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Lee Cronk
Napoleon Chagnon
William Irons



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The Evolutionary Economics and Psychology of the Demographic Transition to Low Fertility

HILLARD S. KAPLAN and JANE B. LANCASTER

There is mounting evidence that people in modern state societies in the developed world do not maximize fitness through their fertility decisions (e.g., Irons 1995; Kaplan, Lancaster, Bock, and Johnson 1995; Vining 1986). Observed fertility behavior deviates from the predictions of fitness maximization in two ways. First, and most important, observed fertility is lower than would be predicted based on models of fitness maximization. For example, we showed that among men in Albuquerque, New Mexico, number of third-generation descendants (i.e., grandchildren) is highest among those who produced the most (i.e., >12) children, yet the observed modal fertility is 2 (Kaplan et al. 1995). Higher parental fertility in modern developed societies is associated with lower achieved educational and economic status of offspring (see Blake 1989 and Downey 1995 for reviews), but the lower earning capacity of children from large families does not decrease their fertility and so there is no apparent fitness reduction associated with lowered parental investment per child.

The second way in which modern behavior deviates from the predictions of simple budget constraint models of quantity-quality tradeoffs is that higher-earning adults produce no more children than their lesser-earning counterparts, even in well-controlled studies. Whereas available data on preindustrial societies consistently exhibit a positive relationship between resources or power and reproductive success (Barkow 1989; Betzig 1986; Boone 1986; Borgerhoff Mulder 1987; Cronk 1991a; Flinn 1986; Hughes 1986; Irons 1995; Kaplan and Hill 1985; Low 1990; Mealey 1985; Turke and Betzig 1985; Voland 1990), studies of post-demographic transition societies either find no relationship (Kaplan, et al., 1995) or a negative one (Lam 1986; Pérusse 1993; Retherford 1993; but see Simons 1974 for data suggesting a positive correlation among wealth and fertility within socioeconomic groups).¹

An adequate theory of the reduction in fertility in modern states (referred to as "the demographic transition") must accomplish two things. First, it must specify what changes led to a reduction of fertility and the observed relationship between

wealth and fitness. Second, it must account for why those changes produce the observed responses within a larger theory of the determinants of fertility in general. From an evolutionary perspective, it is necessary to specify the differences between pre- and post-demographic transition societies and to show the suite of proximate mechanisms that evolved to regulate fertility and parental investment in the past might produce the fertility and parental investment behavior observed in modern, postindustrial societies.

This paper presents the results of an in-depth study of fertility and parental investment among a representative sample of men from Albuquerque, New Mexico. Our goal is to develop and test a general theory of human fertility and parental investment, with a specific focus on explaining recent historical trends in family behavior within developed nations. We present a theoretical framework that unifies life history theory, developed in biology, with human capital and household allocation theories, developed in economics. We then offer a specific theory of modern fertility reduction based upon the emergence of skills-based competitive labor markets. This theory generates a set of empirical predictions that are tested with data derived from the sample of Albuquerque men. The empirical analysis focuses on age at first reproduction, completed fertility, the formation and dissolution of marital and quasi-marital relationships, investment in children, and child outcomes. The analysis examines both historical trends and variation among men within cohorts and time periods.

LIFE HISTORY THEORY AND THE ECONOMICS OF THE FAMILY

Biological and economic theories of life histories and fertility decisions developed independently, yet they share some formal properties and substantive conclusions. They both assume that individuals act to optimize the allocation of limited resources through the life course so as to maximize some currency. Biological models assume that *fitness*, defined in terms of quantity of descendants or the instantaneous growth rate of genes, is the ultimate currency that individuals are designed to maximize. Economic models assume that *utility* or satisfaction is the ultimate currency.

With respect to fertility decisions, both biological and economic approaches treat the problem in terms of a tradeoff between quantity and quality of offspring. This tradeoff is presumed to result from the facts that parents have limited resources to invest in offspring and that each additional offspring necessarily reduces average investment per offspring. Most biological models operationalize this tradeoff as number versus survival of offspring (e.g., Lack 1954, 1968; Lloyd 1987; McGinley and Charnov 1988; Rogers and Blurton Jones 1992; Smith and Fretwell 1974). Natural selection is expected to shape investment per offspring and offspring number so as to maximize the number of surviving offspring.²

In economic models (e.g., Becker 1991; Becker and Lewis 1973; Becker and Tomes 1986; de Tray 1973; Willis 1973), parents are thought to derive satisfaction from both child quality and child quantity, and to chose the combination of offspring number and offspring quality that maximizes the satisfaction derived from children and other forms of consumption.³ In economic models quality is implicitly considered to be an index of the human capital embodied in children. *Human capital* may be defined as a stock of attributes embodied in an individual, such as skills and education, that affect the value of time allocated to labor, and hence affect both earnings and the utility of time spent outside the labor market.

These two approaches can be usefully unified to build on the strengths of each. A major strength of biological models is the causal closure provided by the theory of natural selection and the use of fitness as the currency to be maximized. The theory of evolution by natural selection specifies the causal processes by which the characteristics of organisms change and a justification for why organisms should be designed to maximize fitness. In contrast, the economic assumption that people maximize utility is not derived from a known causal process, but rather is maintained as a working heuristic because it seems to characterize human behavior. Thus, economic models are less specific about the nature of interpersonal utility functions. However, the theory of human capital in economics is much more developed than the corresponding theory of investment in somatic effort in biology.

Figure 14.1 unifies biological and economic approaches with life history decisions by extending the economic concept of human capital to organisms in general (with the term *embodied capital*) and by utilizing biological fitness as the ultimate currency. Ontogeny (the process of development) can be seen as a process in which individuals and their parents invest in a stock of embodied capital. In a physical sense, embodied capital is organized somatic tissue. In a functional sense, embodied capital includes strength, immune competence, coordination, skill, and knowledge, all of which affect the profitability of allocating time and other resources to alternative activities such as resource acquisition, defense from predators and parasites, mating competition, parenting, and social dominance. Since the stock of embodied capital tends to depreciate with time because of physical entropic forces and direct assaults by parasites, predators, and conspecifics, allocations to maintenance such as feeding, cell repair, and vigilance can also be seen as investments in embodied capital. Individuals may invest not only in capital embodied in their own soma, but in the capital embodied in offspring, other relatives, and other individuals with whom they interact.

Figure 14.1 begins with *lifetime income*. Income is defined here in the general sense of the total value of time allocated to alternative activities, such as resource acquisition, childcare, rest, etc. At each age, an individual's income will be a function of her embodied capital. Income can be invested directly in reproductive effort, or in embodied capital. Embodied capital, in turn, can be divided into stocks affecting the ability to acquire the resources for reproduction and stocks affecting the probability of survival.

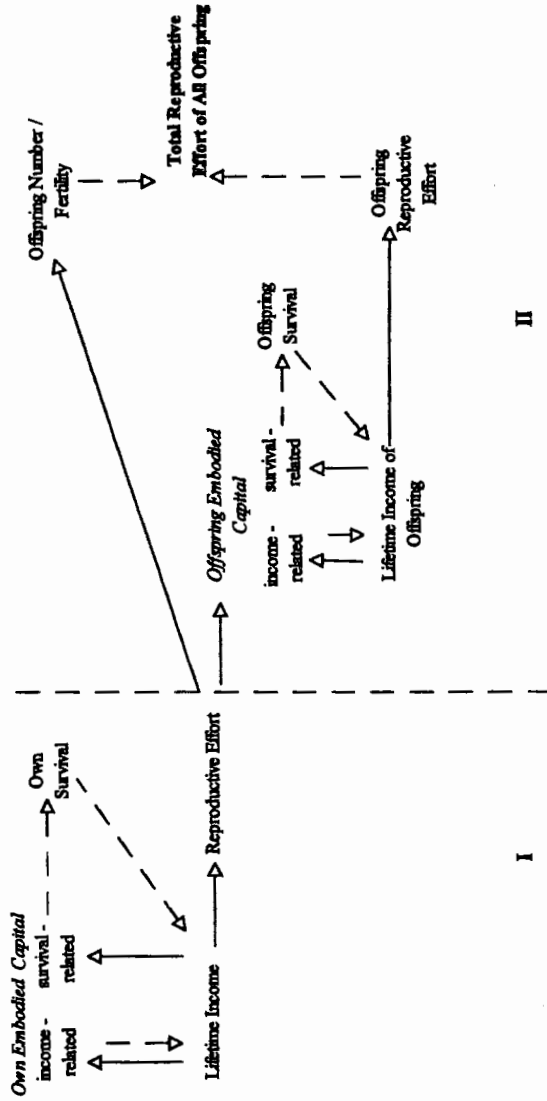


Figure 14.1. Decision model for life history of investments.

The solid arrows depict investment options. The dotted arrows depict the impacts of investments. Investments in income-related capital, such as growth, physical coordination, skills, and knowledge, affect lifetime income through the value or productivity of time in the future. Investments in survival-related capital, such as immune function, predator defense, and tissue repair, affect lifetime income through increasing the expected lifespan of earnings. From an evolutionary point of view, however, income must ultimately be invested in reproduction, since an organism that does not reproduce leaves no descendants. Thus, the first problem acted upon by natural selection is to maximize lifetime allocations to reproduction by optimally allocating income among investments in future income, survival, and reproduction at each age.

The second part of the figure shows the relationships between investments and outcomes for two generations. Here, both the parent and the offspring can invest in the offspring's survival- and income-related capital. For parents, the optimal allocation between fertility and investments in embodied capital of offspring should maximize the total lifetime allocations by offspring to their own reproduction (summed over all offspring). This requires consideration not only of the effects of parental investment on offspring survival, but also on the adult income of offspring as well. If individuals in each generation allocate investments in their own and their offspring's embodied capital optimally, then the "dynastic" or multigenerational fitness of the lineage is maximized.

In this model life histories vary because relationships between investments and outcomes vary ecologically. There is ecological variability in the benefits from investing in income-related capital. The relationships between body size and productivity depend on feeding niche. The value of knowledge, skill, and information-processing ability depends on the type of foods exploited, and more generally on the economy. This is illustrated in Figure 14.2. In panel 2A, two relationships between time invested in development and adult food production are illustrated, representing two different ecologies. In one ecology there is a relatively low payoff to investment in development, and in the other, the payoff is higher. In both ecologies there are increasing returns to investment at low levels of investment (i.e., the slope of the line increases). However, at some point the rate of return begins to diminish with additional time invested in development (i.e., the slope of the line decreases). The principal difference between the two ecologies is that *diminishing returns on investment* occur at a higher level of investment in the high-payoff environment. This difference could be due to the importance of skill or strength in resource production, since skill acquisition and growth require time. In general, the optimum will occur when returns on investment diminish because extra time in development begins to yield a smaller increase in adult income. Thus, the optimum amount of time (T^*) to invest in development is lower for the low-skill environment than for the high-skill environment.

Panel 2B illustrates ecological variability in investment in mortality reduction. Depending on local ecology each major class of mortality (predation, disease,

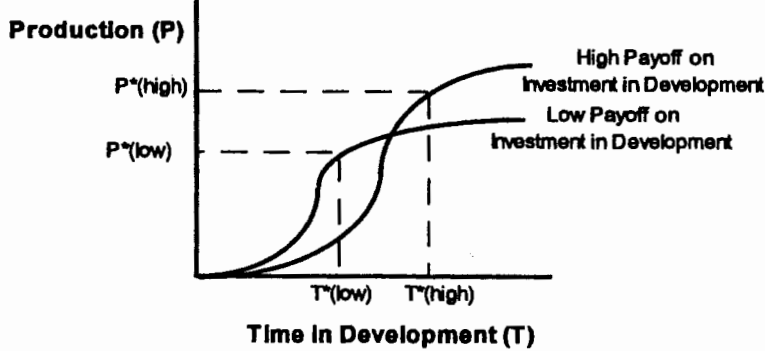
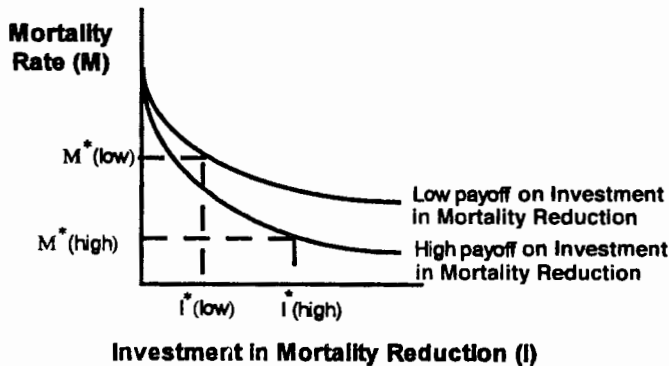
Panel A**Panel B**

Figure 14.2. Ecological variability in payoffs on investments in development and mortality reduction.

intraspecific violence, accidents, starvation) will exhibit a different relationship between the probability of dying and preventative investments made by the organism. Again, two ecologically variant relationships between investments and mortality are depicted. Returns on investments in lowering mortality diminish earlier in the low-payoff than in the high-payoff environment. For example, Austad and Fischer (1991, 1992, 1993) show that the value of tissue repair in order to slow down the rate of aging depends on the ability to escape predation. Primates and bats, which can leave the ground, suffer lower rates of predation than terrestrial mammals of similar body size. They also age more slowly and therefore live longer. Similarly, mammals living on islands with few predators age more slowly than their conspecifics living in continental environments. Thus, diminishing returns to investment in survival occur at higher levels of investment in low-predation environments.

