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Unbalanced sex ratios in Germany caused by World War II and their effect on fertility: A life cycle perspective

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Abstract

This paper analyzes the effects of permanently unbalanced sex ratios in Germany caused by World War II on fertility outcomes over the life cycle. Using Census records linked with individual biography data, our analysis confirms the commonly found short-term pattern of decreased fertility rates due to a stark imbalance of the sex ratio. Yet, the long-term effects of such an imbalance crucially depend on when in the life cycle fertility is evaluated. We find that female cohorts with low sex ratios have fewer children at younger ages and a larger fraction remains childless. While childlessness remains higher throughout their life cycle, mothers from affected cohorts catch up and even overcompensate at later ages with respect to the number of children. Our preferred reading of this result is that with low sex ratios women select themselves into late motherhood according to their fertility preferences. This interpretation is consistent with the finding that women from affected cohorts expand their childbearing period and accept lower quality matches in the marriage market. Our findings have important implications for understanding the long-term consequences of large population shocks.

Keywords

Sex ratio; Fertility; Marriage; Life Cycle; World War II

JEL Codes

J10; J12; J13

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⁵The state Baden-Wuerttemberg in its today's borders was formed out of three smaller states in 1952. Two of the former states were part of the French zone; one state was part of the US zone.

1. Introduction

Sex ratios are important determinants of demographic and economic outcomes as diverse as gender roles and earnings inequality between males and females (Acemoglu et al. 2004). A sex ratio is defined as the number of men per women in the population with a normal equilibrium value close to one. Imbalances in the sex ratio have been shown to have significant consequences for labor and marriage markets (see Abramitzky et al. 2011; Angrist 2002; Bethmann and Kvasnicka 2013). Unbalanced sex ratios change the bargaining position of men and women in the marriage market and shift intra-household resources and family structures. While nowadays sex ratios are balanced in Western societies, the availability of new technologies of gender control in utero creates increasing imbalances in the ratio of men and women in countries where boys are favored over girls. In particular, India and China face the challenge of counteracting an increased skewness in sex ratios and its demographic and economic consequences (Anukriti 2018; Jayachandran 2017).

In this paper, we investigate the long-term effects of highly unbalanced sex ratios in Germany caused by World War II (WWII) on fertility of West German women over the life cycle. While existing papers tend to study effects at one point in time or in the short run, we analyze effects over the life cycle. We document the importance of the life cycle perspective to show that conclusions on the impact of an unbalanced sex ratio crucially depend on when outcomes are measured. We also test whether commonly documented short-term fertility patterns persist over the life cycle or whether there are offsetting mechanisms at work. Some facts taken for granted – e.g. that lower sex ratios lead to lower marriage probabilities and lower number of children – might not hold up if one follows women over the life cycle. One potential reason is that women have different margins of adjustment to achieve desired fertility outcomes: postponing marriage and fertility, extending childbearing to later ages, or accepting lower quality of matches on the marriage market.

An important innovation of our study is that we decompose total fertility into its extensive and intensive margin. The extensive margin refers to the share of women remaining childless, and the intensive margin denotes the total number of children per mother. The relationship between those two margins of fertility is crucial for understanding the impact of low sex ratios on total fertility, as they could work in the same direction, or they could offset each other (Aaronson et al. 2014; Baudin et al. 2015). While a low sex ratio may imply that more women end up childless, the consequences on the number of children per mother is less clear. One potential mechanism is selection along fertility preferences: Under scarcity of men, women with a strong preference for children sort into (late) motherhood, while women with low fertility preferences decide to remain childless.

To identify the impact of the long-lasting imbalance in sex ratios on fertility over the life cycle we exploit a stark drop in sex ratios caused by the large share of men in drafted cohorts dying in WWII. While male cohorts from 1910–1927 were fully drafted and faced a mortality rate up to 38% per cohort, later cohorts remained unaffected. Our identification strategy exploits differences in sex ratio across female birth cohorts 1919–1944 within same region and links them to life cycle fertility. Due to the special situation in post-WWII Germany, factors such as internal migration, the inflow of refugees or the selective loss of

population and physical capital do not invalidate our identification strategy. Thus, the variation in sex ratios is beyond individual control. Abramitzky et al. (2011) use changes in sex ratios due to World War I to analyze changes in mating patterns. Angrist (2002) uses changes in immigrant sex ratios in US to identify effects on labor and marriage markets. Our source of variation is closest to Brainerd (2017), who uses a sharp drop in sex ratios to identify effects of WWII in the Soviet Union on marriage and fertility.

For our empirical analysis we use sex ratios (derived from German Census records) that vary by region and by birth cohort. The main sex ratio measure stems from the first Census after WWII in 1946. We further use sex ratios from 1939 to show that the drop in sex ratios was indeed caused by WWII, and sex ratios from 1950, 1961 and 1970 to illustrate that the imbalance in sex ratios is permanent for those cohorts of women that were affected by the drafting patterns of male cohorts. The Census records on sex ratios are merged to the German Socio-Economic Panel Study (SOEP), which provides detailed biographical information on marriage and fertility over the life cycle. In addition to survey data, we make use of a 1% sample of the West German Census population in 1970 and merge it with records on sex ratios. Individuals in this sample received an additional survey module to collect comprehensive information on their socioeconomic and demographic characteristics. The data allow us to analyze a number of potential margins women may use to adjust to the situation of low sex ratios.

In the empirical analysis we first investigate the effects of the permanent drop in sex ratios on women's total fertility. We find that women facing low sex ratios are significantly less likely to have children in their 20s, which is in line with the short-term effects found in the literature (for instance Abramitzky et al. 2011; Bethmann and Kvasnicka 2013). At later ages total fertility does not significantly differ between cohorts affected by the scarcity of men and unaffected cohorts. This suggests that women with low sex ratios in the longer run catch up in total fertility. The fertility pattern found is accompanied by a short-run delay in first marriage.

We next separately analyze the intensive and the extensive margin of fertility. While the impact of male scarcity on childlessness is large and permanent, a lower number of children at younger ages is followed by a catching up and even overcompensation, leading to a significantly higher number of children at completed fertility. Using the 1% sample of the West German 1970 Census population, we explore the potential margins of adjustment women facing low sex ratios may use to achieve the desired fertility outcome. We find that a low sex ratio postpones marriage and childbearing age and expands the childbearing period. Moreover, male scarcity leads to worse matches in the marriage market (as measured by larger spousal age gaps and worse assortative mating in terms of education).

Our findings lend themselves to the following interpretation. An unprecedented rate of marriage among men made it possible that there were no large drops in marriage rates among women after WWII (Heineman 1999, p. 8–9). However, as we will show in our empirical analyses, this came at a cost for women. Their partners were older and of lower educational status, thus match quality was lower, which could imply a higher price for child quality. In a model for the quantity/quality trade-off of children that allows for differences in

the extensive and intensive margin, Aaronson et al. (2014) predict that an increase in the price of child quality would lead to a decrease in the extensive and an increase in the intensive margin. An alternative interpretation of our findings is that for women with weak fertility preferences the costs associated with having a worse match quality are too high to compensate the benefits of marriage and motherhood. They decide to remain childless. The result of this selection is the observed relationship between the intensive and the extensive margin of fertility. Importantly we observe this relationship over women's life cycle up to completed fertility. This is necessary to understand how fertility reacts to large and permanent population shocks.

We contribute to the literature on unbalanced sex ratios in several ways. Compared to previous studies (Abramitzky et al. 2011; Bethmann and Kvasnicka 2013), we document that an unbalanced sex ratio not only has immediate consequences but also affects fertility in the long run. Importantly, the magnitude of these effects crucially depends on when fertility is measured in the life cycle. By analyzing the intensive and the extensive margin of fertility separately up to completed fertility, we gain a deeper understanding on how fertility reacts to a shock in sex ratios in the long run. Taking account of these margins of fertility also allows us to investigate other possible mechanisms of sex ratio effects. Compared to other studies our fertility patterns seem to be driven by a postponed and prolonged period of fertility and a worse match quality. Finally, while other studies were using transitory changes in sex ratios for the analysis of long-term effects (Acemoglu et al. 2004; Goldin and Olivetti 2013), we document the consequences of a permanent reduction in the number of men per woman for affected female cohorts.

The remainder of the paper is organized as follows. The next section provides a brief summary of the existing literature. Section 3 presents the census data and describes the historical context as well as the variation in the sex ratios. Section 4 describes the individual level data and provides descriptive statistics of the data we will use in this analysis. Section 5 contains our models of the effects of these changing sex ratios on demographic outcomes. Results are presented and discussed in Section 6. The final Section 7 highlights our main conclusions.

