



MAX-PLANCK-INSTITUT FÜR SOZIALRECHT UND SOZIALPOLITIK
MAX PLANCK INSTITUTE FOR SOCIAL LAW AND SOCIAL POLICY

mea *Munich Center for the Economics of Aging*

**Collateral damage: Educational attainment and
labor market outcomes among German war
and post-war cohorts**

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02-2012

MEA DISCUSSION PAPERS



Alte Nummerierung: 253-12

Collateral damage: Educational attainment and labor market outcomes among German war and post-war cohorts

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February 2012

Abstract

We use data from the West German 1970 census to explore the link between being born during or shortly after World War II and educational and labor market outcomes 25 years later. We document, for the first time, that men and women born in the relatively short period between November 1945 and May 1946 have significantly and substantially lower educational attainment and occupational status than cohorts born shortly before or after. Several alternative explanations for this new finding are put to test. Most likely, a short but severe spell of quantitative and qualitative malnutrition immediately around the end of the war has impaired intrauterine conditions in first trimester pregnancies and resulted in long-term detriments among the affected cohorts. This conjecture is corroborated by evidence from Austria.

JEL classification: J24, N34

Keywords: Fetal origins hypothesis, malnutrition, educational attainment, labor market outcomes

*I am grateful to Annemarie Nelen, Steffen Reinhold, Joachim Winter, Douglas Almond, Gerard van den Berg and seminar participants at the University of Munich and the University of Bochum for helpful comments and suggestions. The author wishes to acknowledge the following institutions that provided the underlying data making this research possible: GESIS; National Bureau of Statistics, Austria; Federal Statistical Office, Germany. Author's contact information: juerges@uni-wuppertal.de; Schumpeter School of Business and Economics, University of Wuppertal; Rainer-Gruenter-Str. 21 (FN.01); 42119 Wuppertal, Germany; Phone: +49 (0) 202-439-1385; Fax: +49 (0) 202-439-1384.

1 Introduction and historical background

Labor and health economists have recently begun to study causal effects of early life conditions, in particular intrauterine conditions and early childhood health, on later-life outcomes such as educational attainment or labor market success (e.g. Almond and Currie, 2011; Currie, 2011). For identification, part of this literature uses plausibly exogenous variation in early life conditions, such as famines (Chen and Zhou, 2007; Lindeboom, Portrait, and van den Berg, 2010; Neelsen and Stratmann, 2011; Scholte, van den Berg, and Lindeboom, 2012), man-made disasters (Almond, Edlund, and Palme, 2009), natural disasters (Pörtner, 2010), influenza pandemics (Almond, 2006), or drugs legislation (Nilsson, 2008). By comparing the outcomes of cohorts that were affected for instance by a famine with cohorts that were not, one hopes to isolate the causal effect of intrauterine or early childhood under- and malnutrition on later-life outcomes. One also hopes to contribute to the wider discussion on the origins of the health-wealth gradient—the ubiquitous finding that social status and health are correlated. Early life conditions, if they have an effect on both health and wealth at older ages, could provide one important explanation for this finding. An illustrative example for Germany of the long-term effects of being born during the hunger years of World War I on health and labor market outcomes later in life is given by Börsch-Supan and Jürges (2011), who show a substantial hike in early retirement rates (before age 55) among both German men and women born towards the end of the World War I. The aim of the present paper is to analyze educational attainment and labor market outcomes (occupation and income) of the German war and post-war cohorts of the Second World War. Following the above literature, we hypothesize that intrauterine malnutrition towards the end of the war and in the first months after the end of the war have lead to worse long-term educational and economic outcomes. After showing empirical results that strongly support this hypothesis, we try to rule out alternative explanations.

Our paper makes two important contributions to the literature on the effect of wartime or war-related famines on later-life outcomes. First, most of the current evidence is based on studies of the Dutch hunger winter 1944/1945 (e.g. Stein et al. (1975)). Thus evidence from other regions with similar periods of undernutrition are needed to corroborate the findings from the Netherlands. As we will show, the food crisis in Germany (and Austria) in 1945 may—at least in some parts of the country—have been of similar proportions as in the Netherlands. Second, even for the Dutch hunger winter there is little evidence in terms of economically relevant outcomes. Only very recently, Scholte, van den Berg, and Lindeboom (2012) were able to show that intrauterine malnutrition in the first trimester of pregnancy has significant effects on the likelihood of being employed at the age of 60. Our study corroborates these results and finds substantial effects of the food crisis on education, occupational status (as important markers of economic success in life), and partly also labor market income (at younger ages, though) of cohorts conceived during the crisis. Further, our analysis benefits from the fact that our data

partly allow us to isolate effects of malnutrition in early versus late pregnancy. We find stronger effects of early pregnancy than late pregnancy malnutrition, which is in line with recent animal studies on brain development (Antonow-Schlorke et al., 2011)..

1.1 The post-war food crisis

The German cohorts born shortly before and after the end of the Second World War are of interest because they were subject to adverse prenatal and early childhood conditions. From late 1944 to 1948, Germany suffered a severe food crisis. The three main reasons for the food crisis were (1) the loss of agricultural areas in the former eastern provinces (Germany's "breadbasket"), (2) immediate war consequences such as destruction of machinery, and (3) the inflow of some 12 million refugees from the eastern provinces (Pomerania, Silesia, East Prussia) and other East European countries (e.g., Sudetenland) between late 1944 and 1950. Food was officially rationed from the outbreak of World War II in 1939 until 1950 (in West Germany, the last food to be exempted being sugar) and 1958, respectively (in East Germany). The main medical problems caused by the food crisis were quantitative and qualitative (particularly protein) malnutrition, causing dystrophy, infant mortality, growth problems and an increased susceptibility to infections (Droese and Rominger, 1949). Infant mortality rates in the last year of war and first post-war year were extremely high. Official figures for the whole of Germany are not available, but local estimates indicate that infant mortality rates peaked at more than 20% in March, April, and May 1945—4 times the pre-war average (Droese and Rominger, 1949; Plotz, 1950). Birth rates in general have declined steeply in the last months of the war but were catching-up quickly (this is reflected in Figure 5 below, official birth rates for 1944/1945 are not available).

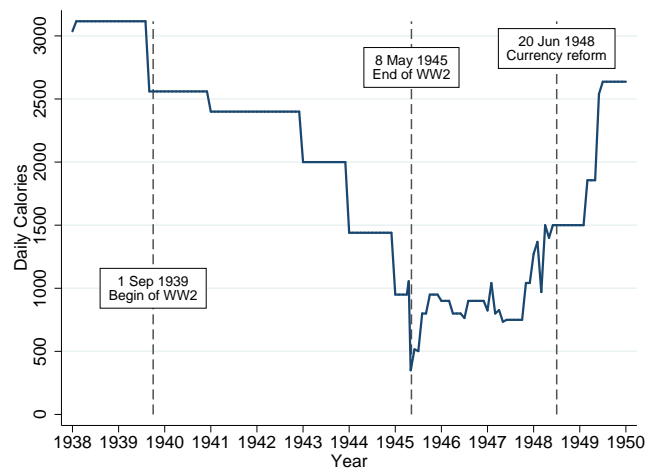


Figure 1: Minimum of reported average daily caloric intake, adults, Germany 1938-1950. Data were collected from various official and unofficial sources and are only indicative of broader trends.

Figure 1 shows data on average daily caloric intake in Germany between 1938 and 1950. We show the per period minimum of the reported number of daily calories to highlight trends in extreme conditions. In order to compute this minimum, we combined data from a number of official and unofficial sources. Especially the fine grained data from 1945 to 1948 include numbers found on internet sites maintained by local historians describing the history of villages and cities in various parts of Germany. Most numbers were originally computed by adding up daily allowances on food ration cards. These are nominal allowances, and there are a number of reasons why actual caloric intake has deviated (in either direction). For instance, food could be bought on the black market, and those living in rural areas were sometimes able to hide produce from the authorities. On the other hand, just because some food item is printed on a ration card, this does not mean that the food is actually available on the market. It is thus not clear how reliable or generalizable data based on ration cards are, but the general picture is clear: average daily caloric intake was actually fairly high in the years immediately before the Second World War. Healthy levels (an average of 2,500 calories across sexes) were maintained until about 1943; only then the situation began to deteriorate visibly. The final dip in May 1945 marks the end of the Second World War in Europe and goes along with the lowest reported number of calories across the entire period (down to 350 kcal per day). Average daily calories hover below 1,000 until about 1948 and then increase in two big steps to pre-war levels in 1948 and 1950. The data show that the food crisis was most severe during the immediate post-war months. In particular, it was more severe than during the “Hungerwinter 1946/47”, which according to many popular accounts (and in German collective memory) was the worst period.¹ Although the absolute numbers for 1947 indicate very dire living conditions (735 kcal in May 1947), contemporary researchers on undernutrition in state that the “difficulties of ordinary life, particularly shopping for food, [...] reached their most serious point in 1945, at the end of the war, and immediately after it” (Dean, 1951, p. 371).

We now add some evidence on *qualitative* malnutrition, particularly with regard to protein, fat, and carbohydrates. Figure 2 shows average daily allowances of various nutrients. The numbers are based on a detailed analysis of food ration cards and actual food available for infants and children in the northern parts Germany (Droese and Rominger, 1949). The data contain average allowances annually until 1944, but then distinguish between wartime 1945 (until mid May 1945) and post-war 1945 (from May to December), early 1946 and late 1946, and also pre-currency reform 1948 and post-currency reform 1948 (the currency reform is often associated with a significant improvement of the supply situation in the West German occupation zones). Figure 2 shows that the post-war part of 1945 was the worst period in terms of underprovision of most (but not all) nutrients. For instance, the provision of milk fat and

¹The term “Hungerwinter” is sometimes also used for the Winter 1945/46 and the Winter 1947/48. A Google search (on 23/09/2011), however, yielded 7,560 entries for “Hungerwinter 1946/47”, but only 96 entries for “Hungerwinter 1945/46” and 181 entries for “Hungerwinter 1947/48”.

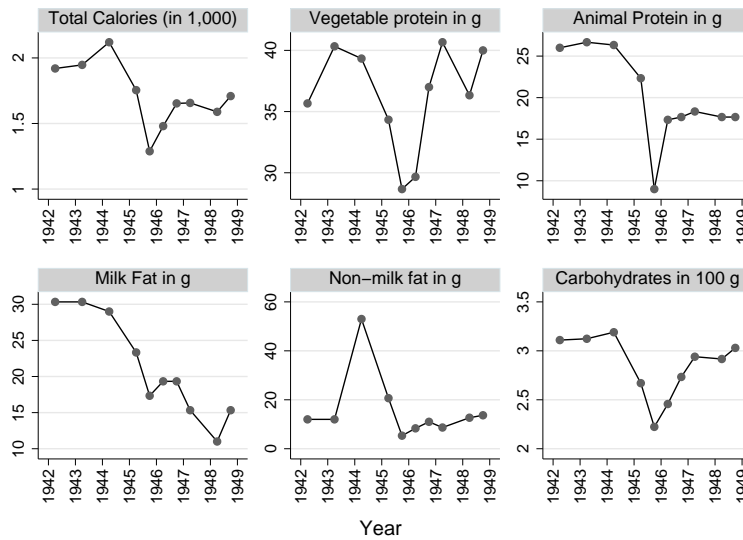


Figure 2: Average daily allowance of calories and nutrients for infants and children, 1942-1948. Own calculations based on Droese and Rominger (1949).

non-milk fat remained low after 1945 or got even worse. In contrast, animal protein, vegetable protein, and carbohydrate malnutrition appears to have been particularly severe in post-war 1945. In sum, Droese and Rominger (1949) characterize the situation depicted in Figure 2 as “short-term qualitative malnutrition”.

Complementary evidence on the immediate post-war period having been the worst in terms of intrauterine nutrition can be derived from records of birth weight by month and year of birth. Birth weight is a widely used measure of intrauterine living conditions and a strong predictor of later-life health and educational outcomes (Behrman and Rosenzweig, 2004; Almond, Chay, and Lee, 2005; Black, Devereux, and Salvanes, 2007; Currie and Moretti, 2007). One important determinant of low birth weight is undernutrition in *late* pregnancy (Stein et al., 2004), i.e. adverse conditions close to the date of birth. Figure 3 shows annual averages of birth weight (in grams) in various cities across Germany as reported in the contemporary medical literature. The overall picture is quite homogeneous. The first years of the war, until about 1943 have been characterised by constant or only slightly decreasing average birth weights. Thus if there was food shortage in the early war years, it had only small effects on the birth weight of the war babies. The biggest drop in average birth weight is observed between 1944 to 1945. In two of the three cities, the annual average continues to decrease until 1946, whereas the minimum average birth weight is reached in one city (Wuppertal, with approx. 300.000 inhabitants) in 1945. Thus for Wuppertal it seems very likely that 1945 was indeed the year with the worst (intrauterine) living conditions. For the other two cities, this is less clear, but the fact that annual averages decrease further in 1946 do not rule out that specific months in 1945 have been particularly bad.

Obviously, monthly data on average birth weight are better suited than annual data to identify particularly critical periods. Figure 4 shows monthly averages for Vienna (Austria) and again Wuppertal. For comparison reasons, we also show the monthly averages for the well-studied Dutch famine and “north control” cities (cf. Stein et al. (1975)). Data from Vienna indicate that average birth weights have been below 3,000g in May to September 1945 and reached their minimum in August 1945 (at 2,852g).² This is clearly compatible with the notion that the nutrition situation was at its worst immediately after the Second World War. Data for Wuppertal were collected by the author from the original hospital records of the local teaching hospital (*Landesfrauenklinik*). The monthly development of birth weights bears similarity with the development in Vienna, albeit on a higher level. Average birth weights were lowest between February 1945 and July 1945.³ Overall, the birth weight data shown here lend some suggestive support to the claim that the last few months of war and the early post-war period was the most critical in terms of intrauterine conditions. The comparison with data from the Netherlands serves to put the German (and Austrian) food crisis in perspective. Of course, the beginning and end of the Dutch famine are well-defined and this reflects in the data on birth weights. However, it is interesting to note that at the height of the food crisis, average birth weights in Vienna were more than 100 grams below the minimum during the Dutch famine. In that sense, the food crisis might have been even more severe at least in some parts of Germany and Austria than in the Netherlands. Birth weights in Wuppertal were below those in the Dutch control but above those of the famine cities, and after the war, birth weights remain on a lower level than in the Netherlands. Finally, it is interesting to note that especially until the end of 1945, the data series bear some remarkably similarities even in short term fluctuations.

Studying the effect of intrauterine or early life conditions of some 50 ago from observational data typically makes some demand on the data. In particular, one needs a sufficient number of observations in order to find significant long-term effects. The long time between being in utero or the first years of life and adulthood gives room to many processes that could ameliorate (but partly also aggravate) the affects of any health insults in early life. To our knowledge, the present paper contains the first study of its kind using data from the West German 1970 census. For 132 month-of-birth cohorts born between January 1939 and December 1949, we show average educational attainment and labor market outcomes (occupational status, income) as measured in 1970. While there are some long-term cohort trends in educational attainment, occupation, and income in these data that might be compatible with post-war cohorts being adversely affected by post-war living conditions, long-term trends are hard to separate from other secular influences. Of more interest are thus “short-term” effects in the sense that they

²The general post-war situation in Austria was very similar to the situation in Germany. This is discussed in more depth below.

³Since individual data are available for Wuppertal, it is possible to look at the distribution of birth weights. Here, we find that the distribution has widened in early 1945 and that the proportion of children born with low birth weight (below 2,500 grams) peaked in May 1945 reaching about 12 percent.

