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Economic Stress or Random Variation?

Revisiting German Reunification as a Natural Experiment to Investigate the Effect of Economic Contraction on Sex Ratios at Birth

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Abstract

The economic stress hypothesis (ESH) suggests that economic decline leads to a decrease in the proportion of males born in a population. A multitude of additional influences on sex ratios that often cannot be accounted for empirically make assessing the validity of the ESH difficult. Thus, as a historical quasi-experiment, German reunification constitutes an interesting test case. The economy in East Germany, but not in West Germany, underwent a rapid decline in 1991. In the same year, the sex ratio decreased in East Germany, but not in West Germany. Catalano (2003) interpreted these developments as evidence in support of the ESH. Using more recent and detailed data, we re-examine this case to test an alternative explanation, the random variation hypothesis (RVH). Using aggregate data on sex ratios between 1946-2010 and individual-level data on over 13 million births from the German Birth Registry between 1991-2009, we find evidence supporting the RVH but not the ESH.

First, the sex ratio in East Germany shows stronger deviations from the time trend in several years, and is seemingly unrelated to economic developments. The degree of variation is associated with the smaller and decreasing number of births in East Germany during the fertility decline following reunification. The individual-level analysis confirms that the 1991 decrease in the East German sex ratio could also be the result of random variation. A specificity of the East German transformation is the buffering of the consequences of economic decline through integration into the West German welfare state. Therefore, the ESH may be applicable in other transformation cases.

1. Introduction

For human populations, a sex ratio at birth of about 105 boys to 100 girls is seen as "natural" (Lazarus 2002). But a number of studies have found that population sex ratios at birth may be affected by "macro-social" shocks that lead to short-term deviations from this ratio (Catalano, Ahern, and Bruckner 2007; James 2012). This renders sex ratio biasing a topic of interest for both the biological and the social sciences. Here we are specifically concerned with the effects of economic contraction on sex ratios. From a social science perspective, this issue is particularly relevant because a systematic influence of economic processes on sex composition could have cascading effects on other social processes, especially those related to gender inequality. If, for example, girls have a higher probability of being selected into adverse conditions at birth than boys, gender-specific health and achievement rates later in life might be affected (cf. Almond and Currie 2011; Mayer 2009). In addition, sex ratio imbalances are suspected to affect a range of other social phenomena, including gender values, career choices, and the prevalence of violence and crime (Durante et al. 2012; Guttentag and Secord 1983;

Hesketh and Xing 2006; Hudson and den Boer 2005; Jin et al. 2010).

A small number of studies provide more detailed analyses of the effects of economic decline on sex ratios at birth, yet with mixed empirical results. Catalano and Bruckner (2005), for instance, reported a negative association between economic development and the sex ratio in Sweden. Helle et al. (2009) also found a negative, yet smaller, association between GDP and sex ratios for births between 1865 and 2003 in Finland, controlling for a range of additional contextual influences on sex ratios. However, a time series analysis examining the links between consumption data and sex ratios for Poland between 1956 and 2005, Żądzińska et al. (2007), found no association. Another finding of a positive association between economic conditions and sex ratios at birth in Cuba after the economic collapse in the early 1990s (Fernández, Medina, Britton, and Fogarty 2011) was later attributed to a temporary, yet systematic bias in official birth registration in Cuba (Simpson 2001, 2012; see also Wilcox and Baird 2011; and Fernández, Medina, Britton, and Fogarty 2011 for earlier speculation on a different mechanism).

Empirical analyses of the purported impact of economic conditions on sex ratios at birth are complicated by the fact that sex ratios are influenced by a multitude of individual and contextual factors, and may therefore produce mixed empirical results (see, e.g., Chahnazarian 1988; Teitelbaum 1972). Due to data limitations, most studies cannot comprehensively account for all of the factors that may confound findings on the association between economic conditions and sex ratios at birth. A recent review on the influence of economic contraction and birth outcomes has therefore concluded that the association between economic development and secondary sex ratios remains speculative (Margerison Zilko 2010).

Against this background, the case of German reunification becomes interesting. The post-reunification economic decline that selectively hit East Germany in 1991 (Buechtemann and Schupp 1992) constitutes a historical quasi-experiment that allows to test for the influence of economic decline on sex ratios at birth. Making use of this case, Catalano (2003) showed on the basis of East and West German aggregate data for the period between 1945 and 1999 that the sex ratio at birth deviated significantly downward from the time trend in East Germany in 1991. This result is consistent with previous findings of a negative association between sex ratios and economic conditions, and may be attributable to the economic decline in East Germany in 1991.

Here, we revisit the case of German reunification, taking into account a longer time series for East and West Germany up to and including the year 2010. Sex ratio data for this longer interval reveal deviations from the time trend in East Germany that are as strong as the deviation observed in 1991, but in in both directions, i.e., as upward or downward spikes. We test two hypotheses that may explain these deviations. First, and in line with the argument made by Catalano (2003), these deviations may be related to differences in the economic development of post-reunification East Germany relative to that of West Germany. Second, the deviations could reflect random variation due to the much smaller number of births in East than in West Germany, especially after reunification (cf. Kreyenfeld 2003). This drop in fertility has been attributed to the economic transition crisis after 1990 (Witte and Wagner 1995). We evaluate both hypotheses by analyzing aggregate and individual-level data from the German birth registry. These data allow us to control for some parental characteristics. In addition, we match these data with contextual information about regional economic development, which allows us to study how the variation in economic development and the variation in sex ratios are associated.

