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Why the marriage squeeze cannot cause dowry inflation

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Abstract

An influential explanation for rising dowry payments is the "marriage squeeze". The present paper shows this explanation to be internally inconsistent. The marriage squeeze argument for inflation relies on the fact that population growth leads to an excess supply of brides in the marriage market. This excess supply is resolved by some women postponing marriage, so that the average age of brides increases. In previous studies the argument is stated informally. Here, a matching model of marriage is developed to formally analyze the link between dowry payments and population growth. It is shown that a marriage squeeze *cannot* yield dowry inflation. In fact, when women who do not find matches at the 'desirable' marrying age re-enter the marriage market as older brides, a marriage squeeze is shown to imply dowry *deflation*. Population change is therefore not a promising explanation for the observed increases in dowry payments.

JEL classification: J11; J12; J16; D10

Keywords: Dowry; Population growth; Marriage

1. Introduction

Income transfers from the family of the bride to the groom, or his parents (dowry), have existed for many centuries. The dowry system dates back to at least the ancient Greco-Roman world [11]. It was particularly prevalent in Medieval and Early Modern Europe and is presently widespread in South Asia. In most of these societies, periods of dowry inflation occurred, and

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currently there is considerable evidence that South Asia is experiencing its own phase of rapid dowry inflation. [1] Dowry payments are substantial, and the severe social consequences of rising dowries have motivated a large body of research aimed at explaining the phenomenon. [2] The most influential and intuitive explanation is one based on a process demographers term the "marriage squeeze" [14,7,4,12]. [3]

The "marriage squeeze" refers to an imbalance between the numbers of marriageable men and women. [4] Most societies are characterized by persistent differences in ages of spouses, with men on average marrying younger women. [5] Since women reach marriageable age ahead of men, increases in population impact upon potential brides first, thus effectively causing an excess supply of potential brides in the marriage market. The severity of this "marriage squeeze" depends on the rate of population growth and the initial age difference between spouses. With monogamous marriage customs, this excess supply of brides can be resolved in one of two ways: one possibility is that fewer women eventually marry. Another possibility is a narrowing in marriageable ages between grooms and brides. This can occur by either the average marrying age of brides increasing (some postpone marriage), or that of grooms falling (some grooms marry younger), so that the difference between the ages of spouses declines. It is generally found that population growth has little effect on the proportions of women and men ever marrying but it does substantially alter the age composition within marriages. [6] In much of South Asia, and more generally in the earlier dowry inflationary phases, women delaying marriage has been the primary equalizing mechanism in response to population growth so that women's ages at marriage have risen. [7]

The marriage squeeze explanation of dowry inflation simply states that, since population growth implies that grooms will be in relatively short supply, a corresponding increase in the price of husbands is part of the marriage market's equilibration process; in short, dowry payments should rise. Though not formally explored, it is conjectured that older brides will outbid those who are younger, so that younger brides will match in later periods when they themselves are older, so that the marriage squeeze is relaxed by a reduction in the average age difference between spouses [14]. Rao [14] introduced this argument to economists to explain dowry inflation in South Asia. Although, his is certainly not the first mention of the phenomenon. In fact, Aristotle put forward a form of the argument to explain the rise in the value of dowries in ancient Sparta, as explained by Hughes [11]. Herlihy and Quale similarly advance this hypothesis to explain rising dowries in Medieval Europe [10,13].

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[1] The empirical evidence of Rao [14] documents the real escalation in South Asian dowries. See [6] for evidence of dowry inflation in Early Europe. Refer to [2] for further references.

[2] Dowry payments have been linked to the practice of female infanticide, bride-burning and dowry-death [5].

[3] Refer to [9] for empirical evidence which challenges the marriage squeeze argument. Anderson [2] proposes an alternative explanation for dowry inflation based on the process of modernization and social stratification.

[4] There is a large demographic literature on the marriage squeeze phenomenon, see [1,15,16].

[5] A study by the United Nations [17] demonstrates this for 90 countries in every time period studied between 1950 and 1985 and [8] find the same for 29 developing countries.

[6] Ted Bergstrom and David Lam develop a marriage assignment algorithm to analyze the effects of a marriage squeeze on the marriage market equilibrium. They demonstrate that very large changes in cohort size can be absorbed by relatively modest adjustments in the age difference between spouses with no necessary adjustments in the proportions of men and women marrying. Refer to, "The two-sex problem and the marriage squeeze in an equilibrium model of marriage markets", CREST Working Paper 91-7, Department of Economics, University of Michigan.

[7] See [7,14] and also a working paper by Andrew Foster and Nizam Khan, "Equilibrating the Marriage Market in a Rapidly Growing Population: Evidence from Rural Bangladesh", University of Pennsylvania, 1994.

