

The Price of Fertility: Marriage Markets and Family Planning in Bangladesh*

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Abstract

This paper considers the impact of family planning on dowry transfers. We construct a marriage market model in which prospective mates anticipate the outcome of intrahousehold bargaining over fertility. As the price of contraception falls, brides may have to compensate men with higher dowries to attract them into marriage. We test the model using data from a family planning experiment in Bangladesh, which lowered average fertility by 0.65 children. We find that the program increased bride-to-groom dowry transfers by at least eighty percent. The response of the marriage market may dampen the welfare benefits of family planning for women.

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1 Introduction

When a daughter in South Asia marries, her parents transfer up to several multiples of annual household income to her in-laws as dowry. This paper studies how these dowry transfers are affected by the number of children a bride is expected to bear. Husbands tend to desire greater fertility than wives in poor countries, where the costs of childbearing for women are particularly high (Bankole and Singh, 1998). Thus, when exposed to a family planning program, we might expect that women would be led to compensate grooms for the anticipated fall in their fertility.

In this paper, we develop a theoretical model of a marriage market in which prospective mates anticipate the outcome of future intrahousehold bargaining over fertility, and show that a fall in the price of contraception for some women may make them less desirable to grooms. We then use dowry data to show that a successful 1970s family planning experiment in Bangladesh led women to compensate grooms with higher dowries in order to attract them into marriage. We find that dowries increased by at least eighty percent as a result of the family planning program; our point estimates are statistically and economically significant.

This study lies in the intersection of two literatures. First, several scholars have examined the impact of the marriage market (through changes in the sex ratio) on household outcomes (Chiappori et al., 2002, for example). A subset of these papers consider effects on fertility (Angrist, 2002; Francis, 2007). Ours is the first paper (that we are aware of) to look at the reverse effect: the impact of an anticipated change in fertility on marital transfers between forward-looking participants in the marriage market.¹

Second, economists have, in the last fifteen years, begun paying serious attention to dowry as an institution in its own right, building upon the insights of Becker (1981). Prominent articles in this vein include Rao (1993); Anderson (2003) and Botticini and Siow (2003); in

¹Goldin and Katz (2002) and Bailey (2006) study how the availability of the pill shaped marriage outcomes, but their mechanism operates through an increase in age at marriage, rather than the direct and immediate forward-looking behavior we study here.

addition, several recent papers consider dowry in the region of Bangladesh that we study (Esteve-Volart, 2004; Mobarak et al., 2007; Do et al., 2006; Field and Ambrus, 2006).² Ours is the first paper in this field to directly link dowry and fertility. This link is a natural one—many anthropologists have emphasized that fertility lies at the core of marriage as an institution, and that in particular men’s desired fertility is key to understanding marital transfers (Srinivas, 1984; Bell and Song, 1994; Borgerhoff Mulder, 1989). Indeed, some of the earliest mentions of dowry in recorded history draw an explicit connection to fertility.³

This paper offers the first formal model of a marriage market with dowry transfers to consider future household bargaining over fertility. While a number of studies examine intrahousehold bargaining in *existing* marriages, only recently have scholars tackled the problem of how future bargaining affects matching in the marriage market (Chiappori et al., 2005; Choo et al., 2006; Iyigun and Walsh, 2007a). At the same time, we build on existing work on bargaining over fertility (Eswaran, 2002; Rasul, 2008; Seebens, 2006) by embedding the anticipated outcome in a marriage market. Our model is closest to Iyigun and Walsh (2007b) but we depart by generating a dowry function that maps each prospective bride-groom pair to a dowry transfer. Building on the recent literature that shows the close relationship between mass transfer problems, optimal matching and hedonic equilibrium (Chiappori et al., forthcoming), our formulation allows us to derive a closed-form solution for the hedonic dowry function.

The model generates conditions under which when fertility is sufficiently high, a fall in the price of contraception causes men to demand higher dowries. Similarly, as fertility falls, this “dowry premium” falls. The intuition is straightforward: at high fertility levels, the substitution effect of the fall in the price of contraception may dominate the income effect, so that the household bargained fertility outcome makes the husband worse off.

²For a nice survey, see Anderson (2007).

³The betrothal ceremony in ancient Greece, which represented the legally binding moment in a marriage, consisted only of a simple contract between a father and his future son-in-law: “Father: I give you this woman for the procreation [literally, ‘ploughing’] of legitimate children. Young man: I take her. Father: And three talents as dowry. Young man: Fine” (Katz, 1998).

The linchpin of our explanation for the program’s effect on dowries is that husbands desire greater fertility than wives.⁴ We give evidence from studies by demographers and anthropologists that support this stylized claim in the context of developing countries and Bangladesh in particular, and discuss some common explanations of the discrepancy in husbands’ and wives’ desired family size.

The empirical analysis exploits the experimental design of the Matlab Family Planning program in rural Bangladesh, which began in 1977. While over 200 studies have examined the fertility effects of the Matlab program, ours is the first paper to examine the marriage market effects of the program—or, to our knowledge, the marriage market effects of any family planning program. The setting is in many ways ideal for our study. Before the program, contraception was virtually unknown to the population of Matlab, and fertility rates in Bangladesh were among the highest in the world (Phillips et al., 1982). The Matlab program generated an immediate and substantial rise in contraceptive use in the treatment villages, causing an immediate and lasting reduction in fertility of approximately .65 fewer children per couple. Finally, the marriage market in Bangladesh is marked by observable dowry transfers, enabling a natural quantitative measure of the impact of family planning on the marriage market.

The key experimental source of variation is the exogenous shock to the price of contraception for households in treatment villages. This price shock is known to couples at marriage, and enters the marriage market as a shift in the conditional distribution of dowry transfers. To document this shift, we employ a difference-in-differences strategy that compares real dowry payments before and after the onset of family planning across treatment and control villages. Our results indicate large, positive effects of the family planning program on dowries. We find that the program increased average dowry amounts by at least eighty percent. Directly investigating the theorized mechanism of reduced fertility, we use

⁴More precisely, in the model, men have a higher marginal rate of substitution of quantity of children for consumption goods.

an instrumental variables approach, instrumenting fertility in marriages after the program onset with a household's residence in a treatment village. While this result is more difficult to interpret, since fertility decisions are made *ex post*, we find that for the average reduction of .65 births (the observed program effect), the *ex ante* dowry amount was on average approximately 63% larger.

We verify the robustness of the main empirical findings in a number of ways. First, we show that the results are robust to including a variety of controls. Second, while we argue that dowry amounts are most likely not censored, we employ a Tobit estimator to address the possibility of censoring. Third, we test for, and reject, sorting on observables as a possible counter-hypothesis. Finally, we develop a placebo test that runs our difference-in-differences estimator using fake years of onset; only in the true year of program onset do we find a statistically significant effect on dowry amount.

Our paper contributes to a growing literature in development economics that looks at the interplay between traditional social institutions and new technologies. For example, Conley and Udry (2007) consider how traditional networks mediate the diffusion of agricultural technology. Closer to our concerns, Munshi and Myaux (2006) consider the same region of Bangladesh as we do, and study the diffusion of contraception takeup within and between religious groups. Ours is the first study in this vein to examine marital transfers.

Regarding family planning, we do not view our findings as tempering enthusiasm for the Matlab program, in light of its substantial long-run welfare improvements for women and children (Joshi and Schultz, 2007). However, our study does indicate that women (or more precisely, their families) to some extent paid for these improvements up front—a wholly unintended consequence of the program. By taking into account the underlying social institutions in which family planning programs operate, such unintended consequences could perhaps be mitigated.

2 Marital Payments and Fertility Preferences

2.1 Historical Context: Dowry in Bangladesh

In the model that follows, we assume that dowry is a transfer from the bride’s family to the groom’s family, rather than a portion of the bride’s marital assets. To understand this assumption, some context may be useful. The term “dowry” historically refers to two distinct types of marital transfers. The first, a pre-mortem bequest to daughters, has roots in South Asia dating to the earliest textual descriptions of marriage almost two millennia ago (Oldenburg, 2002). These bequest dowries have been observed in many other parts of the world, from Europe (Kaplan, ed, 1985) to Latin America (Nazzari, 1991) to East Asia (Zhang and Chan, 1999). Most scholars place the origin of bequest dowry in women’s poor property rights over inheritance in virilocal societies, such that a bequest to a daughter must take place at her marriage rather than upon her parents’ death (Goody, 1973, for example).⁵

The second type of dowry, the type we study in this paper, is also known as a groom-price, and is a marital payment to the groom’s family. The groom-price or price dowry emerged in India beginning in the late nineteenth century (Tambiah, 1973; Srinivas, 1984; Banerjee, 1999). In Bangladesh, price dowry is a more recent phenomenon, dating to the 1940s (Lindenbaum, 1981; Hartmann and Boyce, 1983). A potential concern with our model is that the data do not specify whether dowry serves as a groom-price or as a pre-mortem bequest—if dowries are bequests, an arguably more apt model would follow along the lines of Zhang and Chan (1999) or Brown (forthcoming). This said, a variety of evidence supports our view that dowry should be modeled as a groom-price. Anthropological studies based on long-term fieldwork universally document the demise of bequest dowry and the rise of price dowry in Bangladesh by the early 1970s (Ahmed, 1987; Ahmed and Naher, eds, 1987; Lindenbaum, 1981; Hartmann and Boyce, 1983).⁶ Indeed, this new form of dowry was

⁵Botticini and Siow (2003) posit a novel alternative explanation: virilocality spurs parents to give a pre-mortem bequest to their daughters in order to incentivize their sons, left to tend the familial estate.

⁶Arunachalam and Logan (2008) generate predictions from the economic theories of price dowry and

often called by the English word “demand” rather than the traditional terms for marriage transactions. Furthermore, the decline of bequest dowry and predominance of price dowry is a phenomenon that is common to other parts of South Asia, a fact which has led other economists studying dowries to model them as groom-prices (Rao, 1993; Sen, 1998; Dasgupta et al., 2008; Dalmia, 2004; Mukherjee and Mondal, 2006).⁷

A final stylized fact about dowries in the period and region we study is that payment is made in full at or before marriage, rather than in installments over several years. This fact is important because a system of installment dowry payments would vitiate the non-contractibility over fertility that drives our theoretical model. Installment contracts over fertility have been documented in sub-Saharan Africa (Gonzalez-Brenes, 2005), but we find no evidence of such arrangements in Bangladesh in the period we study. Interestingly, installment dowry or “dowry renegotiation” seems to have proliferated in Bangladesh starting in the early 1990s, although is not as common as in southern India (Bloch and Rao, 2002).⁸

2.2 Fertility Preferences of Husbands and Wives

Demographers have long argued that husbands’ desired fertility is greater than wives’ in developing countries. A number of surveys ask husbands and wives to report their desired fertility directly: “[m]ost of the information gathered from fertility surveys suggests that women consistently desire smaller families than their husbands” (Eberstadt, 1981, pg. 58). Recently, Bankole and Singh (1998) use Demographic and Health Survey data from eighteen developing countries to show that husbands tend to desire larger families than their wives.⁹

bequest dowry to structure an exogenous switching regression model, using the same dataset we use here. They corroborate the historical and anthropological claim that bequest dowries declined in prevalence and price dowries became more common over time.

⁷Anderson (2004) offers a model to explain why dowries have transformed from bequest to price with modernization, focusing on changes in relative heterogeneity of male and female characteristics.

⁸Suran et al. (2004) survey women in a different part of rural Bangladesh in 2003, and find that approximately nine percent of marriages involve a fraction of dowry being paid after marriage.

⁹Bankole and Singh (1998) is partly a response to Mason and Taj (1987), who use aggregate data on men and women rather than husbands and wives to cast doubt on desired family size differences by gender. Bankole and Singh essentially argue that aggregating by gender opens the latter study to composition bias.

Individual country studies also point to this pattern, and in fact indicate that the discrepancy in desired family size may form well before marriage.¹⁰

While the general pattern is well-known, the causes of the discrepancy in fertility preferences are less clear. One reason often posited in the literature is straightforward: women disproportionately bear costs of bearing and raising children (Eswaran, 2002). After a certain number of children, the costs to a wife of an additional child may outweigh the benefits, while the marginal benefit to the husband may still be positive. Maternal mortality rates in developing countries are an order of magnitude higher in poor countries relative to the developed world, raising the biological costs to mothers of childbirth.

Another explanation derives from male property rights over children's labor. Insofar as fertility is motivated by children's productivity (due to child labor) or old age security concerns (due to adult children's remittances), wives will tend to favor smaller families when economic returns largely accrue to husbands. Folbre (1983) argues that in contexts where the patriarch controls the income of children as well as the reproductive labor of his wife, he will prefer a larger number of children than his wife.

