Economics in a Family Way

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Abstract

This paper argues that the economics of the family can be much enriched by incorporating recent developments in evolutionary biology, animal behavior studies, cultural evolution, anthropology, and game theory. Evolutionary foundations of sympathy between relatives are explored. Applications of the theory of cultural evolution to the demographic transition and to wealth transfers between generations are investigated. The economics of marital institutions such as polygyny, polyandry, and matriarchy are discussed, as well as recent work by economists on non-monogamous mating arrangements in our own society. Applications of recent developments in non-cooperative bargaining theory and matching theory to the theory of marriage are presented.

Introduction

The sympathies and affections of most people are entangled in a web of family relationships. To economists, who are accustomed to modeling society as a set of interactions among self-interested individuals, this fact has often been an embarrassing nuisance. Paul Samuelson's [69] classic paper on welfare economics, *Social Indifference Curves*, poses this quandry in a section titled "The Problem of Family Preference: A Parable."

> Who after all is the consumer in the theory of consumer's (not consumers') behavior? Is he a bachelor? A spinster? Or is he a "spending unit" as defined by statistical pollsters and recorders of budgetary spending? In most of the cultures actually studied by modern economists, the fundamental unit on the demand side is clearly the "family" and this consists of a single individual in but a fraction of cases.

In recent years, economists have shown that standard economic methods, carefully applied, can enrich our understanding of the family as an economic unit. This work has been strongly influenced by Gary Becker's *Treatise on the Family* [1]. Some economists have developed interesting models in which the traditional selfish-consumer assumption is relaxed.[1] Several surveys of this literature, including an extensive survey of economists' contributions to the theory of the family by the present author [9], can be found in the forthcoming *Handbook of Population and Family Economics* [66].

This paper, instead of reviewing economists' past achievements in the economics of the family, will focus on work that is less familiar to those who normally work in this area, but which has great potential to enrich our understanding of economic relations within families. Much of this work comes from other disciplines, especially anthropology and biology. Because of the intimate connection between reproduction and the family, it should not be surprising that the theory of evolutionary biology has fundamental implications for the economics of the family. Given the increased prevalence of unwed parenthood, divorce, "serial polygyny", and other non-traditional family arrangements in modern western societies, it should also be no surprise that anthropologists' studies of alternative family structures can help us to understand arrangements for reproduction, child support, and care of the elderly in our own society.

It is easy to convince most economists that economic analysis would greatly enrich all other academic disciplines, but economists are surprisingly reluctant to believe that reading anthropology, biology, history, psychology, or sociology

[1] Bergstrom [4] constructed a model in which several people have interacting benevolent concerns about each others' consumption and characterized efficient allocations in this environment. Pollak [62] proposed several interesting notions of interdependent utilities. Bergstrom [5] and Bernheim and Stark [11] described and resolved some intriguing paradoxes that arise in the interactions among people who love each other.

is important for doing good economic analysis. One objective of this paper is to show samples from these literatures that may help to convince economists to expand their reading.

The first two sections of this paper explore implications of the hypothesis that human preferences were shaped by natural selection, acting through differential effects of preferences on rates of reproduction. The first section outlines a genetically-based theory of the evolution of interpersonal sympathy among family members. This section also discusses the theory of *cultural evolution* and argues that natural selection of culturally transmitted preferences and attitudes operates according to a logic similar to that of natural selection of genetically transmitted traits. The second section applies evolutionary notions suggested in the first section to the riddle of the *demographic transition* and to patterns of intergenerational flows of wealth. The third section reports on studies of non-monogamous family structures in traditional societies and relates this to more recent work on non-monogamous family relations in our own society.

The final selection, like the earlier sections, discusses research that has potential for inspiring important advances in the economic theory of the family. This section draws on developments in game theory, a more traditional source of inspiration for economists than evolutionary biology or anthropology. The discussion advocates an approach to intra-family bargaining that is based on non-cooperative bargaining theory. This section also argues for the importance of integrating a theory of marital bargaining with a theory of marriage markets, and sketches some steps toward building an integrated theory.

1 Preferences in Family Matters

1.1 Adam Smith and Sympathetic Preferences

Let us begin with Adam. Smith opens his treatise, *The Theory of Moral Sentiments* [71] as follows:

> "How selfish, soever, man may be supposed, there are evidently some principles in nature, which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it except the pleasure of seeing it."

In a later chapter, entitled: *Of the Order in which Individuals are recommended by Nature to our care and attention*, Smith elaborates on the "principles in nature which interest men in the fortunes of others":

> "Every man feels his own pleasures and his own pains more sensibly than those of other people. The former are the original sensations; the latter the reflected or sympathetic images of these sensations.

> After himself, the members of his own family, those who usually live in the same house with him, his parents, his brothers and sisters are naturally the objects of his warmest affections... his sympathy with them is more precise and determinate, than it can be with the greater part of other people. It approaches, nearer, in short, to what he feels for himself.
>
> This sympathy too, and the affections that are founded on it, are by nature more strongly directed towards his children than towards his parents, and his tenderness for the former seems generally a more active principle, than his reverence and gratitude toward the latter...
>
> The children of brothers and sisters are naturally connected by the friendship which, after separating into different families, continues to take place between their parents...
>
> The children of cousins, being still less connected, are of still less importance to one another; and the affection gradually diminishes as the relation grows more and more remote." (Part VI, Section II, Chapter I)

The Theory of Moral Sentiments was published exactly 100 years before Charles Darwin's *Origin of the Species*. [25] Not surprisingly, Smith neither sought nor found an evolutionary explanation for a positive association between intensity of sympathy and degree of relatedness. His conclusion appears to be based entirely on empirical observation.[2] Yet Smith's phrase "the Order in which Individuals *are recommended by Nature* to our care and attention," seems felicitiously to foreshadow the possibility of an evolutionary explanation for Smith's remarks on the varying degree of sympathy between relatives.

1.2 Kin Selection in Evolutionary Biology

Hamilton's Rule

Modern evolutionary biologists have developed a beautiful and powerful theory of the evolutionary foundations of sympathy between relatives. The founder of the modern theory of *kin selection*, William Hamilton [40], describes this theory as follows:

> "The social behavior of a species evolves in such a way that in each distinct behavior-evoking situation the individual will seem to value his neighbors' fitness against his own, according to the coefficients of relationship appropriate to the situation."

[2] Smith suggests that this sympathy is caused by close physical association, remarking that physical separation reduces, but does not eliminate these affections. But Smith also observes that "A jealous husband ... often regards with hatred and aversion that unhappy child which he supposes to be the offspring of his wife's infidelity."

Biologists define the "coefficient of relationship" between two individuals to be the probability that a randomly selected gene from one of these individuals and the corresponding gene from the other are both copied from a common ancestor. These coefficients of relationship can be readily calculated under various assumptions about mating patterns. In a sexually reproducing species with diploid genetic structure like our own, if mating couples are not closely related, the coefficients of relationship between kin are as follows:

Coefficients of Relationship Between Kin

Parent-child	1/2
Full siblings	1/2
Half siblings	1/4
Grandparent-grandchild	1/4
Aunt or Uncle-nephew or niece	1/4
First cousins (under monogamy)	1/8

It has become common practice for biologists and evolutionary ecologists to predict animal behavior with a form of benefit-cost analysis, known as "Hamilton's rule." Hamilton's rule states that an animal, when offered an opportunity to confer a benefit of B units of "fitness" on another animal at a cost of C units of "fitness" to itself, will choose to do so if and only if

$$Br > C, \tag{1}$$

where r is the coefficient of relationship between them.

Hamilton's theory of kin selection is central to the modern study of animal behavior, playing an essential role in the understanding of cooperative behavior among animals, parent-offspring conflict, parental investment, and sexual strategies of males and females. The interplay of theory and empirical observation in the evolutionary theory of animal behavior is beautifully demonstrated in Robert Trivers' *Social Evolution* [75].[3]

Genetically-programmed Utility Functions

Hamilton's Rule is usually interpreted as a prediction about genetically hard-wired traits or behavioral rules that are invoked by specific stimuli. Biologists have found many examples in which individuals routinely take actions that reduce their own survival probability but increase the survival probability of their relatives. Small birds and mammals emit shrieks and warnings at the approach of a predator. In some bird species, individuals help to feed the

[3]For economists wanting an introduction to this subject, Trivers' book is a good starting point. It assumes no prior knowledge of biology, but presents the relevant biological information in a way that is readily grasped by economists. The discussion moves smoothly and quickly to matters of profound interest both to biologists and economists.

offspring of their parents or siblings. Caterpillars who leave a bad taste in the mouth of a predator do not improve their own survival probability by this form of revenge, but do reduce the likelihood that the predator will eat a relative.

In species that face highly variable environments, much behavior seems more complex than a direct stimulus-response connection. Individuals are able to process and use information and to choose actions in a consistent way. It is natural for economists to think of such individuals as endowed with a preference ordering or a utility function. Natural selection could act on these preferences, in the same way that it acts on hard-wired behavioral responses.

Much as economists postulate that individuals maximize *utility*, biologists postulate that individuals maximize *fitness*. Typically an individual's fitness is defined to be the expected number of surviving offspring that the individual produces.[4] Hamilton proposed the following definition of *extended fitness*. Let F_j be the fitness of individual j and let r_{ij} be the coefficient of relationship between individuals i and j.The extended fitness H_i of individual i is a weighted sum of i's own fitness and that of its its relatives, namely:

$$H_i = F_i + \sum_j r_{ij} F_j. \tag{2}$$

It is appealing to conjucture that evolutionary biologists may have discovered an evolutionary foundation for Adam Smith's *Order in which Individuals are recommended by Nature to our care and attention.* Not only have they found an *ordinal* ranking of relatives that corresponds with Smith's notion, but they appear to have found a *cardinal* quantitative measure of the degree of sympathy that nature recommends us to extend toward each of our relatives. The language of modern game theory allows us to pose this conjecture more sharply. Consider a set of relatives who interact with each other. Each relative j, selects a strategy s_j from a set S_j of possible strategies. Let s be the vector listing the strategies chosen by each player and let the "fitness" of any individual j be a function $F_j(s)$. For each i, define the extended fitness payoff function $H_i(s)$ so that :

$$H_i(s) = F_i(s) + \sum_j r_{ij} F_j(s) \tag{3}$$

The conjecture is that evolutionary forces tend to produce a population of individuals who act as if they are choosing Nash best responses in a game where their payoff functions are the extended fitness payoff functions given by Equation 3. Hamilton's theoretical argument supports this conjecture only for the special case where benefits conferred and costs incurred interact additively. Economic

[4]This definition can be problematic. For example, it may be that by having fewer but wealthier children, one can have more surviving grandchildren. (See Rogers [65] for an interesting discussion of this issue.) The problem of defining fitness becomes even more complex if children are treated asymmetrically as in the case of primogeniture. Bergstrom [7] suggests a method for calculating reproductive values in a stratified society with primogeniture.

models with diminishing returns and other more complicated interactions between individual contributions do not display this additivity. When interactions are not additive, it is not in general the case that individuals will be extended fitness maximizers in equilibrium. However, as Bergstrom [8] shows, the first-order conditions derived from Hamilton's rule correctly characterize equilibrium behavior. The logic of kin selection and the intuition that underlies these conclusions will be clarified by a look at the special case of kin selection among siblings.[5]

Kin Selection for Siblings

Suppose that individuals do not *choose* their strategies, but are *programmed* by their genes. Assume that the strategy that one uses is determined by the two genes that lie in a single genetic locus and that genes are passed from generation to generation according to the Mendelian laws of inheritance. A *monomorphic population* is a population in which all individuals have identical genes in this locus, so that all individuals are genetically programmed to use the same strategy x. A *monomorphic equilibrium* is a monomorphic population that will resist invasion by any mutant gene that programs individuals to use a different strategy y. A mutant gene will be able to establish a presence in the population if, when it is rare, carriers of the mutant gene are more likely to survive than normal x-strategists. Conversely, there will be a monomorphic equilibrium of x-strategists if carriers of any rare mutant gene that leads to a different strategy are less likely to survive than the normal x-strategists.[6]

Mendelian inheritance is a blunt instrument that does not act on individuals independently of its effects on their kin. Someone who inherits a mutant gene is more likely than a normal individual to have siblings who carry copies of the same mutant gene. An individual who is instructed by a mutant gene to sacrifice some of her own survival probability for the benefit of her siblings is more likely than a normal individual to benefit from the sacrifices of siblings whose genes give them the same instructions. If the mutant gene is a rare dominant gene, then almost all of its carriers will be offspring of one normal parent and one parent who carries a single copy of the mutant gene. By the Mendelian laws of heredity, there is an independent probability of $1/2$ that each sibling of a carrier of the mutant gene carries the same mutant gene.