2. Theory and previous research

The findings of studies on the direction of the effects of stress on sex ratios have been equivocal, leaving researchers to ponder the potential mechanisms at play in producing this mixed pattern. On the one hand, individual-level stressors have been found to be linked to sex ratio decreases. Examples of these kinds of stressors are occupational and psychological stress (Obel et al. 2007; Ruckstuhl et al. 2010), as well as a range of macro-social shocks, like short wars (e.g., Ansari-Lari and Saadat 2002; Abu-Musa et al. 2008:200, 2009; Zorn et al. 2002), terrorist attacks (Catalano et al. 2005, 2006), economic contractions (Margerison Zilko 2010), and natural disasters (Fukuda et al. 1998; Lyster 1974). On the other hand, sex ratio increases have occurred, for example, in the belligerent countries after the First and Second World Wars (Graffelman and Hoekstra 2000; Helle et al. 2009; James 2009).

It is well established that male fetuses are more vulnerable to stressors at any developmental stage (Stinson 1985; Wells 2000). Thus, mortality in utero in response to stress can explain sex ratio *decreases*. It has been more difficult to explain the opposite effect. Several mechanisms have been proposed to account for it. These include the potential effects of parental age, birth order, coital frequency, parental hormone levels, genetic effects, nutrition, and changes in birth registration over time (Cameron et al. 2008; Chahnazarian 1988, 1990; James 2009). Recently, Grant and collaborators proposed a model that integrated some of these explanations into a combined framework that may help to explain why sex ratios have increased after some types of crises, but decreased after others (Grant and Irwin 2009; Grant 2007, 2009). The focus in this framework is on two mechanisms that may be part of an adaptive system of sex ratio variation. First, higher rates of in utero mortality of male fetuses in response to stress during pregnancy lead to a reduction in the sex ratio. Second, concentrations of follicular testosterone and glucose, which are associated with a higher probability of conceiving a boy, tend to increase with stress, and can therefore lead to an increase in the sex ratio (Grant and Irwin 2009; Grant 2007). Direct empirical evidence for the association between both follicular testosterone (Grant and Irwin 2005; Grant et al. 2008; Helle et al. 2008) and glucose levels and the sex of subsequent embryos (Cameron et al. 2008) has been obtained from experimental animal studies. Based on these findings, it appears that in mammals, the uterine environment influences the ovum prior to conception, making the ovum more or less likely to accept a spermatozoon carrying a Y over an X chromosome (Grant and Irwin 2009). This mechanism can be seen as an evolutionary response to male fragility, stabilizing population sex ratios in the medium term when stressful conditions persist (Grant 2007).

The timing of stress exposure at conception and during pregnancy plays an important role in this framework, and allows us to make rough predictions about the direction of the expected sex ratio bias in a population. If stress occurs around the time of conception, more males will be conceived; but if stress persists during pregnancy, more males will die in utero, and the sex ratio will be normal. If stress occurs around the time of conception but subsides during pregnancy, more males will be conceived and more males will survive pregnancy, resulting in a male-biased sex ratio. Finally, under normal conditions, there will be no overproduction of male fetuses. If stress occurs during pregnancy and more males die in utero, the population sex ratios may decrease relative to normal conditions. These two mechanisms, pre-conception testosterone and glucose levels and in utero male vulnerability, together explain some of the inconsistencies in the results of previous studies (Grant and Irwin 2009). Studies that used a more fine-grained timing of measurement of stress in relation to the timing of conception showed that sex ratio effects, which were previously thought to be extremely small and hard to detect (cf. Gelman and Weakliem 2009), may in fact be considerably larger than commonly believed (see, e.g., Almond and Mazumder 2011; Hansen, Møller, and Olsen 1999).

In addition to having to deal with the issue of how to time the measurement appropriately, researchers conducting empirical tests of the underlying mechanisms are faced with the problem that the sex ratio data may be confounded by additional factors. A large number of other potential influences on sex ratios have been suggested, including birth order, parental age, and toxins (Chahnazarian 1988; Teitelbaum 1972). For this reason, Zorn et al. (2003) expressed skepticism about the usefulness of such tests: "Because of the interaction of multiple factors, the aetiology of sex ratio changes after stressful events is not expected to be elucidated in the very near future. Today we are not in the position to make determinate conclusions regarding the association between stress and sex ratio changes, as the existing studies on the relationship between testosterone and adverse events lack appropriate methodologies. These studies are not controlled, much less are they randomized."