A third possible reason is much more general, and is rooted in evolutionary biology. Since Darwin, a long line of evolutionary biologists have pointed to differential selection pressures operating on fertility preferences of males and females. The classic argument in this vein is Trivers (1972): biological reproductive differences (sperm are metabolically cheap, while eggs are dear) drive optimal mating strategies, which in turn drive optimal parental investment strategies, so that males are biologically selected to favor high fertility while females are biologically selected to favor fewer, high-quality offspring. Borgerhoff Mulder (1989) develops this argument to explain why strongly-built women draw higher bridewealth among the Kipsigis of Kenya: their expected fertility is greater. Although the *net* marital

¹⁰Examples include Short and Kiros (2002) for Ethiopia; Mahmood and Ringheim (1997) for Pakistan; Kimuna and Adamchak (2001) for Kenya; and Stycos (1952) for Puerto Rico. Surveys of secondary school children in Costa Rica, Colombia, and Peru (Stycos, 1999b) and India (Stycos, 1999a) point to higher desired family size among premarital boys.

transfer is reversed in South Asia, the claim that men pay for fertility is consistent with our finding that women of lower expected fertility pay a compensation in the marriage market.

2.2.1 Evidence from Bangladesh

We do not have large-sample evidence comparing husbands' and wives' desired fertility preferences from Bangladesh at the time of the onset of the Matlab program. However, qualitative and small-sample survey evidence supports the pattern described above, that husbands desired more children than wives. In their classic study of marriage in South Asia, Dyson and Moore (1983) place Bangladesh within the fertility pattern characteristics of north India, whereby “[within marriage] women are subjected to relatively strong pronatalist pressures, [and] they are faced with particularly severe restrictions on their ability to control their fertility” (pg. 48). The only quantitative evidence we are aware of, a small sample study (51 men and 51 women) in a Bangladesh village around 1976, found that wives' ideal family size was 6.4 while husband's was 7.0 (Bulatao, 1979).

The differential costs of childbearing and childrearing were well known in the Matlab region of Bangladesh. Indeed, the Matlab region reported some of the highest maternal mortality rates in the world (Koenig et al., 1988); during 1967-1970 estimates range from 570 to 770 deaths per 100,000 births, the majority of which stemmed from direct obstetric causes (Chen et al., 1974).¹¹ Maternal morbidity (injury and illness from childbirth) occurs much more frequently; as of the early 1990s incidence of acute maternal morbidity was reported at 67 episodes per maternal death (Goodburn et al., 1995).

Conflicting fertility preferences between husbands and wives was a common theme in focus group interviews conducted in the Matlab region. Women reported that: “In many cases, the husband says to his wife: ‘Look, you can’t use family planning methods: let there be ten babies—if that’s what it’s going to be.’ But the wife thinks otherwise Men

¹¹By way of comparison, the maternal mortality rate in the United States during 1974-1978 was around 12 per 100,000 (Smith et al., 1984).

don't bother about the number of children. While women do, because they are the ones who actually look after the families. The burden of the family is really borne by women" (Simmons, 1996, pg. 253).

Furthermore, husbands' desire for greater fertility manifested in women being ostracized and punished for the use or even possession of contraceptives. A common theme that emerged in interviews with women in the treatment villages was that "many husbands, in the tradition of patriarchy, initially complained about their wives accepting contraception" (Duza and Nag, 1993, pg. 79). Women who sought to use contraception did so "at considerable personal risk of embarrassment, shame, or rejection by her husband and his family" (Cleland et al., 1994). Husbands reportedly punished even the possession of contraceptives (Aziz and Mahoney, 1985). Munshi and Myaux (2006) argue that these factors slowed the uptake of contraceptive technology in Matlab. Adopting contraception challenged the reigning social norm wherein fertility was a wife's primary "socially recognized" contribution to a family.

3 A Model of Marriage Payments and Fertility Choice

Until recently, demographers tended to take husbands' greater desired fertility preferences as manifesting in a rather rudimentary fashion. As a recent survey points out: "Demography has regarded men as economically important but as typically uninvolved in fertility except to impregnate women and to stand in the way of their contraceptive use" (Greene and Biddlecom, 2000, pg. 83). Within the last decade, demographers and economists have urged the development of models incorporating conflicting fertility preferences to generate cleaner predictions regarding fertility behavior (Voas, 2003; Bergstrom, 2003). Economists have taken steps in this direction (Eswaran, 2002; Rasul, 2008; Seebens, 2006), but some prefer models incorporating differential costs of fertility so as not to assume differential fertility preferences between husbands and wives (Iyigun and Walsh, 2007b). Our paper aims to shed light on this question by investigating an observable prediction of the claim of differential

fertility preferences: that prospective grooms require compensation to marry women who face a lower price of fertility control.

The model consists of two environments: a marriage market and an intrahousehold fertility bargain. First, individuals match in a competitive marriage market. The equilibrium dowry function maps the characteristics of each possible bride-groom pairing to a dowry amount, taking the results from the future intrahousehold bargain in that pairing as given. Second, married couples bargain in the household to determine the quantity of children and consumption of a household public good. In this way, the anticipated results from the second-stage bargain affect the dowry in the first-stage marriage market.

The theoretical approach draws from three classes of models: “classical” models of contraception and fertility (Becker and Lewis, 1973; Willis, 1973); models of intrahousehold bargaining (McElroy and Horney, 1981); and hedonic models of dowry (Rao, 1993).

In the last 25 years, classical models of fertility choice have come under attack for eliding the dynamic and sequential decision-making that characterizes contraceptive utilization and fertility outcomes. As critics have pointed out, the Becker-Lewis framework is a “once-and-for-all utility-maximizing decision made in full detail at the beginning of the marriage” (Coelen and McIntyre, 1978, pg. 1093). We return to the classical approach for a simple reason: “once-and-for-all” anticipation of future decisions is precisely that which enters the marriage market (determining matching of individuals as well as marital payments) at the time of marriage. That is, we re-cast the Becker-Lewis framework as the *ex ante* prediction of fertility choice at the time of marriage.

In modeling the fertility decision, we depart from classical fertility models in two ways. First, we incorporate conflicting fertility preferences by gender. This is a necessary component of the model, in that only by positing such conflict can we generate predictions about marriage market effects of future fertility outcomes. Second, we draw from bargaining models of intrahousehold choice. The bargaining approach captures the intuition behind the conflicting fertility preferences at the core of the model.

Finally, we embed fertility choice in a model of the marriage market, wherein individuals anticipate the solution of the fertility bargain given by any prospective match. Here, we extend Rao (1993) and the recent literature on the relationship between hedonic equilibrium and optimal matching to express the dowry paid in a match as a function of the characteristics of the couple. Assembling the complete model, we generate predictions for the marriage market effect of changes in parameters that affect prospective fertility.

3.1 Setup of the Model

We model the marriage market as a large, competitive market for couple characteristics. We assume an equal number of men and women. The market is two-sided: each prospective groom has quality y , distributed with cumulative distribution F^y on support $(\underline{y}, \infty]$. Brides have a cost of contraception p_x , distributed with cumulative distribution F^p with lower support given by $\underline{p}_x > 0$. Following the strategy adopted from Rosen (1974) by Rao (1993), we write the dowry as a function that maps a given couple's characteristics (p_x, y) into a net transfer D transferred at marriage from the bride's parents to the groom's parents. Dowry can act as substitute for characteristics, in that female traits that men desire lower the dowry paid, while male traits that women desire increase it.

The key idea in the model is that dowries incorporate an ex ante compensating differential for ex post fertility bargains. The market imperfection is that fertility is non-contractible; women cannot commit to bearing a certain number of children over the course of the marriage, and dowry cannot be conditioned on fertility. Instead, fertility is negotiated within marriage.¹² We model the intrahousehold fertility decision as a Nash bargain over the quantity of children and household joint consumption (McElroy and Horney, 1981; Lundberg and Pollak, 1993). Recent work in household bargaining theorizes changes in prices as operating on the weights in a family welfare function (Browning and Chiappori, 1998, for example).

¹²The setup has some similarities with the incomplete contracts literature (Grossman and Hart, 1986) in that the ex-ante efficient allocation depends on the outcomes of the ex-post bargain.

One advantage of using instead the Nash bargaining approach is that we can represent the solution as a constrained maximization problem, allowing us to draw extensively from standard results in classical demand theory.

In the first stage, marriages are arranged by parents (parents choose their child’s spouse). Arranged marriage is almost universal in South Asia—in our data, approximately 98% of marriages are arranged by parents. We abstract from any intergenerational bargaining that may transpire due to parents’ and children’s different valuation of spousal traits.

Throughout, we denote the bride and her parents by f , and the groom and his parents by m . Parents of brides and grooms have utility:

$$\begin{aligned} \text{Bride’s parents’ utility:} \quad V^f(c^f, n, g, y; p_x) &= c^f + v^f(y)u^f(n, g; p_x) \\ \text{Groom’s parents’ utility:} \quad V^m(c^m, n, g; y) &= c^m + v^m(y)u^m(n, g; p_x) \end{aligned} \quad (1)$$

The bride’s parents’ utility, V^f , is comprised of their own consumption, c ; their daughter’s utility in marriage, u^f ; and utility v^f they derive from matching their daughter (whose trait p_x they take as given) with a groom of quality y . The groom’s parents’ utility, V^m , is specified similarly, where u^m is the utility of the groom. Finally, both bride’s and groom’s parents’ direct utility from the match (v^f and v^m respectively) are twice continuously differentiable and concave. The bride’s u^f and groom’s u^m utility in marriage are given from the second stage bargain, and are a function of the number of children, n , that they will choose to have, as well as a public good consumed within marriage, g . Bride’s and groom’s utility is increasing, twice continuously differentiable, with positive cross-partials and concave in both arguments. The price of contraception does not enter utility directly; instead, the price will help determine the household’s choice of fertility in marriage.

3.2 Stage 2: Fertility Choice within Marriage

We first consider the outcome of the bride and groom’s intrahousehold bargaining problem. A couple takes natural fertility, \bar{n} , and chooses a level of contraception, x , which, following Michael and Willis (1973) is measured in the number of children avoided, so that $n \equiv \bar{n} - x$ is the number of children.¹³ Substituting $\bar{n} - x$ for n into u^f and u^m , we write bride and groom’s utility as:

$$\begin{aligned} \text{Bride's utility:} \quad u^f(n, g) &= u^f(\bar{n} - x, g) \\ \text{Groom's utility:} \quad u^m(n, g) &= u^m(\bar{n} - x, g) \end{aligned} \tag{2}$$

The household chooses child quantity and consumption as the result of generalized Nash bargaining, subject to a household budget constraint. This is solved by maximizing the Nash product, or the “utility-gain product function” (McElroy and Horney, 1981), which we denote u^h :

$$\begin{aligned} \max_{x, g} \quad u^h(\bar{n} - x, g) &= (u^f(\bar{n} - x, g) - z_f)^w (u^m(\bar{n} - x, g) - z_m)^{1-w} \\ \text{s.t.} \quad &g + \Pi(\bar{n} - x) + p_x x = I \end{aligned} \tag{3}$$

The outside options for husbands and wives within marriage are z_m and z_f respectively, and represent the reservation position within marriage (Lundberg and Pollak, 1993). We assume no divorce, an assumption that is realistic in rural Bangladesh—in the 1970s fewer than 1% of women and fewer than 0.01% of men were reported as divorced in Comilla, the region of Bangladesh from which our data derives (Esteve-Volart, 2004). The wife’s bargaining power is given by w ; Π is the price of raising a child; p_x is the price of contraception; I is household

¹³Here we do not explore the tradeoff between child quality and child quantity (Becker and Lewis, 1973), but the appendix extends the model to include child quality. The nonlinear budget constraint implied by complementarity between child quality and child quantity requires an additional assumption about this complementarity, but does not otherwise weaken the model’s main insights.

income; and the price of the consumption good, g , is normalized to 1.

Assumption 1: $\frac{u_n^m}{u_g^m} > \frac{u_n^f}{u_g^f}$

This assumption is central to our predictions: the husband's marginal rate of substitution of quantity of children for consumption is greater than that of the wife.

Assumption 2:

- a. $x \in [0, \bar{n}]$
- b. $p_x < \Pi$
- c. u^f ; u^m ; v^f and v^m satisfy the Inada conditions

These assumptions guarantee a positive, interior solution. Assumption 2a restricts the number of children to be non-negative and weakly less than \bar{n} ; assumption 2b states that contraception is cheaper than the price of child-rearing, ruling out an immediate choice of $x = 0$; and the assumption about u^f and u^m in 2c rules out the case $x = \bar{n}$.