Consider the case where individuals play a two-person game with each of their siblings and one's payoff in this game is a function $F(\cdot,\cdot)$ of one's own strategy and the strategy of one's sibling. Suppose that individuals with normal genes are programmed to use strategy x and those who carry a mutant gene

[5] This example was introduced by Bergstrom and Stark [10] and is explored in detail by Bergstrom [8].

[6] The discussion here concerns invasion by a *dominant* mutant gene. A more detailed discussion of the genetics involved, along with a treatment of the case of invasion by *recessive* mutant genes is discussed in [8].

are programmed to use strategy y. Then mutants who use the deviant strategy y will find that with probability 1/2, their sibling also uses strategy y and with probability 1/2 the sibling uses the normal strategy x. Therefore in each encounter with siblings, the expected payoff to an individual who carries a copy of the mutant gene is

$$V(y,x) = \frac{1}{2}F(y,y) + \frac{1}{2}F(y,x). \tag{4}$$

The function V is called a *semi-Kantian utility function*, since it can be expressed by a maxim that is "halfway between" selfishness and the Kantian ethic. This semi-Kantian maxim is:

> "Act toward your sibling as you would if you believed that with probability one-half, your sibling would copy your action."

If natural selection is for utility functions rather than for hard-wired actions, then we can expect evolution to produce utility functions towards siblings that take the semi-Kantian form found in Equation 4.

In the case of a symmetric game between siblings, Hamilton's extended fitness function (given in Equation 3) takes the form:

$$H(y,x) = F(y,x) + \frac{1}{2}F(x,y) \tag{5}$$

which can be expressed as the rule:

> "Value your sibling's survival half as much as your own."

Hamilton's extended fitness function is similar to, but not the same as the semi-Kantian utility function. Bergstrom [8] presents examples of simple games (including prisoners' dilemma) in which the equilibrium actions predicted by the extended fitness utility function are not the same as those for the semi-Kantian utility function. However, if the fitness function F is differentiable, then the first-order calculus conditions for equilibrium in a population of extended fitness maximizers are the same as the first-order calculus conditions in a population of semi-Kantian utility maximizers.

1.3 Imitation and Cultural Evolution

The great variety of behavior and values across cultures and subcultures seems to be evidence that human preferences are partially formed by cultural rather than genetic influences. There is abundant direct evidence that people adopt opinions, attitudes, tastes, and goals by imitation of parents, playmates, teachers, and neighbors. In *The Selfish Gene*, Richard Dawkins [27] introduces the term *meme* to describe a culturally transmitted norm that is passed along much in the way genes are inherited. The logic of cultural inheritance and imitation

bears an intriguing similarity to that of genetic inheritance. Luigi Cavalli-Sforza and Marcus Feldman [21] define cultural transmission to be "vertical" if cultural traits are passed from parents to children, "horizontal" if these traits are passed between persons of the same age, and "oblique" if they are passed from members of an older generation to members of a younger generation who are not their own children. Cavelli-Sforza and Feldman, and Robert Boyd and Peter Richerson [19] demonstrate that the abstract structure of cultural transmission lends itself to formal modelling almost as well as the Mendelian genetic model. Bergstrom and Stark [10] explore some applications of cultural evolution in the behavior of siblings and neighbors. While the structure of vertical cultural transmission is very close to that of genetic evolution, horizontal and oblique transmission introduce a number of new possibilities for the pathways of inheritance. It is also important to notice that cultural evolution, especially with horizontal transmission, can occur much more rapidly than genetic evolution, with the rise and fall of cultural institutions being observable well within the range of written history.

1.4 On the usefulness of evolutionary hypotheses

Human evolution proceeds slowly. Most evolutionary biologists believe that our bodies and minds are, for the most part adaptations to hunter-gatherer life in the Stone Age. An extreme "adaptationist" view that current preferences are the optimal preferences for reproductive success under current conditions seems indefensible. This problem is eloquently addressed by Randolph Nesse and George Williams in *Why We Get Sick* [58].[7] Nesse and Wilson ask:

> 'Why, in a body of such exquisite design, are there a thousand flaws and frailties that make us vulnerable to disease?...
>
> Even our behavior and emotions seem to have been shaped by a prankster. Why do we crave the very foods that are bad for us? ... Why do we keep eating when we know we are too fat? ... Why are male and female sexual responses so uncoordinated, instead of being shaped for maximum mutual satisfaction?... Finally, why do we find happiness so elusive? The design of our bodies is simultaneously extraordinarily precise and unbelievably slipshod. It is as if the best engineers in the universe took every seventh day off and turned the world over to bumbling amateurs." (p. 5)

Nesse and Williams propose two kinds of answers: (i) Our bodies are the result of evolution, not design. Although evolution produces outcomes of magnificent complexity and efficacy, evolved creatures remain, in many ways, prisoners of the historical path of evolution and differ drastically from the result of

[7] This book makes a very interesting case for the application of evolutionary principles to medicine.

an optimal top-down design. (ii) Some of our physical and psychological traits that were well-adapted for the Stone Age environments are poorly adapted for the modern environment. While selection may be acting against these traits, the process is extremely slow relative to the rate of change in our environment.

Since our knowledge of Stone Age living conditions is and will remain extremely sketchy, many scholars have concluded that the evolutionary hypothesis has little empirical content and is simply an invitation to unfalsifiable speculation. A more optimistic view is that we can learn much about Stone Age conditions by observing existing tribes of hunter-gatherers. Anthropologists such as Kim Hill and Hillard Kaplan [44], Napoleon Chagnon [22], and Eric Alden Smith [72] have conducted detailed studies of economic life in present-day hunter-gatherer societies that have had minimal contact with the modern world. While these studies are of great interest, the authors are quick to acknowledge that they find great differences among existing hunter-gatherer societies. Moreover, there is no compelling evidence that the conditions that hunter-gatherers face today are sufficiently similar to those faced by the ancestral societies from which we have evolved as to allow us to make useful inferences about evolution.

Matters are made even more difficult by the fact that our preferences seem to be formed partly by cultural forces and partly by genetic coding. Thus a fully satisfactory evolutionary theory of preference formation might have to untangle the genetically inherited from the culturally inherited aspects of our preferences.

The objection that human behavior evolved in a remote, unobservable past would be quite devastating if the theory required that human behavior is determined by evolved reflexes for specific responses in specific situations. Some human behavior seems to be simply reflexive. Nesse and Williams suggest several human responses that appear to be genetically encoded, including specific food-aversions (especially among young children) that may have protected our ancestors from eating poisonous plants, reflex responses to burns, pain in injured limbs, aversion to human feces and vomit, fear aroused by certain cues, and sexual arousal. In these cases, the stimuli being responded to are nearly universal in human experience and it seems likely that the optimal response would not have changed much through the millenia.[8]

For dealing with more variable situations, nature has supplied us with problem-solving abilities and a complex of rather general tastes and desires that are correlated with reproductive success in a great variety of situations. Given the diversity of environments in which our species has thrived, we can expect that those genetically-coded human preferences must be flexible enough to have served our ancestors' reproductive interests in a variety of different environments. Such generally useful preferences would include preferences related to staples of the human condition, such as nutrition, temperature-regulation, leisure, and friendly social relations with peers and allies. Reproduction, child-

[8] Of course there may be selection bias here. Nesse and Williams may have noticed and written about these responses precisely because they are as comprehensible in terms of today's environments as they must have been in the Stone Age.

rearing and growth to maturity must have been central to the experience of those who managed to pass their genes on to future generations. Accordingly, preferences related to the desire for reproduction and to sympathetic concern for one's children and other relatives are prime candidates for genetic encoding.

Even if it is difficult to determine whether preferences are culturally or genetically determined, the hypotheses of genetic transmission and vertical cultural inheritance have similar implications for equilibrium outcomes. Oblique and horizontal cultural transmission allow outcomes that would not be sustained by genetic transmission or vertical transmission. But, as is demonstrated by Cavelli-Sforza and Feldman and by Bergstrom and Stark these hypotheses impose a structure that may help us to analyze and understand the outcomes that we observe.

2 The Demographic Transition

2.1 Cultural Evolution and the Demographic Transition

The *demographic transition*, which began in Western Europe and has now spread to much of Asia, is an especially interesting example of the interaction of economic forces and cultural evolution. A fall in infant mortality in the late 18th and early 19th century was followed, with a time lag, by a sharp decrease in completed family sizes in most countries of Europe.

According to Robert Pollak and Susan Watkins [63], two major rival economic theories have been proposed to explain this outcome. One theory, normally associated with the Chicago School and the work of Becker [1], proposes that changed reproductive behavior is a rational response of well-informed decision makers to changes in incomes and relative prices. An alternative theory, based on Richard Easterlin's [29] relative income hypothesis, also posits well-informed actors who rationally choose actions to maximize their utilities, but proposes that there have been economically-induced changes in tastes and aspirations that have led to different reproductive goals. Pollak and Watkins contrast these "rational actor theories" with theories of cultural diffusion of attitudes and of technical knowledge. They argue that a synthesis of cultural diffusion models and rational actor models is likely to lead to better understanding of the demographic transitions.

This discussion focusses on a cultural evolutionary view of the demographic transition. That birth rates eventually fell in response to a fall in the death rate is not surprising. Declining infant mortality meant that families that maintained the traditional norm for birth rates would have had many more surviving children than the historical norm. Traditionalists who maintained high birth rates would have had untraditionally large families of surviving offspring. In a peasant economy with scarce land, this would leave some surviving children too poor to marry and produce children of their own. It would not be surprising if the

number of births that led to maximization of the number of *fertile* offspring would decline in response to lower infant mortality.

It is also not surprising that the response of birth rates to infant mortality rates was lagged, as people only gradually came to understand that traditional practices led to larger numbers of surviving children than before. The theory of cultural evolution would suggest that as infant mortality declined, persons with "mutant" aspirations, who planned to have *fewer births* and to leave more resources to each of them would have more fertile offspring and hence more grandchildren than those with high birth rates. Thus if aspirations for number of births are "vertically transmitted" from parents to children, the desire for having fewer babies would be passed on to a greater number of fertile offspring than high birth rate aspirations.

But the demographic transition seems to have gone beyond the reduction in fertility that would maximize surviving descendants. Despite increasing per capita wealth during the 19th and 20th centuries, average numbers of *surviving* children per family decreased rather than increased. It has been remarked by Willis [81] and by Becker and Lewis [3] that as family wealth increases, families are likely to choose increased child "quality,"[9] at the expense of numbers of children. The possibility that low fertility in modern settings maximizes the number of grandchildren has been tested by Hillard Kaplan, Jane Lancaster, Sara Johnson, and John Bock [45], who studied fertility and income in a sample of 7,107 men living in Albuquerque between 1990 and 1993. Controlling for other variables, they found that the more children a man has, the lower will be the expected education level and income of each when they reach adulthood. Thus they find a quality-quantity tradeoff as expected by Willis and Becker and Lewis. But higher "quality" has not led to significantly higher fertility. Although the children of fathers who had fewer children were more prosperous than the children of men with more children, they were not more fertile. Over the relevant range, the expected number of one's grandchildren is an increasing, and in fact almost linear, function of the number of one's children.

Cavelli-Sforza and Feldman argue that the cultural norm of having small families could not prevail if reproductive decisions were vertically transmitted from parents to children. With vertical transmission, the reproductive choices of parents who have fewer children will be imitated by fewer people than the reproductive choices of more fertile parents, and the population that carries the cultural trait of desiring low birth rates would dwindle relative to the cultural trait of desiring high birth rates. Cavelli-Sforza and Feldman conclude that the norm of having small families must have been supported by *horizontal* or *oblique* transmission–people imitating their peers or parents peers, rather than their parents.

