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Gender Differences in Education in a Dynamic Household Bargaining Model

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ABSTRACT

We interpret observed gender differences in education as the equilibrium outcome of a two-sex overlapping generations model where men and women of each generation bargain over consumption, number of children, and investment in education of their children conditional on gender. This model represents a new framework for the analysis of the process of intrahousehold decision making in an intergenerational setting.

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1. Introduction

Becker's (1965, 1991) seminal contribution to the theory of household behavior treats the family as a monolithic unit that acts as a single decision maker. Recently, several authors challenged this view by pointing out the limitations of the "unitary" model and proposed alternative "collective" approaches to the analysis of household behavior.¹ A particularly successful line of research initiated by Manser and Brown (1980) and McElroy and Horney (1981) models the process of intrahousehold decision making as a bargaining problem.² This framework has been extended by Chiappori (1992), Lundberg and Pollak (1993), Ulph (1988), and Woolley (1993), among others.³ All these models, however, are static models of marriage that take family composition as given and focus on the way in which income is produced and allocated within the family. Hence, they are ill equipped to study household decisions about fertility and investments in future generations.

In this paper, we extend the work of Manser and Brown (1980) and McElroy and Horney (1981) to a dynamic environment to provide a new framework for the analysis of the process of intrahousehold decision making in an intergenerational setting. We study a two-sex overlapping generations model where men and women of each generation bargain over consumption, number of children, and investment in the education of their children conditional on

¹ For a critical survey of existing theories of the family see Bergstrom (1994).

² Manser and Brown (1980) and McElroy and Horney (1981) consider cooperative game-theoretic models in which husband and wife bargain over the surplus generated by marriage over and above the utility they can achieve by staying single or by getting divorced.

³ Lundberg and Pollak (1993) maintain the cooperative approach but reinterpret disagreement as a noncooperative equilibrium within marriage. Chiappori (1992) assumes that household decisions are Pareto efficient but abstracts from the details of the bargaining process. Ulph (1988) and Woolley (1993) model the intrahousehold decision making process as a noncooperative game.

gender. Our model is dynamic in the sense that altruism toward children and concern for their future as adults link the decisions of each generation into an intergenerational sequence of bargaining problems.

We use our model to explore the issue of gender differences in education. Empirical evidence for a number of developing and developed countries to date suggests that women receive less education than men (Figure 1).⁴ Within the context of a pure investment model, Becker (1991, ch. 2) shows that systematic gender differences in human capital investments may arise as an optimal response to biological differences between men and women. By imposing a constraint on the allocation of women's time, *ceteris paribus*, child bearing lowers the returns from the investment in the education of girls relative to boys. In our model, however, parents take into account the marriage market consequences of their investment decisions. In particular, as adults, their children will also face a bargaining problem, and the education they receive affects both the amount of resources they will bargain over and their equilibrium share. As a consequence, the difference in the education levels of boys and girls implied by our model is smaller than what is consistent with a pure investment model.⁵

Econometric studies of gender differences in human capital investments in specific countries typically emphasize parental responses to labor market gender wage differentials (see, e.g., Rosenzweig and Schultz 1982 for India)

⁴ Figure 1 depicts gender differences in the average number of years of schooling per person age 25 and over in 1992 for 146 countries (United Nations 1994). The gender gap in education levels is larger in developing countries, where the average gap is 1.16 years, than in developed countries, where the average gap is 0.53 years.

⁵ Other models where parents take into account marriage market outcomes when choosing how much to invest in their children are those of Behrman, Pollak and Taubman (1986), Boulier and Rosenzweig (1984), and Cole, Mailath and Postlewaite (1992). None of these models, however, consider the game between husband and wife that determines the intrahousehold allocation of income.

and/or to gender biases in parental preferences (see, e.g., Behrman, Pollak and Taubman 1986 for the United States). These interpretations are, however, difficult to generalize to all countries.⁶ One of the questions we try to answer in this paper is whether abstracting from gender discrimination in both the labor market and the household, and focusing exclusively on biological differences, is sufficient to provide a reasonable explanation for the general phenomenon illustrated in Figure 1. Although highly stylized, the model we propose allows us to construct a measure of the cost to women of having children. We find that the average cost per child implied by our model in order to fit the data summarized in Figure 1, once we control for cross-country differences in fertility and infant mortality rates, is 5-6% of the working lifetime of a woman. We argue that this is a reasonable estimate once we take into account all the components of this cost.

In the next three sections, we describe and solve two versions of our model that abstract from fertility decisions. In Section 5, we extend the domain of the intrafamily bargaining to include the number of children and explore some of the quantitative implications of our model. We conclude in Section 6 with some comments and directions for future research.

2. The Basic Model

We study an overlapping generations model with two types of individuals, men and women, who live one period as children and one period as adults and are altruistic toward their children. Men and women are assumed to be

⁶ Schultz (1993), for example, notes that empirical studies that estimate returns to schooling in a number of developing countries provide no clear evidence that they differ systematically by gender, and Behrman and Deolalikar (1990) find higher returns to schooling for females than for males in Indonesia. The empirical evidence on parental gender discrimination is also mixed (see, e.g., Das Gupta 1987 and Thomas 1994).

identical except for the fact that women bear children. We assume that men and women have the same preferences over their own consumption and over the utility of their progeny and face the same wage schedule conditional on education (i.e., we assume no gender wage differential). We also assume that parental preferences are neutral between boys and girls.

When people are young, they simply receive the education their parents choose for them, and we normalize their consumption level to zero. When people are adults, they decide whether to get married, work, and receive a wage, which is a function of their education. We assume that children are the only public good inside the marriage and that people are not altruistic toward their partners.⁷ If individuals get married, we initially assume they have two children, a boy and a girl, and the intrafamily allocation of their combined income is determined through bargaining. If they stay single, they consume their labor income.

Except for possible gender differences in education, the first generation is assumed to be homogeneous (i.e., in the first period, people of the same gender have the same level of education). As shown below, in equilibrium, all future generations are also homogeneous. Hence, assortative mating is not an issue. Without loss of generality, we assume that each person has only one chance of getting married and that matching is random.

Child bearing has implications on the allocation of women's time. We initially assume that if a woman gets married she has to devote an exogenously given fraction of her working lifetime to bearing two children. This fraction could be small, but it is strictly positive and represents the biological difference between men and women. The time cost associated with child bearing

⁷ The analysis could be easily extended to the case of many public goods as well as to allow for some degree of altruism between spouses.

we refer to here is meant to capture not only the actual time a woman cannot work during pregnancy, recovery from delivery, or lactation, but also all the factors connected with child bearing that affect a woman's earnings profile, such as physical and psychological consequences of child bearing that affect her productivity.⁸ To keep the model simple, we abstract from labor supply decisions and household production.⁹

To decide whether to get married, men and women of each generation bargain over the terms of binding prenuptial agreements specifying their individual consumption within the marriage and the amount of education to give to each of their children conditional on each child's gender. The utility individuals can achieve staying single represents their threat point. This is a one-time bargain we model as a Nash-bargaining problem.¹⁰

The welfare of the members of each generation depends upon the level of education that their parents choose for them, which affects both their threat point and the amount of resources they will bargain over. To choose the level of education to provide for their children, parents need to solve the bargaining problem that their children will face, which also depends upon the education choices of the parents of their children's spouses. This defines a game between the families of the groom and the bride. Altruism toward children links the sequence of bargaining problems for each dynasty, and

⁸ A detailed list can be found in any popular book about pregnancy, such as, for example, the best-seller *What to Expect When You're Expecting*, by Eisenberg, Murkoff and Hathaway (1991).

