Learning your Child's Price: Evidence from Anticipated Dowry Payments in Rural India

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Abstract

Dowry payments are generally thought of as representing a compensating transfer from the bride to the groom. But what does dowry compensate for? In many contexts where the practice of dowry is widespread, grooms are desired not only for their individual ability but also for their family characteristics (such as wealth and caste status). The distinction between individual and family characteristics has implications for the prevalence of dowry as well as the trend in dowry payments, but the existing literature is divided on the relative importance of these characteristics on the marriage market. We combine novel data and methodology to shed light on the distinct marriage-market relevant qualities of men and women, and on how these qualities are priced in terms of dowry.

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1 Introduction

The practice of dowry, generally defined as the transfer of assets and goods from the bride's to the groom's family at the time of marriage, is now a pervasive phenomenon in India despite having been declared illegal in 1961. The practice of dowry in India originated as a bequest from parents to their daughters, but it has gradually acquired the character of a price that brides pay to marry a groom (Caplan 1984, Srinivas 1984). Anderson (2007B) reports that dowry is being practiced in about 93% percent of Indian marriages, and has even replaced brideprice in many communities. Attention has been also drawn in the literature to a parallel phenomenon of dowry inflation that has resulted in dowry payments that are often several multiples of a household's annual income (for a discussion see, among others, Epstein 1973, Rajaram 1983, Caldwell et al. 1983, Billig 1992, Rao 1993a, 1993b, Sautman 2009, Edlund 2000 and 2006, Botticini and Siow 2003 and Anderson 2003 and 2007a, 2007b).

In Anderson (2004), the transformation of dowry from a bequest to a groom-price takes place when there is sufficient heterogeneity in quality among grooms. Relatedly, Anderson (2003) argues that the process of modernization increases the degree of heterogeneity in groom quality and that this increase puts upward pressure on groom-prices in a society such as India, where a groom's inherited caste status is an attribute that is highly valued by prospective brides who have lower inherited status.[1] Understanding how dowries paid and received relate to the individual characteristics of bride and groom and to the characteristics of their respective families may therefore be fundamental to explaining the phenomena of increasing dowry prevalence and dowry inflation.

While there has been a profusion of work on the correlates of dowry in India, the existing literature is divided on the relative importance of individual and household characteristics on the marriage market. Whereas Deolalikar and Rao (1998) and Rao (1993a, 1993b) find that the individual attributes in their data seem to play little role in determining dowry, Dalmia and Lawrence (2005) report that dowry appears to equalize differences in individual characteristics (we should however note that the two studies are not necessarily comparable, since they correspond to different regions and time periods).[2] Anthropological and demographic evidence also points to the importance of the individual attributes of the bridegroom and (according to some) to a lesser extent the attributes of the bride in determining the dowry (see, for example, Caplan 1984, Srinivas 1984, Caldwell et al. 1992).

We contribute to this literature by analyzing a unique dataset that we collected in three Indian villages in 2008. We asked households to indicate the maximum amount that they were willing to pay as dowry for each of their daughters, and the minimum amount they were willing

[1] Household characteristics of bride and groom may also matter to the extent that marriage fulfils a risk diversification objective, as argued by Rosenzweig and Stark (1989).

[2] In a slightly different context, Ambrus et al. (2008), using recall data of about 1,300 marriages from Bangladesh, find that a more educated groom receives a higher dowry (in contrast to the education of a bride, which appears to have no effect on the dowry). Arunachalam and Logan (2008) find, in a similar context, that both bride and groom's education relate in a positive manner to dowry.

to accept as dowry for each of their sons (hereafter, wherever the gender distinction is not essential, we will refer to these amounts as projected dowry or simply dowry). In addition, we elicited parents' beliefs of what each child would be able to earn if he/she were to complete each of a set of educational levels.

We combine these data with a novel empirical methodology to analyze the contribution to dowry of a child characteristic that we refer to as child quality. The essential idea is that the cross-sectional dispersion in projected dowry values for a cohort of children should increase over time as households learn about their children's latent quality. Further, concavity in the learning process implies that the cross-sectional dispersion should be a concave function of child age. This is exactly what we find in the data. This observation is then matched to a Bayesian learning model to obtain an estimate of the dowry price of the underlying quality, the parameters governing the learning process, and the proportion of variation in dowries that can be attributed to heterogeneity in individual quality.

This method of pricing quality by treating it as a latent characteristic presents an appealing alternative to existing studies that must contend with the simultaneity bias inherent in correlations between dowry and observable proxies of quality such as education which are jointly determined along with dowry and marriage. In addition, an advantage of using prospective dowries is that it avoids the recall bias that arises in retrospective dowry data. Because the dowry amounts we elicited are projections based on each household's forecast of what its child's quality will be at time of marriage, changes in projected dowry due to innovations in forecast quality correctly identify the price of quality, regardless of whether the quality forecast is correct or not (assuming however that households know the price of quality). As we discuss below, our results provide a nuanced picture of how dowry relates to individual qualities of bride and groom.

Our findings indicate that dowry values are not determined by household characteristics alone: child quality is a very significant determinant of dowry, as evidenced by the high dowry price of quality. Specifically, a one-standard-deviation increase in child quality changes projected dowry by as much as 60-70%. The estimated dowry "price" of quality is very similar for boys and girls, consistent with positive assortative matching on the basis of quality. The importance of male as well as female quality is in line with Dalmia and Lawrence's (2005) findings that schooling attainment matters for both boys as well as girls. As suggested by Dalmia and Lawrence (2005), there may be a shift in relative importance of individual and household characteristics on the marriage market, with the latter becoming less important over time, which would explain the discrepancy in results between their study and the studies of Rao (1993) and Deolalikar and Rao (1998) which are based on data pertaining to an earlier time period. Indeed, we find in our data that heterogeneity in child quality can explain at least 45- 65% of the variation in dowry.

Interestingly, although our estimates of the dowry price of quality are of comparable magnitude for boys and girls, quality itself appears to connote different things for boys and girls. We are able to distinguish between "high-level" and "low-level" quality: the former correlates with ability as captured by returns to higher education (i.e. college degree and above), while the latter correlates with ability as captured by returns to "lower" (below-college) education. We find that high-level quality is salient for boys, in the sense that parents learn about it as the child grows older, and this learning translates into revisions of projected dowry. However, parents do not appear to be learning about their sons' low-level quality, and it does not correlate with expected dowries. In contrast, only low-level quality is salient for girls - parents do not learn anything about a girl's high-level quality, and it does not seem to factor into dowry projections.

Our finding that high-level ability does not affect girls' dowries is also consistent with the findings of Behrman et al. (1999), who note that female literacy correlates with dowry value but schooling achievement by women beyond levels that enable literacy is not associated with enhanced value in the marriage market. This distinction between high- and low-level quality is congruent with the social context of rural India, where marriage usually curtails the education of women (for evidence on the relation between age at marriage and female education, see Field and Ambrus 2008 and Maertens 2011), who are thereafter restricted to domestic production. Low rates of female participation in the labor market may reflect social norms, poor labor market opportunities or low perceived returns to higher education (see Jensen 2010 and Nguyen 2008 for evidence that perceived returns to education in developing countries are often systematically lower than measured returns). But in addition, our finding that parents do not even seem to be learning about their daughter's high-level ability over time suggests that they (i.e. the parents) do not expend effort to discover the high-level ability of their daughter because they have no intention of providing her with higher education.

We also find suggestive evidence that high- and low-level quality are revealed at different rates. High-level quality (which is what matters for boys) does not begin revealing itself until the child enters school, whereas low-level quality (which matters for girls) starts becoming apparent at an earlier stage. While our data are not particularly suitable for testing the implications of differential learning rates, one may nonetheless speculate that if investments in children are driven by parents' perceptions of their quality, there is a potential for greater divergence in child investments (and measurable outcomes such as health, etc) at an early age in the case of girls (assuming that investments reinforce quality differences). In contrast, such differential investments may not manifest until a later age for boys, by which time the child has already had a chance to develop, possibly resulting in a lower extent of inequality among boys. We believe this is an intriguing hypothesis to pursue in future research.

The remainder of this article is structured as follows. The next section introduces the data and discusses some descriptive statistics. Section 3 presents some preliminary analysis of the dowry data. Section 4 outlines the learning model that will be mapped to the data; Section 5 discusses the econometric issues involved. Section 6 reports the results and section 7 concludes.

2 Data description

We collected data in three villages in South and West India in 2008: Dokur in the Telangana region in Andhra Pradesh, and Kalman and Shirapur in the Solapur district in Maharashtra. These three villages were selected in 1975 by the International Crop Research Institute of the Semi-Arid Tropics (ICRISAT) as part of their Village Level Studies (VLS) program to represent (albeit not statistically) the semi-arid tropics in India.[3] As a general matter, working with households who have been part of a sample for almost 40 years has the advantage that a bond of trust has been established between researchers and respondent, something which is conceivably of great importance when collecting data on activities such as giving and receiving dowry which are technically illegal**.** Moreover, because this is rural India and both enforcement as well as knowledge of the law are lacking, the respondents freely discussed the dowry payments that they had made and received, as well as those they planned to make and receive in the future.

To obtain information on financial transfers at the time of wedding, we resurveyed 339 ICRISAT-VLS households. Only one individual was interviewed in each household - the main decision maker with regard to the education of the individuals up to the age 25 years. In most cases this was the father of the children, but in some cases it was the mother, grandfather or uncle. In the remainder of this article we will refer to this decision maker as the "parent" of the child.

In this survey we included questions on household composition, income, wealth, employment, education, marriage related practices and social norms, as well as the respondents' sub-caste or *jati*. We have not attempted a detailed analysis of the data based on caste, due to the limited number of observations available.

Regarding the returns to education, we first elicited the minimum and maximum earnings the respondent thought the child would earn after finishing particular schooling milestones, for instance, 12^{th} standard. Then, we made three boxes, evenly distributed between this minimum and maximum and asked the respondent to use 20 stones (each stone representing a 5% probability) to form an earnings density function (see Delavande et al. 2011A/B on various methods to elicit beliefs in developing countries). This question was repeated for the various levels that the child still had ahead of him/her, and included 8^{th} standard, 10^{th} standard, 12^{th} standard, diploma, bachelor's degree, master's degree, engineering, and medical doctor degree.[4]

Among the individuals who were below the age of 25 (including those who had married and moved out and excluding those who had married in), we collected detailed data on marriage and dowry. Among the individuals who were married already, this included retrospective information on the kind of marriage (love versus arranged marriage), the spousal selection process, income, wealth and education of both families at the time of wedding, the various transfers made at the time of wedding, and the cost of the ceremony and remaining debts with regard to the wedding.