It is useful to know that horizontal or oblique transmission is needed in order

[9] These authors define child quality to be the amount of human and financial capital inherited per child.

to sustain the cultural trait of wanting small families, while vertical transmission would lead to the extinction of this trait. If the "small-family strategy" succeeded because of horizontal or oblique transmission, then it must have been that the small-family strategy practiced by other families was somehow more attractive to the next generation than the large-family strategy practiced by its parents. This force had to be strong enough to overcome the tendency of vertical transmission to eliminate the small family strategy. The question then becomes "Why would we expect that aspirations to have small families are more likely to be horizontally transmitted than aspirations to have large families."

Posing the question in this way creates, I believe, a useful bridge between the biological literature in which it is expected that natural selection would shape human preferences in such a way as to lead individuals to attempt to maximize their reproductive success, and the economic literature in which preferences are quite arbitrarily determined.

For economists who think it unsurprising that in equilibrium, most people would choose to have only two children when they could afford to raise three or four to a prosperous adulthood, it is instructive to consider the following question: Why would not the small-family norm eventually be overwhelmed by a population of fundamentalists, adhering to a religion with the following pro-natalist doctrine? *It is your duty to produce three or four surviving children and it is your duty to pass this doctrine on to all of your children.* Given current income levels in industrialized countries, the costs of adhering to this doctrine do not seem heavy compared to the obligations that have been imposed by historically successful religions. If this religion were successfully established and maintained, its followers would eventually swamp those who aspire, on average, to have only two children.

Two possible restraining forces might prevent adherents of such a pro-natalist religion from outrunning the adherents of a small-family norm. (i) Even though the fundamentalists cling devoutly to the doctrine, it might be that after a few generations, their wealth would be dissipated and most fundamentalists simply could not afford to raise three or four children who survive to adulthood. (ii) It might eventually not be possible for believing parents would to convince more than two of their children to adopt their parents' pro-natalist doctrine.

There remains a disquieting possibility. Perhaps the low birth rates currently observed in the West do not represent long run equilibrium. If a pro-natalist norm starts with a small number of adherents, even if they are able to pass it on to most of their children, it would take many generations for its descendants to outnumber the original population. In most countries of Western Europe and North America, low average birth rates have been present for only three or four generations–far too short a time for vertical transmission to replace the low-fertility norm.

2.2 The Direction of Intergenerational Wealth Flows

John Caldwell [20], a demographer, advanced the theory that there are two types of societies, *pre-transitional* societies which are characterized by high stable birth rates and by net wealth flows running from younger to older generations and *post-transitional* societies which have low fertility and net wealth flows running from older generations to younger generations. In pre-transitional societies, having children is profitable, so people would choose to reproduce up to the biological limit. In post-transitional societies, where children are costly, people limit their fertility, much as they limit their consumption of other costly consumer goods.

As Paul Turke [77] observes, the view that in traditional societies, resource flows were, on average, directed from younger to older generations is difficult to reconcile either with an evolutionary or a Malthusian model of population. Hillard Kaplan [43] explains the evolutionary viewpoint as follows:

> "In contrast to wealth-flows theory, models of fertility and parental investment derived from evolutionary biology expect that the net flow of resources will *always* be from parents to offspring, even when fertility is high. The logic underlying this expectation is that natural selection will have produced a preponderance of organisms that are designed to extract resources from the environment and convert those resources into descendants carrying replicas of their genetic material. ... Organisms that extracted a net gain from offspring would produce fewer genetic descendants than those that utilized their own labor and excess energy to produce more viable offspring. This does not mean that ... natural selection could not favor a positive flow from *some* offspring to parents or from offspring to parents at *some ages* but that the *overall* intergenerational flow of resources will be downward."

According to Turke [77], most of the data that has been advanced in favor of Caldwell's wealth-flows hypothesis takes the form of interviews without direct quantitative measurement.

> "In many such interviews parents do in fact aver that children are economic assets. Often, however, they assert as well that a reason for limiting births is that children are too costly. A commonly given noneconomic reason is that God (in various forms) wants people to have many children. Of course, no reputable social scientist would accept interview data as a basis for concluding that God is pronatalist, and I suggest we should be just as skeptical of the claim that interview data support the proposition that children are in fact net economic assets in traditional societies."

Turke [76] concludes from field studies in the Micronesian islands of Ifaluk and Yap (where people practice simple agriculture and fishing) that children tend to be a net economic burden on their parents. Thomas Fricke [31] indicates that Turke's evidence is indirect and far from decisive. More convincing evidence is now available, based on remarkably detailed fieldwork conducted by anthropologists[10] among three different tribes of hunter-gatherers, the Ache of Paraguay, the Piro of Peru, and the Masiguenga of Peru. Using this data, Kaplan [43] found that, among hunter-gatherers, resources flow from older to younger generations and not the other way around. These tribes all had very high average fertility (about 8 births per woman), but in each case, children consumed more food than they caught, at all ages from birth until age 18. Grandparents continued to work hard to support their grandchildren and produced more than they ate. At almost no time in their adult lives, did adults produce less than they consumed. When people became too old and frail to work, death followed quickly. Suicide and euthanasia of the enfeebled were frequently reported.

Although the evidence indicates that hunter-gatherers do not behave in a way consistent with Caldwell's hypothesis, there remains the possibility that investment in children is financially profitable in peasant agricultural societies. As Yean-Ju Lee, William Parish and Robert Willis [50] point out, the presence of positive net flows from prime-age adults to their elderly parents would not in itself be sufficient to vindicate Caldwell's hypothesis. For children to be a profitable economic investment, it would be necessary that the *amount* returned to elderly parents is enough to repay the investment they made when their children were small. If the parents have access to borrowing and lending markets or can buy and sell land, then a present-value calculation should be made, in which the future returns for investment in child-rearing are appropriately discounted to reflect the market rate of return.

The evidence available suggests that children are not a profitable investment in peasant economies. Eva Mueller [56] surveyed several studies of consumption and output of peasants and their children over the life cycle and concluded that

> "Children have negative economic value in peasant agriculture. Up to the time that they become parents themselves, children consume more than they produce. "

Thus any economic gain from having children would have to come in the form of a long term investment in the child's obligation to support the parent in her old age. Calculations by Mueller and by Goran Ohlin [59] indicate that a parent who gave birth at age 20 and supported a child from age 1 to age 15

[10] The data collection process is described by Kaplan in [43]. Fieldworkers walked with the male hunters on their hunting expeditions and followed the female gatherers. They weighed all of the food acquired by each individual and converted their measurements to calories. They also observed the distribution of food among the population. Thus they were able to measure output and consumption of each man, woman and child.

would receive a monetary rate of return of less than 1% on her investment if she retired at age 60 and was supported by the child until age 85 at the level of living that is normal for old people in peasant societies. When one accounts for the probability that either parent or child may die before the parent reaches 85 years of age, the expected rate of return becomes negative. In a peasant society, where land ownership is possible and where there are markets for borrowing and lending, such low rates of return are not likely to be acceptable on purely financial grounds.

Ronald Lee and Timothy Miller [49] construct detailed estimates of intergenerational wealth flows in the United States in the 1980's, using data from the 1987 Consumer Expenditure Survey and other sources. The Consumer Expenditure Survey reports interhousehold gifts and transfers. According to Lee and Miller:

> "The gross flows are overwhelmingly downward, from older ages to younger ones. Young households just starting out make no transfers at all, and receive a considerable amount—nearly a thousand dollars a year. ... As couples age, and their children become better established, fewer transfers are made. Somewhat surprisingly, however, there is no increase in transfers received; on the contrary, transfer receipts diminish steadily at older ages."

Lee and Miller calculate that the average *net* payments in gifts and bequests from the parental generation to their children amount to about $25,000 per child.[11] In addition, they estimate average child-rearing costs at $81,000 per child.

Overall, the evidence seems strongly consistent with the evolutionary view as expressed by Kaplan. Over the course of a lifetime, resources tend mainly to flow from the old to the young and not the other way around.

2.3 Economic Support of the Aged

John Caldwell [20] and Donald Cox and Oded Stark [23] maintain that in many traditional societies there are strong cultural norms that urge children to support their parents in their old age. Robert Lucas and Oded Stark [52] emphasize the importance in traditional African societies of remittances sent to their home families by grown children who have left home to work in urban areas. The existence of substantial remittances does not necessarily represent a flow of resources from the younger to the older generation. It may be that the remittances represent a "helpers-at-the-nest" effect, where the resources collected from older siblings are used to support younger siblings and other young kinfolk. Using

[11] To calculate net payments, they subtracted payments from children to parents from gifts in the other direction. Since payments from children to parents are usually made years later than payments than payments from parents to children, these figures are likely to understate the flow from parent to child measured in present value terms.

data from a survey of Taiwanese households, Lee, Parish and Willis [50] found evidence of a widespread pattern of support payments to elders from their adult sons and daughters.

> "...financial support, including both cash and in-kind gifts, continued in an upward direction, from adult children to parents. Whether son or daughter, most married children gave financial gifts to parents while few received gifts in return."

The experience of the population studied by Lee and his coauthors is unusual in the sense that the current generation of adult children in Taiwan is far wealthier on average than their parents. Per capita income in Taiwan increased more than fivefold between 1961 and 1986.

Cox and Stark [23] and Bergstrom and Stark[10] have suggested that adults may support their parents in order to imprint a corresponding behavior pattern on their own children. Thus the more an adult contributes to his aged parents, the more he can expect his children to contribute to him in his old age. The biblical statement of the Fourth Commandment (Exodus 20:12) suggests that the ancient Hebrews may have viewed filial obligation in such a recursive way:

> "Honor thy father and thy mother that *thy* days may be long upon the land... "

The clause "that thy days may be long upon the land" seems to indicate that the reason to treat your parents well is that the treatment you accord to them will ultimately be accorded to you.

It would be problematic to assume that the current generation consciously chooses the way it treats *its* parents while its offspring make no such choice but simply copy *their* parents. Bergstrom and Stark resolve this difficulty by suggesting that in equilibrium a child *might* copy its parents' actions, but with some probability the child makes an independent choice based on its own self-interest.[12] In this environment, imitators take the same actions as some ancestral chooser, so that everyone's behavior will be the same as the optimizing choice for a chooser who is aware that her actions may be copied by her children. Suppose that choosers are expected utility maximizers with utility functions $U(x, y)$, where x represents the way that the chooser treats her aged parents and y represents the way that her children treat the chooser when she is old. Let Π be the probability that the chooser's offspring will be an imitator. Then if $\bar{x}$ is the optimizing action for choosers, then it must be that the following expression is maximized at $x = \bar{x}$.

$$\Pi U(x, x) + (1 - \Pi)U(x, \bar{x}) \tag{6}$$

[12] Alan Rogers [64] offers an interesting model to explain why it might be that equilibrium is polymorphic, with some copiers and some independent choosers.

Expression 6 is formally similar to the semi-Kantian utility function defined in Equation 4. This reflects the fact that in equilibrium, individuals treat their parents in the way that would be in their own self-interest if they believed with probability Π that they would receive the same treatment from their children as they gave to their parents.

An adult chooser must decide whether to support her elderly parents or to ignore the parent and invest her money in financial assets which she can trade for support in her old age. Investing in the well-being of her parents in the hopes that this investment will be copied by her children is risky. If the children are imitators, this investment will be returned by her children when she herself becomes old, but if they are choosers, her actions toward her parents will have no effect on the way her children will treat her. Evidently, in this situation, a chooser will do more to support her elderly parents, the higher the probability that her children are copiers and the lower the expected returns from alternative financial assets.

