RUHR
ECONOMIC PAPERS

Dirk Bethmann
Michael Kvasnicka

Why Are More Boys Born During War?

Evidence from Germany at Mid Century

#154

Imprint

Ruhr Economic Papers

Published by

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, email: W.Leininger@wiso.uni-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI, Phone: +49 (0) 201/81 49-227, e-mail: christoph.schmidt@rwi-essen.de

Editorial Office

Joachim Schmidt
RWI, Phone: +49 (0) 201/81 49-292, e-mail: joachim.schmidt@rwi-essen.de

Ruhr Economic Papers #154

Responsible Editor: Christoph M. Schmidt

ISSN 1864-4872 (online) – ISBN 978-3-86788-174-6

Ruhr Economic Papers #154

Dirk Bethmann and Michael Kvasnicka

Why Are More Boys Born During War?

Evidence from Germany at Mid Century

Bibliografische Informationen der Deutschen Nationalbibliothek

Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über: *http//dnb.ddb.de* abrufbar.

ISSN 1864-4872 (online)
ISBN 978-3-86788-174-6

Dirk Bethmann and Michael Kvasnicka[1]

Why Are More Boys Born During War? – Evidence from Germany at Mid Century

Abstract

In belligerent countries, male-to-female sex ratios at birth increased during and shortly after the two world wars. These rises still defy explanation. Several causes have been suggested (but not tested) in the literature. Many of these causes are proximate in nature, reflecting behavioral responses to the dramatically changed marriage market conditions for women and men that were induced by war-related declines in adult sex ratios. Based on county-level census data for the German state of Bavaria in the vicinity and aftermath of World War II, we explore the reduced-form relationship between changes in adult and offspring sex ratios. Our results suggest that war-induced shortfalls of men significantly increased the percentage of boys among newborns.

JEL Classification: J12, J13, N34

Keywords: World War II, adult sex ratio, sex ratio at birth

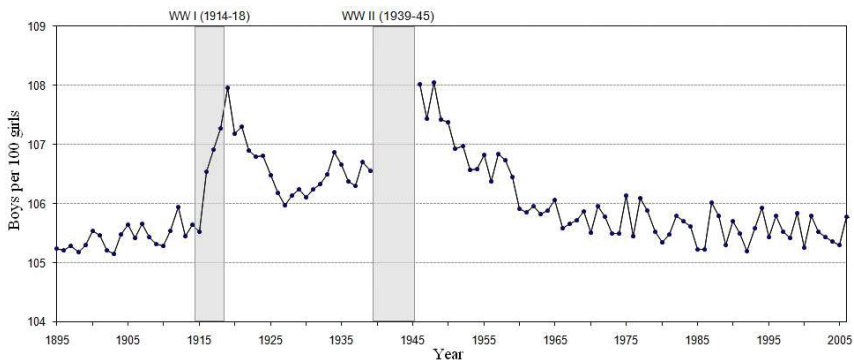
November 2009

1 Dirk Bethmann, Queensland University of Technology, Brisbane, Australia; Michael Kvasnicka, RWI. *– This paper has benefited from useful comments by Thomas Siedler, Martin Spieß, and Stephanie Andrews. All remaining errors are our own. Financial support by the Fritz Thyssen Stiftung is gratefully acknowledged.–* *All correspondence to Michael Kvasnicka, RWI, Berlin Office, Hessische Str. 10, 10115 Berlin, Germany, e-mail: michael.kvasnicka@rwi-essen.de.*

1 Introduction

Among the 218 countries recorded in the 2007 CIA World Factbook, the sex ratio at birth averages 105 boys per hundred girls. This slight excess of boys among newborns is remarkably stable across different populations, regions, and times. Statistically significant deviations from this "natural rate", however, have been recorded at several instances in history. In particular, during and in the immediate aftermath of the two world wars, the sex ratio at birth has temporarily increased in belligerent countries. For World War I (WWI), such a rise is documented for Austria, Belgium, Bulgaria, England, France, Germany, Hungary, Italy, Romania, and South Africa (Bernstein, 1958; Russell, 1936). For World War II (WWII), it has been observed, among others, in Austria, Belgium, Denmark, England and Wales, France, Germany, the Netherlands, and the United States (see Figure 1 for a time series plot of the sex ratio at birth in Germany).[1]

FIGURE 1: Sex ratio at birth in Germany, 1895-2006.



