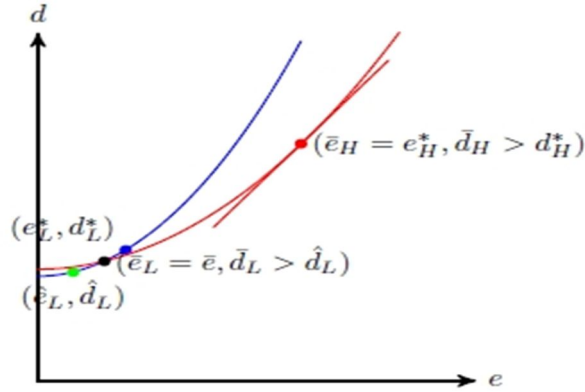
The following proposition summarizes the solution to the above problem.

*Proposition 3. When  $\theta$  is unobservable, and when the government imposes minimum education level  $\bar{e}$ , the optimal marital contract  $[(\bar{e}_H, \bar{d}_H); (\bar{e}_L, \bar{d}_L)]$  takes the following form:  $\bar{e}_H = \mu\theta_H^2$ ;  $\bar{e}_L = \bar{e}$ ;  $\bar{d}_H = \bar{u} + \mu^2\theta_H^3/2 + \bar{e}^2(\theta_H - \theta_L)/2\theta_H\theta_L$ ;  $\bar{d}_L = \bar{u} + \bar{e}^2/e\theta_L$ ;  $\bar{u}_g(\theta_L) = \bar{u}$ ;  $\bar{u}_g(\theta_H) = \bar{u} + \bar{e}^2(\theta_H - \theta_L)/2\theta_H\theta_L$ ;  $\bar{u}_b = \lambda\theta_H + (1 - \lambda)\theta_L - \bar{u} + \lambda\mu^2\theta_H^3/2 + (1 - \lambda)\theta_L\mu\bar{e} - \lambda\bar{e}^2(\theta_H - \theta_L)/2\theta_H\theta_L - (1 - \lambda)\bar{e}^2/2\theta_L$ . Moreover at these values, we have the following:  $\bar{e}_L < \hat{e}_L$ ;  $\bar{d}_L > \hat{d}_L$ ;  $\bar{e}_H = \hat{e}_H$ ;  $\bar{d}_H > \hat{d}_H$ ;  $\bar{u}_g(\theta_L) = \hat{u}_g(\theta_L)$ ;  $\bar{u}_g(\theta_H) > \hat{u}_g(\theta_H)$ ;  $\bar{u}_b < \hat{u}_b$ .*

Compared to the second-best (constrained Pareto optimal) situation, we see that the groom is equally well-off if he is low type but is better off if he is high type, the dowry increases in the high state but falls in the low state. The bride is worse-off.

Refer to Figure 5. Let for example, the minimum education level,  $\bar{e}$  be fixed at a point to the right of  $\hat{e}_L$ . Hence the solution to this new problem lies at the black point (to the right of the green point, denoting the second-best solution). Hence both education and dowry rises in the low state. The bride can actually be better off or worse off in this state compared to the second-best level. If, for example,  $\bar{e}$  is greater than  $\hat{e}_L$  but less than the  $e$  corresponding to where the indifference curve of the bride through the green point intersects the  $\bar{u}$  indifference curve of the groom, then the bride can be better off. But if  $\bar{e}$  is higher than that then she is worse off compared to the second best. In any case she is worse off in the high state and we can algebraically find that overall, her expected utility falls.





**Figure 5.** Equilibrium with Minimum Education Level

Hence the utility of the bride falls from the first-best to the second-best and then with government intervention. The groom of the low type gets the same utility in each case while the groom of the better type gets more and more utility. The level of dowry rises unambiguously in both states (and hence means increasing average dowry levels in the economy). The education level is increasing in the low state and is same in the high state which again means increasing average education levels in the economy.

What if such a provision of an  $(e, d)$  contract was not possible? Suppose that dowry as a payment did not exist. In that case, the bride's utility would be  $u_b = \theta(1 + \mu e)$  while the groom's would be  $u_g(\theta) = \bar{u}$ , some exogenously given parameter. In this case, expected utility of the bride is just  $\lambda\theta_H + (1 - \lambda)\mu\theta_L$ . Is it possible that her expected utility in this case is higher than what she gets in the first-best situation when such a contract is possible? This would mean that she would definitely be better-off compared to all the other situations (second-best and with government intervention, since the first-best gives her the maximum utility possible in the presence of an  $(e, d)$  contract). The finding is summarized in the following proposition.

*Proposition 4. In the absence of any  $(e, d)$  contract, the bride is better off compared to any situation when such a contract is present, only when  $\bar{e} > \lambda\mu^2\theta_H^3/2 + (1 - \lambda)\mu^2\theta_L^3/2$ .*

The inequality in the above proposition is likely to be true the lower are  $\lambda$ ,  $\mu$  and  $\theta$ 's, that is, the lower are the probability of the good type, the benefit from the groom's education and the level of the groom's quality, the better off she is likely to be in the absence of any  $(e, d)$  contract. This makes sense since the very purpose of an  $(e, d)$  contract is to select a groom of good quality, the lesser is such a quality and the associated benefits to the bride, the smaller is the purpose for such a contract to exist at all. Hence we can rationalize the absence of dowries in primitive population.

