

This is a Man's World? Changes in Income Predict Sex Ratio at Birth

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The human sex ratio at birth (SRB) is approximately 107 boys for every 100 girls. SRB was rising until the World War II and has been declining slightly after the 1950s in several industrial countries. Recent studies have shown that SRB varies according to exposure to disasters and socioeconomic conditions. However, it remains unknown whether changes in SRB can be explained by observable macro-level socioeconomic variables across multiple years and countries. Here we show that changes in disposable income at the macro level positively predict SRB in OECD countries. A one standard deviation increase in the change of disposable income is associated with an increase of 1.03 male births per 1000 female births. This is the first evidence to show that economic and social conditions influence SRB across countries at the macro level. This calls for further research on the effects of societal conditions on general characteristics at birth.

The Trivers-Willard hypothesis (*I*) (henceforth TWH) predicts that natural selection favors a positive relationship between sex ratio at birth (SRB) and parents' ability to invest in offspring. This prediction stems from the assumption that a male in good condition at the end of the period of parental investment produces more offspring than a female in similar condition, and a female in bad condition produces more offspring than a male in similar condition. According to TWH we would expect SRB to vary with environmental factors. Indeed, sex ratio has been decreasing in several industrial countries in recent decades. Theories as to why have been put forth, but the proposed explanations are unable to fully account for the changes (2).

Previous studies have found statistically significant associations between SRB and multiple other factors. These studies can be roughly divided into three groups according to the explanatory variables used in them: studies concerning disasters (3–8), parental characteristics (9–15), and other country-level variables (16–18). Notably, there are also studies showing no significant association (19–21). Many studies give credence to TWH, but we see three caveats in the literature: the possibility of publication bias, narrow focus, and in some cases focus on the absolute levels instead of changes.

Our work fulfills all of these three important aspects. First, we study the effects across a wide range of countries. This eliminates the possibility of publication bias almost necessarily involved in studies focusing on single events in a specific context. As some of the studies find no effect, the question remains: how many studies without significant results remained unpublished? Second, we aim to study the effects of large-scale macro-level social phenomena, not those of a specific disaster or event. This has more relevance for societies compared to narrow and specific individual-level determinants or country-level disasters. The fall in SRBs observed in multiple industrialized countries also requires an explanation that can be applied to a wide set of countries. Third, we focus on changes in disposable income – not levels. This is consistent with the idea that a sort of “hedonic adaptation” (22) renders

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gains of the distant past irrelevant to such sociobiological processes as SRB. As much of the literature finding significant results concerns disasters, it is likely that the shock to the status quo is the main mechanism behind the effects, and we expect SRB to adapt to new macro societal conditions quite rapidly.

The timing of the change in disposable income and observed births is illustrated in Figure 1. Lacking monthly data, we have tried to associate the income growth to the interval of births mostly affected by it. This imperfect modeling can be expected to result in more noise in the estimates, and thus it will attenuate the observed statistical associations.

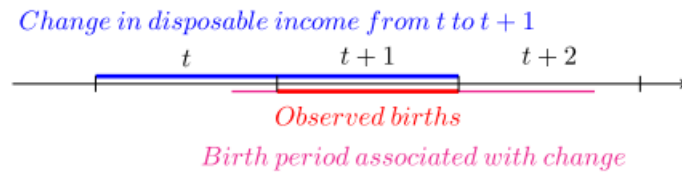


Figure 1. *The timing of birth if conception happens at the time of income change from year t to year $t+1$. When examining the income change at the time of conception at the macro level from t to $t+1$ (presented in blue), the associated birth period with conception happening during the income change is presented in purple. From this period we have taken the only full year ($t+1$, presented in red) that corresponds to the period of income change when calculating the SRB.*

Figure 2 shows the association between the country-level SRB and the relative percent change in disposable income at the yearly level for an unbalanced panel of 23 OECD countries for the years 1971–2012 controlled for year and country effects. The correlation between the two variables is significantly positive at 0.11.