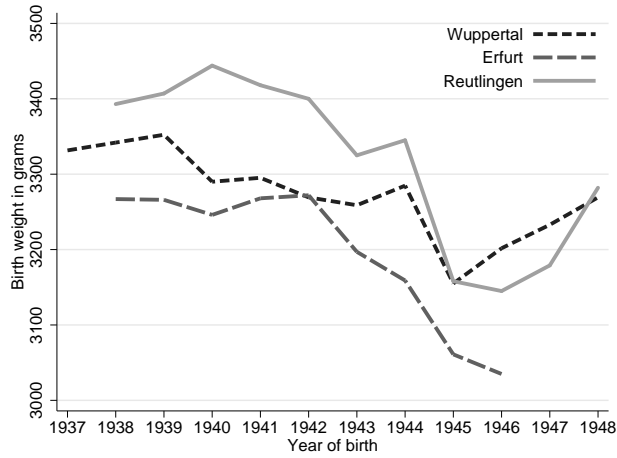


Figure 3: Average birth weight in grams, by year of birth, Germany, 1937-1948. Sources: Dean (1951); Giese and Kayser (1947).

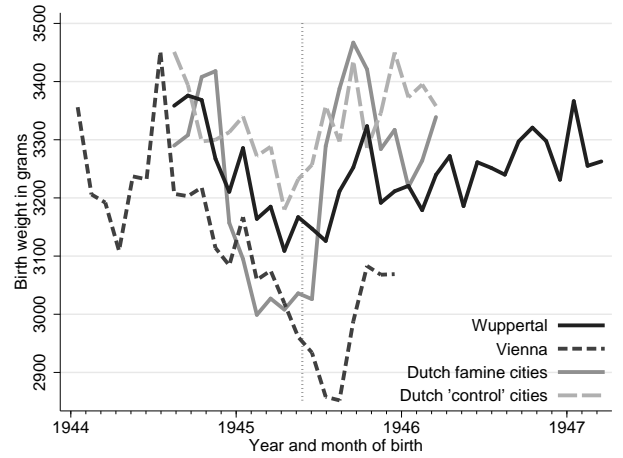


Figure 4: Average birth weight in grams, by month of birth, Wuppertal, Vienna and the Netherlands. Sources: Hußlein (1947); Stein et al. (1975), author's data collection.

affect only a few month-of-birth cohorts. For instance, following the recent literature on the fetal origins hypothesis (Barker, 1995), and based on the background data shown in Figures 1 and 2, we expect that cohorts in utero around and after the end of the war in May 1945 would be most likely to suffer in terms of their later-life outcomes (i.e., lower educational achievement, less prestigious occupations, lower incomes). In fact, we find significantly lower educational and occupation outcomes for a fairly narrow range of birth month cohorts, namely men and women born between November 1945 and May 1946. To the best of our knowledge, this is the first time this finding has been documented. However, we do not find significantly worse outcomes for those in utero in the following two or three years.

Explanations that draw on the notion of intrauterine circumstances having particular long-lasting effects are the most promising candidates. To substantiate this claim, we also show that broad regional variation in adverse effects is compatible with the idea that individuals born in regions that were affected more also suffer more long-term damage. We are aware of the considerable challenges in separating effects in utero from a broad range of other early childhood conditions (Almond and Currie, 2011).⁴ Cohorts born before November 1945 and after May 1946 have also been subject to severe undernutrition for a prolonged period of time after birth. Thus our finding of only a few month-of-birth cohorts showing worse educational and labor market outcomes than others suggests that we actually capture some *additional* effect specific to those cohorts. In contrast to studies for the Netherlands (Stein et al., 1975; Scholte, van den

⁴In a study similar to ours, Neelsen and Stratmann (2011) examine the effect of the Greek famine in 1941/42 on literacy and education of cohorts who were either in utero or in their first two years of life. They find no effect of intrauterine exposure to the famine on educational attainment but significant effects of exposure in the first two years of life. The disadvantage of their data is that they contain only year-of-birth information which makes identification of causal effects of intrauterine conditions by trimester of pregnancy virtually impossible.

Berg, and Lindeboom, 2012), where the eastern parts of the country have not been affected by the blockade that led to the famine 1944/45, we have no obvious “control group”, i.e., German cohorts born around the end of the Second World War but definitely unaffected by the food crisis. Still, in section 4, we construct control groups based on some ad hoc reasoning about regional differences in the severity of the food crisis to show that our data are consistent with the notion of negative education effects of early-life undernutrition.

The biological pathway from intrauterine malnutrition to impaired educational and labor market performance 20 to 50 years hence is via brain development. Of particular importance to the findings in the present paper is timing. Maternal malnutrition in the third trimester of pregnancy can lead to low birth weight (<2,500 grams) and prematurity (less than 37 weeks gestation), both of which have been shown to be associated with reduced intellectual capacity and other impairments (Behrman and Rosenzweig, 2004; Almond, Chay, and Lee, 2005; Black, Devereux, and Salvanes, 2007). But the impact of malnutrition during earlier stages of pregnancy is so far less well documented. Much of the existing evidence on humans that is able to separate early from late pregnancy deficiencies actually comes from the Dutch hunger studies—which did so far reveal some effect of early pregnancy malnutrition on antisocial personality disorder (Neugebauer, Hoek, and Susser, 1999) but not on intelligence or educational success (see Stein et al. (1975), although de Rooij et al. (2010) provide some limited evidence for an effect on cognitive decline at older ages). Recent experimental evidence on baboons, however, shows that even moderate maternal nutrient restriction during the first half of pregnancy occurs can cause severe brain development problems *without fetal growth being impaired* (Antonow-Schlorke et al., 2011).

1.2 Other potential mechanisms

Our analysis is only the beginning of a more systematic study of the collateral damage of World War II on those born in Germany during or after the war. Quite naturally, the reasons for our novel finding of a few specific cohorts being affected (stronger) than others are not fully researched yet. We also offer and try to put to test alternative explanations of the post-war dip in education and labor market success. For instance, besides malnutrition as a more indirect war consequence, some directly war-related events could also have affected intrauterine and early childhood conditions of the war and post-war cohorts. In January 1945, the Red Army started their major offensive on the German border. Mass flight from the Eastern Provinces set in immediately, often under extremely harsh conditions which could have affected children in utero and newborns (Jochims and Doerks, 1947). Until October 1946, an estimated 10 million ethnic Germans fled or were expelled from the Eastern parts of Germany and other parts of Eastern Europe. About 2 million people have died (Faulenbach, 2002). It is likely that intrauterine stress due to flight and expulsion from the East would have peaked during 1945

and added to the detrimental effect of general under- and malnutrition. As our data allow us to distinguish between individuals whose parents lived within the current borders of Germany, in the Eastern Provinces or in other Eastern European countries before the Second World War, we will take up this issue in our empirical analysis. Moreover, during or following the war, an estimated 2 million German women have been raped, mostly by Red Army soldiers. According to some rough estimates, 5% of the children born in and around Berlin between September 1945 and August 1946 were so-called “Russian children” (Sander and Liebman, 1995). Mothers of such children might have consciously or unconsciously resented and neglected these, resulting in worse later-life outcomes.

Further possible explanations for finding associations between being born shortly before or after the end of the war and long-term economic outcomes are selective mortality, selective fertility, and coincidental changes to the education system. Briefly, selective mortality might be a worry because infant mortality during that time was high and those surviving were likely to be “strong types” with better than average outcomes throughout their lives. Selective mortality should thus bias any estimates of long-term negative effects downward, i.e. effects would appear less strong than they actually were. Similarly, if for some reason, infant mortality affected children of better educated or higher ability mothers and fathers less than others, the selected cohort would be of higher innate ability on average and the estimated negative war effect would again be biased downwards. Selective fertility arises if, e.g., better educated or higher ability parents were more likely to have children in the final war months or the first post-war year. Then the average child born would be of higher average ability. One possible reason for selective fertility could be that, for instance, better educated men were less likely to be serving at the front. Again, this type of selection would bias any estimates of long-term negative effects downwards. Finally, changes to the school or education system, such as shifting school entry dates or lengthening compulsory schooling, could affect the educational attainment and later-life economic outcomes of specific cohorts. Attributing these effects to intrauterine living conditions would then be spurious.

While we use primarily German census data to develop and test our hypotheses, we use Austrian data to test them on an independent sample. Broadly, living conditions in Austria towards the end of World War II and the first months afterwards were indeed very similar to those in Germany. It is thus perhaps not too surprising to find exactly the same pattern of association between date of birth and educational and labor market outcomes in Austria as in Germany. This finding allows us to rule out some of the alternative explanations for our findings for Germany (e.g. later changes in the education system) and thus provides further evidence in favor of the fetal origins hypothesis. However, not all alternative explanations can be ruled out with certainty. Better data on living conditions in general and nutrition during pregnancy in particular, and outcomes data collected from a narrow range of affected and not affected birth cohorts, could help generate such tests.

The remainder of the paper is structured as follows: Section 2 briefly introduces our main data source, the German 1970 census. In section 3, we show our main results, the cohort differences in education and labor market outcomes. We also add further evidence from the 1987 census. In Section 4, we show a number of detailed analyses in order to support the plausibility of our main findings. Section 5 expands our analysis to Austria to further corroborate our results. The last section concludes the paper.

2 Data

The main data source of this study is a 10%-subsample of the West German 1970 census.⁵ The data were collected in May 1970. They contain information on month and year of birth, current region of residence (Bundesland) and city size, education (school leaving certificates), occupation (blue-collar vs. white-collar), and net monthly income. Moreover, the data provide some retrospective information on where one's family lived at the beginning of World War II on September 1, 1939 (within the current borders of West Germany incl. West Berlin; within the current borders of East Germany incl. East Berlin; in the former eastern provinces of the German Reich; in Czechoslovakia; in other neighboring countries in Eastern Europe; or other). This information can be used to identify children of refugees. We also know whether someone has migrated from East to West Germany after 1945. We restrict the sample to cohorts of German citizens (thus excluding foreigners and guest workers) born between January 1939 and December 1949. Our working sample contains about 450,000 men and 420,000 women. On average, there are about 6,000 observations per month of birth.

Figure 5 shows the number of observations by month of birth. Important dates are marked by vertical lines: Germany invades Poland (1 September 1939); Germany invades the USSR (22 June 1941); Allied forces invade Normandy (6 June 1944); German capitulation (8 May 1945); West German currency reform (20 June 1948). Note that instead of the actual dates, the lines mark the dates plus nine months. This allows us to relate war-related events to changes in fertility behavior rather than births.

The dashed line shows a six-month moving average. The numbers shown in Figure 5 mirror the development of fertility between 1939 and 1949. Following a period of low fertility in the early 1930s during the Great Depression, the late 1930s were characterized by comparatively high fertility, partly because families were "catching up". The number of observations (and by implication births) fluctuates quite a bit. The run-up to and the beginning of the war in the East in June 1941 appears to have caused a significant drop in the number of births. In contrast to the brief periods of fighting following the attacks on Poland and France, the fighting in the USSR

⁵An exception is the state of Saarland for which we have a 100% sample. In most analyses below, all observations from Saarland are given weight of 10%. The 1970 census data are made available by GESIS, whose hospitality while analyzing the data is gratefully acknowledged.

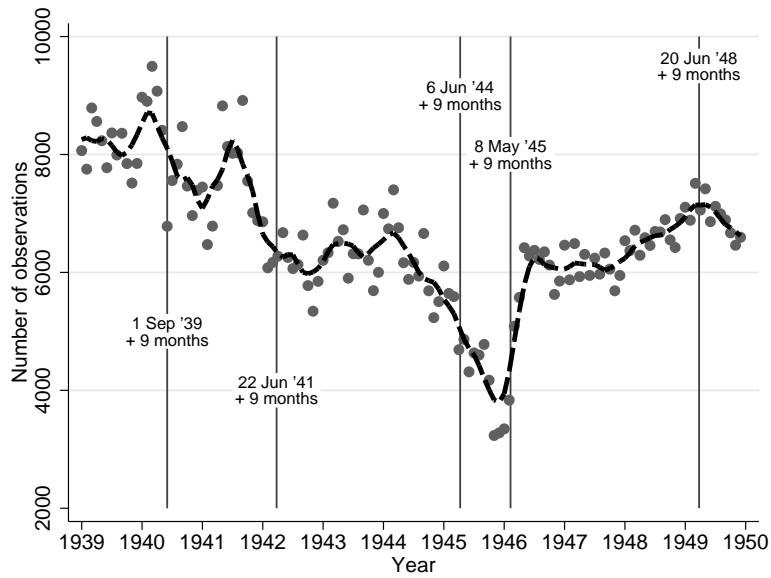


Figure 5: Number of observations (by sex and month of birth). The dashed line shows a six-month moving average to highlight broad trends. Vertical lines indicate important dates (plus 9 months).

proved to be long and fierce and eventually led to a large number of casualties.

The smallest number of observations can be found among those born between April 1945 and February 1946. In terms of the time when these individuals were conceived, this corresponds to the period between the Allied invasion in Normandy and the German capitulation, i.e. when German men were fighting on two fronts. Moreover, especially in the last couple of months of the war, infant mortality was very high (up to 20%—see above). A great number of children born in that period may thus not have survived. In January/February 1946, i.e. exactly nine months after the German capitulation, the number of observations rises steeply. This increase is obviously related to the great number of men returning home from the war.⁶ The analyses presented in the following section are based on month-by-month comparisons of later-life outcomes. It is important to keep in mind that—if the events and conditions that have led to increased infant mortality also affect later-life outcomes negatively—some of the cohorts we study may be positively selected (Bozzoli, Deaton, and Quintana-Domeque, 2009). Also, selective fertility due to famine amenorrhea affecting those women most hit by malnutrition might lead to an underestimate of the true effect of fetal malnutrition on later-life outcomes. In other words, our estimates of effects of intrauterine or early childhood health are most likely lower bounds of the true effects.

⁶The US began to release their approximately 3 million German prisoners of war as early as mid May 1945.

3 Cohort differences in educational attainment and labor market outcomes

This section contains our main results. We show educational attainment, occupational status, and labor market income by month-of-birth cohort. We analyze each outcome separately, although it must be kept in mind that they are not independent. Education is probably the most important variable, because occupational status partly depends on educational attainment and income partly depends on education as well occupation. Further, education has been shown to be related to many non-economic outcomes (Grossman, 2006; Lochner, 2011).

3.1 Educational attainment

We begin by giving a brief description of the German school system as it was relevant for our analysis cohorts. Although in Germany, the federal states are responsible for educational policy, school systems are broadly similar across states. Primary school begins at age six and has four grades. After primary school, students attend one of three secondary school tracks which are taught in separate schools. The lowest track (Volksschule) has 4 grades and leads to a basic school leaving certificate—after 8 years of schooling. A more demanding intermediate track (Realschule) leads to a school leaving certificate after grade 10. Students from the basic track and the intermediate track usually start an apprenticeship or a school based vocational training. The third track (Gymnasium) is the most academic and prestigious track and leads to a general university-entrance diploma (Abitur) after grade 13. After being sent to one of the three secondary school tracks, mobility between tracks is low—with more downward than upward mobility (Jürges and Schneider, 2011). Secondary track choice and the type of leaving certificate a child obtains has strong implications for the entire life course. The selection process itself depends on a mix of formal exams, grades in primary school, recommendations by the class teacher, and parental choice.

The census measures schooling by the highest school leaving certificate. Including drop-outs, four different levels of completed schooling are recorded in the data: (1) No certificate, (2) Basic (Volksschule), (3) Intermediate (Realschule) and (4) High/Academic (Gymnasium). The distribution of leaving certificates in our analytic sample is shown in Table 1. Overall, less than 2% have left school without a leaving certificate. More than 70% of all men and women have a basic certificate, 17% have an intermediate and 9% have an academic leaving certificate. The average number of years in school—with no certificate and basic corresponding to 8 years, intermediate corresponding to 10 years and academic corresponding to 13 years—is 8.8. Men have enjoyed on average 0.2 more years in school, which is due to a larger percentage of them having attended Gymnasium and getting an academic leaving certificate.

