Female Education, Marital Assortative Mating and Dowry: Theory and Evidence from India

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Abstract

This paper studies the association between female education, marital assorting and dowry in India. Marital assortative mating or 'who marries whom' is determined by the characteristics of grooms and brides and the households. Literature suggests that men choose to marry females with higher education in expectation of greater wage income in future. This paper argues that India is characterized by low female labour force participation and poor returns to female education. Thus, female education is a non-monetary rather than a monetary trait. On one hand, a better educated bride brings down the household cost of production and is positively associated to household utility per unit of cost. On the other hand, education levels of bride are negatively associated with dowry payments. A rise in female education would have countering effects on groom's household utility. A household would find positive assorting optimal if the efficiencies in household cost with female education outweighs the fall in dowry. We propose a theoretical model to explain empirical results. The results for India using IHDS-II data suggest existence of positive marital assortative mating based on education. Education levels of groom and bride are reinforcing in reducing household costs but have offsetting effects on dowry. We derive instrumental variable estimates to address potential endogeneity.

Keywords: Female Education, Dowry, Marriage, Assortative Mating, Instrumental Variable Estimates

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1. Introduction

Marriage is an inter-household social arrangement with an objective to maximise household utility. In a typical production function framework, household utility is a function of both monetary and non-monetary traits of the individuals and the households. Monetary traits such as wages are associated positively to household income and utility. On the contrary, non-monetary traits in terms of years of schooling, physical attributes and cognitive abilities determine efficacy in a household's cost of production. These characteristics though do not contribute to household income and assets directly, but raise the 'household output to cost ratio' with a reduction in the total cost of production. The ability of husband and wife measured through, for instance, education, cognitive skills and communication skills leads to time and effort reduction in production and generates synergies with increasing returns to scale. A household hence achieves greater utility with partners in the marriage market from a higher ability distribution.

In theory, household characteristics are also shown to be a strong predictor of marital assortative mating. Marital assortative mating is defined as 'who marries whom'. Marital choices are based on individual and household characteristics such as education, income, physical appearance, etc. When individuals choose to marry from their own characteristic distribution, for example, a tall individual finds it optimal to marry someone who is also tall, is known as positive assortative mating. On the contrary, if a male with high wage finds it optimal to marry a female with lower wages, such that the male has a competitive advantage in labour market and female in managing household chores and children, this is known as negative assortative mating. Different individuals may find positive or negative assortative mating on a given trait optimal, depending upon how the trait enters into their utility function. Literature provides evidence of a strong positive association between household assets, age of the couples, height, etc. Rosenzweig and Stark (1989) show that household wealth and variation in risks to income determine the quality of marital matches. Deolalikar and Rao (1992) in empirical estimates from south-central India find a positive association between individual and household characteristics in marital sorting.

This paper studies marital assortative mating based on female years of schooling in developing countries with reference to Becker's (1991) model on theory of marriage. Literature on

assortative mating in education argues that men choose to marry females with higher education in expectation of increased household income. However, in developing countries such as India, where female labour force participation is as low as 27 percent (Census of India, 2011), with poor female literacy and low returns to female human capital investment, an explanation for positive assortative mating based on education lies beyond the wage market. This means that men with higher education see benefits other than future wage income from marrying females with greater years of schooling. Assortative mating in education may also reflect non-monetary returns to human capital. Potential brides with higher education bring down the cost of household production and contribute positively to household production, per unit of cost. High education level of potential bride adds positively to household utility as a non-monetary rather than a monetary trait.

Besides individual characteristics, marital choices are also determined by strong social and cultural norms. Marital decisions involve strong parental controls and marital transfers such as 'dowry', an important determinant of post-marital household utility levels. Dowry is the inter-household transfer in cash or kind from the bride's family to the groom's family. It could also be the excess of net marriage expenses born by the bride's family. To the best of our knowledge, the literature so far does not assess the impact of female education on marital sorting due to changes in relative bargaining powers of potential grooms and brides reflected in average dowry exchanges. In India, which is characterised by patriarchal norms, groom price or dowry exists as a social culture. In economic theory, dowry in the marriage market is perceived as an equilibrating mechanism to compensate for the differences in the characteristics of the bride and the groom (Anderson, 2007). Any changes in the education level of females would alter the ability gap between the potential groom and the bride. This would affect the marital transfer equilibrium levels and assortative mating decisions. Marital assortative mating outcome of female education would thus be a net effect of positive marginal utility with reduction in cost of household production and fall in marginal utility with fall in dowry.

There are four main aims of this paper. First, we study the presence of assortative mating by looking at the association between years of schooling of husband and wife in India, using data from India Human Development Survey II (IHDS-II). This is an important study for India with historical patriarchal norms and female gender biases, to see how female human capital

investment is perceived in the marriage market. A positive association would indicate societal preferences for higher educated brides. This would have further implications for socio-economic outcomes such as intra-household asset sharing, gender parity and household decisions. On the other hand, if the association is negative, it would indicate absence of net positive utility from bride's education levels in marital ties and a disincentive to invest in female education. Second, we study if assortative mating on education differs for districts with and without prominence of dowry. This may be true because dowry exists as a social norm in India and may be correlated with assortative mating choices. Districts with higher prominence of dowry may view bride education and dowry income as substitutes, such that high amounts of dowry could substitute for lower bride's schooling years. Marital assortative mating outcomes should be weaker in such districts. Third, we study the complementarities or substitutability between spousal education levels and their association with dowry expenditure. If an educated bride's family is willing to pay a higher dowry for a higher educated son-in-law, there would exist complementarities in the bride and groom education levels, and would have a positive association with dowry transfers. However, if the bride's family is less willing to pay a dowry because the daughter is educated or the groom's family is willing to accept a lower dowry for an educated bride, husband and wife schooling years are substitutes in dowry. In this case the marginal increase in dowry transfers with groom's education would fall with incremental education years of wife. Fourth, we propose a basic theoretical model to explain the scenarios under which positive or negative assortative mating would be an ideal outcome.

There are several papers that study the association between husband and wife's level of education. Most of the literature argues that assortative mating based on education is determined by the labour market returns and monetary yields of human capital investment. Pencavel (1998) states that assortative mating by schooling strengthened since 1960. The paper attributes the increase in similarity of schooling levels mainly to increased work opportunities for females. Greenwood et al. (2014) find similar results where Kendall's τ rank correlation[i] between the education of husband and wife is increasing between 1960 and 2005.

Average monetary returns to education however may not completely account for assortative mating patterns in developing nations. Female education is a human capital endowment with substantial non-monetary benefits besides labour market returns in terms of raising children,

their education, health and sanitation, support to household, financial and social decisions. Mother's schooling has been shown to have substantial positive effects on children's schooling. The effects have in fact been found to be larger than father's schooling (Qian, 2008; Behrman, 1997).

Theoretically, assortative mating decisions could be analysed in the framework provided by Becker (1991). The model states that 'who marries who' is a function of joint marginal effect of traits of potential grooms and brides and their respective households. If the traits are complementary which means they offer increasing returns to scale in the household production, a household would find positive assortative mating to be desirable. Negative assortative mating in the marriage market may also be an ideal strategy if the traits of potential groom and bride are substitutes to each other.

This paper suggests that education as a trait for potential brides and grooms may act as substitute in the wage market if years of schooling are a marketable characteristic, with similar returns in education to both male and female. In this case, both husband and wife may want to allocate more time in the labour market vis-à-vis household chores. This would make positive assortative mating unlikely owing to substitution effects in education in the labour market. This argument gains support from Gihleb and Lang's (2016) study for the US where the estimates show that the educational homogamy has not increased in the country, thereby suggesting that male and female do not find it optimal to marry in similar educational distribution due to the presence of potential substitutability in labour work hours. In countries such as India, where market returns to female education are substantially poor and female workforce participation is as low as 27 percent and even lower for married women, i.e., 20 percent (Census of India, 2011), there exists a strong case for a nearly perfect segregation of roles between husband and wife in market and household work, respectively[ii]. This should generate complementarities in education levels of husband and wife, husband with a higher marginal productivity in labour market and wife in household activities with additional years of schooling.

Societies based on patriarchal norms allocate higher weightage to female household roles, rearing of children and attach social stigma to female wage labour. If the husbands have a comparative advantage in labour market and wives in managing household and children, years of

schooling generate complementarities in marital ties in such socio-economic environment. Boulier and Rosenzweig (1984) provide evidence for Philippines where with low female labour force participation, there exist positive payoffs for positive assortative mating in the presence of education as a human capital endowment with non-monetary returns. In contrast, Dalmia and Lawrence (2001) find that age was a stronger predictor of assortative mating in India, and education in the US. However, Anukriti and Dasgupta (2017) in a review of literature on economics of marriage market outcomes in developing countries observe strong homogamy in education. Empirical support on positive assortative mating in education in countries with very low female workforce participation indicates the presence of non-monetary benefits of education for households.