Proposition 1: If fertility is sufficiently high, then a fall in the price of contraception decreases the utility of the husband. That is, if the optimal child quantity n^* is greater than some level \hat{n} : $\frac{du^m}{dp_x} > 0$.

Proofs are given in the appendix. The intuition behind Proposition 1 is straightforward: if the household already has many children, the marginal utility from each additional child is small. Then, the substitution effect of the price decrease outweighs the income effect; the household's reduction in child quantity is sufficient to make the husband worse off. The specific condition stating \hat{n} is given in the appendix.

Conceptually, Proposition 1 follows from the assumption of Nash bargaining, wherein a fall in the price of a good, even one that is enjoyed by both parties, can make one party worse off. When the price of contraception falls, the the budget constraint is pushed out; while the household shifts to an unambiguously superior indifference curve, the husband's utility may actually be lower at the new allocation.

Proposition 2: A rise in the wife’s bargaining power, w , reduces the utility of the husband: $\frac{du^m}{dw} < 0$.

Here the intuition is even more straightforward: the greater the divergence between the husband’s preferred choice of n and g and the household’s bargained outcome, the worse off the husband will be in the bargain.

3.3 Stage 1: Marriage Market

Parents choose a spouse for their child in the marriage market, taking their child’s second stage utility from each potential match as given. We abstract from possible informational asymmetries in that agents in the marriage market know with certainty the outcome of the future household bargain, where $n = \bar{n} - x(p_x, w, \Pi, I)$ and $g = g(p_x, w, \Pi, I)$ is the solution to a given household’s fertility bargain.

Assumption 3: w , Π and I are the same for all couples.

This assumption allows us to focus on the effects of changes in the price of contraception. Empirically, the family planning program that we study may operate on women’s bargaining power as well, but this stage of the model becomes intractable when agents can sort on multiple dimensions.¹⁴ Qualitatively similar results hold if we fix the price of contraception and instead assume that the program operates on women’s bargaining power.

Assumption 4: Dowry is the sole source of parental consumption.

Insofar as the marriage market is concerned, we assume that only the dowry transfer and their child’s utility in marriage enters parental utility. Adding other sources of parental consumption would not qualitatively change the model’s results. Under these assumptions, since no other arguments in parental utility vary, we can write indirect utility functions

¹⁴Allowing for multiple dimensions, existence of equilibrium can only be proven under an assumption of single-crossing, which does not hold in our setting (Ekeland, 2005).

$U^f(p_x)$ and $U^m(p_x)$. Parental utility in (1) then becomes:

$$\text{Bride's parents' utility: } V^f(c, n, g; p_x) = -D(p_x, y) + v^f(y)U^f(p_x)$$

$$\text{Groom's parents' utility: } V^m(c, n, g; y) = D(y, p_x) + v^m(y)U^m(p_x)$$

Here, the parents of a bride with contraception costs p_x pay dowry D in the marriage market when matched with parents of a groom with quality y .

Each set of parents maximizes utility over the trait of their child's partner, taking their child's characteristics and the equilibrium dowry function as given:

$$V^f(p_x) = \max_y -D(p_x, y) + v^f(y)U^f(p_x) \quad (4)$$

$$V^m(y) = \max_{p_x} D(p_x, y) + v^m(y)U^m(p_x) \quad (5)$$

The bride's parents' problem (4) yields a first order condition $-D_y(p_x, y) + v_y^f(y)U^f(p_x) = 0$ and in turn an implicit demand $p_x(y) = U^{f-1}\left(\frac{D_y(p_x(y), y)}{v_y^f(y)}\right)$. Similarly, the groom's parent's problem (5) yields first order condition $D_{p_x}(p_x, y) + v_{p_x}^m(y)U^m(p_x) = 0$ and implicit demand $y(p_x) = v^{m-1}\left(\frac{-D_{p_x}(p_x, y(p_x))}{U_{p_x}^m(p_x)}\right)$.

Suppressing the arguments of the implicit demands for notational convenience, market clearing implies:

$$F^p\left(U^{f-1}\left(\frac{D_y(p_x, y)}{v_y^f(y)}\right)\right) = F^y\left(v^{m-1}\left(\frac{-D_{p_x}(p_x, y)}{U_{p_x}^m(p_x)}\right)\right) \quad (6)$$

Adopting the convention that $F^{y-1}(0) = \underline{y}$, equation (6) yields the main comparative static:

$$D_{p_x}(p_x, y) = -U_{p_x}^m(p_x)v^m\left(F^{y-1}\left(F^p\left(U^{f-1}\left(\frac{D_y(p_x, y)}{v_y^f(y)}\right)\right)\right)\right) \quad (7)$$

Together with Proposition 1, equation (7) yields the following proposition:

Proposition 3: If fertility is sufficiently high, a fall in the price of contraception increases

the dowry a bride’s parents pay in the marriage market.

That is, if initial fertility is greater than \hat{n} so that Proposition 1 “bites,” expression (7) delivers the prediction that parents of women with lower future contraceptive cost pay higher dowries at marriage. Since this result follows from the logic of Proposition 1, we additionally have that the amount that the dowry will increase shrinks as fertility falls.

3.4 Dowry Function

To take the theoretical model to data, we must solve equation (7) to yield a dowry function. An attraction of the relatively simple setup of the model—wherein matching is limited to a single index on each side of the market—is that we can solve for the dowry function explicitly as a solution to a Hamilton-Jacobi-Bellman (HJB) partial differential equation. HJB equations have proven useful in solving mass-transfer problems (Evans, 1998), and their emergence in our setting is a natural consequence of the equivalence between hedonic pricing equilibrium, optimal matching, and optimal mass-transfer problems (Chiappori et al., forthcoming). We extend the existing literature by generating a closed form solution to the market equilibrium, describing the transfer paid at every possible match in terms of the distributions of types and agents’ preferences.

By separating variables, equation (7) yields a family of solutions, called the complete integral (Evans, 1998, pg. 94), given by:

$$D(p_x, y) = -U^m(p_x)v^m (F^{y-1}(F^p(U^{f-1}(C_1)))) + C_1v^f(y) + C_2 \quad (8)$$

By imposing a boundary condition, we can close the model and solve for constants C_1 and C_2 . To simplify the characterization of the boundary condition, we assume that initial fertility lies above \hat{n} so that Proposition 1 applies. Then, a natural boundary condition is that parents of the lowest type on one side of the market get zero surplus from marriage.

Denoting \underline{p}_x as the bride with the lowest contraceptive cost, we have that:

$$-D(\underline{p}_x, y) + v^f(y)U^f(\underline{p}_x) = 0 \quad (9)$$

With this boundary condition in place, we can derive an explicit solution for the dowry function.

Proposition 4: The following dowry function solves the partial differential equation (7) with boundary condition (9):

$$D(p_x, y) = -\Phi U^m(p_x) + \psi^f v^f(y) + \psi^m \Phi \quad (10)$$

where $\Phi \equiv v^m(F^{y-1}(F^p(\underline{p}_x)))$; $\psi^f \equiv U^f(\underline{p}_x)$; and $\psi^m \equiv U^m(\underline{p}_x)$. The dowry paid in a given match increases with male quality y and decreases with women's contraceptive cost p_x .

4 The Matlab Family Planning Program

When the Matlab family planning program was introduced, contraceptive use had been virtually nonexistent in the region. In the mid 1960s, a single family planning clinic served approximately 250,000 households in the area. A decade later, fewer than five percent of the region's women used modern contraception, despite survey evidence suggesting that more than half of women of childbearing age desired no more children. It was decided that instead of making women come to clinics, specialists would go to women, in a door-to-door effort to distribute contraceptives and family planning information. The Matlab program began in October 1977. Seventy villages in a randomly selected treatment area were targeted, with seventy-one villages left as control. A central family planning center and four sub centers were constructed, and eighty female village workers from the area (to begin with) were recruited and given intensive training in family planning counseling. The program workers visited each treatment household approximately once a fortnight, discussing family planning with married

women of childbearing age, and distributing a variety of contraceptives. While condoms were distributed, uptake was limited due to men’s resistance to family planning; the program’s greatest success was in administering tubal ligations and female-use contraceptives (oral pills, and most commonly, depo-medroxyprogesterone acetate (DPMA) injections).¹⁵ The program initially focused on family planning, but beginning in 1982 phased in an extensive maternal and child health component (Phillips et al., 1984).¹⁶

In the estimation of the model, we assume that the Matlab region forms a single marriage market, so that the distributions of characteristics F^y and F^p are common to treatment and control. This assumption is borne out by the qualitative evidence. For many years, the area was not accessible by roads and other modern forms of transportation; the area’s geographic layout has given researchers reasonable grounds to assert its insulation from the outside world (Phillips et al., 1982). Furthermore, no natural boundaries separate the treatment and control areas. While villages in the treatment areas are contiguous, the choice of block randomization was made to minimize spillover; selection into treatment was not based on intrinsic features of the villages. Several studies, most conclusively Joshi and Schultz (2007), have established that covariates were largely balanced at baseline.¹⁷

The Matlab study is the most well-known family planning intervention in the population literature. Freedman (1997, pg. 2) describes the project as “the only reasonably valid experiment that deals with program effects on fertility preferences”—and studies of the effects of family planning in other settings generally begin with a discussion of the Matlab results (Miller, 2007, for example). Not only did contraception rates increase, but Bhatia et al. (1980) found that those who began using contraception were much more likely to remain on contraception for a longer period of time. The effects on fertility were almost immediate—in

¹⁵The program is described in detail in Bhatia et al. (1980).

¹⁶To focus strictly on the family planning aspect of the intervention, we restrict the estimation sample to marriages before 1982.

¹⁷One exception is that the treatment villages contained a larger proportion of Hindus (roughly 14% in treatment compared to 5% in the control). To minimize contamination from this fact, and also because a large body of evidence indicates that Hindus commonly used dowry as bequests rather than a groomprice (Arunachalam and Logan, 2008), we consider only Muslims in the analysis.

our data, we see a large drop in the general fertility rate starting in 1979, when the program began in October 1977.

4.1 Data

We estimate the model using retrospective data from 1996 Matlab Health and Socioeconomic Survey (MHSS), a survey of ever-married women and their husbands in the experimental villages. The complete survey and description of data is available in Rahman et al. (1999). As discussed above, to minimize contamination from the intensive maternal and child health programs implemented in treatment villages in 1982, the estimation sample is restricted to include only marriages during the period 1972-1981. This gives us a total of 1055 marriages; four of these have “missing” for whether dowry was given, yielding a total of 1051 marriages for whom we have information on year of marriage, whether dowry was paid, the dowry amount, and village of residence. Of these, 103 marriages are women’s reports of previous marriages; since the former husband’s characteristics are not reported, we eliminate them from the main estimation sample. Many husbands were difficult to locate, so that the main estimation sample includes a total of 714 marriages. For each couple, we have information on the year of marriage, residence in treatment village, and other characteristics of the husband and wife and their families.

The reported dowry includes the total amount of cash and in-kind value at the time of marriage. In approximately half of the marriages in the sample, the husband also provided a report of dowry amount. When both the husband and wife report dowry amount, we use the average; all results are qualitatively similar when we exclude husbands’ dowry reports. We deflate dowry amounts using the price of rice, as in Khan and Hossain (1989) and Amin and Cain (1998). Details of the deflator are given in Arunachalam and Logan (2008); the empirical results are almost identical if instead nominal amounts are used.

Table 1 reports summary statistics of year of marriage, whether dowry was paid, the dowry amount, residence in treatment village, and the other bride and groom side charac-

teristics, broken down by treatment and control villages. With the exception of wife’s body mass index (BMI), covariates are not statistically significantly different between treatment and control.¹⁸ At the bottom of Table 1, average dowry amounts in treatment and control are broken down by whether the marriage occurred before or after the program. Before the family planning program, average dowries represent roughly sixty percent of a couple’s annual income.¹⁹

5 Empirical Strategy

5.1 Estimation Equation: Reduced Form

Drawing from the description of the Matlab region above, we assume that all villages participate in the same marriage market and therefore share distributions of characteristics F^y and F^p . To derive our estimation equation, we take first-order Taylor expansions of $U^m(p_x)$ and $v^f(y)$ in equation (10). Given the additive separability of the dowry function in p_x and y , we have: $U^m(p_x) = \alpha_U + \gamma_U p_x$ and $v^f(y) = \alpha_V + \gamma_V y$. Substituting into (10):

$$D(p_x, y) = -(\Phi\alpha_U + \Phi\gamma_U p_x) + (\psi^f\alpha_V + \psi^f\gamma_V y) + \psi^m\Phi$$

Second, we suppose that male quality y is a linear single index of a vector of characteristics x^m : $y = \phi^m x^m$. Finally, we assume that the female contraceptive cost is a linear combination of a linear index of a vector of characteristics x^f and an indicator T of treatment by the family planning program: $p_x = \phi^f x^f + \phi_T T$. Adding a random disturbance ϵ produces a

¹⁸A possible explanation for the slightly larger BMI in the treatment villages is that BMI is measured in 1996; maternal health programs had been available since 1982 in the treatment villages.

