

**Abstract**—This paper provides an economic rationale for the practice of consanguineous marriages observed in parts of the developing world. In a model of incomplete marriage markets, dowries are viewed as ex ante transfers made from the bride's family to the groom's family when the promise of ex post gifts and bequests is not credible. Consanguineous unions join families between whom ex ante pledges are enforceable ex post. The model predicts a negative relationship between consanguinity and dowries and higher bequests in consanguineous unions. An empirical analysis based on data from Bangladesh delivers results consistent with the model.

## I. Introduction

CONSANGUINEOUS marriage, or marriage between close biological relatives who are not siblings, is a social institution that is, or has been, common throughout human history (Bittles, 1994; Bittles, Coble, & Rao, 1993; Hussain & Bittles, 2000). Although in the Western world, consanguineous marriages constitute less than 1% of total marriages, this practice has had widespread popularity in North Africa, the Middle East, and South Asia (Maian & Mushtaq, 1994; Bittles, 2001).<sup>1</sup> Scientific research in clinical genetics documents a negative effect of inbreeding on the health and mortality of human populations and the incidence of disorders and disease among the offspring of consanguineous unions (Banerjee & Roy, 2002). To economists, therefore, this contemporary incidence of consanguineous marriage and its persistence in some societies is puzzling.

It is in this setting that this paper makes its contribution: to argue that consanguinity is a rational response to a marriage market failure rather than simply a consequence of culture, religion, or preferences. The starting points of our analysis are the following two stylized facts commonly observed in large parts of South Asia and elsewhere: first, marriage celebrations are often associated with significant dowries, or

transfers of assets from the bride's family to the groom's family, and second, enforcement mechanisms for informal contracts are stronger within kinship networks than outside such networks. The crux of our model is that a marriage is a contract in which two families make a long-term commitment to support their offspring through gifts, bequests, and so forth. These also enhance the value of the match and, consequently, the social status of each family. However, once links have formed and are costly to sever, each family may now prefer to invest in alternative opportunities while free-riding on the other family's investments. To overcome this time inconsistency, early transfers between families are viewed as an ex ante alternative when ex post investment commitments are not credible. In South Asia, where marriage is characterized by patrilocal exogamy, we postulate the commitment problem to be on the bride's side so that these early monetary transfers correspond to dowries. To this aspect, we add two features. First, the extent to which agents are time inconsistent depends negatively on how closely related the partners are. Between cousins, ex ante commitments are more credible arguably because informal contracts are easier to enforce within the extended family. Second, dowries are costly since they imply borrowing on the credit market in order to make payments at the time of marriage. Consequently, our model predicts that consanguinity and dowries substitute as instruments to overcome or mitigate the time-inconsistency problem.

Our data test the central idea that consanguinity may be a relatively cheaper way for families to deal with the problem of dowry costs in rural marriage markets. We use data on 4,364 households from the 1996 Matlab Health and Socioeconomic Survey conducted in 141 villages in Bangladesh. We find that women in consanguineous unions are, on average, 6% to 7% less likely to bring a dowry at marriage, after controlling for other attributes at the time of marriage, suggesting that consanguinity and dowry are substitutes.<sup>2</sup> We also find that women marrying their cousins are on average 4% more likely to receive any form of inheritance. The negative relationship between dowry and consanguinity, on the one hand, and the positive relationship between bequests and consanguinity, on the other, is strongly suggestive of consanguinity affecting the timing of marital transfers. In further analysis, we corroborate the hypothesis that more stringent credit constraints and lower wealth levels will lead to lower dowry payments and a higher prevalence of consanguineous marriages.

The study of consanguineous unions allows us to shed some light on specific agency problems in marriage markets and institutions created to mitigate them. It is therefore of the same class of models as Becker (1981), Bloch and Rao (2002), Botticini and Siow (2003), and Jacoby and Mansuri

<sup>2</sup> These findings are entirely consistent with earlier observations made by sociologists and demographers (Centerwall & Centerwall, 1966; Reddy, 1993).

(2010). Our paper is also naturally related to the literature on dowry payments (see Anderson, 2007a, for a thorough discussion). However, unlike Becker (1981) and Botticini and Siow (2003), our model does not provide a theory of dowry per se but rather links dowries, bequests, and consanguinity in a theory of optimal timing of marital transfers. Finally, by looking at marital sorting, our analysis relates to Lee (2009) and Banerjee et al. (2009) in that we find a preference to choose mates of similar family background.

We review important facts and findings related to consanguinity in section II. In section III, we present and solve a model of incomplete marriage markets and discuss alternative explanations of consanguinity. Section IV uses data from Bangladesh to test the main predictions of the theory. Section V concludes.

## II. Historical and Religious Background

In the field of clinical genetics, a consanguineous marriage is defined as "a union between a couple related as second cousins or closer, equivalent to a coefficient of inbreeding in their progeny of  $F \geq 0.0156$ " (Bittles, 2001).<sup>3</sup> This means that children of such marriages are predicted to inherit copies of identical genes from each parent, which are 1.56% of all gene loci over and above the baseline level of homozygosity in the population at large; the closer are the parents, the larger is the coefficient of inbreeding. A common concern is that consanguinity leads to higher levels of mortality, morbidity, and congenital malformations in offspring due to the greater probability of inheriting a recessive gene (Schull, 1959; Bittles, 1994).

Historically in Europe, consanguineous marriage was prevalent until the twentieth century and was associated with royalty and landowning families (Bittles, 1994).<sup>4</sup> During the nineteenth and twentieth centuries, consanguinity was practiced more in the Roman Catholic countries of southern Europe than in their northern European Protestant counterparts (McCollough & O'Rourke, 1986). Since the sixteenth century in England, marriage between first cousins has been considered legal. But close-kin marriages are not always legally permitted elsewhere. For example, in the United States, different states have rulings on unions between first cousins: in some states, such unions are regarded as illegal; others go so far as to consider first-cousin marriage a criminal offense (Othenheimer, 1996). The overall prevalence of consanguineous marriage, especially in western European

countries like France, Germany, the Netherlands, and the United Kingdom, is now likely to be of the order of 1% to 3% or more. Consanguineous marriage is particularly popular in Islamic societies and among the poor and less educated populations in the Middle East and South Asia (Hussain, 1999; Bittles, 2001).

There is also evidence that different kinds of consanguineous unions are favored by different subpopulations. For example, while Hindu women in South India typically marry their maternal uncles, Muslim populations favor first-cousin marriages (Dronamraju & Khan, 1963; Centerwall & Centerwall, 1966; Reddy, 1993; Iyer, 2002).

The acceptability of consanguineous unions differs across religions. In Europe, Protestant denominations permit first-cousin marriage. In contrast, the Roman Catholic church requires permission from a diocese to allow them. Judaism permits consanguineous marriage in certain situations, for example, uncle-niece unions. Consanguinity is also permitted in Islam. According to the institutional requirements of Islam in the Koran, and the Sunnah, "a Muslim man is prohibited from marrying his mother or grandmother; his daughter or granddaughter, his sister whether full, consanguine or uterine, his niece or great niece, and his aunt or great aunt, paternal or maternal" (Azim, 1997).<sup>10</sup> However, the Sunnah depict that the Prophet Mohammad married his daughter Fatima to Ali, his paternal first cousin; this has led researchers to argue that for Muslims, first-cousin marriage follows the Sunnah (Bittles, 2001; Hussain, 1999).

## III. The Economics of Consanguineous Marriages

The model we present belongs to the class of agency models of marriage. Families are viewed as agents that invest in a joint project: the marriage of their offspring. However, the institution of marriage is characterized by two features: (a) dissolution (divorce) is costly, and (b) marriage contracts are incomplete. The combination of these two features undermines the credibility of some ex ante commitments on the part of the families. For example, in Jacoby and Mansuri (2010), the marriage contract is incomplete because the groom cannot commit ex ante not to be violent toward his wife. Once the marriage takes place, he has incentives to engage in violent behavior to, among other things, extract rents from his in-laws (Bloch & Rao, 2002). The institution of *watta-satta*, or exchange marriages, then emerges to alleviate this market failure; when grooms cannot commit ex ante not to be violent toward their bride-to-be, marrying the groom's sister to the bride-to-be's brother provides a credible retaliation threat that makes the initial nonviolence claim incentive compatible. In the same class of models, Botticini and Siow (2003) argue that in patrilocal societies, daughters cannot commit to manage parental assets with the same care as their male siblings do once they get married. This implies that parental transfers will optimally take the form of dowries for daughters and bequests for sons.

<sup>3</sup> The coefficient of inbreeding is the probability that two homologous alleles in an individual are identical by descent from a common ancestor.

<sup>4</sup> Intermarriage among the aristocracy that occurred in Europe in previous centuries was not always in order only to retain land. Annan's (1999) social history of academic dons in Cambridge, Oxford, and elsewhere in the United Kingdom documents that for several centuries, British academia was dominated by a handful of families, suggesting that there were levels of intermarriage on an unprecedented scale in order to preserve power and influence on intellectual ideas. In particular, the author suggests this was responsible for sustaining an intellectual aristocracy that gave not only social benefits to its members but power and influence over the history of ideas.

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<sup>1</sup> In Iraq, for example, 46.4% of marriages are between first or second cousins (Hamamy, Zuhair, & Al-Hakkak, 1989). In India, consanguineous marriages constitute 16% of all marriages, but this varies from 6% in the north to 36% in the south (IIPS & ORC Macro International, 1995; Banerjee & Roy, 2002). The highest level of inbreeding has been recorded in the South Indian city of Pondicherry, in which 54.9% of marriages were consanguineous, corresponding to a mean coefficient of inbreeding of 0.0449, considered very high by the standards of other populations (Bittles, 2001). Among immigrant populations in the United Kingdom, those of Pakistani origin display a preponderance of consanguineous marriage, estimated to be as high as 50% to 60% of all marriages in this community (Modell, 1991).