We use as educational outcome measure the proportion of each birth month cohort with

Table 1: Leaving certificates (in percent) and years in school, by sex

	Men	Women	Total
No certificate	2.1	1.4	1.8
Basic	70.9	73.1	72.0
Intermediate	15.3	18.6	16.9
Academic	11.7	6.9	9.4
Years in school	8.9	8.7	8.8
Observations	448,137	422,470	870,607

intermediate or high leaving certificates (in short: more than basic education).⁷ Figure 6, Panels A and C show the development of educational attainment over time, separately for men and women. Each data point shows the proportion of individuals with more than basic education. The dashed lines show a six-month moving average. For both sexes, we find a continuous, almost linear increase in the proportion of respondents with more than basic education. This trend continues until about the middle of 1944. This development is best explained by a widespread educational expansion that started in the mid to late 50s. For instance, secondary school fees were abolished in intermediate and academic schools (Riphahn, 2011) and the number of academic secondary schools was largely increased (see Jürges, Reinhold, and Salm, 2011). The secular trend towards more education levels out in early 1945.

For both men and women born between about November/December 1945 and April/May 1946, we observe a sudden drop in educational achievement of about 5 percentage points. Compared to a “baseline” level of some 30%, this drop is substantial. Thereafter, educational achievement quickly resumes to the earlier level and remains fairly constant until the end of the observation period.⁸ Impressive as the dip around 1945/46 might be, it is not clear whether this constitutes a statistically significant drop. To check for statistical significance, we computed the prediction error *for each month of birth* using the following linear regression model (running the regression 132 times):

$$y_{ic} = f(c) + \mu_m + \beta \times d_c + \varepsilon_i \quad (1)$$

where, y_{ic} denotes the educational attainment of individual i of month-of-birth cohort c . $f(c)$ is a non-linear birth cohort trend (modeled as a fifth-order polynomial; alternative specifications using linear splines yield similar results). μ_m is a set of month dummies (e.g., January, February, ...) that captures general seasonal fluctuations. d_c is a dummy variable for being born in one particular month of interest c (e.g., January 1945, May 1948, ...). β then gives the predicted proportion of individuals with more than basic schooling of each the month-of-birth cohort

⁷Alternative specification using average years of schooling as outcome lead to very similar results.

⁸The drop for men born in the second half of 1949 is probably due to individuals still in (academic track) school.

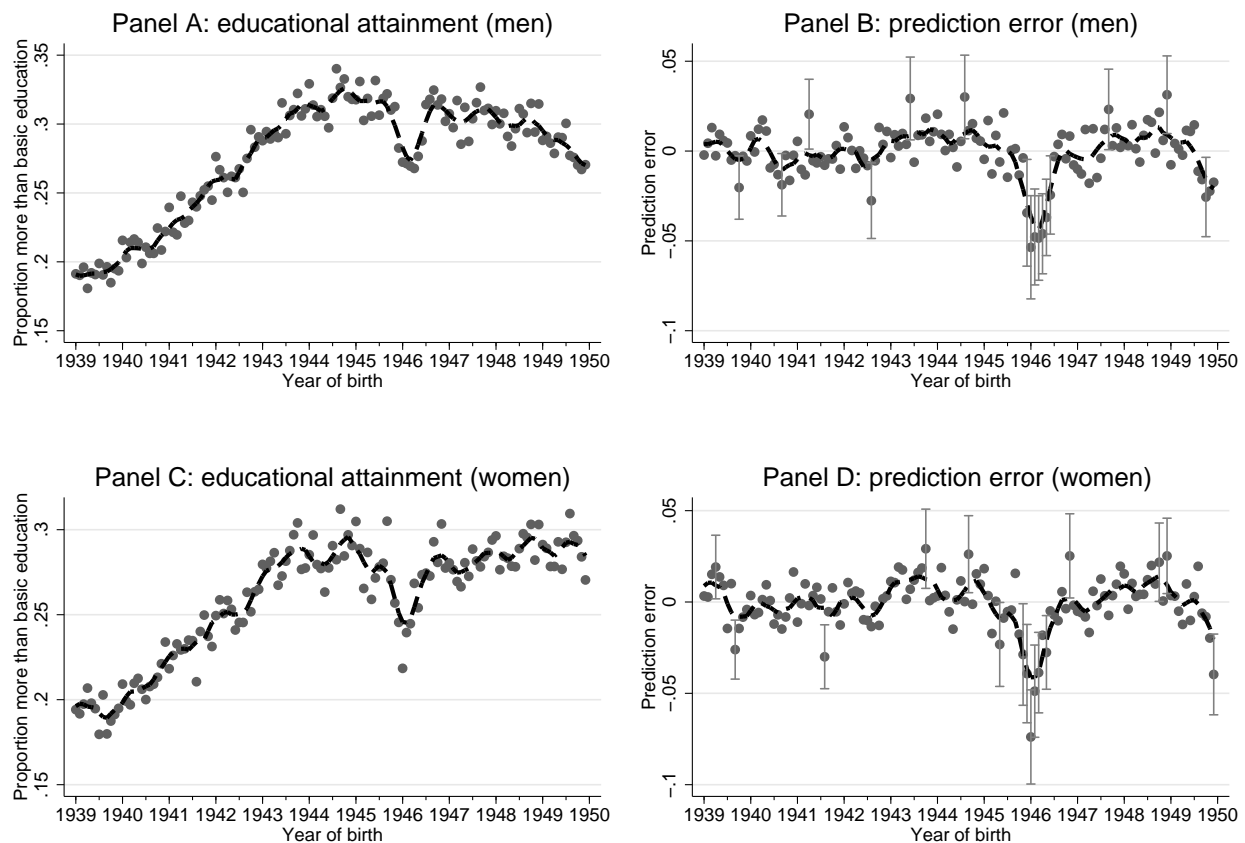


Figure 6: Average number of years in school, by month of birth (Panels A and C), prediction errors with 99% confidence intervals (Panels B and D). The dashed lines show six-month moving averages.

relative to the long-term (fifth-order-polynomial) trend and general season of birth fluctuations. The (heteroskedasticity-consistent) standard error of the month-of-birth dummy coefficient can be used to test for significance or construct confidence intervals.

We show β and 99%-confidence intervals in Figure 6, Panels B and D. For sake of clarity we omitted all confidence intervals that cover the value of zero (i.e., for cohorts that do not deviate significantly from the long term trend). Apart from a few (seemingly randomly distributed) significant prediction errors within the entire observation period, one clearly sees the concentration of seven significant negative prediction errors for male cohorts and six significant prediction errors for women born in the Winter of 1945/1946.

At this point, we should note again that what we find here as some end-of-war or post-war dip is most likely an underestimate of the true effect of being born between November 1945 and May 1946. At least some of these month-of-birth cohorts have been comparatively small, as Figure 5 has shown. Being a member of a small cohort can entail advantages both in the education system and in the labor market (see e.g. Brunello, 2010). First, given a more or less fixed number of schools, teachers and classrooms in the entire system, class sizes could have been smaller on average for the smaller cohorts. Second, if the three tiers in German secondary schools are filled by ability from top to bottom, smaller cohorts should be more likely to attend the academic track and obtain a corresponding leaving certificate. Also, smaller cohorts should be able to find “better” jobs when entering the labor market (again, this holds if jobs are filled by ability or qualification from top to bottom).

3.2 Occupational status

Before looking at occupational status, a few remarks on labor force participation are in order. The unemployment rate in West Germany in 1970 was at a historical low (0.7%). What might otherwise be an interesting indicator of labor market success is thus not useful in the present study because there is just not enough variation in the outcome variable. 11.5% of the men in our sample were not working at the time of the census (see Table 2). Of these, the majority are in fact still in education, i.e. they are visiting university—which basically indicates educational attainment rather than labor market failure. In contrast, of the 45.5% percent of women in our data currently not working, the vast majority were homemakers—of which it is unclear whether this indicates success or failure in the labor market. Obviously, we only observe early career occupational status. The oldest individuals in the data are 31 years old, the youngest are 20 years old. Still, we argue that early career occupational status is an important outcome. For instance, recent research has found that blue-collar occupation at early career stages is associated with worse later-life health even conditional on education (Fletcher and Sindelar, 2009).

For those currently working, we can distinguish between six types of occupation: blue-collar workers, white-collar workers, civil servants, the self-employed, workers in family busi-

Table 2: Occupational status (in percent), by sex

	Men	Women	Total
Not working	11.5	45.6	28.0
Blue-collar	42.0	13.2	28.0
White-collar	26.1	32.7	29.3
Civil servants	10.4	2.8	9.0
Self-Employed	4.0	1.1	2.6
Family worker	1.6	4.7	3.1
Conscript	4.5	0.0	2.3
Observations	448,141	422,469	870,422

ness and conscripts (see Table 2). In the following, we will only distinguish blue collar workers from all others (except conscripts).⁹ At the time of the 1970 census, 42% of the men and 13% of the women born between 1939 and 1949 were in a blue-collar job.

Trends in occupational status by month-of-birth cohort and sex are shown in Figure 7, Panels A and C. Among men, we find a sudden jump in the proportion of blue-collar workers for cohort born in mid 1945 and later. After a peak in mid 1946, the proportion continues to decrease. Thus it seems as if there is a secular trend away from blue collar occupations that has a break in 1945/46. For women, the overall trend in blue-collar occupation looks similar up to cohorts born 1946 (albeit on a lower level). Among the younger cohorts there is a distinct upward trend. Most likely, this is an age effect due to blue collar women successively becoming homemakers.

Again, to assess whether deviations from a long-term trend are statistically significant, we compute prediction errors and their 95% confidence intervals. For men, Figure 7, Panel B shows significant deviations from the long-term trend in four consecutive birth month cohorts in Winter 1945/1946, but we also observe significantly lower proportions of blue collar workers among the cohorts born about a year earlier. This latter finding might be an artifact of the polynomial regression specification. Further, university graduates born in 1945 and 1946 enter the labor market around 1970 (which is a pure age effect). This might also cause problems identifying the underlying cohort trends for these particular birth cohorts. For women, we observe a sharp increase in the proportion working in blue-collar occupations for the cohorts born in Winter 1945/46 (see Figure 7, Panel D), with statistically significant prediction errors for four consecutive month-of-birth cohorts.

⁹Obviously this choice may affect our results. When we restrict our sample to workers, civil servants and the self-employed, results for women remain virtually unchanged. Results for men are qualitatively similar but become less significant statistically. This is clearly due to the fact that almost all non-workers are students and thus highly likely to fill white-collar jobs after our observation year.

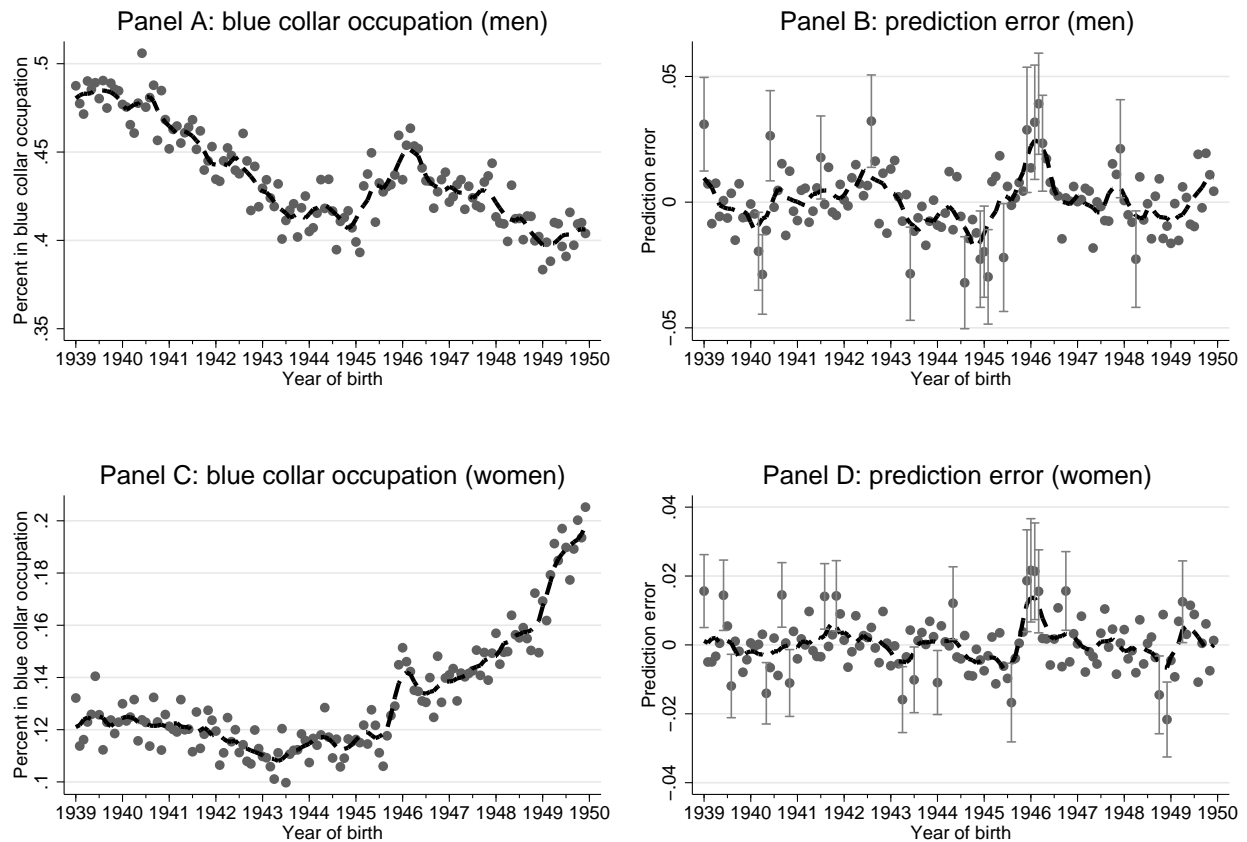


Figure 7: Proportion of men and women in blue collar occupation, by month of birth (Panels A and C), prediction errors with 95% confidence intervals (Panels B and D). The dashed lines show six-month moving averages.

3.3 Income

The third outcome variable is net monthly income. Although *net* income is probably not the best conceivable measure of labor market success, this is what is available in the data. Data on income are available only for workers, so that observations with positive income are a selective group. A similar reasoning applies as before: men who are not working are mainly still in (university) education, which means that if they worked, they would probably earn a higher average income than those who actually work. Thus having no information on (potential) wages of men not working should dampen the size of the measured income effect of being born shortly after the war. Women who are not working are mostly homemakers, and it is not clear a priori if they could earn more or less than working women in the same cohorts.

Another issue is that income is measured in seven brackets: 0 to 300 DM, 300 to under 500 DM, 500 to under 800 DM, 800 to under 1200 DM, 1200 to under 1800 DM, 1800 to under 2500 DM, 2500 DM and over (see Table 3).¹⁰ To account for the bracket coding, we computed cohort average income as the predicted value from an interval regression (using the Stata command `intreg`) of income on month-of-birth dummies.

Table 3: Monthly net income categories (percentages), by sex

	Men	Women	Total
<300 DM	5.7	8.2	6.6
300-499 DM	3.5	23.8	10.7
500-799 DM	32.8	45.1	37.2
800-1199 DM	43.4	18.9	34.7
1200-1799 DM	11.8	3.2	8.8
1800-2499 DM	2.2	0.6	1.6
≥ 2500 DM	0.6	0.1	0.4
Observations	385,148	209,806	594,954

Figure 8, Panels A and C show the average net monthly income in 1970 of men and women born between 1939 and 1949. Among men, average income clearly falls with year of birth (rises with age), apparently at an increasing rate. No obvious deviations from the trend can be seen for the cohorts born immediately after the Second World War. Although we find a number of significant prediction errors, they do not affect the results for cohorts born in Winter 1945/46 (see Panel B). Rather, there are a couple of small *positive* errors for cohorts born in the Summer of 1946 (less than 20 DM or 2.5% of average income). There are also some prediction errors towards the end of the observation period, but these are due to the irregular income patterns of the youngest cohorts.