2. Literature

According to the marriage model (Becker 1973), a decrease in sex ratio improves male bargaining position increasing male marriage rates and economic resources. Several authors studied short-term consequences of reductions of men per women. Abramitzky et al. (2011) document effects of changes in sex ratios in France caused by male mortality in WWI. They show that regions with a larger sex ratio decrease, men were more and women were less likely to marry three years after end of WWI. Divorce rates decreased and out-of-wedlock births also increased.

Lafortune (2013) analyzes sex ratios in second-generation American immigrants and shows that greater scarcity of potential partners leads individuals to invest more in attributes considered attractive by potential partners. Using county-level Census data for the German state of Bavaria for 1939 and 1946, Bethmann and Kvasnicka (2013) document that a

reduction in the number of men per women due to WWII increases probability of non-marital fertility. This effect is stronger for counties with a lower expected return of soldiers. Brainerd (2017) uses both sex ratios and outcomes measured in the first Russian post-war census of 1959 to document that dramatic drops in sex ratios for several cohorts and regions in Russia lead to lower rates of marriage and fertility as well as higher rates of out-of-wedlock births and divorces for women.

There is a literature documenting effects on female labor supply. Angrist (2002) showed that lower male sex ratios among second-generation immigrants in the US lead to higher labor market participation and lower female marriage rates. Acemoglu et al. (2004) find that in US regions where more men were serving in WWII, more women entered the labor market, leading to a lowering in female wages and increased earnings inequality. There is an unresolved discussion on whether women who worked due to WWII mobilization did so permanently or whether they became housewives when soldiers returned from WWII. At least for some groups (those entering white-collar jobs), the change was permanent (Goldin and Olivetti 2013). Effects of increasing labor supply even carry over to the next generation by making sons of working mothers more likely to have working wives themselves (Fernández et al. 2004). The latter two studies considered long-run effects of unbalanced sex ratios. These papers do not document life-cycle effects on individual women and cannot make inferences on age-specific patterns of unbalanced sex ratios. In the US labor market, men absent during the war were replaced by women (Doepke et al. 2015). In Germany, this replacement was mainly done with prisoners of war and forced laborers, while female labor force participation increased only slightly over the course of the war (Kaldor 1945).

The recent literature deals with different processes driving the extensive margin (whether someone becomes a mother) and intensive margin (fertility of mothers) of fertility. Baudin et al. (2015) argue that two forces driving these margins are poverty (poor women not having access to technologies overcoming childlessness) and opportunity costs (higher for highly educated women). Aaronson et al. (2014) show that allowing for an extensive margin of fertility in the Beckerian quantity-quality model generates new insights for fertility transitions. Changes in the price of quality of children can influence intensive and extensive margin differentially.

Lastly, this paper relates to recent studies on long-term effects of war. This literature stresses that there are negative long-term effects on health and labor market outcomes (Akbulut-Yuksel 2014; Kesternich et al. 2014), and on preferences of the surviving population (Bauer et al. 2016). Regarding WWII, the mostly studied channels of how wars affected well-being of survivors has been the experience of hunger (Jürges 2013; Kesternich et al. 2015; Lumey et al. 2011; Neelsen and Stratmann 2011).

3. Sex ratios and historical context

3.1. Sex ratios constructed from German Census data

We collected German Census records from the first Census after WWII in October 1946. The Census was conducted by four occupational powers (USA, UK, France and Soviet Union) for the remaining territories of Germany. By constructing sex ratios at German state

level, we obtain sex ratios that vary across birth cohorts and state of residence. Sex ratios are heterogeneous across different German states. To assess pre-war sex ratios and to compare them with post-war sex ratios, we collected sex ratios from the Census of 1939.¹ Finally, we obtained data on the number of expellees in 1946 by year of birth for the states of Bavaria, North-Rhine Westphalia and states in the Soviet zone to investigate their influence on gender ratios.² To analyze long-term patterns in sex ratios, we collected sex ratios from Census years 1950, 1961 and 1970 in West Germany. From 1949 onwards, the three western occupation zones formed the Federal Republic of Germany (“West Germany”) and the Soviet zone became the German Democratic Republic (“East Germany”).

For the relevant period, most population data by birth year and state level have not been digitally available. We obtained data on sex ratios by gender, birth cohort and German states from State Statistical Offices, the Federal Statistical Office of Germany and from various printed publications. Detailed references for all Census years and states are contained in Online Appendix A. To our knowledge, we are the first assembling a data set with sex ratios by birth cohorts on the state level for Germany for these five Census years.³

3.2. Variation in sex ratios

Sex ratios are typically defined as the number of men divided by number of women stratified by year of birth and region of residence. Figure 1 displays two subfigures for sex ratios in Census years 1939 and 1946. In our main analysis, we will use the sex ratios from 1946 since part of the shifts in later years may be endogenous.⁴ Post-war sex ratios (1946) are displayed in Figure 1A, pre-war (1939) sex ratios in Figure 1B. Before WWII, there is a much smaller regional variation across German states. In addition, for one exception, sex ratios are balanced in 1939. Figure 1B exhibits a sharp but temporary drop in the sex ratios in 1939 for birth cohorts 1915–1920. These birth cohorts were drafted for compulsory military service or labor service in 1939 and hence were not included in the Census (Statistisches Reichsamt 1940). Patterns in Figure 1B alleviate concerns about selective drafting patterns across German states.

By contrast, Figure 1A shows that in 1946 sex ratios strikingly vary over birth cohorts and somewhat less so across region of residence after WWII (see e.g. Grant et al. 2018). The birth-cohort-pattern can be explained by drafting pattern of German armed forces. Over the course of the war, 17.3 million men were drafted in total. While birth cohorts from 1910 to 1927 were fully drafted, those born in 1928 and 1929 were only drafted occasionally (Kroener et al. 1988). This drafting pattern led to a large variation in mortality across birth cohorts. Therefore, sex ratios were highly imbalanced for cohorts born in 1927 and earlier, while they are close to unity for cohorts born after 1927.

¹A challenge in analyzing the data from 1939 is the different regional structure of Germany before and after WWII. Since we analyze Germany in today's borders, “provinces” of 1939 are matched to the post-unification states of Germany. A detailed description of regional differences before and after WWII and the matching procedures are contained in Online Appendix A.

²The term expellees refers to migrants from the former Eastern territories of the German Reich or Ethnic Germans who lived as minorities in countries such as Czechoslovakia. Census results of 1946 include expellees. In a related study, Grant et al. (2018) use sex ratios at the district level. Evidence on Polish expellees shows that they acquired higher levels of education (Becker et al. 2018).

³Note that since we want to make use of the stark variation in sex ratios over birth cohorts, we cannot use data on smaller geographical units than German States, since the Census data is disaggregated either by regions within a State or by cohorts.

⁴As a robustness check, we will also use sex ratios from 1950; see Section 1.8, Online Appendix B.

Figure 1A also shows considerable differences in sex ratios in 1946 across German states. States within the Soviet zone (thick dotted lines in purple) and Berlin (which was divided among the allied forces) were particularly affected by lack of men in 1946. States within the British zone (solid lines in orange) as well as the US zone (dashed lines in black) display much higher sex ratios compared to Soviet and French zones (thick solid lines in blue).⁵ Geographical clusters in sex ratios outlined in Figure 1A were largely a result of different conditions at the Eastern and Western frontlines at the end of the war.⁶ While the German Army was pushed back on all fronts as Allied troops advanced, large numbers of German soldiers on the Eastern front tried to flee to the West to escape imprisonment by the Soviets (Henke 1996). By June 1945, about 5 million had surrendered to the US army, and around 1 million of them fled from the Soviets (Bischof and Ambrose 1992). Battles in the last days of war were much fiercer in the Soviet zone. To hold back the Soviets, available men from the local population including very young boys and old men had to fight as a last resort without proper training and equipment. This strategy led to very high losses among the male population (Steinberg 1991).⁷

Figure 2 shows the fraction of German men in each birth cohort who died in the war. While in total about 5.3 million German soldiers died during the war (Overmans 2004), about 34%–38% of men of birth cohorts 1916–1924 died in war. This fraction declined dramatically after 1925 and more gradually for birth cohorts before 1914.

For reasons outlined above, we assume sex ratios changed permanently due to WWII. Figure 3 illustrates sex ratios for later Census years. Figures 3B and 3C demonstrate that the sex ratios are permanently lower, and that they had not recovered from the shock of WWII up to 25 years later.

The persistence of low level of sex ratios due to WWII is corroborated by Figure 4, which plots sex ratio by Census years for affected and non-affected birth cohorts. It shows that individuals born after 1927 face a balanced sex ratio over the whole life course. Sex ratios for individuals in 1927 and earlier show a dramatic drop between 1939 and 1946. They only slightly improve until 1950 and remain highly imbalanced in later years.⁸

4. Individual level data

4.1. The German Socio-Economic Panel

In the empirical analysis, we combine Census data on sex ratios on the German state level and rich individual level data from the German Socio-Economic Panel (SOEP) (Goebel et. al. 2018). SOEP is a longitudinal panel survey modelled after the PSID that surveying a representative sample of the German population. Since 1984, SOEP interviews about 20,000

⁶We also include the states that became part of East Germany in the figures displaying the sex ratios in 1939 and 1946 to give a better illustration of the historical context.