It is in light of this criticism that the case of German reunification becomes particularly important. As a natural experiment, it provides a good test case for examining hypotheses related to the influence of an economic downturn on population sex ratios. In this case we have two populations that can be assumed to be very similar, with a common institutional framework following reunification, yet one population experiences a sudden economic decline and the other one does not. Catalano (2003) examined the time trends of sex ratios in East and West Germany, and reported that the sex ratio decreased significantly following the economic decline in 1991. This finding seems to support the validity of the economic stress hypothesis, as confounding influences should have been less pronounced in this case. Furthermore, West Germany served as a control group, as West Germany experienced neither an economic downturn nor a decline in the sex ratio. Given the methodological importance that is attributed to German reunification in this case, it is important to evaluate closely the empirical evidence, and to take any new evidence into account. More recent data covering the years up to and including 2010 have shown that additional deviations in the sex ratio have occurred in East Germany, including both upward and downward spikes that are seemingly unrelated to economic developments in East Germany (cf. Brenke and Zimmermann 2009:15). These findings appear to challenge the assumption that the 1991 sex ratio deviation in East Germany was a consequence of the economic decline.

We have therefore chosen to revisit this case, taking into account newer aggregate data up to 2010, and to provide additional analyses on the individual level using German register data on all births between 1991 and 2009. We evaluate the economic stress hypothesis by comparing it to an alternative hypothesis that we propose here, and call the *random variation hypothesis*. According to this latter hypothesis, deviations in the sex ratio in 1991 and in some of the subsequent years were the result of higher variation in the East German sample of births. This was, in turn, partly attributable to the relatively small size of the East German population, and thus to the small absolute number of births. The variation was also due to a further decline in the number of births in East Germany after reunification (cf. Witte and Wagner 1995:389).

3. Data and analysis

We use aggregate yearly data on the sex ratios at birth in Germany. These cover the years 1945-2010, and were obtained from the website of the German Statistical Office[1]. In addition, individual-level monthly data were obtained from birth registers distributed by the joint research center of the

[1] www.destatis.de

German federal and regional statistical offices[2]. These data are available for the years 1991 to 2009[3]. We excluded multiple births and those births that occurred in Berlin, as the data did not allow us to distinguish between East and West Berlin. This leaves a total of more than 13 million births in this period, allowing us to conduct fine-grained analyses based on monthly data, and to control for a number of individual-level and contextual factors.

We first present descriptive results based on our aggregate data. We compare the time series of sex ratios at birth for East and West Germany with the time series of fertility and unemployment. Second, and following the aggregate data analysis, we provide more detailed analyses of the effect of unemployment on sex determination using individual-level data. Whereas Catalano (2003) used time series methods to analyze regional sex ratios over time, we need to use a different approach when dealing with individual-level data (cf. Catalano et al. 2007). Sex determination at birth can be modeled as a binary random process, making logistic regression a suitable approach. We start with a series of models using a pooled sample of births in East and West Germany between 1991 and 2009.

On the individual level, we control for the following maternal characteristics at the time of birth: employment status (employed or not employed), age and marital status (married or unmarried), and nationality (German or foreign) (cf. Lazarus 2002). Additionally, we control for the month of birth to adjust for seasonality effects (cf. Lerchl 1998). Although the age of both parents at the time of birth has been linked to sex composition (Matsuo, Ushioda, and Udoff 2009), we cannot control for paternal

[2] www.forschungsdatenzentrum.de

[3] For 14 of the 16 German states, the birth register covers all years from 1991-2009. We lack the years 1991-1994 for the East German state of Mecklenburg-Vorpommern, and for the year 1991 for the West German state of Saarland. The birth register data unfortunately do not allow us to distinguish between West and East Berlin.

age, as this information is not available for all births[4]. Our data are also limited with regard to parental socioeconomic status. We therefore cannot control for in our data a possible Trivers-Willard effect, which would predict a biased probability of having a male or a female birth depending on status (cf. Schnettler 2013; Trivers and Willard 1973). In some models, we also control for whether the birth was a stillbirth.

On the contextual level, we include the main explanatory variables that are supposed to capture the effect of unemployment: unemployment during the month of birth (measured at the level of the 16 federal states of Germany), and, for comparison, unemployment 10 months prior to the birth as an approximation of the time of conception. The other contextual variables are a dummy for the year of birth (1991 or another year), a dummy for the region of birth (West or East Germany), and an interaction between the two. This allows us to check whether the sex ratio in 1991 deviates from the trend in East Germany. In a second step of the regression analysis, we focus on East Germany only. Here we include dummy variables indicating the federal state in which the birth was registered. In addition, instead of having the dummy indicate whether a birth occurred in 1991 or in another year, we include a set of dummy variables that indicate in exactly which year between 1991 and 2009 each birth occurred. This allows us to study in more detail how a potential deviation in the sex composition in 1991 compares to the sex ratio in other years, controlling for unobserved factors on the state level.

[4] For inclusion in the birth register, recording paternal age is mandatory for marital births only. While no information on the father was collected if the birth was non-marital until 1999, since 1999 the parents of non-marital children can choose whether they want the paternal age to be reported. Given that in East Germany more than 50% of the births are non-marital, we lack information on the paternal age for a substantial share of the sample of births.

