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Paternal Uncertainty and the Economics of Mating, Marriage, and Parental Investment in Children

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Abstract

We develop a theoretical model of mating behavior and parental investment in children under asymmetry in kin recognition between men and women that provides a microfoundation for the institution of marriage. In the model, men and women derive utility from consumption and reproductive success, which is a function of the number and quality of own offspring. Because of paternal uncertainty, men unlike women may err in investing resources in offspring that is not biologically theirs. As a socially sanctioned commitment device among partners, the institution of marriage reduces this risk by restraining promiscuity in society. Both women and men are shown to benefit from lower levels of paternal uncertainty, as does average child quality because of increased parental investments. As an analytical framework, the model is suitable to study a number of societal, economic, and technological changes in their effects on marriage patterns. A combination of factors is argued to underlie the demise of marriage.

Keywords: Mating, Paternal Uncertainty, Parental Investment, Marriage.
JEL Classification: D10, J12, J13, D02.

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1 Introduction

In the history of mankind, marriage ranks among the oldest and most widespread social institutions. Although marital arrangements have varied over time and between cultures, three traits appear commonly shared. As a bond between women and men, marriage requires some form of social sanction, it is the primary place for the bearing and rearing of children, and it involves a commitment of fidelity among partners. Because of their long tradition and central role in societies, it is not surprising that marital arrangements have caught the interest of economic enquiry. Gary Becker's early work on the economics of marriage in the 1970s has spawned an extensive literature on family as an economic unit (see Becker, 1973/1974). Economic theories of marriage focus on the potential gains that accrue to individuals from joint production and cohabitation, including the ability to exploit economies of scale through specialization, risk sharing, and the production and consumption of household public goods.[1] However, none of these potential gains is confined to individuals in conjugal unions alone. Household goods and services can be and in fact often are provided by the market, or may be produced and consumed in unions other than marriage, such as informal cohabitation. Moreover, as these gains accrue no less to individuals of the same sex, they cannot by themselves account for the traditional intersexual nature of marital arrangements. Above all, however, economic theories of marriage are unable to explain the afore mentioned universal traits of marriage. In this paper, we provide a first microeconomic foundation for the institution of marriage that is able to account for these cross-culturally ubiquitous features of marriage, based on a model of mating and parental investment that takes explicit account of biological differences between the two sexes. Marriage as an institution, it will be argued, is first and more basically a reproductive union rather than an economic one.

Outside economics, in evolutionary biology, sociology, and psychology, sex differences have long been recognized as important determinants of both individual and group behavior. The most relevant sex differences in the present context are asymmetries in kin recognition and in reproductive capacity. Because of internal fertilization and life birth, a woman can be absolutely certain about her biological parenthood (maternal certainty), but a man always has to discount the possibility that a child has been fathered by some other man (paternal uncertainty). Men may therefore err in investing parental resources in offspring that is not biologically theirs. Unlike men, however, females are subject to a number of physiological constraints that limit their reproductive capacity, such as extended periods of gestation, lactation, and a generally shorter life-time period of fertility. The maximum reproductive rate of men, in contrast, is limited only by mating access.

[1] For surveys of theories of marriage, see, for example, the work by Weiss (1997) and Bergstrom (1997) in the Handbook of Population Economics, the monograph by Becker (1991), or the recent book by Grossbard-Shechtman (2003).

These two sex differences are likely to have a strong and qualitatively similar bearing on the respective mating behavior of women and men and on the amount of parental investment each sex is likely to devote to offspring, i.e. the respective reproductive strategies pursued by the two sexes. In their strive for reproductive success, a function of both the quantity and the quality of own offspring, men are expected to maximize offspring quantity rather than quality, with the reverse holding true for women (Trivers, 1972; Symons, 1979). High intrasexual competition among males for female partners increases the risk of cuckoldry and thus reproductive failure for men, which makes a quantity-maximizing strategy even more attractive to men as a means to diversify this risk. Moreover, the greater the degree of paternal uncertainty, the less willing will be men to invest in their putative offspring (e.g. Alexander, 1974). Given the obvious difficulties involved in gathering data on perceived paternity, there have been but few direct tests of its effects on paternal investment levels. Anderson et al. (2005), using self-reported retrospective data on men in Albuquerque, New Mexico, find paternal uncertainty to increase the likelihood of men to divorce their wives, to lower the time they spend with their putative children, and to reduce their involvement with the educational progress of their alleged progeny. The importance of paternity and paternity confidence for male behavior is further underscored by a number of empirical findings on related topics, such as mate guarding among men (e.g. Buss, 2002), male jealousy and the sexual double standard (e.g. Daly et al., 1982; Shackelford et al., 2002), inferior investment in offspring by patrilineal than matrilineal kin (e.g. Gaulin et al., 1997), the dependence of rules of inheritance of a man's property across societies on paternal confidence (Gaulin and Schlegel, 1980; Hartung, 1985), and the greater valuation among men of physical resemblance to children as an indirect means to ascertain their paternity (e.g. Daly and Wilson, 1982; Platek et al., 2002/2003; Volk and Quinsey, 2002). In addition, there is ample evidence that stepchildren suffer in a number of ways (e.g. Case et al., 1999; Daly and Wilson, 1985; Wilson and Daly, 1987).