FERTILITY AND PARENTAL INVESTMENT IN TRADITIONAL HUMAN SOCIETIES: AN ECOLOGICAL MODEL

One of the hallmarks of humanity has been the colonization of most of the world's terrestrial and coastal habitats. The life history theory developed above suggests that natural selection would favor sensitivity to environmental variability in returns on investment and the evolution of proximate mechanisms that detect diminishing returns on investment in survival and future income. One of the most important problems in understanding contemporary demographic processes is that the proximate physiological and psychological mechanisms underlying fertility, parental investment, and family formation evolved primarily in the context of a hunting and gathering lifestyle. All but the most recent 10,000 years of evolution in the hominid line occurred among foraging populations. Since most people now live in environments radically different from our ancestral environment, we require an understanding of how our evolved physiology and psychology responds to modern environments. Our goal for this section is to analyze the demands of the hunting and gathering lifeway as they vary across ecologies and to specify the kinds of proximate mechanisms that are likely to have evolved in the past in order to understand how people will react to modern environments.

Compared with those of other primates and mammals, human life histories have three distinctive characteristics: (1) an exceptionally long lifespan with older nonreproductive individuals supporting their offspring's reproduction, (2) an extended period of juvenile nutritional dependence coupled with the provisioning of young of different ages, and (3) marriage and the involvement of men in the care and provisioning of children (Kaplan 1997; Lancaster and Lancaster 1987). Since all hunting and gathering groups for which we have substantial information exhibit these three characteristics, it is likely that some fundamental features of the traditional human lifeway account for their evolution. Kaplan (1996, 1997) has proposed that those three features of the human life course are interrelated outcomes of a feeding strategy emphasizing nutrient-dense, difficult-to-acquire foods. The logic underlying this proposal is that effective adult foraging requires an extended training period during which production at young ages is sacrificed for increased productivity later in life. The returns on investment in training depend on adult survival rates, favoring increased investment in mortality reduction. An extended postreproductive, yet still productive, period supports both earlier onset of reproduction by next-generation individuals and the ability to provision multiple dependent young at different stages of development (see Kaplan, Hill, Lancaster, and Hurtado, in press, for empirical tests of this theory). This life history pattern implies the existence of two critical phases of human parental investment. The first phase is infancy, in which children are fed through lactation and require intensive care. The second phase is childhood and adolescence, in which children require less direct supervision and are provisioned with

solid foods (see Kaplan 1994 and Kaplan et al. 2000 for data showing that this second period can extend into the late teen years in traditional hunting and gathering groups and forager-horticulturalists).

Since humans generally nurse only one infant at a time, the intensity and length of infant investment is a critical decision variable determining fertility. With respect to infant survival, there are two critical forms of parental investment: breast milk and direct care. It is useful to think of infancy in terms of a gradual transition from complete dependence on breast milk to complete dependence on other foods. The provision of breast milk increases during the first few months of life as the baby grows, and then supplemental foods are introduced at about four to six months of age, constituting an increasing proportion of food in the child's diet as its caloric needs increasingly exceed the energy its mother can provide with breast milk (Oftedal 1984; Vitzthum 1994; Whitehead and Paul 1981). Ecological factors affect the relationship between the rate of these transitions and offspring survival (Lee et al. 1991). The digestibility of available foods is one such factor. The level of maturation of the child's digestive system along with the kinds of foods available will determine the optimal age for introducing new foods and the optimal proportion of milk to other foods in the child's diet at each age (Sheard and Walker 1988). Disease organisms are another factor. The density and intensity of diseases that infect individuals through ingestion should be related to length of the breast-feeding period for two reasons. First, breast milk increases the child's immunocompetence (Hanson 1982; Howie et al. 1990). Second, babies that are sickly require the high-quality nutrition provided by breast milk (Sheard and Walker 1988). On the other hand, the relative importance of diseases that are unaffected by diet should be positively correlated with the speed of weaning, since breast milk will account for less of the variance in survival (Borgerhoff Mulder 1992; Harpending et al. 1990; Pennington and Harpending 1988).

In addition, because infancy and early childhood are also the periods during which offspring require the most direct care, maternal food production, and hence her budget for reproduction, should be affected by ecological factors affecting the relationship between direct care and survival. The availability of safe spaces for children, which should be negatively associated with mobility, and the dangers in the environment should both affect the age-specific benefits of direct maternal care. For example, Kaplan and Dove (unpublished data) found that Ache mothers spend much more time in tactile contact with infants and young children when on mobile foraging trips (about 90% of all observations of children under 4 years of age) than at the settlement where safe spaces are cleared for children, even after time spent walking and carrying children is excluded from the analysis.

Parental investment during childhood and adolescence depends on the age-specific productivity of children, which in turn is also likely to depend on ecological factors. The dangers associated with acquisition of different food types should affect whether and how much children forage. This issue has received extensive treatment in a series of papers contrasting the foraging behavior of !Kung and Hadza children (see for example Blurton Jones, Hawkes, and O'Connell, in press;

Hawkes, O'Connell, and Blurton Jones 1997, and references cited therein). The costs and benefits of children's food production differ for !Kung and Hadza foragers. In the !Kung environment, foraging is dangerous for children because it is easy to get lost and food resources are far from water holes where camps are located. In the Hadza environment, topographic relief makes it harder to get lost and fruits are often abundant near camps. This favors greater protection of children and more provisioning by parents among the !Kung than among the Hadza.

In addition, as discussed above, the suite of resources available and the impacts of skill and strength on foraging return rates should determine both children's time allocation to productive labor and the total amount they produce (cf. Bock 1995; Draper and Harpending 1987; Hawkes et al. 1995). Children also face a potential tradeoff between early productivity and later adult production. This tradeoff is clearly evident in the development of hunting skills. Although boys spend a great deal of time hunting during the teen years in many hunting and gathering societies (see Blurton Jones et al. 1999 and Kaplan 1997 for data and discussions), they have very low hunting success until their mid-twenties. Thus, parents face decisions about how long and how much to provision children and adolescents on the basis of features of the environment that affect the productivity of unskilled and smaller individuals, the dangers associated with food production, and the impacts of nonproductive practice/learning on later adult productivity. It is the shape of the relationship between investments and outcomes that determines the optimal amount to invest. When returns on an extra unit of investment in offspring income or survival produce a smaller fitness improvement than a comparable investment in fertility, it no longer pays to invest more in the offspring, even if the investment is beneficial. A slightly longer nursing period, a slightly lower work requirement for children, and slightly more food given to children than are actually observed probably would increase their survival or adult income. However, natural selection appears to have favored people who possess psychological mechanisms that detect diminishing returns and to adjust investment accordingly (Borgerhoff Mulder 1992; Harpending et al. 1990; Pennington and Harpending 1988).

The length and intensity of parental investment during these two phases affect the number of children that people can afford to raise. Thus, there must be some mechanisms by which these parental investment decisions translate into number of children born. This translation process appears to be performed by physiological mechanisms in women. Although the exact details of the process still remain to be identified, it is clear that breast-feeding affects female fecundity by decreasing the likelihood of ovulation, and perhaps implantation (Ellison 1990; Ellison et al. 1993; Jones and Palloni 1994; McNeilly et al. 1985). The impacts of provisioning on fertility also appear to be mediated through the effects of women's net energy balance (energy consumed less energy expended) on the likelihood of ovulation and implantation (Ellison et al. 1993; Huffman et al. 1987; Hurtado and Hill 1990; Prentice and Whitehead 1987). Women's net energy balance should decrease as more food is given to children and as women work more to produce the food consumed by a family. These two main constraints on reproduction, the length of the

infancy period and the net energy balance among women, may vary in their importance in different ecological contexts. When food is abundant, the main constraint on fertility may be the health impacts of weaning. This would likely correspond to periods of maximum population growth rates (cf. Hill and Hurtado 1996: chap. 14). When population density is high relative to the productivity of the environment, the net energy flow to women may be most important.

To summarize, the proposal here is that selection acts on the coordinated outcome of mechanisms that regulate both parental investment and fertility. Investment may be regulated by psychological mechanisms that direct attention to fundamental relationships between investments and outcomes and that detect diminishing returns to investment. Actual decisions will be the product of those mechanisms and some reliance on cultural norms that benefit from accumulated experience. The regulation of fertility may be controlled primarily by physiological mechanisms responsive to breast-feeding regimes and net energy balance. This is not to say that people in traditional societies do not think about fertility. The inability to produce a child is one of the most common reasons given for divorce by people in traditional societies (Rosenblatt et al. 1973). Short birth spacing is also recognized as a problem. For example, the Ache have a term for too short of a birth space, and this can sometimes lead to infanticide.

The critical constraints on fertility and parental investment appear to be the time needed to give intensive care to infants and very young children, and the energy to feed parents and multiple children of varying ages. The physiological mechanisms tracking breast-feeding and energy balance have evolved to respond to those constraints. In environments where the critical constraints on fertility and parental investment include extrasomatic resources, such as land, cattle, or money, it is unclear whether we should expect adaptive responses, given this suite of evolved proximate mechanisms. Since parental investment in modern societies does entail many kinds of goods and services other than food and direct care, there is reason to suspect that nonadaptive responses are likely.

PARENTAL INVESTMENT AND LOW FERTILITY IN INDUSTRIAL SOCIETIES: THE COMPETITIVE-LABOR-MARKET MODEL

The next step in the analysis is to determine which aspects of modernization, in interaction with those evolved psychological and physiological mechanisms, led people to lower their fertility. In brief, our theory is that *skills-based competitive labor markets* increased the payoffs to parental investment. When wages are earned in skills-based labor markets in conjunction with lower child and adult mortality rates, parents do not detect diminishing returns on investment in children until they reach very high levels. This leads to a desired investment per child that

does not permit more than two or three children. There is a conflict between the fertility schedule that our physiological response system would produce and consciously desired fertility. This has stimulated the demand for effective birth control technology.

In order to understand the payoffs on parental investment in modern societies, it is necessary to understand the processes by which wages are determined (see Willis 1987 for a review). Given modern technologies of production, profit-maximizing firms will combine labor and capital in an optimal mix to minimize the costs of producing the goods and services they sell. The value of labor in the production of goods, however, depends on the skills and knowledge embodied in workers. In general, workers with greater education and skills are more valuable (i.e., add more to production for every hour on the job) than less skilled, less educated workers. At the same time, acquiring skills and education is a costly process, because it takes time (e.g., for every year spent in full-time schooling, there is a year of lost earnings) and often requires resource investments (e.g., in the form of tuition). Therefore, there would be little incentive to acquire skills unless skilled workers were paid more than unskilled workers.

From the perspective of the firm, it must decide how many workers of each level of skill to hire. Diminishing returns are important here as well. For example, imagine a firm that already has ten managers whose education allows them to increase production through efficient planning. Adding the eleventh manager might not increase production as much as adding the tenth manager did. If managers are paid twice as much as assembly line workers, at some point adding two assembly line workers will increase production more than adding another manager. Thus, firms are expected to *demand* an optimal mix of workers of different levels of skill. The amount of each type they demand will depend on the type of good or service they produce, on the technologies of production (because they affect the values of workers with different levels of skill), and on the wages that must be paid to workers of different skill levels.

From the perspective of a worker who will *supply* labor to some firm, he or she must decide how much to invest in skill and education. This will depend on both the cost of skill attainment and the increase in wages earned from an extra unit of skill. Becker's (1975) seminal analysis showed that at the optimum, an individual will invest in human capital until the point where an extra unit of investment increases lifetime wages (in real buying power after taking the interest rate into account) by less than the cost of that investment (measured both in terms of lost wages during the training period and direct costs of schooling).