Note: No data is available for the war years 1940-1945.

The causes of these wartime rises are still not understood (Ellis and Bonin, 2004; Hesketh and Xing, 2006). In fact, a myriad of specific causes at mid century have been suggested to have affected the sex ratio among newborns (also called the secondary sex ratio), either via the primary sex ratio, i.e. the sex ratio at conception, or via a differential effect on the risk of miscarriage for male and female fetus (prenatal mortality). Examples include: declines in female and male age at conception (cf. Chahnazarian 1988 Tables 1 and 2), increases in parental age differences (e.g.

[1] See, for example, the cross-country study by Graffelmann and Hoekstra (2000) which covers most of the countries listed in the text, MacMahon and Pugh (1954) for the US during World War II, and Lowe and McKeown (1951) and van der Broek (1997) for respectively England and the Netherlands during both world wars.

Manning et al., 1997), reduced parity (i.e. birth order, see Biggar et al., 1999), and increases in out-of-wedlock childbearing (James, 2009).[2] Empirical evidence for an influence of these factors is still scant, however, as are the precise mechanisms by which they may impact the ratio of boys to girls at birth.[3]

In fact, the aforementioned factors themselves are likely to be only *proximate* in nature, representing behavioral responses to the dramatic changes in marriage market conditions (declines in adult male-to-female sex ratios) that were induced by the great numbers of prime-aged men who went to war in belligerent countries. In the (largely medical and biological) literature on the subject, however, war-induced declines in adult sex ratios have received little to no attention as a potential root cause of the war-time rises in the sex ratio at birth. This continuing disregard is surprising in light of the growing body of literature in economics that has found evidence for a sizeable influence of adult sex ratio imbalances on the aforementioned proximate factors, such as spousal age at marriage, lifetime fertility, and out-of-wedlock births (e.g. Acemoglu, Autor, and Lyle, 2004; Angrist, 2004; Bethmann and Kvasnicka, 2007).

Based on a unique dataset of county-level census data for the south German state of Bavaria in the vicinity and aftermath of World War II, we study the reduced-form relationship between changes in adult and secondary sex ratios. Our results suggest that war-induced declines in adult sex ratios indeed had a sizeable influence on sex ratios at birth: the larger was the female marriage market squeeze in a county, the more on average did the sex ratio at birth increase.

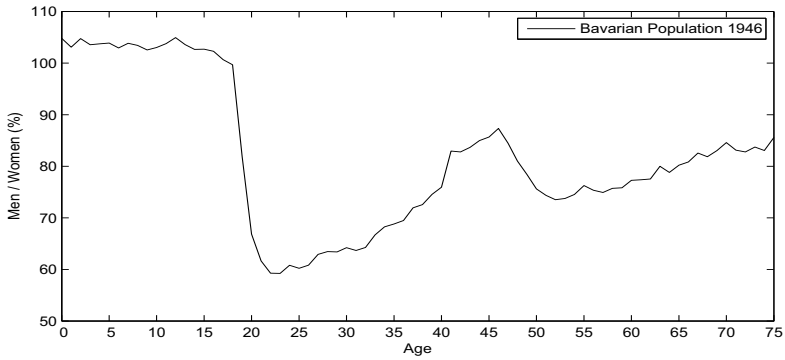
2 Background: World War II and the Shortage of Men

At the time of the first post-war census in Germany (October 1946), 1.7 million refugees, 0.4 million evacuees, and more than 0.6 million soldiers dead, imprisoned, or missing in action (m.i.a.) were recorded in Bavaria. With a pre-war population of roughly 7 million, these war-induced population changes were tremendous. This led to a dramatic shortage of men in Bavaria among age cohorts in their prime fertility years, an unprecedented female marriage squeeze (see Figure 2).[4] Furthermore, declines in adult sex ratios varied in magnitude across Bavarian counties, a fact we exploit for identification. Initial inspection of the raw data suggests that more severe declines in

[2]Note that the technology for prenatal sex determination with ultrasound became available only in the early 1980s. Sex of offspring at birth was hence beyond the direct control of parents in the vicinity of World War II (via sex-selective abortion), that is no choice variable.