¹⁹In 1976, the average daily wage in rice farming for a 20-25 year old man was 6.5 takas (Cain, 1977). The probability of being employed in a given day is low; we take an overestimate of 350 days worked to give an annual income of 2275 takas. Women draw very little in the market; using the 1996 proportion of female to male income as an upper bound, we add five percent to give an annual household income of roughly 2400 takas. The average dowry in 1976 is 1440 takas, giving us the estimate of 60% of annual household income.

regression equation estimable at the couple level (in matrix notation):

$$D = \beta_0 + \beta_T T + X^f \beta^f + X^m \beta^m + \epsilon \quad (11)$$

where $\beta_0 \equiv \alpha_V \psi^f + \psi^m \Phi - \alpha_U \Phi$; $\beta_T \equiv \Phi \gamma_U \phi_T$; $\beta^f \equiv -\Phi \gamma_U \phi^f$; and $\beta^m \equiv \psi^f \gamma_V \phi^m$.

The experimental design of the Matlab program allows us to estimate this dowry function using a difference-in-differences strategy, comparing dowries in marriage that occurred before and after the program across treatment and control. In the estimation, we capture the treatment effect β_T as the interaction between dummies for residence in a treatment village and marriage occurring after the program year. Since the family planning program began in October 1977, but we do not have month of marriage reports for most couples, we indicate a marriage in 1977 using a separate dummy, in order to avoid falsely attributing a treatment effect to marriages that may have taken place before the onset of the program.

5.2 Estimation Equation: Instrumental Variables

Directly analyzing the mechanism proposed in the paper poses several challenges. We only observe actual fertility; we do not directly observe the program's effect on p_x . Since dowries are transferred at marriage, while fertility is observed ex post, regressing dowry amounts on observed fertility captures the noise with which couples anticipate intrahousehold bargains.

More importantly, we do not observe household joint consumption over the lifecycle, which the model predicts will increase as a result of a fall in the price of contraception. We adopt an instrumental variables approach that uses exposure to treatment as an instrument for fertility, providing a lower bound estimate of the dowry response to a decrease in expected fertility. Suppressing w , I , and Π by Assumption 3, we have that $U^m(p_x) \equiv u^m(n(p_x), g(p_x))$. We can thus write a linear approximation as $u^m(n, g) = \chi + \mu^n n + \mu^g g$. Substituting into

equation (10) and using the approximation for $v^f(y)$ yields:

$$D = (\psi^f \alpha_V + \psi^f \Phi - \chi \Phi) - \Phi \mu^n n - \Phi \mu^g g + \psi^f \gamma_V y$$

where Φ , ψ^f , α_V , and γ_V are as defined above.

The model demonstrates that the treatment T is not an excludable instrumental variable for n , since (unobserved) joint consumption g is also affected by the fall in the contraceptive price. This said, the model illuminates the direction of the bias from omitting g , since (ceteris paribus) increased joint consumption reduces the dowry paid. Insofar as one of the Matlab program's effects was to increase consumption, as documented by Joshi and Schultz (2007), restricting our attention to fertility produces an estimate of the effect of fertility on dowries that is biased downward. That is, the model predicts that unobserved variation in household joint consumption is negatively correlated with fertility and also negatively correlated with dowry amounts, so that the estimated instrumental variables coefficient on fertility will be attenuated.

To estimate the dowry function, we assume a counterfactual first-order approximation for $g(p_x)$ that is not affected by the treatment T to give a lower bound on the magnitude of the true fertility effect on dowry. Using the approximation for p_x above, we write g as $g = \xi + \zeta \phi^f x^f$. This yields the second-stage estimation equation (in matrix notation):

$$D = \theta + \theta^n n + X^f \theta^f + X^m \theta^m + \nu_D \tag{12}$$

where $\theta \equiv \psi^f \alpha_V + \psi^f \Phi - \chi \Phi - \Phi \mu^g \xi$; $\theta^n \equiv -\Phi \mu^n$; $\theta^m \equiv \psi^f \gamma_V \phi^m$; $\theta^f \equiv \zeta \mu^g \Phi \phi^f$; and ν_D is a random disturbance.

To generate the first-stage regression equation we follow our reduced form approach by taking a first-order Taylor approximation to $n(p_x)$. Adding a random disturbance ν_n

produces the estimation equation:

$$n = \delta + \delta_T T + X^f \delta^f + X^m \delta^m + \nu_n \quad (13)$$

Here, the simple difference-in-differences identification strategy used to estimate the family planning program's effect in reduced form will not capture the fertility effect on dowry, precisely because all women in treatment villages are treated, regardless of whether they happened to marry before or after the program began. Indeed, plotting fertility by year of marriage (not displayed) shows no break in 1977, because all treatment village women who married around the program years were treated.

We approach the problem in the first stage regression by regressing dowry on fertility interacted with a dummy for marriage occurring after the year of the program's onset. Since dowry is a one-time marital transfer, fertility should affect dowry amounts only for those marriages that took place after the change in expected contraceptive costs.

6 Empirical Results

Before turning to regression results, the main empirical finding can be seen visually. Figure 1 shows the general fertility rate (births in each year divided by the number of women of reproductive age 15-44) in treatment and control villages. The general fertility rate in both areas is approximately constant at around .25 births until about 1970, when it begins to trend downward. Before the program year (1977, marked by the vertical line), the general fertility rate in treatment closely tracks the control villages. Family planning workers began visiting treatment villages in October 1977; the reduction in fertility is visible starting in 1979, and continues through to the end of the period. Figure 2 shows average log real dowry (with a start of 1 added to all dowry amounts) in treatment and control villages, plotted by year of marriage. Due to the limited number of observations in some years, we use the three-year centered moving average, weighted by number of marriages. Immediately upon the onset of

the program (again, marked by the vertical line), dowry amounts in the treatment villages jump relative to control. The gap in dowries between treatment and control begins to close around the mid-1980s.

There are a few points worth highlighting. First, while the effect on fertility takes several months to be realized, as we would expect, dowry amounts immediately respond to the program's onset. This is consistent with our model as capturing the effects of changes in anticipated fertility by forward looking agents in the marriage market. Second, dowries in the treatment villages (relative to control) increases upon the onset of the program, consistent with the result in Proposition 3 that a decline in the price of controlling fertility raises dowry amounts. Third, the difference in dowry amounts between treatment and control villages declines as fertility falls in the control villages, consistent with the result in Proposition 1, that the dowry effect of the program will decline as fertility falls. However, we should note that while the overall pattern in the data is consistent with the model, there are other possible explanations for the decline in the dowry effect, most importantly the proliferation of intensive maternal health services in the treatment villages. Intensive medical services were phased in beginning in 1982, and grew to include, for example, tetanus vaccination for all married women of reproductive age (Phillips et al., 1984). Such programs break our strategy of identifying the dowry effect of changes in anticipated fertility; for this reason, we restrict the estimation sample to marriages before 1982.

Restricting our attention to marriages that occurred in the four years before and after the program year (1973-1981), the main results can be seen from the summary data in Table 1. Real dowries in treatment villages before 1977 averaged approximately 264 rice kg, while average dowry in control villages was slightly larger at 271 kg (the difference is not statistically significant). After the program, dowries in treatment villages jump to an average of 487 rice kg, while the dowries in control villages increased slightly to average 283 rice kg. The raw difference in differences in average dowry amounts is 197 rice kg, representing an approximately 75% increase from the control average before the program.

6.1 Reduced Form

Estimation of equation (11) yields the difference-in-differences estimate of the family planning program’s effect on dowries. The results are reported in Table 2. The coefficient of interest is “Treatment×Post”, where the “Treatment” dummy indicates residence in a treatment village at the time of the survey and the “Post” dummy indicates that the marriage took place in 1978 or afterward. As described above, we indicate a marriage in 1977 using the “Transition” dummy, to avoid contamination of the treated sample by marriages that may have occurred before the onset of the program.

Following from the model, the dependent variable in columns 1-3 is real dowry (in rice kg). The coefficient of interest is reported in first row. Column 1 reports a specification with no controls, which is the regression analogue to the raw difference-in-differences dowry effect described above. Column 2 includes bride and groom characteristics; and column 3 corresponds to reduced form estimation equation derived above, with year of marriage dummies included to control for possible changes in the distributions F^p and F^y . From these first three columns, we see that the difference-in-differences estimate (the coefficient on Treatment×Post) ranges from 212.16 kg to 237.30 kg; using the sample mean of the pre-1977 dowries this represents an 80% to 90% increase in dowry amount.

Since the distribution of dowry is skewed to the right, we also report specifications with the log of real dowry (in rice kg) as the dependent variable in columns 4-6. The fact that we must add a start of 1 to the dowry amounts prevents an exact interpretation in terms of elasticity. Ignoring this fact, the coefficients in this semilog specification would translate to a 152% increase in dowry amounts.

In contrast to the coefficient on Treatment×Post, the coefficient on Treatment×Transition is only significant in the specification without controls. Once other characteristics that affect the dowry are added, the point estimate falls and the estimate loses statistical significance.

Although not directly addressed in the model, a natural question is whether the program

operates solely at the intensive margin. In Table 3, we report marginal effects from a probit model where the dependent variable is a dummy indicating that a non-zero dowry was given at marriage. In columns 1-3, we see that a moderate increase in the likelihood of giving a dowry as a result of the program (the coefficient on $\text{Treatment} \times \text{Post}$ is 15-16%). Again, the estimate remains statistically significant even as other controls and year of marriage dummies are added, while the point estimate on $\text{Treatment} \times \text{Transition}$ shrinks and loses statistical significance once covariates are added to the specification.

To sum, in reduced form we find that the family planning program increased average dowry amounts by at least eighty percent—approximately one-half of an average couple’s annual income.

6.2 Fertility and Dowry

We use a two-stage least squares model to test our purported mechanism: that the program increases dowry amounts by lowering fertility. To measure fertility, we follow Joshi and Schultz (2007) in using the number of live births to each couple. As described above, rather than fertility itself, the coefficient of interest in the second-stage estimation of equation (12) is the interaction term $\text{Births} \times \text{Post}$, since only marriages that occurred after the program’s onset should have their dowries affected by the change in expected fertility. This interaction term is instrumented in the first-stage estimation of equation (13) using $\text{Treatment} \times \text{Post}$. The second stage coefficient of interest captures how fertility affects dowry amount for women married after the program versus women married before the program.

Table 5 reports the results of the instrumental variables model. Column 1 reports the second stage; the coefficient on $\text{Births} \times \text{Post}$ represents an approximate doubling in dowry amount for each fewer birth. Column 2 reports the same result using log dowry; here, the effect is a 112% increase for each fewer birth. The estimate of the fertility effect of the program has been widely estimated at reducing births by .65 by couple (Joshi and Schultz, 2007); at this level, the total instrumental variables estimate is approximately 63% (or 73%

using the log dowry estimates) increase in dowry attributable to the average reduction in births. Column 3 reports the first stage.

6.3 Alternative Hypotheses

A natural concern is that the sharp rise in dowry may have been driven by sorting. For example, the program may have affected matching in some unobservable way that raised average dowries in the treatment villages. While we cannot test this hypothesis directly, we can check for sorting on observables as a result of the program. Table 6 displays the estimated coefficients from a series of separate regressions. In each regression, a covariate is treated as the dependent variable, and the difference-in-differences estimate of the program’s “effect” on this covariate is estimated. Other than the dowry results, which correspond with the reported coefficient in Column 1 of Table 1, only with wife’s BMI do we see a statistically significant difference between marriages before and after the program across treatment and control villages. The fact that the change is positive makes it an unlikely candidate for explaining the *rise* in dowry amounts. While it may seem surprising that the program’s effects were largely absorbed by dowry and did not manifest in other sorting behavior, this may have partly been due to cultural factors which limit responsiveness in other dimensions. For instance, using the same dataset as in this paper, Field and Ambrus (2006) show that female age at marriage typically occurs soon after menarche.

Another possible concern is that the research design may be contaminated in some other way—and that we are spuriously attributing to the Matlab program a dowry effect. As a test of the research design, we duplicate the specification in (11) using “fake program years” from 1951 to 1990. For each fake year, we restrict to marriages that occurred within four years before and after that year, and generate the difference-in-differences estimate of the “program” effect by examining the estimated coefficient $\hat{\beta}_T$. Figure 3 displays the results of this placebo test: the only statistically significant difference-in-differences estimate is the one associated with the true year of onset, 1977.