Among women, average income increases up to about age 27 (cohort 1943) and slightly

¹⁰One 1970 DM corresponds to about 2 Euro in current terms.

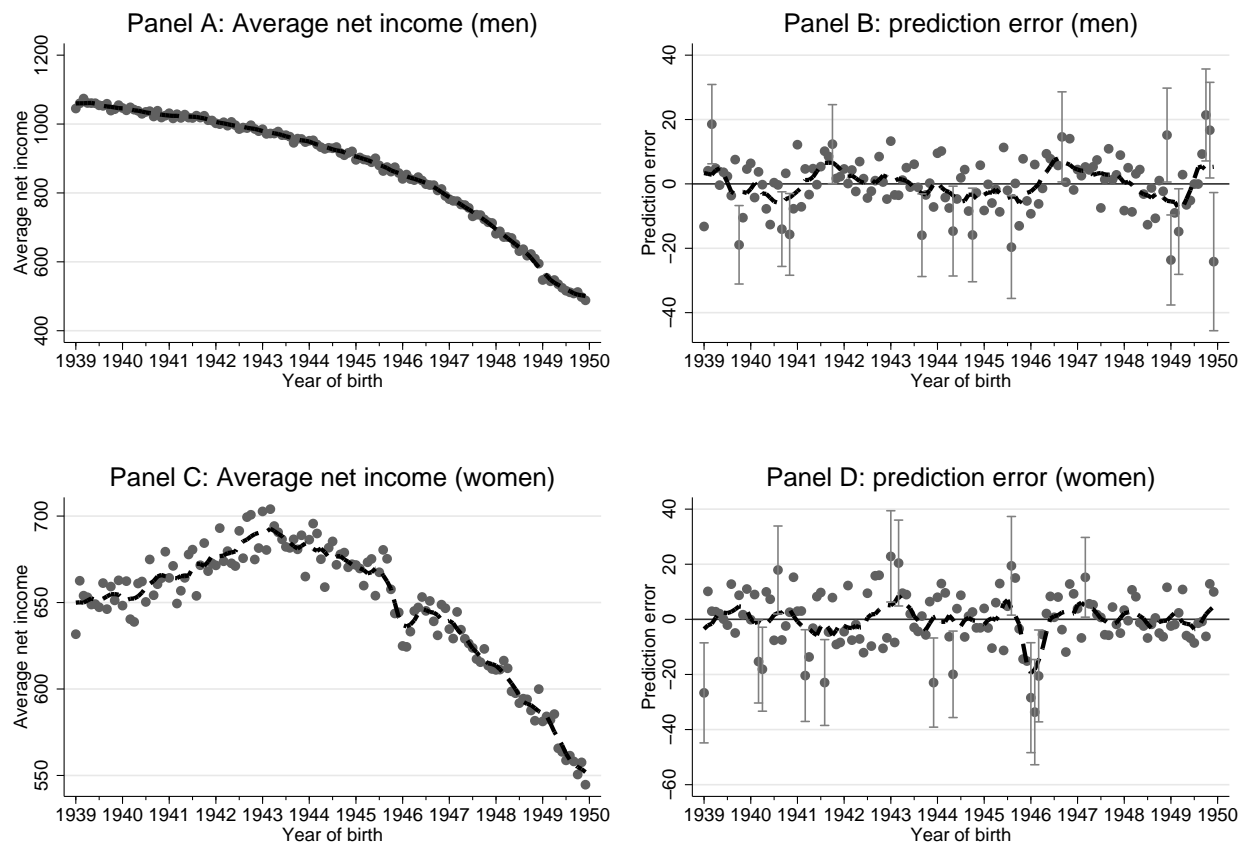


Figure 8: Average net monthly income, by month of birth (Panels A and C) and prediction errors with 95% confidence intervals (Panels B and D). The dashed lines show six-month moving averages.

declines thereafter. Overall, the income profile is much flatter than the profile found for men (note the different scales). A couple of reasons might be brought forward to explain the overall income trend for women, in particular breaks in occupational careers due to family reasons, and selectivity in labor force participation, including part-time work, due to family. However, this is not the main concern of this study. Rather, it is the clearly visible deviation from the long-term trend for cohorts born in the Winter 1945/46. For cohorts born in November 1945 and between January and March 1946, one finds significant negative prediction errors (see Panel D). Some of these errors are sizable (30 to 40 DM or some 5% to 10% of average net income).

3.4 Further evidence: the 1987 census

We now repeat our analyses using a 10% subsample of the German 1987 census, available as part of the Integrated Public Use Microdata Series (IPUMS, Minnesota Population Center, 2011), in order to provide independent evidence on the post-war dip in educational attainment and occupational status. The disadvantage of the IPUMS data (not only from Germany) for the purpose of our study is that they do not always contain month-of-birth information. We would probably not have detected the pattern we try to explain in this paper, had we used year of birth data only. However, combining age at time of the census reference date (May 25, 1987) and year of birth, it is possible to identify whether a person was born between Jan 1st and the reference date—which allows us to estimate education and occupational outcomes on roughly a half-year basis.¹¹ The advantage of the 1987 census is that the all relevant cohorts have completed full-time education by the time of the census (the youngest cohorts being 37 years old), which yields a more comprehensive picture of educational attainment and occupational status. Additionally, there are no more conscripts in our cohorts of interest, which also helps to study occupational status. Finally, the unemployment rate in West Germany in 1987 was at 8.9%, hence it becomes more interesting to study effects on unemployment.

Figure 9 shows the number of observations of German nationality by half-year of birth (total number of available observations: 522,000). Note that due to the way the “half-years” are constructed, the first half-year lasts until May 25 and the second half-year lasts from May 26 to December 31. In order to make the two parts of the year comparable, we computed monthly averages \bar{n}_k as follows:

$$\bar{n}_k = \begin{cases} \frac{n_k}{12} \times \frac{145}{365} & \text{if } yob + age = 1987 \\ \frac{n_k}{12} \times \frac{365-145}{365} & \text{if } yob + age = 1986 \end{cases} \quad (2)$$

where n_k equals the total number of observations in half-year k , yob is the year of birth, and age is the age at the census reference date. The development of the number of observations (and by

¹¹The IPUMS also contain data from the GDR censuses in 1971 and 1981, which could be ideal complements to the West German census data. However, the reference date in those censuses were Jan 1st and December 31st, respectively. We are thus unable to split year of birth cohorts into parts born before and after the reference date.

implication the number of births) shown in Figure 9 is very similar to what is shown already in Figure 5. The number of observations declines during the war years and takes a final plunge in the two half-years after the war (hence fertility was lowest in the months around the end of the war).

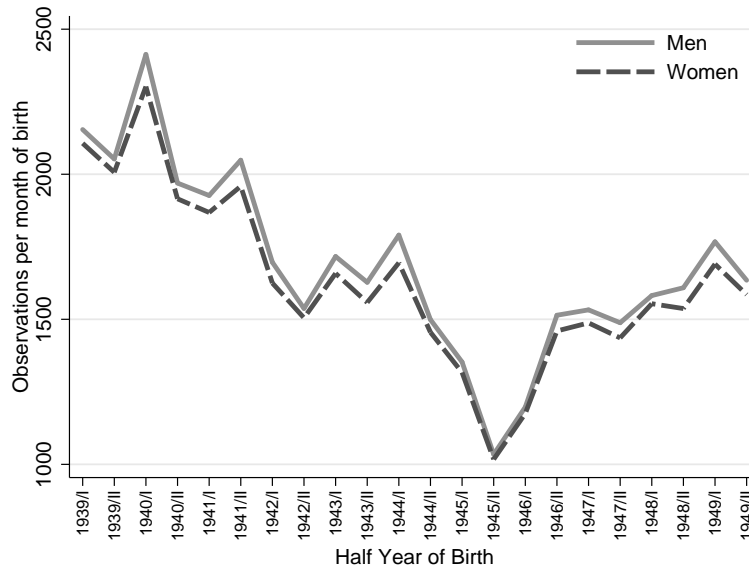


Figure 9: Number of observations per month of birth (by half-year of birth), 1987 census. Note: the first half-year is January 1 to May 25 (the census reference date), the second half-year is May 26 to December 31.

Based on the analyses in the preceding sections, we expect that the cohorts born in the first part of 1946 (in short: 1946/I) should have significantly lower educational attainment and worse labor market outcomes than others. The reason would be that (qualitative) malnutrition was most severe at the end of the war and the immediate post-war weeks and that this had long-term effects on those in utero during that period. We study four different outcomes: the proportion of individuals with more than basic schooling, the proportion of individuals with a college degree, unemployment rates, and the proportion of respondents in blue-collar occupation. Income is not available in the data. Figure 10 shows these outcomes by half-year of birth. The shaded area indicates the first part of 1946 (January to May). The top left panel shows the proportion of men and women with more than basic education. The graph mirrors Figures 6. In particular, we find a substantial drop at 1946/I among both men and women.¹² The top right panel shows the proportion of men and women with college degrees. We find a local minimum in tertiary educational attainment again at 1946/I, but the general pattern suggests that cohorts born in the half-years before and after might also have been affected.

The bottom left panel shows unemployment rates by birth half-years. We find higher than

¹²Note that the levels differ from those in Figures 6. This is due to the fact that the coding of education in the 1970 and 1987 census are not fully compatible.

average unemployment rates for both men and women born in 1946/I but also quite elevated rates for those born half a year and a full year earlier. The bottom right panel shows the proportion of men and women in blue-collar occupations. For men, we do find a spike in blue-collar occupation at 1946/I, but this is only one among a number of similar spikes found for individuals born in the first half of the year. The percentage of women in blue-collar occupations does not show any peculiarity anymore at 1946/I.

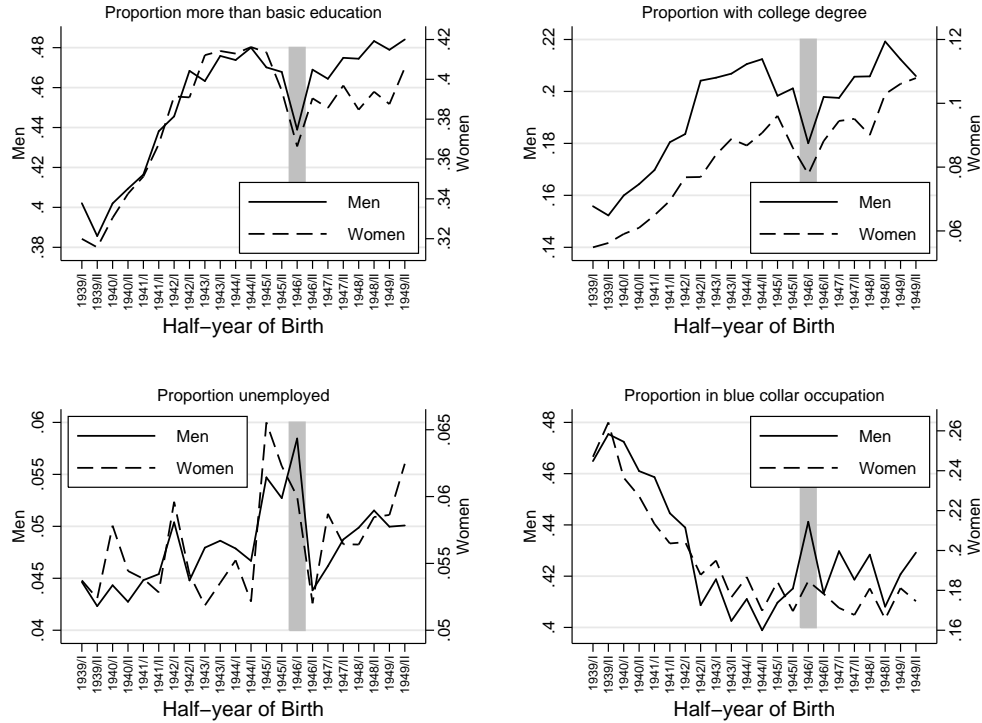


Figure 10: Educational attainment and labor market outcomes, census 1987 (by half-year of birth). Note: the first half-year is January 1 to May 25 (the census reference date), the second half-year is May 26 to December 31.

In order to test whether the spikes in educational attainment and labor market outcomes are statistically significant, we have estimated linear probability models (with heteroskedasticity-consistent standard errors), separately for each outcome and sex. The key explanatory variable is “being born in the first part of 1946”, and we control for a fourth-order polynomial birth cohort trend and a season-of-birth dummy (first versus second part of the year). The results for our coefficient of interest are shown in Table 4. For men, all coefficients are significantly different from zero. Men who are born in January to May 1946 are 3.7 percentage points less likely to have more than compulsory schooling, are 2.7 percentage points less likely to have a college degree, are 0.9 percentage points more likely to be unemployed and 3 percentage points more likely to work in a blue-collar job. For women, only the two coefficients pertaining to education are significant: women who are born in January to May 1946 are 3.8 percentage points

Table 4: Effect of being born in 1946/I on educational attainment and labor market outcomes, percentage point estimates obtained from linear probability models. Data are from the West German 1987 census

	Above basic education	College degree	Unemployed	Blue-collar
Men				
Mean dependent variable	0.450	0.191	0.047	0.432
Born in 1946/I	-0.037*** (0.007)	-0.027*** (0.005)	0.009*** (0.003)	0.030*** (0.008)
Observations	221,492	221,492	214,535	197,192
Women				
Mean dependent variable	0.378	0.081	0.056	0.195
Born in 1946/I	-0.038*** (0.007)	-0.015*** (0.004)	0.003 (0.004)	0.009 (0.007)
Observations	214,193	214,193	126,597	118,181

Note: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables: fourth-order polynomial trend, season of birth dummy (first vs. second half of the year).

less likely to have more than compulsory schooling, are 1.5 percentage points less likely to have a college degree. The analysis of the 1987 census thus by and large confirms the results obtained on the basis of the 1970 census.¹³ Educational attainment remains strongly affected by when exactly one is born. This translates into worse labor market outcomes, which are now found particularly among men.

4 Explanations

To summarize the results of the preceding section: for birth cohorts born November 1945 to May 1946, there is systematic statistical evidence for lower educational attainment, for lower occupational status at ages 25 and 42, partly for lower income at age 25 (only for women) and for higher unemployment rates at the age of 42. As noted earlier, we think that this is the first time this post-war effect has been documented. Hence there are no generally accepted explanations so far. In this section, we discuss a couple of possible explanations for the post-war dip in educational attainment and labor market outcomes: malnutrition, flight and expulsion, selective fertility, and institutional changes to the education system. Since our findings on education appear to be the most systematic and robust, we concentrate on explaining the education dip. Since the exact timing of events plays an important role in ruling out alternative explanations, we now mostly focus the analysis on cohorts born or conceived around the end of the war, i.e., cohorts born between October 1944 and February 1947.

¹³A regression analysis using 1970 data and specifications comparable to Table 4 shows, among men born in the first five months of 1946, a 4.8 percentage point drop in educational attainment and a 3.9 percentage point increase in the probability of being blue-collar worker. Among women, we find a 4.0 percentage point drop in educational attainment and a 3.0 percentage point increase in the probability of being a blue-collar worker.