The final result is that wages and the number of workers hired at every level of skill are determined by the interaction of demand for workers of different levels of human capital by all the firms in the economy and the supply of human capital by individuals who are attempting to maximize net lifetime earnings. The resulting equilibrium occurs when supply is equal to demand; at equilibrium, the differences between wages paid for jobs requiring different levels of embodied capital

are equal to the costs of obtaining the capital, measured in terms of real lifetime income.⁴

As in the case of traditional human societies, much of this investment in embodied capital is financed by parents. The number of children that parents can afford to raise will be determined by the amount they invest in each child and by their own income (measured in terms of both time investments and resources). Thus, in principle, parents face a choice between producing fewer higher-earning offspring and more lower-earning offspring. If all parents were equal, the theory of human capital investment would predict that they would be indifferent to alternative combinations of child quantity and quality. Those who produced more children would have fewer grandchildren per child (because of their children's lower earnings) and those who produced fewer children would have more grandchildren per child, with the net result being equal numbers of grandchildren, on average. As mentioned in the introduction, this is not the case empirically. Most people have few children, and there is either no or a negative relationship between parental income and fertility. One possible explanation of this finding is that higher-earning parents invest more in children than lesser-earning parents, producing higher-earning children in turn. Higher-earning parents will themselves tend to have higher levels of embodied capital. If parents with more embodied capital can produce embodied capital in their children more efficiently (i.e., at less cost), then they may reach diminishing returns on investments at a higher level of investment than lower-earning parents with less embodied capital (see Becker et al. 1990 for a similar suggestion).

First, consider inputs of parents' time. There is significant evidence that the nature of parent-child interaction varies with the educational level of parents (Hart and Risley 1995; Hoff-Ginsberg and Tardif 1995). For example, Hart and Risley (1995) report that by the age of three, children hear six million words if their mothers are professionals, three million words if their mothers are "working class," and only one million words if their mothers are on welfare. By the time children enter the public education system there are clear differences among them in school-related skills, and those differences are related to socioeconomic status. This is illustrated in Figure 14.3A. The dotted curve depicts the relationship between parental time inputs and the child's embodied capital at school entry for lower-earning parents with less embodied capital; the solid curve represents the same function for higher-earning parents. Returns diminish more rapidly for the former than for the latter. Therefore, parents with more embodied capital may actually spend more time with children if the impact of their time is greater at each level than that of the time of parents with less capital [$T^*(H)$ vs. $T^*(L)$].

Second, the rate at which a child learns may depend on the knowledge and skills she already possesses. Much of the education offered in schools is based upon the premise that knowledge is cumulative (Cromer 1993). Basic skills are acquired first, and those skills are used as a foundation for the acquisition of the next set of skills. This would imply that the impact of the child's time inputs would depend upon skills already in place. The impacts of inputs, such as child's time,

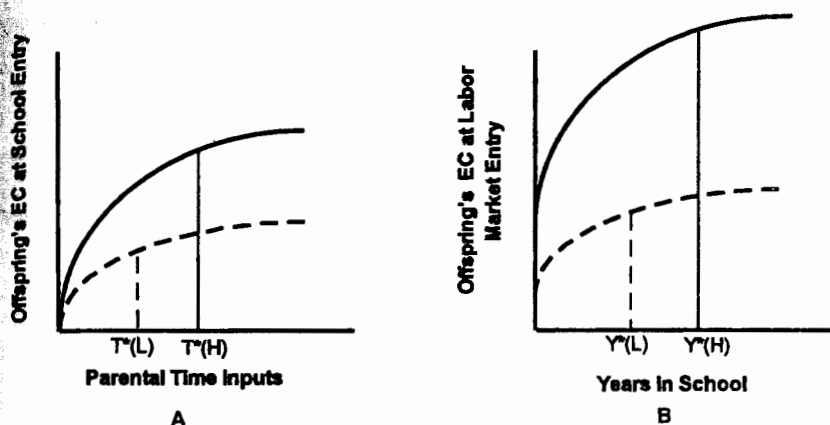


Figure 14.3. Impacts of investment in children's embodied capital as a function of parental embodied capital.

parents' time, others' time (e.g., teachers), and resources, will be greater as the recipient's (i.e., the child's) stock of embodied capital increases. This is important because it means that at each age, optimum investment in the child will be a positive function of the skills the child already possesses, and that variance in investment will increase with age. Thus, skilled parents should invest more, and parents should also invest more in children who are receiving inputs from higher-quality schools. This is illustrated in Figure 14.3B. With each additional year spent in school, the embodied capital of children from different backgrounds becomes progressively greater. Again, this may mean that optimal years of schooling (i.e., to the point at which an extra year of schooling lowers lifetime income) for children whose parents have less embodied capital will be lower than those whose parents have more [$Y^*(L)$ vs. $Y^*(H)$].

If this is true, it has important implications for the supply of and demand for embodied capital in the labor force. Now, the optimal level of investment in children may vary with income. Given the empirical finding that parental income is unrelated to fertility, this would suggest that optimal investments in children increase linearly with income.

This within-population heterogeneity in the costs of embodying capital in children means that diminishing returns on parental investment are not determined by the environment as they would be in primary production economies, but are frequency dependent. First, consider the jobs requiring the highest skill levels. Those jobs would be filled by individuals with the lowest costs of skill acquisition in decreasing rank order until the point is reached when the next cheapest worker is more expensive than the product she produces. Since firms would not be willing to pay more than she produces, the wage would not justify the extra investment in

education. Her parents would therefore invest less in her than would be necessary to obtain the highest-level jobs, and she would find employment in the next tier of skill. That tier would then be occupied by individuals in decreasing rank order until the next cheapest worker will not be paid enough to compensate for skill embodiment. This process would continue through the lowest-level jobs in the economy.

Next, consider the related proposition that technological change in production will be positively related to the stock of embodied capital at the population level (Becker et al. 1990). If higher levels of general education of the population are associated with more rapid technical progress, the demand for more skilled workers will increase as more investment is made in education. Through time, then, the demand for new levels of skill will grow. For the simple model, this would imply that skilled parents not only would have the option of producing children of equal or less skill, but will have the opportunity to reinvest the dividend from their own educational investments in even higher levels of skill for their children. As long as technology is constantly growing and generating demand for new levels of skill, sustained fertility reduction over many generations is possible.

Although the continual intergenerational reinvestment of dividends from investments in embodied capital seems hard to sustain indefinitely, it does seem consistent with the past century of technological growth and increasing investment in education (see, for example, Denison 1985; Lesthaeghe and Wilson 1986; Lindert 1986). In fact, there may be some "excess" return from education, especially at high levels, if there is a significant lag between increases in demand for skilled labor and corresponding increases in supply. Since the embodiment of skills takes time, some lags between demand and supply are likely. This would lead to higher rates of return on investments than would be expected at equilibrium. Such "excess" returns could drive fertility to a minimum level.

So far, we have considered only fertility *reduction* and not the quantitative level of fertility. We have also neglected the integer constraints on fertility and have treated fertility as if it were continuous (but it is not possible to have, for example, 2.3 children). However, minimum fertility greater than zero is one. If there were excess returns on investments in embodied capital, one might expect most people to have one child. Yet evidence suggests most people consider an only child to be undesirable and have a target fertility of two or three. There is also evidence that singleton children do not differ in education and achievement from children raised in two-child families (Blake 1989). Yet families with more than two children do show reductions in educational and income achievement (Blake 1989; Kaplan et al. 1995). This suggests decreases in family size below two children do not increase the total capital embodied by children.

This lack of effect may be due to several factors. Some of the costs of investment in embodied capital may be fixed (see Becker 1991 for an analytical treatment of fixed and variable costs). The choice of neighborhood to live in and the taxes paid for social services, including public education, are obvious examples of fixed costs.

Thus as fixed costs become an increasingly large proportion of total costs, the reduction from two to one child may have less of an impact on the resources parents have to invest in children. Also, men in focus-group discussions in Albuquerque expressed the opinion that interactions with siblings were an important contribution to development, and that mutual assistance among siblings was helpful in attaining life goals. Regardless of the reasons for this lack of impact, there seems little positive incentive to reduce fertility below two. Moreover, since number of children is not continuous, a reduction of fertility below two requires a 50% change in fertility. This fact, coupled with the risk associated with the possible loss of an only child, creates a large disincentive. *Therefore, the two child family may be the result of two competing effects: (1) technological growth, with an increasing premium paid for skills and education driving fertility to a minimum; and (2) high risk and lack of benefits associated with a reduction to one child.*

EMPIRICAL PREDICTIONS DERIVED FROM THE MODEL

To summarize, we propose that two characteristics of modern economies might be sufficient to account for a period of sustained fertility reduction and for a corresponding lack of variation in fertility across income levels. The first characteristic is the direct link between costs of investment and wage rates owing to the forces of supply and demand for labor in competitive economies. The second is the increasing emphasis on cumulative knowledge, skills, and technologies in the production of resources. These two characteristics may together produce the historically novel situation in which (1) investments in offspring income do not reach diminishing returns until very high levels, and (2) embodied capital of parents is positively associated with returns on investment in embodied capital of children, with diminishing returns at the individual level set by the frequency-dependent costs of skill embodiment across the population.

These propositions generate a series of predictions with respect to fertility, parental investment, and child outcomes. Patterns of fertility should reflect investments in embodied capital and efficiency in the production thereof. First, the observed relationship between income and fertility (i.e., no effect) should be the result of two opposing causal processes. Increased resources should be associated with higher fertility, but increased efficiency in the production of human capital should decrease fertility. However, since education and training affect both income and efficiency in the production of human capital in the same direction, the two opposing effects cancel each other out. Second, two kinds of fertility effects of embodied capital should be discernible. One effect is due to investments in one's own embodied capital. Men who invest more in their own training and education are expected to delay fertility. Another effect is due to increased investment in offspring embodied capital. When income is held constant, more-educated men are expected to stop reproducing at lower parities. Third, education has

become increasingly important in determining economic outcomes during the course of this century (Burck 1976; Herrnstein and Murray 1994:93; Newcomer 1955; Vinovskis 1994), so we should find a pattern of increasing importance of education in determining fertility.

A similar series of predictions can be generated with respect to parental investment. First, within economic strata, more-educated parents should invest more time and resources in each child as well as having lower fertility. This should be especially true of investments in the child's education. Second, parental education should be negatively related to the probability of ceasing to live with an offspring, since the negative effect of lowered parental investment will be greater for children of more educated parents. Third, more academically able children should receive higher levels of investment (especially, school-related investment) than less able children, even within families, because there are higher returns to investment in their human capital (see Becker and Tomes 1976 for a similar argument). Fourth, levels of investment at different stages of the child's development should be positively correlated with one another, contingent on the child's progress. The quantity and quality of early investments should positively affect early educational performance that should, in turn, positively affect later investments. The loss of parental investment from dissolution of the marital relationship should also have a negative impact on child outcomes.

METHODS

As discussed in Chapter 9, the research design for the Albuquerque Men sample consisted of two complementary interviews, a short interview administered to a large, representative sample and a longer interview administered to a subset of those men. Between July 1990 and July 1993, 7,107 short interviews and 1,325 long interviews were conducted.

The Interviews

The short interview was designed to obtain the following information on the respondent: place and year of birth, ethnicity, education, religion, income, current mate's income, years in Albuquerque, number of years lived with each biological parent, number of half and full siblings, the fertility and age of siblings, number and age of biological children, years lived with biological children, number of spouses and women with whom he had children, and the number of step and foster children he parented. Information on the respondent's parents' place and year of birth, education, ethnicity, income, and standard of living were also collected. The long interview collected the following information:

1. Basic demographic information about the respondent's father, his paternal grandfather, his mother, and if his biological parents did not raise him, his primary male and female caretakers.