Drawing from economic theories of marriage and fertility, we develop a theoretical model of mating behavior and parental investment in children under asymmetry in kin recognition and reproductive capacity that provides a rival and we believe a more compelling explanation for the institution of marriage, its long history of success, and recent demise. Central to our model is the strive of men for paternal certainty in reproduction, which is jeopardized by female promiscuity and mate poaching among men. Marriage reduces promiscuity and thus paternal uncertainty by raising the cost of mating. Increasing both welfare and parental investment in child quality at sufficiently high levels of mating costs, the institution of marriage is viewed as predominantly reproductive in nature, reflecting a societal consensus on the need to circumscribe promiscuity for the benefit of the public good paternal certainty and biparental investment in offspring. As a microeconomic foundation for the institution of marriage, our model is able to account for the three universal characteristics of marital arrangements. Moreover, it is consistent with the view that early marital arrangements in many cultures served to establish and enforce property rights of men with respect to female reproductive capacity (Wilson and Daly, 1992). The once exclusive definition of adultery with respect to the marital status of women in many societies (e.g. Hadjiyannakis, 1969; Bullough, 1976), the importance attached to female premarital chastity (e.g. Buss, 1989), the commonness of polygyny but rareness of polyandry (Murdock, 1967), and the universality of the paternity presumption in marital arrangements across societies (Edlund, 2005) all bear witness to the predominantly reproductive nature of marriage as an institution and the pivotal role of paternal uncertainty.

The paper is structured as follows. Section (2) develops the basic model, which is solved in Section (3) for a specific parameterization. Based on the analytical framework and the results obtained, Section (4) provides a microeconomic foundation for the institution of marriage and explores various societal, economic, and technological changes in their effects on marriage patterns and the level of parental investment. Section (5) summarizes the main findings and concludes.

2 The Model

In this section, we develop a simple model of mating behavior, reproduction, and parental investment in children under asymmetry in kin recognition. We begin our description of the model with the specification of the preferences, endowments, and reproductive technologies of men and women (Section 2.1). Section 2.2 addresses parental investment and child quality, and Section 2.3 provides a characterization of the optimal strategies of men and women and of the equilibrium in the mating market.

2.1 Preferences, Endowments, and Reproductive Technology

Consider a society populated by a large number of fertile women and men with equal preferences, where individuals of the same sex are homogeneous with respect to their endowments and reproductive technology. Individuals are rational and can spend their economic resources on three competing uses: own consumption, mating, and parental investment in children. We first turn to the optimization problem of women.

Women have economic resources Y_f and derive separable utility W_f from consumption C_f and reproductive success, which is a function of both the number K_f and the quality Q of own biological offspring:

$$W_f\left(C_f, K_f, Q\right) = U\left(C_f\right) + V\left(K_f, Q\right). \tag{1}$$

To simplify the analysis, we follow Willis (1999) in restricting K_f, the number of a female's biological offspring, to be either 0 or 1.[2] U and V are assumed to be twice differentiable in their respective arguments. U is increasing at a diminishing rate, i.e. $U'' < 0 < U'$. Similarly, V has the following properties:

$$V(0,Q) = V(K,0) = 0 \quad \text{and} \quad V_{KK}, V_{QQ} < 0 < V_K, V_Q; \qquad \forall \quad K, Q > 0. \tag{2}$$

Men and women have to mate to reproduce, where mating is costly for both sexes. The respective cost of an additional partner for each sex is determined on the aggregate mating market and treated as exogenously given by individuals. Mating a male individual requires marginal cost s_f relative to female consumption. Child quality too has its price. Denoting by a_f the resources at which an additional female contribution to child quality Q_f can be obtained, each woman faces the following budget constraint:

$$Y_f = C_f + s_f N_f + a_f K_f Q_f, \tag{3}$$

where N_f is the number of her male mates. Choosing her investment in child quality Q_f and her number of male partners N_f, a woman maximizes her utility (1) subject to her budget constraint (3).

Men, too, have identical preferences and endowments Y_m and derive utility from consumption and reproductive success. However, men may sire more than one child by mating several members of the opposite sex. Moreover, men do not recognize their kin. Being rational, however, men can infer the total number of male mates N_f each of their female partners has in equilibrium. For a child born by one of his female partners, a man's probability of fatherhood δ_N is therefore inversely related to the number of male partners N_f the female has mated, i.e.:

$$\delta_N = N_f^{-1} \Leftrightarrow 1 - \delta_N = 1 - N_f^{-1}, \tag{4}$$

where the second equation measures the degree of paternal uncertainty. If N_f is equal to one, i.e. women are monogamous, men can be absolutely certain about their biological parenthood. If women are promiscuous, however, men are exposed to paternal uncertainty. The actual but unknown number of own offspring K_m of a man that mates N_m females can in fact be any integer in the set $\{0, .., N_m\}$. K_m, as a consequence, follows the binomial distribution with parameters N_m and δ_N:

$$f(K_m; N_m, \delta_N) = \binom{N_m}{K_m} (1 - \delta_N)^{N_m - K_m} (\delta_N)^{K_m}. \tag{5}$$

[2]This assumption can be understood as a normalization. It is consistent with the biological fact that women are bottlenecks in reproduction because of their shorter life-time period of fertility and infertility during pregnancy (see, for example, Trivers, 1972).

Denoting by E the expectations operator under the above binomial distribution, the expected number of offspring K_m of a man with N_m female partners is $E[K_m] = \delta_N N_m$. His objective function therefore reads:

$$W_m(C_m, K_m, Q) = U(C_m) + E[V(K_m, Q)]. \qquad (6)$$

Because of asymmetry in kin recognition, therefore, men unlike women only maximize their expected utility W_m. Mating a female individual requires marginal cost s_m in terms of male consumption. Denoting further by a_m the resources at which a marginal male contribution to child quality can be obtained, the representative man faces the following budget constraint:

$$Y_m = C_m + s_m N_m + a_m N_m q_m. \qquad (7)$$

By choosing q_m and N_m, a man maximizes his expected utility (6) subject to his budget constraint (7).

