J. theor. Biol. (1998) **194,** 383–390
Article No. jt980764

Individual Sex Preferences and the Population Sex Ratio of Newborns

C. Y. Cyrus Chu*‡ and R. Yu†

**Department of Economics, National Taiwan University and Institute of Economics, Academia Sinica and †Department of Industrial Economics, Tamkang University*

(*Received on* 22 *December* 1997, *Accepted in revised form on* 1 *June* 1998)

This paper proposes the hypothesis that countries with stronger sex preferences are more likely to have a negative relationship between crude birth rates and male/female ratios of newborn babies. Conversely, the existence of a significantly negative relationship in any country may also be a supportive evidence of its preferences for sons. Our hypothesis is both behavioral and biological: on the behavioral side, parents with strong sex preferences are inclined to continue to bear children if the existing sex ratio of children is less than desirable. On the biological side, parents with many girls are more likely to be "girl producers", who with individual-specific biological characteristics tend to generate higher female births. We use the macro data in the United Nations *Demographic Yearbook* to verify and test our hypothesis. For developing countries which do not have reliable micro data on fertility, our approach using macro data is a useful and interesting alternative.

1. Introduction

Economists have made reference to two types of sex preferences: the first type is related not to birth decision, but to resource allocation among children already born (Behrman *et al*., 1986; Chu, 1991). Parents who prefer sons are assumed to give more resources to sons than to daughters. This kind of *ex post* resource allocation consideration has no evident relationship with *ex ante* child-bearing decisions, and is not the focus of this paper. The second type of sex preference is the desired boy–girl ratio parents have in mind. If the existing sex ratio is not to their liking, they will either bear more children (Ben-Porath & Welch, 1976; DeTray, 1984) or shorten the birth-interval (Rosenzweig, 1986) so as to increase their chance of obtaining the desired ratio. Although there are cases of daughter preferences or even-handed sex preferences, the prevailing preference type in many Asian countries is for sons.§ It would be interesting to know how the prevailing micro household son preferences in these countries would affect their macro population sex ratios. And if a theoretical hypothesis about the relationship between sex preferences and the population sex ratio can be established, we may be able to use macro empirical data to infer whether there are prevalent sex preferences in particular areas of the world.

Most previous empirical research on sex preferences (Repetto, 1972; Ben-Porath & Welch, 1976) used *micro* data concerning family

Present address: Institute of Economics Academia Sinica, Nankang, Taipei, Taiwan.
‡Author to whom correspondence should be addressed.
§See Williamson (1976) for a comprehensive discussion concerning practices of sex preferences around the world.

0022–5193/98/190383 + 08 $30.00/0

decisions. The usual approach is to test whether the existing male/female composition of children has any (significantly) negative impact on parents' decision to have more children. In fact, many papers cited in the previous paragraph support the above-mentioned negative impact. But even if a significant proportion of parents with son preferences do try to have more children so as to achieve their desired boy/girl ratio, the population sex ratio should not be affected. The reasoning is simple: if the probability of bearing a boy or a girl is 50:50, then the intention of parents with son preferences to bear more will still face only 50:50 odds. The realized population sex ratio *outcome* of newborn babies, by the law of large numbers, will always stay at 50:50.

However, recent biological science literature may tell us a different story. Even if the societal average sex ratio of newborns is 50:50, prevalent son preferences will indeed cause a predictable relationship between the total fertility rate and the population sex ratio. Such an implication can be verified and tested using *macro* data. This work is made even more interesting by the fact that many countries with strong son preferences are developing countries where high-quality micro fertility data are not available.

The purpose of this short paper is to derive and test a simple hypothesis which says that, other things being equal, the population sex (male/female) ratio of newborns and the fertility rate should be negatively related in countries with strong son preferences, and should be unrelated for countries with weak sex (son or daughter) preferences. Our hypothesis is derived in Section 2, based upon a combination of biological and economic arguments. Then in Section 3 we use the aggregate United Nations data to test our hypothesis. It turns out that the macro data are compatible with the sociologists' field research summarized in Williamson (1976). The final section contains extensions and conclusions.

2. A Heuristic Derivation of the Hypothesis

As far as we know, previous economic research on sex preferences, unlike biological literature on the same subject, has never focused on population sex ratio. Biological arguments on the macro sex ratio, however, are unrelated to behavioral assumptions or human decisions, which is what the economists are interested in.* Thus, on the subject of sex preferences there appears to be a gap between economic research and biological research. But as we move forward, we will see that to some extent this gap can be bridged.