Although it is possible to construct consistent models in which parental imprinting and social pressure cause adults to support aged parents, the cultural forces in favor of such support must somehow overcome significant pressure from natural selection. If behavior were genetically hard-wired, a gene that led people to spend resources on an elderly relative when these resources could have been used to produce an extra surviving child would eventually be eliminated by genes for maximizing the number of surviving descendants. The same problem arises whether preferences are transmitted genetically or culturally. Old people who hold the view "I don't want to be a burden on my children and grandchildren" and who act on this view will eventually have more descendants than those who try to command resources at the expense of their offsprings' reproductive success. Therefore if preferences tend to be vertically transmitted, we should expect selection for individuals who want to pass resources to their descendants during almost all of their entire lives. Flows of resource from young to old might be sustained by horizontal transmission of cultural views or they might be observed as a "disequilibrium outcome" in societies where medical technology has recently increased the survival of enfeebled elders.

In the hunter-gatherer societies studied by Kaplan, the downward flow of resources is extreme. Not only do children cost more than they return, but there is *never* a substantial period of their lives when old people consume more than they produce. In Western industrial countries, it is common for people to spend a long interval at the end of their lives consuming more than they produce. Lee and Miller [49] point out that the elderly are typically not supported by gifts from their children, but rather by social security payments and by their own savings and private pension plans. Perhaps an explanation for the fact that publicly-funded support of the elderly is much greater than publicly-funded child support is that genetic and/or cultural evolution leads families to be more willing to devote private resources to supporting their children than their parents. On the other hand, there is no corresponding evolutionary reason for people to

oppose taxing the population *at large* for the support of the elderly.

3 Non-monogamous Household Structures

Economic analyses of the household have dealt mainly with single-person households and with monogamous couples and their children. An important exception is Gary Becker's *Treatise on the Family*, in which there is a chapter on polygamous marriage markets. Though it might first seem that Becker's discussion of polygamy is just a virtuoso exercise in the economics of exotica, reflection suggests that the study of non-monogamous mating relationships is of fundamental interest. Not only is it fascinating to learn about the workings of marital institutions in other societies, but our own society is far from universally monogamous and statistics indicate that it is rapidly becoming less so.

Unwed parenthood is no longer rare. In the United States in 1960, only 5% of all births occurred out of wedlock.[13] In 1990, more than 25% of births were to unwed parents.[14] The proportion of all children who live in single-parent, mother-only households has risen from 8% in 1960 to 23% in 1990. For Black Americans, the statistics are even more dramatic. In 1990, two-thirds of births were out of wedlock and more than half of all children live in single-parent households. Not only has unwed parenthood become common, but divorce rates more than doubled between 1960 and 1990. About 20% of all marriages are dissolved within the first five years of marriage. Some estimates have it that nearly two-thirds of all first marriages will be dissolved within 40 years. In 1979, roughly one-third of all marriages involved at least one previously married person.

According to Da Vonza and Rahman, men who divorce are three times more likely to remarry than women. Divorced women who have children are 25% less likely to remarry than those without children. The asymmetry between the remarriage prospects of men and women means that it is more likely for men to have more than one wife over the course of their lives than for women to have more than one husband. Moreover, it is more common for divorced men to have children from subsequent marriages than it is for women. This assymmetry has led some anthropologists [51] [34] to describe current marriage patterns in the United States as "serial polygyny."

3.1 Divorce and Out-of-Wedlock Parenthood

A small, but interesting literature on the economics of divorce and child support has appeared in recent years. Pioneering work was done by Gary Becker,

[13] The statistics cited here come from a review of demographic trends in marriage, divorce and fertility statistics by Da Vonza and Rahman. [26]

[14] About 30% of unwed parents in 1990 were cohabiting couples many of whom maintain stable monogamous marriages.

E. Landes, and Robert Michael [2]. Yoram Weiss [78] has written a good, recent survey of work on the economics of divorce. Weiss and Robert Willis [79], [80] model child-support as a problem in the private provision of public goods. Both parents care about the well-being of the child. In a household where the mother and father live together, it is possible for each to monitor the contributions of the other and the result of this "repeated game" is expected to be a nearly Pareto-optimal amount of child care. But if the parents do not live together, they lose the ability to observe each others' contributions. In this case they will reach a non-cooperative equilibrium in which the amount of resources contributed to child care is suboptimal.

If the economics of child support by divorced couples is in its youth, the economics of out-of-wedlock births is in its infancy. The most prominent progenitor in this area seems to be Robert Willis [82]. Willis addresses the question of how unwed parenthood might become widespread in a population, even though marriage would allow significant gains from coordination of parenting effort. His proposed explanation depends on the presence of an excess of marriageable women over marriageable men. The African-American population in the United States displays exactly such a disparity. Willis builds a model based on observations of the sociologist, William Julius Wilson, [83] who identifies the pool of "marriageable black males" as those who are currently employed and not in prison. Wilson reported that in 1980, the ratio of marriageable black males aged 20-44 to black females aged 20-44 was about .56 in the Northeast and North Central states of the U.S. (In 1960, this ratio was about .67.) The corresponding ratio of marriageable white males to white females was about .85.

The Willis model has an equilibrium in which men choose between entering a monogamous marriage and taking the alternative option of remaining single while fathering children by several women. Monogamous men are confined to a single mate, but are able to reach more efficient agreements with their wives about child care. Unmarried fathers are able to father children by more than one woman, but the children of these relationships are less likely to be well cared for. In this model, the fraction of all males who marry is determined by the condition that in equilibrium, married and unmarried males must be equally well off. Willis defines a threshold number of partners P such that the strategy of unmarried fatherhood is as attractive as monogamy if and only if an unmarried male can expect to have P female sexual partners.

With this model, Willis finds a simple solution for the equilibrium fraction of males who marry monogamously. The algebra is as follows: Let W be the number of marriageable females, let αW be the number of marriageable males (where it is assumed that $\alpha < 1$), and let N be the number of monogamous marriages. Then the number of unmarried women is $W - N$ and the number of unmarried men is $\alpha W - N$. Assuming that all of the unmarried women and men form extra-marital partnerships, the average number of partners per unmarried men will be at the equilibrium level P only if $W - N = P(\alpha W - N)$. Rearranging terms in this equation, we find that the fraction of all women who

marry is

$$\frac{N}{W} = \frac{\alpha P - 1}{P - 1} \tag{7}$$

and the fraction of all men who marry is

$$\frac{N}{\alpha W} = \frac{\alpha P - 1}{\alpha(P - 1)}. \tag{8}$$

It is important to recognize that in the Willis model, equations 7 and 8 are not just accounting identities, but equilibrium conditions. These conditions enable us to predict the effect of changes in the parameters P and α on the marriage rates of men and women. From equations 7 and 8, it follows that the fraction of all members of either sex who maintain monogamous marriages will be smaller: (i) the lower is the ratio of the number of marriageable men to the number of marriageable women (ii) the smaller the threshold number of relationships P needed to induce a man to stay unmarried.

It would be interesting to extend the Willis model by assigning a more active decision-making role to women. A useful extension would allow women to choose when and whether to bear children. It would also be interesting to consider the possibility that an unmarried woman might have sexual relationships with more than one male and might receive varying amounts of child support from her consorts, depending on their beliefs about the likelihood that they have fathered her children.

3.2 Polygamous Marriages

The term *polygamy* encompasses all marital arrangements where the conjugal group includes at least three persons, with at least one person of each sex. Although polygamous marriage is rare in the United States and Western Europe, it is a very common mode of family organization around the world.[15] *Polygyny*, where some men have more than one wife, is prevalent in 850 of the 1170 societies recorded in Murdock's *Ethnographic Atlas*. Officially recognized *polyandry*, where some women have more than one husband is currently prevalent in only a few societies [41], though according to Prince Peter [61] it appears to have been considerably more common in earlier times. Prince Peter and William Durham [28] also found that the practice of *polygynandry* or *conjoint marriage*, in which the conjugal group includes two or more persons of *each* sex occurs in some societies that practice polyandry.

[15] Anthropologists like to point out that societies that are strictly monogamous with respect to *marriage* are often highly polygynous with respect to *mating*. See Robin Fox [30], Laura Betzig [12], and Bergstrom [7] for discussions of societies with monogamous marriage and poygnous mating.

Polygyny and Bridewealth

In polygynous societies that have well-defined property rights in land and cattle, it is usual for brides to command a positive price. This price, which anthropologists call *bridewealth*, is normally paid by the *groom and/or the groom's relatives* to the *bride's male relatives*. *Dowry*, in contrast, is defined to be a payment from the *bride's family* to the *groom and/or the groom's family*.[16] According to anthropologists Steven Gaulin and James Boster [33] "Bridewealth is common and dowry is rare." Gaulin and Boster report that of the 1267 societies recorded in Murdock's *Ethnographic Atlas*, 2/3 have positive bride prices, while only about 3% have dowries.

In societies that allow polygamy and where there are well-established markets for marriage partners, it is not surprising that brides rather than grooms usually command a positive price and that wealthy men would practice polygyny, but wealthy women would not practice polyandry. Because of the nature of sexual reproduction, a wealthy male can greatly increase his fertility by having several wives. Men who share a wife would have their expected fertilities reduced proportionately. In contrast, a wealthy female would increase her fertility only slightly by having more than one husband. Women who share a husband with co-wives would lose only a small amount of expected fertility.

Bergstrom [6] builds a model of polygynous marriage with competitive bride markets, in which parents seek to maximize the number of their surviving grandchildren. In this model, material resources and women of reproductive age are the only scarce resources in the production of children. In the absence of a positive bride price, when polygyny is allowed, there would be excess demand for brides. In market equilibrium with a positive bride price, men must choose between allocating additional resources to the care and feeding of their current wife or wives and the purchase and support of an additional wife. Wealthy men will have more wives than poor men, but the amount of resources supplied to a woman and her children is independent of her husband's wealth. Therefore there is no incentive for a woman and her relatives to seek to match her with a wealthy man rather than a poor man, and wealthy men will have to pay the same price for a bride as poorer men. Polygyny, therefore, tends to equalize the physical well-being and reproductive success of women, while amplifying the effects of wealth on the reproductive success of men.

Biologists who study polygyny among birds and mammals have developed a model called the *polygyny threshold model* [60]. In the polygyny threshold model, females are allocated to males, not by a price mechanism but by *female choice*. Females take account of the amount of resources controlled by a male

[16] Jack Goody [37] emphasizes that dowry is not the same as a "negative bride price" since dowry is usually received by the groom and thus winds up in the hands of the newly formed couple, while bridewealth goes to the bride's male relatives. Goody proposes the separate term "indirect dowry" to describe cases in which a payment is made from the groom's relatives to the bride. Anthropologists do not seem to have distinct terms to indicate whether *dowry* is paid to the groom or to the groom's family.

and the number of other females with whom they would have to share these resources and choose the mate who can supply them with the most resources. Although bride prices are replaced by female choice, the assignment of marriage partners is similar in the two equilibria. In each case, every female has access to the same amount of material resources as all other females and the number of mates that a male has is proportional to the amount of resources that he controls. An interesting difference between the two equilibria is that in the competitive bride price model, males can use the bride prices received for their female relatives to purchase brides for themselves. Thus the relevant distribution of wealth among males includes the distribution of control over the bride prices of female relatives. In the female choice model, no bride prices are paid and no such advantage accrues to males with many sisters or daughters.

The broad outlines of the competitive polygyny model with bride prices appear to fit many polygynous African societies. Monique Borgerhoff Mulder, [15], [16], [17], and [18] has conducted a remarkably detailed anthropological field study of the Kipsigis, a polygynous East-African tribe who engage in agriculture and herding.[17] Borgerhoff Mulder [18] reports that in a simple regression analysis, an extra wife adds about 6.5 children to a man's fertility, while sharing her husband with an additional co-wife reduces a woman's fertility by about 0.5 children. Using cross-sectional data from her study of the Kipsigis, Borgerhoff Mulder, [15] explored the determinants of bridewealth. She found that the average cost of a bride was about 1/3 of the wealth of an average household. The price paid for a bride depended positively on variables related to her health and fertility[18] but did not depend on differences in the wealth of the bride's and groom's family. In a subsequent study [17] Borgerhoff Mulder showed that in any year, the males most likely to attract additional wives were those who could provide the most resources (measured in acres of land) per wife. The number of wives that a man had was roughly proportional to the number of acres of land that he owned, with larger landowners having slightly fewer wives per acre than smaller landholders. [16]

Becker [1] suggested that women would be better off in a society that allowed polygyny than in a society with compulsory monogamy. He reasoned that relaxing the constraint that a man can have only one wife would shift the demand schedule for wives upward, leading to higher bride prices with polygyny than with monogamy. The claim that polygyny leads to high bride prices is theoretically compelling and is consistent with most anthropological field studies. But it does not follow that high bride prices imply welfare gains for females. The theory suggests, and field studies confirm that when "property rights" to

[17] Borgerhoff Mulder's papers contain a great deal of information on the economics and demography of the Kipsigis and are likely to be of interest to many economists. Other anthropologists who have written interesting accounts of polygyny in Africa include Walter R. Goldschmidt [35], P H. Gulliver [38], Thomas Hakansson [39] and Adam Kuper [47].

