Title:
Socioeconomic status and sex ratios at birth in contemporary Sweden. No evidence for a Trivers-Willard effect using longitudinal register data across a wide range of status indicators.

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Introduction

Based on evolutionary reasoning, Trivers and Willard hypothesized that maternal condition should be associated with sex composition at birth. Specifically, reproductive success should be higher if some mechanism existed that produced an excess of male offspring for parents in good condition and an excess of daughters for parents in bad condition. According to the hypothesis, the prerequisites for such a (set of) mechanism(s) to evolve are the following: (1) Offspring condition is determined at least partially by maternal condition during the phase of parental investment, (2) resulting differences in offspring condition persist until adulthood, and (3) variance in reproductive success in response to maternal condition is higher for male than female offspring [1].

Social science research provides evidence for all three of these prerequisites in human societies [2–6]. In contemporary societies the first two prerequisites are clearly supported by evidence from sociological research on social inequalities and the life course [7–11]. The third prerequisite is only partially supported: Despite cross-cultural evidence that women more than men value high socioeconomic status as a mate characteristic [12], fertility has reached below replacement levels in some countries and structural constraints for combining family and work careers has led to a negative

association between status and fertility [13–18]. Whereas this speaks against the possibility that the TW effect should still matter in contemporary developed societies, evolutionary psychologists argue that the three conditions must only have held for extended periods during the human species' ancestral past [19,20].

In human populations, a sex ratio of about 105-106 boys for every 100 girls is considered "natural" [21]. Whereas in a number of historical populations prior to the demographic transition, sex ratios differed markedly from this natural sex ratio for status-based subgroups [6,22,23], empirical evidence in support of the TW hypothesis for humans in contemporary developed societies remains inconclusive [24]. Results are usually based on two types of samples with distinct, but different advantages. The first group of samples covers the general population and obtains estimates that are representative of the overall population. Here, survey studies show mixed results [19,25,26], but they also lack statistical power to detect small expected effect sizes [27]. Large-scale population registers, on the other hand, have reveal statistically significant, yet very small TW-consistent sex-ratio biases [28,29]. The second group of studies focuses on individuals at the upper end of the wealth distribution of a society, individuals that are often not reliably represented in general surveys. Because for these samples expected effect sizes are large [30], these studies can be informative despite their low case numbers, and allow one to assess the upper limit of the TW effect. Existing empirical studies on the wealthy report mixed results, ranging from null-effects to very large TW-consistent effects [30–35].

We argue that two issues regarding the operationalization and measurement of status may be at issue in producing mixed results: First, although Trivers and Willard suggested in their 1973 publication that socioeconomic status may be an appropriate measure of maternal condition in humans, there is currently no theory that suggests which of several indicators of socioeconomic status that are regularly applied in sociology and demography would, in fact, matter most with regard to the effect in question. Second, recent evidence from a meta-analysis and from animal experiments shows that parental condition around the time of conception matters most with respect to the TW effect, as it is likely that follicular Testosterone and/or glucose levels around conception are implicated in producing the primary sex ratio, that is, the sex ratio at conception [36,37]. Therefore, parental status should be as closely measured around the (estimated) time of conception as possible. Quite different from this recommendation, in current studies on the TW effect in human populations, socioeconomic status of

parents is often measured at one particular date either years before or after conception for all people in the sample. An exception is a study on an elite sample of U.S. billionaires which provides tentative evidence that if timing is considered appropriately in the measurement of status, that is, in this study wealth, then group differences emerge that are consistent with the TW hypothesis [31]. But for a general population sample, such a time-sensitive analysis is, to our knowledge, still lacking.

In the following data analysis we provide an improvement on both of these issues: First, instead of focusing on just one status indicator, for example, only education or only income, we test the TW effect across a broad variety of status indicators, including income, wealth, education, and social class, using Swedish register data. Second, by drawing on longitudinal data and operationalizing parental status as time covariant in our statistical models, we are able to select the parental status value in the data that is closest to the estimated time of conception and thus ensure a more conservative estimation of the TW effect than previous studies on the general population. Third, we make use of the fact that register data include several births within the same families. Therefore, we are able to not only compare sex composition effects across families of different status but also within families over time and along intra-family status changes.