For the time being let us consider a simple situation without sex-based abortion.† Based on 1970 U.S. Census data, Ben-Porath & Welch (1976) showed that, for any two families with the same number of children, the one with more boys tends to have a smaller probability of having one more birth.‡ The sex preferences presented above are characterized by the parents' attempt to change the boy/girl ratio within their family. Our question is: whether these micro attempts would affect the macro characteristics of the population.

If the probability of having male and female newborns is not individual-specific, then the sex of each newborn baby is determined independently; hence the resulting aggregate sex ratio will not be affected by the prevalence of sex preference, as we explained in Section 1. But recent biological studies have come up with strong evidence that points to a different direction. According to James (1990, 1992, 1995a, b) and Williams & Gloster (1992), bearing a male or female baby is not totally random. They point out that factors such as follicular phase length, parental hormone level, race, parental coital rates, and caloric intake, all have influence on the newborn sex ratio of humans or

*Although "choices" were discussed in the literature of biology, these are genetic rather than economic choices.

†Although technique of sex-based abortion has been available for some time now, it is still an illegal or at least an uncommon practice in many places. See Bennett (1983) for a discussion of the legal issues along the common law doctrine.

‡The evidence in other countries and other historic periods may be different. For instance, Edwards (1958), citing evidence in some previous work, argued that in some areas of nineteenth-century Germany, the families least likely to continue giving birth were those for which the existing children's sexes were evenly balanced.

other mammalians.* Among those factors that influence the sex ratio, some (such as the hormone level or the parental coital rates) are not society-based but indeed individual-specific. For instance, if a mother has a lower-than-normal hormone level, according to James' research, she is more likely to bear girl babies.† Ben-Porath & Welch (1976) call those mothers who have a higher probability of having female-birth "girl producers". Similarly, parents who have a larger probability than others to bear male babies are called "boy producers". We will show below that this biological finding has helped in establishing the relationship between parental sex preferences and the population sex ratio.

If parents have strong son preferences, ceteris paribus, the boy-producers are likely to be satisfied (with the family size) at a relatively low birth level, while the girl-producers will have to bear many girls before they finally have enough boys. As such, we would predict, as did Ben-Porath & Welch (1976), that for regions without sex preferences or with even-handed sex preferences, the aggregate sex (male/female) ratio of newborn babies should be nearly unrelated to the fertility rate; whereas for regions with strong son preferences, the male/female ratio of newborn babies should have a pattern *negatively-related* to the fertility rate.‡ This is the implication against which we shall test our data.

The above negative-relation prediction is in fact robust even for regions known for prevalent (albeit illegal) sex-based abortion. In these regions, parents do not have to have a lot of births to have the number of sons they desire. They can keep on aborting until a boy is on its way, so that the resulting male/female ratio of newborns may be high, but the fertility rate will remain low. Thus, even with prevalent sex-based abortions, there is still a negative relationship between the fertility rate and the male/female ratio of newborn babies in areas with strong son preferences.

*The most well-known scientific analysis of the equilibrium sex ratio of a specie was the classic work done by Fisher (1958). Research along this line emphasized the mechanism of genetic selection over a very long period of time, whereas the focus of this paper is different.

†There are two types of individual-specific factors which affect the probability of a male-birth: the first type refers to factors which may vary over the parents' life cycles (such as the age and birth order of the parent). The second type refers to factors which are less variant throughout parents' life cycles (such as the relative hormone level or the follicular phase length of mothers). As we average across parents in different life-cycle stages in the society, the *aggregate* proportion bias of male births can be explained only by the second type of factors.

‡Although the above implication is obvious intuitively, a rigorous proof of it is not an easy task. Detailed analysis of this problem is possible only after we specify the exact *type* of sex preferences (at-least-one-boy, stop-at-one-boy, at-least-two-boys, etc.), and the exact *stopping rule* of births (stop trying after three consecutive girls, stop trying when the number of children is four, stop trying when the mother is aged 39 etc.). Crouchley & Pickles (1984) tried to identify the type of process generating the secondary sex ratio under various stopping rules. Yamaguchi (1989) analysed the effects of different stopping rules on the average number of siblings of both sexes. A recent analysis by Leung (1991) showed that under some specifications of parental preferences, parents with son preferences are less likely to stop bearing. It is not the purpose of this paper to go into the detailed mathematical derivation of these hypotheses.