The inequality is also true when  $\bar{u}$  is large, that is the reservation utility by not marrying the particular bride in question, is large. This is likely to be true in societies with free mixing since the groom gets to see many other women and is also possibly true in societies practicing polygyny (where a man has more than one wife) so that again, the man has many other women to choose from. In such circumstances too, the bride maybe better off in the absence of such an education-dowry type contract. This may also help to explain absence of dowries among such societies (with free mixing and polygyny).

#### 4. DISCUSSION OF THE IMPLICATIONS OF THE MODEL

*'For instance,' I continued, 'there are really two ways in which a person may enter a room; one is in a controlled, dignified manner, the other is as if someone had just planted a heavy foot in your backside. Miss Dare has just shown us the second way; I'm quite sure she will now give us a demonstration of the first'. (Braithwaite, 1959)*

The following implications emerge from the above theoretical model: Jeffrey *et al.* (2004) in their ethnographic study of Dalit and Muslim young men of Uttar Pradesh, an Indian state, find that (formal) education (defined to be schooling of at least up to eighth class) invariably imparts an overall personal betterment to its recipients. For instance, educated young men

*... spoke of the capacity of education to instill good manners and refinement, and discretion and morality. Educated people saw themselves as representatives of culture and humanity distinct from illiterates...*

As a result, the general sense was that the illiterates (those lacking formal mainstream education) “not only lacked cultural capital but also acted in an immoral and irreligious manner.”

The gains from being educated was not just cultural, there were also practical benefits - they could read, write, make mathematical calculations and avoid cheats. They could in general be more assured, confident and independent in their day-to-day dealings with the outside world. Moreover, education was also associated with cleanliness of homes, personal hygiene, and attention to self-presentations. Overall, education helps young men secure a kind of sublime respect (*izzat*), quite distinct from the gauche dignity of high earnings. Hence the authors conclude,

*... educated-ness was not the product of conscious decision making, but had in-stead become part of... the habitus, in the sense of a structured set of dispositions inscribed in a person's reflexes, movement, and tastes.*

In short education is seen to provide a “scaffold” upon which many young men and

their parents display their ideas about knowledge, behaviour, morality and respect.

We see a resonance of this thought in a study of Norwegian college students by Solbrekke and Karseth (2006). They say,

*... embedded in the perspective of an expert there is an emphasis on ethical knowledge, moral and/or societal responsibility and the wish to do good for others.*

Popular evidence abound regarding brides and their parents holding education (denoted as  $e$  in the theoretical model), as signal of the actual unobservable quality of the groom (denoted by  $g$  in the model). In particular, the signal is believed to be monotonically increasing so that higher education tend to be associated with better quality,<sup>20</sup> which is consistent with the theoretical prediction where a better quality groom chooses a higher level of  $e$  (since his cost of achieving it is lower).

For example, Paul (1986), in his study of population residing in urban Delhi notes the following:

*Here every attempt is made to judge the match from every angle... For example, Brahmin parents would be searching not only the bridegroom from his caste but also a person having all the requisite modern qualifications like better education and better employment status, etc., so that they can get their daughter suitably married to a boy from higher and "better" section of society".*

Obviously, the sense is that whether a family is "better" can only be judged by other observable traits like education and employment. Hence all along, this sense that parents are concerned about the well-being and welfare of their daughters is discernible, and that they crave for highly educated, well-employed grooms, simply because they implicitly assume that such grooms, being of a superior quality, will keep their daughters happy after marriage.

Again, Bloch *et al.* (2004) conclude from their in-depth interviews and survey of villages in South India, that dowry is determined by "competition for scarce men and by the quality of grooms" (pg. 676). However, quality of the groom is not directly observable and hence predictably they find that dowry given is higher when the groom has more land and schooling (obviously used to proxy for quality).

Similarly, among Muslims in pre-independent India, illiterate grooms have been documented to physically torture their wives who are unable to meet dowry demands while the educated ones at least refrained from doing so (see Waheed, 2009), thereby signalling better quality.

The fact that higher dowry demands are made the more educated the groom is consistent with the finding in the theoretical model that higher  $e$  and higher  $d$  are associated with the better state  $\theta_H$ . Hence in equilibrium, a better quality groom

<sup>20</sup> Occasionally, the relation between type and signal is not monotonic (the best type signal least, Feltovich Harbaugh and To, 2002), but we do not consider such cases here.

chooses more education (or earning) and also is given more dowry.

Numerous instances can be cited where rising dowry levels have been associated with higher education of the grooms. For example, at the beginning of the 20th century, we find dowry rising with education levels of Christian grooms (Caplan, 1984). So a groom with a BA degree can secure more than a groom who has reached the intermediate level, who in turn can command more than one who is just a matriculate.<sup>21</sup>

Similarly, among the Muslims of India, more than caste, it seems educated grooms are more in demand among the Muslims of India. According to Waheed (2009),

*... an educated groom, rather than a groom from the kin group, appeared to have been preferred. ... It, therefore, resulted in more and more demand for educated grooms, on the one hand, and higher demands for dowry, on the other.*

In fact, such inflationary pressures have been exacerbated due to governmental policies spreading education and thereby increasing minimum levels of education as in the theoretical model.