[18] Perhaps married readers will not be surprised to learn that the price paid for a bride was also higher, the greater the distance between parents' residence and her husband's residence.

an unmarried female lie with her family, her family will use the proceeds from selling their daughter to purchase wives for her male siblings rather than to raise her standard of living.

Monogamy, Dowries, and Primogeniture

Gaulin and Boster [33] find that 3/4 of the societies recorded in Murdoch's *Atlas* as having dowries are monogamous with a high degree of economic stratification.[19] In a monogamous society, the wife and children of a wealthy man are more likely to be well cared for than the wife and children of a poor man. Therefore parents who want to increase the number of their descendants would prefer that their daughters married rich men. In this environment, the scarce resource "a rich husband" will attract a positive price.

Laura Betzig [12] argues that most of the historical examples of stratified societies with monogamous *marriage* were also characterized by highly polygynous *mating*. For the nobility, marriage was an economic relationship in which the monogamously married wife was entitled to bear the only child or children to inherit a major portion of the nobleman's estate. Most of these societies practiced *primogeniture*, with the great bulk of the estate going to the oldest son born to the nobleman and his wife. There was a sexual double standard in which the wives of noblemen were expected to remain faithful to their husbands, but the husbands openly maintained sexual liasons with numerous mistresses, concubines, and household servants.[20] Parents were willing to pay large dowries for their daughters to become the wives of noblemen. Although their daughter's own fertility is only slightly improved by marriage to a nobleman, her descendants are likely to be numerous because, given the great wealth of the nobility and the double standard of sexual fidelity, her firstborn son is likely to father many children.

For the British aristocracy in the late medieval and early modern periods, very good demographic and economic data and detailed descriptions of inheritance practices can be found. Bergstrom [7] builds a formal model of a stratified society with monogamy and primogeniture similar to that described by Betzig. He uses historical data on the British aristocracy to estimate the parameters of his model and to test the hypothesis that the nobility were acting so as to maximize their reproductive success.

Polyandry

Although polyandry is far less common than polygyny or monogamy, several societies with polyandrous marriage structures have been studied by ethnolo-

[19] Gaulin and Boster also find that according to Murdoch's classification, societies with dowries tend to be those in which the economic value of work available to women is relatively low.

[20] The historian, Lawrence Stone [73, 74] offers vivid accounts of the sexual behavior of the late medieval and early modern English nobility.

gists. In these societies, *fraternal polyandry* was the usual pattern. A woman would be married to two or more brothers, who in principle are allocated equal sexual access to their joint wife. Two important sources of information on polyandry are studies by Prince Peter of Greece and Denmark, [61] who interviewed polyandrous families in Ceylon, Kerala, Madras and Tibet and by Melvyn Goldstein, [36] who interviewed a large number of refugees from central Tibet, who had made their way to northern India. William Durham [28] presents a thorough discussion of the anthropological literature on Tibetan polyandry and elaborates on theories of polyandry that were proposed by Prince Peter and by Goldstein.

According to Durham, the Tibetan-speaking peoples have the "greatest diversity of socially sanctioned marriage customs known to anthropology" Observed marital forms among the Tibetans include monogamy, polygyny, polyandry, and polygynandry. The landless serfs (the *du-jong*) almost always married monogamously. But among the landed serfs, the *thongpa*, a great diversity of marital customs is found. The thongpa traditionally lived in family units that control 20-300 acres of land to which they had permanent hereditary rights. Goldstein proposed that the entire spectrum of marital forms observed among the thongpa can be explained as an application of two fundamental social principles, 1) *Partible patrilineal inheritance.* In families that had male offspring, inheritance was in principle divided equally among them. In families that had no sons, inheritance was passed to a daughter. 2) *The monomarital principle.* In each generation of a thongpa family, the conjugal group must contain one and only one fertile woman.

In accordance with these principles, male thongpa who had no brothers almost always married monogamously. In families with two sons, the brothers almost always shared a single wife. Groups of three brothers sharing a wife were common, and larger groups of brothers sharing a wife were also found. But Goldstein reported that Tibetans believe that as the number of brothers sharing a wife increases, fraternal harmony becomes more difficult to maintain. Accordingly, when there were several brothers, some might become celibate monks or might be sent out as adoptive bridegrooms to a families with no male children.

If the first wife of a marriage turned out to be infertile, then a second wife, often a sister of the first wife, would be brought to the marriage. This accounts for the occasional instances of polygyny and of polygynandry observed among the thongpa. In families where there were daughters but no sons, the estate would pass to one of the daughters, who married monogamously.

In these societies, the monomarital principle of "one fertile woman per generation, per estate" regulates fertility and hence controls the family's land-labor ratio. Brothers who would be unable to sustain independent families if they divided the land and each had a wife and children, are able to support one wife

and her offspring by working together on the land.[21]

According to Durham, there is evidence that the institution of fraternal polyandry has persisted among the Tibetans for at least 1300 years. Durham argues that this persistence requires explanation and he seeks an explanation in the theory of cultural evolution. Durham maintains that the "marital ideology had, by virtue of its consequences under local conditions, net reproductive benefit for thongpa parents, and ... that the marriage beliefs themselves had been preserved within the cultural system primarily as a result of a thongpa preference for them because of their consequences."

Adherence to the monomarital principle is not enforced by law, but according to the thongpa is a conscious choice, based on the belief that partitioning the family estates would lead to devastating hardship for future generations. Durham maintains that the monomarital principle is supported both by vertical transmission within families and by horizontal cultural transmission. He presents evidence that families that partition their lands between more than one conjugal group will produce more children in the first generation, but that in two or three generations, the number of surviving descendants will be smaller than the number of descendants of families who adhered to the monomarital principle. Thus if children adopt the marital principles of their parents, we would expect the monomarital principle to prevail. There is evidence that the monomarital principle is also supported by horizontal transmission, through imitation of successful families other than one's own. Within Tibetan society, there has been recurrent experimentation with partitioning of family estates. In interviews, Tibetans describe recent instances of "deviant" behavior as having resulted in devastation for one or more heirs. They also cite the extreme poverty of the neighboring Nepalese communities who do not practice polyandry as evidence of the evils of partitioning.

Matriarchal Societies

The Nayar of India are a matriarchal society, who had particularly interesting marriage customs.[22] At any one time, women would maintain formally-recognized sexual relationships with between three and twelve "husbands". When a woman became pregnant, one of the husbands who might possibly be the father had to acknowledge paternity. The putative father, however, had no obligation to the child.

[21] Since with polyandry, more men marry than women, there will, in the absence of infanticide, typically be left-over women who do not find mates. Female infanticide does not appear to be common among the polyandrous people of Kerala or Tibet. Unmarried women frequently work on the farm along with their brothers.

[22] Descriptions of Nayar marriage customs are found in works of Prince Peter [61] and Kathleen Gough [70], and William Irons [42]. The traditional Nayar marriage customs have largely eroded in the twentieth century, but much information is available from written accounts from the fifteenth to the eighteenth centuries.

Men were expected to give money to their maternal household for the support of their sisters. A husband normally visited a wife after eating supper at his mother's house, and left the wife's residence before breakfast. For a man to withhold money from his maternal family and give the money to a wife or to support his biological child was a gross violation of the social norm. Children belonged to the mother's household and were supported and cared for by their mother, maternal grandmother, and maternal uncles. Children were aware of their declared fathers and had occasional dealings with them, but they had much more frequent encounters with their mothers' brothers. A woman's brothers were charged with disciplining her children and with attending to the education of her sons.

In considering the evolutionary stability of Nayar institutions, one must ask whether a "deviant" social norm that asks men to give money to their wives and wives' children rather than to their sisters and sisters' children would be able to invade a population of Nayars who followed the usual norm.

If this behavior is *genetically* determined, the answer depends on whether, on average, men are more closely related to their sisters' children or to their wives' children. Kurland [48] shows how to calculate the *paternity threshold*, which is the minimal level of paternity confidence that would yield a higher genetic payoff to investing in one's wifes children rather than in one's sister's children. Suppose that in every generation, there is a constant probability p that a man is the father of his wife's child. The paternity threshold is a probability p_t such that a man will be more closely related to his sister's children than to his wife's children if and only if $p < p_t$. The degree of relatedness of a man to his wife's children is $p/2$. A man and his sister share the same mother, but the probability that they share the same father is only p^2. Therefore the expected degree of relatedness between a man and his sister is $(1 + p^2)/4$ and the expected degree of relatedness between a man and his sister's child is $(1 + p^2)/8$.[23] Therefore the paternity threshold is a solution to the quadratic equation $p/2 = (1 + p^2)/8$ This equation has only one positive root, which is $p_t = .268$. Thus the genes of men who give resources to their sisters rather than to their wives will eventually dominate the population if and only if the probability that a man is the father of his wife's children exceeds .268.

If marital behavior is *culturally* determined, the calculations are different. If boys learn their behavior from the males with whom they associate most closely, then in Nayar society, we notice that boys are more strongly influenced by the behavior of their maternal uncles than by the behavior of their mothers' husbands. If a deviant man contributed money to a wife rather than to his sisters, then that man's wife would on average have more children and his sisters would have fewer children than would be the case in a normal family. Even if his wife's children are more closely related to him genetically than his sisters' children,

[23] Here we are assuming that a man's wife's other lovers are not close relatives of the man. In the case, for example, of fraternal polyandry, the relationship between a man and his wife's children is closer, because if the child is not his, it is his brother's.

his cultural influence is likely to be stronger on the nephews and nieces whom he shortchanged than on the progeny that he enriched. His relatively numerous genetic children are likely to adopt the cultural practices of his traditionalist brothers in law, while the people most likely to copy his behavior will be the less numerous children of his sisters.

4 Choosing Your Bed and Lying In It

Proposing marriage, an eager suitor may promise a lifetime of devoted service to the whims of his beloved. But a sensible young woman, even if she hasn't studied game theory, is likely to be skeptical. She is more likely to base her expectations about marriage on what she knows of the way her mother and other married female acquaintances have fared, than on her suitor's flattering, but unenforceable promises.

It is not possible to write a prenuptial marriage contract that legally binds the new couple to a detailed program of behavior through the course of their marriage. Most of the important decisions to be made by the couple must be resolved as they arise, after marriage. In a satisfactory theory of courtship and mating, potential partners must anticipate that their well-being after marriage, will depend on the outcome of postnuptial bargaining. Conversely, since one's bargaining power within a marriage may depend on the threat of exercising the "outside option" of divorcing and reentering the marriage market, a satisfactory theory of bargaining within marriage should include a theory of courtship and mating.

4.1 Cooperative Nash Bargaining Solutions

The pioneering work on the theory of household bargaining was done by Marilyn Manser and Murray Brown [54] and Marjorie McElroy and Mary Horney [55], who studied household decision making under the Nash cooperative bargaining model. In these papers, a marriage is modelled as a static bilateral monopoly. A married couple can either remain married or they can divorce and live singly. There is a convex utility possibility set S containing all utility distributions (U_1, U_2) that could possibly be achieved if they remain married. The utility of person i if he or she divorces and lives singly is given by V_i. It is assumed that there are potential gains to marriage, which means that there are some utility distributions (U_1, U_2) in S that strictly dominate the utility distribution (V_1, V_2) that would obtain if they divorced.