2.2 Parental Investment and Child Quality

Child quality Q is determined by female and male investments in children. Because of maternal certainty, the biological mother of a child is the only female that contributes to its quality. Among men, however, all partners of a mother qualify as potential fathers of her child. As a result, all male partners of a mother will invest in the quality of her child. Total child quality Q, therefore, is composed of the parental investment of the biological mother and the sum of the individual contributions of her male partners. Note that as Q enters into the utility functions of both men and women (see equations (10) and (13)), maternal investment in children affects male utility and vice versa. Child quality, therefore, has public good character. Moreover, if $N_f > 1$, the true but unknown biological father benefits from contributions of his male competitors to the quality of his child.

Child quality Q is assumed to be the result of a constant elasticity of substitution aggregation procedure with maternal investment in child quality and the sum of paternal contributions of potential fathers as arguments:

$$Q = \left[\alpha Q_f^{\frac{\eta-1}{\eta}} + (1-\alpha) Q_m^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \qquad (8)$$

where Q_f is the mother's contribution and Q_m denotes the total sum of individual contributions of her male partners. This very general specification permits to study a whole spectrum of possible aggregation procedures, ranging from perfect complementarity to perfect substitutability of female and male contributions to the quality of a child. Parameter α weighs the respective contributions of the two sexes, and η determines the constant degree of substitutability between female and male contributions. A degree of zero gives rise to a Leontief quality function where both contributions are complementary, $\eta = 1$ leads to a Cobb-Douglas specification, and $\eta \to \infty$ implies perfect substitutability. While the actual degree of substitutability between female and male contributions to child quality may be hard if not impossible to determine, it seems fair to say that both extrema, i.e. $\eta = 0$ and $\eta \to \infty$, are rather unlikely to hold in practice.[3]

Symmetry among male individuals implies that the quality investment $q_m^{(i)}$ of a potential father i in a certain child is equal to the representative man's quality investment q_m in one of his potential offspring. Hence, total male contributions to the quality of a particular child are given by the product of the representative man's contribution and the number of male partners of the representative female:

$$Q_m = \sum_{i=1}^{N_f} q_m^{(i)} = N_f q_m. \tag{9}$$

The next section provides a characterization of the optimal strategies of men and women and describes the equilibrium in the mating market, which completes the description of the model.

2.3 Optimal Strategies and Mating Market

For expository and analytical reasons, we will change in the following to a continuous choice framework. By doing so, however, we forego the possiblity that a female refrains completely from mating and procreation. With $K_f = 1$, the female optimization problem can be stated as follows:

$$\{Q_f, N_f\} = \arg\max \{U(Y_f - s_f N_f - a_f Q_f) + V(1, Q)\}. \tag{10}$$

Taking first derivatives, optimal investment in child quality Q_f by a woman has to satisfy:

$$a_f U'(C_f) = \alpha \left(\tfrac{Q}{Q_f}\right)^{\frac{1}{\eta}} V_Q(1, Q). \tag{11}$$

In other words, at the optimum a marginal female contribution to child quality has to equate the marginal loss in utility from forgone consumption to the marginal increase in utility due to higher child quality. Note that as long as Q is larger than Q_f, a decrease in η will lead to a reallocation of resources from consumption to reproduction. The first order necessary condition for the optimal number of male partners N_f chosen by a woman is given by:

$$s_f U'(C_f) = (1 - \alpha) \left(\tfrac{Q}{Q_m}\right)^{\frac{1}{\eta}} \tfrac{Q_m}{N_f} V_Q(1, Q), \tag{12}$$

where the third term in (12), i.e. the fraction Q_m/N_f, is equal to the representative male's contribution q_m. The optimal number of male partners for a woman is therefore such that the

[3]Some types of parental investment, such as baby-sitting, may equally well be undertaken by either mother or father, while others may clearly not. The latter include, for instance, female contributions like lactation and male contributions more generally at the time when the offspring is still very young and the mother is unable to care for and protect the child on her own.

marginal loss in utility from reduced consumption equals the marginal increase in utility from higher child quality when mating an additional partner. As is evident from (12), the only benefit of promiscuity to women are the contributions to child quality of their male partners.

A male individual, in turn, chooses q_m and N_m to maximize his expected utility:

$$\{q_m, N_m\} = \arg\max \{U(Y_m - s_m N_m - a_m N_m q_m) + E[V(K_m, Q)]\}. \tag{13}$$

The first order necessary condition for the optimal contribution to child quality of a man is given by:

$$a_m N_m U'(C_m) = (1-\alpha)\left(\frac{Q}{Q_m}\right)^{\frac{1}{\eta}} E[V_Q(K_m, Q)]. \tag{14}$$

The interpretation of (14) is analogous to the respective condition for females. Note that N_m appears on the left-hand side of equation (14) because a man invests in the children of all of his female partners. Note also that an increase in the number of male competitors N_f would scale down the Q/Q_m ratio and reduce the expected marginal utility from child quality. As a consequence of this decline, a man would lower his investment in child quality, which in turn reduces his marginal utility of consumption and increases his expected marginal utility of child quality. As pointed out before, the true but unknown biological father of a child therefore benefits from the quality investments of other men. The second decision of a male individual concerns his choice of female partners, i.e. N_m. Since N_m is one of the parameters of the binomial distribution (see equation 5), a change in N_m will directly affect the expectations operator. As we merely seek to provide a basic illustration of the general trade-offs male individuals face in their decisions at the present stage, we temporarily return to a discrete specification of N_m.[4] An application of the law of iterated expectations shows that adding one additional partner to a given number of female partners N_m increases the expected utility of a man, as long as the following inequality holds:

$$\delta_N E[V(K_m+1, Q) - V(K_m, Q)] \geq U(C_m^{N_m}) - U\left(C_m^{N_m+1}\right), \tag{15}$$

where C_m^n is the consumption expenditure of a man with n female partners. In other words, the expected increase in male utility derived from an additional reproductive success weighted by the probability of biological fatherhood (δ_N) has to equal or outweigh the loss in utility caused by reduced consumption when resources are transferred to the mating market. Promiscuity is attractive to men, therefore, because it increases their individual probability of fatherhood.