This paper further recognises the association between female education and dowry, and its impact on assortative mating. Dowry may amount to a significant proportion of household wealth as a one-time transfer. Such inter-household transfers act as income insurance in low income countries (Rosenzweig and Stark, 1989). Anderson (2003) shows that with an increase in the average income and modernisation, there is a decline in average dowry payments. However, in India, where there exists caste hierarchy and diversification in the share of social and economic power, modernisation and rise in income is shown to have led to an increase in dowry payments. Rao (1993b) in estimating the rising groom prices in South-Central India shows that dowry transfers rise with the widening gap in bride and groom characteristics such as age, height, land ownership and years of schooling. However, Edlund (2000) in a comment to Rao (1993b) argues that individual traits provide a better fit to dowry estimation as compared to the difference in traits. A positive shift in the potential brides' ability distribution and rise in female education is expected to raise female bargaining power in the marriage market. Sweeney and Cancian (2004) find significant results of a shift in marriage market equilibrium in favour of women with increased earning potential in the US. Therefore, a relative change in the characteristics of the potential brides and grooms either through education, workforce participation or other traits is believed to alter marriage market outcomes in terms of assortative mating and dowry. Anderson's (2007) model derives dowry as an equilibrating factor in the marriage market for gaps in characteristics of the potential groom and bride. The larger is the gap in desirable traits, the higher is the dowry payment.

According to this paper, dowry may compensate for lower education levels of the potential bride. In the presence of low labour market returns to female education and substitutability between dowry and years of schooling, negative assortative mating in years of schooling may be an ideal outcome for the households. However, in the presence of non-monetary human capital endowments that generate positive marginal utilities in household production, positive assortative mating may be optimal if this effect is stronger than the substitution effect between female education and dowry. There exists a trade-off between dowry and household cost reduction with rise in female education. This paper provides a simple theoretical model for assortative mating based on education in the presence of countering effects through dowry and efficiency in household costs. Empirical support on positive assortative mating suggests that positive marginal productivity of female education outweighs the negative effects of dowry substitution.

Given a comparative advantage in female education as a non-monetary rather than a monetary trait in developing nations, we test the proposition that brides and grooms with higher schooling marry with potential mates from a similar ability distribution. Household efficiency of female education is higher than the marginal fall in dowry. The results may however be weak or in contradiction for districts with greater prominence of dowry. The substitutability between female education and dowry may be stronger where dowry persists as a strong social norm. We derive empirical estimates from IHDS-II, 2011 data, a household level survey for the districts of India. The results lend support to our hypothesis. Empirical findings are supported through a basic model of optimal marital sorting decisions with effects through dowry.

Following the introduction, rest of the paper is organised as follows: theoretical model is discussed in section 2; data and empirical strategy are provided in sections 3 and 4 respectively; section 5 discusses the empirical results and validation tests; and conclusive comments are provided in section 6.

2. Theoretical Model

This section provides a basic theoretical model to explain marital assortative mating based on education and presence of dowry. This model is based on Becker's *Assortative Mating in Marriage* (1991) paper which suggests that a household maximizes production per unit of cost

subject to the budget constraint. The proposed model derives conditions under which positive or negative assortative mating would be optimal based on education and in the presence of marital transfers, such as dowry. In this case, groom's household is the decision-making entity that maximizes household production and determines whether to seek a bride with high education or less education, relative to the education levels of the groom. Due to the data limitations, household production function of the bride's family is not considered in this model.

The groom's household utility function is defined as a function of m market goods and services; x_i, and leisure; t_j of each male individual, j. The model assumes that only males participate in the wage market. Therefore, there is no division of time of females between leisure and labour work.

Household Production Function

$$Z = f(x_1, \dots, x_m; t_1, \dots, t_j) \qquad (1)$$

where,

x_i: various Market Goods and Services; $\quad i = 1 \dots . . m$

t_j: leisure hours of male members; $\quad j = 1 \dots . . n$

The household is constrained on budget such that the total expenditure on consumption goods and services, x_i, with price vector p cannot exceed the sum of income from labour l_j at a wage rate w_j for each male individual j in the household, property income v (given and constant) and dowry, D. Dowry is assumed to be a one-time inter-household transfer and adds to the income of the post marital household (groom's household). Dowry is a function of male and female education in the post-marital household, S_m and S_f respectively.

Budget Constraint

$$\sum_{i=1}^{m} p_i x_i = \sum_{j=1}^{n} w_j l_j + v + D(S_m, S_f); \qquad (2)$$

where,

p_i: price of market goods and services

w_j: wages of male individual j

l_j: work hours of male individual j

v: property income

D: dowry

S_f: Education of female, Bride

S_m: Education of male, Groom

Time Constraint

$$l_j + t_j = T, \quad \forall j \qquad (3)$$

Substituting equation (3) in (2), the goods market and time constraints can be represented as a full income constraint:

$$\sum_{i=1}^{m} p_i x_i + \sum w_j t_j = \sum w_j T + v + D(S_m, S_f) = I \qquad (4)$$

where I stands for full income achievable with w_j as given in a perfectly competitive labour market.

In developing nations characterised by low female workforce participation and poor returns to female education, there exists division of work roles between males and females. Males take up larger roles in the labour market and females in household activities. The model therefore assumes that men participate in the labour market and females' education and other traits are non-monetary in nature. It is also assumed that wages are competitive across labour markets such that, $w_j = w$.

2.1 Household Cost of Production

Household production necessitates the employment of inputs in the production process. The household output is the amount of goods and services it could consume, assets it could raise and the quality of children it could rear. Children could be considered as consumption goods that generate positive utility with inputs required in terms of time and effort. Costs would involve

time, effort and human capital required in the process of production. Cost of household production is a function of prices of consumption goods and education levels of household members. Rise in prices makes consumption expensive, raising the opportunity cost of leisure and cost of household production. Education raises individual efficiency through increased marginal productivity in production and affects outcomes such as health and child education positively leading to lower costs of household production.

$$C = C(p, S_m, S_f) \quad (5)$$

Due to improved efficiency with education, marginal cost of the household is assumed to be decreasing in the education of both male and female such that:

$$\frac{\partial C}{\partial S_m} \equiv C_m < 0$$

$$\frac{\partial C}{\partial S_f} \equiv C_f < 0$$

The household production could be represented as a proportion of household production to costs.

$$Z = \frac{Full\ Income}{Average\ Cost\ of\ Production} = \frac{\sum w_j T + v + D(S_m, S_f)}{C(p, S_m, S_f)}$$

$$= \frac{I}{C(p, S_m, S_f)}$$

The greater is the production per unit of cost, the higher is the utility of the household. As is evident from the household income per unit of cost, the education of the potential groom (S_m) and bride (S_f) impacts household production function both via a change in dowry income and a fall in the cost of household production. Education therefore enters the model as a non-monetary trait, such that it affects the household output to cost ratio only via reduction in the household cost of production and dowry, a one-time marital transfer. Labour market is assumed to be perfectly competitive. Wages are assumed to be independent of education. A rise in male education raises the groom-price in the market with a corresponding increase in dowry transfers. Higher male education simultaneously brings down the cost of household production. The total effect of increase in male education is thus positive on household production per unit of cost.

However, a rise in female's education increases bargaining power in the marriage market and leads to fall in dowry transfers. This causes opposing effects on the production to cost ratio. On one hand, the groom's household would see a fall in dowry with rise in female education, reducing the post-marital income. On the other hand, an educated bride would lead to a fall in cost with positive effects on per unit returns. The net effect of female education on household production per unit of cost is thus ambiguous. Mathematical explanations for the same are provided in the following sub-sections.

2.2 Impact of Education on Total Output

To study the effect of education levels of bride and groom on household production per unit of cost, we derive the first order partial derivatives. It is to be noted that education level of the bride is her education status at the time of marriage. We assume that the household decision on assortative mating based on education is not on investing in the education of girl after marriage, but on choice of a female with a given level of education among potential brides (with different education levels) in the marriage market.

First Order Partial Derivatives

A marginal increase in groom's education leads to an unambiguous rise in the production function.

$$\frac{\partial Z}{\partial S_m} = \frac{\partial [IC^{-1}]}{\partial S_m}$$

With the assumption of constant wages in the labour market, education impacts total achievable income I, only through the effect on dowry.

$$\frac{\partial I}{\partial S_m} = \frac{\partial D}{\partial S_m} = D_m$$

$$\frac{\partial I}{\partial S_f} = \frac{\partial D}{\partial S_f} = D_f$$

Therefore,

$$\frac{\partial Z}{\partial S_m} = \frac{\partial \left[D(S_m, S_f)C^{-1}\right]}{\partial S_m}$$

$$= \frac{\partial D}{\partial S_m} C^{-1} - C^{-2} D(S_m, S_f) \frac{\partial C}{\partial S_m}$$

$$D_m - C^{-1} C_m D(S_m, S_f) > 0 \qquad (6)$$

The result from equation 6 would hold with the underlying assumptions of rise in dowry and fall in household cost with male education respectively. This implies $D_m > 0$ and $C_m < 0$. Further, dowry that is the net transfer from bride's family to groom's family is (always assumed to be) positive such that $D(S_m, S_f) > 0$. A rise in male education therefore causes a definite positive effect on household income. Therefore, investment in human capital of sons leads to an unambiguous increase in household utility.

This could also be written in terms of elasticities:

$$\tau_m - \omega_m > 0 \qquad (7)$$

(Derivation in Appendix A.1)

where $\tau_m = \frac{\partial D}{\partial S_m} . \frac{S_m}{D}$ and $\omega_m = \frac{\partial C}{\partial S_m} . \frac{S_m}{C}$

where $\tau_m > 0$ and $\omega_m < 0$

Therefore, the total output would rise with male education if the male education elasticity of dowry (τ_m) and elasticity of household cost (ω_m) together cause equation 7 to be positive (which would always be the case since, $\omega_m < 0$). An increase in human capital investment by the male counterpart unambiguously leads to an increase in household production, both through an increase in dowry that adds to the income of the groom's household and a decrease in the cost of household production.