⁷The influx of expellees did not considerably alter sex ratios on the state level in 1946. Figure A.1 compares sex ratios of the overall population with sex ratios of the native population (without expellees) for states of Bavaria and NRW and Eastern German states. There is no considerable difference between the native population and the population including expellees in 1946. If anything, the sex ratios are even slightly lower if expellees are taken into account, which can be explained by the large share of women and children among them.

⁸In Figure 4, the most affected cohort is individuals born in 1924 whose sex ratio falls to 0.6 and never increases to more than 0.7 over the life cycle.

individuals from more than 11,000 German households, collecting comprehensive respondent information on labor force participation, economic status, health, life history and household composition.

For our demographic outcome measures, we use a spell-based biography module, which is first collected when a respondent enters the sample and is updated in each wave. This module provides comprehensive annual information on marital and fertility history of individuals over the life course. Respondents and non-respondent household members report the onset and duration of marriage, divorce, widowhood, and childbirth from age 15 to the interview date. Using this information, we construct marriage and fertility outcomes. We thus construct our sample starting from the biographical module, rather than restricting the SOEP data based on choosing specific waves.

Since we are interested in impacts of sex ratios around WWII, we restrict our sample to women born between 1919 and 1944. We exclude individuals from older birth cohorts because they were also affected by WWI (1914–1918) providing us with 6,878 women. We restrict data to respondents who were either born within today's borders of the Federal Republic of Germany (West Germany) or immigrated to this area before 1949. We exclude individuals from West-Berlin and the Saarland because of their special status in the years after WWII and up to the reunification in 1989.⁹ This leaves us with a sample of 4,505 women.

To link 1946 Census records with SOEP data, two identifiers are required. We use women's birth year to link sex ratios from birth cohorts. The second identifier is state of residence where women were born or grew up. While this is not available from a direct question in SOEP, we use combined information from two separate questions to proxy women's residence during childhood. First, respondents report federal state of last school attendance available for 1,313 women. Second, respondents are asked if they still live at the place where they were raised or if they moved back to the place of childhood. This information is available for 2,039 women. We combine information from these questions and obtain a proxy for state of residence during childhood for 2,681 women born between 1919 and 1944.¹⁰

Table 1 provides an overview of the main descriptive statistics and gives a comparison of our analytic sample with total sample of West German women in relevant age group. Means and standard deviations for analytic variables are very similar in both samples. On average, women in our sample are born in 1935; 93% of these women get married, and 87% have children. They are 24.5 years old when they marry and give birth to their first child about 11 months later, at age 25.4. Unmarried women are almost three years younger when they give birth to their first child.

⁹Since the Saarland was not part of any occupation zone in October 1946, no census results for 1946 are available.

¹⁰If respondents report valid answers to both questions, we use information on residence of last school attendance. Kesternich et al. (2018) compare this with reliable state of birth obtained from wave 2012 and find it is consistent for about 87% of SOEP respondents born between 1929 and 1955.

A valid issue with our definition of the analytic sample is that some women may have moved immediately after WWII. If this were the case, our results may be explained by (endogenous) selection rather than by the variation in sex ratios. However, we can exclude such an issue since moving was heavily restricted after the war. Allied forces enforced a law that forbade moving within and across zones until summer 1947. Afterwards, moving was restricted by the Allied Control Council Law No 18 (to obtain a moving permission housing space needed to be proved) as well as by moving bans for many cities (Hottes and Teubert 1977). In-migration towards these cities was banned until the end of the 1940s as German cities were facing a severe housing shortage in consequence of aerial bombing during the war (see e.g. Kift 2008).

4.2. 1% sample of West German population

While SOEP provides us with individual life cycle information, it only contains information on current husbands, and a large share of our respondents fill out the biography questionnaire only in 2001. To analyze potential mechanisms linking imbalances in sex ratios and fertility in a data set that is less likely to be affected by selection issues caused by death of husbands or divorce, we exploit individual level data from a 1% sample of the West-German population in 1970.¹¹ This sample received an extra module with detailed questions on individual's marriage, fertility, labor and other SES attributes, and includes information on spouses. This module has two drawbacks compared to SOEP. First, while SOEP tracked women over their whole life course and until completed fertility, the Census reports women's status quo in 1970. Second, most women have not reached the age of completed fertility when surveyed. Thus, while we cannot analyze total fertility or life cycle effects using this sample, we can use the data to conduct an analysis of the potential mechanism linking imbalances in sex ratios and fertility patterns. Still, the 1970 Census is considered the only data set that allows population-wide estimation of fertility for women of the relevant age range, since the question about women's fertility is unfortunately then not asked until the Microcensus of 2008 (Kreyenfeld and Konietzka 2017).

The original 1% sample consists of 623,131 individuals born between 1870 and 1970. To obtain a sample comparable to that of SOEP, we restrict data to female birth cohorts 1919–1944, living in West Germany before WWII. We exclude non-German residents, expellees, refugees from territories of former German Reich and only keep women who are household heads or spouses of household heads. We link the resulting sample with 1946 Census records and obtain an analytic sample of 66,106 women. We construct a second sample containing education and marriage information on wives and husbands, resulting in sample of 58,954 couples. Using year of birth and education, we compute differences in age and education between wife and husband.

Table 2 provides statistics of variables for individual and couple samples. 95% of women are married in 1970, and their first marriage takes place at about age 24. About 84% of women have children and the average number of children is 2.21 along the intensive margin of fertility. Average total fertility is 1.84 children per woman. Married women give birth for

¹¹The data comprise a 10% sample of residents in West Germany from the German Census in 1970. For a detailed description of the data, see Schimpl-Neimanns and Frenzel (1995).

first time at about age 25. By comparing these numbers with descriptive statistics for SOEP in Table 1, we find similar values for age at first marriage and first birth. Fertility numbers are smaller than in SOEP samples, because for part of the sample fertility has not yet been completed.

5. Empirical Strategy

WWII caused a dramatic and sudden drop in the availability of men, resulting in a significant imbalance in sex ratios. Independently of which age our respondents had at the time of the Census, sex ratios measure the drop in number of men that women faced. If someone was too young in 1946 to be affected by drafting of men in WWII, their sex ratio will be close to unity. This individual is unaffected by over-proportional dying of men during WWII. Such a person will face balanced sex ratios throughout her life, as there were no further big shocks to sex ratios in Germany later. By exploiting this source of exogenous variation, we estimate empirical models of sex ratios and marriage linking them to fertility and marriage behavior.

Note that sex ratios vary by cohort and region (state). To control for time and cohort-specific trends, we use region and 5-year cohort dummies. The 5-year birth cohort intervals are 1919–1924, 1925–1929, 1930–1934, 1935–1939, and 1940–1944. We cannot include year of birth fixed effects, since our sample in the SOEP is too small to allow for both cohort and region fixed effects. However, absent of the effect of sex ratios, we would not expect any stark changes in fertility within these 5-year cohorts. We will provide several pieces of evidence to confirm this assumption. In particular, we will additionally control for whether a specific fertility period falls within WWII; take account of region-specific trends by interacting calendar time and region fixed effects; and add measures of GDP and economic uncertainty to our main specification. Given the stark drop of sex ratios for the cohorts born before 1928, we moreover split the birth cohorts at this cutoff date and used this in the regressions instead. As we will show in the robustness section, our main results also go through in this setting. However, for reasons specified in the next paragraph, we do not believe that such a stark cutoff is the right way to think about our variation.

While sex ratios are typically defined as men/women from same region and birth cohort, individuals can substitute towards partners a few years older or younger. On average, men are about 3.3 years older than women (see Table 2). To allow for this type of substitution in our empirical analysis, we define the sex ratio by choosing a window including birth cohorts from up to three years older to two years younger than the respective birth cohort. For a woman born in 1920, the sex ratio is calculated as number of men born in 1917–1922 divided by the number of women from same birth cohorts. The window definition is based on the 1950 Census, which shows that these are most common age differences for our birth cohorts (see Table 3).¹²

¹²We used a window of women ranging from 2 years older up to 3 years younger than men because this covers between 61% (1920) and 82% (1927) of all married couples in 1950 (see Table 3). For checks of the robustness to the definition of this window, we also allowed for broader windows and alternative definitions of the sex ratio measures (see Sections 1.9–1.12 in Online Appendix B).