2. The financial investments made in the respondent by the previous generation, including support for advanced training or education, starting a business, buying a first home, a wedding or establishing a nest egg, and living expenses after marriage.
3. The respondent's employment and income history.
4. Parental investment in each of the respondent's full and half siblings, including how the estates of his father and mother were divided, support given to the parental household by the respondent and his siblings, and the use of physical force on the sibship by parents or primary caretakers.
5. The man's sexual unions, marital relationships, and any relationship that produced a pregnancy, including basic demographic data on the woman, her income and employment history, his attitude about her working, her personality and physical characteristics, conflict over fertility and financial decisions, additional sexual partners of each and their impact on the relationship, causes of any breakups of relationships, techniques of conflict resolution, the use of physical force, information about the relationship after it broke up.
6. A history including outcomes of all pregnancies that the respondent believes or suspects, or someone claimed, he fathered.
7. The parenting of children, both genetic and nongenetic, including information on investment given to each child in elementary and high school; the child's qualities; the way in which he/she was parented; the child's behavioral characteristics; reproductive history; achievements after age 18 (with a special series of questions if the man did not live with the child until age 18 as to why they were separated and what investment the man made in the child); financial investments in all children after the age of 18; money spent on each child during the previous year; the use of physical force or punishment on any of the children parented; and support given by any of these children to the respondent's household.
8. Life course strategies, including data on reproductive or family composition preferences; reasons for not having more children; reasons for not reproducing at all; financial strategies; attitudes about women, relationships, and commitment; engagement in behaviors used by men to get women to have sex with them; total numbers of sexual partners during stages of the life course; and risk-taking behaviors that affect morbidity and mortality.

The Sample

The total short interview sample of 7,107 men comprised 2,789 Hispanics, 3,762 Anglos, and 556 others who were interviewed between July 1990 and July 1993.⁵ The long interview sample consisted of 401 Hispanics, 858 Anglos, and 66 others. In New Mexico, the term "Hispanic" is preferred over "Latino" because most people consider themselves native New Mexicans, tracing their family history

of residence in this area as far back as living memory extends. In our sample, very few Hispanics were of Mexican origin, and even fewer were from other Latin countries. "Anglo" (an ethnic classification peculiar to the Southwest) refers to non-Hispanic men who classify themselves as white.

Potential respondents for the short interview were solicited at the Bernalillo County Motor Vehicle Division (MVD) that served all of Albuquerque. All men who appeared to be over 18 years of age were considered eligible for initial screening and were approached as they received a driver's license photo. If they agreed to the short interview, which took about seven minutes to administer, it was immediately conducted in a private area. On the basis of the answers to the short interview questions, eligibility for inclusion in the long interview sample was determined. The criteria for eligibility were (1) being age 25 or over and (2) having come to the MVD for the purpose of license origination, renewal, or for a photo ID. The purposes of the study then were explained to eligible men in more detail and they were offered the opportunity to participate in the long interview, for which they received a \$30 payment. An appointment was then made to conduct the long interview in either a mobile office vehicle, an office at the University of New Mexico, or at their homes.

Sampling men who are renewing or obtaining driver's licenses and photo IDs at the MVD provides a highly representative sample of the male population in Albuquerque. It is the largest city in New Mexico with a population in 1990 of 480,577 (U.S. Department of Commerce 1992), approximately 32% of the state's population lives in greater Albuquerque. More than 95% of all New Mexican males over age 20 have a current driver's license (U.S. Department of Transportation 1993), compared with an estimated 93.5% telephone availability for the Albuquerque area (U.S. Department of Commerce 1992). In addition, individuals who do not drive use the MVD to obtain valid photo IDs. Drivers' licenses and IDs must each be renewed every four years. By sampling only men who are waiting for license and ID photos, men who visit the MVD more frequently (those who do not have checking accounts and cannot register vehicles by mail, those who frequently pay fines, those who frequently sell and purchase vehicles, etc.) are not over-represented in the sample. Groups who are likely to be absent or under-represented among the licensed drivers include the elderly, disabled, institutionalized, transient, extremely poor, and criminal. These groups are also likely to be under-represented or uncooperative in most other sampling frames as well.

Evaluation of Sample Bias

The methods employed in this study provided several avenues for evaluating potential biases in the composition of the sample. After the first 850 interviews were collected, we compared the demographic characteristics of the sample we obtained with data from other sources such as the census. We arrayed the age and ethnic distributions of our sample against those of licensed drivers and the census population data for males. There were no significant differences in any of these

comparisons. In fact, the ethnic breakdown of the sample obtained at the MVD is almost identical to that obtained from the 1990 Census (U.S. Department of Commerce 1991, 1992).

We also examined refusals. About 78% of all men approached agreed to the short interview. One factor that predicted refusals is whether the potential respondent was alone or accompanied at the MVD; accompanied men refused 28% of the time whereas men who were alone refused only 18% of the time. No other biases such as age or time of day were detected. Refusals decreased steadily through time because of improved interviewer training.

Following this phase of unbiased sampling, we increased the proportional representation of Hispanics and others by not interviewing Anglos on about 20% of sample days. In this way, we obtained a sample that was 53% Anglo, 39% Hispanics, and 8% other ethnicities.

Refusals to participate in the long interview have also been analyzed. Early indications suggested that Hispanics were more likely to refuse. We conducted an experiment to determine whether Hispanic short interviewers were more effective with Hispanic respondents in obtaining agreement to participate in the long interview. Our analysis showed that 64% of Hispanic respondents agreed to conduct the long interview when the interviewer was also Hispanic but only 27% agreed when the interviewer was Anglo. Hispanic and Anglo interviewers were almost equally successful with Anglo respondents, achieving 53% and 58% acceptance rates, respectively. On the basis of these results, we increased the percentage of Hispanic interviewers to 75%. With the exception of education, which was positively associated with probability of acceptance, men's income, number of children, and other background variables did not associate with probability of acceptance.

RESULTS

Fertility

Although the lifetime data show no net effects of income on completed fertility (Kaplan et al. 1995, 1998), the relationship between fertility and income is, in fact, complex and bidirectional. Education is a major pathway to higher income, and education clearly depresses fertility at young ages. Table 14.1 summarizes the results of a set of logistic regression analyses designed to determine the impacts of education and income on the probability of having a child during a year at risk, using data from the short interview sample. All years from age of 15 to age 49 are in the risk set. One regression analysis was conducted for each age class and ethnicity. Income at the time of the interview was controlled for in each analysis. Although it would have been preferable to control for income during each year at risk, only the long interview data allow for that analysis (presented below in Table 14.4). In these analyses, we also controlled for period (i.e., whether the year at risk

Table 14.1. Effect of each additional year of education and each additional thousand dollars of income on male fertility by age class and ethnicity

Age Class	N	Education Parameter	Education Odds Ratio	Partial p	Income Parameter	Income Odds Ratio	Partial p
<i>All</i>							
15-19	29,873	-0.19	0.83	0.0001	0.008	1.008	0.007
20-24	29,868	-0.12	0.89	0.0001	0.005	1.005	0.0001
25-29	29,812	-0.05	0.96	0.0001	0.006	1.006	0.0001
30-34	26,704	-0.00	1.00	0.5120	0.004	1.005	0.0001
35-39	21,627	0.03	1.03	0.0014	0.000	1.000	0.73
40-44	16,474	-0.01	0.99	0.6947	-0.003	0.997	0.16
45-49	12,028	0.03	1.03	0.2792	-0.006	0.994	0.13
<i>Anglo</i>							
15-19	17,378	-0.24	0.79	0.0001	0.005	1.005	0.30
20-24	17,373	-0.15	0.86	0.0001	0.005	1.005	0.002
25-29	17,347	-0.03	0.97	0.0003	0.007	1.007	0.0001
30-34	15,960	0.01	1.01	0.2228	0.005	1.005	0.0001
35-39	13,435	0.05	1.06	0.0001	0.00	1.00	0.81
40-44	10,602	0.03	1.03	0.1902	-0.001	0.999	0.63
45-49	8,028	0.08	1.08	0.0289	-0.002	0.998	0.70
<i>Hispanic</i>							
15-19	12,495	-0.17	0.85	0.0001	0.01	1.01	0.015
20-24	12,495	-0.10	0.90	0.0001	0.004	1.004	0.025
25-29	12,465	-0.06	0.94	0.0001	0.005	1.005	0.003
30-34	10,744	-0.02	0.98	0.0489	0.004	1.004	0.038
35-39	8,192	0.00	1.00	0.8054	0.003	1.003	0.27
40-44	5,872	-0.03	0.98	0.2155	-0.009	0.991	0.079
45-49	4,000	-0.00	1.00	0.9366	-0.023	0.977	0.023

occurred before, during, or after the baby boom), and for ethnicity, in the analyses dealing with "all" men.

The column labeled N is the sample size in risk years for the specific five-year age class. The education and income parameters are the maximum likelihood estimators of the impact of an additional year of education and an additional thousand dollars of income, respectively, on the log odds of a birth occurring. The odds ratio can be interpreted as approximating the relative risk resulting from a unit change in the independent variable when event probabilities are close to zero. Odds ratios of one indicate no effect on the probability of the event occurring (in this case, on the probability of having a child in a year at risk), because the relative risk is the same; odds ratios of less than one mean that an increase in the independent variable decreases the likelihood of the event occurring, and odds ratios greater than one reflect an increase in the likelihood. For example, in the first row of Table 14.1, the education odds ratio of .83 means that the relative risk of giving birth between ages 15 and 19 decreases by 17% for each additional year of education. However,

care must be used in interpreting odds-ratios. First, the odds ratio becomes increasingly different from relative risk as the probability of the event increases, and it is not a very good estimator of relative risks for probabilities above 0.1. Second, the odds ratio depends upon the units chosen for measurement. In Table 14.1, income is measured in thousand dollar units so that the odds ratio refers to the effect of a \$1,000 change in income, whereas education is measured in units of one year. The column labeled *partial p* refers to the probability that the education and income parameters are actually zero for the population as a whole (i.e., there is no effect), given the estimated value of the sample statistic and after controlling for the effects of the other independent variables. For example, in the first three age classes, there is less than a one in ten thousand chance that education is really not associated with the probability of giving birth, given the data in our sample.

The results show that for both Anglos and Hispanics education has a strong negative effect on reproduction during the late teens and even through the twenties. It gets gradually weaker with age and, in fact, is mildly positive among Anglos in the 35–39 and 45–49 age classes, suggesting differential scheduling of births. In these analyses, income at the time of the interview either has a small positive effect or no effect on fertility, after education is controlled. The effect of income is generally positive at the ages when the effect of education is negative, suggesting that finances are a constraint on early reproduction.

The impact of education on reproduction has increased through time. Table 14.2 presents the results of logistic models in which the log odds of a birth occurring in a year at risk prior to the age of 30 are regressed on education by decade of birth and ethnicity. For both Anglos and Hispanics, the negative effect of education increases dramatically for men born after 1940. Again, we find that, in general, the positive effect of income is greater for later cohorts among whom the negative effect of education is greater.⁶

There are also period-parity interactions in fertility. Table 14.3 shows the results of logistic models in which the probability of a birth is regressed on period by parity. The baseline period is all years of risk between 1946 and 1962. The pre-boom period (before 1946) and the post-boom period (after 1962) are then compared with the boom period. For both Anglos and Hispanics, the probability of *first* reproduction (i.e., at parity zero) is about half as high during the pre-boom period (see the odds ratio column). This reflects the much later ages at first reproduction during the depression and war years. For the post-boom period, Anglos delay reproduction relative to the boom period (odds ratio = .85), but Hispanics initiate reproduction sooner (odds ratio = 1.13). The progression from one child to two children also occurs more rapidly during the boom period for both Anglos and Hispanics, but the pre- and post-boom periods are not significantly different. The higher parity progressions show a very different trend. There is no significant difference between the boom and preceding periods in the progressions from two or more children to the next higher parity; however, after the baby boom, men are less than half as likely to progress from two or more children to the next higher parity.