Up to now, however, the link from a marriage squeeze to dowry inflation has not been formally investigated. This paper develops a matching model of marriage to formally analyze the relationship between dowry payments and population growth. Though the preconditions of the marriage squeeze argument are not disputed, the exercise here demonstrates that the marriage squeeze as an explanation of dowry inflation is not internally consistent. There are three indisputable features of the marriage market on which this result is based: (1) women who do not marry at the desirable age, re-enter the marriage market when older (i.e., the average age of marriage of women increases), (2) grooms prefer brides of the desirable age to older ones, and (3) brides prefer to marry at the desirable age rather than when older. The paper here demonstrates that the only time path of dowry payments consistent with points (1)–(3) is in fact downward sloping.

When a marriage squeeze occurs, as in point (1), some brides are delaying marriage to re-enter the marriage market when older. Given that delay is costly, point (3), brides are only willing to do so if they anticipate lower prices in future. From grooms' perspective, point (2), older brides are less desirable than those younger, and hence must make higher dowry payments. Therefore, point (3) implies that older brides make lower dowry payments than they would have as younger brides in the previous period, in order to be willing to delay. But point (2) implies they must make higher payments than younger brides marrying contemporaneously, in order for grooms to accept them. As a result, the prices paid by brides of equal ages across periods must be falling. Therefore, the only time path of dowry payments consistent with preferences on both sides of the market is downward sloping. Hence a "marriage squeeze" from an excess supply of brides in one period, which is equilibrated by brides delaying marriage, can only generate a downward (not upward) sloping time path of dowry payments.

The next section demonstrates this result in two-sided matching framework where an increase in population leads to a marriage squeeze and a reduction in the marriage age gap. [8]

2. The model

2.1. Preferences

Time is discrete and in each period an equal number of males and females are born. Agents of each sex all eventually reach marrying age. There exists an exogenously given optimal marrying age for brides, b, and grooms, g. The desirable age at which brides marry is strictly lower than that of grooms, $g > b$. [9] Individuals either marry at the desirable ages (b,g) or later, where a_b and a_g represent the years beyond the most desired age which brides and grooms, respectively, marry. There are costs associated with delaying marriage beyond the desirable age, represented by $c(a_b)$ and $k(a_g)$, which are increasing and convex: $c' > 0, k' > 0, c'' > 0$ and $k'' > 0$. [10] The only

[8] It can be demonstrated that all of the model's qualitative results will continue to hold if, alternatively, the marriage squeeze is characterized by some grooms entering the marriage market when younger and the average age of grooms is decreasing.

[9] One can think of age b denoting an acceptable level of sexual maturity for reproduction. For husbands, g may denote an age at which men have acquired a sufficient level of human capital, reasonably, $g > b$. Bergstrom and Bagnoli propose a theory to explain this marriage age difference between spouses exactly along these lines [3].

[10] The most obvious cost to marriage delay for a bride is the additional financing of her livelihood absorbed by her parents [12]. More indirectly there are social costs associated with marrying beyond the socially acceptable age levels for both brides and grooms, however the rules are far more stringent for women [7].

heterogeneity is age at the time of marriage. [11] Marriages are monogamous (one bride matches with one groom) and there is full information and costless search in the marriage market.

Dowry payments, denoted by d, are a transfer from brides' families to those of grooms. These payments are derived endogenously and, as will be seen, vary by agents' respective ages at marriage, a_b and a_g, and potentially also by time period, t, of marriage. Denote the dowry payment in a given period, t, of a bride of age a_b who matches with a groom of age a_g by $d(a_b, a_g, t)$.

For simplicity, it is assumed that all benefits and costs of marriage occur in one period only and individuals do not discount the future. A convenient quasilinear specification of utility yields a relatively simple expression for the utility of a bride:

$$U(a_b, a_g, t) = -d(a_b, a_g, t) - m(a_g) - c(a_b), \tag{2.1}$$

where the disutility associated with marrying an older groom is represented by $m(a_g)$. These costs are also increasing and convex: $m' > 0$ and $m'' > 0$.

Proceeding analogously, a groom's utility from marrying is

$$V(a_b, a_g, t) = d(a_b, a_g, t) - k(a_g) - q(a_b), \tag{2.2}$$

where the disutility from marrying an older bride is represented by $q(a_b)$; $q' > 0$ and $q'' > 0$. Normalize so that $q(0) = c(0) = m(0) = k(0) = 0$.

2.2. Marriage market equilibrium

Marriage market equilibria are characterized by analogous conditions to those found in standard two-sided matching models with transferable utility. In the present context, the net transfer for a potential match between a bride of age a_b^* and a groom of age a_g^* is equal to the dowry payment, $d(a_b^*, a_g^*, t)$. The first equilibrium condition asserts that for a bride and groom to be matched, they must both prefer to be married rather than remain unmarried. Let $\overline{U}$ and $\overline{V}$ represent the respective utilities of brides and grooms who remain unmarried for their lifetime. Using (2.1) and (2.2), we have:

Definition 1. A match between a bride of age a_b^* and a groom of age a_g^* is feasible in a given period t, if and only if $d(a_b^*, a_g^*, t)$ satisfies:

$$- d(a_b^*, a_g^*, t) - m(a_g^*) - c(a_b^*) \geqslant \overline{U} \tag{2.3}$$

$$d(a_b^*, a_g^*, t) - k(a_g^*) - q(a_b^*) \geqslant \overline{V} \tag{2.4}$$

for $a_b^* \geqslant 0$, $a_g^* \geqslant 0$, and $-\infty < t < +\infty$.