The optimal individual strategies of women and men described above have to be consistent in equilibrium with a situation of mating market clearing. Per match, total mating costs s accrue, which are assumed to be exogenous and a deadweight loss. In equilibrium, women and men share

[4] Approximations to the first order necessary conditions for men in a continuous choice framework are provided in the appendix for a specific paramterization of the model that is used in the Results Section 3.

these mating costs according to their relative valuations (demands) for another partner of the opposite sex:

$$s = s_f + s_m. \tag{16}$$

Alternatively, one may think of a central dating agency that sets, for a given value of s, the respective mating costs of women and men to levels that are consistent with mating market clearing. Let ϕ denote the ratio of females to males in the population. The mating market clears when the number of female partners per male N_m divided by the number of male partners per female N_f is equal to sex ratio ϕ, i.e.:

$$\frac{N_m}{N_f} = \phi. \tag{17}$$

This completes the description of the model. Note that because individuals behave non-cooperatively, equilibrium allocations of resources will differ from the social optimum. Neither of the two sexes internalizes the social costs of promiscuous behavior. For women, economic resources are wasted on mating in excess of the minimum required for reproduction. For men, female promiscuity implies paternal uncertainty, a direct loss in utility from reproduction. This loss is equal to the difference between the certainty equivalent number of children of a man and his expected number of offspring, which is given by ϕ. A detailed discussion of the social optimum is provided in the appendix.

3 Results

We use a specific parametrization of the model developed in the previous section. The separable utility function of men and women is assumed to be isoelastic in consumption and Cobb-Douglas in the quantity and quality of children:

$$U(C_i) = \gamma \frac{C_i^{1-\sigma} - 1}{1-\sigma} \quad \text{and} \quad V(K_i, Q) = (1-\gamma) K_i^{\kappa} Q^{\theta} \quad \text{with} \quad i \in \{f, m\}, \tag{18}$$

where $\gamma, \kappa, \theta \in (0,1)$, and $\sigma > 0$. Parameter γ, a measure of the degree of parental altruism toward offspring, weights the two sources of utility.[5] Parameter σ is a measure of the relative risk aversion in utility with respect to consumption, where $\sigma = 1$ implies to logarithmic preferences. Parameters κ and θ determine the degree of concavity of utility with respect to the quantity and quality of own children.

The expected utility of a man from reproduction is determined by the κ-th moment of the binomial distribution with N_m draws (female partners) and probability of success (fatherhood)

[5]Parental altruism toward offspring constitutes a special case of concern for biological relatives (Hamilton, 1964a/b).

δ_N:

$$E\left[V\left(K_m, Q\right)\right] = (1-\gamma)Q^{\theta} \sum_{K_m=0}^{N_m} f\left(K_m; N_m, \delta_N\right) K_m^{\kappa}. \tag{19}$$

As there is no closed-form representation of the κ-th moment of the binomial distribution, we apply the delta method. Specifically, we use a third-order Taylor approximation around a man's expected number of offspring $E\left[K_m\right] = N_m \delta_N$ (details are provided in the appendix). The parameter values used in the specification of the model for both men and women are listed in Table 1.

Table 1: Parameterization of the model

Parameters:	Y	γ	σ	κ	θ	η	α	ϕ
Values:	1	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	1	$\frac{1}{2}$	1

The next three subsections explore the effects of variations in the level of mating costs on the equilibrium number of partners per individual and the degree of paternal uncertainty experienced by men (Section 3.1), the levels and shares of female and male contributions to child quality and its overall level (Section 3.2), as well as the welfare of women and men (Section 3.3).

3.1 Mating Costs, Number of Partners, and Paternal Uncertainty

The two diagrams of Figure 1 document how in equilibrium female and male mating costs change in reaction to variations in overall mating costs s and in per-unit child quality costs $a = a_f = a_m$, which are measured in percent of an individual's endowment. As is evident, both s_f and s_m increase in s. Male mating costs, however, exceed female mating costs over the entire range of total mating costs considered in the diagrams. The latter finding reflects a generally greater valuation of promiscuity among men than women due to the different reproductive strategies pursued by the two sexes, a finding akin to the quantity-quality (r- and k-maximizer) distinction in the social science (biological) literature.

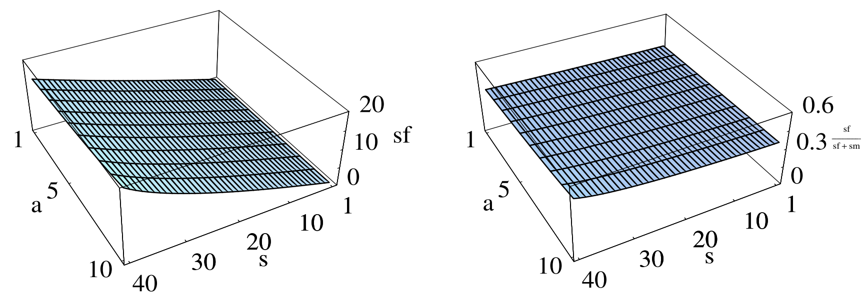

Figure 1: Female and male mating costs. Left: s_f absolute. Right: s_f relative to total mating costs.

