Collateral damage:
The German food crisis, educational attainment and labor market outcomes of German post-war cohorts

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Revised version

Abstract

Using the German 1970 census to study educational and labor market outcomes of cohorts born during the German food crisis after World War II, I document that those born between November 1945 and May 1946 have significantly lower educational attainment and occupational status than cohorts born shortly before or after. Several alternative explanations for this finding are tested. Most likely, a short spell of severe undernutrition around the end of the war has impaired intrauterine conditions in early pregnancies and resulted in long-term detriments among the affected cohorts. This conjecture is corroborated by evidence from Austria.

JEL classification: J24, N34

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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 et al., 2010; Neelsen and Stratmann, 2011; Scholte et al., 2012), man-made disasters (Almond et al., 2009), natural disasters (Pörtner, 2010), influenza pandemics (Almond, 2006), drugs legislation (Nilsson, 2008), pollution (Sanders, 2012), or variations in weather conditions (Maccini and Yang, 2009). 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.[1] Following the fetal origins literature, I 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, I try to rule out alternative explanations.

My 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 confirm the findings from the Netherlands. As I will show, the food crisis in Germany (and Austria) in 1945 may have been – at least in some parts of the country – of similar proportions as in the Netherlands. Second, even for the Dutch hunger winter there is little evidence in terms of economically relevant outcomes. Recently, Scholte et al. (2012) were able to show that intrauterine malnutrition in the first trimester of pregnancy had significant effects on the likelihood of being employed at the age of 60. My study finds substantial

[1] A broader analysis of long-term effects of World War II across a range of European countries can be found in Kesternich et al. (2012).

effects of the food crisis on education, occupational status (as important markers of economic success in life), and also labor market income (at younger ages) of cohorts conceived during the height of the crisis. My analysis benefits from the fact that the data partly allow me to isolate effects of malnutrition in early versus late pregnancy. I 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 World War II and the food crisis

From late 1944 to 1948, Germany suffered a severe food crisis. The three main reasons 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., Czechoslovakia) 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).

Panel A of Figure 1 shows data on average daily caloric intake in a Western part of Germany between 1939 and 1949. The data are based on monthly food rations for adults. These are nominal allowances, and there are a number of reasons why actual caloric intake may have 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, it need not be 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 reasonably high during most of the Second World War. With the exception of a minor trough in 1942 (due to the shortage of potatoes), the average allocated number of calories was close to healthy levels.

The situation begins to deteriorate visibly in early 1945. Between the 72th 4-week allocation period (which began on February 2nd, 1945) and the 75th allocation period (which began on April 30th, 1945), the average daily number of calories dropped from 1,603 to 678. The latter period also marks the end of the Second World War in Europe and goes along with the lowest reported number of calories across the entire period. Afterwards, average daily calories hover between 1,000 and 1,500 until the middle of 1948 and then increase to somewhat less than 2,000 calories after the currency reform. Clearly, the food crisis was most severe during the immediate post-war months. In fact, contemporary researchers on undernutrition in Germany stated that the "difficulties of