Date & Methods

Data

We base our following analyses on Swedish register data. Given that they cover the complete Swedish population in certain birth cohorts, the data provide sufficient statistical power to detect even small effects [cf. 27]. An additional advantage of these register data is that they cover a long duration of individuals' fertility and status histories. Specifically, the data for this study are an assortment of Swedish administrative registers. In the analyses, registered vital events are used to create longitudinal birth histories which are then analyzed using logistic regression. Census data and administrative registers on education and taxes are then linked with demographic data. Due to shifting data availability, different registers and periods are studied for different status variables. The study population consists of births to all Swedish women born in Sweden after 1925 conditioned on the fact that they are present in the registers at some point after 1960. The study population consists of:

N=1,594,737 births for models on income, post-transfer income, wealth and parental wealth, N=2,674,893 for models on occupational status, and N=1,109,127 for models on education.

Data on income, post-transfer income (including various government allowances, unemployment insurance, and social security payments), wealth, and parental wealth for the mother are collected from Swedish tax registers and updated on a yearly basis (see Table 1 for descriptive statistics). Data are available from 1968 until 1989 which is also the start and end date for births for the models including those variables. Incomes are adjusted according to the wage development for industrial workers in Sweden using a time series with 2004 as reference year [38]. Adjustment of incomes according to income growth rather than inflation avoids a population in the data set that gets richer by decades, an important adjustment given that the focus of the current study is primarily on income relative to other individuals. Income data is annual registered income from labor and has been collected from tax-records. Disposable income after government transfers is also included and based on a combination of labor income and income from social support systems, e. g., sickness allowances, unemployment insurance and child allowances. Data on wealth and parental wealth is based on tax registers on taxable fortune. Due to a large number of tax exemptions it is unreliable for fortunes above approximately 1 million US Dollars in contemporary currency. Parents are connected using the Swedish multigenerational register. Parental wealth refers to the sum of the shared fortune of the biological mother and father of the index-persons. Data on education is based on contemporary registers with yearly data starting from 1990 until 2007. The data is time-varying and measure highest achieved level of education.

Data on occupational class are based on information collected in censuses in 1960, 1970, 1980 and 1990. Original data collection and classification is by Statistics Sweden and based on the class measure ‘Socioekonomisk indelning’, SEI [39]. We transformed the SEI measure into the Erikson, Goldthorpe and Portocarero class scheme (EGP). Given that the data is based on decennial status, the population is grouped into cohorts according to the decade they were born, starting with 1930. In the census they are then assigned a SES value from the latest census according to group of birth cohort that is time varying and updated on a 10-year basis. For example, the 1930-1940 cohorts are assigned a SES in 1960 when they are 20-29 years, a new SES in 1970 when they are 30-39 years, etc. In the SES models the population is followed between 1960-2000. SES-data is based on occupation. If either parent is not

working the occupation of the head of the household is used. Additional covariates used in our models are parity, period, and age of the mother and the father. All four of them been shown to be (weakly) related to sex ratios [40–42] and could potentially confound the relationship between socioeconomic status and sex ratios at birth.

Methods

We model the odds for a male birth using logistic regression analysis. Controlling for a number of important characteristics of the parents and the individual birth, separate models are presented across a wide variety of status measures. In addition, we compare effects of status on the odds for a male birth across families and within families to account for both status differences between individuals and status changes across the life course. This is accomplished by comparing logistic regression models that are pooled across births of the same mothers with fixed effects and random effects models that take the dependency of multiple births of the same mothers into account. Our random effects models compare mothers to other mothers in the population. The fixed effect estimates are based on socioeconomic changes across births of the same individual. We did conduct Hausman tests examining if a within-woman analysis (fixed effects analysis) would be preferred over a between women analysis. For every model we found that the between analysis would be unbiased. However we still present within woman results for comparison. When testing for various operationalization of socioeconomic status, we include each different measurement in isolation. Thus, as different measurements are correlated we present an inclusive measure of socioeconomic status when we present each measure. This approach most likely somewhat exaggerates the effect of socioeconomic status in our models, and would thus potentially be associated with a potential for a type 1 error (false positives), if some but not all of our measurements would show a TW-consistent effect. The set of models is further expanded by comparing models in which status is measured at the time of birth with models in which status is measure at one year earlier to be more likely to capture the status shortly before the estimated, average date of conception. In total, this comparison yields 54 models. Since these cannot be presented here in detail, we will present a table that summarizes just if the effects of status variables are consistent with the TW hypothesis or not.