Often higher education is sneered at because it has come to be associated with increasing dowry which is held a social evil. For example, it has been observed that education, instead of heralding change, is becoming a catalyst for perpetuation of dowry practices. Often historians observe that dowry is prevalent more among the 'new rich' and the educated sections, and thereby hold education to be the cause for such an outcome.

Our theoretical model in fact, supports just the contrary view, that is, dowry paid is higher with higher education, precisely because it reflects a better underlying quality which is valuable to the bride.

In fact, if education and earnings are used as a signal of quality and hence determining factors in dowry, then disappearance of dowry does not seem to be occurring any time soon.

Why dowries have not declined with modernization in India has baffled academic researchers and policy makers and practitioners alike. Botticini and Siow (2003), for example, predict that

<sup>21</sup> However, with the passage of time, and as in the theoretical model, education ceased to be the only observable trait that signals quality. In fact, gradually, a notional hierarchy of occupations, came to dictate dowry levels. So, for example, among upper-middle-class Protestants in Madras (modern Chennai), doctors, engineers and IAS (Indian Administrative Service) officers claimed the highest dowries, followed by lawyers, company executives and senior bureaucrats. Within each category again, there are finer distinctions like even among doctors, an MRCP/FRCP doctor (Member or Fellow of the Royal College of Physicians), is better than an MD (Doctor of Medicine) who in turn is better than an MBBS (Bachelor of Medicine and Surgery). Hierarchy in profession has also come to be replaced by ability to migrate to and settle in the West - a permit to work and settle in the US is considered very attractive and claims the highest dowry.

*... as urbanization proceeds and modernization takes place, the relative supply of educated grooms should increase and the urban-rural income differences should fall. Dowry inflation should eventually disappear.*

Unlike this prediction however, this theory predicts that since the purpose of higher dowry and higher education is to act as a signal of quality and help brides screen for different quality grooms, dowry inflation is unlikely to disappear. In fact, with modernization and urbanization, as education levels increase, it is likely to exert even more inflationary pressures on dowry, as is seen in current times.

Similarly, in Anderson's model (2003) dowry should begin to fall when endogamy breaks down, inter-caste marriages begin and there is sufficient overlap in incomes across castes. However, casual observation suggests that even with inter-caste marriages and equalization of incomes across castes, dowry has not begun to dwindle, rather there is across the board evidence of increase in dowry levels. The model in this paper can support such a finding since dowry here primarily reflects the quality of the groom, irrespective of his caste, and hence is not made irrelevant by marriages across castes.

In Europe, for example, according to Goody (2000, 1973) dowry declined by the nineteenth century and it was mainly driven by the industrial revolution. One also knows that in Europe modernization entailed more and more free mixing among men and women, including living together before marriage (Penn, 2011). There are also long periods of dating with each other. Hence the need to learn the quality of the groom before tying knots for the lifetime does not exist - in fact, partners have the chance to learn the quality of each other by mixing freely for as long as they want.

In fact, Narayan (1993) who explicitly connects dowry to arranged marriages prevalent in India hypothesizes that a possible remedy for the dowry malady lies in promoting love matches. She says,

*... such marriages [love matches/self-arranged marriages] may not require a dowry, making the occasion less burdensome to some families.*

However, why (or why not) self-arranged marriages will not entail dowry is not explicitly mentioned. From our model, we know that since information about each other is much better in a love match, information extraction device like the dowry may become redundant in such matches. And in case of arranged marriages, modernization presents instruments like education of the groom which act as a good signal and hence, along with associated dowry levels, help the bride infer hidden quality of the groom.

The model does not explicitly speak of brideprice but is consistent with the absence of dowry and to the extent some of these societies are characterized by brideprices, the model is not inconsistent with brideprices. According to the model, there is unlikely to be the system of dowry the lower is the uncertainty regarding the quality of potential groom, the lower is the quality of the groom in case that is known or can be inferred, and where the reservation utility of grooms is likely to be high.

Anderson (2007), while summarizing characteristics of brideprice paying societies notes that such societies are “often primitive, tribal and often nomadic societies” (quality of the groom is likely to be low), “relatively homogenous” (lower uncertainty regarding the quality of the groom) and “polygyny is practiced” (high reservation utility), along with the “possibility of divorce” (again implying high reservation utility of the groom). Moreover brideprices tend to be relatively uniform within societies that practice it with very few episodes of increasing brideprices while dowry is non-uniform and has episodes of increasing trends in real levels. In our theoretical model, since dowry serves the purpose of a screening instrument (along with education levels) it can easily explain different levels (depending on the level of  $\theta$ s in our model), and also why it increases (especially as education increases with modernization).

According to the theoretical model, the bride is worse off as education-dowry both increase (but the groom can be better off or worse off). This is borne out by numerous accounts of dowry-related predicaments ranging from harassment to physical torture to murders.<sup>22</sup> Brides are often physically tortured when promised dowry is not forthcoming (Bloch and Rao, 2002). According to the National Crime Bureau of the government of India, there are approximately 6,000 dowry deaths every year. Often dowry-related violence are never reported and hence not recorded but Menski (1998) estimates the number to be about 25,000 (see discussion in Anderson, 2007; Oldenburg, 1993).