In our model, altruistic parents make transfers to their children once they are married, and this also enhances the value of the match. At the time of marriage, however, they are unable to contract on such future transfers, and as marriages are costly to dissolve, ex ante commitments are no longer credible. In a patrilocal society, where a bride migrates to the home of her husband after marriage, the incentive to renege is likely to be particularly strong for the bride's parents, since they may prefer to direct their transfers to coresident sons. As in Botticini and Siow (2003), dowries (or bride-prices) then become the second-best solution to this time-inconsistency problem. Social distance between the families of the bride and the groom can significantly influence the terms of the marriage contract. On the one hand, we assume that *ceteris paribus* social distance enhances the outcomes of marriage: families can diversify genes, hedge risks, smooth consumption, or simply integrate their social networks (Rosenzweig & Stark, 1989; La Ferrara, 2003). On the other hand, shorter social distance acts as social capital by making ex ante contracting between families easier: close relatives have more (verifiable) information about each other, are more likely to exert effort in economic activities, are less likely to engage in opportunistic behavior, and are likely to show higher levels of trust, cooperation, and altruism to both their natal and marital families (Putnam, 2000).

We now proceed to a formal description of the forces at play. Proofs are left to the appendix.

#### A. Model Setup

Individuals are assimilated to their families and labeled  $m \in M$  and  $f \in F$  for male and female, respectively. A pair  $(m, f) \in M \times F$  is characterized by wealth levels  $(w_m, w_f)$  and social distance  $d_{mf} \in [0, 1]$ . More specifically, families are points on the surface of a cylinder of radius  $\frac{1}{\alpha}$ . Each family is thus characterized by its cylindrical coordinates  $(w, \alpha)$  where height  $w \in [\underline{h}, \bar{h}]$  measures wealth with  $0 < \underline{h} \leq \bar{h}$ , and social distance between two individuals  $m$  and  $f$  is defined by the difference in azimuths  $d_{mf} = \frac{1}{\alpha} |\alpha_m - \alpha_f|$ , and thus takes values in  $[0, 1]$ . To abstract from marriage market squeeze issues (see Rao, 1993; Anderson, 2007b), we assume brides and grooms to be uniformly distributed over the cylinder.

**Timing and the institution of marriage.** The economy consists of two periods. At  $T = 0$ , couples  $(m, f)$  form, and marriages are celebrated with ex ante transfers  $D_f$  made from the bride's to the groom's family (a dowry) or  $D_m$  made from the groom's to the bride's (a bride-price), or both. At that time, parents also commit to make ex post transfers  $z_f$  and  $z_m$  to the married couple at future date  $T = 1$ . These transfers can be thought of as parental gifts or bequests. However, parents cannot fully commit to these transfers and are subject to the following limited-liability condition: for  $k \in \{m, f\}$ ,

$$z_k \leq (1 - d_{mf}) w_k \quad (1)$$

Equation (1) puts a limit on how credible it is for parents to pledge more than a given fraction of their wealth for their offspring. That fraction is assumed to be decreasing with social distance, capturing the idea that social distance is negatively associated with families' abilities to write binding contracts with each other.

In addition, family transfers cannot exceed their net worth, which translates into a budget constraint on ex ante transfers: for  $k \in \{m, f\}$ ,

$$D_k \leq w_k, \quad (2)$$

as well as ex post transfers;

$$z_k \leq w_k - D_k + D_{-k}, \quad (3)$$

where  $-k$  refers to  $k$ 's in-laws.

Finally, we make two additional assumptions: (a) marriage is always preferred to remaining single, and (b) once celebrated, marriage is indissoluble. These two assumptions are certainly not innocuous. However, in the context of South Asia, social pressure for a woman to get married and the stigma associated with divorce are arguably quite strong. We therefore believe these assumptions to be reasonable first-order approximations.

**Marital technology.** At  $T = 1$ , once brides and grooms have celebrated their marriage, they receive transfers  $t_m$  and  $t_f$  from their parents. These transfers enter a marital production function:

$$Y(t_m, t_f | w_m, w_f, d_{mf}) = A(w_m, w_f, d_{mf}) \times (t_m + t_f).$$

The marital production function has constant returns to scale  $A(w_m, w_f, d_{mf})$ . The coefficient of returns  $A(\cdot)$  is assumed to be continuously differentiable and increasing in  $w_m$  and  $w_f$  with nonnegative cross-partial derivatives (Becker, 1981), and increasing concave in social distance  $d_{mf}$ . Furthermore, we assume that for every  $(m, f) \in M \times F$ , and for  $k \in \{m, f\}$ ,

$$\frac{\partial^2 A(w_m, w_f, d_{mf})}{\partial w_k \partial d_{mf}} (w_m + w_f) + \frac{\partial A(w_m, w_f, d_{mf})}{\partial d} > 0. \quad (4)$$

The positive dependence of  $A(\cdot)$  on parental wealth captures the fact that in addition to monetary transfers, parents transmit social status to their children and share their networks. Second,  $A(\cdot)$  is also assumed to be positively correlated with social distance: when spouses are not related, they can diversify genes, hedge risks, integrate their social networks, and so forth. Furthermore, with the additional assumption made with equation (4), the marital production function  $Y(w_m, w_f, d_{mf})$  is supermodular.

Finally, agents have access to a storage technology with returns normalized to 1. This storage technology proxies for investment and consumption opportunities available to parents outside their offspring's marital production.

**Parental preferences.** At the heart of the model is the asymmetry between the bride's parents and the groom's. We thus assume that while the groom's parents internalize the full marital product, so that

$$U_m(t_m, t_f, D_m, D_f | w_m, w_f, d_{mf}) = Y(t_m, t_f | w_m, w_f, d_{mf}) + w_m + D_f - D_m - t_m, \quad (5)$$

the bride's side discounts marital output by a factor  $\theta < 1$ :

$$U_f(t_m, t_f, D_m, D_f | w_m, w_f, d_{mf}) = \theta Y(t_m, t_f | w_m, w_f, d_{mf}) + w_f + D_m - D_f - t_f. \quad (6)$$

This discrepancy can be interpreted as coming from virilocal-ity, an institution exogenously given to the model. If the bride leaves her parents to live with her in-laws (which is empirically the case in our setting), her parents might not capture the full marital product of the couple. Botticini and Siow (1993) rely on similar asymmetry arguments to construct a theory of dowry and inheritance. To make the analysis relevant, we further assume that for every possible couple  $(m, f) \in M \times F$ ,

$$\theta A(w_m, w_f, d_{mf}) < 1 < A(w_m, w_f, d_{mf}). \quad (7)$$

We henceforth define  $\bar{\theta} = \frac{1}{A(\bar{h}, \bar{h}, 1)}$ , the supremum of all possible values of  $\theta$  that satisfy equation (7) and restrict the analysis to  $\theta < \bar{\theta}$ .

**Equilibrium concept.** As stated earlier, we restrict ourselves to cases in which every individual finds a match. Then a profile  $(m, f)_{m \in M, f \in F}$  with associated payments

$$\{(D_m, D_f), (z_m, z_f), (t_m, t_f)\}_{m \in M, f \in F}$$

is an equilibrium if it satisfies the following conditions:

#### 1. Feasibility:

$$D_k \leq w_k, \quad (8)$$

$$z_k \leq w_k + D_{-k} - D_k, \quad (9)$$

where  $k \in \{m, f\}$  and  $-k$  refers to  $k$ 's in-laws

#### 2. Limited commitment:

$$z_k \leq (1 - d_{mf}) w_k \quad (10)$$

#### 3. Incentive compatibility:

$$t_k \in \arg \max_t U_k(t, t_{-k} | w_m, w_f, d_{mf}), \quad (11)$$

subject to

$$z_k \leq t_k \leq w_k + D_{-k} - D_k \quad (12)$$

4. Gale-Shapley stability: there does not exist two couples  $(m, f)$  and  $(m', f')$  and payments  $\{(\bar{D}_m, \bar{D}_f), (\bar{z}_m, \bar{z}_f), (\bar{t}_m, \bar{t}_f)\}$  that satisfy, equations (8) to (11), and

$$U_{m'}(\bar{t}_m, \bar{t}_f | w_{m'}, w_{f'}, d_{m'f'}) \geq U_{m'}(t_m, t_f | w_m, w_f, d_{mf}), \quad (13)$$

$$U_{f'}(\bar{t}_m, \bar{t}_f | w_{m'}, w_{f'}, d_{m'f'}) \geq U_{f'}(t_m, t_f | w_m, w_f, d_{mf}) \quad (14)$$

with one inequality holding strictly.

#### B. Equilibrium Characterization

First, condition (11) implies that the groom's family has the incentives to invest in their child's marriage, while the storage technology is a more attractive option to the bride's family once marriage has been celebrated. Thus, the use of dowries allows the bride's family to overcome this time inconsistency. Their incentives to do so hinge on the willingness to secure a wealthier groom.

**Proposition 1: Marriage market equilibrium with no credit constraints.** If  $A(\bar{h}, \bar{h}, 1) < 2A(\underline{h}, \underline{h}, 0)$ , there exists a marital discount factor  $\bar{\theta} < \bar{\theta}$ , such that for every  $\theta \in (\bar{\theta}, \bar{\theta})$ , a profile  $(m, f)_{m \in M, f \in F}$  characterized by

- positive assortative matching:

$$w_m = w_f,$$

and

$$d_{mf} = 1$$

- payments equal to

$$(t_m, t_f) = (z_m, z_f)$$

and

$$(D_m, D_f) = (0, w_f) \quad \text{and} \quad (z_m, z_f) = (w_m + w_f, 0)$$

is an equilibrium.

Supermodularity is driving positive assortative matching. However, stability requires a high enough discount factor  $\theta$  so that brides are willing to invest in the marital production function. In this setting, dowries are perfect substitutes for social ties. Couples can be socially distant and lower the costs of consanguinity; they then overcome the commitment problem by pledging payments upfront in the form of dowries.

#### C. Equilibrium with Credit Constraints

We now assume that raising funds to pay for dowries is costly. When family  $k$  transfers  $D_k$  to family  $-k$ ,  $-k$  receives only a fraction  $1 - \gamma$ , the rest being lost. With costly payments,

dowries are no longer perfect substitutes of social proximity, which implies a trade-off between social distance and the cost of funds.

**Proposition 2: Marriage market equilibrium with credit constraints.** If  $A(\bar{h}, \bar{h}, 1) < 2A(\bar{h}, \bar{h}, 0)$ , there exists  $\hat{\gamma} < 1$  and  $\hat{\theta} < \bar{\theta}$  such that for any parameter configurations such that  $\gamma < \hat{\gamma}$  and  $\theta \in (\hat{\theta}, \bar{\theta})$ , a match profile characterized by

- positive assortative matching

$$w_m = w_f,$$

and

$$d_{mf} = d_{mf}^*$$

where  $d_{mf}^*$  satisfies

$$\frac{\partial}{\partial d} A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) = A(w_m, w_f, d_{mf}^*) \gamma w_f \quad (15)$$

- payments equal to

$$(t_m, t_f) = (z_m, z_f)$$

and

$$(D_m, D_f) = (0, d_{mf}^* w_f) \text{ and } (z_m, z_f) = (w_m + (1 - \gamma) d_{mf}^* w_f, (1 - d_{mf}^*) w_f)$$

is an equilibrium.