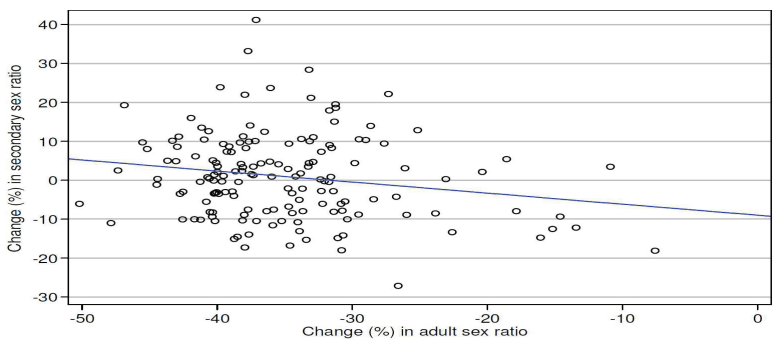
[3]Evidence mostly derives from simple correlations or univariate regression analysis of data that is not from (more

FIGURE 2: Post World War II sex ratios by age in Bavaria, October 1946 census.



prime-aged adult (20-40 year olds) male-to-female sex ratios at county level were indeed associated with greater increases in secondary sex ratios in the vicinity of World War II (see Figure 3).

FIGURE 3: Pre- to post-war changes in prime-aged adult (1939, 1946) and secondary (1939, 1947) sex ratios in Bavarian counties.



3 Data

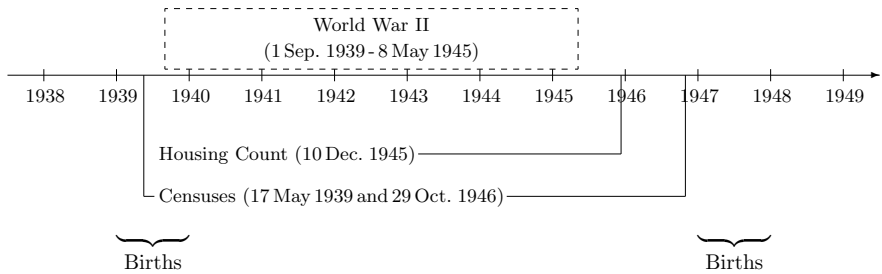
We use aggregate county-level data for the civilian population in Bavaria in the immediate forefront and aftermath of WWII. The data covers 156 counties and has been compiled from printed publications of the Bavarian Statistical Office, and the Statistical Office of the Reich. A timeline summarizing our sampling strategy is provided in Figure 4.

Censuses carried out on May 17 1939 and October 29 1946 - the latter under the auspices of the

recent than) the two world war periods.

[4]The second but more moderate dip observable in the 1946 sex ratio at ages 47-68 reflects the military losses incurred during World War I (WWI). These age cohorts correspond to the 19-40 years olds in 1918.

FIGURE 4: Timeline of data sampling strategy.



allied occupation forces in Germany - are our primary sources of information on the levels and characteristics of county populations in Bavaria shortly before and after WWII. Stock measures sampled from the two censuses include the sizes of county populations (total, by age cohorts, and by sex), and the numbers of refugees and evacuees in counties (1946 census only). From an analytical perspective, the timing of the two censuses is of great advantage. The May 1939 census took place in the vicinity of WWII, but well before its actual outbreak in September. The October 1946 census, in turn, is well timed for a first stock-taking of the main population changes induced by the war.[5] Annual birth statistics for counties (total births, sex of newborns, and number of still births) are taken from place-of-residence birth registries for the years 1939 (pre-war period) and 1947 (post-war period). Finally, data on the percent of the 1939 housing destroyed by December 1945 was taken from a special report of the Bavarian Statistical Office. Based on complete counts of the respective populations considered (residents, births, housing stock), the administrative and vital statistics in these data sources exhibit a very high degree of accuracy and reliability.