We compare both definitions of sex ratio measures in Figure 5 for the SOEP sample, finding they are very similar except for birth cohorts around last fully drafted cohorts. If sex ratio is defined as number of men per women by year of birth, the sex ratio jumps back to one for the cohort of 1928. This is the first cohort of men who were not fully drafted for WWII. By contrast, the sex ratio shock is fading out more gradually when using the window definition of sex ratios. In the robustness section, we will consider several alternative definitions of the sex ratio.

To estimate impact of unbalanced sex ratios we set up a general linear OLS model that links the outcome of interest with the sex ratio in 1946 and with a set of covariates.

$$Y_i = \alpha + \beta_1(\text{sex ratio})_{cm} + \gamma X_i + c + m + \varepsilon_i \quad (1)$$

In this specification, α is the constant term, X_i is a set of covariates, and ε_i is an error term. $(\text{sex ratio})_{cm}$ denotes the sex ratio of an individual belonging to birth cohort c in residence m . Since we have panel data, we can control for both age and cohort effects by keeping the target ages of our outcomes fixed and including 5-year cohort dummies denoted by the parameter c . The parameter m denotes a state of residence fixed effect, controlling for all time-constant differences between German regions. In all regressions, we control for individual's socioeconomic status by including a dummy that takes the value one if the father and the mother had upper secondary education, and is zero otherwise. Additionally, we control for years of schooling. Standard errors are clustered on the state of residence level (see Bertrand et al. 2004).

While sex ratio in 1946 is constant over time, its impact may change over different stages of life cycle. To obtain life cycle profiles of fertility, we separately estimate Equation (1) at different ages. Starting at age 20, we provide estimates for 2–3 year intervals until age 50 which we take as age of completed fertility. Estimated coefficients represent age-specific impact of a unit-change in sex ratio in 1946 on outcome of interest. While result tables will show the original estimated coefficients, we will interpret them as the impact that a reduction in the sex ratio from 10/10 men to women by 1 man to 9/10 men to women has on outcomes of interest.

We analyze issues of sample selection in Section 6.3, and we show results for an alternative estimation strategy (discrete-time proportional hazard models) in Section 6.5.

6. Results

The following section provides results from estimating impacts of sex ratio in 1946 on fertility and marriage. To obtain the effects of interest at different stages over the life cycle we run Equation (1) for age 20, 23, 25, 28, 30, 33, 35, 38, 40, 43, 45, 48, and 50. Table 4 displays the coefficients and standard errors of the life cycle profiles for fertility and marriage outcomes.

6.1. Life cycle patterns of fertility and marriage

Our main interest lies in how imbalanced sex ratios influence fertility over the life cycle. Our hypothesis is that in the short run women with low sex ratios face fewer potential partners and have fewer children, leading to a fertility decline (Brainerd 2017 for post-WWII-Russia). However, in the long-run, women have several margins of adjustment, so the long-run effects on fertility can differ from the short-run effects. We first analyze total fertility.¹³ As illustrated by Figure 6a, we do find a significant reduction for women in their 20s who face low sex ratios. At age 28, a decrease in sex ratio in 1946 from 10/10 to 9/10 men to women decreases the number of children by 0.144, corresponding to a 11.5% reduction in number of children at this age-specific mean. However, the negative effects of a decrease in sex ratio on fertility at young ages turns into a positive albeit insignificant effect at age 35 and until completed fertility. This finding documents an interesting pattern. Even though women exposed to a low sex ratio have fewer children when we evaluate their fertility at younger ages, they catch up with their high sex ratio peers at any age later than 35 and when fertility is completed. It is important at which point in time long-term effects of unbalanced sex ratios are evaluated.

One possible pathway linking sex ratios and fertility is marriage: Most children (91.2%) are born within a marriage. The increased scarcity of men as sex ratio goes down implies that marriage unions will be more difficult to finalize so we expect an increase in age at first marriage and a lower probability of being married at younger ages. This delay in marriage age will be exacerbated by war deployment and post-war occupation. Figure 6b shows impacts of unbalanced sex ratios on probability of being married for the first time. We find reductions in sex ratios result in statistically significant decreases in probability of being married at ages 20–38. The estimated coefficient at age 23 is 1.176, suggesting that a reduction from 10 to 9 men for every 10 women decreases probability of being married at age 23 by about 11.8 percentage points. Given that 50% of women in our sample are married at this age, this corresponds to a reduction in marriage probability of 23.5%. The effect decreases with age, but remains statistically significant at the 5% level until age 38. At age 38, a reduction of 1 man for every 10 women still leads to a 3.5% lower likelihood of being married. From age 40, effects are statistically not significant anymore. This suggests that the consequences of unbalanced sex ratio on the marriage market phase out with age and are offset in the long run. Shifts in marriage patterns from low sex ratios seem to have consequences for women's fertility pattern. As low sex ratios lead to a lower probability of early age marriage, we expect that fertility is delayed due to the scarcity of men at younger ages.

Another important driver of total fertility is the relationship between the extensive and intensive margin (Aaronson et al 2014; Baudin et al. 2015), the share of women remaining childless and number of children among women with children. Hence, we look at the probability of remaining childless – the extensive margin of fertility – over the life cycle. Figure 6c shows that a decline in sex ratios significantly decreases the probability of having a child at ages 25–30. At age 25, we obtain an estimated coefficient of 0.521, suggesting that

¹³Number of children a woman has given birth at given target ages includes women who are childless.

a reduction from 10 men to 9 men per 10 women reduces the probability of having a child by about 5.2 percentage points. This effect remains statistically significant on the 95% confidence level at ages 28 and 30, and it mostly remains statistically significant beyond the age of 30 on the 90% level (see Table 4, Column (3)). At completed fertility, women facing a lower sex ratio still have a lower probability to have children than women facing a high sex ratio.

What about the intensive margin? Figure 6d displays sex ratio effects on fertility excluding childless women. We find a similar pattern in estimated coefficients over target ages as for total fertility (Figure 6a). At age 28, a reduction in sex ratio of 1 man for every 10 women significantly decreases the number of children by about 0.146, a 10.2% reduction. From age 33, women facing a low sex ratio not only catch up but start to significantly outperform women with higher sex ratios in the number of children. This overcompensation remains statistically significant at the 5% level until age 50, implying a 5.7% higher number of children at completed fertility. Thus, for women facing low sex ratios the higher probability of being childless is overcompensated by having more children.

We find that women facing low sex ratios have a higher probability to be unmarried and childless in their 20s, but they catch up. This is supported by results for regressions of age at first/last birth on sex ratios in 1946 and 1950 displayed in Table A.1. We find that a decrease in sex ratios of 1946 by 1 man for every 10 women significantly increases mother's age at first birth by more than 6 months and age at last birth by about 8.7 months. These numbers not only suggest that women facing lower sex ratios in 1946 postpone their childbearing period. It also implies age at last birth increases even more than age at first birth, and that the childbearing period is not shorter, but longer. Column (5) in Table 4 confirms this finding by showing that a decrease in sex ratio decreases the probability of having a child below the age of five at ages 23 to 28. At age 23, the coefficient is statistically significant at the 10% level. By contrast, at ages 33 and 35 a reduction in the sex ratio significantly increases probability of having a child below the age of five.

The previous analysis suggests that imbalances in sex ratios predict a decrease in extensive margin of fertility at younger ages and a catching up effect in fertility along the intensive margin for women older than 30. To illustrate the relationship between the intensive and extensive margin, we plot the distribution of total fertility by birth cohorts with high and low sex ratios separately (see Figure 7). Women with low sex ratios are overrepresented in both tails of the distribution (thus among women with very few and very many children), while women with high sex ratios have a more compressed fertility distribution. These distributions suggest some sort of selection mechanism. Women with strong preferences for children that were affected by the scarcity of men do get married and have many children even if they do so at later ages and, as we will see later, at the cost of obtaining lower quality matches on the marriage market. Women with weak preferences for having children tend not to marry and remain childless. This leads to a higher fraction of childless women in one tail of the distribution but also to a higher number of children in the upper tail of the distribution. Thus, in our case the intensive and extensive margin are substitutes.

6.2. Analysis of mechanisms: matching quality

We move to the 1% sample of the German Census in 1970 to use data not present in SOEP (information on partners) and to re-estimate some cross-sectional results with a larger data set. The data set has the advantage that 1970 is closer to WWII and thus our sample is less affected by selective mortality. The disadvantage is though that we observe neither completed fertility nor effects at different ages already in 1970. Still, we can confirm some of our results. Regression results presented in Column (1) of Table 5 confirm that we find that a low sex ratio significantly increases women's age at first birth. The average age at first marriage for a woman facing a completely balanced sex ratio is about 23.2. A reduction in sex ratio by 1 man to 9 men for every 10 women increases age at first marriage by about 5 months to an age of 23.7. Similarly, a highly imbalanced sex ratio delays birth of the first child (Column (2), Table 5). While a fully balanced sex ratio predicts an age at first birth of 24.2 years, a sex ratio of 0.9 delays this by about 4.5 months to an age of 24.7. Marriage is delayed more than childbearing so married women facing low sex ratios give birth earlier.