The left hand side of equation (15) measures the marginal cost of consanguinity; by construction, marrying farther away has a direct and positive effect on payoffs because families can diversify their pools of genes, hedge risks across families (Rosenzweig & Stark, 1989), or merge social networks for better access to credit or labor markets (La Ferrara, 2003). On the other hand, the right-hand side of equation (15) measures the agency cost. Increasing distance between spouses increases the agency problem, requiring a larger dowry to be paid. This implies a larger transaction cost, which translates into a larger opportunity cost of investment. Since  $A(\cdot)$  is increasing and concave in  $d$ , the second-order condition holds, making equation (15) necessary and sufficient and  $d_{mf}^*$  unique for any given levels of wealth  $w_m$  and  $w_f$ .

In summary, we have so far described a marriage market failure for which consanguinity and dowries are two distinct mitigating practices that act as substitutes. Dowries are viewed as ex ante transfer of control over assets to palliate a lack of ex post incentives to invest. Consanguinity is a practice that directly reduces the agency problem. In so doing, equation (15) determines the optimal trade-off between the two. One immediate implication relates to the prevalence of consanguinity when credit constraints are more

stringent. Applying the implicit function theorem to equation (15) shows that for every wealth level  $w_f$ , the equilibrium distance  $d_{mf}^*$  verifies

$$\text{sgn} \left\{ \frac{\partial d_{mf}^*}{\partial \gamma} \right\} = -\text{sgn} \left\{ d_{mf}^* \frac{\partial A}{\partial d} + A \right\} \leq 0. \quad (16)$$

The intuition underlying equation (16) is straightforward. When credit constraints are more stringent, dowries are more costly relative to close-kin marriage, so that the equilibrium social distance decreases with the cost of equity.

A second implication of the analysis conducted so far is a comparative statics exercise with respect to wealth. We have, on the one hand,

$$\text{sgn} \left\{ \frac{\partial d_{mf}^*}{\partial w_m} \right\} = \text{sgn} \left\{ \frac{\partial^2 A}{\partial w_m \partial d} (w_m + w_f - \gamma d_{mf}^* w_f) + \frac{\partial A}{\partial d} - \frac{\partial A}{\partial w_m} \gamma w_f \right\}, \quad (17)$$

while on the other hand, we have

$$\text{sgn} \left\{ \frac{\partial d_{mf}^*}{\partial w_f} \right\} = \text{sgn} \left\{ \frac{\partial^2 A}{\partial w_f \partial d} (w_m + w_f - \gamma d_{mf}^* w_f) + \frac{\partial A}{\partial d} - \frac{\partial A}{\partial w_f} \gamma w_f - \gamma \left( d_{mf}^* \frac{\partial A}{\partial d} + A \right) \right\}. \quad (18)$$

An increase in the groom's wealth has two effects on spousal distance. Distance positively affects marital productivity, the first two terms on the right-hand side of equation (17), but this also translates into a higher opportunity cost of dowry transfers—the third term. The effect of the bride's wealth comes with an added cost of distance, since higher wealth implies larger dowry payments ceteris paribus, which is captured by the last term on the right-hand side of equation (18). In both cases, assuming that equation (4) holds, and for sufficiently low dowry costs  $\gamma$ , equilibrium spousal distance increases with either spouse's wealth.

#### D. Summary of Testable Implications and Alternative Explanations

We have presented and analyzed a general equilibrium model of the marriage market characterized by positive assortative matching. In this market, parents commit wealth, which determines spousal "market value." However, marriage contracts are incomplete, so that wealth commitments might not be credible. Thus, the institution of dowry emerges as a solution to this time-inconsistency; parents pay ex ante in the form of dowry what they cannot commit to transfer ex post in the form of gifts or bequests. Our agency theory delivers predictions not as much on the size of transfers between families as on the timing of such transfers. Because we stipulate that contract incompleteness is less severe among close kin, consanguineous marriages are a viable alternative when the

payment of dowries comes at too high a cost. Thus, our model predicts that dowry and consanguinity are substitutes:

- Prediction 1: Dowry levels are lower in consanguineous marriages.

Symmetrically, if ex ante payments are lower in consanguineous marriages, we should expect larger ex post transfers.

- Prediction 2: Bequests or gifts to daughters are larger when they marry close kin.

How well consanguinity substitutes for dowries depends in part on the cost of dowry transfers. If credit constraints are stringent, one might expect the consanguinity option to be more attractive.

- Prediction 3: Consanguinity is more prevalent in environments with more severe credit constraints.

We concluded our analysis with an investigation of the relationship between consanguinity and wealth. Since higher spousal wealth implies that more is at stake, consanguinity comes at a higher cost:

- Prediction 4: Consanguineous unions are less prevalent among wealthier unions.

Prediction 4 depends on assumptions about the marital production function. It has, for example, been argued that consanguinity provides a means to consolidate and maintain family assets and resources (Goody, 1973; Agarwal, 1994; Bittles, 2001). Cross-cousin marriages, wherein an individual marries a mother's brother's (or father's sister's) offspring, are able to unite individuals in different patrilineal both in the same bloodline, ensuring a consolidation of resources. This suggests that even at higher levels of wealth, marriage contract incompleteness may come at too high a cost, so that consanguineous marriages are preferred.<sup>5</sup> Consanguinity might yet be driven by multiple other factors. A first alternative explanation for consanguinity is that it is the outcome of personal preference that is mediated by the influence of religion or cultural practice. As discussed in section II, much of the literature from sociology and biological anthropology is predicated on this assumption about consanguinity. The argument here is that because consanguinity is a practice that has enjoyed much support historically in certain populations, it continues to be popular among these communities to the present day. A second explanation for consanguinity is that it may be a favored form of marriage simply because it can

significantly reduce the costs of searching for a suitable partner. The central idea is that since the bride and groom are generally known to each other prior to marriage, consanguineous marriages do not require families to screen each other in order to assess the quality of the upcoming match. In many rural societies, this process can take considerable time as well as resources (Sander, 1995). Moreover, parents in consanguineous unions know their future selves-in-law and their families, reducing the uncertainty about the compatibility of spouses and families. While all these alternative stories have some appeal in explaining the prevalence of consanguinity, they do not speak to the relationship of consanguinity, bequests, and dowries, which is central to this paper. We next move to the empirical section to empirically test the predictions of our model.

#### IV. Empirical Evidence from Bangladesh

The data used in the analysis are drawn from the 1996 Matlab Health and Socioeconomic Survey (MHSS).<sup>6</sup> We supplement these data with those on climate data on annual rainfall levels in the Matlab area for the period 1950 to 1996.<sup>7</sup> The 1996 MHSS contains information on 4,364 households spread over 2,687 *baris*, or clusters, in 141 villages. Matlab is an Upazila (subdistrict) of Chandpur district, which is about 50 miles south of Dhaka, the capital of Bangladesh. Eighty-five percent or more of the people in Matlab are Muslims, and the others are Hindus. Although it is geographically close to Dhaka, the area has been relatively isolated and inaccessible to communication and transportation. The society is predominantly an agricultural society, although 30% of the population reports being landless. Despite a growing emphasis on education and increasing contact with urban areas, the society remains relatively traditional and religiously conservative (Fauveau, 1994).

For the purpose of understanding the incidence of consanguineous marriage in the MHSS data, we rely on the section of the survey that asked men and women retrospective information about their marriage histories. Information on first marriages only was considered.<sup>8</sup> Our working sample consists of 4,087 married women and 3,358 married men, once we require complete information on age and education, marriage (including age at marriage, relationships to their spouses, and payments of dowry), parental characteristics, parental assets, inheritances and inherited assets, and household demographics. Descriptive summary statistics of the variables of interest are provided in table 1. A quick glance

<sup>6</sup> This survey is a collaborative effort of RAND, the Harvard School of Public Health, the University of Pennsylvania, the University of Colorado at Boulder, Brown University, Mitra and Associates, and the International Centre for Diarrhoeal Disease Research, Bangladesh.

<sup>7</sup> The University of Delaware Air and Temperature Precipitation Data are provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA.

<sup>8</sup> About 15% of men and about 7% of women reported that they have had more than one marriage. This gender difference is driven by the fact that while divorced and widowed men typically remarry, most women in these same circumstances do not (Joshi, 2004).

<sup>5</sup> The framework of our model also allows thinking of consanguineous marriages as allowing the enforcement of insurance contracts between families when an insurance motive is driving marriage (Rosenzweig & Stark, 1989).



TABLE 1.—SUMMARY OF KEY VARIABLES FOR FEMALE AND MALE SAMPLES

Variable	Female Sample			Male Sample		
	Mean	SD	N	Mean	SD	N
Married cousin (1 = Yes, 0 = No) <sup>a</sup>	0.107	0.309	4,095	0.107	0.309	3,358
Married relative (1 = Yes, 0 = No) <sup>b</sup>	0.079	0.269	4,095	0.081	0.273	3,358
Married non-relative within village (1 = Yes, 0 = No)	0.143	0.350	4,095	0.140	0.347	3,358
Dowry (1 = Yes, 0 = No)	0.367	0.482	4,095	0.14	0.347	3,358
Log of dowry value (in thousands of taka)	-1.694	1.025	4,095	-2.015	0.759	3,358
Age (in years)	36.652	10.135	4,095	47.482	14.089	3,358
Father's age (in years)	64.786	15.475	4,015	67.984	15.849	3,297
Muslim (1 = Yes, 0 = No)	0.887	0.316	4,095	0.892	0.311	3,358
Years of schooling (in years)	2.204	3.002	4,095	3.356	3.887	3,358
Birth order	2.920	1.801	4,095	2.512	1.566	3,358
Mother attended school (1 = Yes, 0 = No)	0.007	0.082	4,095	0.027	0.162	3,358
Father attended school (1 = Yes, 0 = No)	0.391	0.488	4,095	0.285	0.452	3,358
Mother alive at marriage (1 = Yes, 0 = No)	0.933	0.251	4,095	0.862	0.345	3,358
Father alive at marriage (1 = Yes, 0 = No)	0.842	0.365	4,095	0.656	0.475	3,358
Number of brothers alive at marriage	2.211	1.469	4,095	1.699	1.390	3,358
Number of sisters alive at marriage	1.904	1.368	4,095	1.743	1.338	3,358
Parents farmland (100000)	344.50	2,760.72	4,033	467.475	4,008.87	3,311
Log of parents farmland	0.854	5.085	4,033	1.437	4.782	3,311
Inherited anything from parents (1 = Yes, 0 = No)	0.097	0.296	4,095	0.694	0.461	3,358
Received a transfer from parents (1 = Yes, 0 = No)	0.828	0.377	4,034			
Received an inheritance or a transfer from parents (1 = Yes, 0 = No)	0.848	0.359	4,034			
Rainfall dev when mother aged 13 (in millimeters) <sup>d</sup>	2.079	0.385	4,095			

<sup>a</sup>Includes marriages to first cousins. <sup>b</sup>Includes marriages to all relatives other than first cousins. <sup>c</sup>Calculated as the deviation of rainfall from the average (of the area) at the average age of a woman's marriage.

at the table does not reveal systematic differences in characteristics between male and female samples. Admittedly, when we look at individual characteristics, males are more educated and, by construction of the data set, are older.