⁹ Rupert, Rogerson and Wright (1995) consider household production in a model where the family objective function can be interpreted as a reduced form for a household bargaining problem.

¹⁰ Although we are aware that different specifications of the threat point as well as different solution concepts may induce differences in the equilibrium outcomes (see, e.g., Manser and Brown 1980 and Lundberg and Pollak 1993), the extension of the dynamic framework to allow for such possibilities involves complications that are outside the scope of this paper. They are therefore not explored here.

children's marriages combine the bargaining problems of pairs of families in each generation.

Formally, we assume that in the initial period there is a continuum of individuals, half of which are men and half of which are women. The von Neumann-Morgenstern preferences of the representative individuals in period t are of the form

$$U_{it} = \begin{cases} c_{it} + \beta (U_{mt+1} + U_{ft+1}) & \text{if married} \\ c_{it} & \text{if single} \end{cases}$$

where c_{it} is the consumption of an adult of sex i , $i = m, f$, and $\beta \in (0, 0.5)$ denotes the degree of altruism per child.¹¹ This specification of preferences allows us to derive an analytic solution.

We normalize the labor endowment to be one unit of time. Men inelastically supply one unit of labor regardless of their marital status. Women supply one unit of labor if they stay single and only $(1 - \alpha)$ units if they get married, where $\alpha \in (0, 1)$ represents the time a woman has to devote to child bearing. Let $e_{mt}, e_{ft} \in [0, \infty)$ denote the levels of education of adults in period t . The wage rate is an increasing and strictly concave (time invariant) function of education, $w_{it} = w(e_{it})$, $w' > 0$, $w'' < 0$, $i = m, f$. The price of education is assumed to be constant at p .

Using a recursive formulation, letting e'_m and e'_f denote the education choices for the next generation, and given their education levels e_m and e_f , each couple in any given period solves the following Nash-bargaining problem:

¹¹ If all one's descendants marry, $U_{it} = c_{it} + 0.5 \sum_{\tau=t+1}^{\infty} (2\beta)^{\tau} (c_{m\tau} + c_{f\tau})$. The assumption that $\beta < 0.5$ guarantees that the utility function is bounded.

$$(A) \text{ Max}_{\{c_m, c_f, e'_m, e'_f\}} [c_m + \beta (V^m(e'_m, \tilde{e}'_f) + V^f(e'_f, \tilde{e}'_m)) - w(e_m)] \cdot$$

$$[c_f + \beta (V^m(e'_m, \tilde{e}'_f) + V^f(e'_f, \tilde{e}'_m)) - w(e_f)]$$

s. t.

$$c_m + c_f + p (e'_m + e'_f) = w(e_m) + (1 - \alpha) w(e_f)$$

where, for $i = m, f$,

$$V^i(e_m, e_f) = c_i(e_m, e_f) + \beta (V^m(e'_m(e_m, e_f), \tilde{e}'_f) + V^f(e'_f(e_m, e_f), \tilde{e}'_m))$$

is the utility a person of sex i obtains within marriage, given their own and their partner's level of education.¹² A solution to problem (A) is a pair of such functions V^m and V^f . We write $V^i(e'_i, \tilde{e}'_j)$ to indicate that when choosing the level of education of their children, e'_i , parents take the behavior of the parents of their children's future spouses, \tilde{e}'_j , as given and select a best response to it.¹³ Uniqueness of the equilibrium to the game between the families of the groom and the bride is a necessary condition for existence of a solution to (A).

3. Solution

The assumption of linear preferences simplifies the solution of our model in two important ways. First, the decisions about investment in education are independent of the bargaining over the allocation of

¹² An implicit condition for this problem to be well defined is that there exists some agreement preferred by both partners to the disagreement outcome. This condition needs to be verified in equilibrium.

¹³ To be more precise, we should write $E[V^i(e'_i, E'_m, E'_f, M)]$, where E'_m and E'_f denote distributions of education levels in the population and M denotes the matching function characterizing the marriage market. As we show below, however, the equilibrium distributions are degenerate so the more parsimonious notation we adopt does not imply any loss of generality.

consumption. Second, the optimal human capital investment of each family does not depend upon other families' decisions.

Assuming an interior solution, the first order conditions for (A) imply

$$(1) \quad c_m = w(e_m) - \frac{\alpha w(e_f) + p (e_m' + e_f')}{2}$$

and

$$(2) \quad c_f = w(e_f) - \frac{\alpha w(e_m) + p (e_m' + e_f')}{2}.$$

The spouse with the highest level of education has the highest level of consumption, and consumption levels are equal only when the levels of education are the same. This result follows naturally from the Nash-bargaining specification. Note that husbands partially compensate wives for the income loss associated with having children, $\alpha w(e_f)$. In fact, regardless of their relative income, each parent pays half of the cost of having children and half of the cost of their children's education. This is a consequence of the fact that children are local public goods inside the family, and parental preferences are identical.

From the system of first order conditions for (A) we also obtain

$$(3) \quad 2 \beta V_1^m(e_m', \tilde{e}_f') = p$$

and

$$(4) \quad 2 \beta V_1^f(e_f', \tilde{e}_m') = p$$

where $V_1^i(\cdot)$ denotes the derivative of V^i with respect to e_i' , $i = m, f$. These conditions simply state that parents invest in the education of their children up to the point where the marginal return to their investment equals the

marginal cost. Using the envelope theorem provides

$$(5) \quad V_1^m(e_m', \tilde{e}_f') = w'(e_m')$$

and

$$(6) \quad V_1^f(e_f', \tilde{e}_m') = \frac{(2 - \alpha) w'(e_f')}{2}.$$

By substituting (5) and (6) into (3) and (4), we obtain the following conditions:

$$(7) \quad w'(e_m') = \frac{p}{2\beta}$$

and

$$(8) \quad w'(e_f') = \frac{p}{(2 - \alpha)\beta}.$$

Note that (7) and (8) do not depend on the human capital investment that other families choose for their children. The uniqueness (in dominant strategies) of the equilibrium to the game between the family of the bride and the family of the groom follows trivially. An implication of this result is that in equilibrium all parents behave in the same way. Hence, in each generation, individuals of the same gender have the same level of education. In Appendix 1, we derive V^m and V^f and show that problem (A) has a unique solution.