We refer to conditions (2.3) and (2.4) as the respective participation constraints of brides and grooms. [12] A second equilibrium condition requires that for a pair to be matched, neither individual prefers to marry at another age, or to another spouse, at the prevailing equilibrium dowry prices. Using (2.1) and (2.2), we have:

[11] An earlier working paper version of this paper analyzes a version of the model where individuals are also differentiated by their quality. The dowry deflation demonstrated here arises identically in that more complicated framework.

[12] Throughout the analysis it is assumed that there is a surplus created by marriage, so that: $-m(a_g^*) - c(a_b^*) > \overline{U}$ and $-k(a_g^*) - q(a_b^*) > \overline{V}$.

Definition 2. A match between a bride of age a_b^* and a groom of age a_g^* is stable in a given period t, if and only if equilibrium dowry payments $d(a_b^*, a_g^*, t)$ satisfy:

$$-d(a_b^*, a_g^*, t) - m(a_g^*) - c(a_b^*) \geqslant -d(a_b, a_g, t + a_b - a_b^*) - m(a_g) - c(a_b), \tag{2.5}$$

$$d(a_b^*, a_g^*, t) - k(a_g^*) - q(a_b^*) \geqslant d(a_b, a_g, t + a_g - a_g^*) - k(a_g) - q(a_b) \tag{2.6}$$

for all $a_b \neq a_b^*$, and $a_g \neq a_g^*$, where $a_b^* \geqslant 0$, $a_g^* \geqslant 0$, $a_b \geqslant 0$, $a_g \geqslant 0$, and $-\infty < t < +\infty$.

We refer to conditions (2.5) and (2.6) as the respective stability constraints of brides and grooms.[13] A final condition stipulates that for a marriage market equilibrium, where brides of age a_b^* are matched with grooms of age a_g^*, to be feasible in the aggregate, the supply of these types must be equal. Let $S(a_m, t)$ denote the supply of individuals of age a_m, where $m = b, g$, in the marriage market in period t. Then the marriage market clearing condition for matches between brides of age a_b^* and grooms of age a_g^* is

$$S(a_g^*, t) = S(a_b^*, t) \tag{2.7}$$

for $a_b^* \geqslant 0$, $a_g^* \geqslant 0$ and $-\infty < t < +\infty$.

3. Equilibrium dowry payments

As a benchmark, we first characterize equilibrium dowry payments in the case of no population growth.

3.1. No population growth

Suppose there is a constant population of marriageable individuals through time. If N individuals of each sex are born at every t, for $-\infty < t < +\infty$, then in each period, N brides and grooms reach marriageable age, b and g, respectively. With constant population there cannot be a marriage squeeze and the marriage age gap remains constant.

Proposition 1. *With constant population, the unique equilibrium pattern of matching between brides and grooms involves marrying at ages b and g, respectively. A marriage squeeze cannot occur and the marriage age gap is constant.*

All proofs are in Appendix A. An equilibrium here is a pattern of matching for brides and grooms in each period t, with accompanying payments $d(0, 0, t)$. In the constant population case, equal numbers of brides and grooms reach marriageable age each period, despite the fact that marriageable ages differ. All individuals prefer marrying at these ages to marrying later, and marrying earlier is, by construction, not possible. Since numbers are equal, all individuals marrying at the earliest ages is thus feasible, and is so for a range of equilibrium payments. Individual rationality conditions for both brides and grooms can be satisfied for any sequence within this range of payments, and do not generally bind. However, this is not sufficient to prove an equilibrium, since individuals may be willing to delay in order to reap higher payments (for grooms) or pay less (for brides). The proof demonstrates that, given the equilibrium sequence

[13] Conditions (2.5) and (2.6) are analogous to the standard stability (no-blocking) conditions in two-sided matching models with transferable utility.

$d(0, 0, t)$, payments required to induce such delay would render one side of the marriage market strictly worse off. Intuitively, this follows from the costs of delay. One party's delaying marriage destroys surplus to interaction, which although compensatable through a transfer from the other, also makes the other party worse off. The uniqueness of the matching pattern then follows for similar reasons. Any posited equilibrium matching pattern in which at least one side delays can be undermined by one party marrying early and offering a mutually improving transfer to a potential spouse.

Given there is a range of equilibrium prices under which both sides of the market strictly prefer marriage with no delay, transfers supporting the matching pattern in Proposition 1 are not unique. However, any equilibrium price sequence must fall within well defined bounds, the division of which depends on the division of marriage surplus between both sides of the market:

Proposition 2. *With constant population, for a given division of the marriage surplus, α, the equilibrium time path of dowry payments is uniquely determined by*

$$d(0, 0, t + 1) - d(0, 0, t) = \alpha[m(1) + k(1)] + (1 - \alpha)[-q(1) - c(1)] \tag{3.1}$$

for all t.