## 5. HISTORICAL AND NARRATIVE EVIDENCE

The following can be said to be the salient implications of the above theoretical model: Dowry serves a screening purpose and hence is typical in arranged marriages (where there is likely to be lack of information); As the level of the observable signal (education) rises, so does dowry levels; We try to highlight these among the societies where dowry is still prevalent, namely India, Bangladesh and Pakistan (Anderson, 2007), with somewhat greater details in India.

Both arranged marriages and dowry have been documented to be widely prevalent in India. We first look at evidence in support of our model in ancient India. Most of the discussion on ancient India is based on Altekar (1959); Bhattacharjee (1994); Mitter (2006). They, in turn, have based their research on intense study of Hindu texts, canonical literatures, and their commentaries and their works are often considered the most authentic and impartial on the subject.<sup>23</sup>

<sup>22</sup> It is interesting to note in this context that, contrary to the bride's expectations, higher education can sometimes also lead to decreasing moral and ethical values (see Krishnan, 2008 in the context of MBA education) and hence can possibly exacerbate such a situation.

<sup>23</sup> Especially for the examples cited under Ancient India, the author has benefited immensely from discussions with Professor Rita Chattopadhyay, renowned Sanskrit scholar.

Ancient India. In the most ancient Rigvedic texts (approximately 1200 B.C. to 1000 B.C.), there is no reference to money or other forms of wealth changing hands between the bride and the bridegroom's sides. In fact, according to Bhattacharji (1994), renowned indologist and Vedic scholar, in the Rigvedic society both men and women chose their own partners and most importantly it was a free choice, not based on any kind of payment on either side. This corroborates the model's prediction of 'love' marriages not having any attached strings of monetary transactions. However, from around 8th century B.C. (from the time of the Taittiriya Samhita) there is evidence that the bride leaves her natal home along with gifts or dowry.<sup>24</sup> In fact, the practice of dowry has worked hand-in-glove with the change in marriage method, as 'love' marriages ceased to be in vogue.

To understand the implications of our model, it would be helpful to look at the types of marriages that were practised at that time. Marriages in ancient India have been categorized into eight types: (1) Bramha, (2) Daiva, (3) Prajapatya, (4) Arsha, (5) Asura, (6) Gandharva, (7) Rakshasa, (8) Paisacha.

The last four kinds of marriage was not approved in society while the first four were. Out of the unacceptable ones, the worst is the Paisacha form where the girl is physically over-whelmed and married. The Rakshasa form of marriage is essentially one where the bride is regarded as the prize of war so that the victor carried away the bride and married her. For example, in an episode of Mahabharata (a well-known Indian epic), when Subhadra falls in love with Arjuna, he carries her away and marries her (and justifies it saying that was the only option befitting a brave warrior of his stature), the resulting marriage belonging to this category.

In Asura form of marriage, a bride-price was paid by the husband to the bride's family. Such marriages were few and far between in the Hindu tradition and extremely looked down upon where the son-in-law was considered disreputable (since it amounted to the sale of the bride by her father). Gandharva marriages were love marriages where the parties fall in love with each other and immediately get united, without any prior religious rituals etc.

Now we come to the acceptable marriages. The least favoured among them was the Arsha marriage. In such a marriage, the father of the bride is allowed to accept certain gifts from the groom. This being reminiscent of Asura marriages and hence bride-price which was vehemently condemned by society, the Arsha form of marriage was also not well regarded. Again, Daiva marriage was essentially marriage to a priest.<sup>25</sup> But as

<sup>24</sup> Contrary to commonly held beliefs that the stridhana which the wife had was entirely her possession and hence in no sense, similar to dowry which symbolizes gifts etc. enjoyed by the husband and in-laws, Bhattacharjee (1994) holds that such a notion was only theoretical. The husband and his family could easily disburse her share of wealth at will and declare that it was used for her maintenance. And she could not effectively refute their arguments.

<sup>25</sup> During Vedic times up to about 4th century B.C., sacrifices were fairly common and they often lasted for several weeks. The sacrificer had to invite large number of priests to perform various duties in this

Vedic sacrifices dwindled, so did this marriage form.

The most regarded marriage form was a Brahma marriage. In Brahma and Prajapatya forms of marriage (which are not very different and many commentators actually have not differentiated them), the bridegroom is first selected by the bride's father, invited to their house, and the daughter is offered according to proper religious rites. The daughter was given ornaments and presents out of natural affection which was termed as stridhan.

Essentially, therefore, we can say, that the last four types of marriages (with the exception of Paisacha perhaps) conform to 'love' marriages in the sense that no parental selection of groom is obvious. On the other hand, the first four types of marriages (the ones approved by the Hindu Sastras and the society) are the ones where the bride's family/father selects and groom and supervises the entire marriage procedure and hence can be loosely termed as 'arranged' marriages. Our model would therefore imply that in instances of marriages of the first four category, there are monetary gifts etc. given to the groom and his family while for the last four kinds of marriages such presentations are not necessarily seen.

In fact, such a finding is validated in many instances that are recorded in the long history and tradition of the Indian Hindu society. For example, the marriage between Shakuntala and king Dushmanta in Kalidasa's famous play *Abhijnana Shakuntala*, is a well-known example of Gandharva marriage and we see no mention of any gifts accompanying Shakuntala when she goes to the king's palace. This play is actually an adaptation of an episode from Mahabharata, where too there is no mention of gifts of any kind at the marriage of Shakuntala and Dushmanta. Similarly in Mahabharata's *Adiparvan*, the marriage between Ruru and Pramadabara is a love marriage and again we don't see any monetary transaction taking place.