A potential mechanism is that women facing unbalanced sex ratios accept worse matches on the marriage market (Abramitzky et al. 2011). We test this by using two measures of matching quality, the degree of assortative mating on education and the age gap between spouses. We follow Greenwood et al. (2014) by defining assortative mating through the likelihood that someone marries someone from a similar economic background. We also follow these authors in the way we set up our regressions, thus regressing the wife's educational status on her husband's. Column (1) in Table 6 shows results from regressing years of wife's education on years of husband's education, the sex ratio in 1946, an interaction term between husband's education and the sex ratio, and on covariates. Wife's average years of education increase as the sex ratio decreases.¹⁴ This is in line with women investing more in their labor market prospects in times of male scarcity (e.g. Acemoglu 2004; Angrist 2002). Regarding matching in the education dimension, we find a positive coefficient for the interaction term. The more balanced the sex ratio, the better the educational quality of the husband or, the degree of assortative mating decreases as sex ratio imbalances increase. Consider a completely balanced sex ratio. At a sex ratio of 1 an increase in husband's education by one year increases wife's education by $(0.179 + 1 \cdot 0.112) = 0.291$ years. Compared to a situation with a sex ratio of 0.9, an increase in husband's education by one year increases wife's education by only 0.280 years. Column (2) of Table 6 provides results from an OLS regression of positive and negative absolute differences in the years of education by husband and wife. While not being statistically significant, both coefficients have a negative sign, thus supporting our hypothesis of a worse assortative mating for imbalances in sex ratios.

Table 7 shows the findings from regressing spousal age gaps on sex ratios in 1946. The negative coefficient for the sex ratio in Column (1) indicates that the age gap between husbands and wives increases with a stronger imbalance of the sex ratios. Column (2) of Table 7 shows how a low sex ratio influences the spousal age gap for husbands being older

¹⁴For average years of husband's education, a wife facing a sex ratio of 0.7 has about 8.86 years of education while a wife with a balanced sex ratio of 1 has an average of 8.74 years of education.

than their wives. If the sex ratio is equal to 1, husbands are about 6.9 years older than wives. A reduction in the sex ratio by 1 man to 9 women increases this age gap by 0.13 years or about 1.6 months to 7.05 years. Column (3) provides the OLS results when the husband is younger than the wife. Here, the average age gap for a balanced sex ratio is 2.6 years, compared to an age gap of 2.67 years if the sex ratio is 0.9. This result is broadly in line with the previous literature, for instance Brainerd (2017) who also finds adjustments to male scarcity through increased age gaps. The findings may help to explain the presumed low match quality due to the relative scarcity of men.

How can the fact that women facing low sex ratios are *ceteris paribus* married to lower educated spouses be related to our results on the extensive and intensive margin of fertility? In a collective household model, parents face the usual Beckerian trade-off between quantity and quality of children (Becker and Lewis 1974). Father's education is an input in producing child quality. Thus, a lower educated father makes it more costly to produce "high quality" children and thus the trade-off between more and better children may shift towards more. This leads to a fertility increase along the intensive margin, as women substitute quality for quantity (Aaronson et al. 2014). At the same time, the value of having children decreases, leading to higher shares of childlessness. Note that, unfortunately, we do not have direct evidence on the level of education of children in our data.

6.3. Sample selection

As outlined in Section 4.1 we combine two SOEP questions in order to identify the respondent's residence of birth. This information is only available for a subset of respondents, which may create a problem of non-random selection into the analytic sample. To address such a potential selectivity issue, we use two alternative ways to assign a sex ratio to respondents. This allows us to repeat our analysis with the full sample of SOEP respondents. First, we use the sex ratios in 1946 across birth cohorts for West Germany instead of separate regional measures. Second, we assign respondents the sex ratio in 1946 using the current region of residence instead the residence during childhood. We obtain a full, analytic sample of 4,149 West German women born between 1919 and 1944.

Figures A.2 and A.3 present the estimated coefficients and the 95% confidence intervals from re-estimating Equation (1) on the full sample.¹⁵ Overall, the estimated coefficients are somewhat smaller than in Figure 6, but the life cycle patterns remain unchanged across all outcomes. As in Figure 6, we find a significantly lower total fertility for women in their 20s who face low sex ratios and a catching up pattern at later ages that turns into a positive relationship latest in their 40s. The patterns exhibited for the extensive and the intensive margin of fertility are as expected: Women who experienced low sex ratios have a lower probability of having children and these effects are statistically significant throughout the life cycle (at least on the 10% level, see Figures A.2c and A.3c). At the same time, these women have less children at younger but they again catch up and overcompensate the effects at younger ages with a higher number of children at later ages. Turning to marriage patterns,

¹⁵Estimated coefficients and standard errors are available in Tables 1 and 2 of Section 2 in Online Appendix B.

we again find that low sex ratios result in statistically significant decrease in the probability of being married at early ages – a pattern that is consistent with Figure 6B.

Altogether, we do not find any evidence that the estimates in our main specification biased by our criteria of sample selection. The results support the general observation that the post-war German population exhibited very low geographical mobility with about 95% did not relocate between 1939 and 1950 (see Bauer et al. 2013).

6.4. Robustness

We next perform a number of robustness checks on the long-term relationship between sex ratios and outcomes of interest. We examine several modifications of the main specification, including controlling for potential confounding shocks, using alternative definitions of the sex ratio measures, and using nonlinear models. All Figures discussed in the Robustness Section can be found in Section 1 of Online Appendix B.

In a first set of robustness checks, we explore the impact of variations in the sex ratio relative to other external shocks. First, we consider the possibility that WWII had direct effects on women's fertility, as would be predicted by models as in Bhalotra et al. (2018) and Vandembroucke (2013). We address the consequences of WWII in two ways: First, all our specifications control for five-year cohort effects. Second, we add an indicator for whether a women was younger than 15 years old, aged 15–20, 20–25 or older than 25 years during WWII (where the latest group captures the cohorts 1919 and 1920). Coefficients show a very similar pattern in total fertility when controlling for these age-war dummies (Section 1.1, Online Appendix B). Although the standard errors are rather large, we find a catching up and overcompensating impact of low sex ratio on long-term fertility, such as in Figure 6. The estimated coefficients for the extensive margin are all positive but not statistically significant on the 5% level. The point estimates for marriage probabilities suggest lower changes in marriage probabilities than in our main specification, and the effects mostly do not become insignificant later in life. Third, we further explore robustness of findings with respect to experiencing WWII per se by restricting our analysis on women who gave birth to first child after 1945. This ensures that women who already had children in 1946 do not drive our results. As can be seen in the figures in Section 1.2 in Online Appendix B, the results are very similar to those we obtained from the sample used for our main specification. For the same reason, we also exclude women who were married before 1946. The way in which we define the sample of women does not affect our main conclusions on the impact of imbalances in the sex ratio neither on fertility nor on marriage over the life cycle. The results for this robustness check can be found in Section 1.3 in Online Appendix B. To analyze whether our results are driven by never-married women, we exclude all women who reported that they never married from the sample and re-estimated Equation (1) for fertility and marriage outcomes. The results for ever-married women are very similar to our main findings in Figure 6 (see Section 1.4 in Online Appendix B).

In a further robustness check, we include a measure of economic uncertainty into our regressions. Chabe-Ferret and Gobbi (2018) show that economic uncertainty (as measured by the standard deviation of GDP in a certain age range) can influence fertility choices. We construct a GDP volatility measure that takes account of deviations of national-level GDP

experienced by our respondents before they reach the age at which the outcome is measured. Compared to findings on fertility and marriage for our main specification in Figure 6, the pattern displayed by estimated coefficients is even amplified when controlling for economic uncertainty (see Section 1.5, Online Appendix B). Despite, we also find that economic uncertainty itself reduces total fertility from about age 28, which is driven by both, a lower extensive and intensive margin of fertility. This result is in line with findings of Chabe-Ferret and Gobbi (2018).

As an alternative to controlling for specific shocks, we take account of region-specific cohort trends (Section 1.6, Online Appendix B). While the overall pattern of the estimated coefficients over the life cycle is very similar to the one we obtain from our main specification, we find only a very small overcompensation in total fertility at older ages, and bigger but statistically insignificant effects along the intensive margin. Overall, the estimated coefficients tend to be closer to zero than in the main specification.

To investigate whether the effects are different for women from rural and urban areas, we stratify our sample by area (Section 1.7 in Online Appendix B).¹⁶ The results show that women from rural areas respond to unbalanced sex ratios stronger in the extensive margin of fertility, while women from urban areas are mainly responsible for the overcompensating pattern in the intensive margin of fertility. Women from rural areas also are the main drivers for the found marriage pattern, which is in line with the higher probability of being childless.