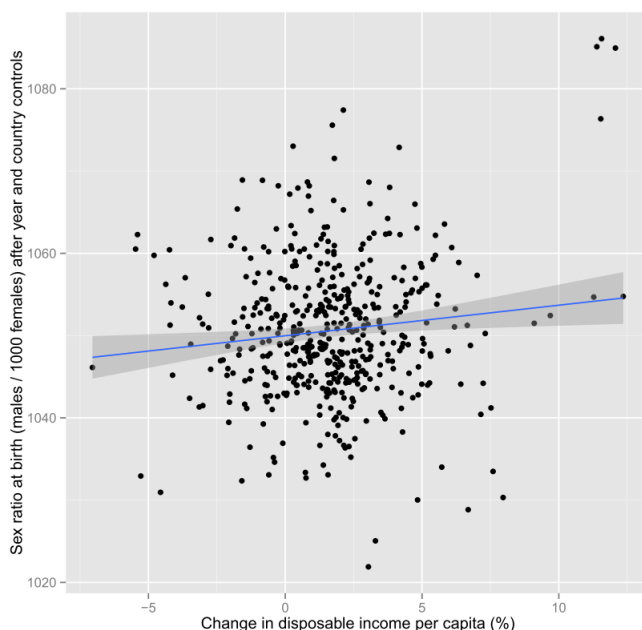


Figure 2. Linear association between changes in disposable income per capita from previous year and SRB net of year and country fixed effects. The x-axis of the scatter plot is the relative per capita change of real household net disposable income deflated by final consumption of households expressed in percent as calculated by the OECD between the years 1971 and 2013 for 23 countries. The population growth numbers were obtained from the World Bank. The y-axis is SRB after controlling for year and country effects. SRB is calculated as the number of male births per 1000 female births from annual live birth data by sex obtained from the United Nations. The year and country effects are estimated with a fixed effects panel regression. The blue line represents the linear regression estimate. The dark gray area around the blue line is the 95% confidence interval. Only countries with more than 10 years of data are included in the unbalanced panel. In addition, South Korea was omitted due to fear of possible sex-selective abortion and certain anomalies in the South Korean live birth data.

To control for unobserved, time-invariant, country-level heterogeneity and common yearly shocks, we introduce a fixed effects regression model to estimate SRB (see supplementary figures S1 and S2 for the distributions of sex ratio by country and year). This simple analytical strategy leads to time- and country-independent effects of disposable income. The effect of Y on SRB is significant at the 5% level (see Table 1). A coefficient of 0.391 means that a one percent growth in disposable income is associated with an increase of 0.39 male births per 1000 female births. A one standard deviation increase in the change of disposable income is associated with an increase of 1.03 male births per 1000 female births.

We also show that the GDP level per capita does not have a statistically significant relationship with SRB for the countries and years studied (see Table S4 in supplementary information, columns 2 and 3). Standard of living per se is unlikely to be a significant determinant, since SRBs have decreased in the industrialized world as living standards have risen (2). However, as the pace of change in living standards has slowed (23), SRBs have decreased as well (2).

	Dependent variable: SRB
Per capita annual proportional change in disposable income, per cent	0.391** (0.157)
Year fixed effects	Yes
Country fixed effects	Yes

N	490
R ²	0.014
Adj. R ²	0.013

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 1. Association between changes in disposable income, GDP per capita, and changes in SRB. The explanatory variable in the fixed effects panel regression is the relative per capita change of real household net disposable income deflated by final consumption of households expressed in percent as calculated by the OECD between the years 1971 and 2013 for 23 countries. The population growth numbers were obtained from the World Bank. The dependent variable is SRB. SRB is calculated as the number of male births per 1000 female births from annual live birth data by sex obtained from the United Nations. The year and country effects are controlled with a fixed effects panel regression. Only countries with more than 10 years of data are included in the unbalanced panel. In addition, South Korea was omitted due to fear of possible sex-selective abortion and certain anomalies in the South Korean live birth data.

Our estimate shows a highly significant association between disposable income change and SRB and is thus consistent with the prediction of TWH. Also, consistent with the hedonic adaptation theory (22), changes in instead of levels of the standard of living exhibit a significant association. However, the result should be interpreted with caution. We control for country-level and yearly variation by using a fixed effects model, but change in income might simply act as a proxy for other social variables that in turn affect SRB. If those variables vary differently in countries over time, they still remain uncontrolled for. A reverse effect from SRB to income change is unlikely to play a role.

This is the first evidence of economic and social conditions influencing SRB at the macro level in a wide range of countries and underlines the significance of feedback loops between biological and social conditions. The results also offer a possible explanation to the puzzle of falling SRBs.

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