Given a $d\,(0, 0, 0)$, condition (3.1) describes a time path of transfers, which vary by α, that induce both parties to marry at the earliest marriageable ages. The change in payments through time is limited by the total utility costs of delay: $m(1)+k(1)$ for groom delay, and $q(1)+c(1)$ for brides. [14] The weighting on each of these components is determined by the proportion of surplus to marriage accruing to brides, α. The higher is α, the steeper the payment path. Intuitively, when brides obtain a large part of the surplus to marrying without delay, they greatly prefer marrying at t over $t + 1$, i.e., the difference in the amount they would pay when marrying later is large. The converse applies when α is low. Condition (3.1) implies that a constant division of the marriage surplus, α fixed, need not imply constant dowry payments. However, there does exist a unique division of the marriage surplus for which the time path of dowry payments is constant. [15]

3.2. Population growth

Here we analyze the effects of a one shot increase in the population. It turns out that most of the effects on the marriage market in such a case also apply for more general increases in population which are slightly more complicated to analyze. In period $t = 0$, assume that the number of births of each sex rises from N to γN, where $1 < \gamma < 2$. [16] The number of births returns to N for all periods thereafter, $t \geqslant 1$.

In periods 0 to $b - 1$, this population increase has no effect on the number of brides and grooms of marriageable ages, b and g. Equal numbers, N, continue to reach marriageable age in each

[14] The results pertaining to equilibrium dowry payments do not require these costs to be convex, only that they are increasing. The assumption of convexity does determine possible patterns of marriage delay. In particular, with convexity, brides and grooms never optimally consider delaying marriage more than one period. Without convexity, the possible deviations of bridal and groom delay will be more complex but do not change anything qualitative in the results.

[15] Refer to an earlier working paper version for details.

[16] The assumption that $\gamma < 2$ ensures that bridal delay will only be until $a_b = 1$. This assumption is inconsequential to the dowry deflation result which holds for any pattern of bridal delay and more general characterizations of population growth. Refer to an earlier working paper version for details.

period. However in period b, brides born in period 0 reach marrying age so that there are γN women of age b and $N < \gamma N$ men of marriageable age g. The number of men of marrying age does not increase to γN until period $g > b$, after which the economy returns to N men and women reaching marriageable age from then on.

It is clear that such a population increase causes a marriage squeeze to occur for periods $b < t < g$ as it raises the relative number of brides entering the marriage market. Recall again that a marriage squeeze here corresponds to a decrease in the relative ages of brides and grooms, which has been argued to be a force causing dowry inflation. Before analyzing its effect on dowry prices we first confirm that the unique equilibrating response of a marriage squeeze, due to a population increase, is a reduction in the marriage age gap, when all continue to marry.

Proposition 3. *The unique equilibrating response of a marriage squeeze from a population increase, when all continue to marry, is a reduction in the marriage age gap in periods* $b < t < g$.

Unlike the equilibrium characterized in the stationary population case, Proposition 1, between periods b and g, unmarried brides from the previous period re-enter the marriage market attempting to marry a year older. This introduces an additional indifference condition for brides: the excess supply of brides precipitated by the population increase can only be equilibrated if brides are indifferent to delaying marriage for a year beyond the marriageable age. As the next proposition demonstrates, this has precise implications for the path of marriage payments.

Proposition 4. *With a population increase, for all periods in which there is a marriage squeeze*: (i) *all of the marriage surplus accrues to grooms*, $\alpha = 0$, *and* (ii) *dowry payments for all aged brides are falling according to*

$$d(a_b, 0, t+1) - d(a_b, 0, t) = -q(1) - c(1) < 0 \tag{3.2}$$

for $0 \leqslant a_b \leqslant 1$ *and* $b \leqslant t < g - 1$. *For periods* $t < b$ *and* $t \geqslant g$, *equilibrium dowry payments satisfy* (3.1).

Condition (3.2) implies that equilibrium dowry payments *fall* at a rate equal to the delay costs to brides. [17] Proposition 4 follows from the fact that, when a marriage squeeze occurs, some brides must be willing to delay marriage and re-enter the marriage market when older, and grooms are on the short side of the market. Given that delay is costly, brides are only willing to do so if they anticipate lower prices in future. This is consistent with grooms being on the short side of the market, since in that case, they obtain all of the surplus to marrying at their earliest marriageable age, and thus extract a price which is higher today than if they were to delay. Under the marriage squeeze there is thus necessarily dowry deflation.

Despite the fact that the average age of brides is increasing during the marriage squeeze, and older brides make higher dowry payments, average dowry payments are falling through time. This follows because in order to induce bridal delay, older brides tomorrow must make lower dowry payments than they would have were they to marry as younger brides today. But for grooms to be willing to marry these older brides, they must be making higher payments than the younger brides who are marrying contemporaneously with them. Both of these factors ensure that average dowry payments are falling through time.