Results

We present a summary of our models in table 1 below. The summary shows if the 54 different models we ran show support for the TW-hypothesis or not. As can be seen from the table, the vast majority of models shows no support and some show very minor support for the TW-hypothesis. Overall, therefore the hypothesis needs to be rejected for data on the contemporary Swedish population. The rejection spans over a wide variety of socioeconomic measurements including education, occupational class, wealth, and wealth in the family of origin. Measuring status at birth or conception doesn't make a difference: in both cases we generally find insignificant results. Similarly, models examining only female status in separation and total socioeconomic status of the couple, as well as the share of male income within a family, in neither case give support for a TW-effect. Comparing changes in socioeconomic status across and within families similarly is not related to sex ratios.

In only two of our models, income from labor, measured at conception for within and between women estimates, we find some support for the TW-hypothesis significant at a 95% confidence level. Mothers who had a yearly income of at least 150,000 SEK (≈22,500 USD) had a 3-4% higher sex ratio, than mothers who reported less or no income. This relationship was only found when looking at only the woman's income, and not when examining total income of the mother and the father. The result was also only found when measuring income at the year of conception, and not if measured at year of birth. As the t-value was just slightly above two for the two models which showed significant results, the meaningfulness of two models out of 54 giving a statistically significant effect at the 95% confidence level is very inconclusive support for a TW-effect.

Overall our results suggest that there is no TW-consistent association between socioeconomic status and sex ratios in Sweden. We applied a wide variety of accurate measurements of socioeconomic status from Sweden, measured both at conception and at birth.

Table 1: Summary of 54 different logistic regressions on sex of child, controlling for different measurements of socioeconomic status, births in Sweden from 1960-2007					
Variable	X=support for TW Measured at birth		O=no support for TW Measured at conception		Period
Metod of measurment	Random Effects*	Fixed Effects**	Random Effects*	Fixed Effects**	
Income					
Female	O	O	X	X	1968-1989
Combined	O	O	O	O	
Male share	O	O	O	O	
Income and government transfers					1968-1989
Female	O	O	O	O	
Combined	O	O	O	O	
Male share	O	O	O	O	
Wealth					1968-1989
Female	O	O	O	O	
Combined	O	O	O	O	
Male share	O	O	O	O	
Parental Wealth					1968-1989
Female	O	O			
Combined	O	O			
Male share	O	O			
Occupational Class (EGP)					1960-2000
Female	O	O			
Highest of both parents	O	O			
Education					1990-2007
Female education	O	O			
Female+male education	O	O			
Workhours					1989-1991
Workhours	O	O	O	O	
*Comparing births across parents. **Comparing the same parents, at different births					

We are unable for space constraints to present our full regression output (it currently consists of a 180X87 matrix), but we will in future versions of the manuscript make it available as an excel file in an appendix.

Discussion

In this study we examined the Trivers-Willard effect on sex ratios at birth in contemporary Sweden. Unlike previous studies that looked at the association of single indicators of socioeconomic status only or very few indicators of status, we were the first to examine the effect across a broad range of status variables. Overall, there is no evidence for changing sex ratios with status along the lines predicted by

the TW effect. This null-finding is robust to different specifications of the timing of socioeconomic status (at conception or at birth) and for status changes measured both between and within women. Therefore, we provide conclusive evidence against any TW effect in contemporary Sweden.

With Sweden we conducted a test in a country with an extensive welfare state. Two other studies that examined the TW effect using birth register data, one conducted in Venezuela and one in the US [28,29], found small effects consistent with the TW effect. The inconsistent pattern between the countries could be sign of the conditionality of the TW effect to overall socioeconomic conditions in a country. Future research should examine cross-nationally how the TW effect changes with economic development, welfare state arrangements, and overall levels of income inequality.

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