4. Results

4.1 Aggregate-level data (1945-2010)

Looking at yearly sex ratio data for East and West Germany, Catalano (2003) found a significant downward deviation in the sex ratio for East Germany in 1991, but not for West Germany. Thus, he argued that the economic contraction had an influence on the sex ratios at birth. We are able to look at more recent data than those available when Catalano's article was published. Figure 1 shows additional peaks and troughs in the East German sex ratio, both before and after 1991, that are seemingly unrelated to unemployment rates. The data in Panel A of Figure 1 show deviations from the overall trend that are about as large as the 1991 deviation, as well as some smaller ones. In three years, the larger of these deviations were in the direction of increased sex ratios (1965, 1979, and 2006); while in three other years, the deviations were in the direction of decreased sex ratios (1998, 2003, 2005). The deviations can also be seen in Panel B, where the differences in the sex ratios between East and West Germany are displayed.

Unemployment rates in East Germany increased sharply in 1991 and 1992, and continued to rise in subsequent years, with two exceptions: from 1995 to 1996 and from 1999 to 2000. In 2006, unemployment peaked and then declined (see Panel A of Figure 2). It is not clear whether the sex ratios should be more sensitive to absolute levels of unemployment or to changes in unemployment. Recent experimental research on mammals has shown that changes in conditions around the time of conception may have a greater effect on sex ratios than absolute levels (Cameron et al. 2008). If the same holds true for economic stress, then the largest decrease in sex ratios should have occurred in 1991, but we would also expect to see a similar effect in 1992. While this suggests that economic stress may indeed have contributed to the 1991 drop in East German sex ratios, the peaks and troughs in the sex ratios that occurred at times when unemployment did not change as dramatically as it did in 1991 suggest that other factors may have played a role.

An alternative explanation for the observed fluctuations is statistical error. Because the size of the population of East Germany is smaller than that of West Germany, the absolute number of births used as the basis for calculating the sex ratio at birth is also smaller. The difference in the absolute numbers of births between East and West Germany even increased after reunification, as fertility dropped significantly in East Germany (see Panel D of Figure 1). Throughout the period studied, the curve for the sex ratio seems to fluctuate more in East Germany than in West Germany (Panel A). A moving variance, calculated over five-year intervals, analogously indicates that the variance in East German sex ratios over time is higher, and rises after reunification (see Panel C of Figure 1). Thus, overall, the aggregative evidence supports the validity of the random variation hypothesis, rather than of the economic stress hypothesis.

4.2 Individual-level data covering all births that occurred between 1991 and 2009

Although the results of the aggregate-level analysis provide initial evidence for the validity of the random variation hypothesis, it is possible that regional variation in unemployment rates and individual-level confounders may hide the influence of economic development on sex composition. Therefore, we have also chosen to look at individual-level data in order to study the influence of unemployment on the probability of giving birth to a male or a female child.

In Table 1 we present the results of a series of logistic regressions on the sex of the children born in East and West Germany between 1991 and 2009. In the bivariate model, the odds ratios for the dummy variables that indicate whether a birth occurred in 1991 or in another year, and in East Germany or in West Germany, are 0.999 (SE: .002) and 0.998 (SE: .002), respectively. Thus, the main effects of both variables are negligible and are not statistically significant. However, according to the economic stress hypothesis, the interaction between the two variables is what matters. As we can see in the first multivariate model reported in Table 1, East German women indeed had lower odds of having a male child in 1991 than West German women (OR=.994|SE=.007). However, this effect was not statistically significant. Adding the unemployment rate at the federal state level at the time of the child's birth in the second multivariate model slightly increases the odds of having a male child among East German women relative to the odds found in the first multivariate model (OR=.995|SE=.008), but the interaction effect still is not statistically significant. Moreover, the unemployment rate has no effect on the odds of having a male child (OR=1.000|SE=.000). This confirms the results of the bivariate model, which showed that neither the unemployment rate at the time of birth nor the unemployment rate 10 months prior to the date of the birth have an effect on the sex of the child (OR=1.000|SE=.000 in both cases).

Thus, overall, none of the contextual variables seems to be relevant with regard to sex determination. This may not be the case, however, for some of the covariates at the level of the individual birth: whereas the age and the marital status of the mother at the time of the birth also do not appear to play a role, a clear seasonal effect can be detected, with the sex ratios being highest in summer and winter, and lowest in early spring and autumn. This finding roughly confirms earlier results that showed the existence of seasonal effects on the sex ratio in Germany (see Lerchl 1998). Furthermore, we find a positive effect of maternal employment on sex determination: the odds that a mother who is employed will have a son is 1.004 (SE=.001) times higher than that of mothers who are not employed. Controlling for maternal employment at the time of birth in the third multivariate model does not change the interaction effect between the dummy variables for the year of birth (1991 vs. another year) and the region of birth (East vs. West Germany) relative to the effect found in the second multivariate model (see Table 1).