Table 14.2. Effect of each additional year of education and each additional thousand dollars of income on fertility for men under 30, by decade of birth

Decade of Birth	N	Education Parameter	Education Odds Ratio	Partial p	Income Parameter	Income Odds Ratio	Partial p
<i>All</i>							
< 1920	8,085	-.05	0.96	0.0033	-.01	0.995	.04
1920-1929	7,410	-0.03	0.97	0.0244	0.00	1.00	0.40
1930-1939	11,910	<u>-0.05</u>	<u>0.95</u>	<u>0.0106</u>	0.003	1.004	0.01
1940-1949	24,675	-0.10	0.91	0.0001	0.006	1.006	0.0001
1950-1959	30,765	-0.12	0.89	0.0001	0.007	1.007	0.0001
1960+	6,705	-0.10	0.90	0.0001	0.005	1.005	0.17
<i>Anglos</i>							
< 1920	6,585	-0.05	0.95	0.0148	-0.002	0.998	0.50
1920-1929	5,100	-0.02	0.98	0.1828	0.004	0.977	0.18
1930-1939	7,350	<u>-0.05</u>	<u>0.95</u>	<u>0.0001</u>	0.001	1.001	0.44
1940-1949	14,400	-0.11	0.90	0.0001	0.006	1.006	0.0002
1950-1959	15,960	-0.14	0.87	0.0001	0.012	1.012	0.0001
1960+	2,700	-0.15	0.86	0.0005	0.009	1.009	0.16
<i>Hispanics</i>							
< 1920	1,500	-0.02	0.98	0.5796	-0.022	0.978	0.001
1920-1929	2,310	-0.03	0.97	0.1782	-0.006	0.994	0.18
1930-1939	4,560	<u>-0.05</u>	<u>0.95</u>	<u>0.0003</u>	0.010	1.010	0.0003
1940-1949	10,275	-0.09	0.91	0.0001	0.007	1.008	0.0007
1950-1959	14,805	-0.10	0.91	0.0001	0.002	1.002	0.28
1960+	4,005	-0.09	0.92	0.0001	0.003	1.003	0.53

Table 14.4 examines marital and cohabiting fertility with the smaller, but more detailed, long interview sample. It displays the results of a logistic model of the predictors of the probability of a first birth. With respect to ethnicity, it shows that Anglos are only 93% as likely to reproduce in a given year than are Hispanics. The period effects on marital/cohabiting fertility reveal the different causal processes at work in determining total fertility for the different periods. The pre-boom period is the baseline. The probability of a birth is about 62% higher during the boom period, and only half as high during the post-boom period relative to the pre-boom baseline. For Anglos, total fertility rates are almost the same for cohorts reproducing prior to the baby boom as for those reproducing after the baby boom (Kaplan et al. 1995), whereas marital fertility is much higher prior to the baby boom. This shows that the low completed fertility prior to the baby boom is due primarily to delay in marriage and higher overall rates of non-reproduction, whereas the low completed fertility after the baby boom is due to decreased marital fertility. To examine the parity effects, a parity of zero is used as the baseline. Since all years from age of 15 to age 49 define the risk set, the lowest probability of reproduction occurs before the first birth. After the first birth, men are almost

Table 14.3. Effect of period on male fertility, by previous parity*

Parity	Anglo			Hispanic			All								
	N	Period Parameter	Odds Ratio	N	Period Parameter	Odds Ratio	N	Period Parameter	Odds Ratio						
0	56,652	Pre	-0.73	0.48	0.0001	31,662	Pre	-0.95	0.39	0.0001	88,314	Pre	-0.80	0.45	0.0001
		Post	-0.16	0.85	0.0005	Post	0.12	1.14	.03	Post	-0.02	0.98	0.50		
1	13,565	Pre	-0.43	0.65	0.0001	9,476	Pre	-0.47	0.62	0.02	23,014	Pre	-0.50	0.61	0.0001
		Post	-.54	0.58	0.0001	Post	-0.47	0.63	0.0001	Post	-.45	0.64	0.0001		
2	15,995	Pre	-.10	0.90	0.57	10,809	Pre	0.01	1.01	0.97	26,804	Pre	-0.11	0.9	0.45
		Post	-0.78	0.46	0.0001	Post	-1.00	0.37	0.0001	Post	-0.71	0.49	0.0001		
3	8,277	Pre	-0.06	.94	0.85	7,248	Pre	0.56	1.75	0.08	15,525	Pre	0.20	1.22	0.39
		Post	-1.06	0.35	0.0001	Post	-1.23	0.29	0.0001	Post	-1.04	0.35	0.0001		
4 or More	5,634	Pre	0.04	1.04	0.96	7,068	Pre	-0.00	1.00	1.00	12,702	Pre	0.12	1.13	0.68
		Post	-.80	0.45	0.0001	Post	-1.15	0.32	0.0001	Post	-0.97	0.38	0.0001		

*The baby boom period, 1946-1962, are the reference years at risk (i.e. odds ratio=1.00). All parameter estimates, odds ratios, and p-values compare years at risk during the pre- and post-boom periods to the reference years. Separate analyses were conducted for each parity progression (parity 0 is for years at risk before the respondent began reproducing, parity 1 is for years at risk between the birth of the first child and the birth of the second child, etc.).

Table 14.4. Logistic regression model for the probability of birth for married and cohabiting couples (N = 10,210, $\chi^2 = 1661.1$, $p < 0.0001$)

Variable	df	Parameter		Standardized	Wald χ^2	Partial p	Odds Ratio
		Estimate	s.e.	Parameter Estimate			
Intercept	1	-4.65	0.81	—	33.24	0.0001	0.01
Anglo	1	-0.08	0.02	-0.07	12.70	0.0004	0.93
During Boom	1	0.49	0.17	0.10	7.68	0.0056	1.62
Post Boom	1	-0.59	0.17	-0.13	12.48	0.0004	0.55
Parity of 1	1	1.08	0.09	0.24	130.41	0.0001	2.94
Parity of 2	1	0.23	0.12	0.05	3.75	0.0528	1.25
Parity of 3	1	0.20	0.17	0.04	1.49	0.2224	1.22
Parity of 4	1	0.95	0.19	0.14	25.57	0.0001	2.59
1st year following a birth	1	-5.45	0.71	-0.87	58.64	0.0001	0.004
2nd year following a birth	1	-4.51	0.59	-0.63	59.97	0.0001	0.01
Her education (yrs)	1	-0.05	0.02	-0.08	11.44	0.0007	0.95
His education (yrs)	1	0.01	0.01	0.02	0.40	0.5277	1.01
No. of her kids from prev. relationships	1	-0.17	0.08	-0.08	4.94	0.0262	0.84
No. of his kids from prev. relationships	1	-0.07	0.08	-0.03	0.93	0.3343	0.93
Income (in thousands of 1990 dollars)	1	0.015	0.00	0.06	7.15	0.0075	1.015
Her age	1	0.43	0.06	1.87	54.25	0.0001	1.54
Her age (squared)	1	-0.01	0.00	-2.93	96.63	0.0001	0.99

(After Kaplan et al. 1998)

three times as likely to have a second child in a given year. The progressions to higher parities, while higher than the probability of first birth, are much lower than the progression probability from first to second birth. Birth spacing effects are evident as well. The baseline is no child under the age of two. Not surprisingly, if there is a child of one year or younger, the probability of the next birth is only .4% as likely. If the child is between one and two years of age, a birth is 1% as likely.

The data also show that the characteristics of a man's mate are highly determinate of fertility rates. The effects of a man's education on fertility appear to operate solely through his mate's education (the Pearson correlation between the two is .6). When both a man and his mate's education are in the regression model, the woman's education has a strong negative effect on fertility (the odds ratio is .95 for each additional year of education), but the man's education is not significant. In addition, if his mate has children from a previous marriage, they are also less

likely to reproduce (see below). If a man has children from a previous relationship, on the other hand, there is no significant decrease in the likelihood of having a child. Since the long interview sample contains data on income earned during each year of a man's life, we can also assess the impact of income on fertility. A man's income in a given year is positively associated with the probability of having a child. This reduces the negative effect of education on fertility.

These data on male fertility indicate that both the onset of reproduction and parity progressions have changed through the course of the century. Age at first reproduction is high for men born early in the century, decreases for men born in 1920–1939, and then increases for men born after 1940. The effect on fertility of investment in the man's own human capital, as measured by years of education, is greatest before the age of thirty. This reflects its greater impact on the onset of fertility than on parity progressions after the first child. However, the impact of investment in one's own human capital on the onset of fertility appears to have changed through time. For men born during the early part of the century, years of education have little effect on age at first reproduction. The delaying effect of education on fertility has increased through time.

One interpretation of these results is that the Great Depression of the 1930s and the World Wars delayed fertility for all men. During the postwar baby boom, low-cost loans for affordable housing and the GI bill allowed men to reproduce at earlier ages, even though investment in education was increasing. Following the baby boom, the onset of fertility is again delayed for everybody, but especially for men investing more in human capital. This may reflect increasing costs of education as well as increasing importance of education in the determination of wages (Burck 1976; Herrnstein and Murray 1994:93; Newcomer 1955; Vinovskis 1994).

The onset of reproduction is probably determined by many factors. In addition to investment in human capital, men must obtain a partner and acquire the resources necessary for reproduction. This is probably why there is a significant delay between completion of schooling and median age of first reproduction (between four and ten years, depending upon ethnicity, cohort, and educational level attained; Kaplan et al., 1998:Table 5). Examination of fertility onset among men without a high school education suggests that those other factors were more important during the early part of this century. Perhaps the earlier onset of reproduction among less educated men in recent cohorts is due to the fact that acquiring the resources for reproduction is less of a constraint now that there are social welfare supports for poor families. It is also possible that educated men are now engaging in more postgraduate on-the-job training. In both national samples (U.S. Department of Commerce 1985) and the Albuquerque sample, men with higher education exhibit greater increases in wages with increasing employment experience than do men with fewer years of education. This may also account for an increasing delay in the onset of fertility with education. Finally, because the educational attainments of spouses are becoming increasingly correlated (Mare 1991)

and because women's education is increasingly associated with delayed reproduction (Bianchi and Spain 1996), some of these time trends among men may reflect changes in education, work, and reproduction among women.

There has also been major historical change in the higher parity progressions. For Anglos, the hazard of progressing from one parity to the next is greater during the baby boom than either prior to or after that period. Different causal processes appear to be underlying the low completed fertility prior to and after the baby boom. The principal cause of low fertility prior to the boom is the low hazard of progression from zero children to the first child. Following the boom, the low fertility is also due to the low hazard of progressing from two to more children. Perhaps this change reflects an increasing trend towards investing in the human capital of children and increasing costs of educating them. Men today are much more likely to stop reproducing at the second or third child. Many men who participated in focus group discussions conducted as part of the Albuquerque Men project reported that they consciously decide to stop reproducing at low parities so that they could both invest more time in their children and provide them with funding for education.

The analysis of the long interview data on marital fertility suggests that once a union is established, it is the man's partner's level of education, rather than his education, that significantly lowers marital fertility. One way men may opt into a parental investment strategy is through the selection of a partner. Men marrying educated women may be selecting a low-fertility, high-investment strategy. It is also interesting that after controlling for partner's education, male income positively affects fertility. This result runs counter to conventional wisdom.

Investment

Parental investment in children is multidimensional and difficult to measure. Men can spend time with their children, take an active interest in their development, spend money on them directly, and attempt to influence their well-being through the choice of a partner, residential location, and school system. Here we examine time investments and monetary expenditures, and in Chapter 9 (Lancaster and Kaplan, this volume) we treat divorce and separation from children.

Table 14.5 presents the analysis of men's time investments in children during their elementary school years. The dependent variable is an index of time involvement, derived from summing time spent alone with the child between the ages of 5 and 12 (in five levels, for ranges of average number of hours per week) and involvement in the child's education (low = 1, mid = 3, and high = 5). Hispanic men report higher time involvement with children than Anglos. Neither sex nor income appears to have any effect, although there is a nonsignificant trend towards slightly more involvement with boys. Men report much lower time involvement with children who are not their biological offspring. Similarly, the number of siblings within two years of the focal child is negatively associated with time involve-

Table 14.5. Least squares regression model of men's time investment in elementary-school-aged children (N = 1,173, F = 18.91, $p < 0.001$, $R^2 = 0.115$)

Variable	df	Parameter Estimate	s.e.	Standardized Estimate	T for H0: Parameter=0	Prob > T
Intercept	1	-30.55	9.77	0.00	-3.06	0.0022
Anglo	1	-0.70	0.14	-0.15	-4.96	0.0001
Child Sex	1	-0.18	0.12	-0.04	-1.55	0.1219
Income when child was 5*	1	-0.00	0.00	-0.02	-0.60	0.5469
Unrelated child	1	-0.58	0.16	-0.10	-3.69	0.0002
No. of siblings 2 yrs older or younger	1	-0.39	0.09	-0.13	-4.60	0.0001
Child's year of birth	1	0.018	0.01	0.11	3.63	0.0003
His education (years)	1	0.07	0.02	0.11	3.53	0.0004
His assessment of child's intelligence	1	0.46	0.07	0.18	6.33	0.0001

*In thousands of 1990 dollars

ment, suggesting a dilution effect. Men's time involvement has increased during this century, as the child's year of birth is positively associated with investment. Both the respondent's education and his assessment of the child's scholastic intelligence are positively related to time involvement. Only 11.5% of the variance in the dependent variable, however, is accounted for by the independent variables in the model.