4.1 Timing of causal effects

A number of studies in the medical literature have tried to establish links between adverse environmental factors, the trimester of pregnancy, and health outcomes (immediate and long-term). For instance, significant relationships were found between exposure to severe malnutrition during *first* trimester of pregnancy and increased adult weight (for women) or reduced self-rated health. In contrast, birth size and body proportions varied only with *late* pregnancy (these results were found in Dutch cohorts born in the Winter of 1944/45, see e.g. Lumey (1998); Roseboom et al. (2001, 2003); Stein et al. (2004, 2007)). We thus begin this section by ordering thoughts in terms of the timing of possible causal effects of early life conditions on the later-life outcomes studied in the present paper. Because it is so difficult to disentangle intrauterine from other early childhood effects (Almond and Currie, 2011), it is helpful to distinguish several stages: Pre-conception, first, second, and third trimester of pregnancy, and infancy including the first month of life (1st to 12th month). Although it is not possible to determine sharp start and end points to the worst period of the German food crisis, we follow the example of the analysts of the Dutch famine 1944/1945 in defining groups by their month of birth relative to what we think was the height of the food crisis (March to July 1945).

Based on a duration of pregnancy from conception to birth of nine month, Table 5 shows for each month of birth from October 1944 to November 1947 the assumed month of conception, and how time in utero relates to the height of the food crisis.¹⁴ This table helps aligning the timing of adverse external events such as food shortage or war-related maternal stress, which are possible causes of the post war education and labor market outcomes, to stages of pregnancy and early childhood. For instance, as we have seen above, the educational disadvantage seems to be strongest among women born in January 1946. Assuming a full term pregnancy, these women have been conceived in April 1945 and belong to cohort D, thus those who have been conceived when malnutrition was particularly severe.

Table 5: Time frame for potential causes before, during, and after pregnancy, by month of birth

Cohort	Conception	Birth	Description
A	Jan 44-May 45	Oct 44-Feb 45	in utero before food crisis
B	Jun 44-Oct 44	Mar 45-Jul 45	late pregnancy/born during height of food crisis
C	Nov 44-Feb 45	Aug 45-Nov 45	conceived before & born after food crisis
D	Mar 45-Jul 45	Dez 45-Apr 46	conception/early pregnancy during food crisis
E	Aug 45-Feb 47	May 46-Nov 47	conceived after food crisis

¹⁴We are aware that the events that we hold responsible for the long-term effects studied in this paper may also have caused preterm births. Thus we may overestimate the length of pregnancies and our estimate of the date of conception may be biased. However, the bias is likely to be very small. For instance, Dean (1951) reports that in the city of Wuppertal, the average period of gestation was 1.25 *days* shorter in 1945/1946 than in 1937/1938. The difference was statistically significant. The shorter period of gestation had impacted on birth weight, accounting for about one-fourth of the total reduction in birth weight of roughly 200g between 1937/38 and 1945/46. But in terms of imputing the date of conception, the reduction in gestation length is clearly negligible.

4.1.1 Number of births

Although shown before, we look again at the number of observations/births, now within the shorter time window around the end of World War II. This is shown in Figure 11. Note that the five groups as defined in Table 5 are represented by five distinct areas. Cohorts B (born during height of food crisis) and D (conceived during height of food crisis) are shown by shaded area. The period before, between, and after the shaded areas correspond to cohorts A, C, and E, respectively. The number of births in cohorts A and E (born before and conceived after the height of the food crisis, respectively) are fairly stable. Cohorts B and C are characterized by a dramatically decreasing number of observations/births, whereas cohort D (conceived during the height of the food crisis) is growing rapidly. Apparently, most of the variation in the number of observations is due to immediate war-related events (two-front war and end of war), not to the food crisis as such. If undernutrition during the height of the food crisis had a major impact on fertility, for instance, we would *not* observe the steep increase in the number of observations in cohort D. Still, the increase in fertility might have been selective with respect to social status, and we try to address this issue in Section 4.5.

4.1.2 Sex ratio at birth

One well documented effect of maternal malnutrition or general war-related stress before conception or during pregnancy is on sex-ratios at birth. Maternal stress pre-conception is often associated with an increased sex ratio at birth. In fact, both in 1919 and in 1946, i.e. in the years following both World Wars, the sex ratio at birth in Germany was 1.08, substantially higher than the norm of 1.05 and it took many years to bring them down to normal levels. Lack of data does not allow showing monthly sex ratios at birth based on official birth records for the World War II period. For our period of interest, we thus use the 1970 census data—but note the caveat that those numbers are also affected by differential infant mortality. Figure 12 shows the sex ratio of observations in our data by month of birth. The data show a lot of variation and we smoothed them by three-month moving averages. Even those averages exhibit a couple of troughs and peaks. First, among those conceived and born before the food crisis, we find a slightly elevated sex ratio of about 1.06. The beginning of the food crisis is associated with a sharp drop in the sex ratio. This can obviously not be the effect of malnutrition at the time of conception because those children were conceived many months before. Rather, it is likely that the survival of boys was affected stronger by late pregnancy or early childhood malnutrition. However, the sex ratio steadily increases to above normal levels of about 1.09 even within the height of the crisis. Eight months after the first sharp drop in the sex ratio comes a second sharp drop which could now be explained by malnutrition in early pregnancy.¹⁵

¹⁵This is in line with a recent paper by Sanders and Stoecker (2011), which exploits variations of the sex-ratio at birth as a measure of intrauterine insults due to pollution exposure and quite convincingly shows that pollution

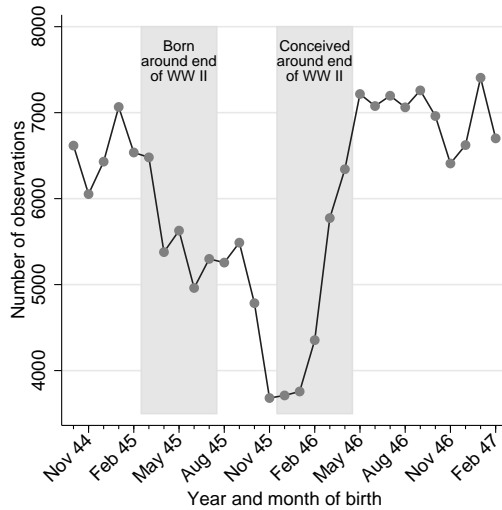


Figure 11: Number of observations by month of birth, October 1944 to February 1947

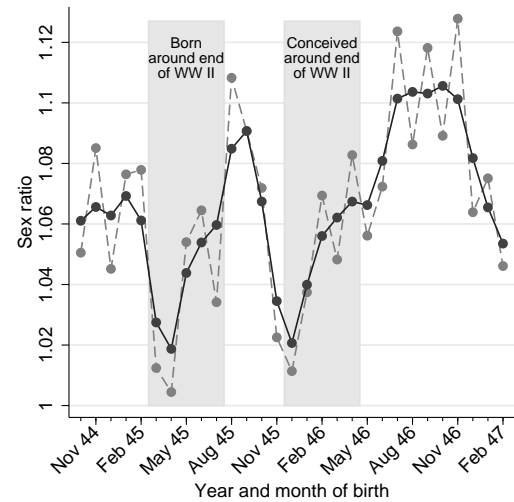


Figure 12: Sex ratio, by month of birth, October 1944 to February 1947. The dark solid line shows the three-month moving average

4.2 Quantitative malnutrition

As demonstrated in Section 1.1, German children born during the war and shortly after the war have suffered from under- and malnutrition in early childhood over a prolonged period of time. Quite obviously, this can be no explanation for the short-period effects (i.e. affecting only few cohorts) observed in the data. The short-period effect rather speaks in favor of bad intrauterine conditions as an independent, additional determinant of later-life outcomes. There is already a larger medical literature on such effects drawing e.g. on the Dutch famine cohorts, suggesting that intrauterine malnutrition increases the likelihood of coronary heart disease, adult weight, and self-rated health (Lumey, 1998; Roseboom et al., 2001, 2003; Stein et al., 2004, 2007). Early analyses of the effect of the Dutch famine on intelligence and cognitive functioning, however, have shown no differences between famine cohorts and those born before or after (Stein et al., 1972). A recent study, however, has shown impaired cognitive performance (in at least one dimension) at ages 56 to 59 among cohorts exposed to the famine in their *first* trimester (de Rooij et al., 2010).

4.2.1 Time-series variation in caloric intake

To tackle the question at which point during pregnancy and early childhood malnutrition might cause the most severe damage in terms of later-life educational outcomes, we now bring together (our rather informally collected) data on daily caloric consumption (Figure 1) and

reduces the sex-ratio. However, the war and post-war effects that raise the sex ratio at birth in Germany long-term far outweigh any Trivers-Willard-type effects, which stipulate that evolutionary pressures will lead to more daughters when living conditions are poor (Trivers and Willard, 1973). Note also that raised sex ratios in response to fetal malnutrition were also found in studies of the Dutch hunger winter (Stein, Zybert, and Lumey, 2004).

data on educational attainment by month of birth as shown in Figure 6. Specifically, we ran regressions of the type

$$y_c = f(c) + \mu_m + \gamma \times x_{c+\tau} + \varepsilon \quad (3)$$

where y_c denotes average education level of cohort c , $f(c)$ is a fourth-order polynomial cohort trend, μ_m is a set of month dummies and $x_{c+\tau}$ denotes the number of available calories in month $c + \tau$. Thus γ is our coefficient of interest. We let τ run from -15 to +15 and estimate 31 different regressions. Negative values of τ (between -9 and 0) indicate periods in utero, values below -9 indicate pre-conception periods, and positive values indicate early childhood periods. Figure 13 shows our estimates of γ and their 95% confidence intervals (based on cohort-clustered standard errors) for both men (top panel) and women (bottom panel).

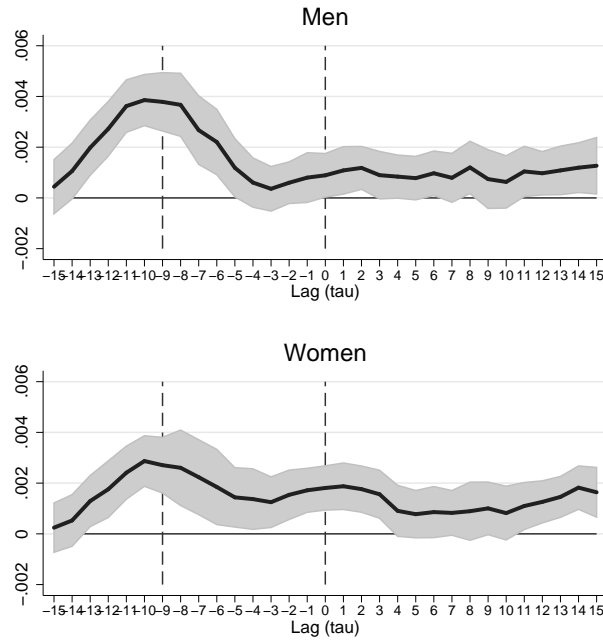


Figure 13: Partial effects of daily caloric intake of mother and/or child (in 100 kcal) in month $c + \tau$ on the probability of attaining more than basic education among cohorts born in month τ , and their 95% confidence intervals. $\tau = 0$ denotes the month of birth, $\tau = -9$ indicates the month of conception. Data on educational attainment based on the 1970 census.

The results suggest that caloric malnutrition (of the mother and/or child) is significantly correlated with worse educational attainment independent of the lag length. However, daily calories available 9 to 10 months before birth appear to be most strongly correlated with later-life outcomes. A reduction of 100 calories 9 months before birth takes some 0.3 (women) to 0.4 (men) percentage points of the chance of attaining more than basic education. The pattern shown in Figure 13 reflects the time structure of the calorie and education data used in our regression and should be interpreted with caution. For instance, based on the numbers one would conclude that living conditions pre-conception may be relevant for later-life outcomes.

Although this is consistent with biological evidence, it is unclear whether the pre-conception environment should have a similar sized effect as the prenatal environment.¹⁶ Certainly the calorie data we collected are not systematic and reliable enough to make such conclusion. The analysis illustrates, however, the value of collecting and using better and more detailed data on prenatal, even pre-conception (rather than postnatal) environmental conditions.

4.2.2 Variations by city size

In Figure 1, we had shown the daily calories for each period across all region of Germany. However, living conditions varied greatly between regions and between the cities and the countryside. Another strategy to test the malnutrition explanation is to split the sample into different groups that were differentially affected by the food crisis. For instance, urban areas were typically affected stronger by the food crisis than rural areas, just because farmers could self-supply. The 1970 census data do not contain information whether the place of birth was in rural or urban area. We only know the size of the *current* (1970) city of residence. We are aware that the urban-rural difference could of course have been attenuated by urban-rural migration between the mid 1940s and the census in 1970, but we are still able to show that urban-rural differences have persisted.

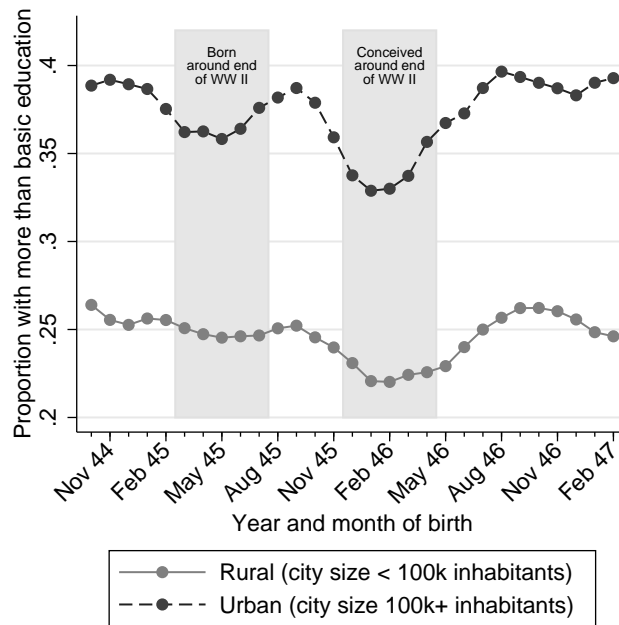


Figure 14: Average number of years in school, by month of birth and city size

¹⁶For instance, a meta-analysis of studies in developing and developed countries conducted by the WHO shows that low maternal pre-pregnancy weight (reflecting nutritional status) is a significant predictor of adverse fetal outcomes such as low birth weight, intrauterine growth retardation or preterm birth, but weight gain during pregnancy appears to be similarly important (WHO, 1995).

Figure 14 shows the average proportion of cohort members attaining more than compulsory schooling among those living in rural areas (city size smaller than 100,000 inhabitants) and those living urban areas (cities with 100,000 inhabitants or more).¹⁷ The overall level of education in urban areas is much larger than in rural areas. This can obviously be a result of selective migration as much as better education opportunities in cities. More importantly, we see larger decreases in the proportion of individuals with more than basic schooling in cities than in rural areas among both “treatment groups”, those who were born (Cohort B) and those who were conceived around the end of the war (Cohort D). It is not immediately clear, however, which difference to rural areas is bigger. We will therefore continue our analysis by estimating the following difference-in-difference model on individual data:

$$y_{imzs} = \alpha_m + \xi_z + \xi_z \times m + \sigma_s + \beta_1 \text{urban}_i I(B_i) + \beta_2 \text{urban}_i I(D_i) + \varepsilon_{imzs} \quad (4)$$

where y_{imzs} represents years of schooling of individual i born in month m living in a city of size z in state s . α , ξ and σ are sets of dummy variables for month of birth (from October 1944 to February 1947), city size (coded in 12 different levels) and federal state of residence, respectively. We estimate equation (4) with and without city-size specific linear deviations from the general non-parametrically specified cohort trend (α_m) in educational attainment. Our coefficients of interest are the difference-in-difference estimators β_1 and β_2 , i.e. the coefficients of an interaction of a rural/urban dummy with *period of birth* dummies $I(B)$ (for cohort B) and $I(D)$ (for cohort D).