Of all the female respondents in our sample, 10% married a first cousin, 8% married a relative other than a first cousin, and 14% married a nonrelative in the same village. It is interesting that 36% of women and only 18% of men report the payment of a dowry at the time of marriage. We believe the difference is in psychological biases in the interpretation of gifts and transfers as "dowries" between the bride and the groom: since women want their dowries to improve their status and acceptance in their new home, they will have a tendency to interpret all gifts given at marriage as dowry. We therefore use the female sample to carry out our analysis and include in our definition of the dowry all transfers that were paid at the time of marriage. The dowry question was asked in two ways: respondents were asked whether they paid a dowry at the time of marriage—a binary variable—and whether this took the form of bride-wealth or gifts and transfers to the woman's in-laws. Respondents were also asked to provide an estimate of the dowry's value. In our analysis, we use both the binary indicator and dowry values.

#### A. Consanguinity and Dowries

Prediction 1 of the model can be tested by examining the simple correlations between the payment of dowries and first-cousin marriages. We look at the conditional correlation between dowry payment and consanguinity by correlating the dummy variable Dowry with the various measures of consanguinity that were considered previously. The results are presented in the first three columns of table 2. They indicate

that compared to women who marry non-relatives, women who marry their first cousins 5% to 6% points less likely to bring a dowry, and this effect is robust to controlling for individual characteristics (age, years of schooling, religion, and birth order), family characteristics (mother and father were alive at the time of marriage, number of brothers and sisters at the time of marriage, and father's landholdings), and rainfall at the time that a woman was of marriageable age. Considering that in this population, about 35% of all women report the payment of a dowry at the time of marriage, this is a substantial and important difference. The results are similar if we expand the definition of consanguinity to include marriages between second cousins and other types of marriages between relatives. Marriage to other kin as well as marriages to nonkin within a village are also associated with a 3.5 percentage point lower likelihood of dowry payment. The relationship between dowry and social distance is strongest in the case of cousins. This is consistent with our theory: dowries are predicted to become more likely as social distance between the families of a bride and groom increases.

In an additional test, we use the logarithm of the dowry values as a dependent variable and obtain similar results for marriages at different social distances (table 2, columns 4–6). After controlling for individual, household characteristics, and year of marriage fixed effects, the results show 6.9%, 12.2%, 7.7% lower dowry values when the two spouses are first cousins, a relative other than first cousin, and nonrelative in the same village, respectively.<sup>9</sup> The coefficients are significant at the 5% level for two of the three variables, presumably because the sample of dowry values is larger for these variables.

<sup>9</sup> Since age at marriage and year of marriage are often not remembered with great precision, we define fixed effects over five-year windows.

TABLE 2.—DOWRY AND CONSANGUINITY: PARTIAL CORRELATIONS

	Paid Dowry			Log Dowry Value		
	(1)	(2)	(3)	(4)	(5)	(6)
Married cousin	-.0507 (.0205)**	-.0550 (.0206)***	-.0613 (.0208)***	-.0454 (.0439)	-.0557 (.0441)	-.0692 (.0447)
Married relative		-.0542 (.0232)**			-.1095 (.0498)**	-.1226 (.0502)**
Married nonrelative within village			-.0347 (.0182)**			-.0771 (.0391)**
Age	-.0295 (.0085)***	-.0289 (.0085)***	-.0301 (.0085)***	-.0545 (.0183)***	-.0536 (.0183)***	-.0560 (.0183)***
Age squared	.0020 (.0012)**	.0019 (.0011)**	.0021 (.0012)**	.0033 (.0025)	.0032 (.0025)	.0035 (.0025)
Years of schooling	-.0117 (.0024)***	-.0118 (.0024)***	-.0120 (.0024)***	.0106 (.0052)**	.0105 (.0052)**	.0100 (.0052)**
Muslim	-.2484 (.0204)***	-.2459 (.0204)***	-.2463 (.0204)***	-.5866 (.0437)***	-.5792 (.0438)***	-.5818 (.0438)***
Birth order	.0012 (.0043)	.0015 (.0043)	.0013 (.0043)	.0046 (.0091)	.0053 (.0091)	.0050 (.0091)
Mother alive at marriage	-.0305 (.0255)	-.0316 (.0255)	-.0313 (.0255)	-.0399 (.0547)	-.0420 (.0547)	-.0416 (.0547)
Father alive at marriage	.0201 (.0181)	.0202 (.0180)	.0199 (.0180)	.0089 (.0387)	.0087 (.0387)	.0084 (.0387)
Brothers at marriage	.0124 (.0050)**	.0124 (.0050)**	.0127 (.0050)**	.0189 (.0108)**	.0187 (.0108)**	.0195 (.0108)**
Sisters at marriage	.0025 (.0052)	.0022 (.0052)	.0022 (.0052)	.0068 (.0112)	.0063 (.0112)	.0061 (.0112)
Mother attended school	-.1573 (.0764)**	-.1553 (.0764)**	-.1563 (.0764)**	-.2322 (.1639)	-.2261 (.1638)	-.2297 (.1638)
Father attended school	-.0351 (.0143)**	-.0346 (.0143)**	-.0350 (.0143)**	-.0867 (.0307)***	-.0864 (.0307)***	-.0866 (.0307)***
Log of parents' farmland	.0036 (.0013)***	.0036 (.0013)***	.0035 (.0013)***	.0104 (.0028)***	.0102 (.0028)***	.0101 (.0028)***
Parents' farmland missing	-.0433 (.0322)	-.0456 (.0322)	-.0446 (.0322)	-.0922 (.0691)	-.0962 (.0691)	-.0951 (.0690)
Rainfall controls	Yes	Yes	Yes	Yes	Yes	Yes
N	4,015	4,015	4,015	4,015	4,015	4,015
R <sup>2</sup>	.3394	.3396	.3407	.3308	.3316	.3323

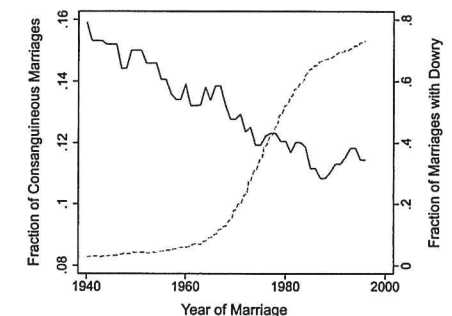
The variable Log Dowry Value assumes a dowry value of 1 taka if no dowry was paid. All regressions have year of marriage fixed effects where year of marriage is coded as five-year intervals. Standard errors, shown in parentheses, are clustered at the bari-level. Significant at \*10%, \*\*5%, and \*\*\*1%.

The relationship between dowry and consanguinity over time can be observed in figure 1. Dowries in Matlab have been increasing as the practice of first-cousin consanguineous marriages has been falling. Our model tells a story consistent with the observed trends: in a setting where improvements in transportation and communication allow individuals to search over greater geographic distances for matches at larger social distances, the problem of ex ante commitment becomes greater, calling for the payment of higher levels of dowry in marriages between individuals who are outside the family network.

#### B. Consanguinity and Bequests

At the heart of our model is an intertemporal shift of transfers: a bride who marries into a socially distant family must bring a dowry at the time of marriage because an ex ante commitment by her natal family to pay future gifts and bequests is not credible. Her natal family will have incentives to free-ride on the investments of the groom's parents and direct their own investments elsewhere. In a consanguineous or socially close union, however, the bonds of trust are likely to be stronger, and interests of the bride and groom's families are less likely to diverge. In this instance, we expect lower dowries and

FIGURE 1.—PREVALENCE OF COUSIN MARRIAGE (SOLID LINE) AND DOWRY (DASHED LINE) OVER TIME (1935–2000). RESULTS ARE BASED ON THE SAMPLE OF ADULT WOMEN



higher marriage transfers and bequests after marriage (prediction 2). To test this prediction, we examine the relationship between inheritance or gifts and social distance within marriages. We define inheritance as a binary variable that takes