[17] The analysis ignores discounting because it is immaterial to the main results. From (3.2), we see that dowry deflation occurs because there are costs to marrying older for brides. Discounting makes these costs lower but still positive.

4. Discussion and conclusion

A key assumption maintained throughout was that brides' and grooms' participation constraints never bind, and hence all continue to marry. Such a construction was necessary to analyze the marriage squeeze argument which is predicated on population growth inducing a narrowing of the marriage age gap while all continue to marry. However, if population growth continues for long enough, the perpetually declining path of dowry payments, implied by the above, cannot constitute an equilibrium price trajectory since eventually grooms' participation constraints will bind. At this point, brides would prefer to offer a higher payment rather than remain unmarried, since their participation constraints are not binding. But such an upward movement in dowry payments is inconsistent with Proposition 4, and consequently a marriage squeeze cannot be equilibrated by a reduction in the marriage age gap. When population growth cannot lead to a change in marrying ages, marriage market clearing conditions require that the consequent excess supply of brides must remain unmarried. In this scenario, brides effectively compete in a spot market to determine who will marry and dowry inflation may occur. [18]

The conclusion from this exercise is therefore that population growth, which leads to a marriage squeeze, either causes an adjustment in marrying ages and dowry *deflation* is the unique outcome, or population growth can lead to some increase in dowry payments but only with no adjustment in marrying ages and instead a fall in the proportion of women ever marrying. Thus the two empirical facts to be explained: (i) a marriage squeeze which causes a reduction in the marriage age gap, and (ii) dowry inflation, cannot be reconciled in a two-sided matching model of the marriage market.

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Appendix A.

Proof of Proposition 1. We first existence of an equilibrium with marriage at earliest marriageable age, $a_b^* = a_g^* = 0$, and transfers for equilibrium matches $d\,(0, 0, t)$. [19] From (2.5), brides will not delay marriage iff:

$$-\,d(0, 0, t) \geqslant -\,d(a_b, a_g, t + a_b) - m(a_g) - c(a_b) \tag{A.1}$$

for any t, $a_g \geqslant 0$ and $a_b > 0$. From (2.6), grooms will not marry older brides iff:

$$d(0, a_g, t) - k(a_g) \geqslant d(a_b, a_g, t) - k(a_g) - q(a_b) \tag{A.2}$$

for any t, $a_g \geqslant 0$ and $a_b > 0$. Inequalities (A.1) and (A.2), defined at $t + a_b$, imply:

$$d(0, a_g, t + a_b) - d(0, 0, t) \geqslant -\,q(a_b) - c(a_b) - m(a_g) \tag{A.3}$$

[18] Refer to an earlier working paper version for details.

[19] Note that, in specifying an equilibrium, equilibrium prices $d\,(\cdot)$ are only specified for equilibrium matches. The prices of matches off the equilibrium path can take any value subject to the requirement that they are (weakly) preferred by both deviating parties.

for all t, $a_b > 0$ and $a_g \geqslant 0$. Since q, c, and m are increasing, the right-hand side of (A.3) is maximized at $a_b = 1$ and $a_g = 0$. As a result, a necessary and sufficient condition for brides not to delay marriage is

$$d(0, 0, t + 1) - d(0, 0, t) \geqslant -q(1) - c(1) \tag{A.4}$$

for all t. This is also sufficient to rule out delay to $a_b > 1$ due to convexity of q and c.

Analogously for grooms, (2.6) ensures they will not delay marriage iff:

$$d(0, 0, t) \geqslant d(a_b, a_g, t + a_g) - k(a_g) - q(a_b) \tag{A.5}$$

for any t, $a_b \geqslant 0$ and $a_g > 0$. Condition (2.5) ensures brides will not marry older grooms iff:

$$-d(a_b, 0, t) - c(a_b) \geqslant -d(a_b, a_g, t) - m(a_g) - c(a_b) \tag{A.6}$$

for all t, $a_b \geqslant 0$ and $a_g > 0$. Inequalities (A.5) and (A.6), defined at $t + a_g$, yield:

$$d(a_b, 0, t + a_g) - d(0, 0, t) \leqslant m(a_g) + k(a_g) + q(a_b) \tag{A.7}$$

for all t, $a_b \geqslant 0$ and $a_g > 0$. The right-hand side of (A.7) is minimized at $a_g = 1$ and $a_b = 0$, given that m, k, and q are increasing. As a result, a necessary and sufficient condition for grooms not to delay marriage is

$$d(0, 0, t + 1) - d(0, 0, t) \leqslant m(1) + k(1) \tag{A.8}$$

for all t. This is also sufficient to rule out delay to $a_g > 1$ due to convexity of m and k.