From this raw data, we construct the following variables for our regression analysis. Firstly, the adult sex ratio, our proxy for marriage market tightness and prime explanatory variable of interest, is operationalized as the ratio of men to women aged 20-40. The age range considered corresponds to the prime fertility years of women and men at the time. In the current application, the use of such a broad age range is preferable to that of a more narrow one, as the latter would, in all likelihood, fail to capture important intra-sexual competition across adjacent age cohorts

[5]Organized expulsions of Germans from the Sudetenland had climaxed already in June 1946, levelled of rapidly thereafter, and were terminated altogether in December of the same year (less than 20,000 arrived in the last two months of 1946). Furthermore, only 0.4% of soldiers m.i.a. and two out of five captives recorded in June 1947 returned by June 1948. Administrative restrictions imposed by the German authorities, including a general ban on cross-county migration in early 1946, made (endogenous) internal movements of civilians difficult if not impossible for 1946 and most of 1947. The last restrictions on cross-country mobility were lifted only in June 1950 (see Allied High Commission, 1950, p. 414).

at the time (see Fossett and Kiecolt, 1991).[6] Secondly, the sex ratio at birth, our endogenous variable, is defined as the number of male live births per hundred female live births. Additional variables constructed to control for potentially confounding influences in our regression analysis include measures for the extent and scope of war effects on the levels, composition, and average standards of living of county populations (population share of refugees and evacuees in a county), a proxy variable (ratio of stillbirths to total births in a county) to capture unobserved environmental influences that may differentially affect prenatal mortality of male and female fetus, and a measure for the extent of local destruction (percentage of housing stock destroyed during the war).[7][8]

Summary statistics for our final estimation sample are provided in Table 1. As illustrated, all variables exhibit great dispersion across counties in both 1939 and 1946 (1947). Our adult sex ratio measure declined by more than one third from 1939 to 1946, a tremendous worsening of the marriage market conditions for women. In contrast, the average sex ratio at birth in counties rose, albeit marginally, which may be attributable to a dampening influence of adverse environmental factors in the immediate aftermath of World War II that tended to affect all counties (e.g. worse nutrition, health care, etc.).

Table 1: Summary statistics on Bavarian counties, pre- and post-WWII

	Year	Mean	Sd	Min	Max
Sex ratio at birth (%)	1939	107.2	7.8	87.5	129.6
	1947	107.6	8.0	85.0	136.3
Adult sex ratio (men 20-40/women 20-40) (%)	1939	95.4	8.5	71.8	130.0
	1946	61.7	5.5	50.9	87.2
Ratio still births/live births (%)	1939	2.2	0.8	0.1	8.2
	1947	2.1	0.6	0.9	3.8
September 1939 housing stock destroyed (%)	1945	4.2	9.3	0.0	74.7
Refugee share in population (%)	1946	21.3	5.8	3.8	33.4
Evacuee share in population (%)	1946	4.4	1.9	2.0	11.0
Number of counties: 156					

[6] At mid century, age differences between eligible partners on the marriage market were often quite large. Furthermore, age differences appear to have increased significantly as a result of the poor (improved) marriage market opportunities that women (men) were facing in the aftermath of WWII. For instance, the share of husbands ten or more years older than their wives at marriage was almost three times as large in 1947 than in 1939 (12.4% vs. 4.5%).

[7] Prenatal mortality rates of boys are generally found to be more sensitive to harsh environmental conditions than those of girls (see Teitelbaum (1970) or James (1987)).

[8] The population shares of refugees and evacuees in a county represent measures of both the economic situation of (often significant) parts of the population and of the extent of potential disruption, stress and hardship caused in counties more generally. As these and the measure of local destruction, by definiton, measure post-war quantities only, they will be re-defined in the regression analyses to measure respectively the share of the September 1939 housing stock that is still intact and the share of non-refugees and non-evacuees in county populations.