As a next step, we focus on births that occurred in East Germany only, and include dummy variables for the five East German states in order to control for the effects of idiosyncratic but unobserved regional factors on sex determination (see Table 2). Again, we omit Berlin from the model, as we are not able to distinguish between West and East Berlin. We have chosen the state of Saxony-Anhalt as a reference group, as on average it experienced the highest level of unemployment in Eastern Germany in the 1990s (see Panel B of Figure 2). The odds of having a male birth are significantly lower in all of the other East German states (*Bundesländer*) than in Saxony-Anhalt. In the full model, the lowest odds ratios are recorded for Thuringia, the East German state that experienced the smoothest transition. Adding controls for the state unemployment rate in the year of birth, the mother's employment status, and a number of additional variables in the first multivariate model leaves the state dummies basically unchanged. Also adding dummy variables for the year of birth slightly exacerbates the difference in the odds of having a male birth between Saxony-Anhalt and the other East German states. Besides the state dummies, only some of the dummy variables indicating the month of birth are statistically significant: in the two multivariate models, women who gave birth in August have 1.017 (SE=.008) times higher odds for the birth of a son than women who gave birth in the reference month of June. Similar deviations are found for births in the months of May and July, but these effects remain slightly below statistical significance.

The state-level unemployment rate in the year of birth does not play a role in sex determination (OR=1.000|SE.001). While maternal employment increases the odds of having a male birth by a factor of 1.006 (SE=.003) – similar to the effect found in the model combining data from East and West Germany –this effect is not statistically significant, and only comes close to having statistical significance ($p < .1$). Compared to the results of the first multivariate model, a unit change in the unemployment rate is, in this case, associated with odds of having a male birth that are 0.998 times lower. However, this effect is not statistically significant. The dummy variable for a birth in 1991 indicates that the odds of having a male birth are lower by a factor of 0.984 (SE=.011) than in the reference year of 2009. This effect is not statistically significant. Reduced odds of having a male birth can also be observed for the birth years 2005 and 2008, but again these effects are not statistically significant (OR=.996 and .993|SE=.013 and .009, respectively). In all of the other years, the odds of having a male birth are higher than in the reference year, but in all cases the effects are not statistically significant. Only the effect for 2006 almost reaches statistical significance (OR=1.023|SE=.012|p <. 1).

We can summarize the results with two observations. First, we can confirm that births that occurred in 1991 stand out from births in other years due to the lower odds that the births were male. However, the odds for having a male birth in 1991 versus another year are not statistically significant in either the model that combines births in East and West Germany, or in the model that focuses on East Germany. Although the second multivariate model reported in Table 2 clearly shows that births in 1991 are associated with the lowest odds of having a male birth relative to the reference year of 2009, the difference in the odds for births occurring in 2005 and 2008, two other years with reduced odds of having male births, is negligible. The results certainly do not reflect the relative changes in unemployment that took place in these years, as there was a sharp increase in unemployment in East Germany in 1991, but not in 2005 and 2008 (see Panel A of Figure 2). Second, unemployment at the state level does not play a role in either of the models. The effect is either non-existent or it is very small and not statistically significant. Moreover, including a control for unemployment at the state level does not remove the effect of 1991 (or any other year), or it affects it minimally without changing the fact that it still is not statistically significant in all cases. We see this, for instance, as we move from the first to the second multivariate model in Table 1: here, the effect size for the interaction effect between the birth year (1991 vs. any other year) and birth region (East vs. West Germany) decreases only slightly when the effect of unemployment is added. Adding maternal employment status in the third multivariate model has no effect on this interaction. Contrary to our expectations, removing the control variable for the state unemployment rate from the second multivariate model reported in Table 2 slightly decreases the effect size of the dummy variable indicating a birth in 1991 (OR = .991|SE=.010; not reported in the table). To be consistent with the economic stress hypothesis, our findings would have to show the opposite: upon the removal of a control for unemployment, the effect of unemployment should be captured by the dummy for a birth in 1991, and thus be slightly inflated in terms of the effect size.

5. Conclusion

At the opening of this paper, we emphasized the importance of the case of German reunification for evaluating the effect of economic stress on sex composition in human populations: as there are a large number of potential influences on sex composition that cannot be empirically controlled for, the case of German reunification and the economic deterioration that selectively hit East Germany in 1991 constitutes a historical quasi-experiment that allows us to evaluate the strength of the effect of economic stress on sex ratios. This case was first examined by Catalano (2003). We re-examined it using longer time series of aggregate data and individual-level data.

On an aggregate level, including additional data up to 2010 showed that 1991 was not the only year in which the sex ratio had decreased in East Germany. In fact, we found similarly strong deviations from the time trend in East Germany in several other years, as both upward and downward deviations from the trend. But the unemployment rate did not change as dramatically in any other year as it did in 1991. This clearly indicates that the economic stress hypothesis cannot be confirmed in the German case. Comparing the time trend in sex ratios against a moving variance of the sex ratio and a time trend on the quantum of fertility provided evidence for the alternative assumption that the deviations in East Germany might be largely attributed to random variation due to the smaller number of births in East Germany than in West Germany.

The individual-level analysis with data covering all births between 1991 and 2009 provided further evidence for the validity of the random variation hypothesis. First, the effect for 1991 was not unique, as other years showed similar deviations when compared with the reference year of 2009. In no case was the effect for 1991 statistically significant. In fact, it was only in 2006, a year that showed an upward deviation in the sex ratio, that the effect almost reached statistical significance. Including or excluding a control for state employment rates altered the effect for 1991 only minimally, and not consistently in one direction. Therefore, we can conclude from the results of the individual analysis that the strength of the effect in 1991 did not stand out when compared to the deviations in the other years, and that this deviation was hardly or not at all influenced by the rates of unemployment.