As shown in Figure 2, the equilibrium number of partners N per individual and, in consequence, paternal uncertainty $1 - \delta_N$ decline monotonically, as mating becomes more costly for both sexes. Increases in the level of per-unit child quality costs also tend to reduce the number of partners, and with it the degree of paternal uncertainty experienced by men.

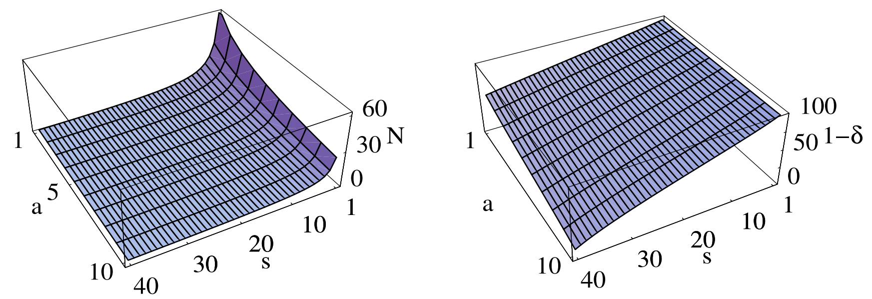

Figure 2: Equilibrium number of partners and the implied paternal uncertainty.
Left: Number of partners. Right: Paternal uncertainty.

3.2 (Parental) Investment in Child Quality

As argued in Section 2.2, the mother and all of her male partners invest in the quality of her child. The first diagram in Figure 3 shows that maternal investment Q_f increases only slightly in overall mating costs. Individual male contributions to child quality among the partners of a woman, however, rise significantly and monotonically when mating costs increase. The reason is simple. As women become less promiscuous when mating costs increase, paternal uncertainty declines. Men are therefore willing to invest more in the children of their partners, who now have a higher probability to be their own. Increased male contributions to child quality at higher levels of mating costs also make mating more attractive to women. It is for these reasons that both men and women reallocate resources from consumption to reproduction when mating costs increase. Expenditure on child quality, however, increases far more than expenditure on mating, as the price of child quality has fallen relative to that of partners when mating becomes more costly.

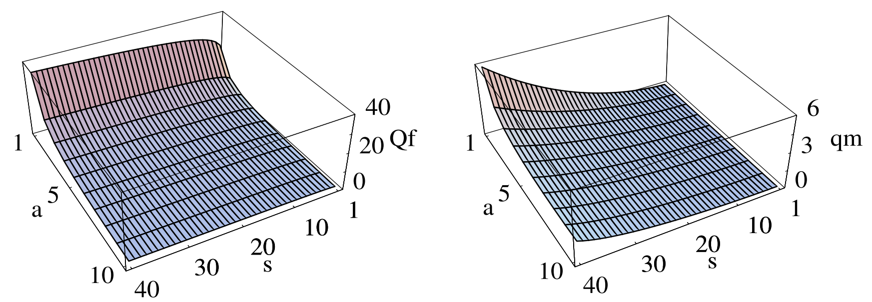

Figure 3: Female and individual male contributions to the quality of a child.
Left: Female contribution. Right: Individual male contribution.

Whether or not total child quality Q rises or falls when mating costs increase depends on the relative rates at which the number of male contributors (partners) N_f to the quality of a child declines and the level of individual male contributions q_m rises, i.e. how total male contributions Q_m change (see equation (9)). As shown in the first diagram of Figure 4, total male contributions to child quality Q_m do in fact increase when mating becomes more costly. As maternal investment in the quality of a child has been shown to increase also in the level of mating costs, overall child quality Q unambiguously rises in s. A mother's share in total child quality, however, declines markedly as fewer male partners contribute more in sum to the quality of her child. Thus, both men (directly) and women (indirectly) benefit from lower levels of paternal uncertainty, which are attained by making promiscuous behavior more costly.

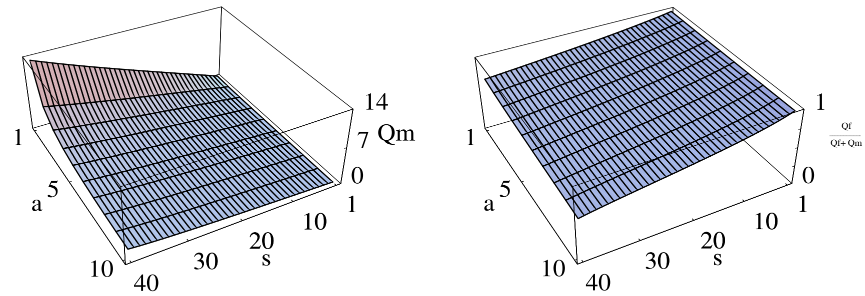

Figure 4: Total male contributions and share of female contributions.
Left: Total male contributions. Right: Female share.

3.3 Welfare

As we have seen, the equilibrium number of partners and the degree of paternal uncertainty decline in the level of mating costs, while overall child quality and the male share in total child investments rises. Men, therefore, benefit primarily from lower levels of paternal uncertainty when mating becomes more costly, and women profit from greater male contributions to child quality. We next explore how different levels of mating costs affect the utility of women and men. Figure 5 plots the welfare of women and the expected welfare of men for different mating costs s and child quality costs a. For all values of a, the utility of women and the expected utility of men increase monotonically in the level of mating costs. Welfare in the economy, therefore, unambiguously rises if the deadweight costs of mating are increased, and promiscuity and paternal certainty decline.