4 Statistical Model and Results

We exploit regional variations across Bavarian counties in adult sex ratio changes between 1939 and 1946 to identify the effects of imbalances in the relative numbers of men and women on the secondary sex ratio. Specifically, we run panel regressions with fixed county effects that control for common shifts in the secondary sex ratio across time t (pre-war, respectively post-war period) and counties i:

$$y_{it} = \theta_t + \delta S_{it} + x'_{it}\beta + \alpha_i + u_{it},$$

where y_{it} is the secondary sex ratio in a county, θ_t a post-WWII indicator variable that controls for influences on the secondary sex ratio that are common to all counties in our observation period (e.g. worsened nutrition and health conditions), and S_{it} our county-level adult sex ratio measure. The vector x_{it} contains a number of variables on time-variant county characteristics to capture effects of potentially confounding influences. These comprise of local differences in economic stress and population disruption caused by the inflow of refugees and evacuees, the immediate physical effects of the war on county infrastructure and living conditions, or factors that may lead to sex-biased rates of miscarriage (proxied by the ratio of still births to total births). Fixed county effects (α_i), in turn, control for time-invariant observable and unobservable characteristics of counties that may influence levels of fertility and its particular modes. This includes regional differences in temperature, altitude, urbanity, and more general features related to reproductive outcomes, such as persistent differences in mating and marriage patterns.[9] Finally, u_{it} is an error term with the usual ideal properties. All variables, except our post-war indicator, are specified in logs.

Our main regression results are reported in Table 2. As is evident, the adult sex ratio exerts a statistically significant negative effect on the sex ratio at birth. In other words, counties with a larger shortfall of men did indeed experience a more pronounced increase in the secondary sex ratio. This finding is robust to different regression specifications (Models 2 - 4). In fact, the magnitude of the estimated effect hardly changes. All potential confounders are insignificant throughout. Moreover, their coefficients are small in magnitude, except for the coefficient for the share of non-evacuees. Finally, the sex ratio at birth on average fell across counties.[10]

[9] A general discussion of these potential factors of influence is provided in Teitelbaum (1970) and James (1987).

[10] General economic hardship, lack of food, limited access to health care, as well as the particularly harsh winter of 1946-1947 are likely to underlie this development. As noted, prenatal mortality rates of boys tend to be more sensitive to harsh environmental conditions than those of girls.

Table 2: Fixed-effects estimates for 1939/1947 secondary sex ratio (in logs)

	Model 1	Model 2	Model 3	Model 4
Sex ratio (men 20-40/women 20-40)	−0.19**	−0.19**	−0.20**	−0.18*
	(0.08)	(0.08)	(0.09)	(0.10)
Ratio still births/live births		0.01	0.01	0.01
		(0.02)	(0.02)	(0.02)
Share 1939 housing stock intact			−0.01	−0.02
			(0.05)	(0.05)
Share non-refugees in population				−0.06
				(0.14)
Share non-evacuees in population				−0.23
				(0.44)
Post-war indicator	−0.08**	−0.08**	−0.08*	−0.10**
	(0.04)	(0.04)	(0.04)	(0.05)
Observations	312	312	312	312

Note: All variables are in logs. *,**,*** denote statistical significance at the 10%, 5%, and 1% level. Standard errors are clustered at the county level and reported in parentheses.

County-level falls in adult sex ratios might, in part, be caused by the disproportionate allocation (inflow) of predominantly female refugees and evacuees to the country-side, which offered better housing and feeding conditions than cities after the war. If such selection indeed took place and affected sex-specific prenatal mortality rates, then our finding of a negative effect of the adult sex ratio on the sex ratio at birth might after all be spurious, or the result of *both* a female marriage market squeeze *and* better environmental conditions. To test for this possibility, we considered the sex ratio among men and women aged 50-65 instead of 20-40, i.e. age cohorts not or only marginally relevant for county-level fertility. If women, younger or older, were disproportionately allocated (e.g. as evacuees) or moved to counties exhibiting conditions more favorable for a male life birth, then we should find the changes in the sex ratio among this older age group to be positively correlated with changes in the sex ratio among 20-40 year olds. Hence - for purely statistical reasons - these changes are also inversely correlated with changes in the sex ratio at birth at county level. However, re-estimating Model 4, using the sex ratio of men and women aged 50-65, produces an estimated coefficient for our adult sex ratio variable that is now virtually zero in magnitude (0.002) and far from any statistical significance (t=0.01). This finding provides further credence to the view that changes in marriage market tightness among age cohorts in their prime fertility years, rather than some potential confounder, contributed causally to the increases in the sex ratio at birth in the aftermath of World War II.