3. An Empirical Test using Macro Data

Let the fertility rate and the sex ratio (boys/girls) of newborn babies in country i at period t be, respectively, $m_{i,t}$ and $r_{i,t}$. Although we are not analysing whether it is the cultural factor (Williamson, 1976) or the economic factor (Ben-Porath & Welch, 1976) that give rise to preferences for sons, our analysis in Section 2 clearly predicts that, other things being equal, $r_{i,t}$ and $m_{i,t}$ should be negatively related in regions with stronger son preferences. This hypothesis will be tested using United Nations data.

3.1. DATA

Based on her extensive review of the previous literature, Williamson (1976, p. 99) provided a summary of rank orderings of parental sex preferences for different societies. Since this kind of general social attitude is unlikely to have significantly changed in the short run, we shall take Williamson's summary rank order as our basic indicator of sex preferences in various places.

Sometimes men and women in the same region were found by Williamson to have different intensities of son preferences, but usually the

TABLE 1
$r_{i,t}$ *and* $m_{i,t}$ *data description*

	Country	Data periods	Son preference by women	αti_i
Group-1 countries	Egypt	1971–74, 1977–89, 1991	+4	9.310
	Tunisia	1974, 78–80, 1985–89	+4	3.783
	Korea	1978–89, 91, 93	+3	−4.791
	Taiwan	1971–94	+3	−4.340
Group-2 countries	Denmark	1971–92	+1	−6.451
	Finland	1971–90	+1	−5.453
	Norway	1971–92	+1	−5.020
	Sweden	1971–93	+1	−5.947
	U.S.A.	1971–88, 91	+1	−2.937
	Israel	1982–85, 87–93	0	4.047
	Chile	1971, 73, 77–91, 93	−1	4.013
	Cuba	1971, 76–88, 91	−1	−1.195
	Mexico	1974, 76, 78, 80, 83, 88, 93	−1	16.147
	Puerto-Rico	1971–85, 87–92	−1	2.994
	Uruguay	1971–79, 83–88	−1	0.649
	Venezuela	1971–79, 81–89	−1	13.523

Notes: $m_{i,t}$ and $r_{i,t}$ are from the United Nations *Demographic Yearbooks* and Taiwan *Population Statistics Yearbooks*. Son preference indexes for all countries are provided by Williamson (1976, p. 99). α_is are part of the estimation results which should be included in another table; they are listed here just to save space for our presentation.

difference is not large. In the empirical analysis presented here, we choose to use women's (mother's) son-preference index.* As shown in Table 1, among the sample countries, Tunisia and Egypt are ranked +4 by Williamson, meaning that there are "very strong son preferences" in these two countries. Women in Taiwan and South Korea also share "strong son preferences", receiving an index of +3. All other countries have son preference indexes less than 1 or negative (daughter preferences).†

*We also redo the regression by using the men's indexes, and the results are qualitatively the same.

†Williamson's focus was on the causes of parental sex preferences; she did not have much discussion on the differential treatment or resource allocation among children of different sexes. Related studies on the latter issue can be found in Kumm *et al*. (1994), and Strauss & Thomas (1995, pp. 1983–1988). But as we show in Table 1, since all countries specified as having girl preferences in our analysis are ranked as having "weak" daughter preferences (indexed −1), the sex-preferential-induced differential treatment among boys and girls is not expected to be serious in these countries.

‡The Philippines has the data for newborns sex ratios only in 1978 and 1983.

Because the fertility rate data for certain "areas" (instead of countries) Williamson studied are not available, we have to limit our study to those countries that appeared in Williamson's summary table (p. 99), including Tunisia, Egypt, Korea, Taiwan, Israel, the Nordic countries (Finland, Norway, Sweden and Denmark), the U.S.A., Latin American and Caribbean countries (Cuba, Mexico, Puerto-Rico, Venezuela, Uruguay and Chile), Algeria, India, Lebanon and the Philippines. Since for many years the United Nations *Demographic Yearbooks* do not carry the sex ratio data of newborn babies for the last four countries,‡ we are compelled to take them out and conduct our study on the remaining 16 countries.