TABLE 3.—CORRELATES OF INHERITANCES AND TRANSFERS

	Female Sample				Male Sample	
	Inheritance		Transfers		Inheritance	
	(1)	(2)	(3)	(4)	(5)	(6)
Married cousin	.0285 (.0165)**		.0326 (.0196)**		-.0232 (.0223)	
Married relative	.0283 (.0180)		.0046 (.0231)		.0246 (.0231)	
Married nonrelative within village	.0249 (.0135)**		.0228 (.0169)		-.0256 (.0198)	
Log of dowry value		-.0106 (.0200)		-.0471 (.0272)**		.0261 (.0360)
Log of dowry $\times$ age		.0007 (.0006)		.0012 (.0009)		-.00007 (.0010)
Age	-.0004 (.0031)	-.0051 (.0061)	-.0166 (.0041)**	-.0193 (.0083)**	.0384 (.0030)**	.0280 (.0048)**
Age squared	.0007 (.0004)	.0016 (.0008)**	.0020 (.0006)**	.0026 (.0012)**	-.0027 (.0003)**	-.0021 (.0005)**
Father's age	-.0006 (.0004)	-.0009 (.0003)	-.0003 (.0005)	-.0003 (.0005)	-.0004 (.0005)	.0002 (.0004)
Muslim	.0663 (.0103)**	.0787 (.0146)**	-.0721 (.0172)**	-.0731 (.0200)**	-.0360 (.0240)	-.0027 (.0191)
Years of schooling	-.0015 (.0015)	-.0010 (.0017)	-.0077 (.0024)**	-.0081 (.0024)**	-.0043 (.0019)**	-.0070 (.0017)**
Birth order	.0151 (.0030)**	.0075 (.0032)**	-.0016 (.0041)	-.0019 (.0044)	.0411 (.0051)**	.0116 (.0045)**
Mother attended school	-.0569 (.0129)**	-.1305 (.0547)**	.1418 (.0415)**	.1249 (.0746)**	.0174 (.0411)	-.0738 (.0368)**
Father attended school	.0054 (.0099)	.0053 (.0101)	.0244 (.0135)**	.0223 (.0138)	.0036 (.0165)	.0002 (.0141)
Mother alive at marriage	.0086 (.0222)	.0120 (.0180)	.0105 (.0250)	.0101 (.0246)	.0733 (.0201)**	.0443 (.0172)**
Father alive at marriage	-.0723 (.0176)**	-.0381 (.0145)**	.0168 (.0191)	.0175 (.0199)	-.1905 (.0150)**	-.1168 (.0142)**
Brothers alive at marriage	-.0288 (.0039)**	-.0247 (.0036)**	.0014 (.0047)	.0016 (.0049)	-.0315 (.0058)**	.0017 (.0048)
Sisters alive at marriage	-.0142 (.0036)**	-.0115 (.0037)**	.0006 (.0048)	.0005 (.0050)	-.0080 (.0061)	.0063 (.0048)
Log parents' farmland	.0037 (.0009)**	.0037 (.0009)**	.0018 (.0013)	.0018 (.0013)	.0271 (.0017)**	.0293 (.0013)**
Parents' farmland missing	-.0083 (.0247)	-.0135 (.0228)	.0034 (.0306)	.0043 (.0311)	-.2714 (.0700)**	-.2249 (.0523)**
N	4,015	4,015	4,015	4,015	3,297	3,296
R <sup>2</sup>	.0845	.1077	.0136	.0149	.3306	.4944
F statistic	15.6947	14.7908	3.6779	2.2383	124.7328	131.3549

Table 2 notes apply here.

the value 1 if the respondent reports that he or she has inherited, or expects to inherit, anything from his or her parents. We define transfers as a binary variable that takes the value 1 if the respondent reports that she has received a transfer from her parents in the year preceding the survey. Among our key independent variables, we then consider three mutually exclusive forms of marriages in decreasing order of social distance: marriages to first cousins, marriages to relatives other than first cousins, and marriages to nonrelatives from within the village. Our regressions control for our standard set of variables of individual, household, family, and climate characteristics.

Table 3 reports the results of the regressions. The positive and significant estimates for the variable Married a Cousin in columns 1 and 3 are consistent with prediction 2: women in consanguineous unions are more likely to receive or expect to receive inheritances or transfers from their parents. The

coefficients for marriage to any relative and marriage to nonrelatives within the same village are not always statistically significant in these regressions. This is consistent with the predictions of our theory: it predicts that the commitment to bequeath their assets to their daughters is likely to be weaker when she marries more distant relatives or nonkin in a village, since the costs or consequences of nonpayment are likely to be smaller in such relationships.<sup>10</sup> The negative coefficient for the variable Log of Dowry Value in columns 2 and 4 also confirm our views that transfers are being optimally timed; women who receive large dowries do not subsequently

<sup>10</sup> This result, in isolation, could also be explained by a higher propensity for parents to make transfers to a consanguineous couple, since they share more genes with them or have better information about in-laws. In our model, this would correspond to having a higher  $\theta$  in consanguineous unions. However, this assumption would not be able to explain the inverse correlation identified in section IVA.

TABLE 4.—CORRELATES OF CONSANGUINITY AND DOWRY

	Married Cousin		Paid Dowry		Log Dowry Value	
	(1)	(2)	(3)	(4)	(5)	(6)
Age at marriage	-.0060 (.0013)**	-.0032 (.0016)**	-.0088 (.0018)**	-.0001 (.0029)	-.0176 (.0038)**	-.0021 (.0062)
Brothers at marriage	-.0110 (.0034)**	-.0088 (.0039)**	.0109 (.0045)**	.0130 (.0051)**	.0190 (.0097)**	.0186 (.0108)**
Sisters at marriage	-.0061 (.0038)	-.0041 (.0041)	-.0023 (.0048)	.0029 (.0052)	.0021 (.0102)	.0074 (.0112)
Parents' farmland	-.7509 (.3152)**	-.7857 (.3280)**	-.5329 (.6335)	.2510 (.6226)	1.8341 (1.3523)	2.5783 (1.3329)**
Parents' farmland squared	.4116 (.1982)**	.4332 (.2060)**	.3054 (.4255)	-.1599 (.4255)	-1.1520 (.9258)	-1.5767 (.9109)**
Age	-.0060 (.0013)**	-.0123 (.0074)**	-.0088 (.0095)**	-.0270 (.0095)**	-.0176 (.0038)**	-.0507 (.0203)**
Age squared		.0012 (.0009)		.0018 (.0012)		.0032 (.0025)
Father's age		.0007 (.0004)**		-.0003 (.0005)		-.0003 (.0010)
Years of schooling		-.0025 (.0018)		-.0110 (.0024)**		.0119 (.0052)**
Muslim		.1188 (.0065)**		-.2468 (.0201)**		-.5718 (.0429)**
Mother alive at marriage		.0067 (.0197)		-.0288 (.0256)		-.0313 (.0548)
Father alive at marriage		-.0317 (.0160)**		.0239 (.0200)		.0071 (.0428)
Birth order		-.0067 (.0032)**		.0023 (.0044)		.0063 (.0094)
Mother attended school		-.0579 (.0526)		-.1710 (.0763)**		-.2724 (.1634)**
Father attended school		-.0089 (.0110)		-.0293 (.0143)**		-.0724 (.0306)**
Rainfall controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,007	4,007	4,007	4,007	4,007	4,007
R <sup>2</sup>	.0126	.0312	.2998	.3373	.2952	.3291

Notes i-iii of table 2 apply.

receive inheritances or transfers. The correlation is negative although statistically significant in the case of transfers to younger couples only.<sup>11</sup>

Next, we run the same regressions for the male sample (table 3, columns 5 and 6). We do not run the regression for transfers for this sample because most men live either with their parents or in close proximity to their parents, making transfers between households very difficult to measure. Note that in column 5, the coefficients for the variable Married a Cousin are negative, although the coefficients are not statistically significant. This lack of significance is consistent with our predictions; we expect no association between inheritance and consanguinity for the male sample, that is, the woman's husband and her in-laws, since patrilocal residence frees this group of the commitment problem faced by the bride's family. Similarly, in column 6, we observe no significant effect of the magnitude of a dowry on inheritances among men.

Taken together, the three results obtained thus far—the negative relationship between dowry and consanguinity, the positive relationship between bequests and consanguinity,

and the negative relationship between bequests and inheritances (for women)—together lend support to our model rather than alternative explanations of consanguinity.

### C. Consanguinity, Credit Constraints, and Wealth

Our next step examines the determinants of consanguinity and dowry payment. Since our survey lacks direct information on parents' financial state at the time of a woman's marriage, we rely on proxy variables. The first of these is the value of the father's landholdings. To the extent that land markets in rural South Asia are thin (Griffin, Khan, & Ickowitz, 2000), current landholdings (or landholdings at the time of father's death) may be regarded as a proxy for past landholdings. The results in table 4 confirm that the incidence of consanguineous marriage decreases with the increase in the extent of father's farmland and the coefficient is significant at the 5% level in the consanguinity regression (column 2). In other words, consanguineous marriages are more common among poorer (and likely credit constrained) households (prediction 3). This relationship however, is nonlinear. After a point, greater landholdings are actually associated with positive dowry payments, consistent with the discussion in section III. The opposite signs of the coefficients on consanguinity and dowry variables are once again consistent

<sup>11</sup> Since information on transfers consists of five-year recalls, it is not surprising that older couples no longer receive transfers from their parents when these are either deceased or no longer income earners.

with prediction 1. These results are also consistent with the results of Mobarak, Kuhn, and Peters (2006), who use a difference-in-differences framework to postulate that the construction of an embankment in Matlab several years prior to the 1996 data created a positive wealth shock for some households, who were then able to pay higher dowries for their daughters and were less likely to enter into consanguineous marriages. Their findings thus reinforce the view that as families get wealthier (starting from an initial condition of low levels of wealth), credit constraints may weaken and the family is able to search for a groom outside the kinship network by providing higher levels of dowries for their daughters.

Finally, we look at alternative proxy variables to test our hypothesis. For example, we could postulate that when marriage takes place at an early age, parents might face steeper cash constraints as they have had less time to accumulate assets. In this case, prediction 3 suggests that a consanguineous union might be chosen instead. We therefore look at the correlation between age of marriage and consanguinity (table 4, columns 1–2) as well as age of marriage and dowry payment (columns 3–6). We find that consanguineous marriages are more likely to be early marriages, while no such association is found with respect to dowry payment. Admittedly, age at marriage, dowry, and consanguinity are joint decisions, so that the results need to be interpreted with caution. Another source of variation in credit is the number of brothers and sisters alive at the time of marriage: a larger number of sisters (or, symmetrically, a smaller number of brothers) would increase the financial burden on the child to be married, so that consanguineous marriage is a more likely option to large dowry payments (prediction 3). The results presented in table 4 are consistent with that hypothesis: an additional male sibling at time of marriage is associated with a lower likelihood that a girl marries a first cousin, though the magnitude of the effect is small, at about 1%. The effect is symmetric when we look at dowry payments (columns 3 and 4) as well as actual dowry values (columns 5 and 6).

## V. Conclusion

This paper has argued that consanguinity is a response to a marriage market failure in developing countries. The starting point of our analysis is the recognition that dowries exist across many societies and that consanguinity is also pervasive across many parts of the world. We propose a theoretical model of the marriage market to reconcile the existence of these two facts. We argue that these two social practices together address an agency problem between spouses' families and then provide empirical evidence that are consistent with the central predictions of the model. By focusing on the economic underpinnings of consanguineous marriage, we identified agency problems in marriage markets and documented the existence of institutions designed to overcome them.