Similarly, the marginal effect of female's education would result in an increase in total household output if:

$$D_f - C^{-1} C_f D(S_m, S_f) > 0$$

i.e.

$$\tau_f - \omega_f > 0 \quad (8)$$

By assumption, since $\tau_f < 0$, thus the total output of the household would increase with female education, if the proportionate fall in household costs is greater than the proportionate fall in dowry.

$$|\omega_f| > |\tau_f| \quad (9)$$

The independent effects of male and female education on household production are easy to interpret. The model shows that a household always gains from investing in male's education since household utility is positive in both dowry and cost reduction. A female's education on the other hand leads to countering effects with a negative impact on dowry income and positive on cost reduction. Thus, there exists a trade-off in decisions on the education level of potential brides. A household would be more acceptable of a bride with higher education if the efficiency gains in cost outweigh the loss in dowry component (We derived the optimal levels of education of the groom and bride by optimizing the groom's household production function. The derivations are shown in appendix A.4)

Assortative mating

Mate seeking in the marriage market is a function of different characteristics of the potential grooms and brides and their respective households (Given the objective of the model, it is assumed that the characteristics of the households such as wealth, location, etc. are similar across the households). On one hand where the household production is monotonic and increasing in education of males, assortative mating, i.e., who marries whom amounts to joint marginal effects of education on household production. As Becker (1991) explains in the paper, if increasing both S_m and S_f increases the total output, Z, by the same amount, as the sum of addition when each is increased separately (in the presence of constant returns to scale, CRS), all sorting of male and female would give same total output, Z. However, with increasing returns to scale (IRS), sorting of large S_m with large S_f and small S_m with small S_f would give greatest total output. Mathematically, positive assortative mating in education, mating of likes (high educated marry the high educated and those with lower levels of education marry the ones with lower education) is desirable if $\frac{\partial^2 Z(S_m, S_f)}{\partial S_m S_f} > 0$. And negative assortative mating of un-likes is desired

if $\frac{\partial^2 Z(S_m,S_f)}{\partial S_m S_f} < 0$. A household would gain from positive assortative mating in education of male and female if the traits act as complements. Men with higher education would seek better educated spouses if the efficiencies achieved with higher bride's education in cost, outweigh the fall in dowry. Dowry may increase with the education level of both male and female if the parents of the bride are willing to pay a higher dowry to secure a groom with higher education than the daughter's. Given the cultural norms in developing countries such as India, it is preferred to marry a boy with higher traits such as education, income, etc. as compared to the bride.

Dowry compensation by the bride's family may offset the cost inefficiencies associated with lower education levels of the girl. In such scenario, households find negative assortative mating as the desirable strategy. The marriage market would thus witness larger gaps in the education levels of husband and wife.

The cross partial effects of male and female education would determine whether marriage sorting would be positive where males and females seek potential partners from similar ability distribution or different. Positive marriage sorting would require the cross partial derivative of Z to be positive, such that there exists increasing returns to scale in education levels of male and the female education. Negative sorting would be an ideal decision for a household if education of husband and wife are substitutes and generate offsetting effects in household production.

Second Order Cross Partial Derivatives

$$\frac{\partial^2 Z}{\partial S_m S_f} = C^{-1}D_{m.f} - C^{-2}D_m C_f - C^{-2}C_m D_f + 2C^{-3}C_m C_f D - C^{-2}C_{m.f}D \qquad (10)$$

(Derivation in Appendix, section A.2)

$$D_{m.f} = \frac{\partial\left(\frac{\partial D}{\partial S_m}\right)}{\partial S_f}$$

$$C_{m.f} = \frac{\partial\left(\frac{\partial C}{\partial S_m}\right)}{\partial S_f}$$

Since $C^{-1} > 0, D_m > 0, D_f < 0, C_m < 0 \; and \; C_f < 0,$ thus the effect of female education on marriage sorting would depend upon the relative magnitude and signs of $D_{m.f}$ and $C_{m.f}$

Education may have either reinforcing or offsetting effects on household cost of production and magnitude of dowry. The cost effects are reinforcing if the education of male and female act as complements, such that $C_{m.f} < 0$. However, such costs could be offsetting if the household costs of production fall at a decreasing rate, such that $C_{m.f} > 0$. For example, if a male is not competitive at managing household chores or children's education, marrying an educated female with higher efficiency in household activities would bring down the household cost of production at a greater rate. However, if education makes a male better in managing household chores or children's education, then an educated female with similar traits would act as a substitute. The costs though would fall due to the individual effect of female's education, but the rate of fall would be lesser.

Under the assumption of dowry as an equilibrating factor in the marriage market, the magnitude of dowry should fall with the rise in female education, i.e., $D_f < 0$. The marginal effect on dowry however with changes in both male and female education is less obvious. If male and female education are substitutes in dowry, an increase in male and female education would cause second order partial effect on dowry to be negative. Education would have offsetting effects such that $D_{m.f} < 0$. However, if the two are viewed as complements, the market would witness an increase in dowry with the education level of the groom and the bride. Though on an average, dowry may fall with the education level of the female, yet an educated female may be willing to pay a higher dowry for a better educated male. Female education may therefore generate complementarities in the marriage market for dowry such that $D_{m.f} > 0$.

The outcome of positive and negative sorting in the marriage market would suggest whether the household costs and dowry are offsetting or reinforcing in the education trait of potential grooms and brides.

Case I: Offsetting household cost and dowry in education of male and female, $C_{m.f} > 0$ and $D_{m.f} < 0$

In this case, equation 10 suggests that households in the marriage market would find positive sorting to be desirable, i.e.,

$\frac{\partial^2 Z}{\partial S_m \partial S_f} > 0$, if

$$2C^{-2}C_m C_f D - C^{-1}D_m C_f > C^{-1}C_{m.f}D + C^{-1}C_m D_f - D_{m.f} \quad (11)$$

This could also be written as

$$2\omega_m \omega_f - \tau_m \omega_f > \omega_{f.m}\omega_f + \omega_m.\tau_f - \tau_{m.f}.\tau_m \quad (11')$$

where $\tau_m = \frac{\partial D}{\partial S_m}\frac{S_m}{D}$; $\omega_m = \frac{\partial C}{\partial S_m}\frac{S_m}{C}$; $\omega_{f.m} = \frac{\partial C_f}{\partial S_m}\frac{S_m}{C_f}$; $\tau_{m.f} = \frac{\partial D_m}{\partial S_f}\frac{S_f}{D_m}$

(Derivation in Appendix, Section A.3)

Under the assumptions of falling marginal costs in education ($C_f < 0, C_m < 0$) and rise in dowry with male education ($D_m > 0$), the left side of equation 11 is always positive. If the costs are offsetting such that $C_{m.f} > 0$, the marriage market can still achieve positive sorting where the likes get sorted in equilibrium if the multiples of direct effects of fall in cost and rise in dowry with male education are stronger than the offsetting effects on cost and dowry. This would be true if the individual efficiencies in cost achieved with higher education are stronger than the offsetting effects on both cost and dowry. If the bride individually is able to bring down the household costs to an extent that it compensates both for the loss in dowry and any substitutions in the cost reductions from male education, positive assortative mating would be ideal even with offsetting education effects on costs and dowry. If direct elasticities of cost are greater than cross elasticities of cost and cross elasticities of dowry in male and female education, then positive assortative mating would be desirable for a household.

Case II: Offsetting household costs and reinforcing dowry effects in education of male and female, $C_{m.f} > 0$ and $D_{m.f} > 0$

With $C_{m.f} > 0$ and $D_{m.f} > 0$, households in the marriage market would find positive sorting to be ideal, i.e.,

$\frac{\partial^2 Z}{\partial S_m \partial S_f} > 0$, if

$$2C^{-2}C_m C_f D - C^{-1}D_m C_f + D_{m.f} > C^{-1}C_{m.f}D + C^{-1}C_m D_f \quad (12)$$

This could also be written as

$$2\omega_m \omega_f - \tau_m \omega_f + \tau_{m.f}.\tau_m > \omega_{f.m}\omega_f + \omega_m.\tau_f$$

The result of positive assortative mating gets strengthened when the dowry effect is reinforcing. Dowry effect may be reinforcing, i.e., dowry increases with the education of male and female together, with the willingness to marry daughter to a higher educated groom. Increased female education levels may also translate into higher ability to make dowry payments with increased probability of workforce participation. The household would achieve higher output with an increase in education levels of both the groom and the bride if the individual cost reducing effects and reinforcing dowry effects are stronger than the joint offsetting effects on cost.

Case III: Reinforcing household costs and offsetting dowry effects in education of male and female, $C_{m.f} < 0$ and $D_{m.f} < 0$

With $C_{m.f} < 0$ and $D_{m.f} < 0$, households in the marriage market would find positive sorting to be desirable, i.e.,

$\frac{\partial^2 Z}{\partial S_m \partial S_f} > 0$, if

$$2C^{-2}C_m C_f D - C^{-1}D_m C_f - C^{-1}C_{m.f}D > C^{-1}C_m D_f - D_{m.f} \quad (13)$$

This could also be written as

$$2\omega_m \omega_f - \tau_m \omega_f - \omega_{f.m}\omega_f > \omega_m.\tau_f - \tau_{m.f}.\tau_m$$

It is possible that an increase in male and female education may have reinforcing effects on the cost of production where the education traits act as complements. However, with a rise in female education, not only does the dowry fall, but witnesses an offsetting effect. This is generally true as females begin to achieve a higher socio-economic status such that males, specifically the more educated, are willing to accept lower dowry for a girl with higher education. In such a scenario, for positive assortative mating to be an optimal outcome, it is required that the fall in costs—both direct and cross—should be high to overcome the fall in dowry with a rise in female education and the corresponding offsetting effects.