Given the assumption of diminishing returns to education, conditions (7) and (8) imply that boys receive more education than girls. However, the difference in the levels of education of boys and girls is smaller than the one that would result from a pure investment model. Consider, for instance, the following problem that could be interpreted as the one a benevolent patriarch in the Beckerian tradition would solve:

$$\begin{aligned} & \text{Max} && U_{m0} + U_{f0} \\ & \{c_{mt}, c_{ft}, e_{mt+1}, e_{ft+1}\} \\ & \text{s. t.} \end{aligned}$$

$$c_{mt} + c_{ft} + p (e_{mt+1} + e_{ft+1}) = w(e_{mt}) + (1 - \alpha) w(e_{ft}), \quad \forall t = 0, 1, 2, \dots$$

This problem reduces to

$$\begin{aligned} & \text{Max} && \sum_{t=0}^{\infty} (2\beta)^t (c_{mt} + c_{ft}) \\ & \{c_{mt}, c_{ft}, e_{mt+1}, e_{ft+1}\} \\ & \text{s. t.} \end{aligned}$$

$$c_{mt} + c_{ft} + p (e_{mt+1} + e_{ft+1}) = w(e_{mt}) + (1 - \alpha) w(e_{ft}), \quad \forall t = 0, 1, 2, \dots$$

and the first order conditions with respect to education imply

$$(9) \quad w'(e_{mt}) = \frac{p}{2\beta}$$

and

$$(10) \quad w'(e_{ft}) = \frac{p}{2(1-\alpha)\beta}, \quad \forall t = 1, 2, 3, \dots$$

Note that while (7) and (9) coincide, (10) implies a lower level of education for girls than (8) does. The magnitude of such a difference depends on the parameter α . This result derives from the fact that in our model, parents internalize the marriage market consequences of their investment decisions. In particular, they take into account that in equilibrium husbands partially compensate wives for the income loss suffered as a consequence of child bearing, which increases the returns from the investment in women's education.

This implication of our model is consistent with the empirical findings of Behrman, Pollak and Taubman (1986). Behrman *et al.* (1986) study the investment decisions in the education of their children of a sample of parents

in the United States who have only two children, a boy and a girl. They find that the level of education that the girls in the sample receive is higher than what is consistent with an investment model. They conclude that parents slightly favor girls. In contrast, our model explains this finding without relying on gender biases in parental preferences.

4. A Simple Extension

Before turning our attention to a more general version of our model that incorporates fertility decisions, we briefly consider a simple extension of the basic framework. The two components of the cost of children considered thus far are the time cost of bearing children, α , which is exogenous to the model and borne by the mother, and the cost of educating them, $p(e'_m + e'_f)$, which is determined endogenously through bargaining. Another component of this cost we may want to consider, however, is the cost of rearing children. Assume that child rearing is provided within the household and can be provided by either parent. If the time cost associated with this activity, $\gamma \in (0,1)$, is exogenously given, we can easily modify problem (A) above to incorporate decisions about the fraction of γ that each parent spends rearing their children. We solve this generalization of problem (A) in Appendix 2. We find that in equilibrium the time cost of bearing and rearing children, $\alpha + \gamma$, is entirely borne by women.¹⁴

For the case in which $\gamma < \alpha$, the intuition behind this result is straightforward. If $\alpha > \gamma$, then it is optimal for parents to invest less in the education of girls than in the education of boys, even if the time cost of rearing children were entirely borne by men. But if women have less education

¹⁴ It is still true that husbands partially compensate wives for the income loss, $(\alpha + \gamma) w(e_f)$.

than men, then it is optimal for a couple to have the woman do all the rearing, since the opportunity cost of her time is lower than that of the man. This, in turn, reduces the equilibrium level of education that parents choose for their daughters. The equilibrium conditions that determine the education levels of boys and girls are

$$(11) \quad w'(e'_m) = \frac{P}{2\beta}$$

and

$$(12) \quad w'(e'_f) = \frac{P}{(2 - \alpha - \gamma)\beta}$$

Although less intuitive, this holds even for $\gamma > \alpha$ in the unique Nash equilibrium to the game between the families of the bride and the groom. The formal argument is presented in Appendix 2.

There are interesting conclusions we can draw from this analysis. As long as the time cost associated with bearing children is positive, if child rearing is provided within the household, then women also bear the entire time cost associated with child rearing, even assuming they do not have any intrinsic comparative advantage in this activity. As a consequence, the cost to a woman of having a child is given by a combination of these two factors (child bearing and child rearing), which are related to each other and difficult to disentangle, although only one of them (child bearing) represents the biological difference between men and women. In particular, even if the cost to women of bearing children were small compared to the cost of rearing children, we would still observe relatively big differences in the education levels of men and women, and women rearing their children. Because of lack of identification, in the remainder of the paper we summarize the time cost

associated with child bearing and rearing into a single parameter α .

5. Endogenous Fertility

In this section, we extend our model to incorporate fertility decisions. We then use our model to construct a measure of the cost to a woman of having a child and to interpret the empirical evidence summarized in Figure 1.

To keep the analysis simple, we assume that every pregnancy yields a pair of children, one boy and one girl, and let n denote the number of children. The main implication of endogenizing fertility decisions is that the time a woman devotes to child bearing and rearing, $\alpha(n)$, depends on the number of children. We assume that $\alpha: R_+ \rightarrow [0,1]$ is an increasing function of n with $\alpha(0) = 0$. To guarantee existence of a solution, we also assume that the degree of altruism per child, $\beta(n)$, is a decreasing function of n .¹⁵

The Nash-bargaining problem faced by couples in each generation becomes

$$(B) \quad \text{Max}_{\{c_m, c_f, e'_m, e'_f, n\}} \left[c_m + \frac{\beta(n) n (V^m(e'_m, \tilde{e}'_f) + V^f(e'_f, \tilde{e}'_m))}{2} - w(e_m) \right] \cdot \\ \left[c_f + \frac{\beta(n) n (V^m(e'_m, \tilde{e}'_f) + V^f(e'_f, \tilde{e}'_m))}{2} - w(e_f) \right]$$

s. t.

$$c_m + c_f + \frac{n p (e'_m + e'_f)}{2} = w(e_m) + (1 - \alpha(n)) w(e_f)$$

where, for $i = m, f$,

¹⁵ More precisely, it has to be true that $0 < \beta(n) < n^{-1}$, for every n . See footnote 11.

$$V^i(e_m, e_f) = c_i(e_m, e_f) +$$

$$\frac{\beta(n(e_m, e_f)) n(e_m, e_f) (V^m(e'_m(e_m, e_f), \tilde{e}'_f) + V^f(e'_f(e_m, e_f), \tilde{e}'_m))}{2}$$

From the first order conditions for problem (B), we obtain the following system of equations.