We should also note that we did not find an effect of maternal employment on sex composition: mothers who were employed had higher odds of having a male birth than mothers who were not employed. Thus, if we assume that maternal employment is an indicator of lower economic stress, then this finding would be consistent with the economic stress hypothesis. Yet including or excluding the effect of maternal employment from models did not significantly change the effect of state unemployment rates and the effect of a birth in 1991. Thus, even though it is consistent with the economic stress hypothesis applied to the individual level, this effect cannot account for the deviation in 1991 or in any other year. Moreover, the lack of information on paternal employment status, part-time vs. full-time employment status, and a more fine-grained version of the parental couple's socioeconomic status, make it difficult to provide an exact interpretation of the employment effect. Previous research suggests that there are different effects of maternal employment on sex composition that cannot be tested with our data. For example, the Trivers-Willard effect predicts a higher share of male births among women of higher status (Almond and Edlund 2007; Trivers and Willard 1973). If maternal employment status corresponds to higher status, our finding is consistent with this hypothesis. However, maternal employment could also indicate low status if it is primarily a buffer against the unemployment of the male partner. Empirical research on maternal employment has shown that having a highly stressful job can be associated with lower sex ratios (Ruckstuhl et al. 2010; cf. Schnettler 2013). In this case, our finding would be inconsistent with these results. Thus, future research should try to test the economic stress hypothesis on the individual level with a more complete measurement of both parents' employment and socioeconomic status. As new administrative data for research purposes is increasingly being made available, there is reason to hope that we will have access to appropriate data for conducting such a test in the medium term.

Finally, we should take into account the particularities of the German case: even though East Germany underwent a rapid increase in unemployment rates in 1991 and continued to experience high unemployment rates in the years that followed, many of the adverse consequences were buffered by a generous welfare state. Therefore, the effects of economic stress on sex ratios may also have been less severe. Other Central and Eastern European countries that underwent a transformation process similar to that of the former German Democratic Republic did not have the benefit of being merged into an existing, generous welfare state. Thus, given the specificity of the case of the German transition from a socialist to a market economy, the results of the current analysis should be compared to the results of a similar analysis of other transformation countries.

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Appendix: Figures and Tables