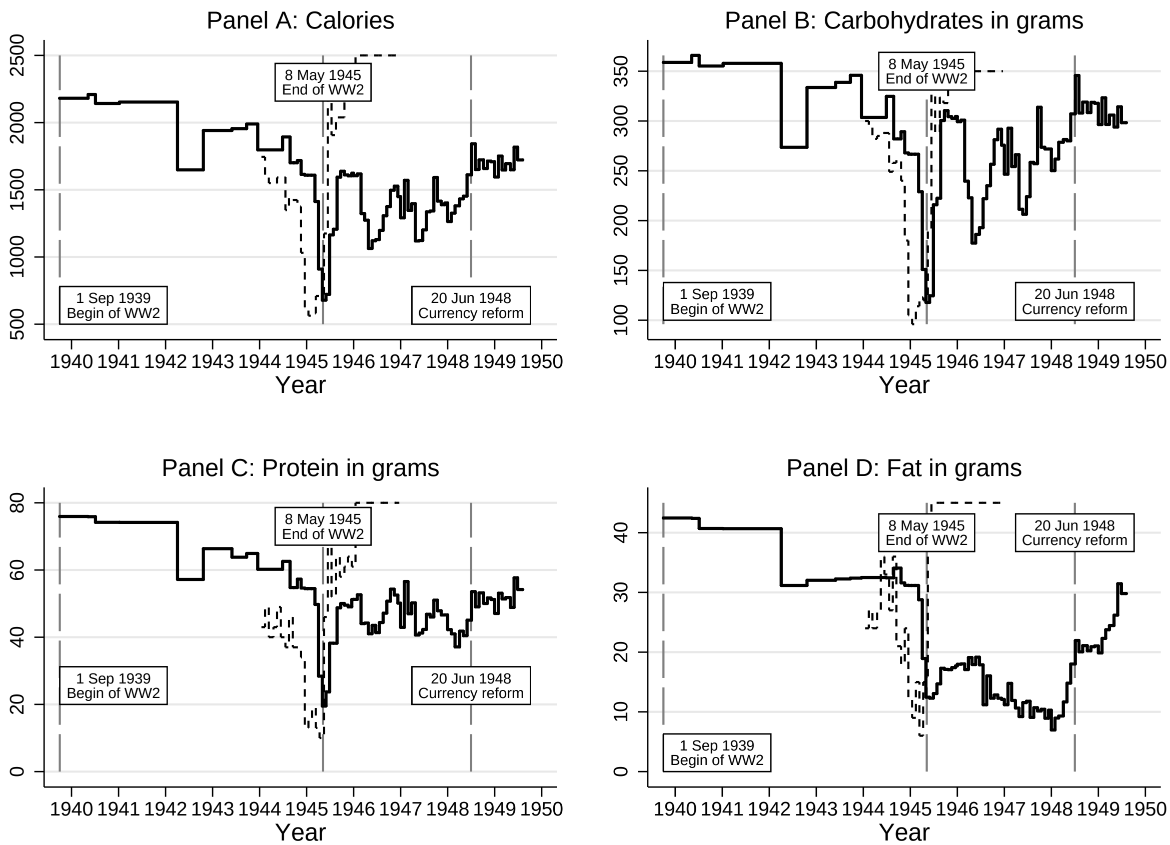

Figure 1: Average daily allowances according to food ration cards. Data are for Wuppertal (September 1939 to August 1944, allocation periods 1 to 65), Düsseldorf and Wuppertal (September 1944 to May 1947, allocation periods 66 to 101), Düsseldorf (June 1947 to November 1947, allocation periods 102 to 107) and Northrhine-Westphalia (December 1947 to August 1949, allocation periods 108 to 129). Sources: Sons (1983, Table 11), Schön (1947). The dashed lines show average daily allowances in the Dutch famine area (Stein et al., 1975)

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).

Figure 1, Panels B, C, and D, show evidence on *qualitative* malnutrition with regard to protein, fat, and carbohydrates. Again, the graphs show average daily allowances, and they clearly illustrate that the months before and after the end of the war in 1945 were the worst periods in terms of underprovision of protein and carbohydrates. In contrast, the provision of fat remained low after 1945 or got even worse.

To put the extent of the German food crisis in perspective, the dashed lines in Figure 1 indicate average available calories, carbohydrates, protein and fat in the "Dutch famine area", i.e. the Western part of the Netherlands that suffered from much studied famine during the German blockade between November 1944 and May 1946. The comparison shows that at the height of the food crisis, availability of food in Germany was quite comparable to the Dutch famine area. But there are two differences. First, the Dutch famine lasted about three months longer than the most severe part of the German food crisis around the end of World War II. Second, there was no notable shortage of food in the Netherlands after the end of the war, while the German food crisis lasted until 1948.

Complementary evidence specifically on intrauterine malnutrition during the food crisis 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 et al., 2005; Black et al., 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 2 shows monthly averages of birth weight for Vienna (Austria) and Wuppertal (an industrial city of approx. 300,000 inhabitants). For comparison, I again show data for the Dutch famine area (Stein et al., 1975). The 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 (the general post-war situation in Austria was very similar to the situation in Germany. This is discussed in more depth below). 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. 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. 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. Thus the food crisis might have been even more severe at least in some parts of Germany and Austria than in the Netherlands.

1.2 Intrauterine malnutrition and economic outcomes

Studying the effect or early life conditions on later-life economic outcomes is data-demanding. 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 or aggravate the effects of any health insults in early life. To my 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, I show average educational attainment and labor market outcomes (occupational status, income) as measured in 1970. Following the recent literature on the fetal origins hypothesis (Barker, 1995), and based on the background data shown in Figures 1 and 2, I expect that cohorts

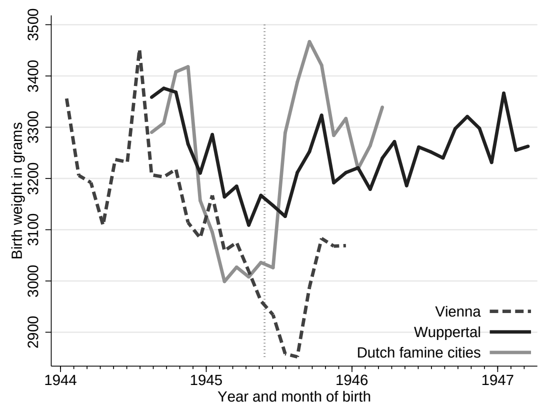

Figure 2: Average birth weight in grams, by month of birth, Wuppertal, Vienna and the Netherlands. Sources: Hußlein (1947); Stein et al. (1975), author's data collection.