Case IV: Reinforcing household costs and dowry effects in education of male and female, $C_{m.f} < 0$ and $D_{m.f} > 0$

With $C_{m.f} < 0$ and $D_{m.f} > 0$, the households in the marriage market would find positive sorting to be ideal, i.e.,

$\frac{\partial^2 Z}{\partial s_m \partial s_f} > 0$, if

$$2C^{-2}C_m C_f D\ - C^{-1}D_m C_f - C^{-1}C_{m.f}D + \ D_{m.f} > C^{-1}C_m D_f \qquad (14)$$

This could also be written as

$$2\omega_m \omega_f - \tau_m \omega_f - \omega_{f.m}\omega_f + \ \tau_{m.f}.\tau_m > \omega_m.\tau_f$$

In a scenario where both the household costs and dowry are reinforcing in male and female education, positive sorting would have a stronger likelihood. In a country such as India, dowry is a cultural norm. Though it may vary and be determined by various factors, with the patriarchal structure and poor socio-economic status of females, a positive groom price is a social standard. On one hand where a rise in female education may lower the dowry component on average, the parents of the bride may be willing to pay a higher dowry for a better, higher educated groom. Bringing a bride with higher education in the family would thus add to the household production, both by reduction in cost and a rise in dowry.

The theoretical model of marital assortative mating and dowry suggests that:

a. Female education contributes positively to household utility as a non-monetary trait.
b. There exists a potential trade-off and substitutability between dowry and female education.
c. In patriarchal societies where dowry exists as a cultural norm, marital choices are governed by differences in marginal utilities between education and dowry.

3. Data

With an objective to examine marriage market sorting and marital decisions on the education level of potential grooms and brides in India, this paper uses household level data from IHDS-II and Census of India. We use data from IHDS-II data available for the year 2011. IHDS-II is a nationally representative, multi-topic survey of 42,152 households across India for 2011-12. The survey gathers extensive details on variables related to health, education, employment status, marriage and other components that are important indicators of economic and social well-being. This paper maps data at the level of household, individual (belonging to the given household) and eligible women[iii] (of the household). The data set on eligible women provides variables on education of the married woman, education of husband, age, expectation of expenses borne on marriage by the groom and the bride side and other forms of gifts received from the community in marriage. These variables are used to assess assortative mating decisions on education and variations in dowry with female education. Factors such as household income and average education level in the household are mapped from the household data. These variables are used as controls since they may play an important role in selection of bride. For example, a household with a higher education on average would prefer an educated bride. Further religious affiliation and caste categories[iv] are also taken from the household data.

Marital decisions of an individual or a household are also governed by the socio-economic environment. Prominence of dowry and sex ratio (males per 1000 males) at the district level are used to control for this and taken from the Indian Census, 2011. Marriage expenditure net of expenses by the bride and groom's family provides for a close proxy of dowry. Marital expenditure by the groom's family was based on the following question from the head of the

household, *"At the time of the boy's marriage, how much money is usually spent by the boy's family?*" Similarly, expenditure by the bride's family was based on the following question, *"At the time of the girl's marriage, how much money is usually spent by the girl's family?*" Dowry was calculated as the difference of average expenditure incurred by the bride and the groom's family. To avoid measurement bias due to differences in cost of living across states, the calculated dowry was weighted by consumer price index of each state in 2011.

Marital expenditure however may not be a good measure for dowry prominence in a district. Marriage expenditure may be determined by other factors also such as ability to pay and preferences of individuals besides the norms of the society on marital transfers. Dowry prominence was therefore generated as a dummy from proportionate number of dowry deaths in 2011 in a district based on data provided by National Crime Records Bureau (NCRB). Dowry deaths provide a good proxy for the prominence of dowry in a district, since it is likely to be reported with a high probability and with greater accuracy. Amount of dowry paid is highly probable to be misreported and with a lesser likelihood. A district is defined as more intensive on dowry culture if the percentage of dowry deaths exceeds 1.5 (average percentage of dowry deaths)[2]. Education levels of the husband and wife are measured as years of education completed.

The descriptive statistics for the variables from IHDS-II and Census 2011 are represented in Table A.1 in appendix. The descriptive statistics suggest that on an average, husbands are more educated than the wives. The net expenses borne on wedding by the bride's family are positive, indicating positive groom price and marital transfers from the bride to the groom's family. This may owe to relatively poor education levels and socio-economic status of the females in the country. On an average, the statistics are representative of sex ratio biased towards males, showing 1098 males as compared to females in the age group of 10-16 years old. Statistics also indicate high dispersion in the number of high schools across districts. Dowry deaths as a percentage of married females in a district range from 0 to 8.4 percent. On an average, the districts in India witness approximately 1.5 percent of dowry deaths as a proportion of married girls. Scatter diagram on the education level of husband and wife in Figure 1 shows a strong

[2] Dowry deaths may be due to weaker institutional arrangements, such as poor governance, weak criminal institutions, greater tolerance to violence against women and could influence the results. However, given the paucity of data, this is the best available proxy as a measure for dowry prominence in a district.

positive association between the two variables. Potential grooms and brides are likely to choose from their own education (ability) probability distribution.

Figure 2 provides an overview of state-wise average net expenditure incurred by the bride's family. The figure suggests large regional variation in the net marital expenditures borne by the bride side of the family. A closer look at the numbers is indicative of least dowry transfers in the north-eastern states of India such as Nagaland, Mizoram, Sikkim, Assam, etc. These states are also known for an above average level of women representation and independence. On the contrary, states from southern India such as Kerala, Tamil Nadu, Karnataka, etc., though possess highest standards of women literacy levels and women workforce participation, rank highest in dowry payments.

Region-wise and state-wise dot plot in Figure 3 provides an overview of the association between average dowry payments and years of schooling of the husband and wife. Dowry payments are seen to be higher in states with higher levels of husband education and lower levels of wife education. For example, Himachal Pradesh and National Capital Territory of Delhi in north both show similar husband years of schooling on an average. Dowry is however higher in Delhi with lower level of wife's education.

4. Identification Strategy

To study the association between female education, marital sorting and dowry payments, the paper estimates the following specification for individual i in household h in state s, district d belonging to religion r and caste c

$$Education\ Wife_{ihd} = \alpha + \beta_1 Education\ Husband_{ihd} + \beta_2 Dowry\ District_d + \beta_3 Education\ Husband_{ihd} * Dowry\ District_d + \gamma_h X_h + \gamma_d X_d + \delta_{rh} + \delta_{ch} + \delta_s + \varepsilon_{ih} \quad \text{(e1)}$$

where $Education\ Husband_{ihd}$ denotes the education level of husband (of the surveyed married female i) in household h.

β_1 is a measure of assortative mating on education levels of husband and wife. A positive estimate of β_1 would indicate positive assortative mating where a household finds it ideal to

marry potential grooms and brides with similar education levels. β_2 measures the difference in education level of brides in districts with greater prominence of dowry. Estimate of β_2, if positive, would indicate greater investment in daughters' education in dowry prevalent districts in expectation of lower dowry payments at the time of marriage for a better educated bride. Estimate of β_2 may be negative, if female education expenditure is substituted with savings for future dowry payment.

β_3 estimates the differential outcome on marital assortative decision of male education in districts with greater dowry prominence. This could be either positive or negative. Districts strongly driven by norms of dowry may exhibit a positive β_3 that would suggest stronger assortative mating in marriage market in dowry prevalent districts. In this case, dowry and female education are complements, such that higher dowry is paid to seek a better educated groom for a bride with higher education. If dowry and female education are substitutes, β_3 would be negative that indicates males with higher education find it desirable to substitute education of potential bride in compensation of dowry.

X_h and X_d are the household and district level controls such as income levels in the household, age gap of husband and wife, and urbanisation rate. δ_{rh}, δ_{ch} and δ_s are the fixed effect controls for religion and caste of a household and state fixed effects, respectively.

Ordinary Least Square estimates may pose potential endogeneity bias due to omitted unobserved factors that may together determine the education levels of husband and wife. To circumvent this problem, we use instrumental variable strategy and instrument husband's years of schooling with his mother's years of schooling. Existing studies show that the education level of mothers is positively and significantly associated with the education level of children (Rihani, 2006; De Coulon et. al., 2008). Husband's mother's years of schooling is derived from the "Eligible Woman" questionnaire for married females in the age group of 15-49 years. An eligible woman's response to mother-in-law's education is recorded from the question that asks, *"How many standards/class your husband's parents completed?"* (The response is recorded for mother and father separately).