The authors propose that the distribution of utilities that result from a marriage is given by the symmetric Nash bargaining solution where the "threat point" is the divorce outcome. According to the Nash bargaining theory, the outcome in this household will be the utility distribution (U_1^*, U_2^*) that maxi-

mizes $(U_1 - V_1)(U_2 - V_2)$ on the utility possibility set S.[24] An implication of this theory is that the outcome in a marriage is completely determined by the utility possibility set and the threat point, (V_1, V_2). The theory makes the interesting prediction that social changes which affect the utility of being single will affect the distribution of utility within the household, even if they have no effect on the budget of the household, while changes in the apparent distribution of earned income within the household will have no effect on the distribution of utility in the household if they do not change the threat point from being single.

Shelly Lundberg and Robert Pollak [53] propose an alternative Nash bargaining model. They suggest that for many marriages the relevant threat point for the Nash bargaining solution should be not divorce, but an "uncooperative marriage" in which spouses would revert a "division of labor based on socially recognized and sanctioned gender roles." Lundberg and Pollak suggest that with their model, if government child-allowances are paid to mothers rather than to fathers in two-parent households, this threat point will shift in the mothers' favor. Accordingly, the outcomes of cooperative bargaining within households are likely to be more favorable to women. By contrast, in the divorce-threat model, a change in who receives the welfare payments when the couple is together will have no effect on the distribution of utilities if there is no change in who gets these payments in the event of a divorce.

4.2 Noncooperative Bargaining Theory and Outside Options

Should the threat point be divorce as suggested by Manser, Brown, McElroy and Horney? Should it be an uncooperative marriage as suggested by Lundberg and Pollak? Will the threat point depend on whether either party can end the marriage or whether mutual consent or a court decree is required to end the marriage? Nash's axioms for the cooperative bargaining solution give us no direct guidance about the appropriate threat points for bargaining in a marriage. Recent work on the noncooperative foundations of bargaining theory not only offers a more convincing foundation for the Nash bargaining solution, but also yields useful insight into the appropriate choice of threat points.

Ariel Rubinstein [68] developed an extensive-form, multi-period bargaining game for two agents in which a cake is to be partitioned only after the players reach agreement. Players alternate in proposing how to divide the cake with one time period elapsing between each offer. Each agent i is impatient, discounting future utility by a factor $\delta_i < 1$, so that the utility to player i of receiving w units of cake in period t is $w\delta_i^t$. Rubinstein proved that in the limit as the time between proposals becomes small, the only subgame perfect equilibrium is

[24] This expression is sometimes known as the Nash product. John Nash [57] proposed a set of axioms for resolution of static two-person bargaining games such that the only outcomes that satisfy the axioms maximize the Nash product on the utility possibility set.

for the cake to be divided in the first period with player i's share of the cake being $\alpha_i = \delta_i/(\delta_1 + \delta_2)$. More generally, if agent i's utility from receiving w_i units of cake in period t is $u_i(w_i)\delta_i^t$ where u_i is a concave function, then the only perfect equilibrium is the allocation that maximizes the "generalized Nash product", $u_1^{\alpha_1} u_2^{\alpha_2}$ on the utility possibility set $\{(u_1(w), u_2(1-w))\,|0 \leq w \leq 1\}$. In case the two agents have equal discount rates, this outcome is the same as the symmetric Nash equilibrium where the threat point is $(0, 0)$.

Ken Binmore [14] extended the Rubinstein model to the case where each of the bargaining agents has access to an "outside option". Binmore's model is like the Rubinstein model, except that each agent i has the option of breaking off negotiations at any time and receiving a payoff of m_i units of cake, in which case the other player receives no cake. Given that the outcome in the game without outside options is the same as the Nash cooperative equilibrium with threat point $(0, 0)$, one might conjecture that the effect of the outside options would be to move the threat point to (m_1, m_2).[25] Binmore shows that this is *not* the answer. The only subgame perfect equilibrium for the game with outside options is an agreement in the first period on the utility distribution (u_1, u_2) that maximizes the Nash product $u_1^{\alpha_1} u_2^{\alpha_2}$ on the utility possibility set $\{u_1(w), u_2(1-w)|0 \leq w \leq 1\}$ *subject to the constraint that* $u_i \geq m_i$ *for each* i. In general, this solution is not the same as maximizing $(u_1 - m_1)^{\alpha_1}(u_2 - m_2)^{\alpha_2}$ on the utility possibility set, which would be the outcome of shifting the threat point to (m_1, m_2).[26]

4.3 Noncooperative Bargaining Theory and Marriage

To many persons with marital experience, it seems unlikely that couples resolve disagreements about ordinary household matters by negotiating under the pressure of divorce threats. If one spouse proposes a resolution to a household dispute and the other does not agree, the expected outcome is not a divorce. A more likely outcome is harsh words and burnt toast, until the next offer is made. If the couple were to persist forever in inflicting small punishments upon each other, the outcome might well be *worse* for one or both of them than a divorce. But divorce imposes large irrevocable costs on both parties, while a bargaining impasse need last only as long as the time between a rejected offer and acceptance of a counteroffer.

The Rubinstein-Binmore model, as applied to marriage, lends formal support to these speculations. This model concludes that so long as the gains from marriage are divided in such a way that both parties are better off being married

[25] If negative values of m_i are considered, this conjecture might be amended to $(\max\{0, m_1\}, \max\{0, m_2\}$.

[26] Binmore, Shaked, and Sutton [13] tested this theory with a laboratory experiment in which subjects played a Rubinstein bargaining game with outside options. Behavior in this game was better predicted by Binmore's model than by the competing model in which the outside option is the threat point.

than being divorced, a divorce threat is not credible. Instead, the relevant threat is delayed agreement and burnt toast, followed by a counterproposal. Here we will explain the workings of the Rubinstein-Binmore model as applied to a highly simplified model of a household.

Consider a married couple who expect to live forever in a stationary environment. Assume that each spouse discounts future utility by the same per-period discount factor δ and that in every time period, the utility possibility frontier is the set $\{(u_h, u_w)|u_h + u_w = 1\}$, where u_h and u_w are the utilities of husband and wife respectively. Each spouse has an intertemporal utility function of the form $\sum_{t=0}^{\infty} u_t \delta^t$. In any period where they remain married, but do not reach agreement, the husband will get a utility of b_h and the wife will get a utility of b_w, where $b_h + b_w < 1$. If either person asks for a divorce, they will divorce and the husband will get a utility of m_h forever and the wife will get a utility of m_w forever, where $m_h + m_w < 1$. [27]

The spouses alternate in offering feasible utility distributions. For concreteness, let us suppose that the wife gets to make the first offer and that she proposes a utility distribution $(u_h, u_w) > (m_h, m_w)$. The husband could either accept the offer, refuse the offer and make a counteroffer, or refuse the offer and ask for a divorce. If the husband accepts the offer, then the distribution of utility in the household will (u_h, u_w) and will remain the same in every subsequent period unless in some future period the husband changes his mind and decides to reject his wife's outstanding offer of (u_h, u_w). Since this is a stationary model, if the husband accepts the offer in the first period, he will continue to accept it in all subsequent periods. If the husband refuses the offer and asks for a divorce, he will get a utility flow of $m_h < u_h$ in all future periods. Therefore, if the only way to refuse an offer were to ask for a divorce, the wife could extract all of the gains from marriage by offering the husband a utility that is just equal to his utility from being divorced.[28] But the husband has the additional alternative of refusing the wife's offer and making a counteroffer in the next period. In equilibrium, it must be the case that the husband can not do better by refusing the offer and waiting for his own turn to make a counteroffer. Since the wife will want to make the smallest offer that the husband will accept, it must be that in equilibrium, the wife offers terms that leave the husband indifferent between accepting immediately and making a counteroffer. If the divorce threat is not credible for either spouse, this process has a unique equilibrium in which the wife gets b_w plus the fraction $\frac{1}{1+\delta}$ of the total gain $1 - b_h - b_w$ from agreement

[27] A more realistic model would allow the possibility that divorced persons can remarry with some probability at some interval of time after divorcing. While it would be worthwhile to develop the model in this direction, it appears that the qualitative conclusions would be little different from the model sketched here

[28] We follow the convention in the principal-agent literature, by assuming that if the agent is offered a deal in which he is just indifferent between two options, he will take the one that the principal wants him to take. This saves mathematical clutter that would arise if we had the principal offer the agent a tiny bit more for taking the desired option.

and the husband gets b_h plus the fraction $\frac{\delta}{1+\delta}$ of the gains $1 - b_h - b_w$.[29] Thus if the wife gets to make the first offer, the equilibrium is

$$(\bar{u}_h, \bar{u}_w) = \left(b_h + \delta \frac{(1 - b_h - b_w)}{1 + \delta}, b_w + \frac{(1 - b_h - b_w)}{1 + \delta} \right).$$

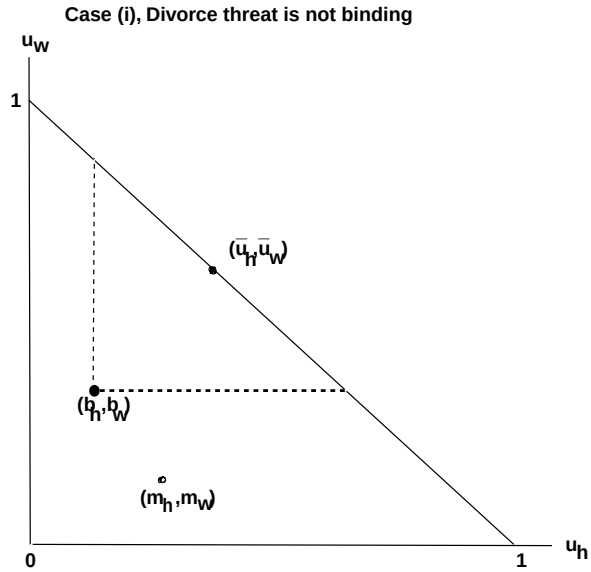
If $\bar{u}_h > m_h$ and $\bar{u}_w > m_w$, then the divorce threat is not credible for either spouse and the solution will be $(\bar{u}_h, \bar{u}_w)$. If $\bar{u}_i < m_i$, then the divorce threat will be relevant for person i, and as Binmore observes, the unique equilibrium outcome is that person i gets utility m_i and i's partner gets utility $1 - m_i$.

If the time between offer and counteroffer is small, then the discount rate for waiting one period is close to 0, so that δ is close to 1. In the limit as δ approaches 1 and the divorce threat is not relevant, the gains from cooperative rather than noncooperative marriage will be divided equally. Thus in the limit as the time between offer and counteroffer becomes small, the equilibrium approaches one of the following three cases.

- Case i. Divorce threats are not credible. If $b_h + (1 - b_h - b_w)/2 > m_h$ and $b_w + (1 - b_h - b_w)/2 > m_w$, then the outcome is $(\bar{u}_h, \bar{u}_w) = b_h + (1 - b_h - b_w)/2, b_w + (1 - b_h - b_w)/2$. The geometry of Case i is illustrated in Figure 1. The point $(\bar{u}_h, \bar{u}_w)$ is the point on the utility possibility frontier that splits the gains above (b_h, b_w) equally. In the example shown here, noncooperative marriage for a single period is worse for the husband (and better for the wife) than being divorced for a single period, but the bargained equilibrium $(\bar{u}_h, \bar{u}_w)$ is better for both spouses than divorce. It is not difficult to see that it would be possible to construct examples that fall into Case i where a single period of noncooperative marriage is worse for both spouses (or better for both spouses) than a single period of divorce, but where the equilibrium from the noncooperative threat point is better for both spouses than divorce.

[29] In the Appendix, we present a simple algebraic proof of this proposition. (This proof is not new. A similar argument can be found in [14].

Figure 1--Household Bargaining Equilibrium

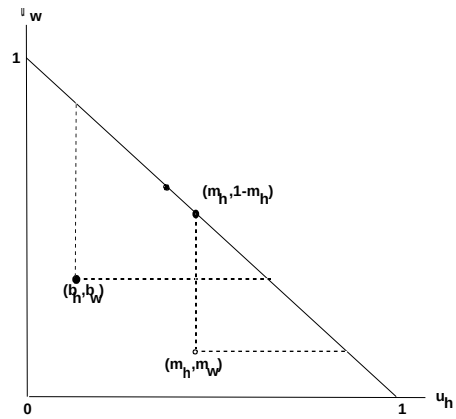


- Case ii. Divorce threat is credible for the husband, but not for the wife. This happens if $b_h + (1 - b_h - b_w)/2 < m_h$.In this case the solution is $u_h = m_h$ and $u_w = 1 - m_h > m_w$. This case is illustrated in Figure 2. In Case ii, not only is noncooperative marriage worse for the husband than divorce, but the equilibrium found taking noncooperative equilibrium as a threat point is worse for the husband than divorce. In this case, equilibrium is the outcome where the husband is indifferent between divorce and marriage

and the wife has utility $1 - m_h$.