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, I 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 (and hence conceived around May 1945). To the best of my knowledge, this is the first time this finding is documented.

There are considerable challenges in separating effects in utero from a broad range of other early childhood conditions (Almond and Currie, 2011).[2] 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 the finding of only a few month-of-birth cohorts showing worse educational and labor market outcomes than others suggests that I actually capture some *additional* effect specific to those cohorts. To substantiate this claim, I exploit broad regional variation in living conditions to show that individuals born in regions that were presumably affected more also suffer more long-term damage. Although I 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, I can nevertheless construct comparison groups based on some ad hoc reasoning about regional differences in the severity of the food crisis to show that the data are consistent with the notion of negative effects of early-life undernutrition.

Of particular importance to the findings in the present paper is the timing of maternal malnutrition. In the third trimester of pregnancy, it is associated with low birth weight (<2,500 grams)

[2] In a study similar to mine, 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.

and prematurity (less than 37 weeks gestation), both of which have often been shown to be associated with reduced intellectual capacity and other impairments (Behrman and Rosenzweig, 2004; Almond et al., 2005; Black et al., 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 et al., 1999) but not on intelligence or educational success (see Stein et al. (1975), although de Rooij et al. (2010) recently provide some limited evidence for an effect on cognitive decline at older ages). In contrast, I find evidence for education effects that very likely originate in first trimester malnutrition. Notably, recent experimental evidence on baboons shows that even moderate maternal nutrient restriction during the first half of pregnancy can cause severe brain development problems *without fetal growth being impaired* (Antonow-Schlorke et al., 2011).

While I use primarily German census data to test my hypotheses, I also 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 very similar patterns 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 discussed below (e.g. later changes in the education system) and thus provides further evidence in favor of the fetal origins hypothesis.

1.3 Alternative explanations

Due to the novelty of the result, the reasons for the collateral damage of World War II on those born in Germany shortly after the war are not researched yet. An important aim of this paper is to put to test alternative explanations of the post-war dip in education and labor market success. Possible explanations are detrimental effects of flight and expulsion from the Eastern Provinces and Eastern European countries, selective infant mortality (probably favoring the better educated), selective fertility and coincidental changes to the education system. I briefly discuss each in turn.

Flight and Expulsion. When the Red Army started their major offensive on the German border in January 1945, mass flight from the Eastern Provinces set in, often under extremely harsh conditions that also affected children in utero and newborns (Jochims and Doerks, 1947). Intrauterine stress due to flight and expulsion from the East peaked during early 1945 and may have added to the detrimental effect of the food crisis. As the 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, I will take up this issue in my empirical analysis.[3]

[3] Moreover, during or following the war, an estimated 2 million German women have been raped, mostly by Red

Selective mortality might be a worry because 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 locally at 20% to 30% in March, April, and May 1945 – four times the pre-war average (Droese and Rominger, 1949; Plotz, 1950; Weber, 1949). Those surviving are 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. Additionally, 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 towards zero. Unfortunately, I have no data to test this hypothesis directly. Another concern is selective mortality among cohorts born just before or after the cohorts that were most affected by the food crisis. As shown below, the most affected cohorts are those *conceived* while infant mortality peaked. If neighboring cohorts are positively selected, the estimated negative effect of the food crisis might be exaggerated. I will address this issue below.

The effect of *selective fertility* could go both ways. On the one hand, it could lead to elevated average education levels if better educated and thus better off mothers were more likely to conceive – planned or unplanned – around the time of the food crisis. Alternatively, education levels among "available" men might have been higher than average because they were working in important civil occupations. On the other hand, the rank and file were released from US and British POW camps already a few weeks after the war. Priorities were given to those older than 50, the sick, and those with anti-Nazi attitudes. Below, Figure 8 illustrates how the number of births increased dramatically nine months after the end of the war. To the extent that those men who were released early have below average education, the average child born 9 months after the end of the war would be of lower average ability. My main data source does not contain information on parental education, but I will address the question whether parents of those born during the food crisis were educated above or below average using complementary data from the German General Social Survey (ALLBUS) and the German SOEP. A related issue is that, after World War II, out-of-wedlock fertility increased to unprecedented heights (Bethmann and Kvasnicka, forthcoming). If children born out-of-wedlock have on average worse educational outcomes, this could explain worse outcomes among those cohort. However, to my knowledge there are no data with large enough sample size to test this hypothesis.