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## APPENDIX: PROOFS

### Proof of Proposition 1

To simplify future discussions, we first restrict strategies to payoff-relevant strategies:

**Lemma 1: Payoff-relevant strategies.** Any match profile  $(m, f)_{m \in M, f \in F}$  with associated payments

$$\{(D_m, z_m, t_m), (D_f, z_f, t_f)\}_{m \in M, f \in F}$$

has an identical payoff profile to match profile  $(m, f)_{m \in M, f \in F}$  with associated payments

$$\{(0, 0, w_m + D_f - D_m), (D_f - D_m, z_f, z_f)\}_{m \in M, f \in F}.$$

Subgame perfection implies that grooms will always invest whatever funds are available to them, or  $w_m + D_f - D_m$ , while brides will not exceed their initial commitment  $z_f$ . We can henceforth limit ourselves to profiles  $\{(D_f, z_f)\}_{f \in F}$  to characterize payments associated with a given match profile  $(m, f)_{m \in M, f \in F}$ .

**Proof of Lemma 1.** Since, by assumption, separation is not a credible threat, equation (7) implies that constraint (12) is binding for the bride's family only, so that  $t_m = w_m + D_f - D_m$  and  $t_f = z_f$  are the unique solutions to maximization of equation (11) subject to equation (12). It is then straightforward to verify that

$$\{(0, 0, w_m + D_f - D_m), (D_f - D_m, z_f, z_f)\}$$

also satisfies equations (8–14) and gives the same payoffs to both  $m \in M$  and  $f \in F$  as  $\{(D_m, z_m, t_m), (D_f, z_f, t_f)\}$  does.

Consider a deviation from two individuals  $(m', f)$ , from equilibrium matches  $(m, f')$  and  $(m, f)$ .  $(\bar{D}_f, \bar{z}_f)$  denotes the associated (payoff-relevant) transfers.

On the equilibrium path, indirect utilities for  $m'$  and  $f$  are given by

$$V_{m'}(w_{m'}, w_f, 1) = A(w_{m'}, w_f, 1)(w_{m'} + w_f)$$

and

$$V_f(w_m, w_f, 1) = \theta A(w_m, w_f, 1)(w_m + w_f).$$

Before focusing on the interesting case (case 4), we first dismiss the obvious cases. Since grooms benefit from in-marriage investments, they are not benefiting from a deviation with a poorer bride (case 1) or a bride with equal wealth (cases 2 and 3):

**Case 1:** If  $w_{m'} > w_f$ , then  $w_f > w_f$ , which implies

$$V_{m'}(w_{m'}, w_f, 1) > V_{m'}(w_{m'}, w_f, d_{mf}).$$

Since  $V_m(w_m, w_f, d_{mf})$  is the highest utility an individual  $m$  can obtain by marrying a spouse  $f$ , the proposed deviation makes  $m'$  strictly worse off. Thus, there is no deviation from the equilibrium such that  $w_{m'} > w_f$ .

**Case 2:** If  $w_{m'} = w_f$  and  $d_{mf} < 1$ , then

$$V_{m'}(w_{m'}, w_f, 1) > V_{m'}(w_{m'}, w_f, d_{mf}).$$

In such case,  $m'$  is made strictly worse off. Thus, there is no deviation from the equilibrium such that  $w_{m'} = w_f$  and  $d_{mf} < 1$ .

**Case 3:** If  $w_{m'} = w_f$  and  $d_{mf} = 1$ , then

$$V_{m'}(w_{m'}, w_f, d_{mf}^*) \geq A(w_{m'}, w_f, d_{mf})(w_{m'} + \bar{z}_f + \bar{D}_f)$$

implies that  $\bar{z}_f = (1 - d_{mf})w_f$  and  $\bar{D}_f = d_{mf}w_f$  so that

$$\begin{aligned} V_{m'}(w_{m'}, w_f, d_{mf}^*) &= A(w_{m'}, w_f, d_{mf})(w_{m'} + \bar{z}_f + \bar{D}_f), \\ V_f(w_m, w_f, d_{mf}^*) &= \theta A(w_m, w_f, d_{mf})(w_m + \bar{z}_f + \bar{D}_f). \end{aligned}$$

Thus, there is no deviation from the equilibrium such that  $w_{m'} = w_f$  and  $d_{mf} = d_{mf}$  and either  $m'$  or  $f$  is made strictly better off.

**Case 4:** The final case is the case  $w_{m'} \leq w_f$ .

Without loss of generality, we can suppose that  $(\bar{D}_f, \bar{z}_f)$  is such that it leaves  $m'$  indifferent between his equilibrium payoff and the deviation payoff:

$$A(w_{m'}, w_f, 1)(w_{m'} + w_f) = A(w_{m'}, w_f, d_{mf})(w_{m'} + \bar{z}_f + \bar{D}_f), \quad (A1)$$

while making  $f$  strictly better off:

$$\begin{aligned} \theta A(w_m, w_f, 1)(w_m + w_f) \\ < \theta A(w_m, w_f, d_{mf})(w_m + \bar{z}_f + \bar{D}_f) + (w_f - \bar{z}_f - \bar{D}_f). \end{aligned} \quad (A2)$$

Equation (A1) implies

$$\frac{A(w_{m'}, w_f, 1)}{A(w_{m'}, w_f, d_{mf})}(w_{m'} + w_f) - w_{m'} = \bar{z}_f + \bar{D}_f,$$

which can be plugged into equation (A2) and, after rearranging, yields

$$\begin{aligned} \frac{A(w_m, w_f, 1)(w_m + w_f) - A(w_{m'}, w_f, d_{mf})(w_{m'} + w_f)}{A(w_{m'}, w_f, d_{mf})(w_f + w_{m'}) - A(w_{m'}, w_f, 1)(w_{m'} + w_f)} \\ < \frac{1}{\theta A(w_{m'}, w_f, d_{mf})} - 1. \end{aligned} \quad (A3)$$

Since  $d_{mf} \leq 1$ , we have

$$\begin{aligned} \frac{A(w_m, w_f, 1)(w_m + w_f) - A(w_{m'}, w_f, d_{mf})(w_{m'} + w_f)}{A(w_{m'}, w_f, d_{mf})(w_f + w_{m'}) - A(w_{m'}, w_f, 1)(w_{m'} + w_f)} \\ \geq \frac{A(w_m, w_f, 1)(w_m + w_f) - A(w_{m'}, w_f, 1)(w_{m'} + w_f)}{A(w_{m'}, w_f, 1)(w_f + w_{m'}) - A(w_{m'}, w_f, 1)(w_{m'} + w_f)} \end{aligned}$$

Since  $w_{m'} < w_m$ , supermodularity implies

$$\begin{aligned} A(w_m, w_f, 1)(w_m + w_f) - A(w_{m'}, w_f, 1)(w_{m'} + w_f) \\ \geq A(w_{m'}, w_f, 1)(w_f + w_{m'}) - A(w_{m'}, w_f, 1)(w_{m'} + w_f) \\ \geq 0. \end{aligned}$$



By transitivity, we thus have

$$\frac{A(w_m, w_f, 1)(w_m + w_f) - A(w_m, w_f, d_{mf})(w_m + w_f)}{A(w_m, w_f, d_{mf})(w_f + w_m) - A(w_m, w_f, 1)(w_m + w_f)} \geq 1$$

and

$$\frac{1}{\theta A(w_m, w_f, d_{mf})} \leq 2 \quad (A4)$$

for any value of  $\theta \geq 0$ , where  $\theta = \frac{1}{2A(\bar{h}, \bar{h}, 0)}$  and  $\theta < \bar{\theta}$  if condition  $A(\bar{h}, \bar{h}, 1) < 2A(\bar{h}, \bar{h}, 0)$  is satisfied.

For any  $\theta \in (\bar{\theta}, \bar{\theta})$ , inequalities (A3) and (A4) form a contradiction; the proposed deviation cannot make  $f$  strictly better off while leaving  $m'$  indifferent. This concludes the proof of proposition 1.

### Proof of Proposition 2

We follow the same strategy as for proposition 1. Consider a deviation from two individuals  $(m', f)$ , from equilibrium matches  $(m', f')$  and  $(m, f)$ . Similarly,  $(\bar{D}_f, \bar{z}_f)$  denotes the associated (payoff-relevant) transfers.

On the equilibrium path, indirect utilities for  $m'$  and  $f$  are given by

$$W_{m'}(w_m, w_f, d_{mf}^*) = A(w_m, w_f, d_{mf}^*) [w_m + (1 - d_{mf}^*) w_f + (1 - \gamma) d_{mf}^* w_f]$$

and

$$W_f(w_m, w_f, d_{mf}^*) = \theta A(w_m, w_f, d_{mf}^*) [w_m + (1 - d_{mf}^*) w_f + (1 - \gamma) d_{mf}^* w_f].$$

**Case 1:**  $w_{m'} > w_f$ . Optimality of  $d_{mf}^*$  implies that

$$W_{m'}(w_m, w_f, d_{mf}^*) \geq W_{m'}(w_m, w_f, d_{mf}).$$

Since  $w_{m'} > w_f$ , hence  $w_f > w_f$ , so that

$$W_{m'}(w_m, w_f, d_{mf}) > W_{m'}(w_m, w_f, d_{mf}^*).$$

By transitivity,

$$W_{m'}(w_m, w_f, d_{mf}^*) > W_{m'}(w_m, w_f, d_{mf}).$$

Consequently,  $m'$  is always worse off when deviating with some  $f$  such that  $w_{m'} > w_f$ . Thus, there is no deviation from the equilibrium such that  $w_{m'} > w_f$ .

**Case 2:** If  $w_{m'} = w_f$  and  $d_{mf} \neq d_{mf}^*$ , then optimality of  $d_{mf}^*$  implies

$$W_{m'}(w_m, w_f, d_{mf}^*) > W_{m'}(w_m, w_f, d_{mf}).$$

Consequently,  $m'$  is always worse off when deviating with some  $f$  such that  $w_{m'} = w_f$  and  $d_{mf} \neq d_{mf}^*$ . Thus, there is no deviation from the equilibrium such that  $w_{m'} = w_f$  and  $d_{mf} \neq d_{mf}^*$ .