The analysis further directly tests for the relationship between dowry and female education in the districts of India. The objective is to examine if dowry and female education are substitutes or

complements in marital decisions on education levels. β_3 coefficient in equation e2 directly tests for the association between female education and dowry.

$$Log(Dowry)_{hd} =$$
$$\alpha + \beta_1 Education\ Husband_{ihd} + \beta_2 Education\ Wife_{ihd} + \beta_3 Education\ Husband_{ihd} * Education\ Wife_{ihd} + \gamma_h X_h + \gamma_d X_d + \delta_{rh} + \delta_{ch} + \delta_s + \varepsilon_{ih} \quad \text{(e2)}$$

β_1 is expected to be positive since higher education of potential groom would reflect greater ability and hence would demand larger dowry. β_2 on the contrary is expected to be negative. A rise in the education level of potential bride would raise her bargaining power in the marriage market and hence would lead to a fall in the transfers made to the groom's family at the time of marriage. β_3 directly tests for the sign of D_{mf}, that is, how does dowry change with an additional year of education of both the groom and the bride. A positive estimate of β_3 would suggest complementarity in education levels for dowry, such that the bride's parents are willing to pay a higher dowry to seek a better ability husband for their daughters with higher education. If β_3 is negative, education levels of husband and wife are substitutes in dowry. With a positive β_1, though dowry may rise with male education, but the marginal increase is smaller with rise in female education with a negative β_3. The household is willing to substitute dowry for a bride with higher education.

Unobserved factors may cause potential endogeneity in both female and male years of schooling. The female years of schooling is instrumented with the number of high schools in the district. Number of high schools in the district are expected to be positively correlated with female education years and exogenous as they are unlikely to be correlated with dowry exchanged in the household. The estimation further exploits the education of groom's mother as an exogenous determinant of male education level (Bride's mother's years of schooling do not provide an exogenous determinant of her own education in a model that studies the association with dowry. The literature suggests that there exist strong inter-dependencies in a mother-daughter relation that may influence dowry exchanges through other factors besides daughter's education levels and hence may not be entirely exogenous) (Walker, Thompson & Morgan, 1987; Troll, 1987; Fischer, 1981).

5. Empirical Assessment

Table 1 shows results for equation e1. The results include controls for district and household specific characteristics that may impact the education level of the male in the family. Estimates on wife education are positive and highly significant which indicates positive assortative mating on education levels. Individuals tend to marry from their own ability distribution. The results are in consensus with the findings of Mare (1991) and Mancuso (1997) who show that it is unlikely for individuals with higher education levels to marry someone with a lower education. Qian (1998) found that highly educated males were more likely to marry females with lesser education whereas females with higher education were less likely to marry someone with a lesser education level.

We derive interesting results from the study of the interaction variable between the dowry district and husband's education. Though the estimates suggest a positive significant association between the education level of the husband and the wife, this association is weaker in the dowry prevalent districts as indicated by the negative significant effect of the interaction variable. The groom's family is willing to accept a bride with lower education level for higher dowry. From the perspective of the girl's family, there exist offsetting dowry effects in education since the parents of the bride, unable to secure a groom with higher education in dowry prominent districts, substitute their daughter's education for dowry. The results support King and Hill's (1993) statement, "In cultures where dowry is customary, securing a more highly educated husband for an educated woman would require a larger dowry – another hidden cost of educating females". If dowry and female education were complements, the positive assortative mating results should have strengthened in districts where dowry is highly predominant.

The results on positive association between husband and wife education, and substitution effects between female education and dowry indicate presence of reinforcing cost effects of male and female education. Since the overall estimates of marital assortative mating based on education is positive despite substitution effects in dowry, it suggests that the cost effects are reinforcing and stronger than the offsetting dowry effects.

Husband's years of schooling may be endogenous as the wife's level of education may determine the choice on husband's level of education. This means that a female with higher education may

choose to marry a male who is better educated and thus the causality may run in the reverse direction. Alternatively, husband and wife's education levels may be determined simultaneously by factors such as cultural norms, preferences, attitude and perception of individuals towards education. Wu-Hausman's F-statistic to test for the endogeneity of education level of husband is 685.43 and rejects the null of the variable being exogenous. The endogeneity is thus addressed using instrumental variable estimation as the identification strategy. Husband's mother's education is used as an IV for husband's own years of schooling. The results are directionally consistent with OLS estimates, which suggest that there exists a positive association between the education level of the husband and the wife. However, OLS estimates are found to have a downward bias.

It may be argued that husband's mother's education may not be entirely exogenous as the groom's mother's education level may influence decision on the education level of her son's future bride. However, statistics for a question in the 'eligible woman' survey, "Please tell me who in your family decides: To whom your children should marry?" show that in 74 percent of the cases, the decision is made mostly by the "husband". The respondent herself has a larger role only in 11 percent of the cases. Since females are less likely to make a decision on the marital choices for the children, it would be valid to assume that husband's mother's education is exogenous to the years of schooling of wife.

Table 2 shows the first stage estimates for instrumental variable estimation in Table 1. First stage estimates for effect of husband's mother's years of schooling on husband's schooling are shown in columns 1 to 3. The estimates suggest that men with mothers of higher education possess higher years of schooling. Husband's mother's education is significantly and positively associated with husband's education level and the overall F-statistic of the model is 1388.22, indicating that the overall model is highly significant. Anderson-Rubin Wald test F-statistic is reported at 838.64. The test rejects the null hypothesis of weak identification and suggests that the husband's mother's education is a relevant instrument for husband's own years of schooling. The instrument is statistically valid in the given model.

Estimates in Table 3 directly test the association between dowry and education levels of husband and wife. OLS estimates in columns 1 and 2 show a positive significant relationship between education levels and the amount of dowry exchanged. However, OLS estimates may be biased due to unobserved factors that may simultaneously affect the education level and dowry. Wu-Hausman F-statistic to test for exogeneity of wife's years of schooling is 29.6 and rejects the null hypothesis and indicates the presence of endogenous factors.

In column 4, instrumental variable estimates suggest that an additional year of husband's schooling is associated with a 1 percent rise in dowry. A rise in wife's schooling year on the contrary shows a fall in dowry by 0.21 percent. The estimates are consistent with the theory that postulates a rise in dowry with a rise in male education as a result of higher price for higher ability ($D_m > 0$). Dowry falls with female education as it raises the bargaining power of potential brides in the marriage market ($D_f < 0$). The coefficient for interaction between education levels of husband and wife tests for the joint marginal effect of additional years of schooling of the bride and groom on dowry. A negative estimate for the interaction term suggests that the marginal rise in dowry with male education is smaller with a rise in female years of schooling. In reference to the theoretical model, this negative coefficient indicates that dowry and female education are substitutes such that $D_{mf} < 0$.

These results provide credence to the assortative mating estimates in Table 1 that show that positive assortative mating result is weaker in dowry prominent districts. Since $D_{mf} < 0$, households tend to substitute female education with dowry, such that in districts where dowry is a strong social norm, females with lesser education get sorted with males of higher education. Dowry compensates for the lower education levels of the females (The analysis also aimed at directly testing joint effect of male and female education on the cost of household, $\mathrm{C_{mf}}$. However, directly testing this parameter requires time use variables to measure effort and time in relation to education levels. The data for the same is not available in IHDS-II). In India therefore, transfers at the time of marriage are significant determinants of marital assortative mating. Other variables included in the analysis are directionally consistent. Those residing in urban areas and households with higher income show larger dowry payments. Large differences in the age of husband and wife amount to lesser dowry payments.

First Stage estimates are presented in Table 4. The estimates show a strong positive association between the number of high schools in the district and wife's years of schooling. Association with other variables is also consistent in reference to the existing literature. In case of higher district sex ratio with a greater number of males, females achieve lesser years of schooling.

Estimates suggest that in households with urban residence and higher income, wives have higher education levels. Higher age difference between husband and wife is negatively correlated to wives' education level. Cragg-Donald F-statistic is reported at 12.32 which rejects the hypothesis of weak identification and suggests that the number of high schools is a relevant instrument for wife's years of schooling. The overall F-statistic of first stage model is 210.92 for wife's schooling and indicates the overall model being significant.

Robustness Tests

It may be argued that the results on positive assortative mating may be driven by females on the higher end of ability distribution, with higher years of schooling and in the workforce. In other words, marital assortative mating is driven by greater expectation of future wage income of wives. We derive estimates for assortative mating on education by excluding females *'who have ever worked for pay/wages'* and with years of schooling more than 10 years. The estimates in Table 5 provide association between years of schooling for husband and wife for a sub-sample where females either do not have sufficient education levels or have never generated any income, such that female education offers pure non-monetary benefits to the household. The estimates are consistent with the main specification, which suggests positive marital assortative mating in education, with results being weaker in districts with greater dowry prominence.

It may be argued that the instrumental variable estimates derived in Table 3, that directly tests for the joint association of husband and wife's years of schooling on dowry, may be driven by certain factors specific to individuals, household or the districts themselves. Robustness tests are presented in Table 6. Mother-in-law's schooling years are taken as an exogenous determinant of husband's education. Since dowry is measured as a perception of the head of the household, mother-in-law's education might not be completely exogenous if she herself is the head of the household. Models 1 and 2 therefore exclude households with female heads to remove

simultaneity between mother-in-law's education and dowry. The estimates are found to be significant and close to the coefficients in the main model.

Models 3 and 4 exclude women from analysis who belonged to a different town or city before marriage so that the instrument, i.e., 'number of high schools in the district' for wife's education level is relevant. The IHDS-II data does not provide information on the district of residence of females before marriage. If a large number of women belonged to a different district, the IV would be irrelevant. Including only those females in the analysis that belong to the same district before marriage ensures that the IV is relevant for the eligible women's education levels.