In a second set of robustness checks, we interchangeably use alternative measures for the sex ratio. First, we use the sex ratio from the 1950 Census. Almost all surviving prisoners of war had returned by the time of the 1950 Census.¹⁷ A further alleviation of the shortage of men was hence not to be expected. As shown by the figures in Section 1.8 of Online Appendix B, the coefficients exhibit a life cycle pattern like that obtained from sex ratio in 1946. While standard errors are larger, coefficients are similar in size. At older ages, coefficients for total fertility are statistically significant at 10% level, indicating overcompensating behavior in number of children is persistent. While the estimated coefficients along the intensive and the extensive margin of fertility are closer to zero when comparing to Figure 6, the age-specific pattern for marriage is almost identical.

In our main specification, we use sex ratios windows with birth cohorts from up to 3 years older to 2 years younger than the female target birth cohort. To investigate the sensitivity with respect to this measure, we use the fraction of men/women from the same birth cohort as a measure of the sex ratio (Section 1.9, Online Appendix B). The overall pattern is like our main specification; the size of the coefficients goes down across all outcomes, but the standard errors are considerably smaller as well.

Next, we change the definition of our window by including men up to two year younger and four (instead of three) years older. As indicated by the figures in Section 1.10 of Online Appendix B, this definition leads to more smoothing across cohorts and thus to larger

¹⁶We split the sample by whether a woman grew up on the countryside or in a small city (rural areas) or in a middle-sized or big city (urban areas).

¹⁷Only a very small share was released later than 1950 (Scientific Research Service of the German Bundestag 2011).

standard errors, but our main results still hold. For the intensive margin of fertility, for instance, the coefficients remain negative and significant at the 10% level at older ages. The pattern for marriage also remains stable.

We further investigate the robustness of our findings in Figure 6 by taking into account that age differences in matched couples are not equally distributed. To this end, we reweight male cohorts relative to female cohorts in the sex ratio window (males are two years younger and up to three years older). According to Table 3, this window covers about 71% of age differences in married couples with males born in 1920–28. We take the average across birth cohorts for each of these age differences to obtain a measure of the contribution of this age difference to the overall distribution of age differences of married couples in our sex ratio window. Using these weights, we compute an adjusted version of the sex ratio where the number of potential partners is calculated by a suitable weighted sum instead of simply counting all men in the sex ratio window. The results from using this weighted version of the sex ratio measure are presented in Section 1.11 in Online Appendix B. Our findings suggest that reweighting the sex ratio even amplifies the life cycle pattern outlined by Figure 6.

As discussed in Section 3.2 the sex ratios suddenly drop around the 1928 birth cohort due to the drafting pattern for men in WWII. We therefore compute a dummy variable taking the value one if a woman was born before 1928 and zero otherwise. By using this measure in Equation (1) instead of continuous measures of the sex ratio, we again find the typical life cycle pattern for fertility and marriage outcomes (Section 1.12, Online Appendix B). Such as in Figure 6, women facing low sex ratios have a lower number of children at early ages but significantly overcompensate at later ages.

In our analytic sample, the number of birth cohorts affected by unbalanced sex ratios is lower than the number of unaffected birth cohorts. To obtain more balanced treatment and control groups, we exclude the nine youngest birth cohorts and restrict sample to cohorts 1919–1935. As shown in the figures in Section 1.13 of Online Appendix B, we do not find any remarkable differences neither in the magnitude of the estimated coefficients nor in the patterns of these coefficients over life course.

We finally investigate whether age-specific patterns in fertility and marriage are driven by how we define age groups. Instead of estimating Equation (1) for single ages over the life cycle, we pool younger ages (age 20–33) and older ages (age 34–50). Table A.2 displays estimation results. Estimated coefficients for the younger age group have positive signs and are statistically significant at the 1% level. A lower 1946 sex ratio leads to a higher number of children but a lower probability of having any children and a lower marriage probability.

Since in Germany, childbearing is associated with a high probability of leaving the labor market or of reducing to part-time employment, our results also have strong implications for the labor market. Indeed, we see the fertility patterns of women facing low sex ratios reflected in their labor market behavior. However, documenting these effects is beyond the scope of this paper and will be investigated in future work.¹⁸

¹⁸We also have investigated the fertility and marriage pattern in East Germany. We find mostly insignificant effects and the reason is that we only have 649 observations for East Germany. Standard errors are very large, such that the effects, which we document for

To show that our results are not prone to functional form misspecification, we estimate our main specification using nonlinear models. For total fertility and the intensive margin, we choose a Poisson model. For the extensive margin of fertility and the probability of being married, we estimate logistic regressions. For comparability of estimated quantities, we calculate average marginal effects (AME). The results can be found in Section 4 in Online Appendix B. The estimated AME are very similar to the estimated coefficients obtained from OLS for all our outcomes of interest.

6.5. Alternative estimation strategy: A discrete-time proportional odds hazard model

To take account of the event time structure of our data, we re-estimate the main relationship of interest (as in Figures 6a–d) using a discrete time proportional odds hazard model with a logistic link function. The baseline hazard is specified as piece-wise constant, assuming that the hazard rate is constant within pre-defined age categories.¹⁹ We then predict the log hazard rate and its confidence intervals (on the 90% and the 95% level). To illustrate how strongly predicted probabilities vary over the distribution of sex ratios, we choose two alternative cut-off values for sex ratio imbalance. The first cut-off value is 0.8 indicating a ratio of 8 men for every 10 women. The second value is 0.6 is more extremes and refers to a sex ratio of 6 men for every 10 women.

Largely, the predicted log hazard rates for our different outcomes confirm our main findings (see the results in Section 3 of Online Appendix B). Irrespective of the choice of the cut-off value, we find a significantly higher probability of being married at younger ages for women with comparably high sex ratios (see figures in Section 3.1). The differences are statistically significant at younger ages regardless of the cut-off value. At later ages, the likelihood of being married is still higher for women with high sex ratios with mixed significance. The figures in Section 3.2 present the results for the extensive margin of fertility. With both cut-off values we find significantly lower chances for having a child up to their mid 30ies for women facing highly imbalanced sex ratios.

While the results from the discrete time logistic hazard models for binary outcomes (probability of being married and extensive margin of fertility) are directly comparable with our main results in Figure 6, this class of models cannot directly be applied to continuous outcomes, such as total fertility and the intensive margin of fertility. We instead estimate a sequence of discrete time logistic hazard models for having an additional child given the number of previous children.²⁰ We restrict this analysis to a maximum of five children as we otherwise are left with too few observations. As shown in the figures in Section 3.3 we find only a slightly higher probability of having a second child for women experiencing high sex ratios at younger ages. This difference is not statistically significant and vanishes as women age. The risk for having a third child is higher for women who have experienced very low sex ratios. This difference is statistically significant and lasts (on the 10% level)

West Germany, are actually contained in the confidence intervals for Eastern Germany. Since there is little we can do about the small sample size and since Eastern Germany is not contained in the Census data we use in the paper, we in the end decided to present the results on East Germany in Section 5 of Online Appendix B.

¹⁹We chose 7 age categories, each of them comprising a 5 year interval: below age 21, 21–25, 26–30, 31–35, 36–40, 41–45, and 46–50.

²⁰We must be careful with the interpretation of the results for total fertility and the intensive margin of fertility, because the discrete-time proportional odds hazard models we estimate does not account for unobserved heterogeneity in the hazard rate.

until age 31–35 (Section 3.4). Section 3.5 presents the predicted risk of having a fourth child for which we again find large differences. However, the confidence intervals are rather large such that differences in risks are not statistically significant. Finally, we consider the risk of having a fifth child by for high and low sex ratios (Section 3.6). Women who face very low sex ratios are now on a much higher risk of having a fifth child than women facing low sex ratios. Even though the confidence intervals are again very big, the risk differences for a cut-off value of 0.8 are still statistically significant on the 5% level. Altogether, the results obtained from discrete-time hazard models corroborate the findings on total fertility and the intensive margin of fertility as illustrated in Figure 6.

7. Conclusions

In this study, we investigate impacts of highly unbalanced sex ratios on fertility patterns over the life cycle of West German women. We argue that WWII induced an exogenous shock in the ratio of men to women in the German population, which led to permanent imbalances in the sex ratios and long-term consequences on fertility behavior of women from affected birth cohorts.

To investigate our hypothesis, we combine individual level Census records and survey data. We show that women facing low sex ratios significantly delay their fertility in the short-run. In the long-run women exhibit a catching up and even overcompensating fertility behavior compared to women not affected by such a shock. We find that highly unbalanced sex ratios lead to a higher number of children (point estimates are significant for the extensive margin only) at later ages as well as when fertility has been completed. While this finding seems to be surprising, it can be rationalized by the women's adjustments along different margins over the life cycle: They postpone first marriage and exhibit a substitutional relationship between the intensive and the extensive margin of fertility; they moreover extend their childbearing period; and accept lower quality of matches on the marriage markets.