**Case 3:** If  $w_{m'} = w_f$  and  $d_{mf} = d_{mf}^*$ , then

$$W_{m'}(w_m, w_f, d_{mf}^*) \geq A(w_m, w_f, d_{mf}^*) (w_{m'} + \bar{z}_f + \bar{D}_f - \gamma \bar{D}_f)$$

implies that  $\bar{z}_f = (1 - d_{mf}^*) w_f$  and  $\bar{D}_f = d_{mf}^* w_f$  so that

$$W_{m'}(w_m, w_f, d_{mf}^*) = A(w_m, w_f, d_{mf}^*) (w_{m'} + \bar{z}_f + \bar{D}_f - \gamma \bar{D}_f),$$

$$W_f(w_m, w_f, d_{mf}^*) = \theta A(w_m, w_f, d_{mf}^*) (w_{m'} + \bar{z}_f + \bar{D}_f - \gamma \bar{D}_f).$$

Thus, there is no deviation from the equilibrium such that  $w_{m'} = w_f$  and  $d_{mf} = d_{mf}^*$  that makes either  $m'$  or  $f$  strictly better off.

**Case 4:** The final case is the case  $w_{m'} < w_f$ . Suppose that  $(\bar{D}_f, \bar{z}_f)$  is the underlying transfers. Before going further, we state a first preliminary result:

**Lemma 2:** Subgame perfect strategies. A match profile  $(m, f)_{m \in M, f \in F}$  with associated payments  $\{(D_m, z_m, t_m), (D_f, z_f, t_f)\}_{m \in M, f \in F}$  is an equilibrium only if

$$\begin{cases} t_m = w_m + (1 - \gamma) D_f - D_m \\ t_f = z_f \end{cases} \quad (A5)$$

and

$$\begin{cases} z_f < (1 - d_{mf}) w_k \Rightarrow D_f = 0 \\ D_m = 0 \end{cases} \quad (A6)$$

**Proof of Lemma 2.** Equalities (A5) are subgame perfect transfers, since  $\theta A(w_m, w_f, d_{mf}) < 1 < A(w_m, w_f, d_{mf})$ . The spouses' utilities are given by

$$U_m(t_m, t_f) = A(w_m, w_f, d_{mf}) [w_m + (1 - \gamma) D_f - D_m + z_f],$$

$$U_f(t_m, t_f) = \theta A(w_m, w_f, d_{mf}) [w_m + (1 - \gamma) D_f - D_m + z_f] + w_f + (1 - \gamma) D_m - D_f - z_f.$$

(i) Suppose that  $D_m > 0$ . Then take  $\eta = \min\{D_m, z_f\}$ . Transfers  $\bar{z}_f = z_f - \eta$  and  $\bar{D}_m = D_m - \eta$  leave  $m$  indifferent while making  $f$  strictly better off.

(ii) Suppose that  $D_f > 0$  and  $z_f < (1 - d_{mf}) w_f$ . Then take

$$\epsilon = \min\{D_f, (1 - d_{mf}) w_f - z_f\}.$$

Transfers  $\bar{z}_f = z_f + \epsilon$  and  $\bar{D}_f = D_f - \epsilon$  make both  $m$  and  $f$  strictly better off.

Therefore (i) and (ii) imply that equation (A6) holds.

Conditions (A6) reflect the fact that in equilibrium, dowry payment is kept to a minimum and thus used only when equation (10) is binding on the bride's side, while grooms do not pay bride-prices. Finally, equalities (A5) are subgame-perfect conditions for ex post transfers.

**Lemma 3:** Supermodularity. Equation (15) defines a unique function  $d(\cdot)$  such that for every  $(m, f) \in M \times F$ ,  $d_{mf}^* = d(w_m, w_f)$ . Furthermore, the indirect utility defined by

$$W^*(w_m, w_f) = A(w_m, w_f, d(w_m, w_f)) [w_m + w_f - \gamma d(w_m, w_f) w_f]$$

is supermodular.

**Proof of Lemma 3.**  $d_{mf}^*$ , when not a corner solution, is implicitly defined by first-order condition

$$\begin{aligned} f(w_m, w_f, d) &= \frac{\partial}{\partial d} A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ &\quad - A(w_m, w_f, d_{mf}^*) \gamma w_f = 0 \end{aligned}$$

and therefore depends on  $(w_m, w_f)$  only. Since  $A(\cdot)$  is increasing and concave in the second-order derivative,

$$\frac{\partial^2 A(w_m, w_f, d)}{\partial d^2} (w_m + w_f - \gamma d w_f) - 2\gamma w_f \frac{\partial A(w_m, w_f, d)}{\partial d} < 0,$$

for every  $d$ , so that for every  $(w_m, w_f) \in [\bar{h}, \bar{h}]^2$ ,  $f(w_m, w_f, d)$  is continuous over  $[0, 1]$  and decreasing in  $d$ . If the solution is interior, then  $d_{mf}^*$  is uniquely defined by  $f(w_m, w_f, d) = 0$ . When  $d_{mf}^*$  is a corner solution and  $f(w_m, w_f, d) > 0$  (resp.  $f(w_m, w_f, d) < 0$ ) for every  $d \in [0, 1]$ , then we

define  $d_{mf}^* = 1$  (resp.  $d_{mf}^* = 0$ ). We can apply the implicit function theorem to determine the derivatives of  $d_{mf}^* \equiv d(w_m, w_f)$  with respect to  $w_f$ , respectively:

$$\begin{aligned} \frac{\partial d(w_m, w_f)}{\partial w_f} &= - \frac{\frac{\partial A}{\partial w_f} (w_m + w_f - \gamma d w_f) + \frac{\partial A}{\partial d} - \frac{\partial A}{\partial w_f} \gamma w_f - \gamma (d \frac{\partial A}{\partial d} + A)}{\frac{\partial^2 A}{\partial d^2} (w_m + w_f - \gamma d w_f) - 2\gamma w_f \frac{\partial A}{\partial d}}, \quad (A7) \end{aligned}$$

where we simplified notations for clarity. A necessary and sufficient condition for

$$W^*(w_m, w_f) = A(w_m, w_f, d(w_m, w_f)) [w_m + w_f - \gamma d(w_m, w_f) w_f]$$

$$g(y, d, w_m, w_f) = - \frac{\frac{\partial^2 A(w_m, w_f, d)}{\partial w_f \partial d} (w_m + w_f - \gamma d w_f) + \frac{\partial A(w_m, w_f, d)}{\partial d} - \frac{\partial A(w_m, w_f, d)}{\partial w_f} \gamma w_f - \gamma (d \frac{\partial A(w_m, w_f, d)}{\partial d} + A(w_m, w_f, d))}{\frac{\partial^2 A(w_m, w_f, d)}{\partial d^2} (w_m + w_f - \gamma d w_f) - 2\gamma w_f \frac{\partial A(w_m, w_f, d)}{\partial d}}.$$

Since  $g(\cdot)$  is well defined over the compact set  $[0, 1]^2 \times [\bar{h}, \bar{h}]$ , there exists a real number  $L$  such that  $\sup_{[0, 1]^2 \times [\bar{h}, \bar{h}]} g(\cdot) \leq L$ . Consequently, there exists  $\bar{\gamma} > 0$  such that (i) holds for every  $\gamma < \bar{\gamma}$ , uniformly with respect to  $(w_m, w_f)$ . This concludes the proof of  $W^*(\cdot)$  supermodularity property.

Consider supporting transfers  $(\bar{z}_f, \bar{D}_f)$  that leave  $m'$  indifferent between his equilibrium payoff and the deviation payoff,

$$\begin{aligned} A(w_m, w_f, d_{mf}^*) (w_{m'} + w_f - \gamma d_{mf}^* w_f) \\ = A(w_m, w_f, d_{mf}) (w_{m'} + \bar{z}_f + (1 - \gamma) \bar{D}_f), \end{aligned} \quad (A11)$$

$$\frac{A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] - A(w_m, w_f, d_{mf}) [w_f + w_{m'} - \gamma \bar{D}_f]}{A(w_m, w_f, d_{mf}) [w_f + w_{m'} - \gamma \bar{D}_f] - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f]} < \frac{1}{\theta A(w_m, w_f, d_{mf})} - 1. \quad (A13)$$

Second, limited liability implies  $\bar{z}_f \leq (1 - d_{mf}) w_f$ , and without loss of generality, we can assume that  $\bar{D}_f \leq d_{mf} w_f$ ; hence,

$$\begin{aligned} d_{mf} w_f - \frac{1}{1 - \gamma} [(w_{m'} + w_f - \gamma d_{mf} w_f) \\ - \frac{A(w_m, w_f, d_{mf}^*)}{A(w_m, w_f, d_{mf})} (w_{m'} + w_f - \gamma d_{mf}^* w_f)] \\ \leq \bar{D}_f \\ \leq d_{mf} w_f. \end{aligned} \quad (A14)$$

The left-hand side of inequality (A13) is strictly positive. To see that, we look at the numerator and denominator separately.

to be supermodular is

$$\begin{aligned} \frac{\partial^2}{\partial w_m \partial w_f} W^*(w_m, w_f) &= \frac{\partial}{\partial w_f} \left\{ \frac{\partial A}{\partial w_m} [w_m + w_f - \gamma d w_f] + A \right\} \\ &= \frac{\partial A}{\partial w_m \partial w_f} [w_m + w_f - \gamma d w_f] \\ &\quad + \frac{\partial A}{\partial w_m} \left[ 1 - \gamma d - \gamma \frac{\partial d}{\partial w_f} w_f \right] + \frac{\partial A}{\partial w_f} > 0 \end{aligned} \quad (A8)$$

The first line, equation (A8), is obtained applying the envelope theorem. Given that  $\frac{\partial A}{\partial w_m} > 0$ ,  $k \in \{m, f\}$ , and  $\frac{\partial^2 A}{\partial w_m \partial w_f} > 0$ , a sufficient condition for  $W^*(\cdot)$  to be supermodular is for every  $(w_m, w_f) \in [\bar{h}, \bar{h}]^2$ ,

$$1 - \gamma d(w_m, w_f) - \gamma \frac{\partial d(w_m, w_f)}{\partial w_f} w_f \geq 0. \quad (A10)$$

We consider function

while making  $f$  strictly better off, or

$$\begin{aligned} \theta A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ < \theta A(w_m, w_f, d_{mf}) (w_{m'} + \bar{z}_f + \bar{D}_f - \gamma \bar{D}_f) + (w_f - \bar{z}_f - \bar{D}_f). \end{aligned} \quad (A12)$$