Models 5 and 6 exclude the outlier districts in dowry deaths to ensure that the results are not driven by extreme values. Excluding the districts that either have a history of almost negligible dowry deaths or a large percentage of dowry deaths, we exclude any biasedness in the results that may be caused due to strong cultural norms or social beliefs.

The estimates from the validation tests are consistent, significant and similar to the main model. It validates that dowry payments are significantly and positively associated to male education. However, the rate of increase is lesser with additional years of female education.

6. Conclusion

An empirical assessment of assortative mating and dowry with rise in the education level of females in India using IHDS-II data suggests significant positive assortative mating on female education. Estimates suggest that brides and grooms tend to choose partners from their own ability distribution. This association however is found to be weaker in districts with relatively higher percentage of dowry deaths. This paper proposes a basic theoretical model to support the empirical estimates. We suggest that a rise in female education would impact household utility or production through both a fall in dowry and reduction in cost of household production. On one hand, fall in dowry reduces the post-marital family income and hence utility and, on the other hand, a reduction in household cost of production would lead to an increase in household production, per unit of cost. A household should always gain from a rise in the education level of a male through both rise in dowry and fall in production cost, however, bride's education would have countering effects. Marital assortative mating decisions based on the education of potential

bride and groom together would be determined by the cross marginal effects of education on household production. Magnitude and direction of cross effects of male and female education on dowry and household costs would determine the net effect on assortative mating. A rise in education of male and female, together, may either lead to offsetting or reinforcing effects on cost and dowry. Effects would be reinforcing in cost if a rise in education of both the bride and the groom generates increasing returns to scale and cost falls at a faster rate. The cost effects would be offsetting in the presence of decreasing returns to scale. Dowry may rise with male education but the marginal increase may be smaller with rise in female education. This generates offsetting effects on dowry. On the other hand, dowry effect in education may be reinforcing. Parents of the bride may be willing to pay a higher dowry for a better educated husband as the daughter attains higher education. The model suggests that positive assortative mating would be desirable for a household if the efficiencies achieved in cost are greater than the loss in dowry with rise in female education.

The empirical results for India using IHDS-II data provide evidence of positive assortative mating and suggest that the cost effects outweigh the fall in dowry effect. The effect is however found to be weaker in dowry prominent districts. This indicates that as social and cultural norms of dowry strengthen, substitutability between dowry and female education also increases. The marriage market allows dowry to compensate for relatively low education level of the bride. The analysis directly tests for joint association between male and female education and dowry. The estimates show that the dowry payments rise with additional years of male schooling and fall with female education. The effect of male and female education interaction variable on dowry is negative, indicating that dowry increases with male education but at a decreasing rate in response to rise in female education. Households are willing to accept lower dowry payments for a better educated bride. Probable endogeneity bias is addressed through instrumental variable estimation where the ‘number of high schools’ in a district is used as instrumental variable for female education and ‘husband’s mother’s education’ as an instrument for ‘husband’s years of schooling’. The estimates are found to be robust to validation tests which exclude factors specific to individuals, households or districts that may have driven the results.

Notes

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[i] Kendall's Tau is a non-parametric rank correlation based on the similarity of ordering of data ranked on each of the quantities. Calculations are based on concordant and discordant pairs.
[ii] IHDS-II 'Eligible Women' survey data suggests that about 40 percent of women are not willing to work even if found a suitable job. And nearly 40 percent of females denied being allowed to work if found a suitable job.
[iii] Ever married women in the household in the age group of 15-49 years are surveyed in a face-to-face interview.
[iv] The Indian social system is characterised by the co-existence of multiple religious affiliations and hierarchy in castes with strong cultural and social beliefs that bear significant impact on socio-economic choices.
[v] We take a generic function of dowry with certain assumptions on the relationship of dowry with the years of schooling of groom and bride. Derivation of equilibrium dowry and equilibrium groom household income levels is out of the scope of this paper and an objective for further analysis.

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Appendix

A.1 Derivation of Equation (7) and equation (8)

$$\frac{\partial Z}{\partial S_m} = \frac{\partial\left[D(S_m, S_f)C^{-1}\right]}{\partial S_m}$$

$$= \frac{\partial D}{\partial S_m} C^{-1} - C^{-2} \frac{\partial C}{\partial S_m} D(S_m, S_f)$$

Household production would increase with male years of schooling if:

$$D_m - C^{-1} C_m D(S_m, S_f) > 0$$

Dividing both sides by D and multiplying by S_m

$$\frac{\partial D}{\partial S_m}\frac{S_m}{D} - \frac{\partial C}{\partial S_m}\frac{S_m}{C} > 0$$

$$\tau_m - \omega_m > 0$$

Where $\tau_m = \frac{\partial D}{\partial S_m} . \frac{S_m}{D}$ and $\omega_m = \frac{\partial C}{\partial S_m} . \frac{S_m}{C}$

Equation (8)

$$\frac{\partial Z}{\partial S_f} = \frac{\partial\left[D(S_m, S_f)C^{-1}\right]}{\partial S_f}$$

$$= \frac{\partial D}{\partial S_f} C^{-1} - C^{-2} \frac{\partial C}{\partial S_f} D(S_m, S_f)$$

Household production would increase with female years of schooling if:

$$D_f - C^{-1} C_f D(S_m, S_f) > 0$$

Dividing both sides by D and multiplying by S_f

$$\frac{\partial D}{\partial S_f}\frac{S_f}{D} - \frac{\partial C}{\partial S_f}\frac{S_f}{C} > 0$$

$$\tau_f - \omega_f > 0$$

Where $\tau_f = \frac{\partial D}{\partial S_f}.\frac{S_f}{D}$ and $\omega_f = \frac{\partial C}{\partial S_f}.\frac{S_f}{C}$

A.2 Derivation of Equation (10)

$$\frac{\partial Z}{\partial S_m} = \frac{\partial\left[D(S_m, S_f)C^{-1}\right]}{\partial S_m}$$

$$= \frac{\partial D}{\partial S_m}C^{-1} - C^{-2}\frac{\partial C}{\partial S_m}D(S_m, S_f)$$

$$= D_m C^{-1} - C^{-2}C_m D(S_m, S_f)$$

$$\frac{\partial^2 Z}{\partial S_m S_f} = D_{m.f}C^{-1} - C^{-2}D_m C_f - [\,C^{-2}C_m D_f - 2C^{-3}C_m C_f D + C^{-2}C_{m.f}D]$$

$$= C^{-1}D_{m.f} - C^{-2}D_m C_f - C^{-2}C_m D_f + 2C^{-3}C_m C_f D - C^{-2}C_{m.f}D$$

A.3 Derivation of Equation (11')

$$2C^{-2}C_m C_f D - C^{-1}D_m C_f > C^{-1}C_{m.f}D + C^{-1}C_m D_f - D_{m.f} \qquad (11)$$

Multiplying both sides by S_m and dividing by D

$$2\frac{\partial C}{\partial S_m}\frac{S_m}{C} - \frac{\partial D}{\partial S_m}\frac{S_m}{D} > C\left[\frac{C_{m.f}DS_m}{C.D.C_f} + \frac{C_m D_f S_m}{C.D.C_f} - \frac{D_{m.f}S_m}{D.C_f}\right]$$

The left-hand side could be written as:

$$2\omega_m - \tau_m$$

We have three terms on the right sides of the equation.

The first term on the right-hand side could be written as:

$$C\left[\frac{C_{m.f}DS_m}{C.D.C_f}\right]$$

$$= \frac{\frac{\partial\left(\frac{\partial C}{\partial S_f}\right)}{\partial S_m}.S_m}{C_f}$$

$$= \frac{\partial C_f}{\partial S_m}\frac{S_m}{C_f}$$

$$= \omega_{f.m}$$

The second term on the right-hand side could be written as:

$$C\left[\frac{C_m D_f S_m}{C.D.C_f}\right]$$

Multiplying and dividing by S_f

$$= \frac{C\frac{\partial C}{\partial S_m}\frac{\partial D}{\partial S_f}S_m}{C.D\frac{\partial C}{\partial S_f}}.\frac{S_f}{S_f}$$

$$= \frac{\omega_m.\tau_f}{\omega_f}$$

Third term on the right-hand side could be written as:

$$C\left[\frac{D_{m.f}S_m}{D.C_f}\right]$$

$$= C\frac{\frac{\partial\left(\frac{\partial D}{\partial S_m}\right)}{\partial S_f}.S_m}{D.C_f}$$

$$= \frac{\frac{\partial D_m}{\partial S_f} . S_m}{\frac{D}{C} . \frac{\partial C}{\partial S_f}}$$

In the numerator, multiplying and dividing by D_m and S_f

$$= \frac{\frac{\partial D_m}{\partial S_f} \frac{S_f}{D_m} \frac{D_m}{S_f} . S_m}{\frac{D}{C} . \frac{\partial C}{\partial S_f}}$$

$$= \frac{\tau_{m.f} . \tau_m}{\omega_f}$$

Equation (11) therefore could be written as:

$$2\omega_m \omega_f - \tau_m \omega_f > \omega_{f.m} \omega_f + \omega_m . \tau_f - \tau_{m.f} . \tau_m \qquad (11')$$

A.3 Optimal years of schooling

Total achievable income by the groom's household is given by the equation below,

$$\sum w_j T + v + D(S_m, S_f) = I$$

Since income is variable only in dowry[3], which is further a function of education levels of groom and bride, the iso-income curve could be derived by total differentiation of the income equation.

$$\frac{\partial D}{\partial S_m} dS_m + \frac{\partial D}{\partial S_f} dS_f = 0 \qquad \text{(Income } I \text{ is constant along the iso-income curve)}$$

$$\frac{\partial D}{\partial S_m} dS_m = -\frac{\partial D}{\partial S_f} dS_f$$

$$\frac{dS_m}{dS_f} = -\frac{\frac{\partial D}{\partial S_f}}{\frac{\partial D}{\partial S_m}} = -\frac{D_f}{D_m} \qquad (e.1)$$

[3] Under the assumptions of constant wages, w, constant property income, v, and T is the total time available for work and leisure.