Table 14.6 examines financial support by the respondent for offspring's higher education. The cause-and-effect relationship between educational attainment and support for education is difficult to disentangle. If a child decides not to attend college, it is not possible to provide support for college; however, it is also possible that a lack of support is the cause of nonattendance. For this reason, we restrict our analysis to only those children of the respondent who attended college, about half of whom received some support. A logistic regression analysis was conducted. Hispanics are less likely to provide support. Number of siblings (i.e., the child's number of living siblings when he/she reached age 18) is negatively associated with support, and the effect is strong. The respondent's income is also associated with the probability of support, although his mate's is not. The education of both mother and father are significant with small effect sizes, as is the father's prior time involvement with the child (i.e., when she/he was in elementary school; see definition above).

Again, we find strong effects of biological paternity. Men invest less in children from previous unions of their mate. Both time investment and support during the college years is greater for genetic offspring than for a mate's child. In addition, the investment in a mate's child is contingent on a continuing relationship with

Table 14.6. Logistic regression model of the probability of a man providing financial support for an offspring's higher education ($N = 387$, $\chi^2 = 84.2$, $p < 0.0001$)

Variable	Parameter Estimate	s.e.	Z	Partial p	Odds Ratio
Intercept	-5.09	1.45	-3.50	0.0005	0.01
Offspring's year of birth	0.05	0.03	1.87	0.0615	1.05
Man's year of birth	-0.03	0.02	-1.36	0.1739	0.97
Sex	0.18	0.25	0.73	0.4648	1.20
Anglo	0.62	0.33	1.86	0.0628	1.85
Total number of siblings when offspring was 18	-0.33	0.07	-4.39	0.0000	0.72
Man's income* when offspring was 18	0.01	0.00	2.88	0.0039	1.01
Wife's income* when offspring was 18	-0.01	0.01	-1.39	0.1638	0.99
Man's education (years)	0.10	0.05	2.03	0.0426	1.10
Mother's education (years)	0.11	0.06	1.80	0.0714	1.11
Man's time involvement with offspring when offspring was young	0.15	0.07	2.13	0.0333	1.16
Unrelated offspring, man lived with the mother when child was 18	-0.99	0.50	-1.97	0.0492	0.37
Genetic offspring, man not living with the mother when child was 18	-1.35	0.40	-3.36	0.0008	0.26
Unrelated offspring, man not living with the mother when child was 18	-3.34	0.94	-3.56	0.0004	0.04

*in thousands of 1990 dollars

(After Kaplan et al. 1998)

that partner. Men cease to invest in a child after they stop living with the child's mother, unless the child is also the biological offspring of the man, and even then, support is reduced significantly (see Weiss and Willis 1985 for a theoretical treatment of this effect, and Anderson, Kaplan, and Lancaster, 1999, for a detailed presentation and discussion of these results).

The predictions of the competitive-labor-market model, discussed above, were supported by the analysis of the data on investment in children and on child outcomes. Consistent with the idea that human capital of parents is positively associated with rates of return on investment in offspring human capital, men's education is associated with higher levels of investment in children, including time involvement and monetary investments. Also, as predicted by the model, men's time involvement with children is positively associated with their assessment of the child's scholastic intelligence, although the direction of causality may be unclear. A third prediction of the model is that investments in children are positively correlated over the child's life course. This prediction is supported by the fact that financial support for college is positively correlated with the man's earlier time involvement with the child during elementary school years. The negative impact of

fertility on parental investment is reflected in both time spent with young children and financial support for higher education. This indicates that there is a dilution effect of number of siblings on the investment that children receive. There is no effect of income on time involvement, but it does predict monetary expenditures.

Outcomes

In a previous paper (Kaplan et al. 1995), we reported that the respondents' education and income were negatively associated with numbers of siblings, and positively associated with fathers' income and number of years that they lived with their fathers prior to age 18. Those analyses were based on the short interview data set. Here, we examine outcomes for the respondents' children using the long interview data set. An Ordinary Least Squares regression analysis of the children's years of education is presented in Table 14.7. Only individuals older than 22 years of age are included in the analysis. The child's sex, year of birth, and number of siblings apparently have no effect, once the other predictors are controlled for (even though in uncontrolled analyses, individuals with more siblings have lower educational attainment). Anglos have about 0.6 more years of education, on average. The

Table 14.7. Least squares regression model of the number of years of education obtained by respondents' children age 23 and older (N = 559, F = 16.30, $p < 0.0001$, adjusted $R^2 = 0.263$)

Variable	Parameter Estimate	s.e.	Z	Partial p
Constant	11.46	1.06	10.86	0.0001
Sex	0.01	0.19	0.04	0.97
Offspring's year of birth	-0.01	0.02	-0.28	0.78
Man's year of birth	-0.02	0.02	-1.27	0.20
Total number of siblings when offspring was 18	-0.05	0.05	-0.99	0.32
Anglo	0.64	0.26	2.50	0.013
Man's income* when offspring was 18	0.01	0.00	2.62	0.009
Wife's income* when offspring was 18	0.00	0.01	-0.26	0.80
Man's education (years)	0.07	0.03	2.12	0.03
Mother's education (years)	0.21	0.04	5.42	0.0001
Man's time involvement with offspring when offspring was young	0.11	0.05	2.05	0.04
Unrelated offspring, man lived with the mother when child was 18	-0.74	0.36	-2.07	0.04
Genetic offspring, man not living with the mother when child was 18	-1.28	0.30	-4.33	0.0001
Unrelated offspring, man not living with the mother when child was 18	-2.65	0.59	-4.52	0.0001

*(in thousands of 1990 dollars)

respondent's income when the child was 18 is positively associated with educational attainment, although his mate's income is not. Both the respondent's and the child's mother's years of education are positively associated with the child's education, although mother's effect is greater. The respondent's time involvement has an additional positive effect (a separate analysis, not shown, indicates that this effect of time involvement operates through elementary and secondary school). Children who are not genetically related to the respondent but whose mothers were living with the respondent when they were 18 years of age achieve about 0.7 years less education than genetic offspring with both parents living together when they were 18 years of age. Offspring whose mothers ceased to live with the respondent before the child turned 18 achieve about 1.3 fewer years of education, whereas children who are not genetic offspring and whose mothers ceased to live with the respondent before the child turned 18 achieved 2.6 years less education.

The data on outcomes suggest that those investments do increase the educational achievement of children. Interestingly, even after the effects of investments are taken into account, there is still a residual effect of both mother's and father's education on children's educational achievement. This result is consistent with the idea that the rate of return on investments in human capital of offspring increases with the level of parental human capital. However, it is also possible that the effect is due to genetically mediated parent-offspring correlations in academic ability or motivation. Another possibility is that educated parents instill more positive attitudes towards education and greater expectations of educational achievement in their children. The effects of paternity and the man's relationship to the child's mother are also seen in child outcomes, with children who are raised by men other than their biological father or who are not fully raised by their father achieving lower educational outcomes (even after parental income and education are controlled for).

DISCUSSION AND CONCLUSIONS

In this analysis of modern fertility behavior we followed a four-step process. The first step is to develop a general theory of the action of natural selection on the behavior of interest (in this case, fertility and parental investment). To that end, we unified economic and life history theories of fertility and parental investment to develop an overall framework for analysis (see Kaplan 1996, 1997, and Kaplan et al. 2000 for a more complete discussion of the theory). The second step is to apply the theory to the ecology of evolving hominids, with specific reference to what is known about extant hunter-gatherers. Of course, care must be taken in this step because extant hunter-gatherers only represent a small and probably biased sample of the variability exhibited by evolving *Homo sapiens*. The third step is to specify the kinds of psychological and physiological proximate mechanisms that evolved to produce adaptive responses to the ecological conditions of the past. The fourth

step is to develop models of how those proximate mechanisms would respond to modern, socioecological conditions and to individual and socioeconomic variation in those conditions. Successful accomplishment of this process is quite difficult because each step is vulnerable to mistaken assumptions. However, we feel that this analytical procedure takes advantage of the knowledge derived from optimality analysis in biology and economics, evolutionary psychology, and the study of cultural evolution. Taken together our results provide substantial indirect support for the embodied capital approach to fertility and parental investment, and for the specific model of investment in embodied capital in skills-based labor markets. However, the support is based largely on qualitative predictions, each of which is potentially consistent with some other theoretical model. An adequate assessment of the model will require more rigorous tests of quantitative predictions.

Two major difficulties must be overcome. First, the model's theoretical constructs are very difficult to measure. Years of education is only a proxy for embodied capital. Measuring the embodied capital of both parents and children is especially challenging, given that it is multidimensional and heterogeneous. Similarly, parental investment is only poorly approximated by our recall-based measures of expenditures of time and money. The effect sizes we obtained are probably smaller than the true sizes because random measurement error always dilutes actual associations. The statistical models could show stronger effects than the true associations if either the measurement error were biased (e.g., if more educated men tended to recall higher investments than they really gave and/or less educated men tended to recall lower ones) or the model was mis-specified and important variables were omitted. In order to determine the quantitative relationship between parental embodied capital and the rate of return on investments in children's embodied capital, a prospective study that overcomes those measurement problems will be necessary.

Selection bias produces another difficulty. Educational achievement, fertility, parental investment and mate selection are endogenous choices. Men are not randomly assigned to educational achievement levels, parities, etc. As a result, it is difficult to assess the impacts of those characteristics on child outcomes. For example, the association between parental education and the child's education could be due in part to unobserved characteristics that affected the parent's choices about how many years of education to pursue as well as to the effect of education, *per se*. Since the theory presented here implies an intricate causal pathway relating endogenous choices to one another and, ultimately, to child outcomes, the problem of selection bias must be solved so an accurate quantitative assessment of those relationships can be obtained.

There are also alternative and complementary explanations that require consideration. A great deal of scholarly attention has been focused on women and fertility. Many economic models emphasize the opportunity costs of women's time. As women have entered the labor force in increasing numbers and as women's wages have risen, the time costs of caring for children have increased. Other

anthropological and sociological models have postulated that women's education and economic autonomy reduce female fertility because children are no longer the only avenue by which women can gain power, and because they are less subject to men's fertility desires. In fact, our data show that a man's mate's characteristics do affect fertility. The increasing effectiveness of birth control technologies is probably also relevant (Barkow and Burley 1980; Easterlin et al. 1980; Potts 1997) because cost-effective birth control lowers unwanted fertility. Cultural transmission of fertility values is also receiving increased attention (Boyd and Richersen 1985; Cleland 1985; Cleland and Wilson 1987; Zei and Cavalli-Sforza 1977). Changing kin networks and the decreased involvement of extended kin in child rearing have been postulated as a cause of the shift to fewer, higher-quality children (Turke 1989). Clearly, future research must focus on testing alternative models within the same study to determine if some alternatives can be excluded and if a complete explanation requires the amalgamation of several models.

In fact, the life history model presented in the second section of this chapter, together with the proximate model of fertility determinants among traditional societies in the third section, suggests another, more general, explanation. Adults not only face a tradeoff between quantity and quality of children, but also between investment in their own embodied capital and reproduction (see Figure 14.1). For most organisms, including humans living under traditional conditions, food energy is the primary source of adult investment in embodied capital, which is then allocated to alternative physiological functions. In modern society, people face a tremendous array of consumption goods, such as housing, clothing, electronic equipment, and vehicles. The medium of exchange for obtaining those goods is money. Money is highly fungible in that it can be translated into any one of those goods. As diminishing returns from consumption of one good are reached, money can be allocated to other goods. Given all the goods that are available, there is always some good of which little has been consumed and for which returns on purchasing some amount of it are still high. The same can be said for investment in offspring's embodied capital, which appears to include investments not only in schooling but in goods associated with social training and social status, such as hobbies and sports, clothing, and toys, much of these investments being commitments to favorable placements of children in the mating market. Our best guess at this time is that the low fertility exhibited in modern societies reflects both the payoffs on investments in offspring income and a perceived lack of diminishing returns from other forms of consumption. Understanding the role of status competition during human evolutionary history may prove particularly illuminating in explaining the pattern of high consumption and low fertility.