$$(13) \quad c_m = w(e_m) - \frac{\alpha(n) w(e_f) + \frac{n p (e'_m + e'_f)}{2}}{2}$$

$$(14) \quad c_f = w(e_f) - \frac{\alpha(n) w(e_f) + \frac{n p (e'_m + e'_f)}{2}}{2}$$

$$(15) \quad w'(e'_m) = \frac{p}{2 \beta(n)}$$

$$(16) \quad w'(e'_f) = \frac{p}{(2 - \alpha(n')) \beta(n)}$$

$$(17) \quad \alpha'(n) w(e_f) + \frac{p (e'_m + e'_f)}{2} =$$

$$(\beta(n) + n \beta'(n)) (V^m(e'_m, \tilde{e}'_f) + V^f(e'_f, \tilde{e}'_m)).$$

Restricting our attention to the role played by fertility, note that investment in education of both males and females decreases with the number of siblings. Also, the amount of education that girls receive is inversely related to the number of children they will have (n'). Hence, although it is still true that boys receive more education than girls, the gap increases with fertility. Finally, note that for the equilibrium number of children to be

positive it has to be the case that $(\beta(n) + n\beta'(n)) > 0$ and $\beta'' < 0$, which implies that parents' utility is increasing and concave in the number of children.¹⁶

To investigate the quantitative implications of our model, we restrict our attention to steady state equilibria and make the following additional assumptions.¹⁷ We assume that wages are a logarithmic function of education, that is, $w(e_i) = \theta \ln(e_i)$, $\theta > 0$, $i = m, f$, and that the time cost associated with having children is a linear function of the number of children, that is, $\alpha(n) = \alpha n$.¹⁸ Under these assumptions, we combine (15) and (16) to obtain an expression for α , the cost per child, that depends only on the percentage gender gap in education levels and on fertility (which are both endogenous to our model) and that is independent of the other parameters in the model:

$$(18) \quad \alpha = \frac{2(e_m - e_f)}{n e_m}.$$

We exploit (18) to obtain a measure of the cost to a woman of having a child for each of the 146 countries depicted in Figure 1 using data on mean years of schooling by gender and fertility rates contained in the *1994 Human Development Report* published by the United Nations (the data refer to 1992). Figure 2 displays a histogram of the values of α we computed, which are reported in Appendix 3. This measure is noisy for a variety of reasons. In particular, aggregate education and fertility are likely to be measured with

¹⁶ See, e.g., Becker and Barro (1988).

¹⁷ The dynamics of the model with endogenous fertility are more complicated than those of the model in Section 2, as we can see by comparing equations (15) and (16) to equations (7) and (8) (see Appendix 1).

¹⁸ The assumption that earnings are a logarithmic function of education is quite standard in the literature on the returns to education (see, e.g., Mincer 1974). The assumption that $\alpha(n)$ is linear in n may be more controversial, but it represents an obvious starting point given the lack of empirical evidence in support of any particular specification.

error, and years of formal schooling represent an imperfect measure of total education in many developing countries (see, e.g., King and Hill 1993). The mean (standard deviation) in the sample is 0.134 (0.115), and a *chi-square* test of normality of the distribution does not reject the null hypothesis at conventional significance levels (*P*-value 0.144). Once we separate the developing and developed countries in our sample into two subsamples, we find that the average value of α for developing countries is 0.151 versus 0.066 for developed countries.¹⁹ A *t*-test of equality of the two means rejects the null hypothesis at conventional significance levels (*P*-value 0.000).

Although our model abstracts from infant mortality, α represents the cost of "producing" a surviving child. Hence, α should be positively correlated with infant mortality, which affects the number of pregnancies and births that are necessary to produce a surviving child. We test the plausibility of the measures that we constructed by regressing α on a constant, infant mortality rates (IMR), and a dummy variable (D) that takes the value one for developing countries and zero for developed countries:²⁰

$$(19) \quad \alpha = 0.059 + 0.050 D + 0.620 \text{ IMR}, \quad R^2 = 0.128$$

$$\quad \quad \quad (0.016) \quad (0.028) \quad (0.268)$$

where the numbers in parentheses are heteroskedasticity-consistent standard errors (White 1980).

Several results are noteworthy. The coefficient associated with infant mortality is positive and significant at conventional levels. This suggests

¹⁹ The classification of countries into developing and developed countries that we use is taken from United Nations (1994).

²⁰ Infant mortality rates for the developing countries in the sample are obtained from United Nations (1994). Infant mortality rates for the developed countries in the sample are from United Nations (1993).

that our measure captures the fact that a higher infant mortality rate implies a higher cost of producing a surviving child. The coefficient associated with the dummy variable for developing countries, instead, is not significantly different from zero at the 5% level. This result implies that once we control for differences across countries in infant mortality rates, the mean values of α for developing and developed countries are no longer statistically different from each other. Thus, the estimate of the intercept in our linear regression can be interpreted as an estimate of the fundamental cost to a woman of having a child. The point estimate we obtain indicates that such cost amounts to about 6% of the working lifetime of a woman, with a 95% confidence interval of (2.8%, 9%).

To evaluate the influence of outliers on the least squares estimates we obtained, we also present the results of a robust regression (Huber 1973) of α on IMR and D:²¹

$$(20) \quad \alpha = 0.050 + 0.025 D + 0.997 \text{ IMR.}$$

$$\quad \quad (0.018) \quad (0.024) \quad (0.222)$$

Note that all our previous findings are confirmed. The estimate of the coefficient associated with infant mortality is still positive and significant at conventional levels. The estimate of the difference between the mean values of α for developing and developed countries is not significantly different from zero at conventional levels. The point estimate of the average cost to a woman of having a child amounts to 5% of her working lifetime (or equivalently, 5% of her lifetime earnings), and its 95% confidence interval is

²¹ The technique proposed by Huber is an iterative weighted least squares procedure aimed at reducing the influence of outliers (see, e.g., Rousseeuw and Leroy 1987).

(1.4%, 8.5%).

Since α represents a composite measure that is meant to capture a variety of factors related to child bearing and rearing, we think our estimates are reasonable. Also, although not directly comparable, our estimates are in line with the findings of microeconomic studies investigating the effects of motherhood on female earnings in the United States and Canada. For example, using the 1982 wave of the U.S. National Longitudinal Survey of Young Women, Korenman and Neumark (1992) find that "children lower wages 'directly,' and women respond to these lower wages by curtailing their labor supply and hence the accumulation of labor market experience and tenure" (p. 254). They estimate a direct negative effect of children on wages of 4% for one child and 19% for two or more children. For a sample of Canadian women in 1980, Smith and Stelcner (1988) report a decrease in hours worked of 16% for each pre-schooler at home and a permanent decrease in the hourly wage rate offered of 3.9% for each child ever born. Since the effect on wages is interpreted as a consequence of lost working experience, it can be considered as part of our measure of the cost to women of having children.