Among the individuals who were not yet married (again below the age of 25), we asked the parent the maximum amount he or she was willing to pay for dowry at the time of the wedding

[3]This ongoing program collects detailed household and plot level agricultural data among a sample of households in six villages in semi-arid India. The sample selected is representative for each village in terms of landholding size. For an overview of the ICRISAT-VLS program see Bantilan et al. (2006), Rao and Charyulu (2007), Singh et al. (1985) and Walker and Ryan (1990).

[4]Thus, for a child currently enrolled in 11^{th} standard, one was asked to predict the returns to completing 12^{th} standard, diploma, bachelors, engineering, medical doctor and masters, but not for 8^{th} or 10^{th} standard.

for each of the daughters and the minimum amount he or she was willing to accept for each of the sons.[5] In this article we analyze the latter data, i.e., the child-specific projected (i.e. anticipated) transfers at the time of wedding.

Note that as dowry is frequently given in the form of home-produced goods, jewelry, household appliances, and assets, such as a bicycle or three-wheeler or land, and often in several installments (Sautman 2009), the dowries elicited should be interpreted as the total value of these various goods and assets, including gifts and cash.

While we recognize the complexity of the various transfers that take place at wedding time (the bride's family offers gifts, assets, goods and cash to the groom's family and vice versa; both families transfer gifts, assets, goods and cash to the bride and groom; and both families contribute to the expenses of the wedding ceremony), our measure of projected dowry does not include the gifts transferred from the groom's family to the bride's family, or distinguish the *stridhan* component of the dowry from the price component of the dowry.[6] We are therefore measuring what Edlund (2006, 2009) refers to as "gross dowry", rather than "net dowry".[7] From the retrospective data, however, it appears that the median value of the gifts etc. transferred from the groom's family to the bride's family is only about 8% of the value of the amount spent by the bride's family. The *stridhan*, on the other hand, is a large component of the total amount spent by the parents of the bride (for the median household, *stridhan* is about 40% of gross dowry).[8] Qualitative interviews preceding the data collection however indicated that the gifts to the bride consist of clothes, gold and household appliances, and the latter are often used by the entire family-in-law.[9] This phenomenon, where the line between the *stridhan* and the price component of the dowry is blurred, has also been documented by anthropologists (see for instance, Miller 1981, den Uyl 2005). For this reason, we think treating the *stridhan* component separately from payments to the groom's family may not be justified.

[5]During the qualitative and trial round preceding the data collection, it appeared that the respondents were unable to answer the question: "how much do you expect to pay in terms of dowry", and responded in terms of how much they are willing to set aside (and/or borrow) in the case of girls, and for how much they were willing to "let their sons go" in the case of boys. Hence, the questions were rephrased to reflect this.

[6]Historically, dowry consisted of two components, the *stridhan,* which served as a pre-mortem bequest to the daughter, and hence defined as a transfer from the bride's natal family to the bride at the time of wedding, and the *dakshina,* defined as the transfers given directly to the family-in-law, as a way of compensating the groom's family for the economic support they had to provide their new family member (Srinivas 1996).

[7]Anthropologists and sociologists also traditionally focus on gross dowry (see Srinivas 1984 and Tambiah 1989).

[8]This is in contrast with what Ambrus et al. (2008) find in the Bangladeshi context where the dowry given from parents to the bride (which they call "bequest dowry") is small compared to the dowry given to the groom's household (which they call "gift dowry").

[9]Regression analysis of the retrospective data (results available on request) indicates that the *stridhan* appears to depend on whether or not the groom lives with his parents, consistent with the notion that *stridhan* has an element of price.

3 Preliminary analysis

3.1 Summary statistics and projected dowry

Table 1 introduces the sample villages. With a total number of households of 1,720 and a sample size of 339 households (a total of 1,876 individuals), the sampling rate is almost 20%. The average size of a household is 5.6 members, the average *kharif* income is 51,176 Rupees (about $1,280 at the time of the survey)[10], and the average education level of the respondent is low, 4.8 years.

The sample includes a total of 838 individuals under the age of 25 (recall that this excludes those who have married in and includes those who have married and moved out). Of these, 719 are unmarried: 429 boys and 290 girls. The difference between the number of boys versus girls in the unmarried sub-sample reflects in large part a difference in average age of marriage: girls typically get married earlier[11]. Correspondingly, we find that 85 out of the 119 married children under the age of 25 are girls.

The median projected dowry for both boys and girls is 50,000 Rs (about $1100 at the time of the survey). The average projected dowry for boys is 70,671 Rs and the average projected dowry for girls is 79,130 Rs. Comparing these numbers with the average *kharif* (or rainy season) income in Table 1, it is evident that these amounts are significant. It should be noted that these projected dowry statistics exclude the children with zero projected dowry[12] and the children for whom the parent could not answer the dowry question.[13]

Table 2 examines the correlates of projected dowry, using a regression of projected dowry on observed household characteristics. Household income, wealth, and the educational level of the decision maker are positively correlated with projected dowry, for both boys as well as girls. Interestingly, parents are willing to let their son go for a lower price if there are more unmarried boys in the family, while parents of girls are willing to pay less if there are more unmarried daughters in the family.

Figure 1 overlays the kernel density estimates of the projected dowry for boys and girls. Remarkably, the two distributions are practically identical (a Kolmogorov-Smirnov test cannot reject equality between the two distributions, with a p-value of 0.74). An intuitively obvious matching scheme would simply be to match households on the basis of their willingness to pay and accept dowry: that is to say, a household that is willing to pay no more than 5000 rupees for their daughter would be matched up with a household that is willing to accept no less than 5000

[10]The *kharif* season is the rainy season, and the main agricultural season in the semi-arid tropics of India.

[11]The (average) "socially acceptable" age of marriage (as reported by the households) is 18.3 years in the case of girls and 22.7 years in the case of boys.

[12]There are 38 boys and 8 girls for whom the respondent mentioned that they will not accept or give any dowry. As we mentioned earlier, the illegality of dowry came up not even once during the qualitative discussions preceding the data collection, so we are inclined to take these responses at face-value. Several of the respondents who told us that they would not accept dowry mentioned in the same breath that they were a "modern family" who would opt for a "registered marriage".

[13]Among the unmarried children, there are 45 boys and 12 girls for whom the respondent reported "don't know", or "it will depend" when asked about their dowry expectations. These children are excluded from the analysis. In terms of observable characteristics, there are few significant differences between this group of children and the rest of the sample.

rupees for their son. Figure 2 compares the kernel density of projected dowry for girls with the kernel density of the gross dowries that were actually paid by households of married girls (the dowries received by boys' households are not directly comparable with the projected dowry data for boys because the former do not contain the *stridhan* component). One can see that the distributions match up quite well in the lower values of dowry - a Kolmogorov-Smirnov test cannot reject equality between the two distributions, with a p-value of 0.25. The actual dowries are however not as skewed to the right - this is due to sample selection: the retrospective data only include dowries paid and received for children up to the age of 25, but the prospective sample includes children who will go on to complete higher education and get married at a later age for a higher dowry.[14]

In short, the dowry amounts elicited not only look reasonable but are also comparable to equilibrium payments.

3.2 The role of child quality

3.2.1 Projected dowry and learning

Figure 3 graphs (separately for boys and girls) the kernel density of the logarithm of projected dowry[15] for each of three age groups: pre-school (0-4 years),[16] kindergarten, primary and middle-school (5-14 years), and high school and above (15 years and upwards).[17] What is immediately apparent for boys is that the distribution of projected dowry is highly peaked for children who are in their pre-school years, but flattens significantly and spreads out thereafter. This phenomenon is strongly suggestive of a learning process, whereby new information that comes in over time improves households' forecasts of the quality of their children, thereby creating cross-sectional divergence in projected dowries. We also note that this phenomenon does not appear to extend to girls, although we must caution that at this point we have not controlled for confounding differences between households.

Before presenting some additional evidence in favor of the learning hypothesis, we briefly discuss here some alternative explanations for the cross-sectional divergence in dowry expectations with age. The first possibility is that the phenomenon is related to the dispersion of household characteristics. As we will show in Section 6, the dispersion in dowry predicted by differences in observable household characteristics has no relation to child age. A second possibility is that households are not really learning anything new, but that differences in child-specific investments cumulate over time to create a deterministic divergence in children's qual-

[14]Comparing, for instance, 18 year old girls who are married with 18 year old girls who are not married, it appears that the unmarried counterparts are more likely to belong to a higher caste, have a higher educated father, and come from wealthier families (these results are available on request).

[15]Because the dowry distribution appears to be log-normal, we have taken the logarithm of dowry. Normality will be an important element in the analysis in Section 4.

[16]We treat age 5 as the onset of school age. In the data about 38% of boys are in school at age 4 and about 53% of girls are in school at age 4, but these figures jump to 89% and 92% respectively at age 5.

[17]To re-iterate, our data were collected at a single point in time: we are therefore not comparing a cohort of children over time, but rather different age-cohorts of children.

ity. It is worth emphasizing at this point that what is being elicited is the household's forecast of the child's *future* (i.e. at time of marriage) dowry value. Presumably, this forecast takes into account future investments planned by the household. Thus, the evaluation of *current* quality may diverge in the cross-section in a deterministic way, but this by itself would not affect the distribution of forecasts of *future* quality.

One may also wonder about the role of uncertainty regarding the dowry price of quality: perhaps households only begin to find out about prices once their children start nearing marriageable age. However, this implies that (absent any innovations in child quality) the dispersion in price forecasts would be lower, rather than higher, for older children. Similarly, if households are adjusting their forecasts for inflation in the price of quality (i.e. the nominal price is lower for children who are close to marriageable age), this would also tend to reduce rather than increase dowry dispersion for older children.[18] In sum, it is difficult to explain the phenomenon of increasing dowry dispersion in terms of factors other than innovations in child quality.

3.2.2 Projected dowry and the perceived returns to education

Our data allow us to provide an additional confirmation of the learning hypothesis and to relate projected dowry to a measure of child quality. While we treat child quality as by and large unobservable (to us), we nonetheless have a rough correlate of quality in the form of the perceived returns to different levels of education that the households report for each of their children. Recall that the perceived returns were elicited for all children who were still in school, and for each of the levels of education that the child was yet to attain. In contrast with dowry projections, which were elicited as a single number for each child, the perceptions about educational returns were elicited as distributions. We can therefore test whether parents learn about the child's quality as the child grows older by examining whether the perceived distribution of returns is flatter (i.e. the variance of the perceived distribution is greater) for younger children.