On the other hand, there are several instances of Brahma marriages where plenty of gifts are seen to accompany the bride. Again, to draw from Mahabharata, the marriage between Yayati and Devayani is an arranged marriage and we see plenty of presents being given at marriage.<sup>26</sup>

The other prediction of the model would be that grooms who are demonstrably better quality (in the ancient world that might mean those with greater skills at archery, etc.) would command higher gifts at the time of marriage. We find evidence of this too in the Mahabharata. In fact Mahabharata presents us with a unique case where there are two royal brothers Dhritarastra and Pandu of the Bharata dynasty, the ruling dynasty of Hastinapur. However, Dhritarastra happens to be blind.<sup>27</sup> Since Pandu therefore is better

connection. During this close and prolonged connection, he could be impressed by any priest and select him for his marriageable daughter (who could also influence such a choice). Such a marriage was called a Daiva marriage (since it was settled while a sacrifice to the Gods or Devas was being performed).

<sup>26</sup> As seen in Mahabharata, Devayani gets 2000 girls to serve her and her husband and enormous amounts of wealth.

<sup>27</sup> In those days of physical strength and prowess, blindness must have been a great handicap preventing



than Dhritarastra, according to the model, we should expect Pandu to get more dowry than his brother. This is exactly what we find - when Gandhari gets married to Dhritarashtra, she is just left with some clothes etc. (even though she is a princess) while when Kunti gets married to Pandu, she is seen to bring in lavish gifts.

Our theoretical model also seems to be reinforced by dowry practices among the Christians in the city of Madras (modern Chennai). Following Caplan (1984), we will briefly look at the heterogeneous group that Christians form. Christians in South India have mainly sprung from ritually low Hindu groups, but because of their access to mission education were able to gain qualifications far beyond those normally reached by the Hindu groups. Gradually these Christians begun to compete for several high status occupations and positions as and when they became available. Thus a significant Protestant upper-middle-class core was formed in the city to add to the existing Christian elites of the city (mainly intellectuals, theologians and university teachers centred on the Madras Christian college).

Within this group again, there were two sub-classes - some Protestants had 'castes' while some did not - to understand this one has to consider the arrival of western missionaries in south India and the process of early conversions. Initially the western missionaries tried to convert Hindus of the highest castes (with the hope that the others will follow them) but having met with considerable failure, they turned their attention to the lowest rungs. The latter converted to Christianity in large numbers. In fact, approximately four-fifths of all Protestants entered the faith this way. Hence such large scale conversion patterns allowed these people from the same (pre-conversion) caste to reproduce themselves in endogamous circles and maintain their caste pedigree.

The few members of the high castes that converted did so individually and often defying their social and caste groups, thereby giving up their most intimate personal ties. Hence at the time of marriage it was hard for them to maintain caste boundaries and so most matches were across the boundaries of caste. Hence the elite portion of Protestant community consists of quite a number of such 'casteless' members. In other words, the elite Protestant community has two sub-classes, 'caste' households containing members of the same ('pre-conversion') caste and 'casteless' households with members not belonging to any one caste.

For 'caste' households, arranged marriages were mostly the norm, the primary concern during the search for matrimonial alliances being the 'caste' status of the potential affine, even though openly such a practice is mostly condemned and called 'unchristian'. For 'casteless' households, forging matrimonial ties is often difficult since many 'caste' Christians who are larger in numbers will not tie knots with them, and hence in terms of mere numbers, choices of a potential affine are much lower for 'casteless' Christians than 'caste' households. Moreover among the 'casteless' households, it is seen that about half the marriages are arranged by the elders while about half the couples choose their partners themselves.

the king to wage wars and in general be incapable of any physical feat or achievement.

Caplan (1984) then discusses dowry payments among these Christians - as is concomitant with the theoretical model, dowry payments exists among the 'caste' households of the Protestant middle-class (which practice arranged marriages) while is practically absent among the 'casteless' households (where love matches are predominant). He however ascribes this phenomenon to dowry being a 'societal fund' in case of 'caste' households and it not being so in case of 'casteless households. Nevertheless one can also interestingly decipher marriage patterns (and associated dowry payments) also being different among the two different sub-classes of Protestants (arranged marriages associated with dowry and love matches with no dowry).

Modernization has entailed increased migration of families, especially the male members, in search of education and jobs. As termed by Narayan (1993), this has resulted in 'caste dispersion', that is, geographic scattering of members of the same caste. As a result, marriages that were usually arranged within ones relatives like marriage with one's maternal uncle (Narayan, 1993) or among cousins (like Muslim marriages, Waheed, 2009) are increasingly decreasing.

According to Waheed (2009), the Muslim community in general, has shifted from brideprice to dowry and this has happened with increased marriages outside, not only one's kin group but also outside one's own biradari (hierarchical categories into which North Indian Muslims are divided). Traditionally, marriage within one's biradari was the preferred alliance, and this entailed minimised bargaining for dowry, but socio-economic changes crept in from the beginning of the 20th century. An educated groom, rather than a groom from the kin group (biradari) started being preferred. Again, the Partition had far-reaching consequences for Indian Muslims. Waheed writes:

*Families of Ashrafs (biradaris of the highest social status, such as Saiyads, Mughals, Pathans and Shaikhs), the educated intelligentsia, service personnel, doctors and lawyers migrated to Pakistan en masse from urban areas of the north and the Deccan.*

Large-scale migration of Muslims, especially the educated youth, had considerably changed patterns of marital alliances among higher-status groups and those of urban areas. Though a majority do prefer marriage within their own biradaris, yet a lack of eligible grooms means that often marriages are arranged within the class instead of the kin circle within a biradari. Waheed ascribes the change to 'the new symbols of status such as education, wealth and political power'. And dowries has also increased with these changes in marital patterns.