From equation (A11), we have

$$\bar{z}_f + (1 - \gamma) \bar{D}_f = \frac{A(w_m, w_f, d_{mf}^*)}{A(w_m, w_f, d_{mf})} [w_{m'} + w_f - \gamma d_{mf}^* w_f] - w_{m'}.$$

First, we can substitute for  $\bar{z}_f + (1 - \gamma) \bar{D}_f$  into equation (A12) and obtain after rearranging (the same way we did for the proof of proposition 1),

The numerator on the left-hand side of equation (A13) is therefore bounded by

$$\begin{aligned} A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ - A(w_m, w_f, d_{mf}) (w_{m'} + w_f - \gamma d_{mf} w_f) \\ - \frac{\gamma}{1 - \gamma} [A(w_m, w_f, d_{mf}) (w_{m'} + w_f - \gamma d_{mf} w_f) \\ - A(w_m, w_f, d_{mf}^*) (w_{m'} + w_f - \gamma d_{mf}^* w_f)] \\ \leq A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ - A(w_m, w_f, d_{mf}) [w_f + w_{m'} - \gamma \bar{D}_f] \\ \leq A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ - A(w_m, w_f, d_{mf}) (w_{m'} + w_f - \gamma d_{mf} w_f). \end{aligned} \quad (A15)$$

Given the optimality of  $d_{mf}^*$ , we have

$$\begin{aligned} & A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ & - A(w_m, w_f, d_{mf}) (w_m + w_f - \gamma d_{mf} w_f) \\ & \geq A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ & - A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \end{aligned}$$

and

$$\begin{aligned} & A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & - A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & \leq A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & - A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f). \end{aligned}$$

Lemma 3 states that  $d_{mf}^*$  can be written as a function of  $(w_m, w_f)$  only and the indirect utility  $W^*(w_m, w_f) = A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f)$  is supermodular for low enough values of  $\gamma$ . Thus, we have the following inequality:

$$\begin{aligned} & A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & - A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & \leq A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & - A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f). \end{aligned}$$

By transitivity, assuming that  $\frac{1-\gamma}{1-\gamma} < 1$ , the left-hand side term of inequality (A15) is nonnegative:

Similarly, the denominator on the left-hand side of equation (A13) can be bounded above and below by

$$\begin{aligned} & A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma d_{mf} w_f] \\ & - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ & \leq A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma \bar{D}_f] \\ & - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ & \leq \frac{1}{1-\gamma} \{A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma d_{mf} w_f] \\ & - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f]\}. \end{aligned} \quad (A16)$$

$$\frac{A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] - A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma \bar{D}_f]}{A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma \bar{D}_f] - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f]} \geq 1 - 2\gamma.$$

Assuming that  $\gamma < \frac{1}{2}$ , the same argument as in proposition 1 applies,

$$\frac{1}{\theta A(w_m, w_f, d_{mf})} \geq 2(1 - \gamma), \quad (A18)$$

for every  $\theta \geq \frac{1}{2(1-\gamma)A(\bar{h}, \bar{h}, 0)} \equiv \hat{\theta}$ , so that there is no profitable deviation from the equilibrium. If condition  $A(\bar{h}, \bar{h}, 1) < 2A(\bar{h}, \bar{h}, 0)$  is satisfied,

Since  $m'$  is indifferent between his equilibrium payoffs and the deviation payoffs,

$$\begin{aligned} & A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & = A(w_m, w_f, d_{mf}) [w_m + \bar{z}_f + (1 - \gamma) \bar{D}_f], \end{aligned}$$

and given that  $\bar{z}_f + (1 - \gamma) \bar{D}_f \leq w_f - \gamma d_{mf} w_f$ , we have

$$\begin{aligned} & A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & \leq A(w_m, w_f, d_{mf}) (w_m + w_f - \gamma d_{mf} w_f). \end{aligned}$$

We have shown that the left-hand side of equation (A13) is nonnegative. To conclude the proof, we remark that optimality implies

$$\begin{aligned} & A(w_m, w_f, d_{mf}) (w_m + w_f - \gamma d_{mf} w_f) \\ & \leq A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f), \end{aligned}$$

and supermodularity yields the following inequality:

$$\begin{aligned} & A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ & - A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & \geq A(w_m, w_f, d_{mf}^*) (w_m + w_f - \gamma d_{mf}^* w_f) \\ & - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f]. \end{aligned} \quad (A17)$$

We therefore have

$$\begin{aligned} & A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ & - A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma \bar{D}_f] \\ & \geq \frac{1-2\gamma}{1-\gamma} \{A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma d_{mf} w_f] \\ & - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f]\} \end{aligned}$$

and from inequality (A16) we have

$$\begin{aligned} & A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma \bar{D}_f] \\ & - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f] \\ & \leq \frac{1}{1-\gamma} \{A(w_m, w_f, d_{mf}) [w_f + w_m - \gamma d_{mf} w_f] \\ & - A(w_m, w_f, d_{mf}^*) [w_m + w_f - \gamma d_{mf}^* w_f]\}, \end{aligned}$$

so that the ratio

$\{\gamma \in [0, 1] \mid \gamma < 1 - \frac{A(\bar{h}, \bar{h}, 1)}{2A(\bar{h}, \bar{h}, 0)}\}$  is nonempty. This in turn yields  $\hat{\theta} < \bar{\theta}$  so that the set of possible parameters  $\theta$  verifying equation (A18) uniformly with respect to  $(m', f)$  is nonempty.

By choosing  $\bar{\gamma} = \inf \left\{ \frac{1}{2}, 1 - \frac{A(\bar{h}, \bar{h}, 1)}{2A(\bar{h}, \bar{h}, 0)}, \bar{\gamma} \right\}$ , where  $\bar{\gamma}$  has been defined in lemma 3, we have shown that for any  $\gamma < \bar{\gamma}$  and any  $\theta \in (\hat{\theta}, \bar{\theta})$ , there does not exist a deviation that makes both spouses weakly better off while making one of the two strictly better off. This concludes the proof of proposition 2.

## BREASTFEEDING AND CHILDREN'S EARLY COGNITIVE OUTCOMES

Donna S. Rothstein\*

**Abstract**—This paper investigates whether breastfeeding affects 5- to 6-year old children's cognitive development using three U.S. longitudinal data sets. The results for the full samples roughly point to a dose-response effect of breastfeeding on children's cognitive outcomes, with breastfeeding six months or more associated with about one-tenth of a standard deviation increase in cognitive test scores. The breastfeeding effects do not appear to be due to differences in maternal employment, cognitive ability, or parenting skills. In contrast, within-sibling results show no statistically significant breastfeeding effect.

### I. Introduction

THE American Academy of Pediatrics (2005) recommends exclusive breastfeeding for the first six months of a child's life and then continued breastfeeding through at least the first year. Data show increasing rates of breastfeeding from the mid-1990s to the mid-2000s in the United States (McDowell, Wang, & Kennedy-Stephenson, 2008). In the mid-1990s, about 60% of infants were ever breastfed, and by the mid-2000s the number had increased to over 75%. The rate of breastfeeding at six months remained steady over this period, at a little over 30%. Breastfeeding rates are spread unevenly across demographic groups, with children in poor families, born to young mothers or non-Hispanic black less likely to be breast-fed. Any benefits of breastfeeding are thus spread unequally across children from different demographic backgrounds.

The medical literature points to a plethora of health benefits for breastfeeding mothers and their children. For mothers, breastfeeding has been linked to decreased postpartum bleeding, earlier return to prepregnancy weight, and a reduced risk of breast cancer, among other benefits. The list of potential health benefits for breast-fed children is extensive and includes a lower incidence of bacterial meningitis, diarrhea, respiratory tract infections, otitis media, and urinary tract infections. (See American Academy of Pediatrics, 2005, for a research summary.) In addition, medical researchers have found a dose-response relationship between breastfeeding and health benefits to infants (Chantray et al., 2006).

Medical researchers have posited two key theories as to why breastfeeding may be linked to cognitive development. The first relates to the act of breastfeeding itself, which causes the release of the hormones prolactin and oxytocin in the mother. These hormones may enhance positive mothering behaviors and thus indirectly influence children's

cognitive development (Feldman & Eidelman, 2003). The second relates to the content of breast milk. The long-chain polyunsaturated fatty acids docosahexaenoic acid (DHA) and arachidonic acid (ARA), which are found in breast milk, quickly build up in the brain during the third trimester and first months of life. Medical researchers have found that these fatty acids have a positive influence on neural development.<sup>1</sup>

In general, however, the evidence in the medical literature on the association between breastfeeding and children's cognitive outcomes is mixed—sometimes positive and sometimes not different from 0 (Jain, Concato, & Leventhal, 2002, Slykerman et al., 2005; Ip et al., 2007).

Children's cognitive test scores are related to later educational and labor market attainment (Murnane, Willett, & Levy, 1995). Cunha and Heckman (2007) posit that early investments in children are particularly advantageous because they can have multiplier effects on investments in later childhood. They note that these effects help to explain why the return to early investments in disadvantaged children is so high. Thus, a breastfeeding effect on children's early cognitive development can have important implications for outcomes later in life.

Any study that attempts to evaluate a causal effect of breastfeeding on children's cognitive or health outcomes needs to worry about selection. That is, mothers who breast-feed and their children may be systematically different from those who do not. The differences may be related to observable characteristics, such as the child's birth weight or prematurity, or the mother's age or education, or to unobservable characteristics, such as the mother's ability or motivation. If these characteristics also affect children's cognitive outcomes, it may appear that breastfeeding itself has beneficial consequences, when in fact it is really due to the characteristics of the mothers and their children. Rich data sets that include a measure of maternal cognitive ability, prenatal health behaviors, and children's birth weight should help to mitigate this problem. Much of the medical literature on breastfeeding and children's cognitive and health outcomes does not take into account selection issues.

This paper studies the relationship between breastfeeding and children's early cognitive outcomes using three national U.S. longitudinal data sets that contain both breastfeeding information and young children's cognitive test scores. It examines whether maternal employment in the months after the child's birth affects breastfeeding estimates and whether supplementing breast milk with infant formula or food reduces any breastfeeding effect. Only a

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<sup>1</sup> See the discussion in Horta et al. (2007). Formula companies began to add DHA and ARA to infant formula in 2002. However, the evidence is mixed on whether the supplemented infant formula has additional beneficial effects on children's cognitive development compared to non-supplemented formula (see the discussion in McCann & Ames, 2005).