Even though the situation in Germany during and after WWII was in many ways special, there are two more general points to take away from our analysis. First, even in a situation where sex ratio imbalances were extreme and where short-term effects on marriage and fertility were as expected, in the long-run women found several margins of adjustment that made it possible that these short-term effects faded out or were even reversed. This occurred in a policy environment that was explicitly not pro-natalist, unlike in Eastern Germany or the Soviet Union (Kreyenfeld and Konietzka 2017). An analysis of only short-term effects on fertility would miss a significant piece of evidence. Instead, a life course perspective is required to obtain a comprehensive view on overall social and economic consequences. The second important point is that the adjustments along the extensive and the intensive margins among the affected cohorts went into different directions and that these margins of adjustment remain hidden when one considers total fertility alone.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix A

Table A.1

Regression results on the impact of sex ratios in 1946 and 1950 on women's age at birth of the first child and the last child

VARIABLES	(1) Mother's Age at Birth of first child		(2) Mother's Age at Birth of last child	
	first child	last child	first child	last child
Sex ratio (men/women), 1946	-5.305 * (2.499)	-7.227 *** (2.068)		
Sex ratio (men/women), 1950			-6.165 (4.322)	-6.353 (3.537)
Constant	24.687 *** (1.649)	31.900 *** (0.914)	26.029 *** (3.266)	32.137 *** (2.373)
Observations	2,037	2,038	2,037	2,038
R-squared	0.094	0.074	0.093	0.072

Standard errors are clustered on the state of residence level

p<0.01

**
p<0.05

*
p<0.1.

OLS regressions at target ages. Controls: 5-year birth cohort fixed effects, state of residence fixed effects, father/mother obtained upper secondary education, years of schooling. The analysis is based on SOEP data.

Table A.2

Regression results on the impact of sex ratios in 1946 on fertility and marriage outcomes by women's age at birth, younger versus older ages

	(1) total fertility		(2) extensive margin fertility		(3) intensive margin fertility		(4) probability marriage	
	age 20–33	age 34–50	age 20–33	age 34–50	age 20–33	age 34–50	age 20–33	age 34–50
sex ratio (men/ women), 1946	0.734 *** (0.208)	-0.439 (0.305)	0.438 *** (0.100)	0.209 * (0.110)	0.656 ** (0.282)	-1.115 *** (0.430)	0.606 *** (0.120)	0.181 * (0.102)
birth cohort 1919– 1924	-0.019 (0.143)	-0.119 (0.139)	0.038 (0.067)	0.028 (0.055)	-0.036 (0.169)	-0.251 (0.211)	0.062 (0.078)	0.007 (0.062)

	(1) total fertility		(2) extensive margin fertility		(3) intensive margin fertility		(4) probability marriage	
	age 20–33	age 34–50	age 20–33	age 34–50	age 20–33	age 34–50	age 20–33	age 34–50
birth cohort 1925–1929	–0.126 (0.109)	–0.043 (0.147)	–0.050 (0.044)	–0.027 (0.043)	–0.111 (0.131)	–0.005 (0.173)	0.013 (0.039)	0.034 (0.030)
birth cohort 1930–1934	–0.143 *** (0.043)	0.168 ** (0.065)	–0.076 *** (0.016)	–0.030 (0.023)	–0.126 ** (0.057)	0.275 *** (0.071)	–0.034 * (0.018)	0.042 * (0.024)
birth cohort 1935–1939	–0.001 (0.032)	0.235 *** (0.048)	–0.031 ** (0.013)	0.004 (0.006)	–0.005 (0.041)	0.259 *** (0.066)	–0.032 (0.023)	0.028 (0.020)
father has high school degree	0.088 (0.089)	0.059 (0.130)	0.027 (0.036)	0.032 (0.039)	0.076 (0.082)	0.004 (0.076)	0.003 (0.020)	–0.032 (0.049)
mother has high school degree	–0.101 (0.150)	0.277 (0.191)	–0.061 (0.067)	0.006 (0.066)	–0.087 (0.125)	0.358 *** (0.134)	–0.012 (0.056)	0.052 (0.047)
years schooling	–0.087 *** (0.008)	–0.083 *** (0.018)	–0.039 *** (0.003)	–0.023 *** (0.004)	–0.079 *** (0.007)	–0.045 *** (0.015)	–0.034 *** (0.004)	–0.017 *** (0.004)
Constant	1.183 *** (0.206)	3.127 *** (0.411)	0.615 *** (0.104)	1.019 *** (0.113)	1.196 *** (0.309)	3.385 *** (0.490)	0.452 *** (0.144)	0.871 *** (0.113)
NxT	33,964	40,907	33,964	40,907	29,652	35,689	33,698	39,454
N	2,426	2,426	2,426	2,426	2,118	2,118	2,426	2,372

Standard errors are clustered on the state of residence level

p<0.01
**
p<0.05
*
p<0.1.

Random effects regression controlling for all variables presented in the Table. Reference categories: birth cohorts 1940–1944, state of residence Bremen. Models include dummy variables for the following German states: Schleswig-Holstein, Hamburg, Lower Saxony, North Rhine-Westphalia, Hesse, Rhineland-Palatinate, Baden-Wuerttemberg, and Bavaria. The analysis is based on SOEP data.

Figure A.1.

Sex ratios of overall population and native population on state level in 1946

Note: .Details on data used for the figures can be found in Online Appendix A. This figure is also contained in Grant et al. (2018).

Figure A.2.

Regression results of the impact of imbalances in sex ratio in 1946 on fertility and marriage over the life cycle using average sex ratios across birth cohorts

Note: estimated age-specific coefficients of sex ratio in 1946 and corresponding 95% confidence intervals are plotted against age. The analysis is based on SOEP data.

Figure A.3.

Regression results of the impact of imbalances in sex ratio in 1946 on fertility and marriage over the life cycle using sex ratios from current region of residence

Note: estimated age-specific coefficients of sex ratio in 1946 and corresponding 95% confidence intervals are plotted against age. The analysis is based on SOEP data data.

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Figure 1.

Sex ratios by year of birth in 1939 and in 1946

Note: Soviet zone states refer to thick dotted lines; US zone states refer to dashed lines; French zone states refer to thick solid lines; UK zone states refer to solid lines; Berlin is the dotted line. UK zone: Census data record all individuals attending this zone during data collection. Other zones: Census data collected for resident population. Population in all zones includes camp inmates, but excludes camp inmates of displaced person camps. . Details on data used for the figures can be found in Online Appendix A.

Figure 2.

Male share of birth cohort that died in war by year of birth

Data source: Kroener et al. (1988), p. 986.

Figure 3.

Sex ratios in 1950, 1961 and 1970, West Germany

Data source: Census data 1950, 1961 and 1970. Details on data used for the figures can be found in Online Appendix A.

Figure 4.

Persistence in sex ratios over the life cycle for birth cohorts 1924–1932

Note: This figure displays the sex ratio for the birth cohorts 1924–1932 in the five different Census years 1939, 1946, 1950, 1961 and 1970. Data source: Census data 1939, 1946, 1950, 1961 and 1970. Details on data used for the figure can be found in Online Appendix A.

Figure 5.

Comparison of sex ratios with using $+3/-2$ birth cohorts to sex ratios with men and women from same birth cohorts, West Germany

Data source: SOEP data and Census data 1946. Details on Census data used for the figure can be found in Online Appendix A.

Figure 6.

Coefficients and 95% CI for the impact of unbalanced sex ratios in 1946 on total fertility and marriage over the life cycle, West Germany

Note: Estimated age-specific coefficients of sex ratio in 1946 and 95% confidence intervals are plotted against age. The analysis is based on SOEP data.

Figure 7.
Distribution of total fertility for women with low sex ratios (born before 1928) and high sex ratios, West Germany (born 1928 and after)
The analysis is based on SOEP data.

Table 1.

Comparison of analytic sample to sample of West German women: outcomes and control variables, SOEP data.