The period of our data collection starts from 1971, when the post-war baby-boom was long over and data for most of our sample countries are available. Even if we had data prior to 1971 for some of the developing countries listed in Williamson's table, they might be of little use for this analysis for the following reason: in our previous discussion, we see that one premise of our negative-relation prediction is that fertility rates are a variable under the active control of parents. When fertility rates are generally high (in the baby-boom period or in the early period of developing countries), parents will just keep on having more babies even after they have their desired number of boys. So in periods or countries without family planning, son preferences will not be reflected in parents' birth decisions, and therefore will not affect the fertility rate.

The data available for our empirical analysis are yearly time series of fertility rates and newborn male/female sex ratios for 16-countries. Thus, essentially we have a panel data set of $r_{i,t}$ and $m_{i,t}$. An effective data point can be counted for country i and period t only if *both* $r_{i,t}$ and $m_{i,t}$ are available; partial information would not be of help because we are interested in the relationship between variables r and m. The data of all countries except Taiwan are from the United Nation *Demographic Yearbooks*. Table 9 of the *Yearbook* contains crude live-birth rates; the newborn sex ratios are shown in Table 10 of the *Yearbooks*. The data for Taiwan left out in the UN *Yearbook* are obtained from *Population Statistics* published by the Ministry of Interior Affairs of Taiwan.

From Table 1 we see that we have unbalanced data across countries; i.e. different countries have different effective data periods. Fortunately, this is not going to be a problem since Hsiao (1986) has shown clearly how to estimate panel data models with unbalanced observations, and LIMDEP has available a program to deal with this unbalanced-data estimation.

3.2. ESTIMATION

Since observations on any single country may be too narrow in scope, we decide to separate our observations into two diverse groups, and test if there is any distinction between these two groups. The first group includes Korea, Taiwan, Tunisia and Egypt which, according to Table 1, have strong ($\geqslant +3$) son preferences. The other group includes Latin American and the Caribbean countries, the U.S.A. and Nordic countries. These 12 countries have weak sex preferences. Our analysis in the previous section tells us that there should be a (significantly) negative relationship between $r_{i,t}$ and $m_{i,t}$ for countries in group 1, and almost no relationship for countries in group 2.

In order to obtain an estimation of the relationship between $r_{i,t}$ and $m_{i,t}$, we have to control for country-wise difference in fertility rates. There is also a general decline in fertility for almost all our sample countries. To take into account the above cross-section and time trend effects, we consider the following two-factor fixed effect model:*

$$m_{i,t} = \alpha_0 + \alpha_i + \gamma_t + \beta r_{i,t} + \epsilon_{i,t} \qquad (1)$$

where α_i is the country effect, γ_t is the time effect, and $\varepsilon_{i,t}$ is the error term associated with the (i,t)-th observation. α_i characterizes the country-specific differences in birth rates, due to factors such as age structure or cultural background. γ_t characterizes the trend of fertility decline or other common time-dependent factors. There are also two constraints.

$$\sum_i \alpha_i = \sum_t \gamma_t = 0,$$

which are imposed to normalize the total country effect and time effect to zero. Given that the country effect and the trend effect are controlled, the sign of the coefficient of $r_{i,t}$ tells us whether there is any relationship between $r_{i,t}$ and $m_{i,t}$† Notice that our hypothesis is compatible with a possible difference in newborn sex ratios across countries due to race or other factors, as suggested by James (1990); the possible difference in the *level* of sex ratios across countries should be absorbed by the α_i term, and should not affect the validity of our hypothesis.

*See Hsiao (1986, Chaps 3 and 8).

†An alternative approach is to run the following simple regression:

$$m'_{i,t} = \alpha_0 + \beta r_{i,t} + \epsilon'_{i,t}, \qquad (*)$$

where $m'_{i,t} \equiv m_{i,t} - \hat{\alpha}_i - \hat{\gamma}_t$ is the normalized birth rate. In this normalization process, $\hat{\alpha}_i$ and $\hat{\gamma}_t$ are obtained by the demean regression $m_{i,t} = \hat{\alpha}_i + \hat{\gamma}_t + u_{i,t}$. Let the β estimate obtained from (1) be $\tilde{\beta}$ and that obtained from (*) be $\hat{\beta}$. Then it can be easily shown that $\tilde{\beta}$ and $\hat{\beta}$ are both unbiased and consistent estimators of β. The advantage of estimating (1) is that the problem of unbalanced observations has been solved by Hsiao (1986) and the computer program is readily available.