Figure 2--Household Bargaining Equilibrium

Case (ii), Divorce threat binds on u_h



- Case iii. Divorce threat is credible for the wife, but not for the husband. This happens if $b_w + (1 - b_h - b_w)/2 < m_w$. In this case the solution is $u_w = m_w$ and $u_h = 1 - m_w > m_h$.

The first case corresponds to the Lundberg and Pollak's cooperative solution where the threat point is not divorce, but a noncooperative marriage. In the other two cases, the divorce threat is relevant, but notice that the outcome is never the outcome predicted by the Manser-Brown and McElroy-Horney models. In an equilibrium where both persons are better than they would be if divorced, equilibrium is calculated as if the threat point were eternal burnt toast rather than divorce. Small changes in the utility of being divorced would have no effect on the outcome of household bargaining. In the only cases where the divorce threat is relevant, the gains from marriage are not split equally as in the divorce-threat bargaining models. In this case, one partner enjoys all of the surplus and the other is indifferent between being divorced and being single.

To some observers, this model's stately minuet of offer and counteroffer may seem not to reflect the realities of domestic conflict. But Rubinstein's canonical bargaining model can be much relaxed in the direction of realism

without altering the main results. Binmore shows that qualitatively similar results obtain when the length of time between offers and the person whose turn it is to make the next offer are randomly determined after every refusal. It is also a straightforward matter to add a constant probability of death for each partner without seriously changing the model. On the other hand, stationarity of the model seems to be necessary for Rubinstein's beautifully simple result. This stationarity is lacking in a model where children grow up and leave the family and where the probability of death increases with age. It would be useful to know more about the robustness of the Rubinstein results to more realistic models of the family.

4.4 Marriage Markets for Bargaining Spouses

A satisfactory theory of bargaining between spouses should be embedded in a theory of marriage markets. In order to explore issues that arise when marriage markets are combined with bargaining between spouses, let us consider a drastically simplified model of the marriage market.[30] This model makes the barbaric assumption that every male and female would, if they married, face the same utility possibility frontier as any other married couple.[31] The only difference between any two individuals of the same sex is in the utility that they could achieve by remaining single.

Assume that the utility possibility frontier for every married couple consists of all utility divisions (u_h, u_w) such that $u_h + u_w = 1$, and that there is a continuum of persons of each sex. Let $F_h(u)$ be the number of males in the population for whom the utility of being single is less than u and let $F_w(u)$ be the number of females in the population for whom the utility of being single is less than u. Assume that these distribution functions are strictly increasing and continuous, and that $F_h(0) = 0$, $F_h(1) > 0$, $F_w(0) = 0$ and $F_w(1) > 0$.

Suppose that it were possible at the time of marriage to write and enforce a marital contract that determined the distribution of utility within the marriage. Then there would be a unique equilibrium utility distribution $(u_h^*, 1 - u_h^*)$ such that the number of males who are willing to marry and get utility u_h^* equals the number of females who are willing to marry and get $u_w^* = 1 - u_h^*$. When the utility distribution between husbands and wives is (u_h, u_w), the supply of men wanting to marry is $F(u_h)$ and the supply of women wanting to marry is $F(u_w)$. The unique equilibrium utility distribution (u_h^*, u_w^*) is found by solving the equation $F_h(u_h^*) - F_w(1 - u_h^*) = 0$.[32]

[30] Essentially the same model was introduced by Lundberg and Pollak [53]

[31] The theory of mating and matching, which is thoroughly surveyed by Al Roth and Marilda Sotomayor, [67] incorporates models in which different individuals could have arbitrarily different rankings over members of the opposite sex as possible partners. It appears that most of the qualitative results of the model presented here would extend to this more general environment.

[32] Existence follows from the assumption of continuity and the assumption that $F_h(1) - F_w(0) > 0$ and $F_h(0) - F_w(1) < 0$. The assumption that F_h and F_w are strictly increasing

Now consider the more realistic case where neither party to a marriage can credibly promise a utility distribution within that marriage. Suppose that the utility distribution within marriages is determined by the Binmore-Rubinstein model of non-cooperative bargaining. Let the utility distribution for any couple during a period where they have not reached agreement be (b_h, b_m) and assume that the time between offer and counteroffer is very short. Then, as predicted in our model of non-cooperative bargaining, the distribution of utility in all marriages will be (approximately)

$$(\bar{u}_h, \bar{u}_w) = \left(b_h + \frac{(1 - b_h - b_w)}{2}, b_w + \frac{(1 - b_h - b_w)}{2} \right).$$

Given this utility distribution within marriages, the number of males who wish to marry will be $F_h(\bar{u}_h)$ and the number of females who wish to marry will be $F_w(\bar{u}_w)$. It is interesting to notice that there is no reason to expect that $F_h(\bar{u}_h) = F_w(\bar{u}_w)$. Therefore, there will in general be either more men seeking wives than women seeking husbands or *vice versa*. The inability to make prior commitments to utility distributions within marriage has the same kind of effect as price inflexibility in a commodity market. If, for example, the equilibrium bargained utility distribution within marriages is such as to leave an excess demand for wives, then all women who wish to marry under the current terms of marriage will be able to do so, but some men who want to marry will not find wives. Such a man would be willing to offer more favorable terms for a wife than the current equilibrium utility. If he could make such promises credible, then he would be able to induce some woman who currently prefer remaining single to marry him, but she realizes that once married, they will be playing a bargaining game in which the inevitable result is the equilibrium utility enjoyed by all other married women.

The two best-known theories of marriage assignments are the theory of stable marriage algorithms, developed by David Gale and Lloyd Shapley [32] and the linear programming assignment model which was introduced to economics by Martin Beckmann and Tjalling Koopmans [46] and applied to marriage markets by Gary Becker [1]. Both of these models are more general than the example considered here in that they allow for differences in preference rankings over possible marriage partners. In the Gale-Shapley theory no "side-payments" are allowed and there are no possibilities for negotiation about the terms of marriage.[33] The assignment problem assumes transferable utility and allows binding premarital agreements on any possible distribution of utility for any possible married couple. The model of bargaining with non-cooperative marriage as the threat point could be applied to the more general environment assumed in these models. In such a model, for any possible marriage there is a

functions implies that $F_h(u) - F_w(1 - u)$ is a strictly decreasing function of u. Therefore equilibrium must be unique.

[33] Crawford and Knoer [24] show how the Gale-Shapley algorithm can be extended to allow side payments.

unique distribution of utility that will be determined by the utility possibility frontier, the time-discount rates of each party and the distribution of utility that will prevail if they remain married but do not reach agreement. Therefore, the appropriate model would be like the original Gale-Shapley in that each person assigns a fixed utility to each possible marriage partner and that utility can not be altered by proposing different terms of marriage.

Conclusion

The economics of the family is currently an attractive area for research. Economists have only begun to exploit a wealth of fascinating ideas from modern evolutionary biology, anthropology and game theory. An evolutionary perspective on standard topics of economic demography, such as fertility, care for the elderly, patterns of marriage, and division of responsibility for childcare is likely to produce deeper insights and better-posed questions than theory based on arbitrary assumptions about preferences. Since a significant and growing fraction of our own population lives in family arrangements other than stable, monogamous family units, it has becomes important to try to understand the logic of alternative familial arrangements. Much can be learned by attention to the great body of enthographic work in which anthropologists have studied stable, functioning marital systems other than traditional monogamy.

Modern game theory, particularly recent work in bargaining theory and in matching theory, has much to contribute to the understanding of the formation, functioning, and dissolution of marriages. The theoretical discussion in the last section of this paper concerns courtship and marriage in a monogamous society, with divorce functioning largely as an unexercised threat. It would be interesting to apply these tools to less monogamous societies, including a more realistic model of our own society. Such models might encompass out-of-wedlock parenthood, unmarried cohabiting couples, and serial polygamy, with marriages expected to be temporary, and with interlocking reconstituted families that include children from previous marriages.

Appendix–The algebra of noncooperative equilibrium

Let u_1^h be the equilibrium utility for the husband if he gets to make the first offer and let u_2^h be his equilibrium utility if the wife gets to make the first offer. Let u_1^w be the equilibrium utility for the wife if she gets to make the first offer and let u_2^w be her equilibrium utility if the husband gets to make the first offer. Let b_h and b_w be the utilities that the husband and wife respectively would get in any period where they do not reach agreement. Let $b_h + b_w < 1$ and let the utility possibility frontier for each period be $\{(u_1, u_2) \geq 0 | u_1 + u_2 = 1\}$. Let us suppose that there if the wife makes the first offer, the equilibrium payoffs will be $\bar{u}_1^w$ for the wife and $\bar{u}_2^h$ for the husband and if the husband makes the first offer, the equilibrium payoffs will be $\bar{u}_1^h$ for the husband and $\bar{u}_2^w$ for the wife.

In the first period, if the husband accepts the offer of $\bar{u}_2^h$, then since the problem is stationary, he will continue to accept $\bar{u}_2^h$ in all subsequent periods. Therefore his utility will be $\sum_0^\infty \bar{u}_2^h \delta^t$. If he rejected her offer, he would receive b_h in the first period and in the next period it would be his turn to make the offer. Then he would demand $\bar{u}_1^h$ and offer his wife $\bar{u}_2^w$ and she would accept the offer and continue to accept $\bar{u}_2^w$ in all subsequent periods. The husband's utility if he follows this strategy would be $b_h + \sum_{t=1}^\infty \bar{u}_1^h \delta^t$. In equilibrium, the husband must be just indifferent between accepting his wife's initial offer and waiting one period to make a counteroffer. This will be the case if $\sum_0^\infty \bar{u}_2^h \delta^t = b_h + \sum_{t=1}^\infty \bar{u}_1^h \delta^t$, or equivalently if

$$\bar{u}_2^h - b_h = \frac{\delta}{1-\delta}(u_1^h - u_2^h). \tag{1}$$

Similarly, it must be that if $\bar{u}_1^w$ and $\bar{u}_2^w$ are equilibrium strategies for the wife, then she will be indifferent between accepting u_2^w if it is her husband's turn to make an offer and refusing his offer and countering with a demand of $\bar{u}_1^w$ in the next period. This leads by an exactly parallel argument to the equation

$$\bar{u}_2^w - b_w = \frac{\delta}{1-\delta}(u_1^w - u_2^w). \tag{2}$$

The feasibility constraints for offers are:

$$\bar{u}_1^w + \bar{u}_2^h = 1 \tag{3}$$

$$\bar{u}_1^h + \bar{u}_2^w = 1 \tag{4}$$

When we solve the linear equations 1-4 for the variables $\bar{u}_1^w$, $\bar{u}_2^w$, $\bar{u}_1^h$, and $\bar{u}_2^h$, we find that the solutions are:

$$\bar{u}_1^w = b_w + \frac{1}{1+\delta}(1 - b_h - b_w),$$

$$\bar{u}_2^w = b_w + \frac{\delta}{1+\delta}(1 - b_h - b_w),$$

$$\bar{u}_1^h = b_h + \frac{1}{1+\delta}(1 - b_h - b_w)$$

and

$$\bar{u}_2^h = b_h + \frac{\delta}{1+\delta}(1 - b_h - b_w).$$

This is the result claimed in the text.

References

[1] Gary Becker. *A Treatise on the Family*. Harvard University Press, Cambridge, Ma, 1981.

[2] Gary Becker, E. Landes, and R. Michael. An economic analysis of marital instability. *Journal of Political Economy*, 85(6):1141–1187, December 1977.

[3] Gary Becker and H. Gregg Lewis. On the interaction between the quantity and quality of children. *Journal of Political Economy*, 81(2):S279–288, March/April 1973.