	Analytic sample			Sample West German women		
	N	mean	SD	N	mean	SD
<i>Marriage</i>						
Ever married	2681	0.93	0.25	4505	0.93	0.26
Age first marriage	2500	24.49	6.05	4170	25.76	8.34
<i>Fertility</i>						
Extensive margin: any children	2681	0.87	0.33	4505	0.83	0.37
Intensive margin: number children	2343	2.33	1.22	3748	2.31	1.23
Total fertility	2681	2.04	1.38	4505	1.92	1.41
Age at first birth if married	2086	25.35	4.35	3291	25.53	4.46
Age at first birth if unmarried	182	22.41	4.39	328	22.54	4.30
<i>Controls</i>						
Year of birth	2681	1935.41	6.78	4505	1933.91	7.18
Father has upper secondary education	2681	0.08	0.28	4505	0.08	0.27
Mother has upper secondary education	2681	0.02	0.16	4505	0.02	0.15
Years of schooling	2426	10.88	2.19	4121	10.82	2.14
<i>State of residence childhood</i>						
Schleswig-Holstein	2681	0.05	0.22			
Hamburg	2681	0.03	0.17			
Lower Saxony	2681	0.13	0.33			
Bremen	2681	0.01	0.11			
North Rhine-Westphalia	2681	0.30	0.46			
Hesse	2681	0.09	0.28			
Rhineland-Palatine	2681	0.05	0.23			
Baden-Wuerttemberg	2681	0.14	0.35			
Bavaria	2681	0.20	0.40			

Table 2.

Descriptive statistics for 1% sample German Census 1970

	N	Mean	SD
Individual sample			
<i>Marriage</i>			
Ever married	66,106	0.95	0.20
Age first marriage	59,132	23.79	4.08
<i>Fertility</i>			
Extensive margin: have any children	66,106	0.84	0.37
Intensive margin: number children	55,186	2.21	1.26
Total fertility	66,106	1.84	1.41
Age at first birth if married	50,115	25.16	4.14
Year of birth	66,106	1931.52	7.50
Couple sample			
wife: year of birth	58,954	1931.84	9.00
husband: year of birth	58,954	1929.12	7.39
wife: years education	58,948	8.85	3.02
husband: years education	58,692	9.81	2.04
Husband-wife: Difference in age	58,954	3.30	4.90
Husband-wife: Difference in years education	58,687	0.94	2.71

Table 3.

Fraction men married to women between 2 years older and up to 6 years younger, Census 1950

100 married men belonging to birth cohorts in first column were married to a woman who was born									
	6	5	4	3	2	1	0	1	2
Birth year men	years later than husband							years earlier than husband	
1928			3.5	8.4	13.9	17.4	12.5	16.0	10.7
1927		1.4	4.3	8.3	14.6	15.7	19.1	9.4	10.8
1926	0.6	3.2	8.0	11.2	13.9	15.0	14.6	9.7	8.3
1925	1.1	3.8	6.0	11.9	12.8	15.0	15.0	11.1	7.3
1924	2.2	4.9	6.4	11.3	17.4	17.3	14.2	8.5	5.0
1923	4.3	6.3	9.6	12.2	14.3	15.6	12.1	7.3	6.7
1922	4.8	7.6	9.8	12.4	14.4	13.6	11.4	7.8	5.1
1921	4.8	8.1	10.8	13.4	14.5	14.1	13.0	5.7	3.2
1920	6.4	8.2	11.5	11.4	13.9	15.1	11.7	5.7	2.7

Source: Niehuss, M. (2001). Familie, Frau und Gesellschaft: Studien zur Strukturgeschichte der Familie in Westdeutschland 1945–1960, Vol. 65, S.345. Vandenhoeck & Ruprecht.

Table 4.

Regression results of the impact of imbalances in sex ratios on fertility and marriage outcomes

	(1)	(2)	(3)	(4)	(5)
	Total fertility	Pr(first marriage)	Extensive margin of fertility	Intensive margin of fertility	Intensive margin & child below age 5
Target age	Coef	coef	coef	coef	coef
Age 20	−0.032 (0.082)	0.217 (0.139)	−0.054 (0.073)	−0.064 (0.111)	−0.088 (0.100)
Age 23	0.656 * (0.333)	1.176 *** (0.232)	0.501 (0.274)	0.693 (0.458)	0.618 (0.347)
Age 25	1.051 *** (0.297)	0.857 ** (0.265)	0.521 ** (0.218)	1.102 ** (0.401)	0.575 * (0.271)
Age 28	1.435 *** (0.330)	0.521 ** (0.199)	0.785 *** (0.162)	1.460 *** (0.383)	0.493 (0.271)
Age 30	1.133 *** (0.326)	0.399 ** (0.164)	0.592 *** (0.158)	1.018 ** (0.354)	0.416 (0.241)
Age 33	0.031 (0.246)	0.358 * (0.160)	0.186 (0.105)	−0.432 (0.299)	−0.494 ** (0.209)
Age 35	−0.144 (0.244)	0.365 ** (0.151)	0.197 (0.142)	−0.698 * (0.335)	−0.724 *** (0.216)
Age 38	−0.451 (0.309)	0.299 ** (0.111)	0.262 * (0.121)	−1.113 ** (0.426)	−0.542 (0.298)
Age 40	−0.348 (0.307)	0.179 (0.102)	0.220 * (0.101)	−1.009 ** (0.421)	−0.226 (0.205)
Age 43	−0.559 (0.346)	0.065 (0.132)	0.199 * (0.106)	−1.281 ** (0.487)	−0.149 (0.138)
Age 45	−0.567 (0.349)	0.080 (0.118)	0.195 (0.105)	−1.292 ** (0.491)	−0.332 * (0.159)
Age 48	−0.576 (0.348)	0.165 (0.151)	0.201 * (0.102)	−1.318 ** (0.479)	−0.046 (0.078)
Age 50	−0.572 (0.349)	0.125 (0.156)	0.202 * (0.102)	−1.317 ** (0.483)	−0.004 (0.006)

Standard errors are clustered on the state of residence level

p<0.01**
p<0.05*
p<0.1.

Results of OLS regressions at different target ages corresponding to Figures 6a–d (Columns (1)–(4)). Column (5) reports the estimated age-specific OLS coefficients for the number of children that are younger than five years old. Controls: 5-year birth cohort fixed effects, state of residence fixed effects, father/mother obtained upper secondary education, years of schooling. The number of observations varies across outcomes and slightly across target ages (due to panel attrition). Sample size for Columns (1) and (3): 2,426 women at age 20 and reduces to 2,345 women at age 50. Sample size for Columns (4) and (5): 2,118 women at age 20 and reduces to 2,043 women at age 50; Sample size for Column (2): 2,426 women at age 20 and reduces to 2,228 women at age 50 (only first marriage considered). The analysis is based on SOEP data.

Table 5.

OLS regressions of imbalances in sex ratios on age at first marriage and age at first birth

VARIABLES	(1) age at first marriage	(2) age first child
Sex ratio (men/women), 1946	−4.439 *** (0.358)	−3.775 *** (0.368)
Constant	27.650 *** (0.721)	27.952 *** (0.349)
Observations	59,120	50,104
R-squared	0.153	0.157

Standard errors are clustered on the state of residence level

p<0.01**
p<0.05*
p<0.1.

OLS regressions on age at first marriage and age at giving birth for the first time. Controls: 5-year birth cohort fixed effects, state of residence fixed effects, wife's and husband's education, household income. The analysis is based on the 1% sample of the German Census 1970.

Table 6.

Matching by education, OLS regression of wife's years of education on husband's years of education

VARIABLES	(1) wife's years education	(2) differences years education wife < husband	(3) differences years education wife > husband
Husband: years education	0.179 *** (0.021)		
Sex ratio (men/women), 1946	-1.426 *** (0.263)	-0.009 (0.292)	-0.519 (0.410)
Husband: years education X sex ratio, 1946	0.112 *** (0.026)		
Constant	7.021 *** (0.243)	2.186 *** (0.297)	-4.484 *** (0.340)
Observations	54,977	13,336	3,762
R-squared	0.263	0.091	0.549

Standard errors are clustered on the state of residence level

p<0.01**
p<0.05*
p<0.1.

OLS regressions on wife's years of education, differences in education between husband and wife, probability of wife marrying down, probability of wife marrying up. Controls: 5-year birth cohort fixed effects, state of residence fixed effects, husband's year of birth fixed effects, household income. The sample consists of women in their first marriage. First marriage means that women that are separated/divorced or widowed are excluded. The analysis is based on the 1% sample of the German Census 1970.

Table 7.

OLS regression of spousal age gap on imbalances in sex ratios

VARIABLES	(1) spousal age gap, abs.	(2) age husband > age wife	(3) age husband < age wife
Sex ratio (men/women), 1946	-0.986 *** (0.260)	-1.312 *** (0.330)	-0.801 *** (0.181)
Constant	5.158 *** (0.177)	8.227 *** (0.259)	3.392 *** (0.171)
Observations	57,276	46,696	7,580
R-squared	0.023	0.049	0.037

Standard errors are clustered on the state of residence level

p<0.01**
p<0.05*
p<0.1.

OLS regressions on age differences between husband and wife; age differences if husband is older than wife; age differences if husband is younger than wife. Controls: 5-year birth cohort fixed effects, state of residence fixed effects, wife's and husband's education, household income. The sample consists of women in their first marriage. First marriage means that women that are separated/divorced or widowed are excluded. The analysis is based on the 1% sample of the German Census 1970.