To check for the robustness of this result with respect to different degrees of substitutability between female and male contributions to child quality η, Figure 6 plots the utility of women and the expected utility of men for different levels of s and η, with per-unit child quality costs set to $a = 4$.

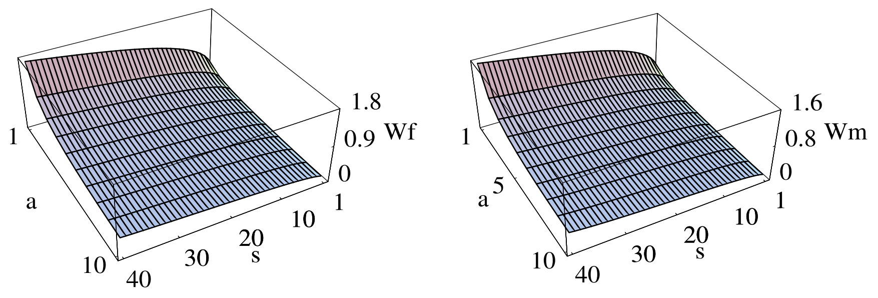

Figure 5: Welfare of women and expected welfare of men.
Left: Female welfare. Right: Expected male welfare.

For low values of η, the (expected) welfare of women (men) increases strictly in the level of mating costs s. For higher values of η, however, the respective curves become u-shaped, a change that sets in earlier for men, i.e. at lower degrees of substitutability. Welfare levels attained by both sexes at sufficiently high levels of mating costs nevertheless continue to exceed those at low levels of mating costs. Men and women are therefore always strictly better off at some high level of mating costs. A decrease in child quality costs a raises the respective welfare of women and men for a given level of mating costs and compresses the u-shaped welfare curves such that a higher level of welfare than at baseline is attained by both sexes already at lower levels of mating costs.

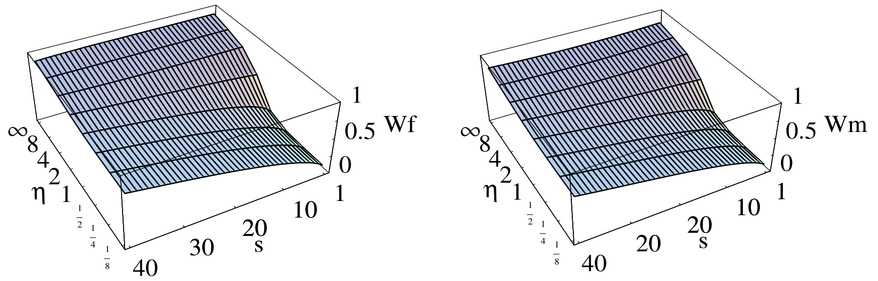

Figure 6: Welfare of women and expected welfare of men with respect to η.
Left: Female welfare. Right: Expected male welfare.

In the analysis so far, mating costs have been treated in generic terms only and their level has been varied but exogenously. In the next section, we explore the nature and the determination of mating costs in greater detail. Marriage as an institution is interpreted as a means to realize the potential Pareto improvements from reduced paternal uncertainty.

4 Marriage

4.1 Marriage as an Institution

In an archaic world, mating is rather inexpensive, being subject to little more than shoe-leather costs. In civilizations, however, mating costs tend to be larger, as they are predominantly societal in kind. Being determined and enforced by social, legal, and religious conventions, mating costs reflect rules of courtship and norms of partnership formation and breakup that govern the kind and the scope of acceptable mating behavior in societies. Once a virtual precondition for childbearing and for a long time the only tolerable form of union between the two sexes, marriage remains to the present day the single most important social institution on the mating market. Marital arrangements determine the costs to individuals of divorce, informal cohabitation, and out-of-wedlock childbearing. In short, the stricter marital arrangements are in societies, the more circumscribed is mating in general and the more costly is promiscuous behavior to individuals.

In the context of our model, the stringency of marital arrangements is measured by the level of mating costs. As these are inversely related to the degree of paternal uncertainty, and welfare-enhancing if set to sufficiently high levels, individuals by consensus would favor the enactment of strict marital arrangements. If prevalent social norms reflect majority preferences, then marriage as an institution can be explained as the result of this shared interest among individuals to reduce paternal uncertainty in society. This microeconomic foundation for the institution of marriage is not only consistent with the scholarly view on the origin and purpose of marriage in many ancient cultures, but also able to account for the three traditional characteristics of marriage, i.e. its socially sanctioned nature, its status as the primary place of childbearing, and above all its inherent requirement of fidelity among spouses.

In the next subsection, we explore several trend changes common to many countries that may account for the recent demise of marriage as an institution.

4.2 Accounting for Changes in Marriage Patterns

The model is suitable to study qualitatively the effects on marriage patterns of a number of societal, economic, and technological changes. These include the no-fault revolution in divorce laws, a decline in the costs of child quality, an increase in the economic resources available to women, the introduction of paternity tests, and an increase in the female / male sex ratio. Given the postulated nature and purpose of marriage as an institution, the following discussion focuses in particular on the respective effects these changes have on the attractiveness and effectiveness of marriage as a commitment device between partners.