Finally, since no negative dowry amounts are reported in the data, a potential concern is that dowry amounts are left-censored. We would argue that this is unlikely; that is, a “zero” for dowry amount is most likely a meaningful zero—the match is sustained without a dowry being transferred. While we do not have brideprice amounts reported in our dataset, historical evidence indicates that this is probably not an omission. Technically prescribed by the Muslim Family Laws Ordinance, brideprice (“mehr” or “mahr”, often translated as dower) was supposed to include two sums: one to be given to the bride at marriage and the other to be transferred to her only in the event of divorce. However, in Comilla District (which contains Matlab), dower payments were historically rare and of nominal size, and most importantly had declined in prevalence to the point where dower had disappeared by the 1950s, unlike in other parts of Bangladesh (Ambrus et al., 2008). The disappearance of the brideprice was widely discussed by contemporaries and is documented in detail by Amin and Cain (1998); Ahmed (1987); Ahmed and Naher, eds (1987), and (most relevant because it refers to Comilla) Lindenbaum (1981). In addition to transfers prescribed by Islamic law, there were a number of customary groom-to-bride marital transfers (such as the “khailoti”) that also had all but disappeared by the 1950s. The only payments from the groom’s side that continued into our study period were nominal wedding-related customs—for example, the groom was required to give the mullah a nominal sum of 2-4 takas.²⁰

This said, we assess the robustness of our results to the possibility of censoring by using a Tobit model. The estimates in Table 4 indicate much larger program effects than the OLS estimates—in the most complete specification, the estimate is almost double that of the OLS estimate. Since the qualitative evidence does not justify the Tobit assumptions, we do not put much weight in these estimates, except to note that they do not reject our findings.

²⁰For further evidence of the non-existence of brideprice in our sample period, see Esteve-Volart (2004).

7 Conclusions

Consistent with a model in which men demand larger dowries from brides with lower anticipated fertility, we found large and positive effects of a family planning program on dowry transfers in Bangladesh. Our results speak to two literatures which have, up to this point, remained separate. With regard to the growing literature on dowries—particularly the literature regarding dowry inflation in South Asia—we offer a distinct explanation for the rise in dowry-giving and dowry amounts: falling fertility. Our model furthermore predicts that the fertility effect on dowry amounts is initially large and then falls as overall fertility drops. Insofar as our findings generalize to other parts of South Asia, *ceteris paribus* we would predict a decline in dowry-giving as the income effect of the declining price of fertility control dominates the substitution effect.

With regard to the efficacy of family planning programs, our findings indicate that the marriage market responded to attempts to shape fertility outcomes. The Matlab program was responsible for important long-run improvements in women’s health and economic outcomes (Chaudhuri, 2007; Joshi and Schultz, 2007). However, our study does indicate that women (or more precisely, their families) to some extent paid for these improvements up front—a wholly unintended consequence of the program. The effect is analogous to other public policy measures in a variety of settings where only one side of the market is “treated.” Economists have found that the beneficial effects of interventions may be mitigated; if, for example, sex workers are educated about health risks from non-condom use but clients are not, the effect of public health interventions may be to simply raise the compensating differential to risky sex (Gertler et al., 2005). In our context, targeting men’s fertility preferences may be an effective method of improving the efficacy of family planning in poor countries.

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Table 1: Summary Statistics

Variable	Treatment	Control	Difference (Treatment-Control)
Year of marriage	77.12	77.26	-0.14
Wife's age at marriage	15.37	15.39	-0.03
Husband's age at marriage	24.39	24.32	0.06
Wife's BMI	19.6	18.91	0.69***
Husband's BMI	18.81	18.76	0.05
Wife did not attend school (=1)	0.55	0.54	0.01
Wife attended some primary school (=1)	0.34	0.38	-0.04
Wife attended some secondary school (=1)	0.11	0.09	0.03
Husband did not attend school (=1)	0.58	0.58	0.00
Husband attended some primary school (=1)	0.19	0.22	-0.02
Husband attended some secondary school (=1)	0.23	0.20	0.03
Wife's mother's school (yrs)	0.76	0.79	-0.04
Wife's father school (yrs)	2.41	2.37	0.04
Husband's mother's school (yrs)	0.20	0.17	0.03
Husband's father's school (yrs)	1.22	1.12	0.1
Wife's parents' land value (1996 takas)	76078.90	60188.19	15890.71
Husband's parents' land value (1996 takas)	108034.6	90262.11	17772.46
Wife was previously married (=1)	0.18	0.18	-0.01
Husband is polygynous (=1)	0.03	0.02	0.01
Dowry given at marriage (pre-1977) (=1)	0.31	0.32	-0.01
Dowry given at marriage (post-1977) (=1)	0.62	0.49	0.14***
Nominal dowry in takas (pre-1977)	1033.43	1170.76	-137.33
Nominal dowry in takas (post-1977)	2794.68	1689.75	1104.93***
Real dowry in rice kg (pre-1977)	264.07	271.46	-7.39
Real dowry in rice kg (post-1977)	487.38	282.6	204.77***
Births	3.93	4.55	-0.62***

Note: Statistical significance: * 10% ; ** 5% ; *** 1%.

Table 2: Difference-in-Differences Effect on Dowry Amount

	Dowry (1)	Dowry (2)	Dowry (3)	log(Dowry+1) (4)	log(Dowry+1) (5)	log(Dowry+1) (6)
Treatment×Post	212.16 (90.79)**	230.21 (102.99)**	237.30 (102.64)**	0.98 (0.37)***	1.05 (0.44)**	1.09 (0.44)**
Treatment×Transition	293.60 (130.14)**	164.96 (152.70)	183.51 (151.94)	1.25 (0.62)**	0.79 (0.7)	0.84 (0.7)
Treatment	-7.39 (59.09)	-1.05 (67.43)	-14.01 (65.73)	-.07 (0.34)	-.07 (0.39)	-.12 (0.39)
Post	11.15 (44.11)	330.00 (163.18)**		0.94 (0.27)***	-.02 (0.57)	
Transition	-59.34 (70.84)	167.39 (102.59)		-.11 (0.43)	-.26 (0.54)	
Year of marriage (19–)		-52.41 (27.11)*	2.28 (13.69)		0.25 (0.1)***	0.18 (0.07)**
Wife’s age at marriage		-33.55 (7.40)***	-29.14 (6.38)***		-.21 (0.04)***	-.21 (0.04)***
Husband’s age at marriage		1.06 (2.51)	1.30 (2.66)		0.002 (0.02)	0.004 (0.02)
Eligible sex ratio (males/females)		61.28 (217.74)	265.99 (326.40)		-.25 (0.65)	-.67 (0.79)
Wife attended some primary school		27.16 (70.93)	32.38 (69.77)		-.02 (0.28)	-.02 (0.28)
Wife attended some secondary school		22.03 (142.06)	35.79 (143.78)		-.67 (0.5)	-.76 (0.52)
Husb. attended some primary school		15.68 (63.93)	16.79 (66.89)		-.79 (0.25)***	-.81 (0.25)***
Husb. attended some secondary school		209.84 (87.10)**	197.36 (82.99)**		-.27 (0.32)	-.33 (0.31)
Wife’s parents’ land (’000s takas)		0.17 (0.18)	0.17 (0.17)		-.00 (0.00)	-.00 (0.00)
Husband’s parents’ land (’000s takas)		-.05 (0.13)	-.03 (0.12)		0.00 (0.00)	0.00 (0.00)
Wife’s BMI		5.68 (17.60)	5.54 (17.75)		-.03 (0.05)	-.02 (0.05)
Husband’s BMI		-10.01 (16.56)	-11.76 (16.64)		-.01 (0.06)	-.01 (0.06)
Constant	271.46 (35.77)***	4560.92 (2160.45)**	253.93 (1306.78)	2.06 (0.24)***	-12.09 (7.57)	-6.74 (6.63)
Obs.	1051	714	714	1051	714	714
R ²	0.02	0.06	0.08	0.06	0.13	0.14
F statistic	3.35	4.26	4.23	15.12	10.5	8.89

Note: In columns (1)-(3) the dependent variable is real dowry (rice kg); in columns (4)-(6) the dependent variable is log real dowry with a start of 1 added to dowry amounts. Columns (3) and (6) include year of marriage dummies. “Treatment” indicates residence in a treatment village; “Post” indicates a marriage in 1978-1981; “Transition” indicates a marriage in 1977. Parents’ land value is given in 1996 takas. For the schooling dummies, the omitted category is “no school attended.” Robust standard errors, clustered by village. Statistical significance: * 10% ; ** 5% ; *** 1%.

Table 3: Difference-in-Differences Effect on Dowry Participation

	Any Dowry (1)	Any Dowry (2)	Any Dowry (3)
Treatment×Post	0.15 (0.06)***	0.15 (0.08)**	0.16 (0.07)**
Treatment×Transition	0.16 (0.09)*	0.08 (0.12)	0.09 (0.12)
Treatment	-0.01 (0.05)	0.01 (0.07)	0.00 (0.07)
Post	0.18 (0.04)***	-0.03 (0.10)	
Transition	-0.03 (0.07)	-0.10 (0.09)	
Year of marriage (19–)		0.06 (0.02)***	0.04 (0.01)***
Wife’s age at marriage		-0.04 (0.01)***	-0.04 (0.01)***
Husband’s age at marriage		0.00 (0.00)	0.00 (0.00)
Eligible sex ratio (males/females)		-0.22 (0.13)*	-0.36 (0.17)**
Wife attended some primary school		0.02 (0.05)	0.02 (0.05)
Wife attended some secondary school		-0.10 (0.08)	-0.12 (0.08)
Husband attended some primary school		-0.18 (0.04)***	-0.19 (0.04)***
Husband attended some secondary school		-0.12 (0.05)**	-0.14 (0.05)***
Wife’s parents’ land value (’000s takas)		-0.00 (0.00)	-0.00 (0.00)
Husband’s parents’ land value (’000s takas)		0.00 (0.00)*	0.00 (0.00)*
Wife’s BMI		-0.01 (0.01)	-0.01 (0.01)
Husband’s BMI		0.00 (0.01)	0.01 (0.01)
Obs.	1051	714	714
χ^2 statistic	104.52	167.64	191.45

Note: Probit model with marginal effects reported. The dependent variable is “Was any dowry paid at marriage?”. Column (3) includes year of marriage dummies. “Treatment” indicates residence in a treatment village; “Post” indicates a marriage in 1978-1981; “Transition” indicates a marriage in 1977. Parents’ land value is given in 1996 takas. For the schooling dummies, the omitted category is “no school attended.” Robust standard errors, clustered by village. Statistical significance: * 10% ; ** 5% ; *** 1%.

Table 4: Robustness: If Dowry Amounts Are Censored—Tobit Model

	Dowry (1)	Dowry (2)	Dowry (3)	log(Dowry+1) (4)	log(Dowry+1) (5)	log(Dowry+1) (6)
Treatment×Post	428.16 (200.42)**	442.13 (238.94)*	457.71 (236.35)*	1.84 (0.87)**	1.89 (1.02)*	1.96 (1.00)*
Treatment×Transition	656.43 (314.67)**	359.13 (342.53)	395.01 (339.84)	2.71 (1.48)*	1.62 (1.54)	1.71 (1.53)
Treatment	-24.47 (171.51)	3.17 (199.14)	-20.67 (195.84)	-1.15 (0.86)	-0.09 (0.97)	-0.16 (0.95)
Post	301.62 (129.42)**	532.42 (303.58)*		2.37 (0.66)***	0.42 (1.25)	
Transition	-96.23 (216.16)	196.01 (250.44)	-112.08 (240.50)	-0.19 (1.13)	-0.37 (1.22)	-1.26 (1.20)
Year of marriage (19–)		0.85 (40.81)	47.15 (38.05)		0.56 (0.2)***	0.36 (0.17)**
Wife’s age at marriage		-129.71 (31.73)***	-131.35 (29.73)***		-0.61 (0.11)***	-0.68 (0.12)***
Husband’s age at marriage		4.07 (6.57)	5.28 (6.66)		0.01 (0.03)	0.02 (0.03)
Eligible sex ratio (males/females)		-339.15 (373.35)	-431.11 (494.64)		-2.25 (1.58)	-4.46 (1.82)**
Wife attended some primary school		10.41 (134.84)	17.69 (131.35)		-0.12 (0.57)	-0.09 (0.56)
Wife attended some secondary school		-134.69 (271.17)	-143.93 (272.27)		-1.46 (1.15)	-1.64 (1.16)
Husb. attended some primary school		-178.58 (116.53)	-192.83 (117.68)		-1.70 (0.57)***	-1.79 (0.56)***
Husb. attended some secondary school		143.62 (163.23)	93.08 (152.77)		-0.83 (0.68)	-1.07 (0.66)
Wife’s parents’ land (’000s takas)		0.14 (0.34)	0.1 (0.35)		-0.00 (0.00)	-0.00 (0.00)
Husband’s parents’ land (’000s takas)		0.18 (0.24)	0.21 (0.24)		0.00 (0.00)*	0.00 (0.00)*
Wife’s BMI		1.80 (32.15)	3.47 (32.38)		-0.07 (0.12)	-0.05 (0.11)
Husband’s BMI		-15.11 (32.01)	-14.60 (31.57)		-0.02 (0.12)	-0.009 (0.12)
Constant	-562.66 (159.19)***	1600.93 (3439.31)	-1616.76 (3316.48)	-1.58 (0.65)**	-29.98 (15.85)*	-12.31 (15.03)
Obs.	1051	714	714	1051	714	714
χ^2 statistic	25.49	47.84	60.05	86.12	136.38	159.08

Tobit model: In columns (1)-(3) dependent variable is real dowry (rice kg); in columns (4)-(6) log real dowry. Columns (3) and (6) include year of marriage dummies. “Treatment” indicates residence in a treatment village; “Post” indicates a marriage in 1978-1981; “Transition” indicates a marriage in 1977. Parents’ land value is given in 1996 takas. For the schooling dummies, the omitted category is “no school attended.” Robust standard errors, clustered by village. Statistical significance: * 10% ; ** 5% ; *** 1%.