Yet another explanation for the post-war education dip might be later *changes to the school*

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.

system that have worked to the disadvantage of the cohorts coincidentally born at the end of World War II. 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 compulsory schooling and the education expansion in terms of widening access to academic track schools.[4] Abolition of school fees and the 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 the early 1950s 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. I appreciate that this argument leaves some room for speculation about other school reforms that I have not taken into consideration. A better approach to refute the "school systems reform" explanation is to look at data from Austria, which has suffered the same adverse living conditions after the war but has otherwise evolved independently from Germany.

The remainder of the paper is structured as follows: Section 2 briefly introduces the main data source, the German 1970 census, and shows the main results, the cohort differences in education and labor market outcomes. I also add further evidence from the German 1987 census. In Section 3, I show a number of detailed analyses in order to support the plausibility of my hypothesis. Section 4 expands the analysis to Austria to further corroborate my results. Section 5 presents a calculation of the aggregate loss in life-time earnings due to the food crisis, and the last section concludes the paper.

2 Cohort differences in educational attainment and labor market outcomes

First, I show educational attainment, occupational status, and labor market income by month-of-birth cohort. Each outcome is analyzed separately, although they are not independent. Education is probably the most important outcome, because occupational status partly depends on educational

[4]These reforms have been used to identify causal effects of education on wages (Pischke and von Wachter, 2008) or health (Reinhold and Jürges, 2010; Kemptner et al., 2011; Jürges et al., 2011). Details are given in those papers.

attainment and income partly depends on education as well as occupation.

2.1 Data

The main data source in this section is a 10%-subsample of the West German 1970 census (GESIS-file).[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; within the current borders of East Germany; 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. I also know whether someone has migrated from East to West Germany after 1945. I restrict the sample to cohorts of German citizens (thus excluding foreigners and guest workers) born between January 1939 and December 1949. My working sample contains about 450,000 men and 420,000 women. On average, there are about 6,000 observations per month of birth. The number of observations (and by implication births) fluctuates quite a bit. The smallest number of observations (around 4,000 per month) can be found among those born between April 1945 and February 1946. In terms of the time of conception, 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. In January/February 1946, i.e. exactly nine months after the German capitulation, the number of observations rises steeply (also see Figure 8 below). This increase is related to the great number of men returning home from the war.

2.2 Educational attainment

I begin by a brief description of the German school system as it was relevant for the analysis cohorts. 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

[5]More precisely, the sample consists of all individuals who lived in a 10% random sample of the census tracts in 1970. A census tract consisted of a cluster of 80 to 100 households. Those individuals were given supplementary questions, e.g. on refugee status. The data are made accessible by GESIS, whose hospitality while analyzing the data is gratefully acknowledged. Further details (in German language only) can be found at http://www.gesis.org/en/services/data-analysis/official-microdata/vz-1970/dok/.

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). 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.

I use as educational outcome measure the proportion of each birth month cohort with intermediate or high leaving certificates (in short: more than basic or compulsory education). Figure 3, 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, I 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 (Jürges et al., 2011; Riphahn, 2012). This 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, I 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. I check for statistical significance of the dip by computing the prediction error *for each month of birth* using the following linear regression model (running the regression 132 times):

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

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). 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 relative to the long-term (fifth-order-polynomial) trend and general season of birth fluc-