Table 3 shows (separately for boys and girls) the results from household fixed-effects regressions of the variance in returns for each of the various levels of attainment on the age of the child. We are therefore estimating the following regressions:

$$v_{ijc} = \alpha_c + \beta_c Age_{ij} + \eta_{jc} + e_{ijc} \tag{1}$$

where v_{ijc} denotes the variance in perceived returns to completing education level c for child i in household j; Age denotes child i's age; η_j denotes a fixed-effect for household j and e_{ij} denotes an individual-specific error term. The coefficient β_c is expected to be negative if parents learn about the quality of their child as it pertains to the child's returns from completing education level c. Given that variance in perceived returns reflects not only uncertainty about child quality but also uncertainty about the average returns to education, one may worry that households that have older children may be better informed about the average returns to education

[18] Our sense from the interviews, however, is that households are not factoring inflation into their forecasts.

than households that have young children, which would also lead to a negative correlation between child age and variance in returns. To address this concern, we have restricted ourselves to within-household comparisons by including household fixed-effects in the regressions in (1).

The results in Table 3 tell an interesting story: In the case of girls, there is strong evidence that parents are learning about child quality as it pertains to the returns to completing 10th grade, but there is little evidence that they are learning about quality as it pertains to the returns to higher education i.e. from the college level onwards. Conversely, for boys, there is strong evidence that parents learn about quality as it pertains to the returns to getting a college degree, but there is little evidence that they are learning about quality as it pertains to the returns to lower education.

We think a possible interpretation of these results is that because parents are habituated to thinking of boys and girls as performing distinct adult roles, only that dimension of quality that is relevant to each of those roles is salient in their (i.e the parents') minds. In particular, women are traditionally confined to home production which requires a certain set of skills, while men are engaged in market production which calls for a different set of skills. For convenience, we descriptively label the associated aspects of quality as "high-level" and "low-level" quality: High-level quality is apparently more salient in the case of boys, while low-level quality is more salient in the case of girls. This raises a natural question: What is the relation between projected dowry values and these two kinds of quality? In particular, does projected dowry correlate with high-level quality in the case of boys and low-level quality in the case of girls?

To answer this question we first aggregate the returns for the various levels of attainment into two broader levels. Specifically, denote by r_{ic} the average return to completing educational level c for child i. We compute the average return to lower education by averaging r_{ic} over the various levels from 8th-grade to diploma: we denote this average return by r_{iL}. Similarly, we compute the average return to higher education by averaging r_{ic} over the levels from college degree upwards: we denote this average return by r_{iH}. Some households could not guess the returns to education for some levels and in addition, households were not asked to guess returns for educational levels that the child had already completed. To avoid averaging over returns to different sets of levels for different children, we only compute averages for children for whom returns were identified at all levels of higher and lower education. This results in smaller sample sizes in the following regressions.

Columns 1 and 2 in Table 4 report (separately for boys and girls) the results from a regression of projected dowry on r_{iH} and r_{iL}, controlling for household fixed effects. These are within-household estimations. For comparison, Columns 3 and 4 report the results of between-household regressions, controlling for the full set of household variables, i.e. we are estimating the regression:

$$d_j = \alpha + \beta_1 r_{jH} + \beta_2 r_{jL} + \gamma X_j + e_j$$

where d_j is the average projected dowry for children in household j; r_{jH} and r_{jL} are averages of r_{iH} and r_{iL} for children in household j and X_j is the vector of household variables.

The within-household estimations indicate no significant relation between educational returns and projected dowry in the case of boys, while in the case of girls, higher returns to lower education reduce projected dowry. The between-household results however indicate that in the case of boys, higher returns to higher education increase projected dowry (but returns to lower education do not matter), while in the case of girls, higher returns to lower education *increase* projected dowry (and returns to higher education do not matter). The inconsistencies between the two sets of results are puzzling.

However, the positive price of female quality from the between-household regression is in line with other studies that have found that dowry appears to increase with proxies of quality such as the girl's education (Dalmia and Lawrence 2005, Edlund 2006; see also Anderson 2004 for an explanation for why the equilibrium price of quality may indeed be positive for girls). While a positive dowry price of educational attainment in these studies may simply reflect statistical bias due to the simultaneity of marriage and educational choices, the problem of simultaneity should not arise in our data given that we are not looking at educational investments, but rather at beliefs about returns to education.

That the equilibrium price of quality for girls should be positive rather than negative makes intuitive sense, because if this were not the case (and the price were negative), then high-quality boys (who demand more dowry) could only be matched to low-quality girls (who would be willing to pay more). In accordance with Becker's (1973) model of marriage-market matching, such negative assortative matching would only be efficient if male and female inputs were substitutes. If, as is more likely in the Indian context where men and women perform distinct roles, male and female inputs are complementary in joint production, the efficient assignment should reflect positive assortative matching, i.e. the men who are most efficient in market production will be paired with the women who are most efficient in home production. This requires that a (perceived) increase in a girl's quality should increase her parents' willingness to pay in order to secure her a better match. If the perceived increase in quality is small, an envelope theorem result suggests that her parents are now also willing to pay more to the groom they originally had in mind - we explain this point a little more formally in Appendix A.

We believe (but are not able to prove) that the resolution of the conflicting results in Table 4 rests on the fact that the within-household comparison (i.e. using household fixed effects) of children is fundamentally different from the between-household comparison of children. In the case of girls, a given household may have a fixed wealth constraint and this wealth must be divided up to pay the dowries of all its daughters. If the household has a preference for achieving equality of outcomes for its daughters, it may choose to compensate a low-quality daughter with a higher dowry, resulting in a negative within-household price of quality. This hypothesis of parental concern for equality is consistent with the findings of Botticini (1999), who finds that in 15th century Tuscany, daughters who "married down" received a larger dowry from their parents.

Lastly, we should note that there is an issue of sample selection in the results in Table 4 because the returns data were not obtained for children of school-going age who had dropped out of school. The attrition from school begins early, as revealed in Figure 4 which graphs the fraction of children in school at each age. If the attrition is based only on educational returns (e.g. children with low expected returns dropping out of school), this should not create any selection bias in the results above. But if attrition is also influenced by unobservable household circumstances (such as credit constraints, etc), selection bias becomes an issue. The within-household regression is capable of removing the bias due to selection on unobservable household variables, but as we noted above, the within-household price of quality may be quite different from the between-household price of quality. For these reasons, we do not rely on the educational returns variables to estimate the dowry price of quality. In the following sections, we outline an estimation strategy that treats quality as unobservable and infers its price from the pattern of increase of cross-sectional dowry variance.

4 Modeling the evolution of dowry variance

We propose to use the evolution in dowry variance with age to estimate the price of child quality, the latter being defined as the change in willingness-to-pay (or accept in the case of boys) due to an increment in child quality. We will assume that the logarithm of the willingness to pay (accept) function, denoted by $g(\cdot)$, takes the following form:

$$g(\mathbf{x}_t^i, z_t^i) = f(\mathbf{x}_t^i) + pz_t^i \tag{2}$$

where the subscript t indexes the age of the child and i indexes the child (we have omitted gender superscripts to reduce notational clutter). The vector $\mathbf{x}$ indexes household characteristics of child i while p is the price of child quality, z. We have indexed z by child age to emphasize that quality is learnt over time. z_t^i therefore refers to the expectation of child quality, based on information available at time t.

We adopt the following convention: because child quality is unobservable, we will define it so that its price (as defined above) is always positive. Thus, for example, suppose an increase in child quality of a girl, z, lowers the maximum willingness-to-pay. We would then re-define z as the negative of child quality so that its price becomes positive.

Our goal is to develop an estimable model that relates learning about quality to changes in dowry dispersion. We are treating quality as though it is a single characteristic, but it is possible that there may be more than one child attribute that is revealed over time. In that case, we may end up estimating the average price of a set of child characteristics. We will address this issue in the estimation (Section 6). It is also possible that households have different forecasts of the price of quality, and this would also contribute to the dispersion in dowry values. We will address this point in Section 5 as well as in the estimation (Section 6).

The essential theoretical complication in modeling the relationship between dowry and perceived quality is that quality is not completely pre-determined: while it is plausible that some part of quality is "given", there is no doubt that purposeful investments such as schooling, time spent with the child, etc can influence overall quality. These investments, in turn, are (a) sensitive to new information about latent child quality and (b) constrained by household resources. This makes it extremely difficult (if not impossible) to derive any clear predictions about how the distribution of overall quality evolves over time. To proceed, we therefore focus on a component of quality that is not affected by household resources or constraints. To be clear, this component of quality may still be correlated with household resources to the extent that innovations in quality may cause adjustments in household assets (for example), but this is not a problem in terms of theoretical modeling (although it does constitute an econometric problem, as we discuss in the next section).

To flesh this out a little more formally, suppose that there is a (perceived) production function for overall quality:

$$Z_t^i = \Phi(\mathbf{x}_t^i, Q_t^i) \tag{3}$$

where the production function Φ depends on an exogenously given child-quality term denoted by Q_t^i and household resources $\mathbf{x}_t^i$. Exogenous child-quality is fixed, but is gradually revealed over time, with Q_t^i representing its expected value at time t. We are assuming that this production function is multiplicatively separable as follows:

$$Z_t^i = K(Q_t^i)H(\mathbf{x}_t^i) \tag{4}$$

In this formulation, K subsumes that part of household investment that does not depend on $\mathbf{x}$. Using lower-case letters to denote logarithms, we can write:

$$z_t^i = q_t^i + h(\mathbf{x}_t^i) \tag{5}$$

where $q_t^i =$***log***$(K(Q_t^i))$. We will henceforth refer to q_t^i as quality, and model its evolution.

To model the evolution of cross-sectional variance of q_t^i (i.e. $Var(q_t^i|t)$), we consider a simple learning model. We assume that before a child is born, his or her parents have a prior belief about his or her quality. Denote by θ^i the true (unobserved) quality of child i. In particular, we assume that the prior is normally distributed with mean and variance θ and σ_θ^2, and that this prior corresponds exactly to the actual distribution of child quality in the population. Thereafter, the parents receive independent signals in each period about the child's productivity which they then use to update their priors. These signals are drawn from a normal distribution with mean θ^i and variance σ_ϵ^2:

$$s_t^i = \theta^i + \epsilon_t^i, \quad \epsilon_t^i \sim N(0, \sigma_\epsilon^2) \tag{6}$$

In addition, we assume that the signal errors ϵ_t^i are uncorrelated over time and across individuals. Using the notation introduced above, denote by q_t^i the expected quality of child i at age t. Denote now by ρ_t the precision of this belief after the t-th signal has been received - this is the inverse of the variance of the belief distribution. Similarly we denote by ρ_ϵ the precision of the signal (i.e. the inverse of the variance of the signal, σ_ϵ^2). Bayesian updating implies:

$$q_{t+1}^i = (1 - \alpha_{t+1})q_t^i + \alpha_{t+1}s_{t+1}^i \tag{7}$$

where s^i_{t+1} denotes the signal of child i's quality at age $t+1$ and $\alpha_{t+1} = \frac{\rho_\epsilon}{\rho_t+\rho_\epsilon}$.