Many countries have adopted no-fault (unilateral or uncontested) divorce laws over the last decades. Prior to no fault, mutual consent among spouses or proof of spousal marital misconduct (fault) was required for divorce, and financial settlements following divorce were dependent on assessments of fault.[6] Marriage, therefore, has become more easily and costlessly revocable. In the context of our model, the no-fault revolution can be interpreted as a reduction in the level of mating costs s from a previously high level. As we have seen in Sections 3.1 and 3.2, a decline in s leads to an increase in promiscuity among previously monogamous individuals (Figure 2) and a decline in the level of parental investments in children (Figures 3 and 4). The introduction of no-fault divorce laws, therefore, has made marriage less effective as a commitment device. Supportive evidence for these predictions is provided in a number of studies for the US, which exploit time lags in the introduction of no-fault divorce laws at the state level to identify their effects on marriage and divorce patterns, as well as child quality. According to Rasul (2004), 10% of the overall decline in the marriage rate since 1970 can be attributed to the adoption of unilateral divorce laws. Furthermore, Friedberg (1998) finds the latter to explain 17% of the rise in divorces per capita in the period 1968 to 1988. With respect to child quality, Gruber (2004) shows that children born under no-fault are subsequently less well educated and have lower family incomes than children that grew up in fault states.

Improvements in household technology and the expansion of the welfare state are likely to have reduced child quality costs a and the (technical) dependency of women and men on each other with respect to their child quality contributions η. A decrease in a makes child quality investments more attractive for both sexes. However, expenditures on child quality by women and men rise less than proportionally, as some of the economic resources previously spent on child quality are now transferred to the mating market. Promiscuity, as a consequence, increases and thus paternal uncertainty (see Figure 2). Because of the latter, the share of men in total child quality investments falls (see Figure 4). For a given strictness of marital arrangements (level of mating costs), therefore, the effectiveness of marriage in reducing paternal uncertainty decreases in the costs of child quality. An increase in η, in turn, makes mating less attractive for women (quality maximizers) and more attractive for men (quantity maximizers). This asymmetric effect is reflected in a higher male share in total mating costs, as men reallocate resources from child quality investments to mating. The effect on promiscuity, however, depends on the level of mating costs. At low levels of mating costs, the equilibrium number of partners increases. At high levels, it falls. In other words, the effect of a decrease in the dependency among sexes with respect to child quality depends on the strictness of marital arrangements. For the US, Rosenzweig (1999) finds a significant positive effect of AFDC (Aid to Families with Dependent Children) on the probability of out-of-wedlock childbearing for low-income women. Similarly, Lefebvre and Merrigan (1998)

[6]Traditional fault grounds include, among others, emotional or physical cruelty, adultery, and desertion.

conclude that directing welfare benefits to single mothers in Canada has reduced their probability of remarriage.

In the last century, female labor supply has increased significantly to the effect that women, on average, now have an independent command over greater economic resources. A relative increase in the economic endowment of women Y_f leads to higher female expenditures on consumption, maternal quality investments, and mating. Because of the latter, promiscuity and the female share in total mating costs increase. Higher paternal uncertainty, in turn, causes total child quality investments of a man to fall.[7] Overall child quality, however, increases. Marriage, therefore, becomes less effective as a commitment device and less important as a means for females to secure male contributions to child quality. In line with these predictions, Blau et al. (2000) find better labor market prospects for women in the US to have lowered marriage rates for whites.

A particularly interesting technological innovation in the present context are paternity tests. Prior to their introduction, men had to rely on mate guarding or marriage to reduce the risk of cuckoldry, and on but indirect cues to ascertain their fatherhood ex post, such as the physical resemblance to their putative offspring. With paternity tests, asymmetry in kin recognition disappears. Paternal uncertainty is eliminated and men no longer need to bind women to themselves for their reproductive success. Marriage as a commitment device, therefore, becomes obsolete. Note that in our model, the introduction of paternity tests raises the welfare of both sexes. To the best of our knowledge, there are no empirical studies on the effects of paternity tests on marriage patterns.

An increase in the female / male sex ratio (ϕ) renders men more and women less promiscuous. As men are in short supply, women incur a larger share of total mating costs. Individual male contributions to the quality of a child increase as paternal uncertainty falls. Maternal, total male, and overall quality investments in a child, however, decline, except for very large mating and child quality costs. As noted by Becker (1974), decidedly titled sex ratios due to wartime deaths of men have at times encouraged the spread of polygyny. For the US, a shortage of black marriageable men, among others due to high rates of incarnation and mortality, has also been argued to underlie the generally lower marriage rate among blacks (Wilson, 1987; Brien, 1997).

As the preceding discussion has shown, a number of trend changes is likely to have reduced the attractiveness of marriage. The no-fault revolution turned marriage into a non-credible bond. Technological advances in household appliances, government sponsored child care facilities, and increases in the economic resources available to women, in turn, have reduced the dependency of females on men for child support and parenting. Marriage as a commitment device for women to

[7]Note that if $\phi = 1$, the sum of all child quality investments by a single man are equal to the total male contributions to the quality of a single child, i.e. Q_m.

elicit high paternal investment, as a consequence, has lost in relative importance. While all these trend changes work in the same direction, their respective quantitative importance for the demise of marriage still remains to be determined empirically.

5 Conclusion

This paper has developed a microeconomic foundation for the institution of marriage that is based on asymmetry in kin recognition between the two sexes. Unlike existing economic theories of marriage, our model is able to account for the three traditional characteristics of marriage, i.e. its socially sanctioned nature, its status as the primary place of childbearing, and its inherent requirement of fidelity among spouses. Despite its simplicity, it provides a powerful analytical framework for the study of a whole number of societal, economic, and technological changes in their effects on marriage patterns.

Well researched in other disciplines, such as evolutionary biology, sociology, and psychology, asymmetry in kin recognition has long been recognized as an important determinant of mating behavior and parental investment. Not so in economics. Primary motives for marriage identified in the economics literature, such as potential gains from joint production and consumption, are likely to be of only secondary importance for the institution of marriage, as they fail to take adequate account of the fundamental fact that women and men rather than members of either sex traditionally enter into conjugal unions. The intimate relationship between marriage and reproduction makes asymmetry in kin recognition a natural and a more plausible explanation for the institution of marriage.