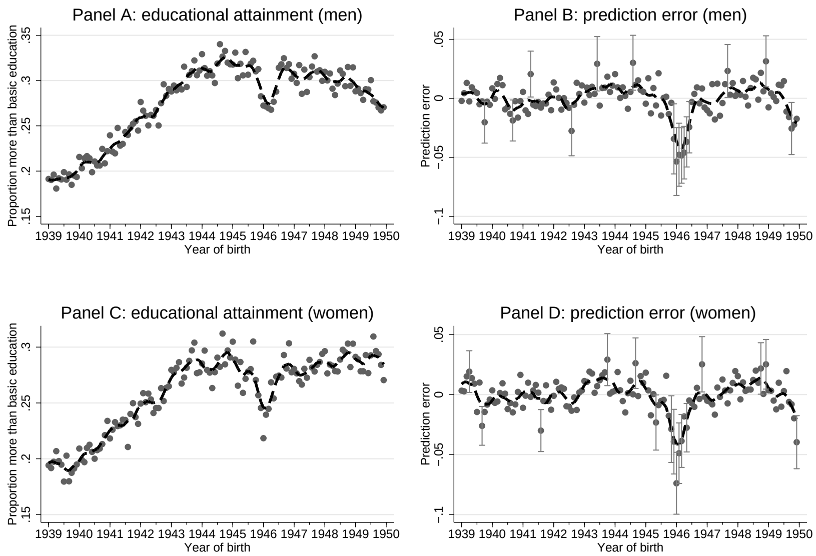

Figure 3: Proportion with more than basic schooling, by month of birth (Panels A and C), prediction errors with 99% confidence intervals (Panels B and D). The dashed lines show six-month moving averages.

tuations. I show β and 99%-confidence intervals based on heteroskedasticity-consistent standard errors in Figure 3, Panels B and D. For sake of clarity I 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.

2.3 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 the sample were not working at the time of the census. Of these, the majority were in fact still in education, i.e. visiting university – which reflects educational attainment rather than labor market failure. In contrast, of the 45.5% percent of women in the data currently not working, the vast majority were homemakers, and it is unclear whether this reflects success or failure in the labor market. Obviously, one observes early career occupational status. The oldest individuals in the data are 31 years old, the youngest are 20 years old. Still, I argue that early career occupational status is an important outcome. 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, one can distinguish between six types of occupation: blue-collar workers, white-collar workers, civil servants, the self-employed, workers in family business and conscripts. In the following, I will only distinguish blue collar workers from all others (except conscripts).[6] 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.

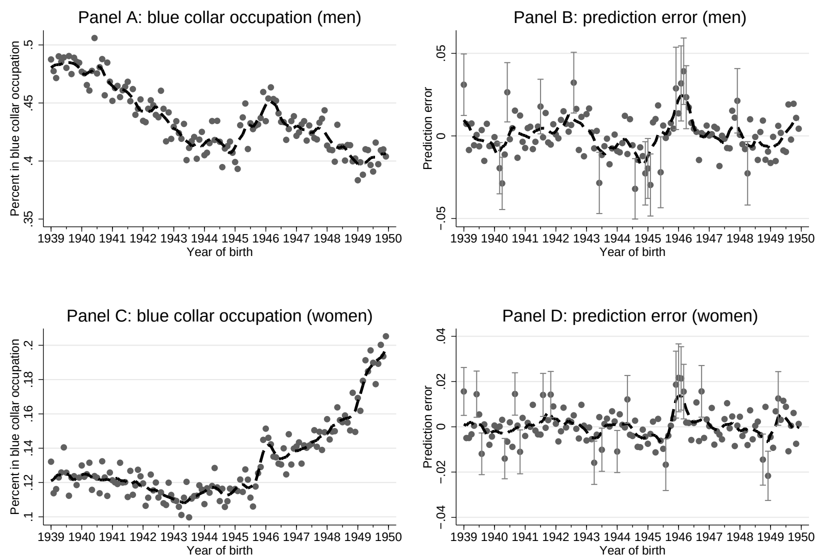

Figure 4: Proportion of men and women in blue collar occupation, by month of birth (Panels A and C), prediction errors with 95% confidence intervals (Panels B and D). The dashed lines show six-month moving averages.

Trends in occupational status by month-of-birth cohort and sex are shown in Figure 4, Panels A and C. Among men, I 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 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 is fairly flat up to cohorts born 1946. After a hike in early 1946, 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, I compute prediction errors and their confidence intervals. For men, Figure 4, Panel B shows significant

[6]Obviously this choice may affect my results. When I restrict the 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 the year of observation.

deviations from the long-term trend in four consecutive birth month cohorts in Winter 1945/1946, but I find 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 entered the labor market around 1970 (this is a pure age effect), which might cause problems identifying the underlying trend for these particular cohorts. For women, I find a sharp increase in the proportion working in blue-collar occupations for the cohorts born in Winter 1945/46 (see Figure 4, Panel D), with statistically significant prediction errors for four consecutive month-of-birth cohorts.

2.4 Income

The third outcome 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.

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.[7] I divided the distribution at the sex-specific median to maximize the variance of the binary dependent variable and computed the proportion of men with more than 800 DM income and women with more than 500 DM income as my outcome variables. Panels A and C of Figure 5 show those proportions for cohorts born between 1939 and 1949. Among men, the proportion with high income clearly falls with year of birth (rises with age), apparently at an increasing rate. No strong deviations from the trend can be seen for the cohorts born immediately after the Second World War; still, I find two significant prediction errors for those born in January and March 1946 (see Panel B).