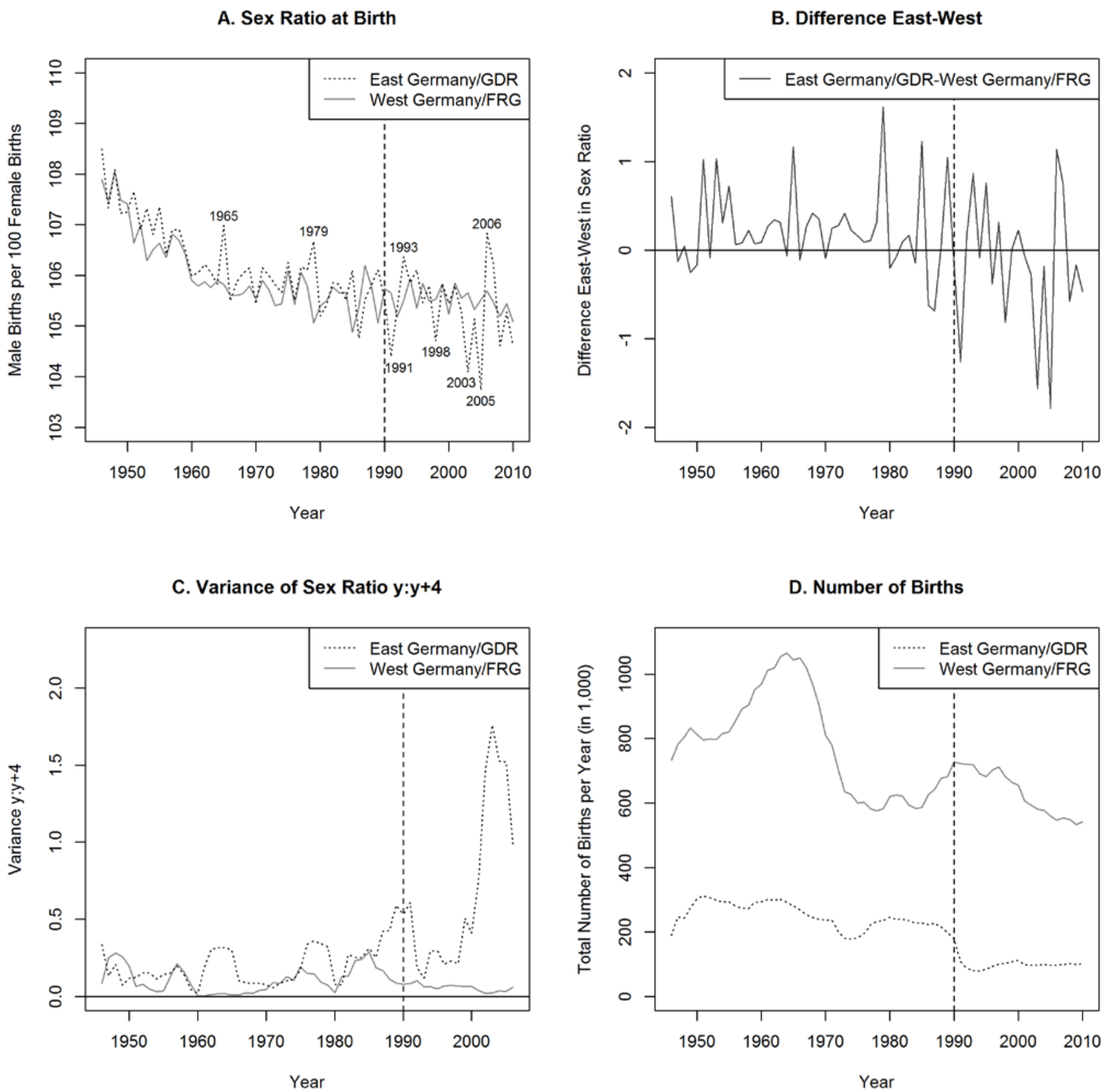

Figure 1: Development and variance of sex ratio, number of births (by region and year, 1946-2010; East and West Berlin are included in the respective regions until 2000, but are excluded from 2001 onward)

Source: Federal Statistical Office of Germany (Destatis)

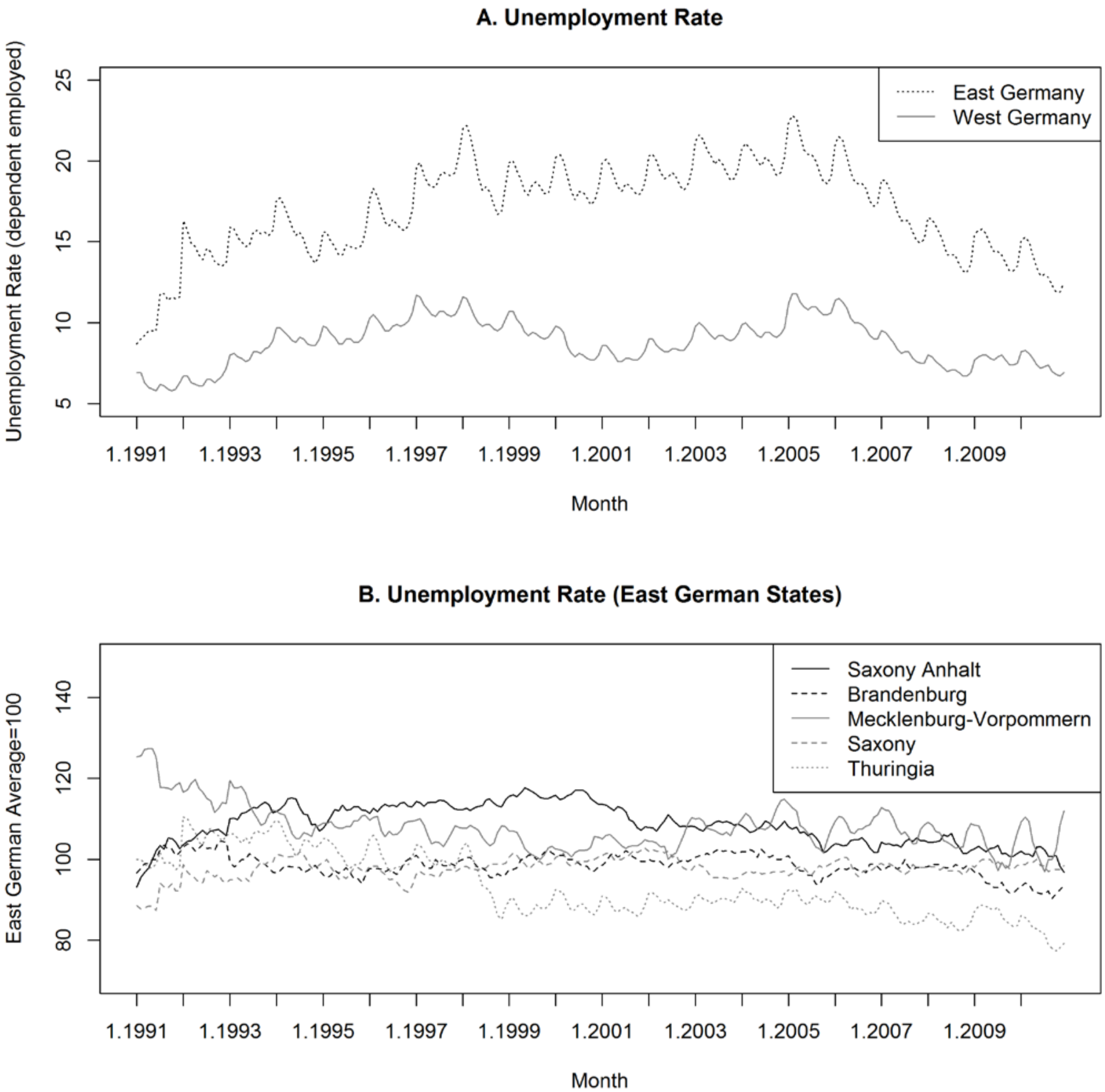

Figure 2: Unemployment trends in Germany and in the East German federal states (1991-2009), West Berlin is included in the numbers for East Germany