6 Appendix

6.1 The Social Optimum

Denote by ξ $(1-\xi)$ the weight a social planner attaches to the utility of the representative female (male). For $\phi = 1$, the mating market clearing condition (17) implies that the set of socially optimal number of partners per individual is $N \in \{0, 1\}$. Reproduction is socially optimal if:

$$V(1, Q) \geq \xi \left(U(Y_f) - U(Y_f - s_f - a_f Q_f)\right) + (1-\xi)\left(U(Y_m) - U(Y_m - s_m - a_m Q_m)\right), \quad \text{(A1)}$$

i.e. the increase in the joint utility of women and men from reproduction is equal to or larger than the weighted sum of female and male utility losses from reduced consumption, when resources are transferred from consumption to the mating market and parental investment. Assuming (A1) holds, socially optimal child quality investments have to satisfy:

$$\frac{a_f}{a_m}\frac{U'(Y_f - s_f - a_f Q_f)}{U'(Y_m - s_m - a_m Q_m)} = \frac{\alpha}{1-\alpha}\left(\frac{Q_m}{Q_f}\right)^{\frac{1}{\eta}}. \quad \text{(A2)}$$

Condition (A2) is obtained by dividing the respective expressions for female and male contributions to child quality. It requires that the ratio of female to male marginal child quality costs transformed in utility units is equal to the technical rate of substitution between female and male contributions in the child quality function (8). Note that the weights ξ and $1-\xi$ do not appear in the respective first order necessary conditions for Q_f and Q_m. Moreover, because of the public good nature of child quality, V_Q is identical for women and men and therefore irrelevant for the determination of the socially optimal level of child quality investments. Mating costs s are divided among women (s_f) and men (s_m) by the social planer such that the weighted marginal utilities of both sexes with respect to consumption are equal:

$$\xi U'(Y_f - s_f - a_f Q_f) = (1-\xi) U'(Y_m - s_m - a_m Q_m). \tag{A3}$$

Using (A3), the condition for optimal child quality contributions (A2) can be simplified to:

$$\frac{1-\xi}{\xi} = \frac{a_m}{a_f} \frac{\alpha}{1-\alpha} \left(\frac{Q_m}{Q_f} \right)^{\frac{1}{\eta}}. \tag{A4}$$

It requires the ratio of marginal quality costs times the technical rate of substitution to equal the ratio of the respective weights attached by the social planer to the utilities of men and women.

Socially optimal allocations on the mating market will be different if $\phi \neq 1$. Optimality, however, still requires mating expenditures not to exceed the minimum necessary for reproduction and the absence of paternal uncertainty. In other words, a woman will be matched to but a single man at most. If men outnumber women ($\phi < 1$), this implies that some men have to remain childless. If, in contrast, women outnumber men ($\phi > 1$), then it will not only be optimal for all males to reproduce, but even for some men to father more than one child with more than one woman.

6.2 Approximation

A third-order Taylor expansion of equation (19) around a man's expected number of offspring $E[K_m] = N_m \delta_N$ gives the following approximation to the utility he receives from children:

$$V(K_m, Q) \approx V(N_m\delta_N, Q) + (K_m - N_m\delta_N) \frac{\partial V}{\partial K_m} + \frac{(K_m - N_m\delta_N)^2}{2} \frac{\partial^2 V}{\partial K_m^2} + \frac{(K_m - N_m\delta_N)^3}{6} \frac{\partial^3 V}{\partial K_m^3}. \tag{A5}$$

A third-order approximation is necessary, because of the skewness of the binomial distribution that determines the reproductive success of men. Only for symmetric distributions, i.e. for the special case where $\delta_N = \frac{1}{2}$, will skewness have no influence on the utility maximization problem of men. For given N_m and δ_N, the expected utility a man derives from children is given by:

$$E[V(K_m, Q)] \approx (1-\gamma) Q^\theta (N_m\delta_N)^\kappa \left[1 + \frac{(1\text{-}\delta_N)\kappa(\kappa\text{-}1)}{2(N_m\delta_N)} + \frac{(1\text{-}\delta_N)(1\text{-}2\delta_N)\kappa(\kappa\text{-}1)(\kappa\text{-}2)}{6(N_m\delta_N)^2} \right]. \tag{A6}$$

Hence, the marginal change in the expected utility a man derives from children due to a marginal increase in the number of his female partners N_m is:

$$\frac{\partial E[V(K_m,Q)]}{\partial N_m} \approx (1-\gamma)\, Q^{\theta}\, (\delta_N)^{\kappa}\, (N_m)^{\kappa-1} \left[\kappa + \frac{(1\text{-}\delta_N)\kappa(\kappa\text{-}1)^2}{2(N_m\delta_N)} + \frac{(1\text{-}\delta_N)(1\text{-}2\delta_N)\kappa(\kappa\text{-}1)(\kappa\text{-}2)^2}{6(N_m\delta_N)^2}\right]. \tag{A7}$$

Using (A7), the first order necessary condition for men with respect to N_m in a continuous choice setting is given by:

$$\gamma\,(a_m q_m + s_m)\,(Y_m - s_m N_m - a_m N_m q_m)^{-\sigma} = \frac{\partial E[V(K_m,Q)]}{\partial N_m} \tag{A8}$$

The solution to the model is therefore described by the first order conditions (11) and (12) for females, the first order conditions for males (14 with A6 inserted) and (A8), and the mating cost constraint (16) and market-clearing condition for the mating market (17). This system of equations is solved for Q_f, N_f, q_m, N_m, s_f, and s_m.

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