5 Conclusion

Belligerent countries during World War I and II experienced temporary, yet marked increases in the secondary birth ratio that have long defied explanation. Based on German data from mid century, we investigated the adult sex ratio as a potential deep determinant of these rises. Our findings suggest that male shortfalls were indeed important for the observed increases in the relative number of boys among newborns.

Being reduced-form in kind, our analysis does not provide information on the particular causal pathways by which declines in the adult sex ratio impacted the sex ratio at birth. However, such an investigation would require more detailed county-level data than the one used in our analysis, data that is not available for Bavaria at mid century. Research on other belligerent countries is necessary to answer this question and to provide external validity for our findings.

References

Acemoglu, D., D.H. Autor, and D. Lyle 2004. "Women, War and Wages: The Effect of Female Labor Supply on the Wage Structure at Mid-Century." *Journal of Political Economy*, 112(3): 497-551.

Allied High Commission 1950. "Repeal of legislation restricting freedom of movement within the territory of the federal republic" *Official Gazette of the Allied High Commission for Germany*, 24: 414.

Angrist, J.D. 2002. "How Do Sex Ratios Affect Marriage and Labor Markets? Evidence from Americas Second Generation." *Quarterly Journal of Economics*, 117(3): 997-1038.

Bernstein, M.E. 1958. "Studies in the human sex ratio. 5. A genetic explanation of the wartime increase in the secondary sex ratio." *American Journal of Human Genetics*, 10: 68-70.

Bethmann, D., and M. Kvasnicka 2007. "World War II, Missing Men, and Out-of-wedlock Childbearing." *SFB 649 Discussion Paper, Humboldt University of Berlin*, 2007-053.

Biggar, R.J., J. Wohlfahrt, T. Westergaard, and M. Melbye 1999. "Sex Ratios, Family Size, and Birth Order." *American Journal of Epidemiology*, 150(9): 957-962.

Chahnazarian, A. 1988. "Determinants of the Sex Ratio at Birth: Review of Recent Literature." *Social Biology*, 35(3-4): 214-235.

Ellis, L., and S. Bonin 2004. "War and the secondary sex ratio: are they related?" *Social Science Information*, 43(1): 115-122.

Fossett, M.A., and K.J. Kiecolt 1991. "A Methodological Review of the Sex Ratio: Alternative Comparative Research." *Journal of Marriage and the Family*, 53(4): 941-957.

Graffelman, J., and R.F. Hoekstra 2000. "A Statistical Analysis of the Effect of Warfare on the Human Secondary Sex Ratio." *Human Biology*, 72: 433-445.

Hesketh, T., and Z.W. Xing 2006. "Abnormal sex ratios in human populations: Causes and consequences." *Proceedings of the National Academy of Sciences of the United States of America*, 103(36): 13271-13275.

James, W.H. 1987. "The human sex ratio. Part 1: A review of the literature." *Human Biology*, 59(5): 721-752.

James, W.H. 2009. "The variations of human sex ratio at birth during and after wars, and their potential explanations." *Journal of Theoretical Biology*, 257: 116-123.

Lowe, C. R., and T. McKeown 1951. "A Note on Secular Changes in the Human Sex Ratio at Birth." *British Journal of Sociology*, 5: 91-96.

MacMahon, B., and T.F. Pugh 1954. "Sex Ratio of White Births in the United States during the Second World War." *American Journal of Human Genetics*, 6: 284-292.

Manning, J.T., R.H. Anderton, and M. Shutt 1997. "Parental age gap skews child sex ratio." *Nature*, 389: 344.

Russel, W.T. 1936."Statistical study of the sex ratio at birth." *J. Hyg.*, 36: 381-401.

Teitelbaum, M.S. 1970. "Factors affecting the sex ratio in large populations." *Journal of Biosocial Science*, Supplement 2: 61-71.

Van der Broek, J.M. 1997. "Change in Male Proportion among Newborn Infants." *Lancet*, 349: 805.