Under the assumptions, $D_m > 0, D_f < 0$ the iso-income curve with respect to male and female education would be upward sloping. The iso-income curve could be explained through figure A.1. A given level of income I, could be achieved with different combinations of years of schooling of groom and the bride. For instance, S_f^* and S_m^* years of schooling of bride and groom respectively, at point i, generate income I on the iso-income curve. If the years of schooling of bride are raised to S_f', holding groom's education constant, the income falls to a lower iso-income curve, at point i'[4]. This is because, a rise in education of bride holding groom's education constant, would lead to a fall in dowry and hence reduction in household total income. If the income is to be kept constant at I, groom's education should increase to S_m', such that it leads to an increase in dowry. This effect from increase in education of groom should outweigh the negative effect of rise in bride's education on dowry income. Thus, i'' at (S_f', S_m') is another arrangement of bride and groom's education for income level I.

Similarly, the equation of the iso-cost curve could be derived by total differentiation of the cost function.

$C(p, S_m, S_f)$ = C

$$\frac{dS_m}{dS_f} = -\frac{\frac{\partial C}{\partial S_f}}{\frac{\partial C}{\partial S_m}} = -C_f/C_m \qquad \text{(e.2)}$$

Since, $C_m < 0 \; and \; C_f < 0$, the iso-cost curve in the education levels has a negative slope. The optimal levels of education are determined at the intersection of the iso-income and iso-cost curve as shown in figure A.2.

Substituting the optimal levels of education in the dowry function, would give the equilibrium levels of dowry and income[v].

$$D^* = D^*(S_f^*, S_m^*)$$

$$I^* = \sum w_j T + v + D^*(S_f^*, S_m^*)$$

[4] The iso-income curves to the left reflect higher levels of household income. The income levels are higher as the iso-income curves shift towards the left and lower with a rightward shift of the iso-income curve.

Tables

Table 1: Marital assortative mating on years of schooling and difference in dowry prominent districts

Wife's Years of Schooling	(1) OLS 1	(3) OLS 2	(4) OLS 3	(5) IV 1	(7) IV 2	(8) IV 3
Husband's Years of Schooling	0.606***	0.0935***	0.156***	1.301***	2.537***	2.652***
	(0.00407)	(0.00824)	(0.0128)	(0.0174)	(0.143)	(0.149)
High Dowry Deaths Districts		0.108*	0.625***		0.0298	1.029**
		(0.0550)	(0.0953)		(0.161)	(0.435)
Dowry Death District*Husband's Years of Schooling			-0.0702***			-0.144***
			(0.0108)			(0.0529)
Household Urban/Rural		0.739***	0.739***		0.566***	0.565***
		(0.0398)	(0.0398)		(0.0975)	(0.0972)
Average Education of Household		0.730***	0.731***		-1.341***	-1.329***
		(0.00952)	(0.00951)		(0.121)	(0.121)
Age Difference between Husband and Wife		-0.00824*	-0.00819*		0.0192	0.0186
		(0.00466)	(0.00466)		(0.0133)	(0.0133)
Log (Household Income)		-0.146***	-0.147***		-0.103**	-0.105**
		(0.0194)	(0.0194)		(0.0489)	(0.0487)
District FE	Yes	No	No	Yes	No	No
State FE	No	Yes	Yes	No	Yes	Yes
Observations	37,612	35,985	35,985	37,415	35,795	35,795

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

Table 2: First Stage: Husband's mother's years of schooling as instrumental variable for husband's years of schooling

	Husband's Schooling			Husband's Schooling*Dowry District
	(1)	(2)	(3)	(4)
Husband's Mother's Schooling	0.563***	0.101***	0.0901***	-0.467***
	(.0087)	(.0066)	(.016)	(.0161)
Dowry District Dummy		0.0723	0.0544	6.157***
		(.0631)	(.0668)	(.0674)
Dowry District*Husband's Mother's Schooling			0.0136	0.6349***
			(.0168)	(.0170)
Household Urban/Rural		0.0005	0.0004	-0.0142
		(.0367)	(.0367)	(.0370)
Average Education of Household		0.821***	0.8214***	0.7369***
		(.0043)	(.0043)	(.0044)
Age Difference between Husband and Wife		0.0192***	-0.0256***	-0.0237***
		(.0047)	(.0047)	(.0048)
Log (Household Income)		-0.0388**	-0.0389**	-0.0486***
		(.0181)	(.0181)	(.0182)
District FE	Yes	No	No	No
State FE	No	Yes	Yes	Yes
Observations	37,415	35,795	35,795	35,795
Adj. R-squared	0.21	0.64	0.63	0.66
F-statistic	134.86	1237.42	1213.62	1388.22

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

Table 3: Association between dowry and years of schooling

	(1) OLS 1	(2) OLS 2	(3) IV 1	(4) IV 2
Wife's Years of Schooling	0.0362***	0.0295***	-0.0532**	-0.212***
	(0.00130)	(0.00143)	(0.0235)	(0.0635)
Husband's Years of Schooling	0.0209***	0.0164***	0.0804***	1.003***
	(0.00233)	(0.00607)	(0.0171)	(0.349)
Wife's Schooling*Husband's Schooling		-0.000217		-0.0745**
		(0.000515)		(0.0302)
Age difference Husband and Wife		0.00405**		-0.0124**
		(0.00168)		(0.00580)
Log (Household Income)		0.145***		0.387***
		(0.00629)		(0.0586)
District Sex Ratio		0.00140***		0.00007
		(0.000154)		(0.000581)
Household Residence: Urban		0.0360***		0.527***
		(0.0132)		(0.122)
State Fixed Effects	Yes	Yes	Yes	Yes
Observations	31,525	29,116	15,972	14,767
Adj. R-squared	0.29	0.31	0.19	0.01

Includes controls for caste and religion
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: First Stage: Number of high schools in the district as instrumental variable for wife's years of schooling

	Wife's Schooling		Wife's Schooling*Husband's Mother's Schooling
	IV 1	IV 2	IV 2
Number of High Schools in District	.0018***	.0013***	-.0001*
	(.0001)	(.00019)	(.0008)
Husband's Mother's Schooling	.7115***	4.2216***	9.4592***
	(.0135)	(.16768)	(.06790)
Age difference between Husband and Wife		-.0461***	-.0084**
		(.01056)	(.00427)
Log (Household Income)		.7598***	.18435***
		(.0376)	(.0152)
District Sex Ratio		-.0069***	-.0006
		(.00108)	(.00043)
Household Residence: Urban		1.7590***	.3296***
		(.07920)	(.0320)
Number of High Schools*Husband's Mother's Schooling		-.00071**	.00054***
		(.00032)	(.00013)
State Fixed Effects	Yes	Yes	Yes
Observations	15,972	14,767	14,767
Adj R-square	0.29	0.34	0.89
F-statistic	203.08	210.92	3438.13

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

Table 5: Robustness validation instrumental variable estimates for marital assortative mating based on husband and wife's years of schooling

	Excludes women who have ever worked for wages		Excludes women with years of schooling>10	
Wife's Years of Schooling	(1)	(2)	(3)	(4)
Husband's Years of Schooling	1.352***	1.504***	1.102***	1.139***
	(0.0201)	(0.0557)	(0.0300)	(0.0748)
Dowry Death District*Husband's Years of Schooling		-0.211***		-0.179**
		(0.0552)		(0.0750)
High Dowry Deaths Districts		1.608***		1.089**
		(0.494)		(0.441)
District FE	Yes	No	Yes	No
State FE	No	Yes	No	Yes
Includes Controls	No	Yes	No	Yes
Observations	22,239	21,932	28,826	28,472

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

Table 6: Robustness validation instrumental variable estimates for the association between dowry payments and years of schooling

	Exclude Household with Female Heads		Exclude Women from different Districts before marriage		Exclude Outlier Dowry Deaths Districts	
	(1)	(2)	(3)	(4)	(5)	(6)
Wife's Years of Schooling	-0.0632***	-0.216***	-0.0721***	-0.240***	-0.0620**	-0.244***
	(0.0240)	(0.0643)	(0.0266)	(0.0661)	(0.0266)	(0.0751)
Wife's Schooling*Husband's Schooling		-0.0775**		-0.0700***		-0.0726**
		(0.0317)		(0.0271)		(0.0354)
Husband's Years of Schooling	0.0878***	1.041***	0.0929***	0.930***	0.0826***	0.992**
	(0.0174)	(0.366)	(0.0194)	(0.298)	(0.0192)	(0.409)
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Include Controls	No	Yes	No	Yes	No	Yes
Observations	14,819	14,342	13,033	12,001	12,589	11,614

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

Appendix Table

A.4 Descriptive Statistics

Table A.1: Descriptive statistics for individual, household and district characteristics (IHDS-II)