[4] Theodore Bergstrom. A scandinavian consensus solution for efficient allocation with non-malevolent preferences. *Journal of Economic Theory*, 2(4):383–398, December 1971.

[5] Theodore Bergstrom. Love and spaghetti, the opportunity cost of virtue. *Journal of Economic Perspectives*, 3(2):165–173, Spring 1989.

[6] Theodore Bergstrom. On the economics of polygyny. Technical report, University of Michigan, Ann Arbor, Mi, July 1994.

[7] Theodore Bergstrom. Primogeniture, monogamy and reproductive success in a stratified society. Technical report, University of Michigan, Economics Department, Ann Arbor Mi, 48109, October 1994.

[8] Theodore Bergstrom. On the evolution of altruistic ethical rules for siblings. *American Economic Review*, 85(1):58–81, March 1995.

[9] Theodore Bergstrom. A survey of theories of the family. In Mark Rosenzweig and Oded Stark, editors, *Handbook of Population and Family Economics*. North Holland, Amsterdam, 1996.

[10] Theodore Bergstrom and Oded Stark. How altruism can prevail in an evolutionary environment. *American Economic Review*, 83(2):149–155, May 1993.

[11] B. Douglas Bernheim and Oded Stark. Altruism within the family reconsidered: Do nice guys finish last? *American Economic Review*, 78(5):1034–1045, December 1988.

[12] Laura Betzig. Sex, succession, and stratification in the first six civilizations. In Lee Ellis, editor, *Social Stratification and Socioeconomic Inequality*, pages 37–74. Praeger, New York, 1993.

[13] Ken Binmore, Avner Shaked, and John Sutton. An outside option experiment. *Quarterly Journal of Economics*, 104(4):753–770, November 1989.

[14] Kenneth George Binmore. Bargaining and coalitions. In Alvin Roth, editor, *Game Theoretic Models of Bargaining*, pages 259–304. Cambridge University Press, Cambridge, 1985.

[15] Monique Borgerhoff Mulder. Kipsigis bridewealth payments. In Laura Betzig, Monique Borgerhoff Mulder, and Paul Turke, editors, *Human Reproductive Behavior*, pages 65–82. University of Cambridge Press, Cambridge, 1988.

[16] Monique Borgerhoff Mulder. Marital status and reproductive performance in kipsigis women: Re-evaluating the polygyny-fertility hypothesis. *Population Studies*, 43:285, 1989.

[17] Monique Borgerhoff Mulder. Kipsigis women's preferences for wealthy men:. *Behavioral Ecology and Sociobiology*, 27(4):255–264, October 1990.

[18] Monique Borgerhoff Mulder. Women's strategies in polygynous marriage. *Human Nature*, 3(1):45–70, 1992.

[19] Robert Boyd and Peter Richerson. *Culture and the Evolutionary Process*. University of Chicago Press, Chicago, 1985.

[20] John Caldwell. A theory of fertility: From high plateau to destabilization. *Population and Development Review*, 4(4):553–577, December 1978.

[21] Luigi Cavalli-Sforza and Marcus Feldman. *Cultural Transmission and Evolution*. Princeton University Press, Princeton, 1981.

[22] Napoleon Chagnon. *Yamamamö*. Harcourt Brace Jovanovich, Fort Worth, TX, fourth edition, 1992.

[23] Donald Cox and Oded Stark. Intergenerational transfers and the demonstration effect. Technical report, Harvard University, Department of Economics, Harvard University, 1992.

[24] Vincent Crawford and Elsie Knoer. Job matching with heterogeneous firms and workers. *Econometrica*, 49(2):437–451, March 1981.

[25] Charles Darwin. *The Origin of Species*. John Murray, London, first edition, 1859.

[26] Julie DaVonza and M. Omar Rahman. American families: Trends and correlates. *Population Index*, 59(3):350–386, Fall 1994.

[27] Richard Dawkins. *The Selfish Gene*. Oxford University Press, Oxford, 1967.

[28] William Durham. *Coevolution*. University of California Press, Berkeley, 1991.

[29] Richard Easterlin. On the relation of economic factors to recent and projected fertility. *Demography*, 3(1):131–153, 1966.

[30] Robin Fox. *Reproduction and Succession*. Transaction Pubishers, New Brunswick, N.J., 1993.

[31] Thomas Fricke. Darwinian transitions? a comment. *Population and Development Review*, 16(4):107–19, March 1990.

[32] David Gale and Lloyd Shapley. College admissions and the stability of marriage. *American Mathematical Monthly*, 69:9–15, 1962.

[33] Steven Gaulin and James Boster. Dowry as female competition. *American Anthropologist*, 92(4):994–1005, December 1990.

[34] Steven Gaulin and Carole J. Robbins. Trivers-willard effect in contemporary north american society. *American Journal of Physical Anthropology*, 85(1):61–69, May 1991.

[35] Walter R. Goldschmidt. *Culture and behavior of the Sebei*. University of California Press, Berkeley, 1976.

[36] Melvyn Goldstein. Stratification, polyandry, and family structure in central tibet. *Southwestern Journal of Anthropology*, 27(1):64–74, Spring 1971.

[37] Jack Goody. Bridewealth and dowry in africa and eurasia. In Jack Goody and S. Tambiah, editors, *Bridewealth and Dowry*, pages 1–57. Cambridge University Press, 1973.

[38] P.H. Gulliver. *The Family Herds*. Routledge, 1955.

[39] Thomas Hakkansson. *Women and Land*. Alqvist and Wiksell International, Stockholm, 1988.

[40] William D. Hamilton. The genetical evolution of social behavior, i and ii. *Journal of Theoretical Biology*, 7(1):1–52, July 1964.

[41] John Hartung. Polygyny and inheritance of wealth. *Current Anthropology*, 23(1):1–12, February 1982.

[42] William Irons. Investment and primary social dyads. In Napoleon Chagnon and William Irons, editors, *Evolutionary Biology and Human Social Behavior*, chapter 7, pages 181–212. Duxbury, North Scituate, Ma, 1979.

[43] Hillard Kaplan. Evolutionary and wealth-flows theories of fertility. *Population and Development Review*, 20(4):753–791, December 1994.

[44] Hillard Kaplan and Kim Hill. The evolutionary ecology of food acquisition. In Eric Alden Smith and Bruce Winterhalder, editors, *Evolutionary Ecology and Human Behavior*, pages 167–202. Aldine de Gruyter, Hawthorne, N.Y., 1992.

[45] Hillard Kaplan, Jane Lancaster, and Sara Johnson. Does observed fertility maximize fitness among new mexican men? *Human Nature*, 6(4):325–360, 1995.

[46] Tjalling Koopmans and Martin Beckmann. Assignment problems and the location of economic activities. *Econometrica*, 25(1):53–76, January 1957.

[47] Adam Kuper. *Wives for Cattle*. Routledge, London, 1982.

[48] Jeffrey Kurland. Paternity, mother's brother, and human sociality. In Napoleon A. Chagnon and William Irons, editors, *Evolutionary Biology and Human Social Behavior*, chapter 6, pages 145–180. Duxbury Press, North Scituate, MA, 1979.

[49] Ronald Lee and Timothy Miller. Population age structure, intergenerational transfer, and. *Journal of Human Resources*, 29(4):1027–63, Fall 1994.

[50] Yean-Ju Lee, William L. Parish, and Robert J. Willis. Sons, daughters, and intergenerational support in taiwan. *American Journal of Sociology*, 99(4):1010–1041, January 1994.

[51] J.S. Lockard and R.M. Adams. Human serial polygyny: Demographic reproductive marital and divorce data. *Ethology and Sociobiology*, 2(4):177–186, 1981.

[52] Robert Lucas and Oded Stark. Motivations to remit: Evidence from botswana. *Journal of Political Economy*, 93(5):901–918, October 1985.

[53] Shelly Lundberg and Robert Pollak. Separate spheres bargaining and the marriage market. *Journal of Political Economy*, 101(6):998–1011, December 1993.

[54] Marilyn Manser and Murray Brown. Marriage and household decision theory–a bargaining analysis. *International Economic Review*, 21(1):21–34, February 1980.

[55] Marjorie McElroy and Mary Horney. Nash-bargained decisions: Toward a generalization of demand theory. *International Economic Review*, 22(2):333–349, June 1981.

[56] Eva Mueller. The economic value of children in peasant agriculture. In Ronald G. Ridker, editor, *Population and Development*, chapter 4, pages 98–153. Johns Hopkins University Press, Baltimore, 1976.

[57] John Nash. The bargaining problem. *Econometrica*, 18(1):155–162, January 1950.

[58] Randolph Nesse and George Williams. *Why We Get Sick*. Random House, New York, 1994.

[59] Goran Ohlin. Population pressure and alternative investments. In *World Population Proceedings*, volume 3, pages 1703–98. International Union for the Scientific Study of Population, London, 1969.

[60] G.H. Orians. On the evolution of mating systems in birds and mammals. *American Naturalist*, 103(934):589–603, November-December 1969.

[61] Prince Peter. *A Study of Polyandry*. Mouton, The Hague, 1963.

[62] Robert Pollak. Interdependent preferences. *American Economic Review*, 66(3):309–320, June 1976.

[63] Robert Pollak and Susan Watkins. Cultural and economic approaches to fertility. *Population and Development Review*, 19(3):467–496, September 1993.

[64] Alan Rogers. Does biology constrain culture? *American Anthropologist*, 90(4):819–831, December 1988.

[65] Alan Rogers. Evolutionary economics of human reproduction. *Ethology and Sociobiology*, 11(6):479–495, November 1990.

[66] Mark Rosenzweig and Oded Stark. *Handbook of Population and Family Economics*. North-Holland, Amsterdam, 1996.

[67] Alvin Roth and Marilda Sotomayor. *Two-Sided Matching*. Cambridge University Press, Cambridge, 1990.

[68] Ariel Rubinstein. Perfect equilibrium in a bargaining model. *Econometrica*, 50(1):97–109, January 1982.

[69] Paul Samuelson. Social indifference curves. *Quarterly Journal of Economics*, 70(1):1–22, February 1956.

[70] David Schneider and Kathleen Gough. *Matrilineal Kinship*. University of California Press, Berkeley, 1961.

[71] Adam Smith. *The Theory of Moral Sentiments*. A. Millar, London, 1759.

[72] Eric Alden Smith. *Inujjuamiut Foraging Strategies*. Aldine de Gruyter, Hawthorne, N. Y., 1991.

[73] Lawrence Stone. *The Family, Sex, and Marriage in England, 1500-1800*. Harper and Row, New York, 1977.

[74] Lawrence Stone. *The Road to Divorce*. Oxford University Press, Oxford, 1990.

[75] Robert Trivers. *Social Evolution*. Benjamin/Cummings, Menlo Park, California, 1985.

[76] Paul Turke. Helpers at the nest: Childcare networks on ifaluk. In Laura Betzig, Monique Borgerhoff-Mulder, and Paul Turke, editors, *Human Reproductive Behavior: A Darwinian Perspective*, pages 173–88. Cambridge University Press, Cambridge, 1988.

[77] Paul Turke. Evolution and the demand for children. *Population and Development Review*, 15(1):61–90, March 1989.

[78] Yoram Weiss. The formation and dissolution of families: Why marry? who marries whom and what happens on marriage and divorce? Technical report, Economic Research Center NORC, 1155 E. 60th Street, Chicago IL 60637, August 1993.

[79] Yoram Weiss and Robert Willis. Children as collective goods in divorce settlements. *Journal of Labor Economics*, 3(3):268–292, July 1985.

[80] Yoram Weiss and Robert Willis. Transfers among divorced couples: Evidence and interpretation. *Journal of Labor Economics*, 11(4):629–679, October 1993.

[81] Robert Willis. A new approach to the economic theory of fertility behavior. *Journal of Political Economy*, 81(2):S14–S64, March/April 1973.

[82] Robert Willis. A theory of out-of-wedlock childbearing. Technical report, University of Chicago, Chicago, Illinois, 1994.

[83] William Julius Wilson. *The Truly Disadvantaged*. University of Chicago Press, Chicago, 1987.