Among women, the proportion of cohort members with high income slightly increases up to age 24 (cohort 1946) and declines thereafter. Overall, the 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. However, this is not the main concern of this study. Rather, it is the clearly visible deviation from the long-term trend

[7] One 1970 DM corresponds to about 2 Euro in current prices.

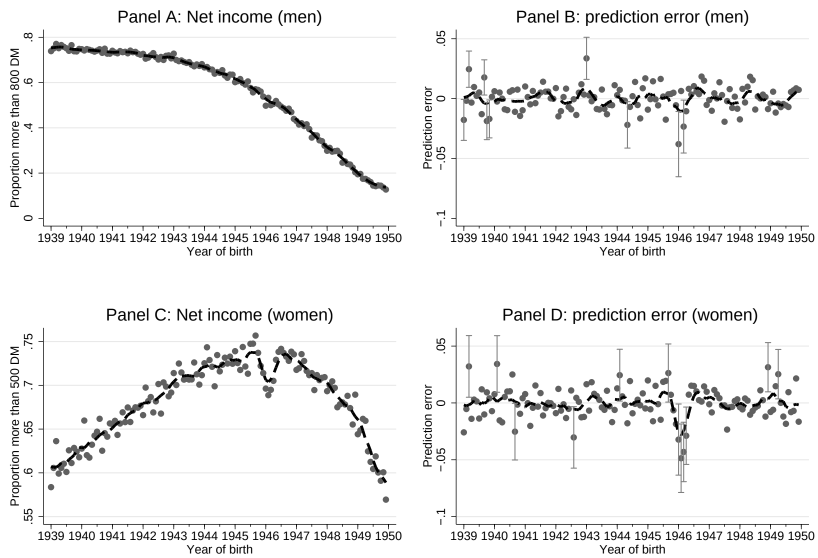

Figure 5: Proportion of individuals with high income, by month of birth (Panels A and C) and prediction errors with 95% confidence intervals (Panels B and D). The dashed lines show six-month moving averages.

for cohorts born in the Winter 1945/46. For cohorts born between January and April 1946, one finds significant negative prediction errors (see Panel D). Some of these errors are sizable (up to five percentage points).

2.5 Further evidence: the 1987 census

I now repeat my 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 German IPUMS data do not contain month-of-birth information, but by combining age at time of the census reference date (May 25, 1987) and year of birth, it is possible to identify persons born between Jan 1st and the reference date – which allows me to estimate outcomes on roughly a half-year basis.[8] In 1987, all relevant cohorts have completed full-time education and military service (the youngest cohorts being 37 years old), which yields a more comprehensive picture of educational attainment and occupational status. The unemployment rate in West Germany in 1987 was at 8.9%, hence it becomes interesting to study effects on unemployment. Income is not available, however. The overall number of observations in the working sample is 522,000.

Based on the analyses in the preceding sections, I expect that the cohorts born between Jan-

[8]The IPUMS also contain data from the GDR censuses in 1971 and 1981. However, the reference date in those censuses were Jan 1st and December 31st, respectively.

uary and May 1946 (in short: 1946/I) should have significantly lower educational attainment and worse labor market outcomes than others. I 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. In order to test whether the 1946/I cohorts differ from others, I 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 I 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 the coefficient of interest are shown in Table 1. For men, all coefficients are significantly different from zero. Men who are born 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 born January to May 1946 are 3.8 percentage points less likely to have more than compulsory schooling and 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. Lower educational attainment is associated with birth in early 1946. This translates into worse labor market outcomes, which are now found particularly among men.

Table 1: 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***	-0.027***	0.009***	0.030***
	(0.007)	(0.005)	(0.003)	(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***	-0.015***	0.003	0.009
	(0.007)	(0.004)	(0.004)	(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).

3 Explanations

The preceding section has documented that birth cohorts born November 1945 to May 1946 have lower educational attainment, lower occupational status at ages 25 and 42, lower income at age

25 (women only) and higher unemployment rates at the age of 42. In this section, I explore four explanations for the post-war dip in educational attainment and labor market outcomes: malnutrition, flight and expulsion, selective mortality, and selective fertility. Institutional changes to the education system have already been discussed and dismissed in Section 1.3. Since my findings on education are the most systematic and robust, I concentrate on the education dip.