Table 5: Instrumental Variables Model

	Dowry	log(Dowry+1)	Births×Post
Births×Post	-259.30 (133.58)*	-1.12 (0.56)**	
Births	68.38 (55.62)	0.38 (0.24)	0.41 (0.03)***
Treatment×Post			-.79 (0.14)***
Treatment			0.38 (0.08)***
Post	1439.05 (663.21)**	5.55 (2.60)**	4.98 (0.14)***
Year of marriage	-42.61 (25.62)*	0.18 (0.09)*	-.06 (0.03)**
Wife's age at marriage	-35.22 (7.94)***	-.23 (0.04)***	-.03 (0.01)**
Husband's age at marriage	-1.52 (2.58)	-.004 (0.02)	-.002 (0.006)
Eligible sex ratio (males/females)	-55.86 (199.26)	-.87 (0.73)	-.57 (0.2)***
Wife attended some primary school	3.03 (67.17)	-.09 (0.28)	-.03 (0.07)
Wife attended some secondary school	-10.14 (142.83)	-.71 (0.54)	0.009 (0.15)
Husband attended some primary school	11.89 (65.14)	-.77 (0.26)***	0.02 (0.07)
Husband attended some secondary school	220.44 (79.56)***	-.22 (0.31)	0.02 (0.06)
Wife's parents' land ('000s takas)	0.18 (0.16)	-.00 (0.00)	0.00 (0.00)
Husband's parents' land ('000s takas)	-.04 (0.14)	0.00 (0.00)	-.00 (0.00)
Wife's BMI	-1.10 (17.48)	-.05 (0.06)	-.03 (0.01)**
Husband's BMI	-4.14 (15.81)	0.008 (0.06)	0.02 (0.01)
Constant	3764.73 (2060.56)*	-7.88 (7.40)	3.54 (2.16)
Obs.	714	714	714
R^2	0.002	0.01	0.88
F Statistic	0.63	1.48	335.66

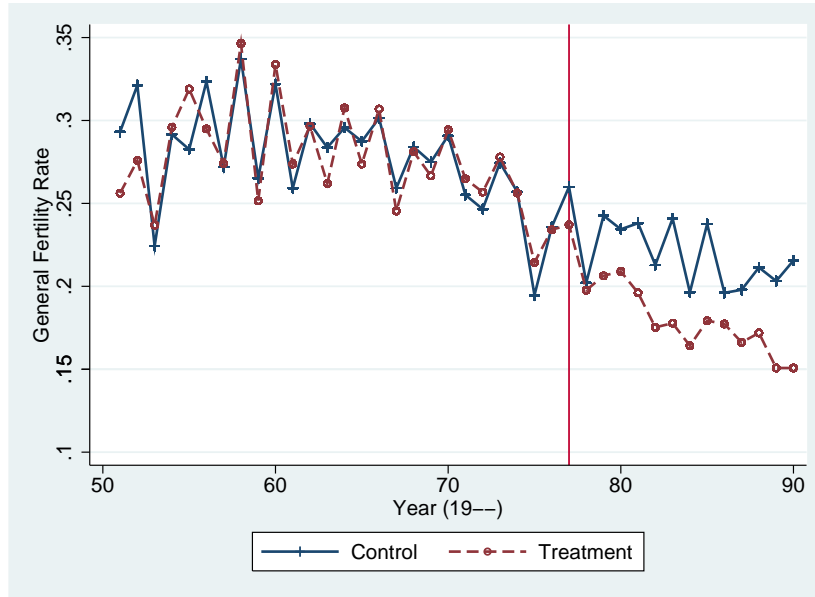
Note: First and second stages of two-stage least squares instrumental variables model. "Treatment" indicates residence in a treatment village; "Post" indicates a marriage in 1978-1981; "Transition" indicates a marriage in 1977. Parents' land value is given in 1996 takas. For the schooling dummies, the omitted category is "no school attended." Robust standard errors, clustered by village.

Table 6: No Evidence of Sorting on Observables

Variable	Treatment×Post (Std Error)	Treatment×Transition (Std Error)
Wife's age at marriage	0.33 (0.42)	0.61 (0.81)
Husband's age at marriage	1.06 (1.17)	0.85 (1.47)
Wife's BMI	-0.77 (0.34)**	0.42 (0.49)
Husband's BMI	-0.24 (0.34)	0.17 (0.75)
Wife did not attend school	-0.01 (0.06)	-0.06 (0.10)
Wife attended some primary school	0.02 (0.06)	-0.01 (0.11)
Wife attended some secondary school	-0.00 (0.04)	0.07 (0.05)
Husband did not attend school	-0.00 (0.06)	-0.22 (0.10)**
Husband attended some primary school	0.04 (0.05)	0.01 (0.09)
Husband attended some secondary school	-0.03 (0.05)	0.21 (0.08)***
Wife's mother's school (years)	0.24 (0.24)	0.52 (0.33)
Wife's father's school (years)	-0.49 (0.46)	1.22 (0.61)**
Husband's mother's school (years)	-0.09 (0.10)	0.14 (0.15)
Husband's father's school (years)	-0.07 (0.38)	-0.38 (0.48)
Wife's parents' land value (1996 takas)	-27110.52 (21853.84)	-37885.55 (28872.56)
Husband's parents' land value (1996 takas)	21916.91 (25108.02)	14354.74 (31398.74)
Wife was previously married	0.05 (0.05)	-0.01 (0.08)
Husband is polygynous	0.01 (0.02)	0.04 (0.03)
Dowry given at marriage	0.14 (0.05)***	0.15 (0.09)*
Nominal dowry (takas)	1242.26 (401.08)***	1156.51 (480.98)**
Real dowry (rice kg)	212.16 (90.79)**	293.60 (130.14)**
Births	-0.03 (0.22)	-0.30 (0.36)

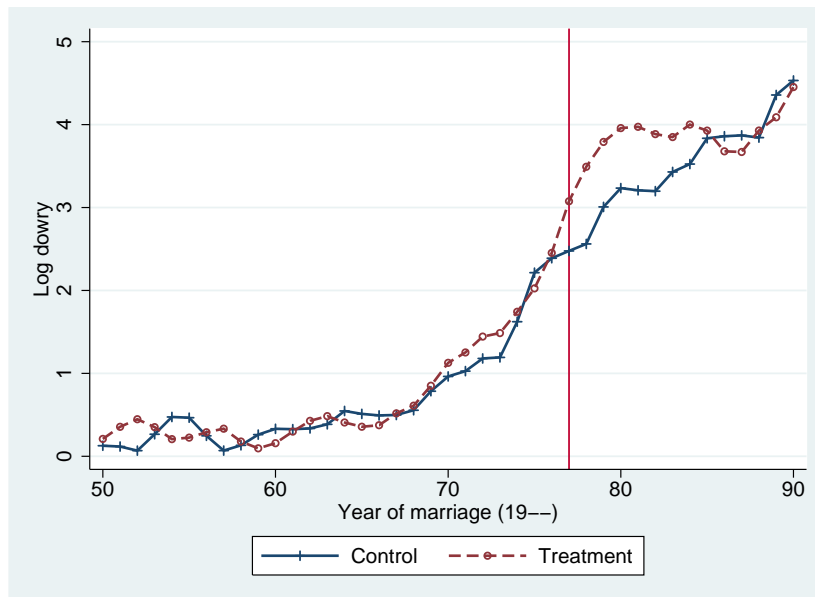
Note: Each row reports the estimated coefficient on the interactions Treatment×Post and Treatment×Transition in a series of separate OLS regressions. The specification for each regression is:

Variable = $\delta + \gamma_1 \text{Treatment} \times \text{Post} + \gamma_2 \text{Treatment} + \gamma_3 \text{Post} + \gamma_4 \text{Treatment} \times \text{Transition} + \gamma_5 \text{Transition} + \nu$
For dummy variables, the specification is a linear probability model. Statistical significance: * 10% ; ** 5% ; *** 1%.



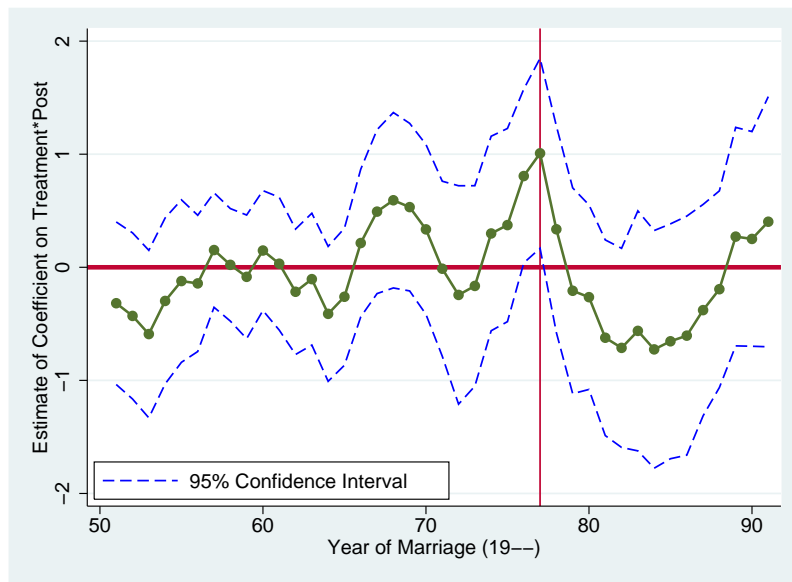
Note: The general fertility rate is the ratio: $\frac{\# \text{ children born in Year } X}{\# \text{ women age 15-44 in Year } X}$. The vertical line marks the year of onset of the Matlab program (1977).

Figure 1: General Fertility Rate



Note: Dowry is in log rice kg. The vertical line marks the year of onset of the Matlab program (1977).

Figure 2: Log Real Dowry by Year of Marriage



Note: The y-axis is the estimated coefficient on the variable $\text{Treatment} \times \text{Post}$ ($\hat{\beta}_1$) in a series of separate placebo regressions.

Figure 3: Placebo Reduced Form Regressions

Appendix

A Proofs of Propositions

Proposition 1:

The proof proceeds in three steps. We first derive a statement comparing the marginal rates of substitution of quantity of children (n) for household consumption (g) of the husband and the household.²¹ Second, we derive (in terms of the husband's marginal rate of substitution) conditions under which a fall in the price of contraception lowers the husband's utility (i.e., $\frac{du^m}{dp_x} > 0$). Third, we use the expressions from the first two steps to state a condition about fertility (n) under which $\frac{du^m}{dp_x} > 0$.

Without loss of generality we can characterize the household decision by maximizing the log of the Nash product:

$$\begin{aligned} \max_{x,g} \quad \log u^h(\bar{n} - x, g) &= w \log (u^f(\bar{n} - x, g) - z_f) + (1 - w) \log (u^m(\bar{n} - x, g) - z_m) \\ \text{s.t.} \quad &g + \Pi(\bar{n} - x) + p_x x = I \end{aligned} \tag{A.1}$$

Step 1: From the expression for $\log u^h$ in (A.1), we take derivatives with respect to quantity of children (n) and the household consumption good (g):

$$\begin{aligned} \frac{d \log u^h}{dn} &= \frac{w u_n^f}{u^f - z_f} + \frac{(1 - w) u_n^m}{u^m - z_m} \\ \frac{d \log u^h}{dg} &= \frac{w u_g^f}{u^f - z_f} + \frac{(1 - w) u_g^m}{u^m - z_m} \end{aligned} \tag{A.2}$$

²¹Here, we slightly abuse terminology by calling $\frac{u_n^h}{u_g^h}$ the household marginal rate of substitution; strictly speaking u^h is not a utility function but a "utility-gain product function" (McElroy and Horney, 1981).