TABLE 2
Estimated $\tilde{\beta}$

Model	Countries with strong son preferences	Countries with weak sex preferences	F statistic
$m_{i,t} = \alpha_0 + \alpha_i + \gamma_t + \beta r_{i,t} + \varepsilon_{i,t}$	-65.247* (-3.29)	-1.608 (-1.21)	44.593*
$r_{i,t} = \alpha_0 + \alpha_i + \gamma_t + \beta m_{i,t} + \varepsilon_{i,t}$	-0.003* (-3.29)	-0.0005 (-1.21)	7.075*

Note: *indicates one-tailed significance at the 1% level. Values in parentheses are t-statistics.

In Table 2 we list the estimated coefficients of these two equations for group-1 countries (with strong son preferences) and group-2 countries (with weak sex preferences). There are 16 α_is and 24 γ_ts to be estimated. The estimated α_is, denoted as $\tilde{\alpha}_i$s, are listed in the last column of Table 1, the 24 estimates of γ_ts are not relevant and are therefore omitted. From the estimated coefficient $\tilde{\beta}$, we see that while $\tilde{\beta}$ is not significantly different from zero for group-2 countries, it is significantly negative for group-1 countries. We also carry out an F test: the null hypothesis is that the β coefficients for the two groups of countries are equal, and the alternative hypothesis is that the β coefficients for group-1 countries should be significantly smaller. The result shows that the null hypothesis is rejected in a one-tail test at the 1% level: 44.593 is larger than the threshold F value $F(1,\infty) = 6.63$.

4. Extensions and Conclusions

As was mentioned in the previous subsection, eqn (1) can be interpreted as a behavioral relationship, in which parents' fertility decisions are variables to be "explained" by the existing sex ratios. Biologists are examining this phenomenon the other way around. James (1987) showed that fewer males are born as birth order increases; fewer males are born as paternal age increases; and more males are born during and after wars when there is a reduced male–male competition for mates.

In fact, the relationship between $r_{i,t}$ and $m_{i,t}$ can also be explained in accordance with the causality biologists are used to. If we reverse the dependent and independent variables in (1), we can rewrite (1) as

$$r_{i,t} = \alpha_0 + \alpha_i + \gamma_t + \beta m_{i,t} + \epsilon_{i,t}, \tag{2}$$

with the following interpretation. In a country with strong son preferences, parents with a smaller male/female child ratio are more likely to be "girl producers". These parents' attempts to have more children make the $m_{i,t}$ on the right hand side of (2) larger. But the high fertility rate so generated is likely to be accompanied by a smaller male/female sex ratio for the population, because these high-fertility mothers are mostly "girl-producers". To go even further, we might treat $r_{i,t}$ as a dependent variable, and test whether there is any difference in $\tilde{\beta}$ for these two country groups. The result listed in Table 2 shows that the β coefficients are also significantly different for the two groups.*

It is also interesting to compare our regression in (2) with the one done by Williams & Gloster (1992) who also based their research on the sex ratio data provided in the United Nations *Demographic Yearbooks*. But in their correlation analysis, they did not control for the possible fertility differences in distinct countries over distinct periods. Neither did they provide any behavioral hypothesis to support their empirical analysis. Although they found that the male/female sex ratio across countries is negatively related to caloric availability, the result is hard to interpret. Our analysis shows that there may be an alternative explanation for the Williams &

*A more satisfactory approach is to allow for the endogeneity of *both* $r_{i,t}$ and $m_{i,t}$, and estimate eqns (1) and (2) as a system of simultaneous equations. However, to estimate such an equation system requires the incorporation of additional exogenous variables. Owing to the limitation of the current data set, this approach cannot be accomplished at the current stage.

Gloster finding. Suppose countries with low caloric availability are most likely traditional developing countries. As is well known, production activities in developing countries mostly depend upon primary labor. If the productivity of male labor is generally higher than that of female labor, which explains the economic incentive behind son preferences, then our hypothesis tells us that it is likely that we will observe high fertility rate and low male/female sex ratios in these countries. Caloric availability in a country may be just one variable among many that is correlated with the general attitude of son preferences in that country.

Finally, our result is quite robust with respect to sample countries not included in Williamson's analysis. Based on the general belief that many Asian countries share the tradition of son preferences, we add Japan and Singapore to the group-1 countries, and rerun eqn (1). It turns out that the β coefficient is still significantly negative. We then add some European countries that are not known to have significant sex preferences to group-2 countries. No matter what combinations of countries we choose from groups 1 and 2 for the corresponding F tests, the results are qualitatively the same.