Table 6: Effect of being born or conceived between March and July 1945 on educational attainment interacted with city size

VARIABLES	(1) All	(2) All	(3) Men	(4) Men	(5) Women	(6) Women
Mean dependent variable	0.285	0.285	0.301	0.301	0.269	0.269
Urban \times born March-July 45 (Cohort B)	-0.0158** (0.00760)	-0.0136* (0.00823)	-0.000982 (0.0109)	0.00189 (0.0118)	-0.0324*** (0.0108)	-0.0307*** (0.0117)
Urban \times conceived March-July 45 (Cohort D)	-0.0221*** (0.00792)	-0.0223*** (0.00792)	-0.0134 (0.0113)	-0.0138 (0.0113)	-0.0309*** (0.0113)	-0.0309*** (0.0113)
Sex dummy	yes	yes	no	no	no	no
City size dummies	yes	yes	yes	yes	yes	yes
Month of birth dummies	yes	yes	yes	yes	yes	yes
State dummies	yes	yes	yes	yes	yes	yes
City-size specific cohort trend	no	yes	no	yes	no	yes
Observations	134,453	134,453	69,497	69,497	64,956	64,956
R-squared	0.048	0.049	0.040	0.040	0.025	0.025

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

¹⁷Note that the time series are mildly smoothed as $x_t^* = 0.25(x_{t-1} + 2x_t + x_{t+1})$

Table 6 shows the regression results. In the full sample, we find a 1.6 percentage points difference in the proportion of individuals with more than basic schooling between “treated” (urban) and “control” (rural) areas for cohort B (born March-July 1945) and a 2.2 percentage points difference for cohort D (conceived March-July 1945). These results suggest that both undernutrition at the time of conception and undernutrition at the time of birth harm the unborn child or infant, but the effect at conception appears to be more detrimental. However, we also observe important sex differences: the rural-urban difference in educational attainment effects appears to be driven mostly by women. Moreover, among women, the effect size is practically the same in the period of birth and conception. In contrast, among men, point estimates for effect differences at the time of birth are practically zero and effect differences are small and not significant.

4.2.3 Variations by region

Another strategy to test the malnutrition explanation is to split the sample by broader regions that might have been differentially affected. For example, average caloric intake was different across the four occupation zones. Over the entire period from 1945 to 1948, people living in the French and Soviet occupation zones are reported to have had less average calories than those in the American and British zones. However, if immediate post-war living circumstances were particularly dire and thus responsible for the education and occupation dip, it should be more useful to consider events and living circumstances in early 1945. Two factors could have played an important role: first, *when* a region was occupied (March, April, or May 1945), and second, *by whom* of the Allies a region was occupied (American, British, or Soviet).

Timing might have been important because those regions that were occupied relatively early might have suffered less; the spell of malnutrition was shorter and maybe also less severe. For instance the regions west of the River Rhine were occupied already in March 1945. Behind the front lines, American troops were bringing 600,000 tons of grain, both as food for the civilian population and spring grain for sowing in March and April, which could be harvested as early as in July (Rothenberger, 1995). The census data do not allow us to identify where exactly someone’s mother lived in 1945. We know the current state of residence and we also know whether someone moved from the Soviet occupation zone to the current state of residence *after the end of the war* (but not exactly when). Based on this information, we have computed trends in educational attainment by federal state.

Figure 15 shows the proportion of individuals with more than basic education by month of birth for two regions: (1) federal states that are (mainly) to the west of the River Rhine (Saarland and Rhineland-Palatinate)¹⁸ and (2) mainly rural states east of the Rhine (Bavaria,

¹⁸About 80% of the inhabitants of Rhineland-Palatinate live in counties west of the River Rhine. Another state that stretches the Rhine is Northrhine-Westfalia. About 20% of inhabitants live to the west, but we exclude this state from our analysis anyway.

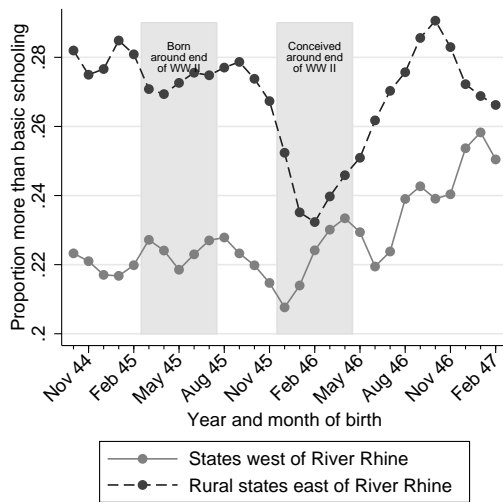


Figure 15: Average proportion with more than compulsory education, by month of birth and regions west and east of the River Rhine. To make regions comparable, states west of the Rhine were restricted to mostly rural states and inhabitants of cities with more than 200,000 inhabitants were excluded.

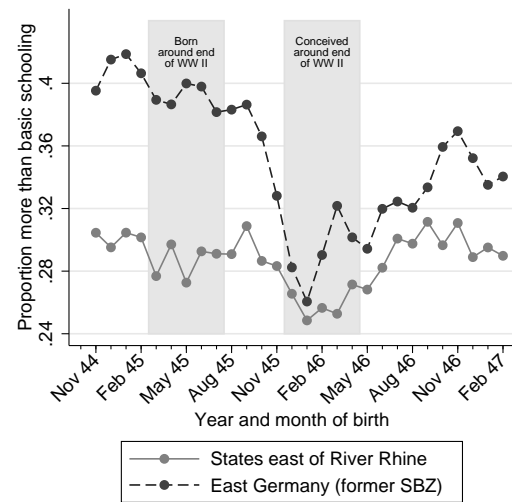


Figure 16: Average number of years with more than compulsory education, by month of birth and regions in East and West Germany (excluding states west to the Rhine).

Baden-Wuerttemberg, Hesse, Lower Saxony, Schleswig-Holstein). Further, to make those states comparable to Saarland and Rhineland-Palatinate, we also drop individuals living in cities with more than 200,000 inhabitants. Figure 15 shows that the educational attainment of those born or conceived around the end of the war and who lived west of the Rhine in 1970 does not seem to be systematically different from the adjacent cohorts. A trough can be found for those born in December 1945 (which corresponds to conception in March 1945). Although this could be a mere coincidence, it could also be explained as an immediate effect of combat in the area. In states east of the Rhine, we find the familiar pattern of lower educational attainment particularly among those conceived around the end of the war.

Table 7 contains difference-in-difference regression results. The full regression specification is the same as in equation (4), except that we specify state specific trends rather than city-size specific trends in columns (2), (4), and (6). We find significantly less people having attended more than basic school if they were conceived in March-July 1945 in states east compared to west of the River Rhine. The overall effect difference is 2 percentage points, but again, this is mainly driven by women, for which we find coefficients that are twice as large as those for men. There is no difference across the Rhine among those who were *born* around the end of the war.

Another interesting region is the former Soviet occupation zone (SBZ). There are two reasons why food for civilians might have been even scarcer than in other parts of Germany. First, it was among of the last German regions to be occupied. Second, one might assume that given the previous atrocities of the German army in the USSR, the Soviet military was

Table 7: Effect of being born or conceived between March and July 1945 on educational attainment interacted with region (east versus west of River Rhine)

VARIABLES	(1) All	(2) All	(3) Men	(4) Men	(5) Women	(6) Women
Mean dependent variable	0.257	0.257	0.275	0.275	0.236	0.236
East of Rhine × born March-July 45	0.00274 (0.00782)	-0.00712 (0.00837)	0.0133 (0.0113)	0.00307 (0.0121)	-0.00820 (0.0107)	-0.0175 (0.0115)
East of Rhine × conceived March-July 45	-0.0215*** (0.00829)	-0.0208** (0.00830)	-0.0148 (0.0121)	-0.0140 (0.0121)	-0.0298*** (0.0113)	-0.0292*** (0.0113)
Sex dummy	yes	yes	no	no	no	no
City size dummies	yes	yes	yes	yes	yes	yes
Month of birth dummies	yes	yes	yes	yes	yes	yes
State dummies	yes	yes	yes	yes	yes	yes
State specific cohort trend	no	yes	no	yes	no	yes
Observations	101,634	101,634	52,757	52,757	48,877	48,877
R-squared	0.046	0.046	0.049	0.049	0.043	0.043

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note: regressions include all observations from Saarland – not a 10% subsample

less concerned with feeding German civilians than U.S. or even British military.¹⁹ For these two reasons, we expect that individuals who were conceived or born in the area of the Soviet occupation zone could have been hit harder by the food crisis than others. Figure 16 shows average years in school by month of birth of those who have lived in the SBZ compared to those who have not. The graph clearly shows a huge dent in educational attainment among those conceived around the end of the war. Again, we substantiate our analysis by differences-in-differences regressions (see Table 8). Being conceived in March-July 1945 has a significantly stronger negative effect on the educational attainment of those who lived in the SBZ than on others. In contrast to our findings reported above, the effect appears to be homogeneous across sexes.

4.3 Qualitative malnutrition

In this section, we add evidence on qualitative malnutrition, particularly with regard to protein, fat, and carbohydrates. Our analysis is based on the data already shown in Figure 2, which shows the amount of nutrients available for infants and children in the northern parts Germany. In light of the fetal origins hypothesis, it might appear irrelevant to have information of food available for children and preferable to have information on food rations for pregnant women. However, for several reasons we believe that the data we have are useful to understand the

¹⁹Roughly one third of the area of the former GDR was initially occupied by U.S. and British forces and vacated only on July 1st 1945.

Table 8: Effect of being born or conceived between March and July 1945 on educational attainment interacted with region (former Soviet occupation zone versus West Germany – east of the Rhine)

VARIABLES	(1) All	(2) All	(3) Men	(4) Men	(5) Women	(6) Women
Mean dependent variable	0.295	0.295	0.311	0.311	0.280	0.280
SBZ × born March-July 45	0.0303*** (0.0114)	0.0116 (0.0119)	0.0242 (0.0159)	0.00534 (0.0167)	0.0358** (0.0163)	0.0171 (0.0170)
SBZ × conceived March-July 45	-0.0387*** (0.0133)	-0.0313** (0.0134)	-0.0374** (0.0187)	-0.0305 (0.0188)	-0.0389** (0.0188)	-0.0309 (0.0189)
Sex dummy	yes	yes	no	no	no	no
City size dummies	yes	yes	yes	yes	yes	yes
Month of birth dummies	yes	yes	yes	yes	yes	yes
State dummies	yes	yes	yes	yes	yes	yes
State specific cohort trend	no	yes	no	yes	no	yes
Observations	141,458	141,458	73,068	73,068	68,390	68,390
R-squared	0.043	0.043	0.047	0.048	0.039	0.039

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

development of qualitative malnutrition over time. In Germany, it was common for food ration cards to allocate more than proportionally to infants and less than proportionally to older children and adults.²⁰ Assuming intra-household redistribution of calories, it is likely that undernutrition affected everyone in the family to a similar extent. Although it is possible that family members gave pregnant women a larger than average share of the family total (Almond and Currie, 2011), this might not necessarily have been the case in the first trimester when the pregnancy was not yet even known to the mother or not yet made known to family members.

Figure 17 shows the data, by observation period, together with the proportion of individuals attaining more than basic education among those who have been in the *second month of pregnancy* in the respective period. In other words, Figure 17 shows the co-movement of qualitative malnutrition (albeit measured among children, not pregnant women in their second month) and educational attainment of those in the womb at that time. Some of the graphs seem to suggest that the diet was short on calories, fat, or carbohydrates already at the beginning of the war. This is an artifact of the way the data were generated. In the early war years, enough food was available on the free market, and this was not included in Droese and Rominger's calculations.²¹ Nevertheless, it is obvious that the low in nutritional quality in post-war 1945 coincides with a low in educational attainment among those being in the womb in their first

²⁰For instance, in the city of Wuppertal in June/July 1946, children aged 0 to 12 months were allocated 1,062 calories, (normal) adults over 18 years were allocated 1,052 calories, and expectant and nursing mothers were allocated 2,174 calories (McCance and Widdowson, 1951).

²¹Thus the computations are somewhat inconsistent. This is because Droese and Rominger computed nutritional values in the early war years retrospectively (and did not want to impute free market food), while the data from 1945 onwards were collected contemporaneously.

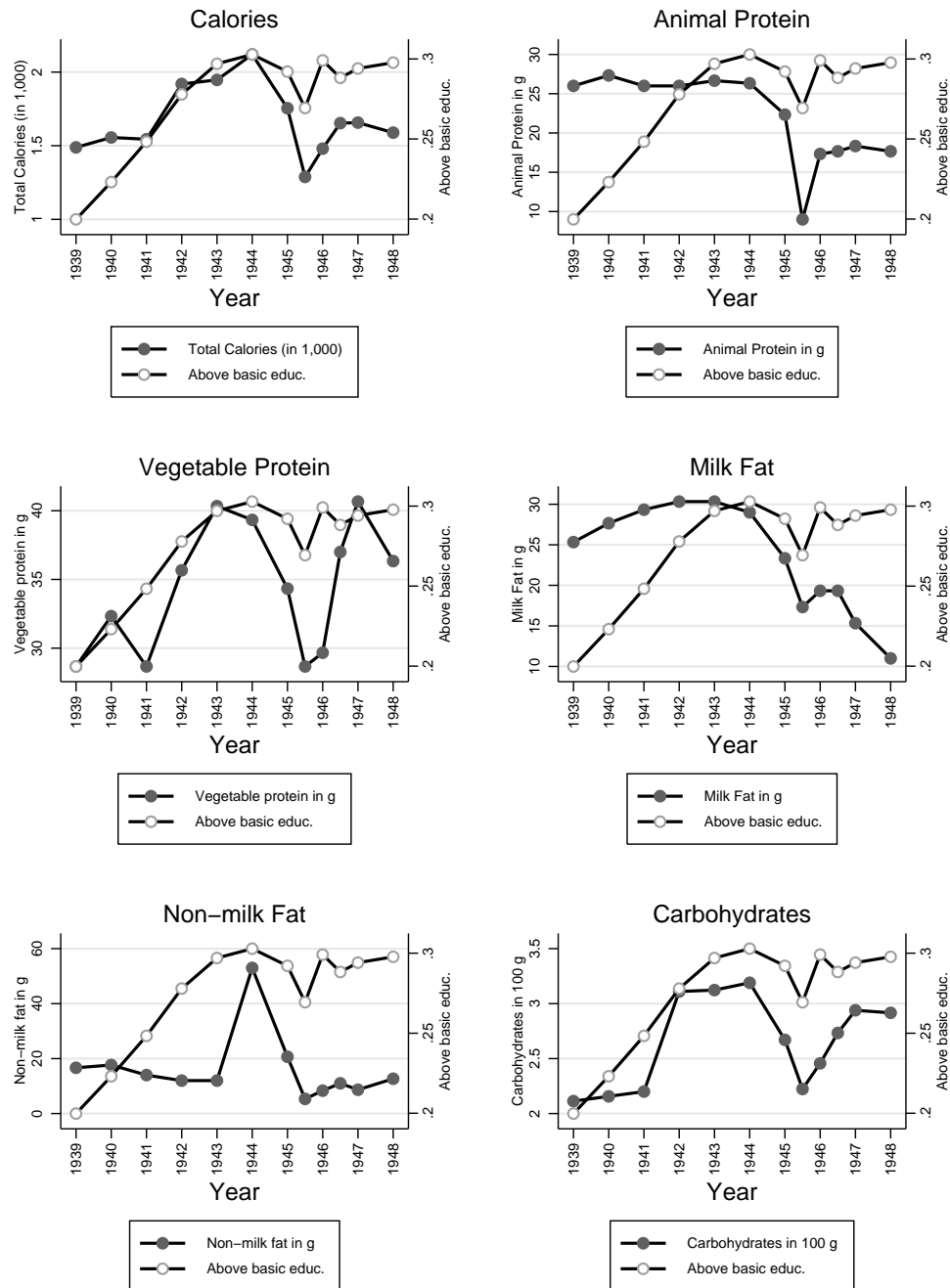


Figure 17: Average daily allowance of calories and nutrients for infants and children (left scale, source: Droese and Rominger (1949), Fig. 1), and proportion attaining more than basic education (right scale, source: own computations based on the German 1970 census), 1939-1948 . Educational attainment in a specific period is computed for individuals in the second month of pregnancy (i.e., in the middle of the first trimester) in that period.

trimester. This relationship is quantified in Table 9, which shows the results of a series of (macro-) regressions of average years of schooling on a second-order polynomial trend and one of our six variables indicating qualitative nutrition, of which we show the estimated coefficient, its standard error and the increase in explained variance (ΔR^2) by including this variable in the regression. Each coefficient comes from a separate regression. We ran each regression twice. First we used the full sample, then we used a restricted sample beginning in 1942 (and avoiding potentially mismeasured nutrition in the first war years).