We claim that:

$$\frac{u_n^h}{u_g^h} < \frac{u_n^m}{u_g^m} \quad (\text{A.3})$$

Cross-multiplying, noting that $\frac{\frac{d \log u^h}{dn}}{\frac{d \log u^h}{dg}} = \frac{u_n^h}{u_g^h}$, and substituting from (A.2) :

$$\begin{aligned} \frac{u_n^h}{u_g^h} < \frac{u_n^m}{u_g^m} &\iff u_n^h u_g^m < u_g^h u_n^m \\ \iff \left(\frac{w u_n^f}{u^f - z_f} + \frac{(1-w)u_n^m}{u^m - z_m} \right) u_g^m &< \left(\frac{w u_g^f}{u^f - z_f} + \frac{(1-w)u_g^m}{u^m - z_m} \right) u_n^m \\ \iff \frac{w u_n^f u_g^m}{u^f - z_f} + \frac{(1-w)u_g^m u_n^m}{u^m - z_m} &< \frac{w u_g^f u_n^m}{u^f - z_f} + \frac{(1-w)u_g^m u_n^m}{u^m - z_m} \\ &\iff \frac{w u_n^f u_g^m}{u^f - z_f} < \frac{w u_g^f u_n^m}{u^f - z_f} \\ &\iff u_n^f u_g^m < u_g^f u_n^m \\ &\iff \frac{u_n^f}{u_g^f} < \frac{u_n^m}{u_g^m} \end{aligned}$$

This last inequality is true by Assumption 1, proving the claim.

Step 2: The budget constraint in (A.1) is equivalent to:

$$g + (\Pi - p_x)(\bar{n} - x) = I - p_x \bar{n}$$

Defining $Y \equiv I - p_x \bar{n}$ and $p_n \equiv \Pi - p_x$, we rewrite the budget constraint using the definition of child quantity, $n \equiv \bar{n} - x$:

$$g + p_n n = Y \quad (\text{A.4})$$

Denote by $n(p_n, Y)$ and $g(p_n, Y)$ the household demand functions for number of children and family good consumption, respectively. That is, $n(\cdot)$ and $g(\cdot)$ give the maximand of the constrained Nash product.

We are trying to find the conditions under which $\frac{du^m}{dp_x} > 0$. The husband's utility using

the new notation is $u^m(n, g)$. Differentiating, we have:

$$\frac{du^m(n, g)}{dp_x} > 0 \iff u_n^m(n, g) (-n_{p_n} - n_Y \bar{n}) + u_g^m(n, g) (-g_{p_n} - g_Y \bar{n}) > 0 \quad (\text{A.5})$$

By the Slutsky equation, we have:

$$\begin{aligned} g_{p_n} &= g_{p_n}^C - n g_Y \\ n_{p_n} &= n_{p_n}^C - n n_Y \end{aligned} \quad (\text{A.6})$$

where g^C and n^C denote compensated demands. Substituting the expressions in (A.6) into (A.5) yields:

$$\frac{du^m(n, g)}{dp_x} > 0 \iff u_n^m(n, g) (-n_{p_n}^C - x n_Y) + u_g^m(n, g) (-g_{p_n}^C - x g_Y) > 0 \quad (\text{A.7})$$

By symmetry of compensated demands, we have:

$$g_{p_n}^C = -p_n n_{p_n}^C \quad (\text{A.8})$$

Substituting for $g_{p_n}^C$ from (A.8) into (A.7):

$$\frac{du^m(n, g)}{dp_x} > 0 \iff u_n^m(n, g) (-n_{p_n}^C - x n_Y) + u_g^m(n, g) (p_n n_{p_n}^C - x g_Y) > 0$$

To derive an expression in terms of compensated elasticities, we divide throughout by

$nu_g^m(n, g)$, and then rearrange and multiply through by p_n :

$$\begin{aligned}
\frac{du^m(n, g)}{dp_x} > 0 &\iff \frac{u_n^m(n, g)}{u_g^m(n, g)} \left(\frac{-\epsilon_{n, p_n}^C}{p_n} - \frac{x}{n} n_Y \right) + \left(\epsilon_{n, p_n}^C - \frac{x}{n} g_Y \right) > 0 \\
&\iff \frac{u_n^m(n, g)}{u_g^m(n, g)} \left(\frac{-\epsilon_{n, p_n}^C}{p_n} - \frac{x}{n} n_Y \right) > \left(-\epsilon_{n, p_n}^C + \frac{x}{n} g_Y \right) \\
&\iff \frac{u_n^m(n, g)}{u_g^m(n, g)} \left(-\epsilon_{n, p_n}^C - \frac{x p_n}{n} n_Y \right) > p_n \left(-\epsilon_{n, p_n}^C + \frac{x}{n} g_Y \right) \quad (\text{A.9})
\end{aligned}$$

where ϵ_{n, p_n}^C is the compensated own-price elasticity of demand for quantity of children.

In order to sign the expression $\left(-\epsilon_{n, p_n}^C - \frac{x p_n}{n} n_Y \right)$, note that the definitions $p_n \equiv \Pi - p_x$ and $n \equiv \bar{n} - x$ yield: $n_{p_n}^C = -x_{p_x}^C = x_{p_x}^C$ and $n_Y = -x_Y$. Writing out the definition of the compensated own-price elasticity and using these substitutions gives:

$$\begin{aligned}
\left(-\epsilon_{n, p_n}^C - \frac{x p_n}{n} n_Y \right) &= - \left(\epsilon_{n, p_n}^C + \frac{x p_n}{n} n_Y \right) \\
&= - \left(\frac{p_n n_{p_n}^C}{n} + \frac{x p_n}{n} n_Y \right) \\
&= - \left(\frac{(\Pi - p_x)(-x_{p_x}^C)}{n} + \frac{x(\Pi - p_x)}{n} n_Y \right) \\
&= - \left(\frac{(\Pi - p_x)(x_{p_x}^C)}{n} - \frac{x(\Pi - p_x)}{n} x_Y \right)
\end{aligned}$$

Collecting terms:

$$\left(-\epsilon_{n, p_n}^C - \frac{x p_n}{n} n_Y \right) = - \left(\frac{\Pi - p_x}{n} \right) (x_{p_x}^C - x x_Y) \quad (\text{A.10})$$

By the Slutsky equation: $x_{p_x} = x_{p_x}^C - x x_Y$. Substituting into (A.10):

$$\left(-\epsilon_{n, p_n}^C - \frac{x p_n}{n} n_Y \right) = - \left(\frac{\Pi - p_x}{n} \right) x_{p_x}$$

As long as x is not a Giffen good, $x_{p_x} < 0$, allowing us to sign the expression:

$$\left(-\epsilon_{n,p_n}^C - \frac{xp_n}{n}n_Y\right) > 0 \quad (\text{A.11})$$

Now, using (A.11) in (A.9):

$$\frac{du^m(n, g)}{dp_x} > 0 \iff \frac{u_n^m(n, g)}{u_g^m(n, g)} > p_n \left(\frac{-\epsilon_{n,p_n}^C + \frac{x}{n}g_Y}{-\epsilon_{n,p_n}^C - \frac{xp_n}{n}n_Y} \right) \quad (\text{A.12})$$

Step 3: Since n and g are chosen to maximize the constrained Nash product, we have that:

$$p_n = \frac{u_n^h(n^*, g^*)}{u_g^h(n^*, g^*)} \quad (\text{A.13})$$

That is, at the optimum, the household marginal rate of substitution of child quantity for consumption is equal to the ratio of prices. Using (A.13) in (A.12) and substituting in for n_Y yields:

$$\frac{du^m(n^*, g^*)}{dp_x} > 0 \iff \frac{u_n^m(n^*, g^*)}{u_g^m(n^*, g^*)} > \frac{u_n^h(n^*, g^*)}{u_g^h(n^*, g^*)} \left(\frac{\epsilon_{n^*,p_n}^C - \frac{x^*}{n^*}g_Y}{\epsilon_{n^*,p_n}^C - \frac{x^*p_n}{n^*}x_Y} \right) \quad (\text{A.14})$$

We can implicitly define some number of avoided children \hat{x} :

$$\frac{u_n^m(n^*, g^*)}{u_g^m(n^*, g^*)} = \frac{u_n^h(n^*, g^*)}{u_g^h(n^*, g^*)} \left(\frac{\epsilon_{n^*,p_n}^C - \frac{\hat{x}}{n^*}g_Y}{\epsilon_{n^*,p_n}^C - \frac{\hat{x}}{n^*}p_n x_Y} \right) \quad (\text{A.15})$$

Expression (A.15) gives us the desired sufficient condition under which a fall in the price of contraception lowers the husband's utility. We know that $\hat{x} > 0$ since as $x^* \rightarrow 0$ in (A.14), the right hand side goes to $\frac{u_n^h}{u_g^h}$, which is less than $\frac{u_n^m}{u_g^m}$ by (A.3). If $x^* < \hat{x}$, then $\frac{du^m(n^*, g^*)}{dp_x} > 0$. In the proposition, we state this in terms of fertility n : if $n^* > \hat{n} \equiv \bar{n} - \hat{x}$, then $\frac{du^m(n^*, g^*)}{dp_x} > 0$.

Proposition 2:

We prove the proposition in two steps. First, we show that the household marginal rate of substitution of quantity of children for consumption is decreasing in the wife's bargaining power. Second, we use this result and the principle of diminishing marginal rate of substitution to show that the husband is made worse off with an increase in the wife's bargaining power.

Step 1: We begin by introducing the notation $MRS_{ng}^h \equiv \frac{u_n^h}{u_g^h}$ to denote the household's marginal rate of substitution of quantity of children for consumption. We claim that:

$$\frac{dMRS_{ng}^h}{dw} < 0 \quad (\text{A.16})$$

Since:

$$\frac{dMRS_{ng}^h}{dw} = \frac{d\frac{u_n^h}{u_g^h}}{dw} = \frac{u_{nw}^h u_g^h - u_{gw}^h u_n^h}{(u_g^h)^2}$$

We have that:

$$\frac{dMRS_{ng}^h}{dw} < 0 \iff u_{nw}^h u_g^h < u_{gw}^h u_n^h \quad (\text{A.17})$$

Defining $\alpha \equiv \frac{u^h}{(u^f - z_f)}$ and $\beta \equiv \frac{u^h}{(u^m - z_m)}$, (A.2) implies:

$$\begin{aligned} u_g^h &= w\alpha u_g^f + (1-w)\beta u_g^m \\ u_n^h &= w\alpha u_n^f + (1-w)\beta u_n^m \end{aligned} \quad (\text{A.18})$$

Differentiating (A.18) with respect to w yields:

$$\begin{aligned} u_{gw}^h &= \alpha u_g^f - \beta u_g^m \\ u_{nw}^h &= \alpha u_n^f - \beta u_n^m \end{aligned} \quad (\text{A.19})$$

Now we expand (A.17) using (A.18) and (A.19):

$$\begin{aligned} \frac{dMRS_{ng}^h}{dw} < 0 &\iff \alpha u_n^f(w\alpha u_g^f + (1-w)\beta u_g^m) - \beta u_n^m(w\alpha u_g^f + (1-w)\beta u_g^m) < \\ &\alpha u_g^f(w\alpha u_n^f + (1-w)\beta u_n^m) - \beta u_g^m(w\alpha u_n^f + (1-w)\beta u_n^m) \end{aligned}$$

Multiplying out and cancelling yields:

$$\begin{aligned} \frac{dMRS_{ng}^h}{dw} < 0 &\iff (1-w)\alpha\beta u_n^f u_g^m - w\alpha\beta u_n^m u_g^f < (1-w)\alpha\beta u_g^f u_n^m - w\alpha\beta u_g^m u_n^f \\ &\iff (1-w)u_n^f u_g^m - wu_n^m u_g^f < (1-w)u_g^f u_n^m - wu_g^m u_n^f \\ &\iff u_n^f u_g^m < u_g^f u_n^m \\ &\iff \frac{u_n^f}{u_g^f} < \frac{u_n^m}{u_g^m} \end{aligned}$$

This last inequality is true by Assumption 1, proving the claim.