The main implication of our findings is that relatively small differences between men and women are enough to understand relatively large differences in the levels of education of men and women. This result is consistent with Becker's (1991) view that "small biological differences between men and women can cause huge differences in the activities of husbands and wives" (p. 4). This does not imply, however, that discrimination is not an important factor in many countries. In fact, we believe discrimination may very well explain variations in the data that a highly stylized model such as ours cannot possibly explain.

6. Concluding Remarks

In this paper, we have interpreted observed gender differences in education as the equilibrium outcome of a two-sex overlapping generations model in which men and women of each generation bargain not only over their own consumption but also over the number of children and the investment in their children's education. This model represents a new framework for the analysis of the process of intrahousehold decision making in an intergenerational setting.

Abstracting from gender discrimination in both the labor market and the household, we have assumed that men and women are identical except for the fact that women bear children. Hence, gender differences in education emerge in equilibrium as a consequence of this basic difference between men and women. However, the difference in the levels of education of boys and girls implied by our model is smaller than what is consistent with a pure investment model. This result derives from the fact that parents take into account that husbands partially compensate wives for the income loss suffered as a consequence of child bearing, which increases the returns from the investment in women's education.

We have shown that incorporating the time cost of child rearing--understood as care that is provided inside the household--into the analysis reinforces our results. Even if this cost can be borne by either parent, as long as the time cost associated with bearing children is positive, our model predicts that women also bear the entire time cost associated with child rearing. Thus, the cost to a woman of having children is a combination of child bearing and child rearing, and these two components cannot be identified separately.

Since the time cost to women of having children increases with the number of children, the gender gap in education levels increases with fertility. We have exploited the simple structure of our model to construct a measure of the cost to a woman of having a child in 146 countries, using aggregate data on fertility rates and mean years of schooling by gender. The measure we have obtained indicates that this cost is higher on average in developing countries than in developed countries. Our measure is also positively correlated with infant mortality, which affects the number of pregnancies and births that are necessary to produce a surviving child. Once we control for cross-country differences in infant mortality rates, however, the difference between developing and developed countries is no longer statistically significant. Thus, we have interpreted the intercept in a linear regression of our constructed measure of the cost to a woman of having a child on infant mortality and a dummy variable for developing countries as an estimate of the fundamental cost associated with having a child. The estimate we have obtained indicates that such cost amounts to 5-6% of the working lifetime of a woman, a number we believe to be reasonable. Since this estimate includes the time cost of rearing children, we conclude that a relatively small biological difference between men and women is enough to understand relatively large differences in the levels of education of men and women.

The stylized model studied here can be extended in a number of directions. Two generalizations that are currently on our research agenda consist of allowing for more general specifications of preferences and endogenizing labor supply decisions. One of the results we expect to obtain by allowing a more general specification of preferences is to provide an

explanation for the existence of dowries in the form of transfers from the family of the bride to the family of the groom.²² To illustrate the logic, consider the basic model presented in Section 2 but assume that individuals are risk averse and each child is either a boy or a girl with probability one-half. Since boys receive more education than girls, then total consumption of families with two boys is lower than that of families with one boy and one girl, that in turn is lower than the total consumption of families with two girls. By transferring income from families with girls to families with boys, dowries provide a way of smoothing consumption across states of nature. *Ex ante*, risk averse parents would then be willing to enter such a Pareto improving contract. This provides an insurance explanation for the existence of dowries that complements the one proposed by Becker (1991) based on marriage market imperfections.²³

²² Such an institution plays an important role in many developing countries and, in particular, in India.

²³ We thank Ken Wolpin for pointing out this implication of our model.

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Appendix 1

As we can see from equations (7) and (8), the state variables of our economy depend only on the parameters of the model. Therefore, if in the initial period the levels of education are not those corresponding to the steady state, the steady state will be reached in one period. Hence,

$$\begin{aligned}
 V^m(e_m, e_f) &= w(e_m) - \frac{\alpha w(e_f) + p (e'_m + e'_f)}{2} + \beta (V^m(e'_m, e'_f) + V^f(e'_m, e'_f)) \\
 &= w(e_m) - \frac{\alpha w(e_f) + p (e'_m + e'_f)}{2} + \\
 &\quad \frac{1}{2} \sum_{t=1}^{\infty} (2\beta)^t (w(e'_m) + (1 - \alpha) w(e'_f) + p (e'_m + e'_f)) \\
 &= w(e_m) - \frac{\alpha w(e_f) + p (e'_m + e'_f)}{2} + \\
 &\quad \frac{\beta (w(e'_m) + (1 - \alpha) w(e'_f) + p (e'_m + e'_f))}{(1 - 2\beta)}
 \end{aligned}$$

and similarly,

$$\begin{aligned}
 V^f(e_m, e_f) &= w(e_f) - \frac{\alpha w(e_f) + p (e'_m + e'_f)}{2} + \\
 &\quad \frac{\beta (w(e'_m) + (1 - \alpha) w(e'_f) + p (e'_m + e'_f))}{(1 - 2\beta)},
 \end{aligned}$$

where $e'_m = w'^{-1}\left(\frac{p}{2\beta}\right)$ and $e'_f = w'^{-1}\left(\frac{p}{(2-\alpha)\beta}\right)$. The conditions we impose on the wage function guarantee that there is a unique solution to (1)-(2), (7)-(8). Therefore, V^m and V^f exist and are unique.

To guarantee that marriages occur in every period, it has to be true

that the utility level people attain by marrying is greater than the one they can achieve if they remain single, that is, $V^m(e_m, e_f) \geq w(e_m)$ and $V^f(e_m, e_f) \geq w(e_f)$. These conditions imply

$$\frac{2 \beta (w(e'_m) + (1 - \alpha) w(e'_f) - p (e'_m + e'_f))}{(1 - 2 \beta)} \geq \alpha w(e_f) + p (e'_m + e'_f).$$

The left-hand side of this expression represents the utility from having children, and the right-hand side represents the cost of having them.