Table 9: Associations between nutrition supply during the first trimester of pregnancy and educational attainment (proportion attaining more than basic schooling)

	Calories	Anim. Protein	Veg. Protein	Milk Fat	Other Fat	Carbohydrates
Full sample (years 1939-1948)						
Coefficient	0.0465***	0.0027***	0.0017*	0.0056***	0.0002	0.0269*
Standard error	0.0129	0.0002	0.0008	0.0007	0.0002	0.0080
ΔR^2	0.0481	0.0515	0.0297	0.0522	0.0059	0.0490
Restricted sample (years 1942-1948)						
Coefficient	0.0439**	0.0025***	0.0016	0.0049***	0.0004	0.0333**
Standard error	0.0136	0.0002	0.0011	0.0010	0.0002	0.0121
ΔR^2	0.5877	0.7655	0.3638	0.6700	0.2812	0.5749

Note: Standard errors are heteroskedasticity-consistent; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control variables: second-order polynomial cohort trend. Analysis based on 1970 census.

Table 9 clearly suggest that some of our indicators of intrauterine qualitative mal-nutrition are related to educational attainment. We find significant coefficients for total calories, animal protein and carbohydrates in the full and in the restricted sample. The most relevant nutritional indicator, judged by ΔR^2 is animal protein. Overall, this pattern suggests that it was primarily severe (protein) malnutrition in the first trimester of pregnancy that has caused the lower average education, occupational status and income of those born in the seven months between November 1945 and May 1946. Still, it would be interesting to know more in more detail what was happening exactly in the second part of 1945. The May 1946 born—as the last cohort in that critical period—were in their first trimester until about September 1945. Has the factual food situation suddenly improved in October 1945 with the new harvest? Obviously, this is difficult to tell from the scarce data that are available, but it seems at least plausible.

4.4 Flight and expulsion

On January 12, 1945, the Red Army started their offensive on Germany's eastern border. An unprecedented flight wave of some 9.6 million people, mostly ethnic Germans, set in from the eastern provinces of Germany. Many of those who did not leave voluntarily were expelled. One explanation for the post-war education dip is that the affected cohorts were born to mothers who fled or were expelled from the East. Some of the children born between November 1945

and May 1946 had been in utero during the flight and thus presumably exposed to short spells (one to four weeks) of extreme undernutrition and particularly high physical and psychological strain. Indeed, some contemporary observers attribute the high infant mortality rates of above 20% in March, April, and May 1945 to the “influx of masses of refugees from eastern Germany and their infants harmed by flight” (Droese and Rominger, 1949, p.621).²²

Further, many German women were raped by Allied soldiers. In and around Berlin alone, some 100,000 women were assaulted between Spring and Fall of 1945, of which 20% are estimated to have been impregnated (Sander and Liebman, 1995). Abortions were numerous, but more easily obtained in Berlin than in rural areas. Some pregnancies were carried to term, i.e. there are children in our cohorts of interest who were conceived following rapes (and the pregnancy was not aborted). Their mothers might have consciously or unconsciously resented and neglected these “Russian children”, resulting in worse later-life outcomes. In a review of the literature on effects of *denied* abortions on mothers and children, Dagg (1991, p. 584) concludes: “the most disturbing part of the whole issue is the evidence of significant negative effects on the child. With the caveat that the unwanted pregnancy does not necessarily result in an unwanted child, [...] prospective studies reveal long-lasting, broadly based, negative effects of the denial of abortion on the children subsequently raised”. Notably, these negative effects include poorer school performance and lower educational attainment.

The census contains information where the family of the respondents lived on September 1st, 1939, i.e. on the day the Second World War began. If adverse effects of flight and expulsion are a valid explanation for the disadvantage of immediate post-war cohorts, we would expect that those whose parents lived in the former Eastern Provinces of Germany are more affected than those who always lived within the current (1990) borders of Germany. Figure 18 shows the proportion with more than basic schooling for birth cohorts October 1944 to February 1947 and three distinct groups by parental residence in 1939. Our “control group” are those whose parents lived within the 1990 borders (i.e. former East and West Germany). The first “treatment group” are those whose parents lived in the Eastern Provinces (Pomerania, Silesia, East Prussia). These provinces were occupied by the Red Army in January and February 1945, and the main flight wave was in early 1945. The second “treatment group” are those whose parents lived in Sudetenland, a part of Czechoslovakia. These individuals were ethnic Germans who were expelled from Czechoslovakia *after* the war. Especially the “wild” expulsions during the first few post-war months (between May 1945 and July 1945) took place under extremely harsh conditions (Pykel, 2004).

First, one can see that a larger share of the individuals in the two treatment groups has more than basic education than individuals whose parents lived within the 1990 borders. One explanation could be that refugees settled primarily in federal states with generally larger proportions of children attending intermediate and academic secondary school tracks. More

²²See also Jochims and Doerks (1947) for a detailed account of health problems of infants surviving the flight.

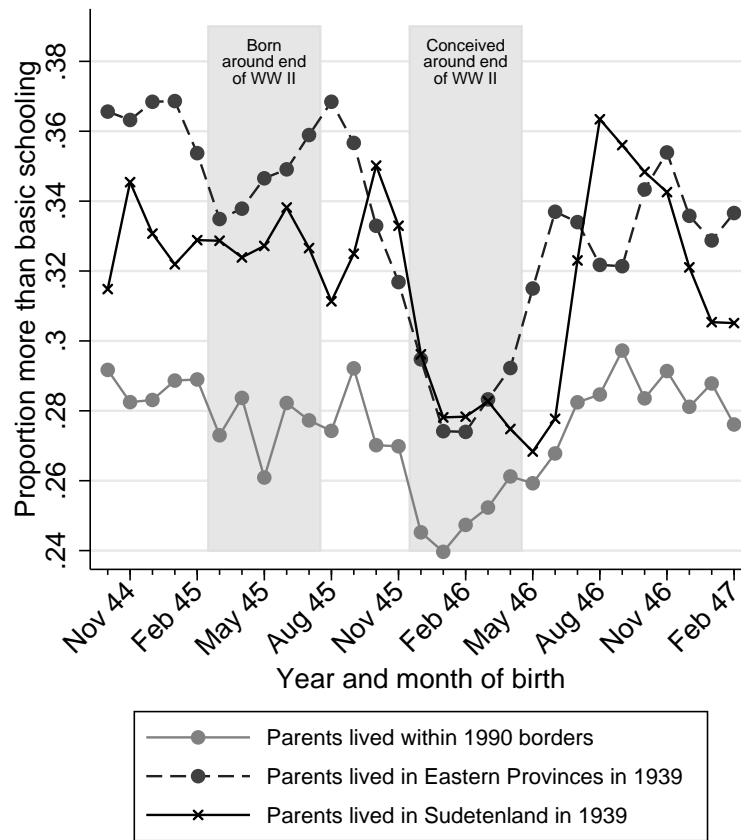


Figure 18: Educational attainment, by month of birth, and parental place of residence in 1939.

importantly, consistent with the idea that flight or expulsion are harmful to the fetus, the educational attainment dip appears to be bigger for those whose parents lived in the Eastern Provinces or Sudetenland in 1939. Further, the trough in educational attainment is somewhat prolonged for those coming from Sudetenland. This matches the historical pattern, namely, that the Sudeten Germans were expelled after the war, and the “wild” expulsions may have harmed children in utero.

A more systematic analysis is shown in Table 10, which contains results of two separate difference-in-difference regressions, one for those from the Eastern Provinces and one for those from Sudetenland. Note that we deliberately shifted the definition of the treatment periods in order to capture *additional* effects of flight and expulsion. For the former group we shifted the treatment period to January-May 1945 and for the latter group to May-September 1945. The results are quite homogenous in the sense that men conceived during the treatment period appear to be particularly vulnerable to the additional hardship of flight and expulsion. Results for women are less clear, though.

Table 10: Effect of being born or conceived during flight or expulsion

VARIABLES	(1) All	(2) All	(3) Men	(4) Men	(5) Women	(6) Women
Eastern Provinces (treatment periods shifted backwards by two months)						
Born January to May 45	0.0120 (0.0113)	-0.00848 (0.0137)	0.0168 (0.0158)	-0.0128 (0.0193)	0.00518 (0.0161)	-0.00357 (0.0195)
Conceived January to May 45	-0.0200 (0.0129)	-0.0255* (0.0131)	-0.0457*** (0.0177)	-0.0541*** (0.0180)	0.00648 (0.0188)	0.00430 (0.0189)
Sudetenland (treatment periods shifted forward by two months)						
Born May to September 45	-0.00974 (0.0179)	-0.0148 (0.0184)	-0.0294 (0.0248)	-0.0331 (0.0256)	0.0121 (0.0258)	0.00598 (0.0265)
Conceived May to September 45	-0.0386** (0.0194)	-0.0347* (0.0196)	-0.0667** (0.0263)	-0.0641** (0.0267)	-0.00654 (0.0284)	-0.00116 (0.0289)
Sex dummy	yes	yes	no	no	no	no
Month of birth dummies	yes	yes	yes	yes	yes	yes
Region dummy	yes	yes	yes	yes	yes	yes
Region-specific cohort trend	no	yes	no	yes	no	yes
N obs. control	137,792	137,792	71,059	71,059	66,733	66,733
N obs. Eastern Provinces	12,614	12,614	6,721	6,721	5,893	5,893
N obs. Sudetenland	4,698	4,698	2,497	2,497	2,201	2,201

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.5 Selective fertility and mortality

As Figure 5 has shown, the numbers of observations who were born in late 1945 and early 1946 are comparatively low. Depending on the reasons for this drop, these cohorts could be a specific

selection—subject to several observable and unobservable selection mechanisms. The post-war education dip could then be explained as a statistical artifact rather than being the result of some causal mechanism that particularly affected the cohorts born in Winter 1945/1946.

For instance, in the final war and first post-war months, infant *mortality* rates were very high. Many of those born in late 1945 to early 1946 may have died and are not represented in the 1970 census data. If for some reason, infant mortality affected children of better educated or higher ability mothers and fathers more than others, the selected (and observed) cohort would be of less innate ability on average. A related selectivity issue concerns fertility per se. If for some reason, better educated or higher ability (and better educated) mothers and fathers were less likely to conceive children in the final war months or the first post-war months, the average child born approximately nine months after would be of lower average ability. One such mechanism would be that, for instance, the better educated officers were kept longer in POW camps, while the rank and file were released immediately after the war or very early.

The census data do not contain information on parental education or other family background variables, so that one has to rely on alternative data sources to study this explanation. We used the German SOEP, which has biographical information on a reasonably large sample of Germans in the cohorts we are interested in. Results are shown in Figure 19. The figure shows, by month of birth, the proportion of children born to mothers and fathers of more than basic education. The shaded area indicates the World War II period plus 9 months. We find that the war cohorts are *positively* selected.²³ Cohorts born between 1941 and 1947 have on average better educated fathers than cohorts born before or after, and cohorts born between 1941 and 1946 have on average better educated mothers. Apparently, the better educated had *relatively more* children during the war years and in the first one or two years after the war. This might be explained by selective exemption of better educated men from serving at the front. Whatever the reason for the positive selection of war children, the pattern does not suggest that immediate post-war children were particularly disadvantaged (although there seems to be some end-of-war decline in maternal education. The SOEP sample has not enough observations to establish this drop as statistically significant).

4.6 Institutional changes to the education system

Yet another explanation for the post-war education dip might be changes in the school system later on that have worked to the disadvantage of just the cohort born in Winter 1945/46. That these cohorts were conceived just around the end of the war would then be a mere coincidence. Important education reforms in West Germany include the standardization of school entry legislation across states, the abolition of secondary school fees, the increase in the length of

²³Evidence from the birth records of the Landesfrauenklinik Wuppertal supports this finding. The proportion of privately insured (thus higher social status) women delivering in the clinic was around 22 percent in 1945/46 compared to only 5 percent before the war in 1937/1938 (Dean, 1951).

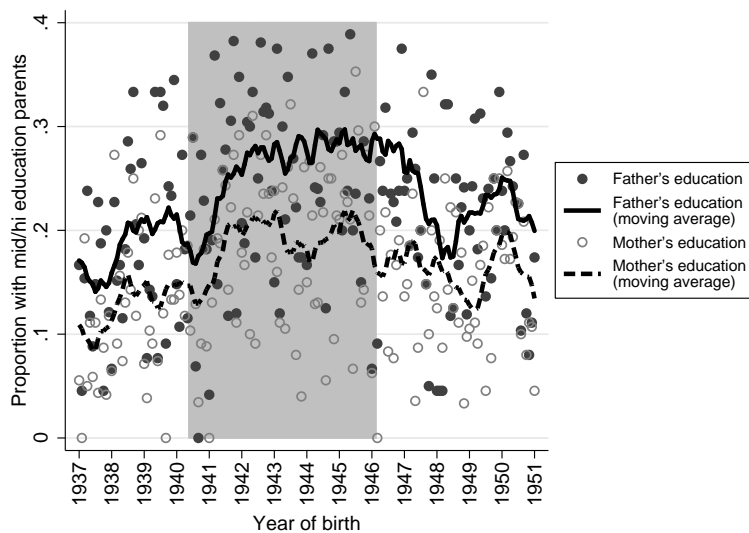


Figure 19: Parental education level, by month of birth. The solid and dashed lines show 12-month moving averages of father's and mother's education level, respectively. The shaded area indicates the World War II period *plus 9 months*.

compulsory schooling and the education expansion in terms of widening access to academic track schools.²⁴

As mentioned earlier, abolition of school fees and widening of the academic track have most likely led to long-term improvements rather than short-lived dips in educational attainment. Changes in school entry regulations, however, could have put a few birth month cohorts in a particularly bad situation because of their low *relative* age in class. In most German states, for instance, the cut-off date for school entry was shifted at some point in time from January to July. Such a six month shift, if implemented in one go, would lead to 18 birth month cohorts entering school at the same time, and the youngest students to enter school would have been 18 months younger than the oldest (and not 12 months as this is usually the case). Education research has shown that relative age at school entry plays a significant role in determining who enters upper tier secondary schools in Germany (Jürges and Schneider, 2011). However, for this to be an explanation for the educational attainment dip of some six birth months cohorts born immediately after the war, the cut-off date reform would need to have taken place in 1951 in all federal states. This was not the case. Most states changed their school entry regulations in a coordinated approach following the “Hamburg accord” of October 1964. We appreciate that this argument leaves some room for speculation about other school reforms that we have not taken into consideration. A better approach to refute the “school systems reform” explanation is to look at data from another country that has suffered the same adverse living conditions

²⁴These reforms have been used to identify causal effects of education on wages (Pischke and von Wachter, 2008) or health (Reinhold and Jürges, 2010; Kemptner, Jürges, and Reinhold, 2011; Jürges, Reinhold, and Salm, 2011). Details are given in these papers.

after the war but has otherwise evolved independently from Germany. This country is Austria and we will now study educational and labor market outcomes of Austrian war and post-war cohorts.