In summary, we see that marriages outside one's kin circle, have been accompanied by increasing levels of dowry among the Muslims of North India (see Munshi, 2012 for a slightly more elaborate treatment).

Chanana (1998) documents the custom of arranged marriages among the Sikhs in India while Penn (2011) studies the persistence of arranged marriages among the Sikhs in Britain. On the other hand, Jhutti (1998) elaborates on the composition of dowry among the Sikhs in Britain. Hence we see how arranged marriages and dowry go

hand-in-hand even among Asian communities settled in the Western nations where neither arranged marriages nor dowry is in vogue.

Our model is consistent with dowry practices in Bangladesh. As Rozario (1998) documents, dowry very much exists in Bangladesh (not only among Hindu families but also among Muslims and Christians residing in Bangladesh). Arranged marriage is usually the norm<sup>28</sup> and like the Muslims in India, once marriages started getting arranged outside one’s kin group (due to greater education of grooms, for example), the amounts of dowry also increased. Rozario (1998) writes,

*As some men began to take advantage of these new changes, acquiring education, wealth and new status, women began to pay a price for men’s success.*

Dowry practices in Pakistan are also consistent with the model’s predictions. According to Korson (1968), though cousin marriages are common among the Muslims, it is often the case that the bride and the groom haven’t seen each other till the marriage ceremony. Marriages can therefore be viewed as arranged, as the following quotation suggests,

*It is well known that Muslim marriages are arranged by the families of the principals, usually the fathers or other male representatives of the bride and groom, although sometimes the women in the family will take the lead in making the arrangements, which will in the last analysis, be approved by the father or other male head of the family. Such marriages serve the predominant interests of the families, not the romantic interests or inclinations of the couple.*

Moreover, not only does such marriages involve mehr or dower, paid by the groom to the bride, at the time of marriage or at a later time, but also payment of jahez or dowry, which seems to be escalating.

*It is not unusual for the father of the bride to find himself in straitened circumstances and resort to borrowing important sums to meet these obligations.*

## 6. CONCLUDING COMMENTS

How are ‘arranged’ marriages related to the practice of dowry? The present paper provides a contract-theoretic explanation of dowry based on arrangement of marriages in dotal (dowry giving) societies and proposes that it acts a screening device of different

<sup>28</sup> Rozario (1998) says, “...when the parents have given up trying to arrange a marriage for their daughters, the girls find partners for themselves in urban centres.”

quality grooms in the presence of observable traits that are easier for the better quality groom to achieve. Thus this is a theory of dowry in an incomplete information world as against other models of dowry which are set in complete information situations.

We see that such a view of dowry can explain why it is declining in many western countries (where marriages are fixed with much more information about potential spouses) but is on the rise in India (where arranged marriages make information extraction very important). Moreover, with increased education levels, the model explains how there is inflationary pressures on dowry as is seen in reality. Hence the model has interesting and important policy implications since it means that increased public expenditure on education may actually be forcing dowry levels to rise.

Needless to say there is a lot of scope for future research in this realm and this paper is a very humble beginning. For example, the model is a partial equilibrium one where we assume, the bride has all the bargaining power. In reality, since there is competition among brides to find high quality mates, our micro -model has to be embedded in the larger model for marriage market as a whole. That is, the “monopolistic screening” model has to be extended to a framework of “competitive screening” where the principals (brides) compete with each other to attract agents (grooms). Of course the problem with such models is existence problem (see the seminal works of Rothschild and Stiglitz, 1976, and Riley, 1975, for example). However, under some assumptions, there is likely to exist a competitive equilibrium in the marriage market.<sup>29</sup>

What the competitive equilibrium would look like would possibly depend on things like the sex ratio. The fewer girls there are, the more bargaining power the girls ought to have but in countries like India, Bangladesh and Pakistan though there are more boys than girls, girls do not seem to have such bargaining powers. This is probably true since there are not enough high quality boys to give one high quality mate to every girl. Then, the girls in fact do not have all the bargaining power: if marrying a high quality male gives higher utility, the girls will compete with each other, bidding up the dowry for high quality males until the girls are indifferent between marrying high quality and low quality male. Moreover education-dowry choices of different types of males must be incentive-compatible for each type (there is likely to be upward pressure on educational achievements to achieve separation).

The next step then would be to endogenize the number of boys and girls, assuming parents can choose. If the girls compete for high quality males, perhaps the expected payo from having a boy is greater than the expected payo from a girl. Then the sex ratio would change until there is equilibrium (resulting in a sex ratio with more males than females).