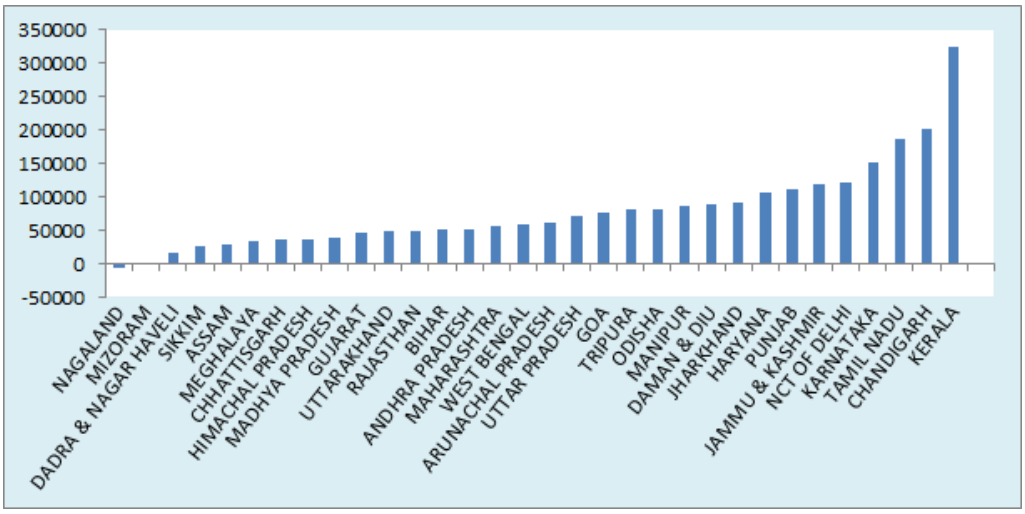
Individual and Household	Obs.	Mean	Std. Dev.	Minimum	Maximum
Wife Education	40349	5.14	4.90	0	16
Husband Education	37675	7.08	4.82	0	16
Wife's Mother's Education	40191	1.47	3.03	0	16
Husband's Mother's Education	40105	1.10	2.64	0	16
Average Education of Household	41912	7.04	4.55	0	16
Average Wedding Expenditure by Groom	45308	161,248	184,746	-	8,500,000
Average Wedding Expenditure by Bride	45302	248,641	257,202	-	8,500,000
Net Wedding Expenditure of Bride over Groom	45295	87,393	192,686	(6,750,000)	7,500,000
Household Income	45581	131,613	214,195	(1,037,040)	11,400,000
District					
Number of Schools in District	186	352	273	30	1373
Sex Ratio (10-16 years)	365	1098	70	951	1331
Dowry Deaths (proportion of married females)	349	1.48	1.23	0	8.40

Figures

Figure 1: Scatter plot for association between the education level of husband and wife in a household (IHDS-II)

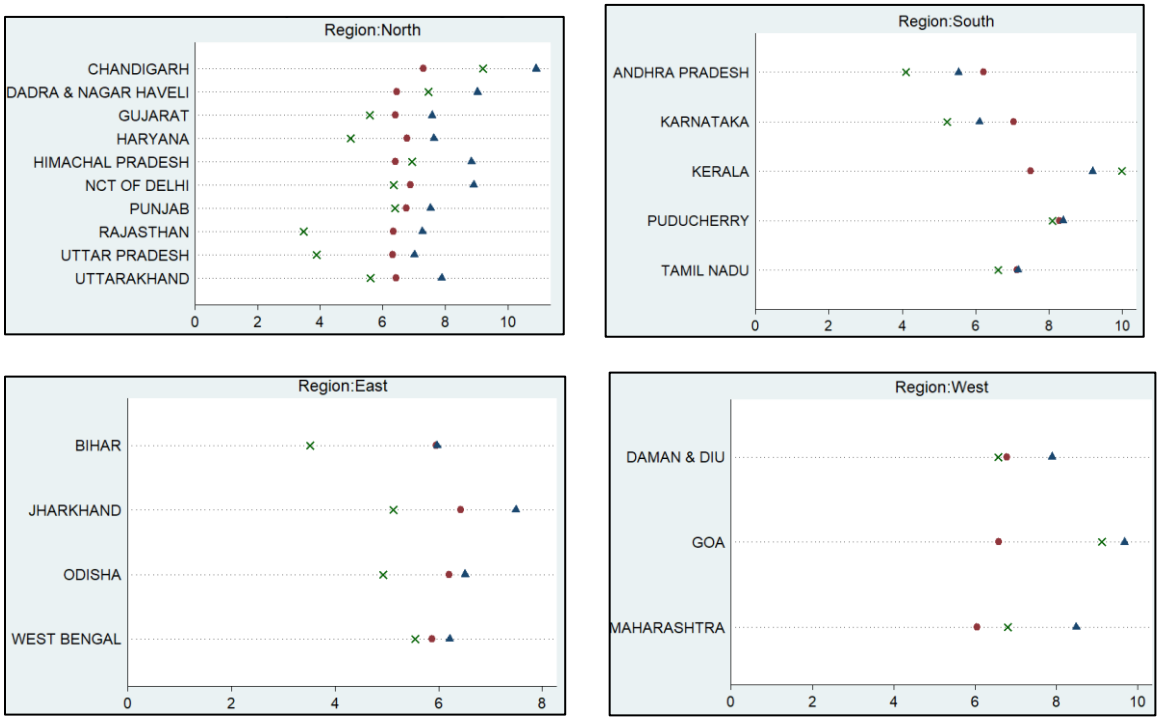
Author's own calculations using data from IHDS-II survey

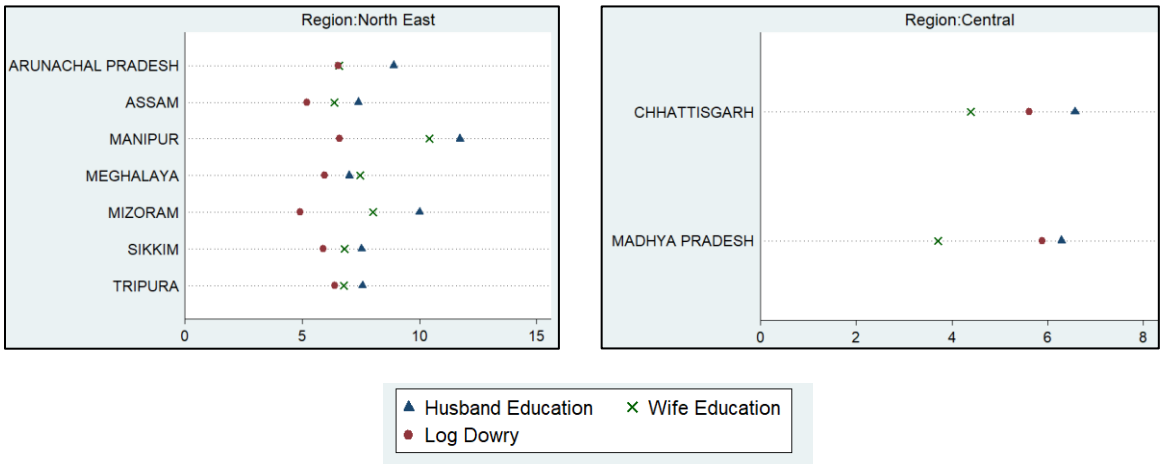
Figure 2: Average dowry expenditure across states of India (IHDS-II)



Author's own calculations using data from IHDS-II survey

Figure 3: Region-wise dot plot of average dowry across states and average schooling years of husband and wife

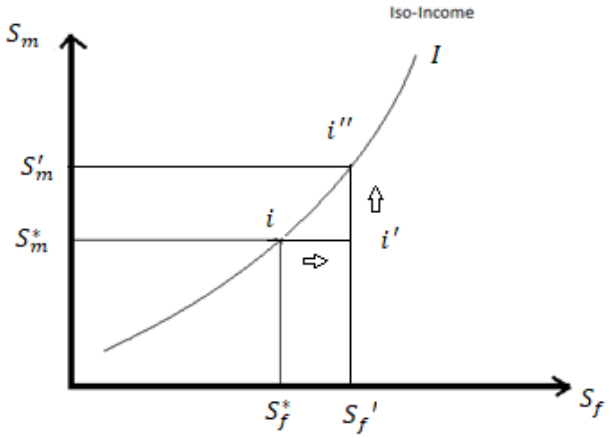




Author's own calculations using data from IHDS-II survey

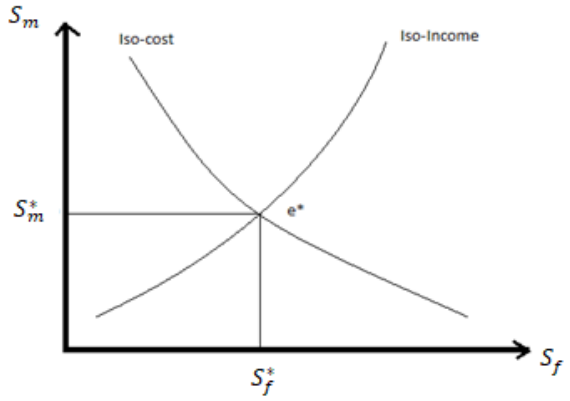
Appendix Figures

Figure A.1 Iso-income curve



Author's own drawings

Figure A.2 Optimal level of male and female education



Author's own drawings