5 Evidence from Austria

In March 1938, Austria was occupied by Nazi Germany and became part of the Third Reich. Living conditions in Austria closely mirrored those in the rest of the Reich. Austrian men had to fight alongside their German counterparts, Austrian cities were bombed by allied air force (but to a much lesser extent), and finally, Austria went down together with the rest of the Third Reich in 1945. The Red Army occupied Austrian territory by the end of March 1945 and reached Vienna on April 13. US troops reached Austrian territory only by the end of April. As in Germany, the final weeks of the war and the first couple of months after the war were characterized by masses of refugees and expelled persons, under- and malnutrition as well as mass rape.

We replicate our analysis for Germany using 10% subsamples of the Austrian censuses 1971, 1981, 1991, and 2001, again drawn from the Integrated Public Use Microdata Series. As before, we combine age at time of the census and year of birth to identify whether a person was born between Jan 1st and the day of the census (May 12th in 1971 and 1981 and May 15th in 1991 and 2001). Figure 20 shows the average number of observations per month by half-year of birth in the four censuses combined (total number of observations used: 433,000). The development of the number of observations (and by implication the number of births) is remarkably similar to Germany. A gradual decline during the war years is followed by a final drop in the two half-years after the war. In fact, the correlation between the German and Austrian time series is 0.90 for men and 0.92 for women.

We can use the Austrian data to test again our hypothesis of (qualitative) malnutrition having had long-term effects on those in utero during the immediate post war period. As noted above, this exercise cannot only be viewed as testing our prediction out-of-sample, but also as a way to exclude changes in the education system as a rivaling explanation. If we find similar results for Austria and Germany, it is very likely that they are caused by common factors, such as World War II events and their immediate consequences.

Figure 21 shows educational attainment and labor market outcomes by half-year of birth. We computed averages across all four censuses except when looking at proportion of individuals with college degree, where we excluded the 1971 data (because in 1971 many individuals would still be in tertiary education). The top left panel, showing the proportion of individuals with more than compulsory or basic education is very much alike the corresponding figure for Germany. Note that the proportions for men and women are shown on different scales

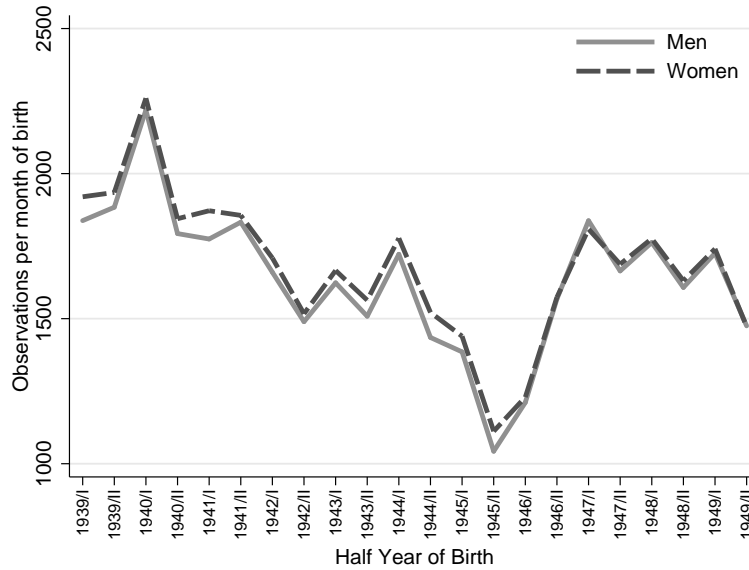


Figure 20: Number of observations per month of birth (by half-year of birth). Austrian censuses 1971, 1981, 1991, and 2001. Note: the first half-year is January 1 until the day of the census (May 12 or May 15), the second half-year is from the day of the census to December 31.

(men have generally higher education levels), but the shape of the cohort trend in educational attainment is virtually the same for men and women. The most notable feature of Figure 21, however, is the sharp drop in educational attainment for men and women born in the first part of 1946. This matches our prediction exactly. The size of the drop appears to be smaller in Austria than in Germany. For men it is about 2 percentage points from an initial level of 78%, and for women it is about 5 percentage points from an initial level of 60%. The top right panel of 21 shows the proportion of individuals with college degree. Here, the picture is less clear. We find some local minimum for women born in 1946/I, but for men, the minimum is a half year later and the proportion of college graduates remains on a fairly low level thereafter. Unemployment rates—shown in the bottom left panel—are particularly high among women born in the first half of 1946 but nothing special can be seen for men. Finally, the proportion of blue-collar workers, defined as having an ISCO -level of 6 to 9, is shown in the bottom right panel. Again, proportions for men and women are shown on different scales (a larger proportion of men works in blue-collar occupations). For both sexes, we find a spike in the percentage of blue-collar workers among those born in the first part of 1946, matching again our expectations.

As before, we back up our graphical analyses with linear probability regression analyses, separately for each outcome and sex. Similar to the specification we used with the German 1987 census data, we estimate a regression of education or labor force success on a “treatment dummy” (being born in 1946/I), a fourth-order polynomial trend, a season-of-birth dummy, plus a set of census year dummies. Results are shown in Table 11. We find a significant 2.4 percentage point drop in the proportion of men and a 5.7 percentage point drop in the proportion of women

attaining more than compulsory schooling. Further, among those born in 1946/I, the proportion of college graduates is between 0.5 and 0.7 percentage points lower than expected, but the dip is significant only for women. Unemployment rates are 2.7 percentage points higher than expected among women born in the first half of 1946, but they do not show a significant deviation from the long-term trend among men. Finally, the proportion of individuals in blue-collar jobs is raised significantly for both men (2.9 percentage points) and women (3.9 percentage points)

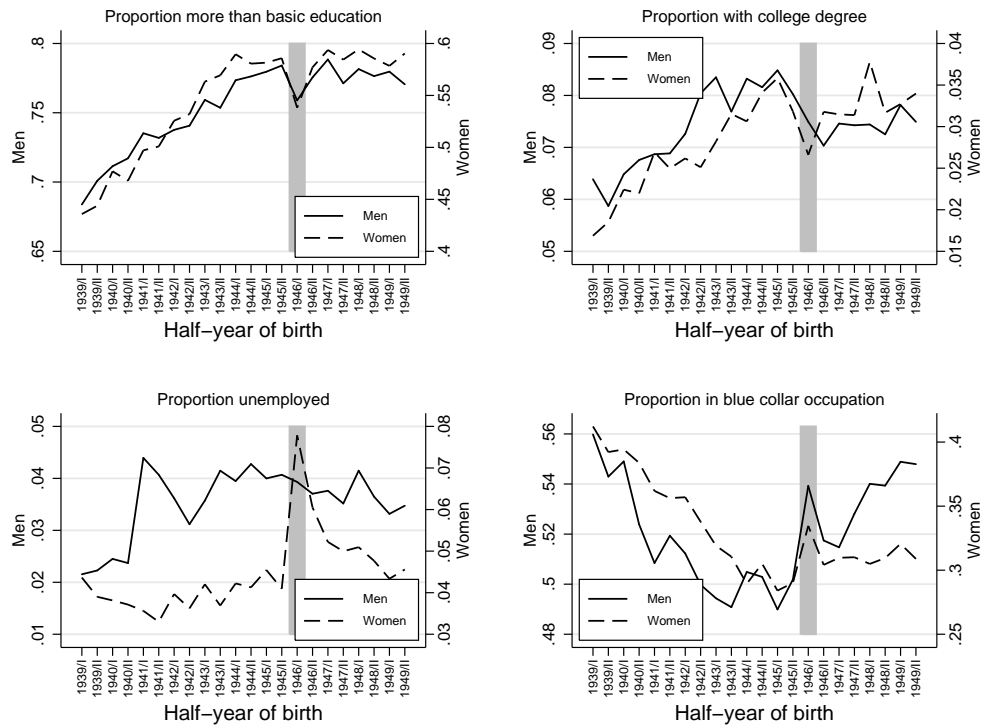


Figure 21: Educational attainment and labor market outcomes, Austrian censuses 1971, 1981, 1991, 2001 (by half-year of birth). Note: the first half-year is defined as January 1 to May 12/May 15 (the respective census reference date), the second half-year is May 13/May 16 to December 31.

We also used the Austrian data to study whether the post-war birth “penalty” varies along the rural-urban dimension. We distinguish three types of regions: rural (less than 50,000 inhabitants in 1939), urban (between 50,000 and 250,000 inhabitants), and Vienna (approximately 2 million inhabitants). Table 12 shows the estimation results of linear probability models of educational attainment—with general specifications analogous to those above. The reported coefficients show cumulative affects: “Born in 1946/I” shows the effect among those currently living in a rural area, “Born in 1946/I × Urban” shows the *additional* effect among those currently living in a city with more than 50,000 inhabitants, and “Born in 1946/I × Vienna|Urban” shows the effect among those currently living in Vienna compared to those living in an urban area. To obtain the total effect among those currently living in Vienna, one has to add up all three parameters. We find that all parameters are negative, that is, there is a the post-war birth penalty

Table 11: Effect of being born in 1946/I on educational attainment and labor market outcomes, percentage point estimates obtained from linear probability models. Data are from the Austrian censuses in 1971, 1981, 1991, and 2001

	Above basic education	College degree	Unemployed	Blue-collar
Men				
Mean dependent variable	0.752	0.073	0.035	0.522
Born in 1946/I	-0.024*** (0.006)	-0.005 (0.005)	-0.001 (0.003)	0.029*** (0.008)
Observations	213,941	157,916	186,680	185,926
Women				
Mean dependent variable	0.541	0.028	0.044	0.330
Born in 1946/I	-0.057*** (0.007)	-0.007*** (0.003)	0.027*** (0.005)	0.039*** (0.009)
Observations	219,018	163,138	119,782	118,060

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. Control variables: fourth-order polynomial trend, season of birth dummy (first vs. second half of the year), census year dummies.

and it increases with city size. We also find that the additional “Vienna” effect is quite strong (about 3.5 percentage points) and homogeneous across sexes. For men, the “Vienna” effect actually accounts for most of the post-war effect in the population. In the introduction, we have inferred from average birth weights in Vienna’s university hospital that intrauterine conditions should have been particularly bad in May to September 1945. Individuals in their first trimester during that time would have been born exactly during our “treatment” period.

Table 12: Effect of being born in 1946/I on attaining more than basic education, by sex and region of residence (linear probability models).

Variable	Full sample	Men	Women
Born in 1946/I	-0.0200*** (0.0064)	-0.0109 (0.0085)	-0.0293*** (0.0096)
Born in 1946/I × Urban	-0.0166 (0.0106)	-0.0036 (0.0137)	-0.0285* (0.0163)
Born in 1946/I × Vienna Urban	-0.0345*** (0.0133)	-0.0348** (0.0169)	-0.0350* (0.0201)
Observations	432,959	213,941	219,018

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05, *p<0.1. Coefficients are percentage point estimates and show cumulative effects. Control variables: urban and Vienna dummy, fourth-order polynomial cohort trend, season of birth dummy (first vs. second half of the year), census year dummies, sex dummy (only in full sample specification).

Overall, the results for Austria provide corroborating evidence for the malnutrition hypothesis, in particular because they rule out a competing explanation discussed above. Although some institutional changes of the education system have been similar as in German, the timing was different. Major school reforms had been decided nationally in 1962 (such as lengthening

compulsory schooling from 8 to 9 years) but often did not take effect until a few years later. It is hard to see how these reforms would have affected the schooling of the specific cohorts born in early 1946.

6 Summary and conclusion

The aim of our research was to study the long-term effect of adverse intrauterine and early childhood conditions, exploiting as “natural experiment” the consequences of World War II for the German population, and, in particular, the “food crisis” between late 1944 and 1948. In line with the current literature on the effect of environmental conditions in utero on later-life health and other outcomes (the fetal origins hypothesis), we hypothesized that cohorts in utero immediately after the war (and born in early 1946) and/or possibly cohorts in utero in the “Hungerwinter” 1946/47—the height of the food crisis as it is commonly described in the literature and as it lives on in collective memory—would have less favorable education and labor market outcomes than cohorts born earlier or later.

Using data from a 10% subsample of the German 1970 census, we found a remarkably sharp negative dent in outcomes among cohorts *conceived* at the end of the war (around May 1945) and born between November 1945 and May 1946 (but notably no specifically negative outcomes for the “German Hungerwinter 1946/47” cohorts). It is particularly striking that the long-term costs show up even in comparison to cohorts born immediately before and after that period, who have also undergone serious economic and psychological hardship in early childhood. To our knowledge, this is the first time these significant long-term costs in the form of lower educational achievement, higher unemployment, lower occupational status and lower labor market income 25 years later have been documented. This novel finding is clearly due to the advantage of using the West German 1970 census data, which contains month-of-birth information in combination with a sufficiently large sample size. This allowed us to identify even small effects or effects that are easily masked by other influences over the life course in smaller data sets. Without such large samples it is often impossible to find anything in the data, and without month-of-birth data, important short-term effects can be masked by annual averages.

In order to show that our novel finding is indeed a consequence of intrauterine malnutrition, we examined a number of empirical implications emanating from our theory. For instance, we analyzed how average educational outcomes by month-of-birth cohort are related to data on daily caloric intake across Germany. We found that quantitative malnutrition around the time of conception has the strongest correlation (compared to late pregnancy or infancy) with the level of completed education. We also showed that *qualitative* malnutrition especially in terms of animal protein has been particularly bad around the time the low-education cohorts were in

utero (particularly during early pregnancy).

Further, we studied competing explanations. For instance among the affected cohorts, there are children who were born to mothers who lived in the former eastern parts of Germany—and who suffered from flight and expulsion in utero when and after the Red Army marched towards Berlin. When comparing the educational attainment of those whose parents lived in the Eastern Provinces or Eastern European countries before the war (in 1939) to those whose parents did not, we find a drop among the latter group (not subject to flight and expulsion) and also that being exposed to flight-related stress in utero has inflicted some *additional* damage on unborn children. Moreover, there was no strong evidence that selective fertility (if children born immediately post war had less educated parents) or coincidental changes to the education system (unrelated to the events in 1945) might explain our findings.

In sum, we believe that quantitative and qualitative malnutrition in utero (partly combined with flight and expulsion) is the most plausible explanation for our finding. In order to further substantiate our claim, we extended our analysis in time and space. First, using data from the German 1987 census to look at education and economic outcomes another 17 years onwards, we were able to confirm our findings from the analysis of the 1970 data. Second, we used census data from Austria, which—as part of the Third Reich from 1938 to 1945—has been occupied by Allied forces after the war and also suffered from under- and malnutrition around the end of the Second World War. The Austrian data provide independent evidence of a specific effect of being born in the first part of 1946 on educational attainment and labor market outcomes.

Our paper suggests several directions for future research both into the fetal origins hypothesis and into the long-term consequences of the Second World War for German war and post-war children. In particular it has identified cohorts of Germans which are worth being studied further: we know now among whom to look for damages to long-term outcomes that may have had their origins in the womb. That we found similar results in the Austrian censuses makes us confident that we found something real. Still, it will be important to replicate our analysis in this paper with other large scale data sets. Further, it would be useful to look at non-economic long-term effects. For instance, the epidemiological literature is naturally concerned with health outcomes. Following the example of the “Dutch Famine” studies, it would be interesting to collect data on health outcomes of birth cohorts born a few months before November 1945 to a few months after May 1946, possibly on several subsamples exploiting the regional variation in living conditions in early to mid 1945. Overall, we believe that our analysis has the potential to spark an exciting line of future inter-disciplinary research.

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