There exist many sequences of dowry payments, $d(0, 0, t)$ that simultaneously satisfy the two necessary and sufficient equilibrium conditions, (A.4) and (A.8), since $m(1) + k(1) > -q(1) - c(1)$. This pattern of matching also ensures that the marriage market clearing condition, (2.7), is satisfied for all t, since within each period the total number of brides, N, is equal to the total number of grooms, N.

Note that the equilibrium is only unique upto the matching pattern, as shown above, many payments can support this matching pattern. We now demonstrate that this is the unique matching pattern with no population growth. First note that equilibria where only brides delay but grooms do not, or vice versa, are not possible given that the marriage market clearing condition, (2.7), must hold. Therefore, it is sufficient to rule out alternative equilibria where brides and grooms marry at age $a_b^*, a_g^* > 0$, respectively. The payments in any such conjectured equilibrium are denoted by $d(a_b^*, a_g^*, t)$. Using (2.5), brides prefer to delay marriage until age a_b^* and marry grooms of age a_g^* iff:

$$-d(a_b^*, a_g^*, t + a_b^*) - m(a_g^*) - c(a_b^*) \geqslant -d(a_b, a_g, t + a_b) - m(a_g) - c(a_b) \tag{A.9}$$

for all t, $0 \leqslant a_b < a_b^*$ and $a_g \geqslant 0$. Using (2.6), grooms prefer to match with brides of age a_b^* in any period t iff:

$$d(a_b^*, a_g^*, t) - k(a_g^*) - q(a_b^*) \geqslant d(a_b, a_g^*, t) - k(a_g^*) - q(a_b) \tag{A.10}$$

for all t and $0 \leqslant a_b < a_b^*$. Inequalities (A.9), defined for $a_g = a_g^*$ and $a_b = a_b^* - 1$, and (A.10), defined at $a_b = a_b^* - 1$ and $t + a_b^* - 1$, yield:

$$\begin{aligned} d(a_b^*, a_g^*, t + a_b^*) - d(a_b^*, a_g^*, t + a_b^* - 1) \leqslant & -q(a_b^*) + q(a_b^* - 1) - c(a_b^*) \\ & + c(a_b^* - 1), \end{aligned} \tag{A.11}$$

which implies:

$$d(a_b^*, a_g^*, t+1) - d(a_b^*, a_g^*, t) \leqslant -q(a_b^*) + q(a_b^* - 1) - c(a_b^*) + c(a_b^* - 1) \tag{A.12}$$

for all $t \geqslant a_b^* - 1$. By the same reasoning, but using (2.6), defined for $a_b = a_b^*$, and (2.5), defined for $a_g = a_g^* - 1$, an analogous condition is obtained for grooms:

$$d(a_b^*, a_g^*, t+1) - d(a_b^*, a_g^*, t) \geqslant m(a_g^*) - m(a_g^* - 1) + k(a_g^*) - k(a_g^* - 1) \tag{A.13}$$

for all $t \geqslant a_g^* - 1$.

The two conditions (A.12) and (A.13) are necessary for the conjectured equilibrium. However, there does not exist a sequence of payments, $d(a_b^*, a_g^*, t)$, which can satisfy both (A.12) and (A.13) because $m(a_g^*) - m(a_g^* - 1) + k(a_g^*) - k(a_g^* - 1) > -q(a_b^*) + q(a_b^* - 1) - c(a_b^*) + c(a_b^* - 1)$, given that m, k, q, and c are increasing. Therefore, it is not possible for there to exist an equilibrium with $a_g^*, a_b^* > 0$. Consequently no marriage squeeze can occur and the average age of brides remains constant at age b for all t. □

Proof of Proposition 2. From Proposition 1, two necessary and sufficient conditions for the no population growth equilibrium are (A.4) and (A.8). Clearly, any $\alpha \in [0, 1]$ satisfies conditions (A.4) and (A.8) and is feasible. The time path of dowry payments is thus determined by (3.1). □

Proof of Proposition 3. We first show that when a population increase occurs in period 0 an equilibrating response is: (1) N brides and grooms marry at ages b and g, respectively, in each period t, for $t < b$ and $t > g$; (2) for periods $b \leqslant t < g - 1$, $(\gamma - 1)N$ brides delay marriage until age $a_b = 1$, $(2 - \gamma)N$ brides do not delay, and no grooms delay marriage; and (3) in period $t = g$, γN brides and grooms marry at ages b and g, respectively. The equilibrium matching pattern is supported by a sequence of dowry payments such that, for periods $t < b$ and $t \geqslant g$, neither brides nor grooms delay marriage, whereas for periods $b \leqslant t < g - 1$, some, but not all brides delay marriage until age $a_b = 1$, but no grooms delay.