3.1 Malnutrition

As shown in the introduction, the German food crisis lasted from 1944 to 1948. Thus children born during that period have suffered hunger in early childhood over a prolonged period of time. Quite obviously, this type of chronic undernutrition cannot explain the short-term effects (i.e. affecting only few cohorts) observed in the data. Rather, bad conditions during critical intrauterine periods may have *independently* and *additionally* affected later-life outcomes. The medical literature on such effects, drawing e.g. on the Dutch famine cohorts, suggests 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). The link with cognitive outcomes is less clear. Early analyses of the effect of the Dutch famine on intelligence and cognitive functioning have shown no differences at age 20 between famine cohorts and those born before or after (Stein et al., 1972), but recently, de Rooij et al. (2010) found impaired cognitive performance (in at least one dimension) at ages 56 to 59 among cohorts exposed to the famine in their *first* trimester.

3.1.1 Time-series variation in malnutrition

To analyze at which point during pregnancy and early childhood malnutrition is most strongly related with later-life educational outcomes, I bring together the time-series variation in calories and nutrients (Figure 1) and the variation in educational attainment by month of birth (Figure 3). Although the data reflect food rations for normal adults and do not include supplements for pregnant women, I believe that the data are useful to understand the development of malnutrition over time. Until July 1945, supplements for pregnant women (worth roughly 1,000 kcal per day) were available only from the seventh month of pregnancy onward. Between July 1945 and August 1946, pregnant women in the fifth month were eligible, and afterwards eligibility began in the fourth month of pregnancy. Further, although it is possible that family members allowed 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 6 shows partial cross-correlations between the calories and the educational attainment time-series (controlling for a fourth-order polynomial trend in time and calendar month dummies).

I let the time lag τ run from -15 to +15 and estimate 31 different partial correlations (see 6). Values below -9 indicate pre-conception periods, values between -9 and 0 indicate periods in utero, and positive values indicate early childhood periods. The dashed lines indicate 95% confidence intervals around zero calculated by using Fisher's z transformation, i.e. values outside this interval are significantly different from zero. The pattern shown in Figure 6 suggests that caloric malnutrition even before conception may be highly relevant for later-life outcomes. The partial correlation at lags -10 and -11 are of similar magnitude as those at lags minus -9 and -8. This finding is consistent with biological evidence in a qualitative sense, but it is unclear whether the pre-conception environment can have a similar *sized* effect as the intrauterine environment.[9]. The analysis suggests, however, that it might be important to take into account pre-conception environmental conditions.

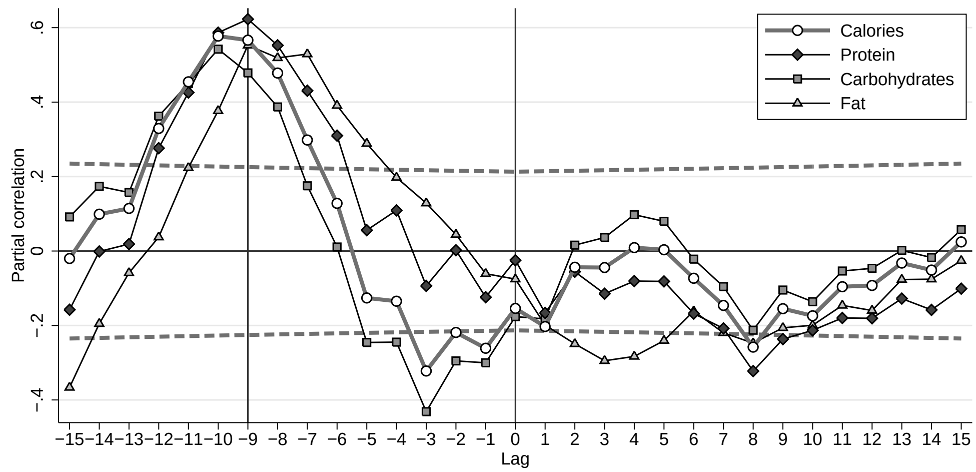

Figure 6: Partial correlation between daily caloric intake, protein, carbohydrates, and fat of mother and/or child in month $c + \tau$ and the probability of attaining more than basic education among cohorts born in month τ. $\tau = 0$ denotes the month of birth, $\tau = -9$ indicates the month of conception. Dashed lines indicate 95% confidence intervals around zero calculated by using Fisher's z transformation. Data on educational attainment based on the 1970 census.

Figure 6 also adds evidence on partial cross-correlations between the protein, fat, and carbohydrate time series on the one hand and educational attainment on the other hand. The overall structure of cross-correlations is very similar to the one for calories. Cross-correlations peak around nine months before birth, with some minor shifts. Whereas the availability of carbohydrates has the strongest correlation with educational outcomes just before conception, the availability of fat correlates strongest with educational outcomes if measured in the first three months of pregnancy.