A standard result in Bayesian learning models (see for example Chamley 2003) is that with normal priors and signals, the precision of the belief increases deterministically in a linear way, i.e. $\rho_{t+1} = \rho_t + \rho_\epsilon$. Using the recursivity of (7), we can then show that:

$$q^i_t = \frac{\rho_0}{\rho_t} q^i_0 + \frac{\rho_\epsilon}{\rho_t} \sum_{\tau=1}^{t} s^i_\tau \tag{8}$$

$$= \frac{\rho_0}{\rho_t} q^i_0 + \frac{\rho_\epsilon}{\rho_t} (t\theta^i + \sum_{\tau=1}^{t} \epsilon^i_\tau) \tag{9}$$

where q^i_0 denotes the expected quality immediately after birth. Recall that q^i_0 equals θ because when the child is born, its expected quality is θ. We can now write:

$$q^i_t = \frac{\rho_0}{\rho_t}\theta + (1 - \frac{\rho_0}{\rho_t})\theta^i + (1 - \frac{\rho_0}{\rho_t})\frac{1}{t}\sum_{\tau=1}^{t} \epsilon^i_\tau \tag{10}$$

As t increases, the precision of the belief, ρ_t, increases unboundedly. Because the signal errors are mean-zero, it follows that the expected quality, q^i_t, converges to true quality θ^i in the probability limit. Thus the parents' belief about their child's quality collapses to true quality in the limit.

In contrast, the cross-sectional dispersion in expected qualities increases over time. To see this, we start by writing the cross-sectional variance of q^i_t:

$$Var(q^i_t|t) = (\frac{\rho_\epsilon}{\rho_t})^2[t^2\sigma^2_\theta + t\sigma^2_\epsilon] \tag{11}$$

where we have used (6) and the assumption that parents have common priors before the child is born. With a little bit of algebra, this can be rewritten as:

$$Var(q^i_t|t) = \frac{\sigma^2_\theta ct}{1+ct} \tag{12}$$

where $c = \frac{\rho_\epsilon}{\rho_0}$. A more revealing form of this expression is given by:

$$Var(q^i_t|t) = \sigma^2_\theta - \sigma^2_t \tag{13}$$

where σ^2_t is the variance of the individual belief distribution at t. Recalling that $\sigma^2_0 = \sigma^2_\theta$ and that σ^2_t falls with t, the expression above reveals that the cross-sectional dispersion in quality increases from 0 and asymptotes to σ^2_θ, the rate of convergence being governed by the parameter c. It can be verified from (12) that $Var(q^i_t|t)$ increases at a diminishing rate, i.e. $Var(q^i_t|t)$ is a concave function of age.

5 Identification and econometric methodology

When quality is priced in dowry terms, the cross-sectional variance in dowry due to quality (assuming for the moment that projected dowry is solely a function of quality) is given by:

$$Var(pq_t^i|t) = \frac{p^2\sigma_\theta^2 ct}{1+ct} \tag{14}$$

The quantity $p\sigma_\theta$ represents the standardized price of quality: it is the percentage increase in projected dowry (recall that we are now working with the logarithm of dowry) due to a one-standard deviation increase in quality. Figure 5 plots the function given in (14) for some selected values of $p\sigma_\theta$ and c. The figure confirms that $p\sigma_\theta$ and c are separately identifiable: $p^2\sigma_\theta^2$ is the value that $Var(pq_t^i|t)$ asymptotes to, while c and $p^2\sigma_\theta^2$ together control the curvature (notice that we cannot identify the sign of the price).

However, $Var(pq_t^i|t)$ is not directly observed because q_t^i is unobservable. We must therefore distinguish q_t^i from other time-varying determinants of dowry by isolating it as a residual. The difficulty with this approach is that q_t^i may be correlated with household variables because innovations in expected quality change the lifetime wealth of the family and may result in the adjustment of household assets, for example (recall, however, that by definition, q does not change in response to changes in household resources). Thus, a regression approach that removes variation in dowry that is due to variation in household variables will also remove some of the variation that is due to quality. As long as the correlation between q and household variables is independent of age, however, it is possible to consistently estimate c and estimate a lower bound on the price of quality, as we now show.

We adopt a linear regression framework in what follows. Using (2) and (5), we consider the projected dowry function:

$$g(\mathbf{x}_t^i, q_t^i) = \{f(\mathbf{x}_t^i) + ph(\mathbf{x}_t^i)\} + pq_t^i \tag{15}$$

Suppose that we can approximate $\{f(\mathbf{x}) + ph(\mathbf{x})\}$ by a linear combination of the variables in $\mathbf{x}$. We can then write:

$$g(\mathbf{x}_t^i, q_t^i) = \boldsymbol{\beta}\mathbf{x}_t^i + pq_t^i \tag{16}$$

We must however consider the fact that just as projected dowry depends on expected quality, it may also depend on expected (i.e. at time of marriage) household variables, and the latter need not be identical to current (i.e. at time of survey) household variables. For instance, assets may be expected to accumulate interest over time and household forecasts of dowry may be based on the expected value of assets at the time of marriage. To accommodate this possibility in a simple yet flexible way, we consider a specification which interacts the variables in $\mathbf{x}$ with age dummies, i.e. we allow the effect of household variables to vary by child age:

$$g(\mathbf{x}_t^i, q_t^i) = \boldsymbol{\beta}_t\mathbf{x}_t^i + pq_t^i \tag{17}$$

Denote by e_t^i the residual from a least-squares regression of Eqn (17) above. We can write:

$$pq_t^i = \widetilde{pq}_t^i + e_t^i \tag{18}$$

where $\widetilde{pq}_t^i$ is the linear projection of pq_t^i on $\mathbf{x}_t^i$ for a given value of t, and we must therefore have $cov(e_t^i, \widetilde{pq}_t^i|t) = 0$. The conditional variance of e_t^i is thus given by:

$$\begin{aligned} Var(e_t^i|t) &= Var(pq_t^i|t) - Var(\widetilde{pq}_t^i|t) \qquad (19)\\ &= (1 - R_t^2)Var(pq_t^i|t) \qquad (20)\end{aligned}$$

where R_t^2 denotes the R-squared from a regression of pq_t^i on $\mathbf{x}_t^i$ (for the given age group t). If $\mathbf{x}$ were a scalar, R_t^2 would simply be the correlation between pq_t^i and $\mathbf{x}_t^i$ at time t. Using (14) we can now write:

$$Var(e_t^i|t) = \frac{(1 - R_t^2)p^2\sigma_\theta^2 ct}{1 + ct} \tag{21}$$

Suppose now that R_t^2 does not change with t. That is, the proportion of cross-sectional variation in pq for a given age-group that can be explained by $\mathbf{x}$ is independent of the age of the children (in the scalar case, this means that the correlation between pq and x does not change with t). In that case, an inspection of (21) suggests that we can estimate $(1 - R^2)p^2\sigma_\theta^2$. We would necessarily be underestimating $p\sigma_\theta$ unless changes in q do not induce any adjustments in $\mathbf{x}$ (i.e. q and $\mathbf{x}$ are uncorrelated and therefore $R_t^2 = 0$). The latter condition cannot be directly tested, although as we discuss in Section 6 there is reason to think that it may be approximately true in our data.

Having obtained the residual e, we estimate price by casting (21) in estimable form as follows:

$$Var(e_t^i|t) = \frac{\tilde{p}^2 ct}{1 + ct} + \xi_t \tag{22}$$

where $\tilde{p}^2 = (1 - R^2)p^2\sigma_\theta^2$ and ξ_t represents sampling error. We estimate the coefficients $\tilde{p}$ and c by non-linear least squares. To account for the fact that the variance in each age-group is constructed from a different number of observations, we also implement a weighted version of this regression. In practice, there turns out to be virtually no difference between the estimates from the weighted and unweighted regressions.

We have not so far allowed for the possibility that there may be omitted household variables in the regression equation (17). Denote by v the part of the omitted variables that is not correlated with the included variables $\mathbf{x}$, i.e. the regression residual is $(v + e)$. Because of the uncorrelatedness of e and $\mathbf{x}$, it is plausible that e is also uncorrelated with v. Even so, the variance of the regression residual would then be given by $Var(v) + Var(e)$. It is obviously important for the identification of $\tilde{p}$ and c that the variance of v does not evolve with child age in a way that mimics the variance of e. As we will see, the variance of the dowry component that can be predicted by the variables in $\mathbf{x}$ does not bear any relation to child age, which is reassuring in that it suggests that the same may be true of the variance of v. Nonetheless, in the estimation, we will examine the robustness of the estimates to allowing $Var(v)$ to be a polynomial function of child age. That is, we will be estimating by non-linear least-squares the equation:

$$Var(u_t^i|t) = Var(v_t^i|t) + Var(e_t^i|t) = \omega(t) + \frac{\tilde{p}^2 ct}{1+ct} + \xi_t \tag{23}$$

where u is the composite regression residual, and $\omega(.)$ is a polynomial function of t.

Lastly, we have implicitly been assuming that households agree on the dowry price of quality, p. However, if households hold different expectations on the price of quality and if price forecasts are independent of quality forecasts, then we would have:

$$Var(pq_t^i|t) = \theta^2 Var(p) + \frac{E(p^2)\sigma_\theta^2 ct}{1+ct} \tag{24}$$

where $Var(p)$ denotes the cross-household dispersion in price forecasts.[19] Thus, Eqn (23) would be written as:

$$\begin{aligned} Var(u_t^i|t) &= Var(v_t^i|t) + Var(e_t^i|t) = [\varpi(t) + (1-R^2)Var(p)] + \frac{(1-R^2)E(p^2)\sigma_\theta^2 ct}{1+ct} + \xi_t \quad (25) \\ &\equiv \psi(t) + \frac{(1-R^2)E(p^2)\sigma_\theta^2 ct}{1+ct} + \xi_t \end{aligned}$$

Assuming that the average household's price forecast is correct, Jensen's inequality implies $E(p^2) < p^{*2}$ where p^* is the true price of quality. Thus, the estimated price parameter will further underestimate the true price of quality. A possible test for detecting a non-zero variance of household forecasts is to test whether the constant term in $\psi(t)$ is zero.

If $Var(p)$ changes with child age then Eqn (25) is mis-specified if we assume $E(p^2)$ to be constant, and the resulting bias will depend on the correct relation between $E(p^2)$ and t.