The existence of extrasomatic wealth may be the critical condition to which our evolved proximate mechanisms do not respond so as to maximize fitness. By implication, post-demographic transition settings are not the only ones in which deviations from fitness maximization are likely to be observed. When there is heritable wealth, such as cattle or land, the breast-feeding/energy-balance system

may generate higher fertility than parents desire in terms of their own wealth and wealth they wish to pass on to their children. Adjustments to this situation may primarily involve differential inheritance, such as primogeniture and illegitimacy, but may also include late age of marriage (Coale and Treadway 1986) or even celibacy (Boone 1986), and lowered rates of polygyny by wealthy men (Luttbeg, Bergerhoff Mulder, and Mangel, this volume). Thus, perhaps we should not be surprised to find deviations from fitness maximization as soon as there are forms of extrasomatic wealth. The extremely low fertility in modern societies may reflect the extreme importance of extrasomatic wealth and the multiple ways in which it can be used.

SUMMARY

1. Modern fertility behavior deviates from fitness maximization in two ways: (1) fertility is much lower than the level that would maximize descendants in future generations, and (2) increases in wealth are not associated with increases in number of children produced.

2. To understand the causes of those deviations, we employed a four-step process in theory building: (1) develop a general theory of the action of natural selection on fertility and parental investment; (2) apply the theory to the ecology of evolving hominids, with specific reference to what is known about extant hunter-gatherers; (3) specify the kinds of psychological and physiological proximate mechanisms that evolved to produce adaptive responses to the ecological conditions of the past; (4) develop models of how those proximate mechanisms would respond to modern socio-ecological conditions and variability among them.

3. We combined life history theory and economic models of human capital investment into a general model of investments in one's own embodied capital, reproduction, and offspring's embodied capital. In a physical sense, embodied capital is organized somatic tissue. In a functional sense, embodied capital includes strength, immune competence, coordination, skill, and knowledge, all of which affect the profitability of allocating time and other resources to alternative activities such as resource acquisition, defense from predators and parasites, mating competition, parenting, and social dominance. The two most important forms of embodied capital investment are those that affect survival and those that affect income. Natural selection is expected to act on embodied capital investment to maximize reproduction effort over the life course and to allocate reproductive effort optimally between quantity and quality of children.

4. Among hunter-gatherers, the critical constraints on fertility and parental investment appear to be the time needed to give intensive care to infants and very young children, and the energy to feed parents and multiple children of varying ages. The level of those investments may be regulated by psychological mecha-

nisms that direct attention to ecologically variable relationships between investments and outcomes and that detect diminishing returns on investment. Most proximally, however, fertility appears to be regulated by physiological mechanisms responsive to breast-feeding regimes and net energy balance.

5. In modern society, investments in one's own and one's offspring's embodied capital includes resources other than food energy. The low fertility in modern societies may be due to the importance of skill in competitive labor markets, which directly link wages to the costs of obtaining skills. The fact that fertility is not correlated with wealth may be due to an increased payoff from investment in children's education by wealthier parents because of their higher levels of education and their ability to impart those skills to children.

6. We tested predictions derived from this model with data collected from men in Albuquerque, New Mexico. Consistent with the theory, we found (1) education has become an increasingly important determinant of age at first reproduction and fertility during this century; (2) holding education constant, increases in income is generally correlated with increased fertility; (3) educated parents invest more in children than less-educated parents, in terms of both time and monetary expenditures; (4) the child's scholastic abilities and earlier parental investments are associated with the likelihood of providing support for higher education; (5) the level of parental investment children receive is positively associated with their educational attainments.

7. Future research must test the predictions of this model alongside other competing and complementary explanations of modern fertility behavior.

The extremely low fertility exhibited in modern society may result not only from the costs of investing in children but because of the large array of consumption goods available and the existence of money as a medium of exchange. Deviations from fitness maximization may exist not only in modern societies evidencing extremely low fertility, but in any society in which there are extrasomatic forms of wealth.

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NOTES

1. Studies of traditional small-scale societies suggest that fertility may be optimized to maximize the production of descendants over the long run (e.g., Blurton Jones and Sibly 1978 and Blurton Jones 1986 for the !Kung in Botswana, but see Hill and Hurtado 1996 for disconfirmation among the Ache). The abrupt change in the association between wealth and fertility that occurs at the same time fertility is historically reduced (Retherford 1993) requires explanation.
2. Trivers (1974) points out that parental and offspring fitness interests conflict to some extent, because parental fitness will be maximized by a lower level of offspring survival than would maximize offspring fitness.
3. Later models (e.g., Becker 1991; Becker and Barro 1988; Becker et al. 1990) treat fertility decisions explicitly in terms of an intergenerational utility function. The individual's optimization problem is to maximize satisfaction derived from both his or her own consumption and the consumption of descendants.
4. Compensation for additional embodied capital can come in the form of benefits, working conditions, and prestige, as well as wages.
5. Individuals were offered the opportunity to conduct the interview in Spanish, but all of our potential interviewees felt comfortable with an English interview.
6. The nonsignificant p -value for the 1960 cohort is probably due to the smaller sample size, given that the parameter estimate is similar to the 1940 and 1950 cohorts with bigger sample sizes.

REFERENCES

- Anderson, K. G., H. K. Kaplan, and J. B. Lancaster. 1999. Parental care by genetic and step-fathers II: Reports by Albuquerque Men. *Evolution and Human Behavior* 20(6): 405-32.
- Austad, S. N., and K. E. Fischer. 1991. Mammalian aging, metabolism, and ecology: Evidence from the bats and marsupials. *Journal of Gerontology* 46(2):47-53.
- . 1992. Primate longevity: its place in the mammalian scheme. *American Journal of Primatology* 28:251-261.
- . 1993. Retarded senescence in an insular population of Virginia opossums (*Didelphis virginiana*). *Journal of Zoology* (London) 229:695-708.
- Barkow, J. 1989. *Darwin, Sex, and Status*. Toronto: Toronto University Press.
- Barkow, J., and N. Burley. 1980. Human fertility, evolutionary biology, and the Demographic Transition. *Ethology and Sociobiology* 1:163-180.
- Becker, G. S. 1975. *Human Capital*, 2nd ed. New York: Columbia University Press.
- . 1991. *A Treatise on the Family*, 2nd ed. Cambridge: Harvard University Press.
- Becker, G. S., and R. J. Barro. 1988. A reformulation of the economic theory of fertility. *Quarterly Journal of Economics* 103:1-25.
- Becker, G. S. and H. G. Lewis. 1973. Interaction between quantity and quality of children. In *Economics of the Family: Marriage, Children, and Human Capital*, T. W. Schultz, ed. Pp. 81-90. Chicago: University of Chicago Press.

- Becker, G. S., and N. Tomes. 1976. Child endowments and the quantity and quality of children. *Journal of Political Economy* 84:s143-S163.
- . 1986. Human capital and the rise and fall of families. *Journal of Labor Economics* 4:s1-S39.
- Becker, G. S., K. M. Murphy, and R. Tamura. 1990. Human capital, fertility and economic growth. *Journal of Political Economy* 98:s12-s37.
- Betzig, L. L. 1986. *Despotism and Differential Reproduction: A Darwinian View of History*. Hawthorne, New York: Aldine.
- Bianchi, S. M., and D. Spain. 1996. *Balancing Act: Motherhood, Marriage, and Employment among American Women*. New York: Russell Sage.
- Blake, J. 1989. *Family Size and Achievement*. Los Angeles: University of California Press.
- Blurton Jones, N. G. 1986. Bushman birth spacing: A test for optimal interbirth intervals. *Ethology and Sociobiology* 7:91-105.
- . 1987. Bushman birth spacing: a direct test of simple predictions. *Ethology and Sociobiology* 8:183-203.
- . 1993. The lives of hunter-gatherer children: Effects of parental behavior and parental reproductive strategy. In *Juvenile Primates*, M. E. Pereira and L. A. Fairbanks, eds. Pp. 309-326. Oxford: Oxford University Press.
- Blurton Jones, N. G., and R. M. Sibly. 1978. Testing adaptiveness of culturally determined behavior: Do Bushman women maximize their reproductive success by spacing births widely and foraging seldom? In *Human Behavior and Adaptation*, N. G. Blurton Jones and V. Reynolds, eds. Pp. 135-157. London: Taylor and Francis.
- Blurton Jones, N. G., K. Hawkes, and J. O'Connell. 1989. Modeling and measuring the costs of children in two foraging societies. In *Comparative Socioecology: The Behavioral Ecology of Humans and Other Mammals*, V. Standen and R. Foley, eds. Pp. 367-390. Oxford: Blackwell.
- . 1997. Why do Hadza children forage? In *Unity Psychology and Biology: Integrative Perspectives on Human Development*. N. L. Segal, G. E. Weisfeld, and C. C. Weisfeld, eds. Pp. 279-313. Washington, DC: American Psychological Society.
- Blurton Jones, N. G., K. Hawkes, and P. Draper. 1994a. Foraging returns of !Kung adults and children: Why didn't !Kung children forage? *Journal of Anthropological Research* 50:217-248.
- . 1994b. Differences between Hadza and !Kung children's work: Affluence or practical reason? In *Key Issues in Hunter-Gatherer Research*, E. S. Burch Jr. and L. J. Ellanna, eds. Pp. 189-215. Oxford: Berg.
- Blurton Jones, N. G., K. Hawkes, and J. F. O'Connell. 1999. Some current ideas about the evolution of human life history. In *Comparative Primate Socioecology*, P. C. Lee, ed. Pp. 140-66. Cambridge, UK: Cambridge University Press.
- Bock, J. 1995. *The Determinants of Variation in Children's Activities in a Southern African Community*. Ph.D. dissertation, Department of Anthropology, University of New Mexico, Albuquerque.
- Boone, J. 1986. Parental investment and elite family structure in preindustrial states: A case study of late medieval-early modern Portuguese genealogies. *American Anthropologist* 88:859-878.
- Borgerhoff Mulder, M. 1987. On cultural and reproductive success: Kipsigis evidence. *American Anthropologist* 89:617-634.
- . 1988. Reproductive consequences of sex-biased inheritance for the Kipsigis. In *Comparative Socioecology of Mammals and Man*, V. Standen and R. Foley, eds. Pp. 405-427. London: Blackwell.
- . 1992. Reproductive decisions. In *Evolutionary Ecology and Human Behavior*, E. A. Smith and B. Winterhalder, eds. Pp. 339-374. Hawthorne, New York: Aldine de Gruyter.

- Boyd, R., and P. Richerson. 1985. *Culture and the Evolutionary Process*. Chicago: University of Chicago Press.
- Burck, C. G. 1976. A group profile of the Fortune 500 chief executives. *Fortune* (May), 173–177.
- Chagnon, N. 1988. Life histories, blood revenge, and warfare in a tribal population. *Science* 239:985–992.
- Cleland, J. 1985. Marital fertility decline in developing countries: Theories and evidence. In *Reproductive Change in Developing Countries: Insights from the World Fertility Survey*, J. Cleland and J. Hobcraft, eds. Pp. 223–252. Oxford: Oxford University Press.
- Cleland, J., and C. Wilson. 1987. Demand theories of fertility transition: An iconoclastic view. *Population Studies* 41:5–30.
- Cromer, A. 1993. *Uncommon Sense: The Heretical Nature of Science*. New York: Oxford.
- Cronk, L. 1991a. Human behavioral ecology. *Annual Reviews in Anthropology* 20:25–53.
- . 1991b. Wealth, status and reproductive success among the Mukogodo. *American Anthropologist* 93:345–360.
- Coale, A. J., and R. Treadway. 1986. A summary of the changing distribution of overall fertility, marital fertility and the proportion married in the provinces of Europe. In *The Decline of Fertility in Europe*, A. J. Coale and S. C. Watkins, eds. Pp. 31–181. Princeton: Princeton University Press.
- Denison, E. F. 1985. *Trends in American Growth, 1929–1982*. Washington, D.C.: Brookings Institute.
- de Tray, D. N. 1973. Child quality and the demand for children. *Journal of Political Economy* 81:s7s–95.
- Downey, D. B. 1995. When bigger is not better: Family size, parental resources, and children's educational performance. *American Sociological Review* 60:746–761.
- Draper, P., and H. Harpending. 1987. Parental investment and the child's environment. In *Parenting across the Lifespan: Biosocial Dimensions*, J. Lancaster, J. Altmann, A. Rossi, and L. Sherrod, eds. Pp. 207–235. New York: Aldine.
- Easterlin, R. A., R. Pollack, and M. L. Wachter. 1980. Toward a more general economic model of fertility preferences. In *Population and Economic Change in Developing Countries*, R. A. Easterlin, ed. Pp. 81–135. Chicago: Chicago University Press.
- Ellison, P. T. 1990. Human ovarian function and reproductive ecology: New hypotheses. *American Anthropologist* 92:933–952.
- Ellison, P. T., C. Panter-Brick, S. F. Lipson, and M. T. O'Rourke. 1993. The ecological context of human ovarian function. *Human Reproduction* 8:2248–2258.
- Flinn, M. 1986. Correlates of reproductive success in a Caribbean village. *Ethology and Sociobiology* 9:1–29.
- Hanson, L. A. 1982. The mammary gland as an immunological organ. *Immunology Today* 3:168–172.
- Harpending, H. C., P. Draper, and R. Pennington. 1990. Cultural evolution, parental care, and mortality. In *Health and Disease in Traditional Societies*, A. Swedlund and G. Armelegos, eds. Pp. 241–255. South Hadley, Massachusetts: Bergin and Garvey.
- Hart, B., and T. Risley. 1995. *Meaningful Differences in the Everyday Experience of Young American Children*. Baltimore: Brookes.
- Hawkes, K., J. O'Connell, and N. Blurton Jones. 1991. Hunting income patterns among the Hadza: Big game, common goods, foraging goals and the evolution of the human diet. In *Foraging Strategies and Natural Diet of Monkeys, Apes and Humans*, A. Whiten and E. Widdowson, eds. Pp. 243–251. Proceedings of the Royal Society of London 334. Oxford: Clarendon Press.
- . 1995. Hadza children's foraging: Juvenile dependency, social arrangements and mobility among hunter-gatherers. *Current Anthropology* 36:688–700.