Appendix 2

Consider the generalization of the basic model presented in Section 4, where we extend the domain of the intrafamily bargaining to incorporate decisions about the fraction of the time cost associated with rearing children borne by each parent. If we let γ denote such (fixed) total time cost, and let γ_m and γ_f denote, respectively, the time spent by the father and by the mother rearing their children, the Nash-bargaining problem faced by couples in each generation becomes

$$(A') \text{ Max}_{\{c_m, c_f, e'_m, e'_f, \gamma_m, \gamma_f\}} [c_m + \beta (V^m(e'_m, \bar{e}'_f) + V^f(e'_f, \bar{e}'_m)) - w(e_m)] \cdot$$

$$[c_f + \beta (V^m(e'_m, \bar{e}'_f) + V^f(e'_f, \bar{e}'_m)) - w(e_f)]$$

s. t.

$$c_m + c_f + p (e'_m + e'_f) = (1 - \gamma_m) w(e_m) + (1 - \alpha - \gamma_f) w(e_f),$$

and

$$\gamma_m + \gamma_f = \gamma.$$

From the system of first order conditions for (A'), we obtain

$$(1') \quad c_m = \frac{2 - \gamma_m}{2} w(e_m) - \frac{\alpha + \gamma_f}{2} w(e_f) - \frac{p}{2} (e'_m + e'_f)$$

$$(2') \quad c_f = \frac{2 - \alpha - \gamma_f}{2} w(e_f) - \frac{\gamma_m}{2} w(e_m) - \frac{p}{2} (e'_m + e'_f)$$

$$(3') \quad e'_m = w'^{-1} \left[\frac{p}{(2 - \gamma'_m) \beta} \right]$$

$$(4') \quad e_f' = w'^{-1} \left(\frac{p}{(2 - \alpha - \gamma_f') \beta} \right)$$

$$(5') \quad \gamma_m = \begin{cases} 0 & \text{if } e_m > e_f \\ \xi & \text{if } e_m = e_f \\ \gamma & \text{if } e_m < e_f \end{cases}$$

$$(6') \quad \gamma_f = \begin{cases} 0 & \text{if } e_f > e_m \\ \gamma - \xi & \text{if } e_f = e_m \\ \gamma & \text{if } e_f < e_m \end{cases}$$

where $\xi \in [0, \gamma]$, and γ_m' and γ_f' denote decisions about the allocation of the time cost associated with child rearing between husband and wife of the next generation.

To decide how much education to provide for their children, parents take into account the amount of time that their daughter and their son will devote to child rearing, which depends upon the education that they and their spouses receive:

$$(7') \quad \gamma_m'(e_m', \tilde{e}_f') = \begin{cases} 0 & \text{if } e_m' > \tilde{e}_f' \\ \xi & \text{if } e_m' = \tilde{e}_f' \\ \gamma & \text{if } e_m' < \tilde{e}_f' \end{cases}$$

and

$$(8') \quad \gamma_f'(e_f', \tilde{e}_m') = \begin{cases} 0 & \text{if } e_f' > \tilde{e}_m' \\ \gamma - \xi & \text{if } e_f' = \tilde{e}_m' \\ \gamma & \text{if } e_f' < \tilde{e}_m' \end{cases}$$

Consider, for instance, a representative couple that must decide how much to invest in the education of their son. Using (7') and (8'), note that his

consumption will be

$$(9') \quad c'_m(e'_m, \tilde{e}'_f) = \begin{cases} w(e'_m) - \frac{\alpha + \gamma}{2} w(\tilde{e}'_f) - \frac{p}{2} (e''_m + e''_f) & \text{if } e'_m > \tilde{e}'_f \\ \frac{2 - \xi}{2} w(e'_m) - \frac{\alpha + (\gamma - \xi)}{2} w(\tilde{e}'_f) - \frac{p}{2} (e''_m + e''_f) & \text{if } e'_m = \tilde{e}'_f \\ \frac{2 - \gamma}{2} w(e'_m) - \frac{\alpha}{2} w(\tilde{e}'_f) - \frac{p}{2} (e''_m + e''_f) & \text{if } e'_m < \tilde{e}'_f \end{cases}$$

which, for any given level of education of his spouse, is increasing in his

education.²⁴ Using (3'), we have that for any given $\tilde{e}'_f < w'^{-1}\left(\frac{p}{2\beta}\right)$, it is a

best response for the parents of the boy to choose $e'_m = w'^{-1}\left(\frac{p}{2\beta}\right)$, while if

$\tilde{e}'_f \geq w'^{-1}\left(\frac{p}{2\beta}\right)$, then their best response is $e'_m = w'^{-1}\left(\frac{p}{(2-\gamma)\beta}\right)$.

Analogously, if we consider a representative couple that must decide how much to invest in the education of their daughter, we have that their best

response to any given $\tilde{e}'_m < w'^{-1}\left(\frac{p}{(2-\alpha)\beta}\right)$ is $e'_f = w'^{-1}\left(\frac{p}{(2-\alpha)\beta}\right)$, while if

$\tilde{e}'_m \geq w'^{-1}\left(\frac{p}{(2-\alpha)\beta}\right)$, their best response is $e'_f = w'^{-1}\left(\frac{p}{(2-\alpha-\gamma)\beta}\right)$.

Combining the two problems we obtain that the unique Nash equilibrium to the game between the families of the bride and the groom is characterized by the following conditions:

$$(10') \quad e'_m = w'^{-1}\left(\frac{p}{2\beta}\right)$$

²⁴ We are assuming here that an interior solution to problem (A') exists at any date. Because of the linearity of preferences, this implies that the optimal investment decisions of parents do not depend on their income.

and

$$(11') \quad \tilde{\epsilon}'_f = w'^{-1} \left(\frac{p}{(2 - \alpha - \gamma) \beta} \right).$$

A graphical illustration of the equilibrium is presented in Figure 3.

Appendix 3

Developing Countries

<u>Country</u>	<u>Alpha</u>	<u>Country</u>	<u>Alpha</u>
Afghanistan	0.254	Honduras	0.029
Algeria	0.325	Hong Kong	0.536
Angola	0.139	India	0.329
Argentina	-0.040	Indonesia	0.259
Bahamas	0.060	Iran, Islamic Rep. of	0.107
Bahrain	0.162	Iraq	0.111
Bangladesh	0.296	Jamaica	0.015
Barbados	0.073	Jordan	0.115
Benin	0.205	Kenya	0.181
Bhutan	0.203	Korea, Dem. Rep. of	0.315
Bolivia	0.170	Korea, Rep. of	0.456
Botswana	0.015	Kuwait	0.112
Brazil	0.034	Lao People's Dem. Rep.	0.124
Brunei Darussalam	0.114	Lebanon	0.212
Burkina Faso	0.103	Lesotho	-0.193
Burundi	0.168	Liberia	0.223
Cambodia	0.116	Libyan Arab Jamahiri	0.232
Cameroon	0.239	Madagascar	0.105
Cape Verde	0.270	Malawi	0.143
Central African Rep.	0.222	Malaysia	0.064
Chad	0.203	Maldives	0.075
Chile	0.064	Mali	0.241
China	0.345	Mauritania	0.264
Colombia	-0.041	Mauritius	0.327
Comoros	0.094	Mexico	0.024
Congo	0.205	Mongolia	0.023
Costa Rica	0.022	Morocco	0.283
Côte d'Ivoire	0.186	Mozambique	0.140
Cuba	-0.027	Myanmar	0.140
Cyprus	0.126	Namibia	0.000
Djibouti	0.173	Nepal	0.246
Dominican Rep.	0.075	Nicaragua	-0.036
Ecuador	0.045	Niger	0.141
Egypt	0.283	Nigeria	0.214
El Salvador	0.043	Oman	0.231
Equatorial Guinea	0.261	Pakistan	0.241
Ethiopia	0.152	Panama	-0.040
Fiji	0.119	Papua New Guinea	0.185
Gabon	0.256	Paraguay	0.052
Gambia	0.251	Peru	0.111
Ghana	0.181	Philippines	0.050
Guatemala	0.050	Qatar	0.030
Guinea	0.229	Rwanda	0.157
Guinea-Bissau	0.296	Saudi Arabia	0.230
Guyana	0.071	Senegal	0.215
Haiti	0.143	Sierra Leone	0.000