6 Results

We begin by isolating the quality component of dowry for boys and girls separately, using the regression framework outlined in Section 5. To recapitulate the discussion in the preceding sections, we will obtain the residuals from a regression of projected dowry on a set of household characteristics. The regression equation is:

$$g_t^i = \boldsymbol{\beta}_t \mathbf{x}_t^i + u_t^i \tag{26}$$

where g_t^i is the logarithm of the willingness-to-pay (accept, in the case of boys) and $\mathbf{x}$ is a vector of observable household characteristics. Because this constitutes a demanding specification, we narrow down the set of household variables to those that appeared to be significant

[19] We have made use of the formula for the variance of a product of independent variables, namely $Var(XY) = E(Y^2)Var(X) + [E(X)]^2 Var(Y)$.

correlates of projected dowry in Table 2 (we will also present estimates from a less demanding specification which includes all the household variables in levels, i.e. not interacted with age). Specifically, for boys we retain the following variables: (1) Logarithm of household income, (2) Logarithm of total value of household assets, (3) Education level of decision maker, (4) Number of adults in the family, (5) Number of unmarried boys in the family, and (6) Overall (i.e. not within-gender) child order. For girls, we replace the variable "number of unmarried boys in the family" with "number of unmarried girls in the family". The age-wise variance in the residual will then be mapped to the learning model to estimate the price of quality, $\tilde{p}$, and the learning parameter c.

At this point we limit the estimation sample to include only children up to the age of 18, in order to limit the effect of attrition from unmarried status on the age-wise dowry variance. This attrition is likely to be more important for girls than for boys - about 10% of 16 year-old girls, 30% of 17 years-old girls and 38% of 18 year-old girls in our sample are married, whereas none of the boys below the age of 19 is married. At the same time, because the final estimation of parameters will be based on age-wise variance we would like to keep the estimation sample from being too small. While our base specification will include boys and girls up to and including the age of 18, we will also present the results for different age-cutoffs, to determine the robustness of our estimates.

Figure 6 graphs the age-wise variance of actual (i.e. raw), predicted and residual dowry from the base regression specification. Because the variance in each age-category is constructed from a different number of observations, the graphs are weighted. An immediate observation is that for boys as well as girls, actual and residual dowry dispersion appear to increase in a concave fashion, strongly supporting the idea of a concave learning effect.

Also notable is that the part of dowry dispersion that is predicted by household variables does not seem to be strongly related to age (although we also note that the estimated relationship is noisy). This is interesting because one might intuitively expect that if there is a correlation between child quality and household variables, then increasing dispersion in child quality would also show up as increasing dispersion in household variables, and possibly an increasing dispersion in predicted dowry. We conjecture that the weak correlation between household variables and child quality is due to the fact that many households have multiple children. As many as 72% of unmarried boys and 60% of unmarried girls are in households with more than one unmarried boy and more than one unmarried girl, respectively. Nearly 94% of unmarried children are in households with at least one other unmarried child (of either gender). If children in the same household have independent innovations in quality, then this would dampen the adjustment of household variables to any particular child's innovation.

We now turn to the analysis of residual dowry, i.e. the quality component. Figure 7 graphs the kernel densities of residual dowry for each of the three age categories; 0-6 years, 7-14 years and 15 years and upwards. In the figures, the spreading-out of the dowry distribution with age, that was noted in Section 3, is even more starkly apparent, and this time for girls as well.

The figure reinforces an important fact that we had also noted in Section 3. The peakedness of the perceived quality (in dowry terms) distribution changes dramatically for boys going from pre-school to school, suggesting that sending boys to school may reveal a substantial component of their quality. In contrast, the peakedness of the quality distribution has already diminished substantially by the time girls reach school age. Formally, a Kolmogorov-Smirnov test for equality of distributions rejects the equality of pre-school and primary-middle school quality distributions in the case of boys (with a p-value of 0.04), but fails to reject equality in the case of girls (with a p-value of 0.42).

This result bears an intuitive correspondence with the descriptive analysis in Section 3, where we commented on the fact that "high-level" ability seems to matter for boys but not for girls, whereas the converse is true of "low-level" ability. If "high-level" ability is only revealed by performance in school whereas "low-level" ability begins to become apparent much earlier, this might explain our findings above. As we will see, the estimated learning rates are correspondingly quite different for boys and girls.

Figures 6 and 7 indicate that the principal benefit of controlling for household variables is that by doing so we remove a significant amount of variation in dowry values that is unrelated to quality and masks the effects of the latter. At the same time, Figure 7 also suggests that the correlation between these variables and quality may be quite weak. If so, we may be able to carry out our estimation of the structural parameters without adjusting for the effects of household variables (i.e. using the raw dowry data) and hope to obtain similar (albeit more noisy) estimates. We test this conjecture shortly.

We now present the results from our estimation of the learning model. To compare estimates for boys and girls, we pool the samples and jointly estimate separate parameters for the two groups using Eqn (22). Table 5 reports the estimated coefficients from a variety of specifications, and also tests whether the differences in estimated coefficients for boys and girls are statistically significant.

We describe the results briefly before discussing their interpretation. The estimates in Column 1 indicate that both price as well as the learning parameter c are comparable for boys and girls, although the latter is not very precisely estimated. Column 2 repeats the estimation, but this time restricting the price to be the same for boys and girls. As we noted above, however, it appears that learning about quality may begin at a later age for boys. We therefore redo the estimations, setting age 5 (the first year of primary school) as the starting year for boys. Column 3 reports the results. Prices are again comparable between the groups, but this time there appears to be a large difference in learning rates: the rate of learning is greater for boys than for girls. In Column 4 we repeat the regression in Column 3 but restrict the price to be equal across the two groups: because this restriction appears to be generally valid, we impose it throughout in the remaining estimations.

In all specifications, the price of quality is stable and very strongly significant, both in economic as well as in statistical terms. In particular, a one-standard deviation increase in quality would appear to increase dowry by about 60%-70% for both boys and girls. These are very significant amounts and speak to the importance of child attributes in determining dowry values. To get a better sense of these magnitudes, recall that, assuming that quality is perfectly observed, the square of the standardized price can also be interpreted as the variance in dowry that is due to variation in quality (not accounting for any unobservable correlation between quality and the other determinants of dowry). Given that the variance in (the logarithm of) projected dowry at age 18 (when quality has been largely revealed and the dowry variance levels off) is 0.80 for boys and 0.58 for girls, quality variation can account for about 46% of dowry variance for boys and about 64% of the dowry variance for girls (and to the extent that our estimates of price are downward biased, these figures represent lower bounds).

That the standardized price of quality is comparable for boys and girls seems intuitive to us: if boys and girls are being matched on the basis of their qualities, then it would make sense that an increase in quality would have the same equilibrium price (in absolute terms) for both sexes. The difference in estimated learning rates for boys and girls (though short of statistical significance) may be understood as follows. The equality of price of quality for boys and girls implies that the dowry variance due to quality must converge to the same value for the two groups. If quality only starts to be revealed at a later age for boys, it follows that once learning begins, the rate of learning must be greater for boys than for girls.

Table 6 examines the robustness of the estimates to using different regression specifications in Eqn (26) and Eqn (23). In Column 1, instead of interacting a restricted set of household variables with age dummies, we simply include the full set of household variables in levels, i.e. not interacted with child age. Column 2 estimates the model coefficients but does so using the residuals from a regression of dowry on a set of household dummies. In Columns 3 and 4 we perform the estimation but this time dropping women older than 17 and 16, respectively, in order to assess the sensitivity of the estimates to attrition from unmarried status for women.

A concern with our methodology is that instead of capturing the effects of a single well-defined quality characteristic, we may be estimating the average dowry price of multiple child attributes that are being learnt over time. In particular, the onset of puberty may trigger changes in physical appearance, etc. that may affect the child's marriage-market value. To exclude this possibility, we restrict the sample to children under the age of 12 - the results are reported in Column 5.

Lastly, as we noted in Section 5, if there are omitted variables in the regression specification, they will enter into the variance of the residual. In Columns 6, 7, 8 and 9, we estimate Eqn (25), allowing $\psi(.)$ to take different polynomial forms. As discussed earlier, this also allows for dispersion in price forecasts. Thus, Column 6 sets $\psi(t) = \psi_0$, Column 7 sets $\psi(t) = \psi_1 t$, Column 8 sets $\psi(t) = \psi_2 t^2$ and Column 9 sets $\psi(t) = \psi_0 + \psi_1 t + \psi_2 t^2$.

We find that including the full set of household variables in levels (Column 1) produces estimates that are qualitatively quite similar to the results using the base specification. However implementing a household fixed effects regression in Eqn (26) produces very poorly estimated coefficients (Column 2). The parameter estimates in Columns 3 and 4 are quite similar to the base results, indicating that attrition out of unmarried status is not significantly biasing our results. Restricting the sample to children who are yet to attain puberty (Column 5) also produces qualitatively similar estimates for the price and learning parameters (the estimated learning parameters are lower than in the base results, but we do not have enough power in our data to reject the hypothesis that the estimates from the two specifications are equal).

Finally, even though the precision of the estimates suffers, the point estimates are stable when allowing the control term $\psi(.)$ to be up to a quadratic function of child-age (Columns 6-9). In particular, allowing $\psi(.)$ to be quadratic is a particularly demanding specification given that the variance of child quality is well approximated by a quadratic function of child-age (see Figure 5). The estimated $\psi(.)$ coefficients are small and insignificant in these specifications. Together with the robustness of the price and learning parameter estimates, this is evidence that neither omitted variables nor dispersion in household forecasts of the price of quality is a significant concern.

7 Concluding discussion

Using a novel dataset that contains elicited child-specific expectations of dowry payments, as well as expected educational returns and among households in three Indian villages, we have analyzed the contribution to dowry of a set of characteristics that we refer to as "child quality". We hypothesize that certain aspects of this child quality are only revealed gradually over time, as the child grows older. Consistent with this hypothesis, the cross-sectional dispersion in projected dowry values bears a concave relation to child age, and this relationship is used to fit a learning model to the data to estimate the price of quality as well as the parameters governing the learning process.

We have found that child quality is an important determinant of dowry, and that parents learn about this quality as children grow older. However, we show that "quality" correlates with different characteristics for boys and for girls. In particular, returns to higher (but not lower) education matter for boys on the marriage market, while the returns to lower (but not higher) education matter for girls. The distinction between high- and low-level quality is also important in terms of their salience. Parents only learn about the low-level quality of their daughters, and only about the high-level quality of their sons.