First consider stability constraints in periods, $b \leqslant t < g - 1$. During this phase brides are indifferent between marrying at ages $a_b^* = 1$ and $a_b^* = 0$. Using (2.5):

$$-d(1, 0, t+1) - c(1) = -d(0, 0, t) \tag{A.14}$$

for $b \leqslant t < g - 1$. Using (2.6), grooms are indifferent to matching with brides of ages $a_b^* = 1$ and $a_b^* = 0$ iff:

$$d(1, 0, t) - q(1) = d(0, 0, t) \tag{A.15}$$

for $b < t < g$. Equalities (A.14) and (A.15) imply:

$$d(0, 0, t+1) - d(0, 0, t) = -q(1) - c(1) \tag{A.16}$$

for $b \leqslant t < g - 1$. The same equalities, (A.14) and (A.15), defined for period $t + 1$, yield:

$$d(1, 0, t+1) - d(1, 0, t) = -q(1) - c(1) \tag{A.17}$$

for $b \leqslant t < g - 1$.

When (A.17) holds, there does not exist a deviation payment for which brides would prefer to delay marriage until age $a_b > 1$ and under which grooms are simultaneously no worse off. To see this, consider a deviation under which brides marry at age $a_b = 2$, denoted by $d(2, 0, t + 2)$. Using stability constraint (2.5), this implies:

$$-d(2, 0, t + 2) - c(2) > -d(1, 0, t + 1) - c(1). \tag{A.18}$$

Using (2.6), grooms will accept these brides iff:

$$d(2, 0, t + 2) - q(2) > d(1, 0, t + 2) - q(1). \tag{A.19}$$

Inequalities (A.18) and (A.19) yield:

$$d(1, 0, t + 2) - d(1, 0, t + 1) < -q(2) + q(1) - c(2) + c(1). \tag{A.20}$$

However, (A.20) and equilibrium condition (A.17) can never simultaneously hold since: $-q(2) + q(1) - c(2) + c(1) < -q(1) - c(1)$, given the convexity of q and c. A similar argument rules out deviations to $a_b > 2$. Therefore, for periods $b \leqslant t < g - 1$, the necessary and sufficient conditions are (A.16) and (A.17).

As demonstrated in Proposition 1, a necessary and sufficient condition for grooms not to delay marriage is (A.8). Therefore (A.8) must hold for all t. Likewise the necessary and sufficient condition for brides not to delay marriage is (A.4) which must therefore hold for periods $t < b$ and $t \geqslant g - 1$. As demonstrated in Proposition 1, there always exists a sequence of dowry payments such that both (A.8) and (A.4) are satisfied for periods $t < b$ and $t \geqslant g - 1$. By the same reasoning, there always exists a sequence of dowry payments for periods $b \leqslant t < g - 1$ such that equilibrium conditions (A.8) and (A.16) are both satisfied.

Finally, the marriage market clearing condition, (2.7) is satisfied for all t, under this sequence. In periods, $t \leqslant b$ and $t \geqslant g$, an equal number, of brides and grooms marry at ages b and g, respectively, in each period. For periods $b < t < g$, the total supply of brides $(\gamma - 1)N$, of age $a_b^* = 1$, and $(2 - \gamma)N$ of age $a_b^* = 0$, is equal to the total supply of grooms, N, of age g.

We now show that, provided all individuals marry, the time path of bridal delay characterized above is the unique pattern of matching that occurs when population increases. Equilibria where both grooms and brides prefer to delay marriage cannot exist since conditions (A.12) and (A.13) cannot simultaneously hold. If all brides eventually marry, equilibria where brides do not delay marriage after the population increase are also not possible since the marriage market clearing condition, (2.7), would then imply that $(\gamma - 1)N$ brides must go unmarried in period b. Therefore, the only alternative marriage sequence is for some brides to delay marriage until age $a_b^* > 1$. Denote the sequence of payments supporting this conjectured path by $d(a_b^*, 0, t)$. Under this, marriage pattern, brides are willing to delay marriage until a_b^* but not to $a_b < a_b^*$. Thus constraint (2.5) implies:

$$-d(a_b^*, 0, t + a_b^*) - c(a_b^*) = -d(0, 0, t) \geqslant -d(a_b, 0, t + a_b) - c(a_b) \tag{A.21}$$

for all $0 < a_b < a_b^*$, $t \geqslant b$, and $t + a_b^* \leqslant g$. For grooms to accept brides of age a_b^*, condition (2.6) requires:

$$d(a_b^*, 0, t) - q(a_b^*) = d(0, 0, t) \geqslant d(a_b, 0, t) - q(a_b) \tag{A.22}$$

for all $0 < a_b < a_b^*$ and $b < t \leqslant g$. Inequalities (A.21) and (A.22), defined in period $t + a_b^*$, imply:

$$d(0, 0, t + a_b^*) - d(0, 0, t) = -q(a_b^*) - c(a_b^*). \tag{A.23}$$

Inequalities (A.21), defined for $a_b = a_b^* - 1$, and (A.22), defined for period $t + a_b^* - 1$, imply:

$$d(0, 0, t + a_b^* - 1) - d(0, 0, t) \geqslant -q(a_b^* - 1) - c(a_b^* - 1). \tag{A.24}$$