Developing Countries

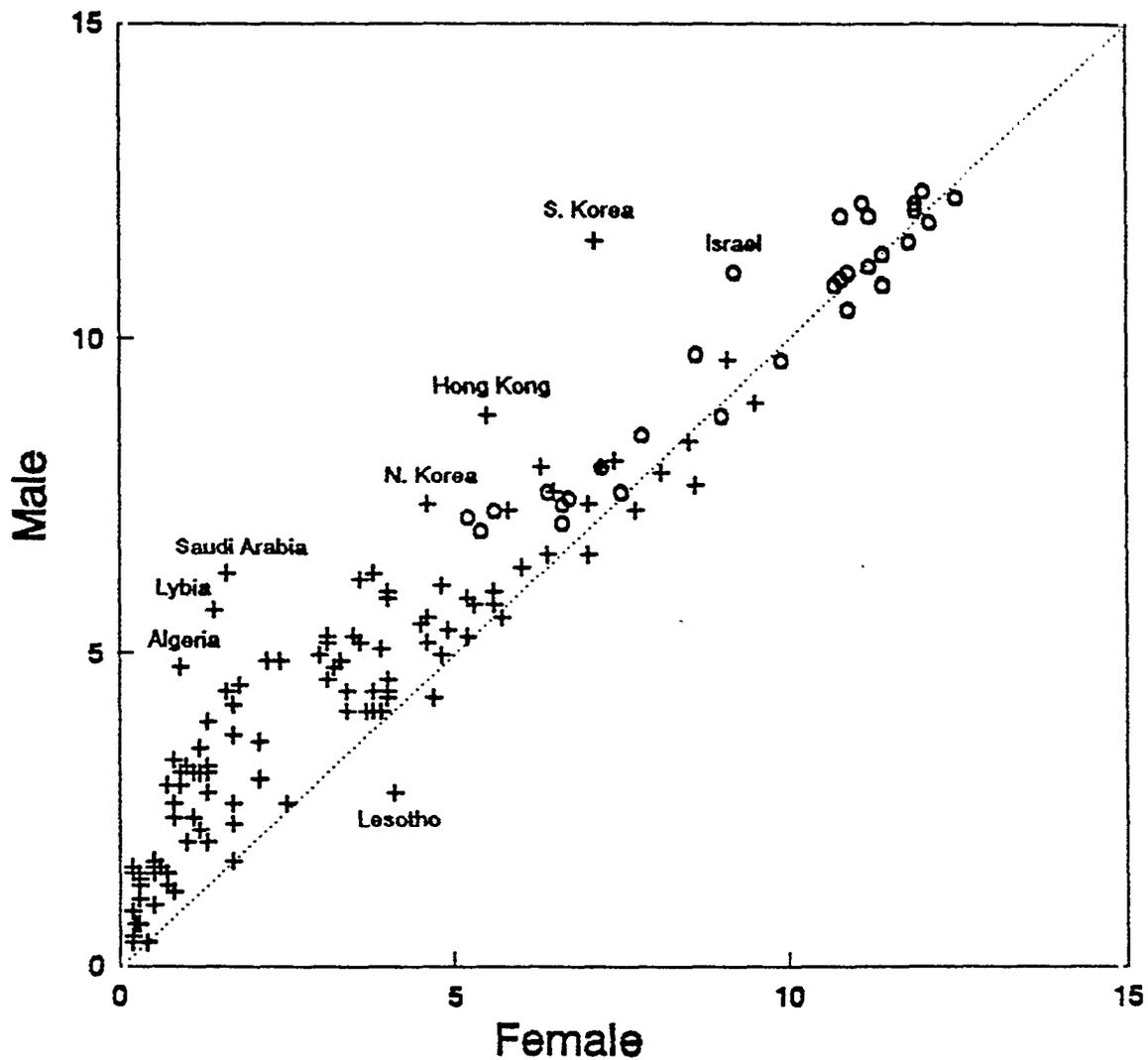
<u>Country</u>	<u>Alpha</u>
Sri Lanka	0.170
Sudan	0.161
Suriname	0.050
Swaziland	0.068
Syrian Arab Rep.	0.128
Tanzania, U. Rep. of	0.158
Thailand	0.198
Togo	0.202
Trinidad and Tobago	-0.009
Tunisia	0.341
Turkey	0.283
Uganda	0.171
United Arab Emirates	-0.008
Uruguay	-0.097
Venezuela	0.019
Viet Nam	0.210
Yemen	0.237
Zaire	0.199
Zambia	0.166
Zimbabwe	0.218

Developed Countries

<u>Country</u>	<u>Alpha</u>
Bulgaria	0.166
Canada	0.036
Czechoslovakia	0.122
Denmark	0.021
Finland	0.020
France	-0.019
Germany	0.120
Greece	0.144
Hungary	-0.023
Ireland	-0.021
Israel	0.118
Italy	0.020
Japan	0.022
Netherlands	-0.054
New Zealand	-0.036
Norway	0.026
Poland	0.078
Portugal	0.311
Romania	0.097
Spain	0.101
Sweden	0.000
Switzerland	0.083
USA	-0.016
USSR*	0.087
United Kingdom	-0.018
Yugoslavia*	0.241

* Data refer to 1990.

Figure 1: Mean Years of Schooling



+ : Developing Countries

o : Developed Countries

Source: United Nations, Human Development Report, 1994.