These results are consistent with the qualitative interviews we conducted in the villages at the start of this study. According to the respondents' own account a girl's physical appearance, "homely nature" and more general ability with regard to household work and management are characteristics which are highly valued on the marriage market. Note that our results do not imply that girl's education is not valued on the marriage market. Over 90% of the children under the age of 15 years in our study are enrolled in school, with little difference between the sexes. As Behrman et al (1999) note using the 1983 ICRISAT data, a literate wife is associated with a lower dowry, but any education beyond that does not affect dowry. Literate women, in their data, are more effective home teachers and command a premium in the marriage market. In the same way, it is plausible that today, girls who received 10 years of education are considered more effective home makers, while beyond that, girls bump into marriage and labor market related social norms. In the case of boys, respondents mentioned education, and more generally, the ability to earn a living, as the most important quality. Several respondents indicated that the potential groom's educational attainment matters for dowry even if he does not have a job.

In terms of quantitative studies set in India, our results can be compared to Dalmia and Lawrence (2005) who, using retrospective dowry data from almost 1,900 households collected in 1995 in Karnataka and Utter Pradesh, find that both groom's schooling and bride's schooling increase the net dowry the bride family pays. Deolalikar and Rao (1998) and Rao (1993 A/B), on the other hand, using a dataset of 120 households collected retrospectively in 1983 in the same set of villages as we consider in this study, find that none of the individual traits of the bride and groom such as schooling or height seems to matter. However, as we already noted, Behrman et al (1999) have reported the dowry value of female literacy using the same data. While the difference in their results is driven by choice of specification, the differences with our own results are more likely to relate to the fact that there are 25 years between the two surveys, and the returns to education have changed drastically during this period.

Finally, the differences in the rates of learning for boys and girls offers an interesting avenue for future research. The fact that quality is revealed earlier for girls may disadvantage them relative to boys, particularly if investments in children are indeed driven by parents' perceptions of quality and if such investments tend to reinforce existing differences among children.

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Appendix A: Interpreting a positive dowry price of female quality

We outline here an envelope theorem interpretation of a positive dowry price of quality. We outline the argument in terms of the maximum dowry that a girl's household is willing to pay. The setup is analogous for the minimum dowry that a boy's household is willing to accept. Consider a girl's household that anticipates that at time of marriage $\mathbf{x}^F$ will be the vector of household characteristics and $\mathbf{z}^F$ will be the set of individual (i.e. the girl's) characteristics. To keep matters simple, we restrict attention to a single individual characteristic z^F that we refer to as "quality".

Suppose, for the moment, that only individual qualities matter. We can therefore ignore households in what follows. Denote by $V(z_M; z_F)$ the relationship value (in monetary terms) to the girl whose quality is given by z_F arising from the match with the groom whose quality is denoted by z_M. Denote by $R(z_F)$ the reservation value of the girl, which may represent her autarkic value or in a search framework the expected value of turning down an offer from z^M and continuing her search. The maximum transfer that she is willing to make to the groom is given by:

$$G^{\max}(z_M; z_F) = V(z_M; z_F) - R(z_F) \tag{27}$$

Clearly, the girl will be willing to pay the most to the groom who produces the greatest match value, V_F. Denote by z_M^* the groom who maximizes $G^{\max}(z_M; z_F)$ with respect to z_M. Substituting optimal groom quality into (27), we obtain the (unconditional) maximum willingness to pay (i.e. the value function of the optimization problem), which we denote by $G^*(z_F)$.

$$G^*(z_F) = V(z_M^*(z_F); z_F) - R(z_F) \tag{28}$$

Now consider the change in G^* due to a marginal increment in z_F:

$$\frac{dG^*}{dz^F} = (\frac{\partial V}{\partial z_M})|_{z_M = z_M^*}(\frac{\partial z_M^*}{\partial z_F}) + (\frac{\partial V}{\partial z_F})|_{z_M = z_M^*} - \frac{\partial R}{\partial z_F} \tag{29}$$

If the envelope theorem holds, the first term above is zero. That is, *for small changes in quality*, the associated change in willingness-to-pay may be thought of as the increment in the dowry that the girl is willing to pay to the previously optimal groom. In general, this increment is positive if the increase in quality increases the value the girl derives from that particular relationship to a greater extent than it increases her reservation value.

The framework outlined above is Beckerian in the sense that relationship values are determined independently of dowry, the latter playing the role of equilibrating transfers (see Becker 1991 for a model of marriage market transfers). Alternative, one could conceive of a framework in which dowry itself determines relationship value. For example, the amount of dowry that a bride brings with her may determine her bargaining power, and hence her own welfare in the new household (Zhang and Chan 1999). If the marginal effect of dowry on bargaining power (and post-marriage bridal welfare) increases with girl's quality, then the envelope theorem may again imply that the dowry price of girl's quality is positive.

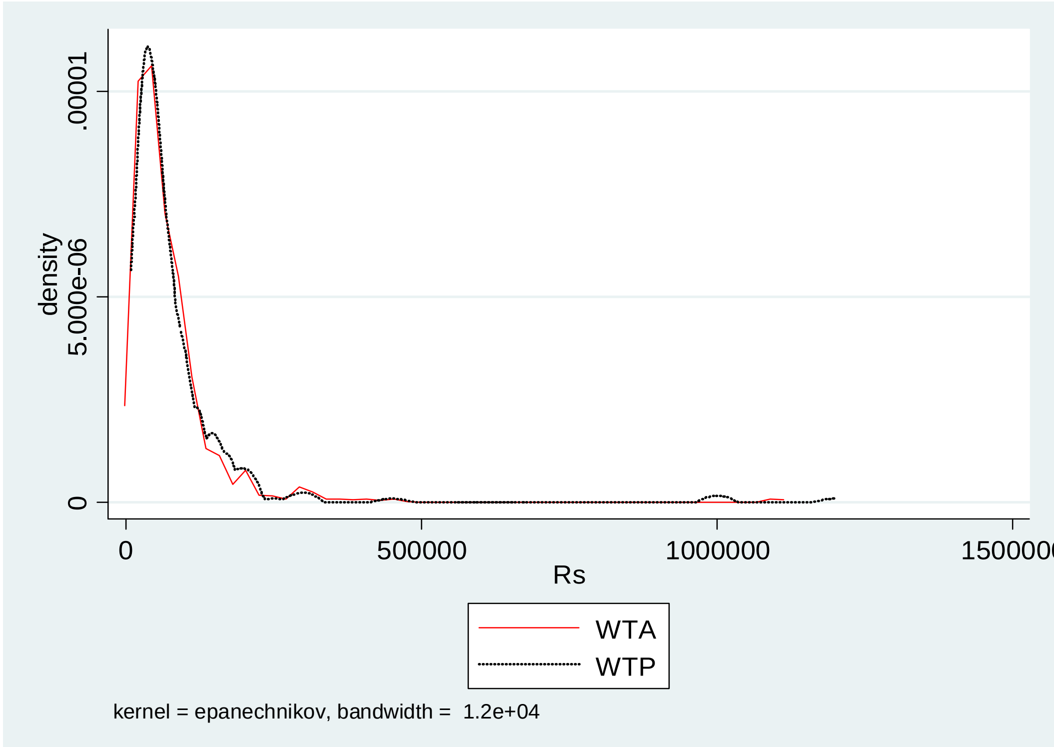

Figure 1: The kernel density of projected dowry for boys and girls

Note: Excludes children with zero dowry and the children for whom the parent could not answer the dowry question

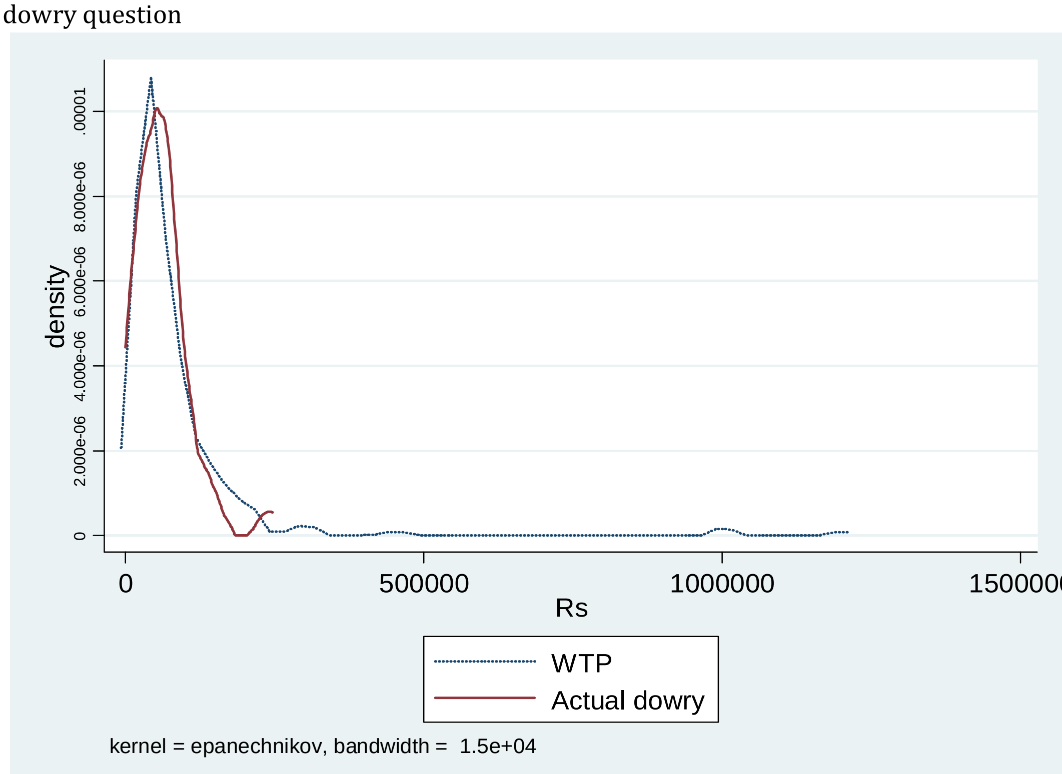

Figure 2: The kernel densities of projected dowries for girls as well as the kernel density of actual dowries from the retrospective data

Note: Excludes children with zero dowry and the children for whom the parent could not answer the dowry question