Step 2: Differentiating the husband's utility $u^m(n, g)$ with respect to the wife's bargaining power w yields:

$$u_w^m = u_n^m n_w + u_g^m g_w \tag{A.20}$$

By (A.3) and (A.13), we have at the optimum:

$$\frac{u_n^m(n^*, g^*)}{u_g^m(n^*, g^*)} > \frac{u_n^h(n^*, g^*)}{u_g^h(n^*, g^*)} = p_n \tag{A.21}$$

Differentiating the budget constraint in (A.4) yields:

$$p_n = \frac{-g_w^*}{n_w^*} \tag{A.22}$$

Substituting (A.22) into (A.21):

$$\frac{u_n^m(n^*, g^*)}{u_g^m(n^*, g^*)} > \frac{-g_w^*}{n_w^*} \tag{A.23}$$

By the implicit function theorem:

$$n_w = \frac{\frac{dMRS_{ng}^h}{dw}}{\frac{dMRS_{ng}^h}{dn}} \quad (\text{A.24})$$

Since we have assumed u^m and u^f are concave, we know that the Nash product is log-concave and thus quasi-concave. This immediately implies that $\frac{dMRS_{ng}^h}{dn} < 0$. From (A.16), we have that $\frac{dMRS_{ng}^h}{dw} < 0$. Thus, the denominator of (A.24) is negative and the numerator is positive, allowing us to state: $n_w < 0$. Using this fact in cross-multiplying (A.23) yields:

$$u_n^m(n^*, g^*)n_w^* < u_g^m(n^*, g^*)(-g_w^*)$$

Finally, substituting back into (A.20) yields:

$$u_w^m(n^*, g^*) = u_n^m(n^*, g^*)n_w^* + u_g^m(n^*, g^*)g_w^* < 0$$

proving the desired result.

Proposition 3:

This proposition follows directly from Proposition 1 and equation (7).

Proposition 4:

For clarity, we begin by reproducing equations (7) and (9), and expanding (10).

$$\begin{aligned} D(p_x, y) &= -U^m(\underline{p}_x)v^m (F^{y-1}(F^y(\underline{p}_x))) + v^f(y)U^f(\underline{p}_x) \\ &\quad + U^m(\underline{p}_x)v^m (F^{y-1}(F^p(\underline{p}_x))) \end{aligned} \quad (\text{A.25})$$

$$D_{p_x}(p_x, y) = -U_{p_x}^m(\underline{p}_x)v^m \left(F^{y-1}(F^p(U^{f-1}(\frac{D_y(p_x, y)}{v_y^f(y)}))) \right) \quad (\text{A.26})$$

$$D(\underline{p}_x, y) = v^f(y)U^f(\underline{p}_x) \quad (\text{A.27})$$

We want to verify that the dowry function (A.25) stated in the proposition solves the partial differential equation (A.26) with boundary condition (A.27). We first show that the function solves the partial differential equation. Differentiating (A.25) with respect to p_x yields:

$$D_{p_x}(p_x, y) = -U_{p_x}^m(\underline{p}_x)v^m (F^{y-1}(F^p(\underline{p}_x))) \quad (\text{A.28})$$

Differentiating (A.25) with respect to y gives:

$$D_y(p_x, y) = v_y^f(y)U^f(\underline{p}_x) \quad (\text{A.29})$$

Plugging (A.29) into (A.26) gives:

$$\begin{aligned} D_{p_x}(p_x, y) &= -U_{p_x}^m(\underline{p}_x)v^m \left(F^{y-1}(F^p(U^{f-1}(\frac{D_y(p_x, y)}{v_y^f(y)}))) \right) \\ \Rightarrow D_{p_x}(p_x, y) &= -U_{p_x}^m(\underline{p}_x)v^m \left(F^{y-1}(F^p(U^{f-1}(\frac{v_y^f(y)U^f(\underline{p}_x)}{v_y^f(y)}))) \right) \\ \Rightarrow D_{p_x}(p_x, y) &= -U_{p_x}^m(\underline{p}_x)v^m (F^{y-1}(F^p(\underline{p}_x))) \end{aligned}$$

which is equivalent to (A.28). Therefore (A.25) solves (A.26).

To show that the boundary condition is satisfied, plug $p_x = \underline{p}_x$ into (A.25):

$$\begin{aligned}
D(\underline{p}_x, y) &= -U^m(\underline{p}_x)v^m(F^{y-1}(F^y(\underline{p}_x))) + v^f(y)U^f(\underline{p}_x) \\
&\quad + U^m(\underline{p}_x)v^m(F^{y-1}(F^p(\underline{p}_x))) \\
&= v^f(y)U^f(\underline{p}_x)
\end{aligned}$$

which is clearly equivalent to (A.27), so (A.25) also satisfies the boundary condition.

B Extension: Becker-Lewis in a Bargaining Framework

In this extension, we include another choice variable, child quality, in the fertility bargain, to place our framework within the classical setting of Becker and Lewis (1973).

As before, fertility is chosen in the intrahousehold bargain in the second stage of the model. Corresponding to equation (2), we now have:

$$\begin{aligned}
\text{Bride's utility:} \quad u^f(n, q, g) &= u^f(\bar{n} - x, q, g) \\
\text{Groom's utility:} \quad u^m(n, q, g) &= u^m(\bar{n} - x, q, g)
\end{aligned} \tag{A.30}$$

Here, child quality q enters the utility of the bride and groom. All other variables are as previously defined.

The new utility-gain product function corresponding to equation (3) is:

$$\begin{aligned}
\max_{x, q, g} \quad u^h(\bar{n} - x, q, g) &= w \log(u^f(\bar{n} - x, q, g) - z_f) + (1 - w) \log(u^m(\bar{n} - x, q, g) - z_m) \\
\text{s.t.} \quad \Pi(\bar{n} - x) + \Pi_s q(\bar{n} - x) + p_g g + p_x x + p_q q &= I
\end{aligned}$$

Here, Π_s is the price of child services; p_q is the price of child quality; and p_g is the price of the consumption good (previously normalized to 1). All other variables and parameters

are as defined previously.

Proposition 1A: If fertility is sufficiently high, and the joint consumption good is a net complement with the number of children, then $\frac{du^m}{dp_x} > 0$.

Following the proof of Proposition 1, we first rewrite the budget constraint, utilizing the same definitions as before: ($Y \equiv I - p_x \bar{n}$; $p_n \equiv \Pi - p_x$; and $n \equiv \bar{n} - x$):

$$(\Pi - p_x)(\bar{n} - x) + \Pi_s q(\bar{n} - x) + p_g g + p_q q = Y$$

Again, we can write the husband's utility using the new notation as $u^m(n, q, g)$. We want to find conditions under which $\frac{du^m(n, q, g)}{dp_x} > 0$. Differentiating, we have:

$$\begin{aligned} \frac{du^m(n, q, g)}{dp_x} > 0 \quad \iff \quad & u_n^m(n, q, g) (-n_{p_n} - n_Y \bar{n}) + u_g^m(n, q, g) (-g_{p_n} - g_Y \bar{n}) \\ & + u_q^m(n, q, g) (-q_{p_n} - q_Y \bar{n}) > 0 \end{aligned} \quad (\text{A.31})$$

The interaction term of child quantity and quality makes the budget constraint nonlinear. Utilizing the general results on optimization under nonlinear budget constraints in Blomquist (1989), we can write the Slutsky conditions from the linear component of the budget constraint as:

$$\begin{aligned} n_{p_n} &= n_{p_n}^C - (\bar{n} - x)n_Y \\ g_{p_n} &= g_{p_n}^C - (\bar{n} - x)g_Y \\ q_{p_n} &= q_{p_n}^C - (\bar{n} - x)q_Y \end{aligned} \quad (\text{A.32})$$

Again following Blomquist (1989), the symmetry of compensated demands gives:

$$\begin{aligned} n_{p_g}^C &= g_{p_n}^C \\ n_{p_q}^C &= q_{p_n}^C \end{aligned} \tag{A.33}$$

Substituting the expressions in (A.32) and (A.33) into (A.31), we have:

$$\begin{aligned} \frac{du^m(n, q, g)}{dp_x} > 0 \quad \iff \quad & u_n^m(n, q, g) (-n_{p_n}^C - xn_Y) + u_q^m(n, q, g) (-n_{p_q}^C - xq_Y) \\ & + u_g^m(n, q, g) (-n_{p_g}^C - xg_Y) > 0 \end{aligned}$$

Multiplying where appropriate using $1 = \frac{\Pi_s q + p_n}{\Pi_s q + p_n} = \frac{\Pi_s n + p_q}{\Pi_s n + p_q} = \frac{p_g}{p_g}$ yields:

$$\begin{aligned} \frac{du^m(n, q, g)}{dp_x} > 0 \quad \iff \quad & \frac{u_n^m}{\Pi_s q + p_n} (-(\Pi_s q + p_n)n_{p_n}^C - x(\Pi_s q + p_n)n_Y) \\ & + \frac{u_q^m}{\Pi_s n + p_q} (-(\Pi_s n + p_q)n_{p_q}^C - x(\Pi_s n + p_q)q_Y) \\ & + \frac{u_g^m}{p_g} (-p_g n_{p_g}^C - xp_g g_Y) > 0 \end{aligned}$$

At the optimized Nash product, we have that:

$$\begin{aligned} u_g^h &= \lambda p_g \\ u_n^h &= \lambda(\Pi_s q + p_n) \\ u_q^h &= \lambda(\Pi_s n + p_q) \end{aligned}$$

where $\lambda > 0$ is the Lagrange multiplier on the budget constraint. Substituting and dividing

throughout by λ , we get:

$$\begin{aligned} \frac{du^m(n, q, g)}{dp_x} > 0 \quad \iff & \frac{u_n^m}{u_n^h} \left(-(\Pi_s q + p_n)n_{p_n}^C - (\Pi_s q + p_n)xn_Y \right) \\ & + \frac{u_q^m}{u_q^h} \left(-(\Pi_s n + p_q)n_{p_q}^C - x(\Pi_s n + p_q)q_Y \right) \\ & + \frac{u_g^m}{u_g^h} \left(-p_g n_{p_g}^C - xp_g g_Y \right) > 0 \end{aligned}$$

From Blomquist (1989) we have:

$$(\Pi_s q + p_n)n_{p_n}^C + (\Pi_s n + p_q)n_{p_q}^C + p_g n_{p_g}^C = 0 \quad (\text{A.34})$$

Note that this implies, since net complementarity of joint consumption and fertility implies $n_{p_g}^C < 0$, that quality and quantity are net substitutes, so that $n_{p_q}^C > 0$

Dividing throughout by $\frac{u_g^m}{u_g^h}$ and substituting:

$$\begin{aligned} \frac{du^m(n, q, g)}{dp_x} > 0 \quad \iff & \frac{\frac{u_n^m}{u_q^h}}{\frac{u_g^h}{u_g^h}} \left(-(\Pi_s q + p_n)n_{p_n}^C - x(\Pi_s q + p_n)n_Y \right) \\ & + \frac{\frac{u_q^m}{u_g^h}}{\frac{u_q^h}{u_g^h}} \left(-(\Pi_s n + p_q)n_{p_q}^C - x(\Pi_s n + p_q)q_Y \right) \\ & + \left(-p_g n_{p_g}^C - xp_g g_Y \right) > 0 \end{aligned}$$

To see the result, group all the income and substitution effects together:

$$\begin{aligned} \frac{du^m(n, q, g)}{dp_x} > 0 \quad &\Leftrightarrow \quad \frac{\frac{u_n^m}{u_g^m}}{\frac{u_n^h}{u_g^h}} \left(-(\Pi_s q + p_n)n_{p_n}^C \right) \\ &+ \frac{\frac{u_q^m}{u_g^m}}{\frac{u_q^h}{u_g^h}} \left(-(\Pi_s n + p_q)n_{p_q}^C \right) - p_g n_{p_g}^C \\ &- x \left(\frac{\frac{u_n^m}{u_g^m}}{\frac{u_n^h}{u_g^h}} (\Pi_s q + p_n)n_Y + \frac{\frac{u_q^m}{u_g^m}}{\frac{u_q^h}{u_g^h}} (\Pi_s n + p_q)q_Y + p_g g_Y \right) > 0 \end{aligned}$$

The result follows as x goes to 0. This is true because $\frac{\frac{u_n^m}{u_g^m}}{\frac{u_n^h}{u_g^h}} > 1 > \frac{\frac{u_q^m}{u_g^m}}{\frac{u_q^h}{u_g^h}}$, so that the weight on a positive component of the expression, $-(\Pi_s q + p_n)n_{p_n}^C$, is larger than 1, and the weight on the only negative component, $-(\Pi_s n + p_q)n_{p_q}^C$, is less than 1. Thus when the income effect term is negligible, the linear dependence of the substitution effects in (A.34) implies that this expression must be greater than 0.