Conditions (A.23) and (A.24) imply:

$$d(0,0,t+a_b^*) - d(0,0,t+a_b^*-1) \leqslant -q(a_b^*) + q(a_b^*-1) - c(a_b^*) \\ +c(a_b^*-1) \tag{A.25}$$

for $b < t < g$ and $t+a_b^* \leqslant g$. Inequalities (A.21), defined for $a_b = 1$, and (A.22), for period $t+1$, also imply:

$$d(0,0,t+1) - d(0,0,t) \geqslant -q(1) - c(1) \tag{A.26}$$

for $b < t < g-1$. Conditions (A.25) and (A.26) are simultaneously satisfied, iff: $-q(a_b^*) + q(a_b^*-1) - c(a_b^*) + c(a_b^*-1) \geqslant -q(1) - c(1)$, which never holds with convexity of q and c. Consequently, it is never an equilibrium for brides to delay marriage to age $a_b^* > 1$ in response to a population increase. Therefore, the unique matching pattern when there is an excess supply of marriageable women, in periods $b \leqslant t < g-1$, is for $(\gamma-1)N$ brides to delay marriage until age $a_b^* = 1$, $(2-\gamma)N$ brides to not delay, and no grooms delay marriage. A marriage squeeze occurs and the average age of brides is equal to $b + (\gamma - 1) > b$ for periods $b < t < g$. □

Proof of Proposition 4. (i) As demonstrated in Proposition 3, for periods $b \leqslant t < g$, two necessary and sufficient conditions for this equilibrium are (A.16) and (A.17), which yield (3.2). From (3.2), the division of marriage surplus from (3.1), implies $\alpha = 0$.

(ii) Equilibrium dowry payments for periods $t < b$ and $t \geqslant g$ follow from Propositions 2 and 3. These payments are unique for a given α, as demonstrated in Proposition 2. To prove that (3.2) is the unique time path of equilibrium dowry payments for periods $b \leqslant t < g$, define $\Delta = -q(1) - c(1)$. Consider an alternative time path of dowry payments $d(a_b, 0, t+1) - d(a_b, 0, t) = \Delta^* > \Delta$. In this case, brides prefer not to delay marriage so that (A.4) holds with strict inequality. As a result, brides will only marry at age $a_b = 0$, and the marriage market clearing condition, (2.7), cannot be satisfied unless some brides go unmarried. Alternatively, consider $d(a_b, 0, t+1) - d(a_b, 0, t) = \Delta^* < \Delta$. In this case all brides prefer to delay marriage so that (A.4) is contradicted. As a result all brides marry at age $a_b = 1$, and the marriage market clearing condition, (2.7), does not hold unless some brides go unmarried. □

References

[1] D.S. Akers, On measuring the marriage squeeze, Demography 4 (1967) 907–924.

[2] S. Anderson, Why dowry payments declined with modernization in Europe but are rising in India, J. Polit. Economy 111 (2003) 269–310.

[3] T. Bergstrom, M. Bagnoli, Courtship as a waiting game, J. Polit. Economy 101 (1993) 185–202.

[4] M.S. Billig, The marriage squeeze and the rise of groomprice in India's Kerala state, J. Compar. Family Stud. 23 (1992) 197–216.

[5] F. Bloch, V. Rao, Terror as a bargaining instrument: dowry violence in rural India, Amer. Econ. Rev. 92 (2002) 1029–1043.

[6] M. Botticini, A. Siow, Why dowries?, Amer. Econ. Rev. 93 (2003) 1385–1398.

[7] J. Caldwell, P. Reddy, P. Caldwell, The causes of marriage change in South Asia, Population Stud. 37 (1983) 343–361.

[8] J.B. Casterline, L. Williams, P. McDonald, The age difference between spouses: variations among developing countries, Population Stud. 40 (1986) 353–374.

[9] L. Edlund, The marriage squeeze interpretation of dowry inflation: a comment, J. Polit. Economy 108 (2000) 1327–1333.

[10] D. Herlihy, The medieval marriage market, Medieval Renaissance Stud. 6 (1976) 3–27.

[11] D.O. Hughes, From brideprice to dowry in Mediterranean Europe, in: M. Kaplan (Ed.), The Marriage Bargain: Women and Dowries in European History, Havorth Press, New York, 1985, pp. 13–58.

[12] S. Lindenbaum, Implications for women of changing marriage transactions in Bangladesh, Stud. Family Planning 12 (1981) 394–401.
[13] G.R. Quale, A History of Marriage Systems, Greenwood Press, Westport, Connecticut, 1988.
[14] V. Rao, The rising price of husbands: a hedonic analysis of dowry increases in rural India, J. Polit. Economy 101 (1993) 666–677.
[15] R. Schoen, Measuring the tightness of a marriage squeeze, Demography 20 (1983) 61–78.
[16] R. Schoen, J. Baj, The impact of the marriage squeeze in five western countries, Sociology Soc. Res. 70 (1985) 8–19.
[17] United Nations, Patterns of First Marriage: Timing and Prevalence, Department of International Economic and Social Affairs, United Nations, New York, 1990.