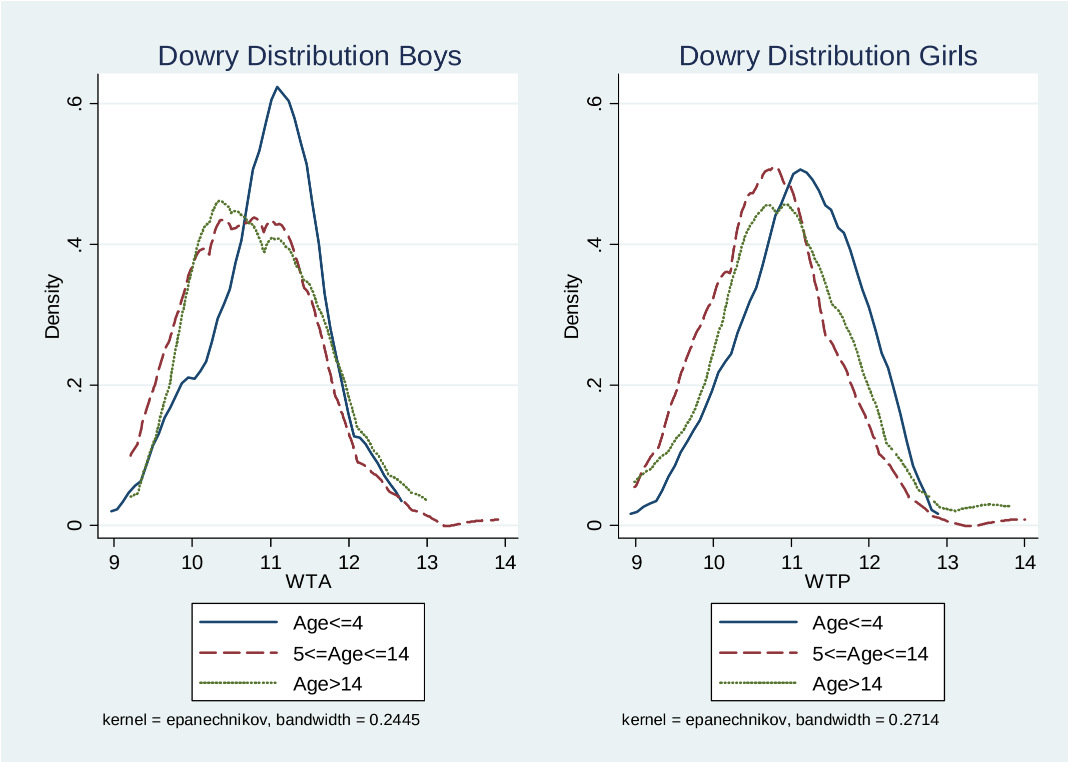

Figure 3: The kernel density of the logarithm of projected dowry for each of the three indicated age categories. The figure on the left panel refers to the results for boys and the panel on the right contains the results for girls

Note: Excludes children with zero dowry and the children for whom the parent could not answer the dowry question

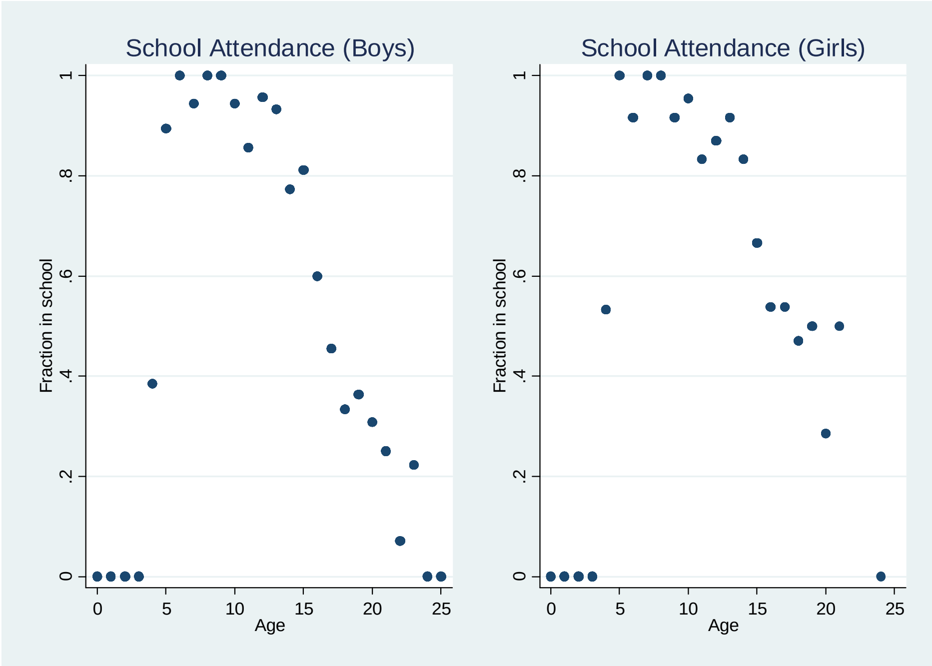

Figure 4: The figure graphs for each gender the fraction of unmarried children currently attending school at each age.

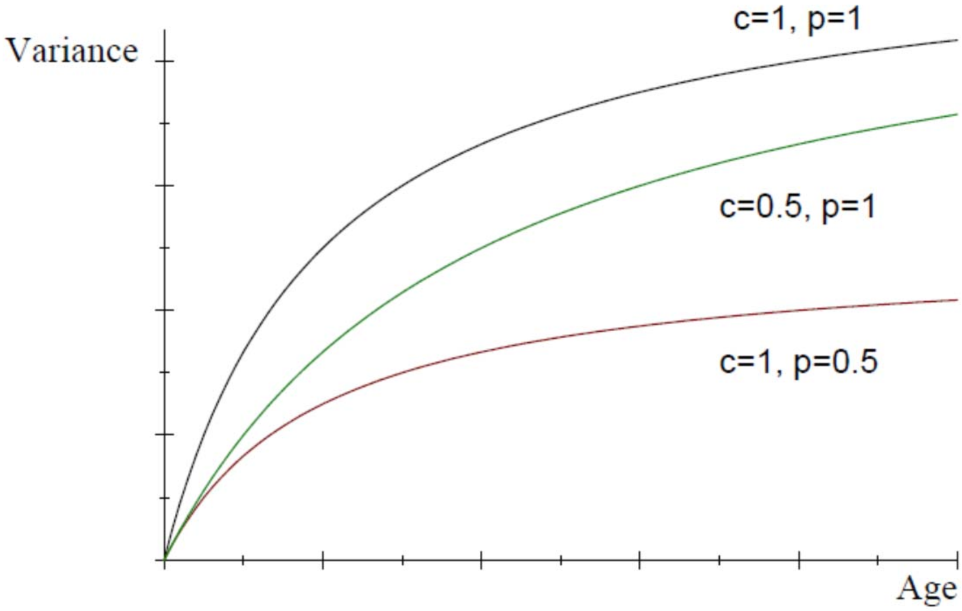

Figure 5: The figure plots the theoretical cross-sectional variance in dowry as a function of age for various parameter values of the price of quality and the learning parameter, c.

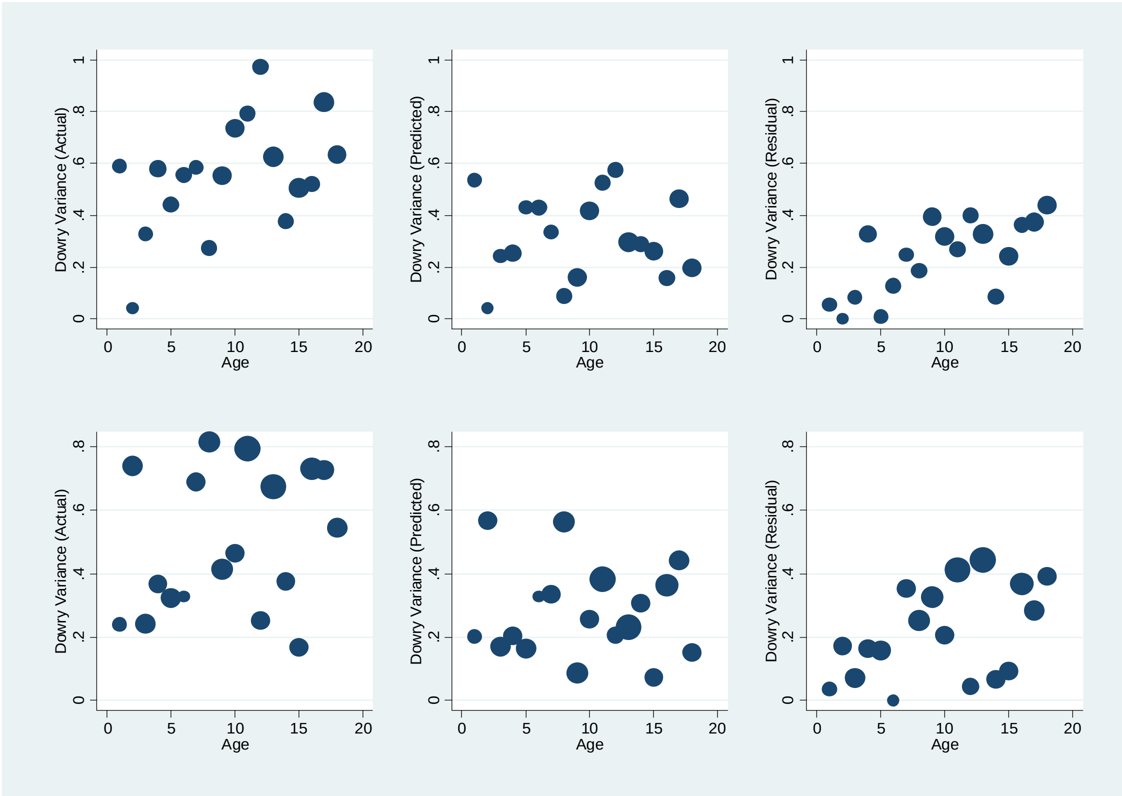

Figure 6: The age-wise variance of actual, predicted and residual dowry, where the predicted and residual values are obtained from a regression of projected dowries on household variables. The top panel contains the results of the exercise for boys and the bottom panel contains the results of the exercise for girls.