The message contained in this short paper is simple: a country's sex preferences can be revealed by the relationship between its fertility rate and the sex ratio of newborn babies. Our hypothesis is both behavioral and biological: on the behavioral side, parents with strong sex preferences are inclined to continue bearing children if the existing sex ratio of children is less than desirable. On the biological side, parents who have many girls tend to be "girl producers" with individual-specific biological characteristics that generate higher probability of female future births. Our hypothesis says that countries with stronger sex preferences are more likely to have a negative relationship between fertility rates and male/female baby ratios. Conversely, the existence of a negative relationship can also be interpreted as objective evidence for son preferences.

For countries lacking reliable micro data on fertility, our macro estimation and testing may be an interesting alternative. A similar panel regression can be implemented with respect to data covering several countries or several areas of the same country. For instance, it is generally believed that rural areas, which have more intensive demand for male labor, tend to have stronger son preferences than urban areas. This general belief can be easily verified once we get the panel data of $r_{i,t}$ and $m_{i,t}$ of rural and urban areas.

We thank two anonymous referees for their detailed and helpful comments and suggestions.

REFERENCES

BEHRMAN, J., POLLAK, R. & TAUBMAN, P. (1986). Do parents favor boys? *Int. Econ. Rev.* **27,** 33–54.

BENNETT, N. (1983). *Sex Selection of Children*. New York: Academic Press.

BEN-PORATH, Y. & WELCH, F. (1976). Do sex preferences really matter? *Q. J. Econ.* **90,** 285–307.

CHU, C. Y. C. (1991). Primogeniture. *J. Polit. Econ.* **99,** 78–99.

CROUCHLEY, R. & PICKLES, A. R. (1984). Methods for the identification of Lexian, Poisson and Markovian variations in the secondary sex ratio. *Biometrics* **40,** 165–175.

DE TRAY, D. (1984). Son preferences in Pakistan: an analysis of intention vs. behavior. *Res. Popul. Econ.* **V,** 185–200.

EDWARDS, A. W. F. (1958). An analysis of Geissler's data on the human sex ratio. *Ann. Human Gen.* **15,** 6–15.

FISHER, R. A. (1958). *The Genetical Theory of Natural Selection*, 2nd Edn. New York: Dover.

HSIAO, C. (1986). *Analysis of Panel Data*. New York: Cambridge University Press.

JAMES, W. H. (1987). The human sex ratio. Part 1: A review of the literature. *Hum. Biol.* **59,** 721–752.

JAMES, W. H. (1990). The hypothesized hormonal control of human sex ratio at birth—an update. *J. theor. Biol.* **143,** 555–564.

JAMES, W. H. (1992). The hypothesized hormonal control of mammalian sex ratio at birth—a second update. *J. theor. Biol.* **155,** 121–128.

JAMES, W. H. (1995a). What stabilizes the sex ratio. *Ann. Hum. Gen.* **59,** 243–249.

JAMES, W. H. (1995b). Follicular phases, cycle day of conception and sex ratio of offspring. *Hum. Repro.* **10,** 2529–2533.

KUMM, J., LALAND, K. N. & FELDMAN, M. W. (1994). Gene-culture coevolution and sex ratios: the effects of infanticide, sex-selective abortion, sex selection, and sex-biased parental investment on the evolution of sex ratios. *Theor. Popul. Biol.* **46,** 249–278.

LEUNG, S.-F. (1991). A stochastic dynamic analysis of parental sex preferences and fertility. *Q. J. Econ.* **106,** 1063–1088.

REPETTO, R. (1972). Son preference and fertility behavior in developing countries. *Stud. Family Planning* **3,** 70–76.

ROSENZWEIG, M. (1986). Birth spacing and sibling inequality: asymmetric information within the family. *Int. Econ. Rev.* **27,** 55–76.

Strauss, J. & Thomas, D. (1995). Human resources: empirical modeling of household and family decisions. In: *Handbook of Development Economics*, Vol. III, (Behrman, J. & Srinivasan, T. N., eds). Amsterdam: North Holland.

Williams, R. & Gloster, S. (1992). Human sex ratio as it relates to caloric availability. *Soc. Biol.* **39,** 285–291.

Williamson, N. (1976). *Sons or Daughters: A Cross-Cultural Survey of Parental Preferences*. Beverly Hills: Sage.

Yamaguchi, K. (1989). A formal theory for male-preferring stopping rules of childbearing: sex differences in birth order and in the number of siblings. *Demography* **26,** 451–465.