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Some further evidence against the Trivers Willard hypothesis in *homo sapiens*

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Summary:

The Trivers Willard hypothesis – that higher maternal quality is associated with a higher sex ratio – is tested using a large population survey from 12 European countries. Several outcomes are studied, the proportion of children born who are male and the sex of the first three children. The principal explanatory variables of interest are mother's education, marital status and age at birth. Little evidence, if any, of such a relationship is found.

Keywords: sex ratio, maternal quality

Short title: Evidence against Trivers Willard hypothesis

Introduction

The paper by Trivers and Willard (1973) on the sex ratio has generated a huge literature. As Carranza (2002) points out "Probably no other case exists in behavioural ecology where a couple of pages have sired so many studies". This research has not necessarily brought clarity and what the theory actually implies, whether it can be tested and whether it applies to humans is disputed (see, for example, Carranza (2002), Brown (2001), Freese and Powell (2001)). An important recent contribution is Almond and Edlund (2007) who analyse all births and infant deaths to white mothers in the US between 1983 and 2001, a total of 48 million births. Consistent with the hypothesis, they find that married, better educated and younger mothers bore more sons. There is much less evidence for non-US populations. Given that the hypothesis is based on natural selection one would expect it to hold, if true, in most populations. This note uses a new cross country dataset for 12 European countries to revisit the question.

Materials and methods

The dataset used is SHARE: the Survey of Ageing, Health and Retirement in Europe. This collects data from nationally representative samples of the non-institutional population aged 50 years and older. The primary sampling unit is a household and all individuals in the household who are in the target age category are interviewed. This paper used release 2 of the dataset which includes 12 countries: Austria, Belgium, Denmark, France, Germany, Greece, Italy, Netherlands, Spain, Sweden, Switzerland and Israel. The first release of the data which was collected in 2004 consists of the first 11 countries listed. Preliminary data from Israel, collected in 2005-2006, was included in release 2. Visit http://www.share-project.org/ for more information.

The sampling plan follows a complex probabilistic multistage design. Hence probability weights (calibrated by age and sex) are used to ensure that the sample is representative. For estimation purposes, each country is treated as a stratum and estimated standard errors allow for clustering within households.

Several outcomes are used as a dependent variable. Firstly we use the proportion of the respondent's (i.e. mother's) children that are male – the ratio of male to female children would not be defined where there were no daughters. Secondly we consider, separately, the sex of the first, second and third born children. Several indicators of maternal quality are used. In analyzing the proportion that are male we use the total number of children born, years of full time education, whether the mother ever married, verbal fluency and height as covariates. When modeling the sex of individual births, age at birth is used. Clearly the choice of measures is to some extent arbitrary; one could question the inclusion of some of these variables and also argue for alternative measures. This is partly why testing the hypothesis is difficult: if one tries enough variables then one may well eventually find a variable which predicts the sex ratio and could be argued to be an indicator of maternal quality. Height is included as it has been argued by Kanazawa (2005) that, as part of a generalized Trivers-Willard hypothesis, parental size predicts the sex ratio although the evidence is extremely unconvincing (see Gelman(2007), Denny(2008)). Verbal ability is measured at the current age of the respondent so it may differ from that which prevailed when they were having children. The test score is the number of animals that the respondent could name in one minute. It has a mean and standard deviation of 18.1 and 7.4 respectively.

Results

The results of the data analysis are in Table 1.The first column is a linear regression of the proportion of a woman's children who are boys. None of the three measures of maternal

quality are individually statistically significant nor can one reject the hypothesis that they are jointly insignificant (p value=0.2557). The second column generalizes the specification by including maternal height and verbal ability. This changes the results as higher maternal education is now associated with a *lower* proportion of boys born, contrary to what one might expect. However verbal fluency is associated with a higher proportion of boys. Verbal fluency and years of education are highly correlated (ρ=0.40) which partly explains why the inclusion of verbal ability in column 2 has such an impact on the estimated coefficient for education. These results provide a fairly limited support for the hypothesis. In column 3 the probability that the first born child is a boy is modelled. Age at birth, in quadratic form, is included because while younger mothers may, in general, be healthier, the effect may be non-linear or indeed non-monotonic. As with the previous model one finds negative and positive effects, respectively from education and verbal ability. The effect of age at birth on the probability of a boy is initially decreasing and increases from approximately 28 years (=.057/(2x 0.001)). It is doubtful if one can interpret this as supporting the hypothesis. In analysing the sex of the second born child (column 4) the age effect disappears (the two coefficients are jointly statistically insignificant (p=0.96)) as does the effect of education. The results for the third child are similar to those of the first and second, again with only very limited support for the hypothesis. It seems highly unlikely that looking at subsequent births will give very different results.

Discussion

Using a large representative sample from 12 European countries, it is found there is little support for the hypothesis that higher maternal quality is associated with a higher proportion of boys. Education has, if anything, a negative effect on the outcome of interest, marital status has no effect and the effect of the age at birth varies with birth order. There are

some variables which, it could be argued, are indicators of maternal quality and which are positively associated with the sex ratio.

In trying to rationalize the diverse findings associated with the Trivers-Willard hypothesis it may be necessary to look more closely at the concept of maternal quality which has tended to be treated as a "black box" in this literature. Moreover analyses of the determinants of the sex ratio frequently have little to say about the mechanism through which any such adjustments are made. One recent study which addresses this issue is Mathews *et al* (2008). They show that mothers with a relatively high energy diet produce more sons than daughters. Interestingly, this paper finds that neither socio-demographic not anthropometric variables predict the sex of the foetus. This may help to explain some of the inconsistent results.

Acknowledgements

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Table 1: Testing the Trivers Willard hypothesis

	(1) Proportion of boys	(2) Proportion of boys	(3) First child a boy	(4) Second child a boy	(5) Third child a boy
Number of children	0.005	0.005			
	(1.52)	(1.51)			
Years of education	-0.001	-0.004	-0.010	0.002	-0.022
	(0.61)	(2.61)**	(2.08)*	(0.30)	(2.67)**
Ever married	0.043	0.046	0.184	0.019	-0.071
	(0.93)	(1.01)	(1.41)	(0.09)	-0.24
Verbal ability		0.004	0.008	0.008	0.014
		(5.16)**	(2.77)**	(2.41)*	(2.81)**
Height (in cm.)		0	0.004	-0.005	0.01
		(0.21)	(1.28)	(1.41)	(2.13)*
Age at birth			-0.057	-0.005	-0.033
			(2.17)*	(0.14)	(0.74)
Age at birth squared			0.001	0.00	0.001
			(2.24)*	(0.1)	(0.80)
Constant	0.477	0.387	-0.009	0.629	-1.249
	(20.18)**	(2.78)**	(0.01)	(0.86)	(1.19)
n	9795	9795	9691	7633	3768
R-squared	0.00	0.01			

Note: Z statistics (in parentheses) reported. * significant at 5%; ** significant at 1%. A set of 11 country dummies are also included in the models. Sampling weights are used. Columns 1 and 2 are linear regressions. Columns 3, 4 and 5 are probit models as the outcome is binary. Stata 9 is used for estimation. All models use the design weights supplied with the data.