There is also lots of work to be done on the empirical front. For one, exactly what role education plays in terms of dowry transactions need to be explored. Some hold the view that educated grooms have higher earnings and hence families of brides are ready to pay more dowry (the supply side). Some hold that the grooms’ parents see it as a

<sup>29</sup> This is currently work under progress by the author.

chance to recuperate their investment in their son’s education and possibly use it to meet expenses for marriage of unmarried daughters (the demand side). However, as this paper shows, since higher education is associated with better values, it could just be a price paid for underlying quality (and hence serves a screening purpose). That is, higher education of the groom leads to higher dowry (this is more or less an empirically established fact), the question that needs to be empirically answered is why is it so.

## APPENDIX

### A1. Proof of Proposition 1

Refer to problem (1). Notice that the objective function is increasing in  $d$  and the participation constraint of the groom is decreasing in  $d$  for every  $\theta$ . Hence the bride will maximize utility by setting  $d$  to its minimum possible feasible level which is where the participation constraint binds. In other words, the constraint  $d - e^2/2\theta \geq \bar{u}$  holds with equality. Substituting  $d$  from the constraint into objective function, differentiating w.r.t.  $e$ , and setting it equal to 0, we get the optimal level of education in state as follows:

$$e_i^* = \mu\theta_i^2, \quad i = H, L.$$

From the participation constraint, we get optimal dowry level as follows:

$$d_i^* = \bar{u} + \frac{\mu^2\theta_i^3}{2}.$$

At these values, non-negativity of  $e$  and  $d$  hold for every  $\theta$  and moreover since  $\theta_H \geq \theta_L$ , both education and dowry are higher in state  $\theta_H$  than in state  $\theta_L$ . The groom is equally better off in both states with utility  $\bar{u}$ , that is  $\bar{u}_g^*(\theta_H) = u_g^*(\theta_L) = \bar{u}$ . The bride’s expected utility can be calculated to be

$$u_b^* = \lambda\theta_H + (1 - \lambda)\theta_L - \bar{u} + \frac{\lambda\mu^2\theta_H^3}{2} + \frac{(1-\lambda)\mu^2\theta_L^3}{2}.$$

### A2. Proof of Proposition 2

Refer to problem (2). We use Kuhn-Tucker (KT) conditions to find the solution to this constrained optimization problem. Firstly, we solve this problem with only PCL and ICH and then show that at this solution PCH and ICL holds. Let us rewrite problem (2) as follows:

$$\min \lambda[d_H - \theta_H(1 + \mu e_H)] + (1 - \lambda)[d_L - \theta_L(1 + \mu e_L)],$$

subject to

$$e_L \geq 0, \quad \mu_1,$$

$$d_L \geq 0, \quad \mu_2,$$

$$e_H \geq 0, \quad \mu_3,$$

$$d_H \geq 0, \quad \mu_4,$$

$$d_L - \frac{e_L^2}{2\theta_L} - \bar{u} \geq 0, \quad \gamma_1,$$

$$d_H - \frac{e_H^2}{2\theta_H} - d_L + \frac{e_L^2}{2\theta_H} \geq 0, \quad \gamma_2,$$

The variables on the right hand side refer to the Lagrange multipliers associated with the respective constraints. According to KT conditions, we get the following (by differentiating the objective function w.r.t. the variables and setting it equal to the derivatives of the constraints, multiplied by the Lagrange multipliers, see Mas-colell, *et al.* (1995)):

$$-(1 - \lambda)\theta_L\mu = \mu_1 - \gamma_1 \frac{e_L}{\theta_L} + \gamma_2 \frac{e_L}{\theta_H},$$

$$(1 - \lambda) = \mu_2 + \gamma_1 - \gamma_2,$$

$$\lambda\theta_H\mu = \mu_3 - \gamma_2 \frac{e_H}{\theta_H},$$

$$\lambda = \mu_4 + \gamma_2.$$

Complementary slackness (CS) conditions imply the following (we replace  $\mu_1, \dots, \mu_4$  from the above equations):

$$e_L \left[ -(1 - \lambda)\theta_L\mu + \eta \frac{e_L}{\theta_L} - \eta \frac{e_L}{\theta_H} \right] = 0,$$

$$d_L [(1 - \lambda) - \eta + \gamma_2] = 0,$$

$$e_H \left[ -\lambda\theta_H\mu + \gamma_2 \frac{e_H}{\theta_H} \right] = 0,$$

$$d_H [\lambda - \gamma_2] = 0,$$

$$\gamma_1 \left[ d_L - \gamma_2 \frac{e_L^2}{2\theta_L} \right] = 0,$$

$$\gamma_2 \left[ d_H - \frac{e_H^2}{2\theta_H} - d_L + \frac{e_L^2}{2\theta_L} \right] = 0.$$

Let the proposed solution be such that all the variables are ‘interior’, i.e.  $e_H > 0$ ,  $d_H > 0$ ,  $e_L > 0$ ,  $d_L > 0$ ,  $\gamma_2 > 0$ . Then from the CS conditions we get the optimal values of the choice variables as follows:

$$\hat{e}_H = \mu\theta_H^2,$$

$$\hat{e}_L = \mu\theta_L^2 \frac{(1-\lambda)\theta_H}{\theta_H - \lambda\theta_L},$$

$$\hat{d}_L = \bar{\mu} + \frac{\mu^2\theta_L^3(1-\lambda)^2\theta_H^2}{2(\theta_H - \lambda\theta_L)^2},$$

$$\hat{d}_H = \bar{\mu} + \frac{\mu^2\theta_H^3}{2} + \frac{\mu^2\theta_L^3(1-\lambda)^2\theta_H(\theta_H - \theta_L)}{2(\theta_H - \lambda\theta_L)^2}.$$