Figure 2: Measures of Alpha

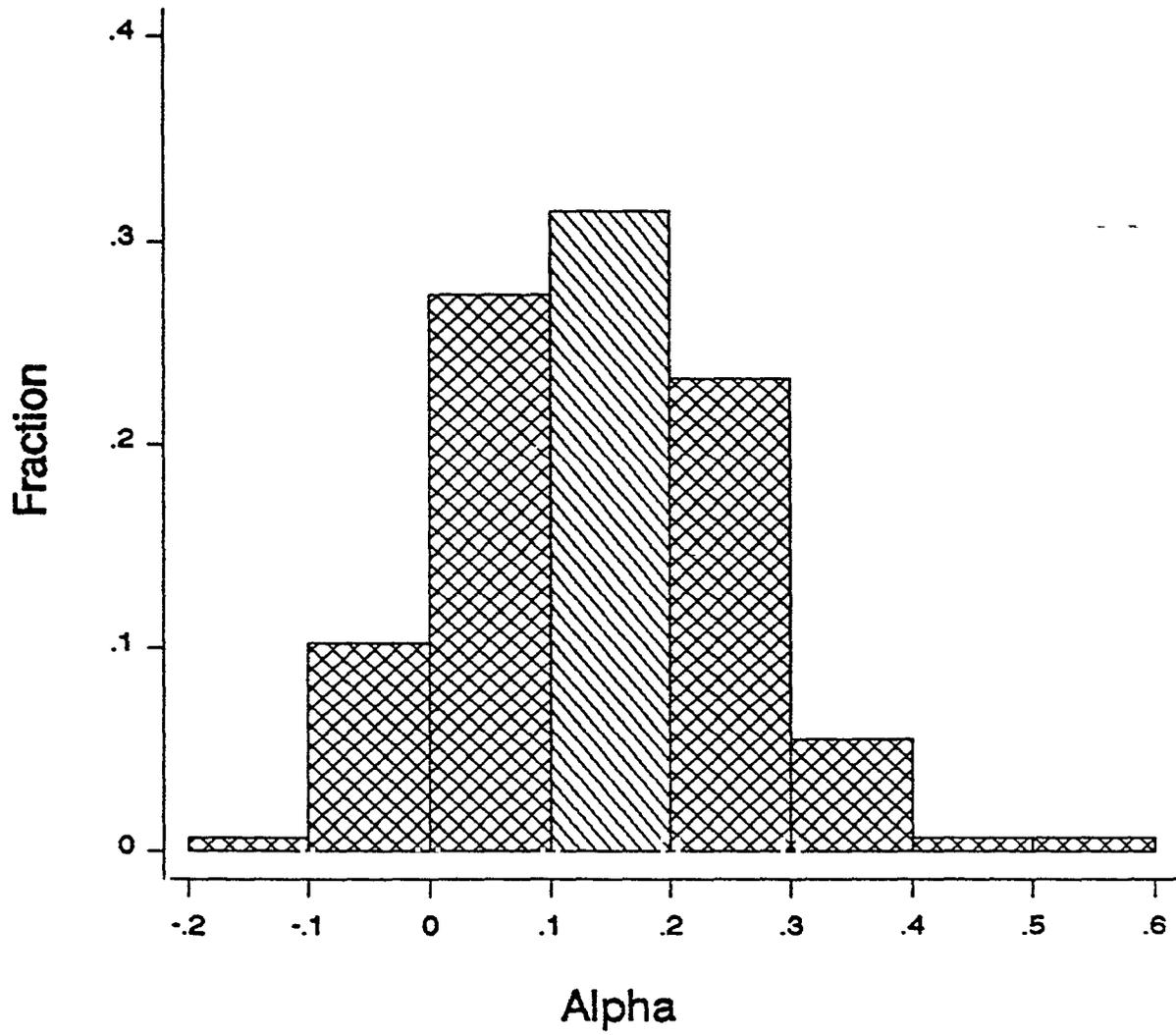
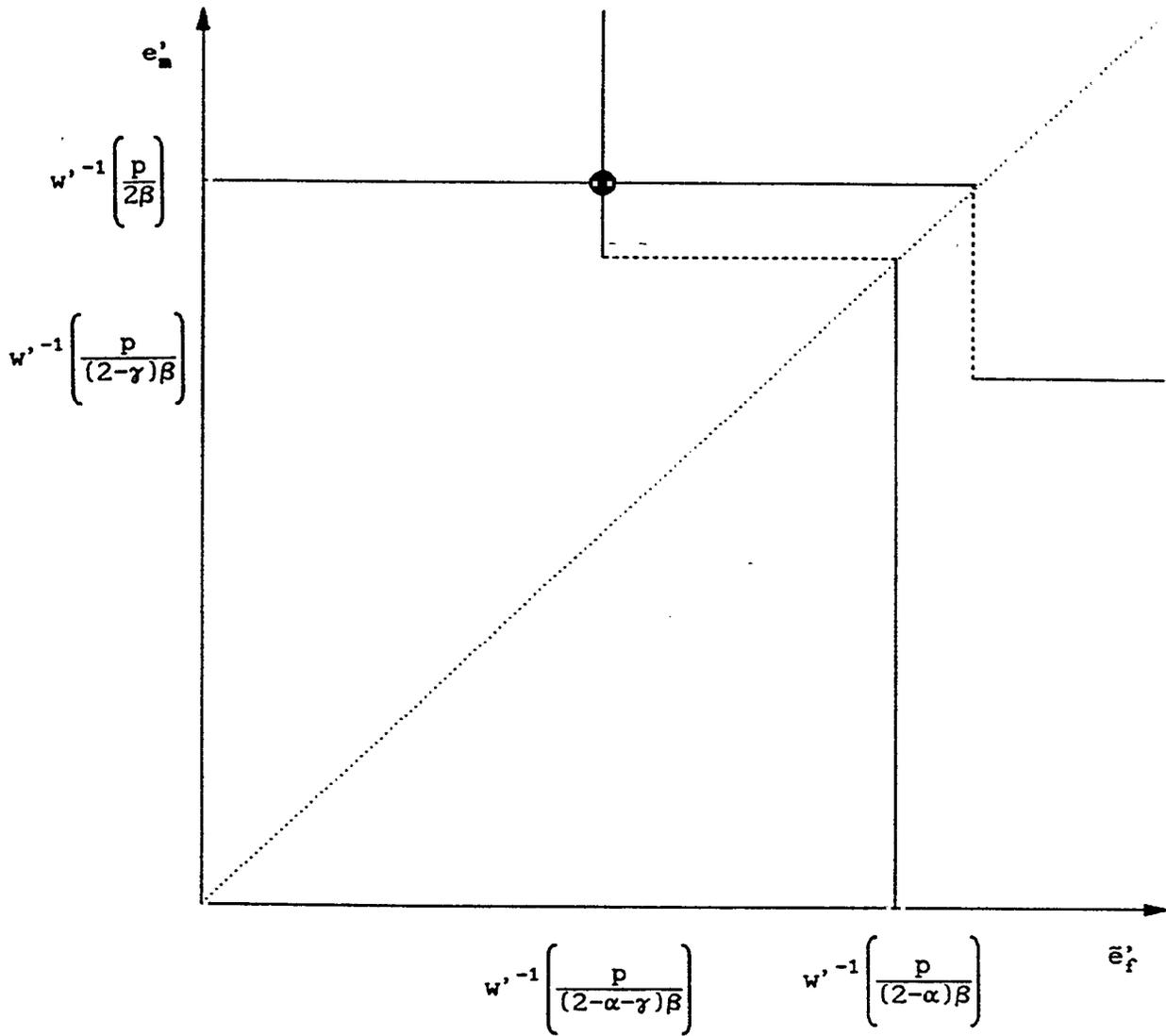


Figure 3: Nash Equilibrium



— : Best Response Functions

● : Nash Equilibrium