Source: Federal Statistical Office of Germany (Destatis)

Table 1: Logistic regression on sex of child for all births in East and West Germany, 1991-2009 (excluding Berlin)

		Bivariate		Multivariate 1		Multivariate 2		Multivariate 3	
		OR	(SE)	OR	(SE)	OR	(SE)	OR	(SE)
Unemployment rate:	at conception	1.000	(.000)						
	at birth	1.000	(.000)			1.000	(.000)	1.000	(.000)
Year of birth = 1991		.999	(.002)	1.000	(.003)	1.000	(.003)	1.000	(.003)
Birth region = East Germany		.998	(.002)	.999	(.002)	.997	(.003)	.997	(.003)
Interaction: 1991*East Germany				.994	(.007)	.995	(.008)	.995	(.008)
Mother employed (yes = 1)		1.003**	(.001)					1.004***	(.001)
Non-marital birth (yes = 1)		.997°	(.001)					.998	(.001)
Maternal age at birth:	15-19	1.000	(.003)					1.003	(.003)
	20-24	.997°	(.002)					.998	(.002)
	25-29	Reference group						Reference group	
	30-34	1.000	(.001)					.999	(.001)
	35-39	.998	(.002)					.998	(.002)
	40-40	.996	(.004)					.997	(.004)
Mother is German (yes = 1)		.999	(.001)					.999	(.002)
Month of birth:	Jan	.997	(.003)					.997	(.003)
	Feb	.992**	(.003)					.991***	(.003)
	Mar	.990***	(.003)					.990***	(.003)
	Apr	.997	(.003)					.996	(.003)
	May	.998	(.003)					.998	(.003)
	Jun	*Reference group*						*Reference group*	
	Jul	.999	(.003)					.999	(.003)
	Aug	.995°	(.003)					.995*	(.003)
	Sep	.990***	(.003)					.990***	(.003)
	Oct	.992**	(.003)					.992**	(.003)
	Nov	.993**	(.003)					.993**	(.003)
	Dec	.995°	(.003)					.995°	(.003)
	N			13'133'607		13'133'607		13'133'405	
	LL	--		-9'098'581.0		-9'098'580.6		-9'098'413.5	
	Pseudo			.000		.000		.000	

Source: FDZ (2012): German Birth Register 1991-2008 (Scientific Use File), own calculations

Table 2: Logistic regression on sex of child (East German births, 1991-2009, excluding Berlin)

	BV1		MV1		MV2	
	OR	(SE)	OR	(SE)	OR	(SE)
Saxony-Anhalt (REF)	Reference group		Reference group		Reference group	
Brandenburg	.990*	(.005)	.989*	(.005)	.986**	(.006)
Mecklenburg-Vorpommern	.983**	(.006)	.983**	(.006)	.982**	(.006)
Saxony	.988**	(.004)	.988**	(.005)	.985**	(.005)
Thuringia	.984**	(.005)	.983**	(.005)	.979***	(.006)
Unemployment (Land)	1.000	(.000)	1.000	(.001)	.998	(.002)
Employment mother (1=yes)	1.005	(.003)	1.006°	(.003)	1.006°	(.003)
Month of birth: 01			1.012	(.008)	1.015°	(.008)
Month of birth: 02			1.002	(.008)	1.006	(.008)
Month of birth: 03			1.004	(.008)	1.007	(.008)
Month of birth: 04			1.005	(.008)	1.007	(.008)
Month of birth: 05			1.014°	(.008)	1.014°	(.008)
Month of birth: 06			Reference group		Reference group	
Month of birth: 07			1.013°	(.008)	1.013	(.008)
Month of birth: 08			1.017*	(.008)	1.017*	(.008)
Month of birth: 09			1.004	(.008)	1.004	(.008)
Month of birth: 10			1.001	(.008)	1.001	(.008)
Month of birth: 11			1.005	(.008)	1.004	(.008)
Month of birth: 12			1.006	(.008)	1.004	(.008)
Mother's age at birth: 15-19			1.005	(.007)	1.005	(.007)
20-24			1.005	(.004)	1.006	
25-29			Reference group		Reference group	
30-34			1.005	(.004)	1.006	(.004)
35-39			1.007	(.006)	1.007	(.006)
40-49			.989	(.012)	.989	(.012)
Stillbirth (1=yes; 0=no)			.998	(.003)	.998	(.003)
Year of birth: 1991					.984	(.011)
(Ref.: 2009) 1992					1.001	(.010)
1993					1.011	(.011)
1994					1.001	(.011)
1995					1.010	(.010)
1996					1.007	(.011)
1997					1.015	(.013)
1998					1.003	(.012)
1999					1.016	(.012)
2000					1.009	(.012)
2001					1.014	(.012)
2002					1.006	(.012)
2003					1.002	(.013)
2004					1.010	(.013)
2005					.996	(.013)
2006					1.023°	(.012)
2007					1.011	(.010)
2008					.993	(.009)
N				1'670'048		1'670'130
LL	--			-1'156'965.4		-1'157'013.4
Pseudo R^2				.000		.000

Source: FDZ (2012): German Birth Register 1991-2008 (Scientific Use File), own calculations