Notice that  $\hat{e}_H = e_H^*$  but since  $(1-\lambda)\theta_H/(\theta_H - \lambda\theta_L) < 1$ , we get  $\hat{e}_L < e_L^*$  and  $\hat{d}_L < d_L^*$ . Also, since  $\mu^2\theta_L^3(1-\lambda)^2\theta_H(\theta_H - \theta_L)/2(\theta_H - \lambda\theta_L)^2 > 0$ ,  $\hat{d}_H > d_H^*$ . Moreover, at these values, the utilities can be calculated to be the following.

$$\hat{u}_g(\theta_L) = \bar{u},$$

$$\hat{u}_g(\theta_H) = \bar{u} + \frac{\mu^2\theta_L^3(1-\lambda)^2\theta_H(\theta_H - \theta_L)}{2(\theta_H - \lambda\theta_L)^2},$$

$$\hat{u}_b = u_b^* - \frac{\mu^2\theta_L^3(1-\lambda)(\theta_H - \theta_L)}{2(\theta_H - \lambda\theta_L)^2}.$$

Compared to the first-best solutions, we get to deduce that  $\hat{u}_g(\theta_L) = u_g^*(\theta_L)$ ,  $\hat{u}_g(\theta_H) > u_g^*(\theta_H)$ , while  $\hat{u}_b < u_b^*$ .

### A 3. Proof of Proposition 3

Refer to problem (3). We use Kuhn-Tucker (KT) conditions to find the solution to this constrained optimization problem. As before, we solve this problem with only PCL and ICH and then show that at this solution PCH and ICL holds. Let us rewrite problem (3) as follows:

$$\min \lambda[d_H - \theta_H(1 + \mu e_H)] + (1 - \lambda)[d_L - \theta_L(1 + \mu e_L)],$$

subject to

$$e_L \geq \bar{e}, \quad \mu_1,$$

$$d_L \geq 0, \quad \mu_2,$$

$$e_H \geq \bar{e}, \quad \mu_3,$$

$$d_H \geq 0, \quad \mu_4,$$

$$d_L - \frac{e_L^2}{2\theta_L} - \bar{u} \geq 0, \quad \gamma_1,$$

$$d_H - \frac{e_H^2}{2\theta_H} - d_L + \frac{e_L^2}{2\theta_H} \geq 0, \quad \gamma_2,$$

Again, the variables on the right hand side refer to the Lagrange multipliers associated with the respective constraints. According to KT conditions, we get the following:

$$-(1 - \lambda)\theta_L\mu = \mu_1 - \gamma_1 \frac{e_L}{\theta_L} + \gamma_2 \frac{e_L}{\theta_H},$$

$$(1 - \lambda) = \mu_2 + \gamma_1 - \gamma_2,$$

$$\lambda\theta_H\mu = \mu_3 - \gamma_2 \frac{e_H}{\theta_H},$$

$$\lambda = \mu_4 + \gamma_2.$$

Complementary slackness (CS) conditions imply the following (we replace  $\mu_1, \dots, \mu_4$  from the above equations):

$$(e_L - \bar{e}) \left[ -(1 - \lambda)\theta_L\mu + \gamma_1 \frac{e_L}{\theta_L} \right] = 0,$$

$$d_L [(1 - \lambda) - \gamma_1 + \gamma_2] = 0,$$

$$(e_H - \bar{e}) \left[ -\lambda\theta_H\mu + \gamma_2 \frac{e_H}{\theta_H} \right] = 0,$$

$$d_H [\lambda - \gamma_2] = 0,$$

$$\gamma_1 \left[ d_L - \frac{e_L^2}{2\theta_L} - \bar{u} \right] = 0,$$

$$\gamma_2 \left[ d_H - \frac{e_H^2}{2\theta_H} - d_L + \frac{e_L^2}{2\theta_H} \right] = 0.$$



For  $\bar{e}$  to be a meaningful constraint, let us assume that  $\bar{e} > \hat{e}_L = \mu\theta_L^2(1-\lambda)\theta_H/(\theta_H - \lambda\theta_L)$  and hence let the proposed solution be such that at the optimum  $e_L = \bar{e}$ . Let all the other variables be ‘interior’, i.e.,  $e_H > 0$ ,  $d_H > 0$ ,  $e_L > 0$ ,  $d_L > 0$ ,  $\gamma_2 > 0$ . Then from the CS conditions we get the optimal values of the choice variables as follows:

$$\bar{e}_L = \mu\theta_H^2,$$

$$\bar{e}_L = \bar{e},$$

$$\bar{d}_L = \bar{u} + \frac{\bar{e}^2}{2\theta_L},$$

$$\bar{d}_H = \bar{u} + \frac{\mu^2\theta_H^3}{2} + \frac{\bar{e}^2(\theta_H - \theta_L)}{2\theta_H\theta_L}.$$

Compared to the solutions of (2), we can calculate that  $\bar{u}_g(\theta_L) = \hat{u}_g(\theta_L)$ ,  $\bar{u}_g(\theta_H) > \hat{u}_g(\theta_H)$ , while  $\bar{u}_b < \hat{u}_b$ .

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