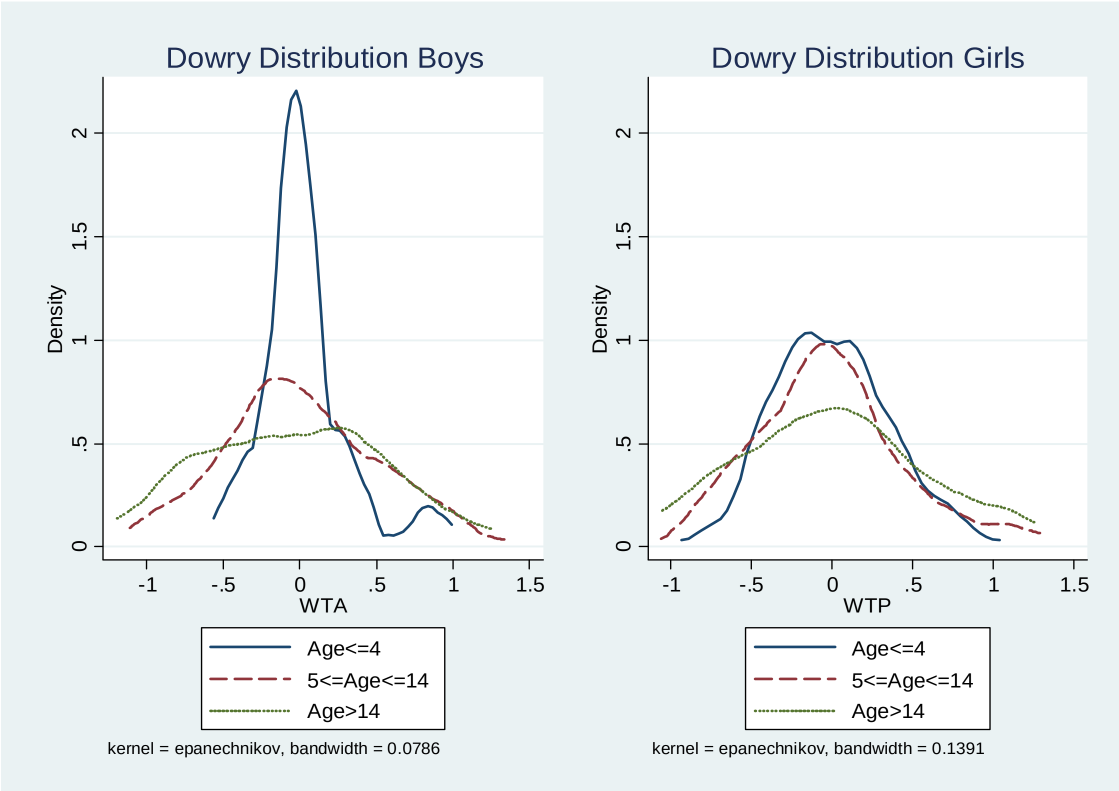

Figure 7: The kernel density of residual dowry for each of the three indicated age categories. The residual dowry was obtained from a regression of the logarithm of projected dowry on a set of household and individual level variables. The figure on the left panel refers to the results for boys and the panel on the right contains the results for girls.

Table 1: Selected descriptive statistics

Number of households in village	1,720
Number of households in sample	339
Number of married children[1]	119
Number of unmarried children[1]	719
Average age of married children	21
Average age of unmarried children	11
Average number of household members	5.55
Average *Kharif* income (Rs)[2]	51,176
Average education level of respondent (in years)[3]	4.77
Average dowry willing-to-accept (boys) (Rs)[4]	70,671
Average dowry willing-to-pay (girls) (Rs)[4]	79,130
Median dowry willing-to-accept (boys) (Rs)[4]	50,000
Median dowry willing-to-pay (girls) (Rs)[4]	50,000

Notes: [1]A child is defined as an individual up to the age of 25. Note that the adults also include the daughters-in-law under 25; [2]The Kharif season is the rainy season; [3]The respondent is the main decision-maker with regard to the education of the children under 25 years in the household; [4] Excludes children with zero dowry and the children for whom the parent could not answer the dowry question.

Table 2: Correlates of ln(WTP) and ln(WTA)

	Boys	Girls
	(1)	(2)
Logarithm of household income (Rs)	0.08**	0.22***
	(0.04)	(0.05)
Logarithm of household wealth (Rs)	0.18***	0.13***
	(0.03)	(0.03)
Education level of decision-maker (in years)	0.04***	0.03***
	(0.01)	(0.01)
Number of unmarried boys	-0.12***	-0.03
	(0.04)	(0.05)
Number of unmarried girls	0.01	-0.11**
	(0.03)	(0.05)
Number of adults	0.01	0.07**
	(0.02)	(0.03)
Within-gender child order	0.06	0.05
	(0.06)	(0.09)
Overall child-order	-0.08*	-0.09**
	(0.04)	(0.04)
Observations	338	263
R-squared	0.713	0.698

Notes: *** p<0.01, ** p<0.05, * p<0.1; Standard errors have been clustered at household level. The dependent variable in column (1) is the logarithm of the minimum dowry that the boy's family is willing to accept, and the dependent variable in column (2) is the logarithm of the maximum dowry that the girl's family is willing to pay. All regressions include caste and village dummies (coefficients not reported). Adults include the married boys and girls in the household. Household wealth includes durables, land, animals, stock, equipment, savings and net-lendings.

Table 3: Do parents learn about their child's quality?

	Variance of belief distribution							
	8th	10th	12th	Diploma	BA	MS	Doctor	Engineer
Boys								
Age	0.16	0.16	-0.10	-3.52	-5.23***	7.05	-15.79	-8.10
	(0.17)	(0.18)	(0.42)	(3.03)	(1.89)	(28.71)	(16.19)	(13.06)
Constant	2.95**	6.90***	12.89***	120.87***	124.89***	150.65	687.98***	461.49***
	(1.35)	(1.53)	(3.85)	(29.78)	(18.97)	(283.92)	(160.21)	(129.42)
Observations	235	259	269	269	273	253	257	260
Girls								
Age	-0.18	-5.35**	0.84	-10.55	-0.44	-7.27	7.03	1.59
	(0.35)	(2.24)	(5.05)	(27.82)	(2.01)	(6.85)	(8.71)	(6.33)
Constant	5.54**	54.61***	11.72	209.35	57.68***	202.83***	263.06***	212.17***
	(2.59)	(17.94)	(45.41)	(257.42)	(18.83)	(64.67)	(81.05)	(58.46)
Observations	201	219	222	213	219	197	206	208

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; The dependent variable in each column is the variance of the belief distribution corresponding to the individual-specific returns to completing that level of education. For convenience of display, the variances have been divided by 10,000. The table reports the results from regressing each of the dependent variables on child age, including household fixed effects in the estimation. The upper panel reports the results of these regressions for boys, while the lower panel reports the results for girls. The number of observations differs across regressions firstly because not all households were able to answer the educational returns question for all levels of education, and secondly because parents were not asked to guess returns for levels that a child had already completed.

Table 4: Projected dowry and the returns to education

	Within-household		Between-household	
	Boys	Girls	Boys	Girls
	(1)	(2)	(3)	(4)
Average return to higher education (in 10,000 rupees)	0.04	0.13	0.23**	-0.09
	(0.15)	(0.13)	(0.10)	(0.13)
Average return to lower education (in 10,000 rupees)	-0.90	-0.42***	0.11	1.43***
	(0.73)	(0.13)	(0.27)	(0.34)
Household fixed effects	Yes	Yes	No	No
Household-level controls	No	No	Yes	Yes
Observations	160	147	155	142

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; The dependent variable in columns (1) and (3) is the logarithm of the willingness-to-accept dowry for one's son, and the dependent variable in columns (2) and (4) is the logarithm of the willingness-to-pay dowry for one's daughter. The average return to higher education is the average over the child- and level-specific expected returns to education for levels above and including a bachelor's degree. The average return to lower education is the average over the child- and level-specific expected returns to education for levels below and including a diploma. The regressions in columns (1) and (2) control for household fixed effects. The regressions in columns (3) and (4) control for the following observable characteristics: (1) Household income, (2) Household wealth, (3) Education of decision maker, (4) Number of unmarried boys, (5) Number of unmarried girls, (6) Number of adults, (7) Within-gender child order, (8) Overall child order, (9) Village and caste dummies.

Table 5: Estimates from the structural model: Base Specification

	(1)	(2)	(3)	(4)
Price (girls)	0.61***	0.71***	0.61***	0.60***
	(0.08)	(0.08)	(0.08)	(0.03)
Price (boys)	0.78***	0.71***	0.60***	0.60***
	(0.14)	(0.08)	(0.04)	(0.03)
c (girls)	0.19	0.09**	0.19	0.20**
	(0.13)	(0.04)	(0.13)	(0.07)
c (boys)	0.08	0.11*	0.84*	0.82*
	(0.06)	(0.06)	(0.48)	(0.45)
Price(boys)-Price(girls)	0.17		-0.01	
	(0.16)		(0.09)	
c(boys)-c(girls)	-0.11	0.02	0.65	0.62
	(0.14)	(0.03)	(0.50)	(0.41)
Obs	38	38	33	33

Notes: Robust standard errors are reported in parentheses. The estimated parameters were derived from a weighted non-linear least-squares regression where the dependent variable is an age-specific cross-sectional variance in dowry. In Columns 1 and 2, the dependent variable is the age-specific variance in the residual dowry, the latter being obtained from a regression of dowry on a set of household variables interacted with age. In Columns 2 and 4 we restrict the price of quality to be the same for boys and girls. In Columns 3 and 4, we set age 5 to be the starting year for boys.

Table 6: Estimates from the structural model: Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Price	0.76***	0.78***	0.60***	0.60***	0.69***	0.61***	0.58***	0.58***	0.92***
	(0.06)	(0.03)	(0.03)	(0.04)	(0.08)	(0.09)	(0.08)	(0.05)	(0.26)
c (girls)	0.21*	0.81	0.19**	0.19**	0.13*	0.26	0.22**	0.23**	0.27
	(0.11)	(0.74)	(0.08)	(0.08)	(0.07)	(0.24)	(0.10)	(0.10)	(0.22)
c (boys)	0.72	4.42	0.97*	0.97	0.44*	1.09	1.08	1.16	0.49
	(0.47)	(5.17)	(0.58)	(0.61)	(0.24)	(1.00)	(1.00)	(0.92)	(0.56)
ψ_0						-0.03			-0.10
						(0.12)			(0.13)
ψ_1							0.001		-0.05
							(0.005)		(0.05)
ψ_2								0.00008	0.001
								(0.0001)	(0.001)
Obs	33	33	32	31	18	33	33	33	33

Notes: Robust standard errors are reported in parentheses. The estimated parameters were derived from a weighted non-linear least-squares regression where the dependent variable is an age-specific cross-sectional variance in dowry. In all regressions, we restrict the price of quality to be the same for boys and girls and set age 5 to be the starting year for boys. In Column 1 the dependent variable is the variance in residual dowry, the latter obtained from a regression of dowry on the full set of household variables in levels. In Column 2 the dependent variable is the variance in residual dowry, the latter being obtained from a regression of dowry on household dummies and child-order. In Column 3, we perform the estimation omitting women above the age of 17. In Column 4 we perform the estimation omitting women above the age of 16. In Column 5 we perform the estimation omitting children age 12 and above. In Column 6 we control in the non-linear estimation for an intercept term. In Column 7 we control in the non-linear estimation for a linear term in child age. In Column 8 we control in the non-linear estimation for a quadratic term in child age. In Column 9 we control in the non-linear estimation for an intercept term as well as terms linear and quadratic in child age.