- . 1997. Hadza women's time allocation, offspring provisioning, and the evolution of long post-menopausal lifespans. *Current Anthropology* 38:551–557.
- Herrnstein, R. J., and C. Murray. 1994. *The Bell Curve: Intelligence and Class Structure in American Life*. New York: Free Press.
- Hill, K., and A. M. Hurtado. 1996. *Ache Life History: The Ecology and Demography of a Foraging People*. Hawthorne, New York: Aldine de Gruyter.
- Hoff-Ginsberg, E., and T. Tardif. 1995. Socioeconomic status and parenting. In *The Handbook of Parenting*, vol. 2, M. Bornstein, ed. Pp. 161–188. Hillsdale, New Jersey: Erlbaum.
- Howie, P. W., J. S. Forsyth, S. A. Ogston, A. Clark, and C. du V. Florey. 1990. Protective effect of breast feeding against infection. *British Medical Journal* 300:11–16.
- Hughes, A. 1986. Reproductive success and occupational class in eighteenth-century Lancashire, England. *Social Biology* 33:109–115.
- Huffman, S. L., K. Ford, H. A. Allen, and P. Streble. 1987. Nutrition and fertility in Bangladesh: Breastfeeding and post partum amenorrhoea. *Population Studies* 41:447–462.
- Hurtado, A. M. and K. Hill. 1990. Seasonality in a foraging society: Variation in diet, work effort, fertility and the sexual division of labor among the Hiwi of Venezuela. *Journal of Anthropological Research* 46:293–345.
- Irons, W. 1979. Cultural and biological success. In *Evolutionary Biology and Human Social Behavior*, N. Chagnon and W. Irons, eds. Pp. 257–272. North Scituate, Massachusetts: Duxbury.
- . 1983. Human female reproductive strategies. In *Social Behavior of Female Vertebrates*, S. K. Wasser, ed. Pp. 169–213. New York: Academic Press.
- . 1990. Let's make our perspectives broader rather than narrower: A comment on Turke's "Which humans behave adaptively, and why does it matter?" and on the so-called Da-Dp debate. *Ethology and Sociobiology* 11:361–375.
- . 1993. Monogamy, contraception, and the cultural and reproductive success hypothesis. *Behavior and Brain Sciences* 16:295–296.
- . 1995. Cultural and reproductive success in traditional societies. Unpublished ms. Department of Anthropology, Northwestern University, Evanston.
- Jones, R., and A. Palloni. 1994. Investigating the determinants of post-partum amenorrhoea using a multistate hazards approach. *Annals of the New York Academy of Sciences* 709:227–230.
- Kaplan, H. 1996. A theory of fertility and parental investment in traditional and modern societies. *Yearbook of Physical Anthropology* 39:91–135.
- . 1997. The evolution of the human life course. In *Between Zeus and Salmon: The Biodemography of Longevity*, K. Wachter and C. Finch, eds. Pp. 175–211. Washington, D.C.: National Academy of Sciences.
- Kaplan, H. K., and K. Hill. 1985. Hunting ability and reproductive success among male Ache foragers. *Current Anthropology* 26:131–133.
- Kaplan, H., J. B. Lancaster, J. Bock, and S. Johnson. 1995. Does observed fertility maximize fitness among New Mexican men? A test of an optimality model and a new theory of parental investment in the embodied capital of offspring. *Human Nature* 6:325–360.
- Kaplan, H., J. B. Lancaster, and K. G. Anderson. 1998. Human parental investment and fertility: The life histories of men in Albuquerque, NM. In *Men in Families: When Do They Get Involved? What Difference Does it Make?* A. Booth and N. Crouter, eds. Pp. 55–110. Mahwah, New Jersey: Lawrence Erlbaum.
- Kaplan, H., K. Hill, J. Lancaster, and A. M. Hurtado. 2000. A theory of human life history evolution: Diet, intelligence, and longevity. *Evolutionary Anthropology* 9(5):1–30.

- Lack, D. 1954. *The Natural Regulation of Animal Numbers*. Oxford: Oxford University Press.
- . 1968. *Ecological Adaptations for Breeding in Birds*. London: Methuen.
- Lam, D. 1986. The dynamics of population growth, differential fertility, and inequality. *American Economic Review* 76:1103–1116.
- Lancaster, J. B. 1997. The evolutionary history of human parental investment in relation to population growth and social stratification. In *Feminism and Evolutionary Biology*, P. A. Gowaty, ed. Pp. 466–488. New York: Chapman and Hall.
- Lancaster, J. B., and C. S. Lancaster. 1987. The watershed: Change in parental-investment and family-formation strategies in the course of human evolution. In *Parenting across the Life Span: Biosocial Dimensions*, J. B. Lancaster, J. Altmann, A. S. Rossi, and L. R. Sherrod, eds. Pp. 187–205. Hawthorne, New York: Aldine de Gruyter.
- Lee, P. C., P. Majluf, and I. J. Gordon. 1991. Growth, weaning and maternal investment from a comparative perspective. *Journal of Zoology* (London) 225:99–114.
- Lesthaeghe, R., and C. Wilson. 1986. *Modes of production, secularization, and the pace of fertility decline in western Europe, 1870–1930*. In *The Decline of Fertility in Europe*, A. J. Coale and S. C. Watkins, eds. Pp. 261–292. Princeton: Princeton University Press.
- Lindert, P. H. 1986. Unequal English wealth since 1670. *Journal of Political Economy* 94:1127–1162.
- Lloyd, D. C. 1987. Selection of offspring size at independence and other size-versus-number strategies. *American Naturalist* 129:800–817.
- Low, B. 1990. Occupational status, landownership, and reproductive behavior in 19th-century Sweden: Tuna Parish. *American Anthropologist* 92:457–468.
- Mare, R. D. 1991. Five decades of educational assortative mating. *American Sociological Review* 56:15–32.
- McGinley, M. A., and E. L. Charnov. 1988. Multiple resources and the optimal balance between size and number of offspring. *Evolutionary Ecology* 2:77–84.
- McNeilly, A. S., A. Glasier, and P. W. Howie. 1985. Endocrine control of lactational infertility. In *Maternal Nutrition and Lactational Infertility*, J. Dobbing, ed. Pp. 1–16. New York: Raven Press.
- Mealey, L. 1985. The relationship between social status and biological success: a case study of the mormon religious hierarchy. *Ethology and Sociobiology* 11:83–95.
- Newcomer, M. 1955. *The Big Business Executive: The Factors That Made Him, 1990–1950*. New York: Columbia University Press.
- Oftedal, O. T. 1984. Milk composition, milk yield and energy output at peak lactation: A comparative review. *Symposium of the Zoological Society of London* 51:33–85.
- Pennington, R., and H. Harpending. 1988. Fitness and fertility among the Kalahari !Kung. *American Journal of Physical Anthropology* 77:303–319.
- Pérusse, D. 1993. Cultural and reproductive success in industrial societies: Testing the relationship at the proximate and ultimate levels (with comments). *Brain and Behavioral Sciences* 16:267–323.
- Potts, M. 1997. Sex and the birth rate: Human biology, demographic change, and access to fertility-regulation methods. *Population and Development Review* 23:1–39.
- Prentice, A. M., and R. G. Whitehead. 1987. The energetics of human reproduction. *Symposium of the Zoological Society of London* 57:275–304.
- Retherford, R. D. 1993. Demographic transition and the evolution of intelligence: Theory and evidence. Unpublished ms. Program on Population, East-West Center, Honolulu, Hawaii.
- Rogers, A. R., and N. G. Blurton Jones. 1992. Allocation of parental care. Unpublished manuscript. Ms. Department of Anthropology, University of Utah, Salt Lake City.

- Rosenblatt, P. C., P. Peterson, J. Portner, M. Cleveland, A. Mykkanen, R. Foster, G. Holm, B. Joel, H. Reisch, C. Kreuscher, and R. Phillips. 1973. A cross-cultural study of responses to childlessness. *Behavior Science Notes* 8:221-231.
- Sheard, N. F., and W. A. Walker. 1988. The role of breast milk in the development of the gastrointestinal tract. *Nutrition Review* 46:1-8.
- Simons, J. L. 1974. *The Effects of Income on Fertility*. Chapel Hill, North Carolina: Carolina Populations Center.
- Smith C. C., and S. D. Fretwell. 1974. The optimal balance between size and number of offspring. *American Naturalist* 108:499-506.
- Trivers, R. L. 1974. Parent-offspring conflict. *American Zoologist* 14:249-264.
- Turke, P. W. 1989. Evolution and the demand for children. *Population and Development Review* 15:61-90.
- Turke, P., and L. Betzig. 1985. Those who can do: Wealth, status and reproductive success on Ifaluk. *Ethology and Sociobiology* 6:79-87.
- U.S. Department of Commerce, Bureau of the Census. 1985. Money income of households, families and persons in the United States, 1985. Current Population Reports. Series P-60, No. 156, Table 35. Washington, D.C.: U.S. Government Printing Office.
- . 1991. Census of Population and Housing, 1990: Summary tape files 1 and 3 on CD-ROM (New Mexico). Washington, D.C.: Bureau of the Census.
- . 1992. 1990 Census of Population: general population characteristics (New Mexico). CP-1-33, Table 54, Pg. 82. Washington, D.C.: U.S. Government Printing Office.
- U.S. Department of Transportation, Federal Highway Administration. 1993. Highway Statistics 1987. (TD2.22:991) Washington, D.C.: U.S. Government Printing Office.
- Vining, D. R., Jr. 1986. Social versus reproductive success: The central theoretical problem of human sociobiology. *The Behavioral and Brain Sciences* 9:167-216.
- Vinovskis, M. A. 1994. Education and the economic transformation of nineteenth century America. In *Age and Structural Lag: Society's Failure to Provide Meaningful Opportunities in Work, Family, and Leisure*. M. W. Riley, R. L. Kahn, and A. Foner, eds. Pp. 171-196. New York: Wiley and Sons.
- Vitzthum, V. 1994. Comparative study of breastfeeding structure and its relation to human reproductive ecology. *Yearbook of Physical Anthropology* 37:307-349.
- Voland, E. 1990. Differential reproductive success within the Krummhörn population (Germany, 18th and 19th centuries). *Behavioral Ecology and Sociobiology* 26:65-72.
- Weiss, Y., and R. Willis. 1985. Children as collective goods and divorce settlements. *Journal of Labor Economics* 3:268-292.
- Whitehead, R. G., and A. Paul. 1981. Infant growth and human milk requirements: A first approach. *Lancet* 2:161-163.
- Willis, R. J. 1973. A new approach to the economic theory of fertility behavior. *Journal of Political Economy* 81:s14-s64.
- . 1987. Wage determinants: A survey and reinterpretation of human capital earnings functions. In *Handbook of Labor Economics*, O. Ashenfelter and R. Layard, eds. Pp. 525-602. Amsterdam: North Holland.
- Zei, G., and L. L. Cavalli-Sforza. 1977. Education and birth control. *Genus* 33:15-42.