[9]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).

The correlation of protein availability with educational attainment peaks at 0.62 nine months before birth. This also represents the largest correlation of all nutrition indicators. To sum up, the available indicators of intrauterine and pre-pregnancy malnutrition are significantly related to educational attainment. Because of their high correlation with each other, it is hard to judge which of the indicators overall calories, protein, carbohydrates and fat is the most relevant. Further, it should be noted that the large correlations around $\tau = -9$ in Figure 6 are entirely driven by the immediate-post war period.

3.1.2 Regional variation in malnutrition

A strategy to test the malnutrition explanation is to split the sample into groups that were differentially affected by the food crisis. In fact, living conditions varied greatly between regions and between the cities and the countryside. 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. This is clearly problematic. First, many people fled from the bigger cities, which were bombarded and partly destroyed during the war, and came back in the months after the war. Second, there was substantial rural-urban migration during the German economic upswing ("Wirtschaftswunder") between 1950 and 1970.[10] I am aware that any rural-urban difference in the estimated malnutrition effect will suffer from attenuation bias due to rural-urban migration. If one is able to demonstrate such urban-rural differences in the data, one can assume that the true differences were indeed larger.[11]

I restrict the sample to individuals born October 1944 to February 1947 and split them into those living in rural areas (city size smaller than 50,000 inhabitants) and those living urban areas (cities with 50,000 inhabitants or more), and estimate the following difference-in-difference model on individual data:

$$y_{imzs} = \alpha_m + \xi_z + \xi_z \times m + \sigma_s + \beta_1 \text{urban}_i \, I(B_i) + \beta_2 \text{urban}_i \, I(C_i) + \varepsilon_{imzs} \qquad (2)$$

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.

[10] For instance, the population of Munich, Germany's third largest city, fell from some 820,000 in 1939 to 480,000 in May 1945. In the October 1946 census, 751,967 inhabitants were counted. In 1957, the population was 1 million (Statistical Office of Munich, 1958).

[11] In fact, a very simple back-of-the-envelope calculation, using actual rural-to-urban migration rates and assuming that the true effect of the food crisis was twice as large in the cities than in the countryside, would place the ratio of the true difference to the difference reported below between 1.3 in the case of random migration and 2.3 in the case of education-selective migration. Details of these computations are available on request.

I estimate equation (2) with city-size specific linear deviations from the general non-parametrically specified cohort trend (α_m) in educational attainment. The 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 cohorts born March to August 1945 who endured the food crisis during late pregnancy) and $I(C)$ (cohorts born November 1945 to April 1946 who endured the food crisis in early pregnancy).

Table 2, Column (1), shows the regression results. In the full sample, I find a 1.3 percentage points difference in the proportion of individuals with more than basic schooling between "treated" (urban) and "control" (rural) areas for cohorts born March-August 1945 and a 2.4 percentage points difference for cohorts conceived around that time and born November 1945 to April 1946. Since nutritional status was worse in urban areas, these results are in line with the idea that both undernutrition at the time of conception and undernutrition at the time of birth harmed the unborn child or infant, but that the effect at conception was more detrimental.

Now I divide the sample by broader regions that might have been differentially affected by the food crisis. For example, average caloric intake was different across the four occupation zones. Over the entire period from mid 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 Allieds a region was occupied (U.S., 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, U.S. 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 also 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, I have split the sample into two regions: (1) federal states that are (mainly) to the west of the River Rhine (Saarland and Rhineland-Palatinate)[12] and (2) mainly

[12] About 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 I exclude this state from my analysis anyway.

rural states east of the Rhine (Bavaria, Baden-Wuerttemberg, Hesse, Lower Saxony, Schleswig-Holstein). Further, to make those states comparable to Saarland and Rhineland-Palatinate, I also drop individuals living in cities with more than 200,000 inhabitants.

Table 2, Column (2) contains difference-in-difference regression results obtained from a specification that is analogous to equation 2, except that I specify state specific trends rather than city-size specific trends. Significantly fewer people attended more than basic school if they were born November 1945 to April 1946—and hence had endured the end of war during early pregnancy—in states east compared to west of the River Rhine. The difference is 1.8 percentage points. In contrast, there is hardly any difference across the Rhine among those who were *born* around the end of the war.

Table 2: Regional differences in educational attainment differences among cohort born or conceived around the end of the war. Estimates reflect percentage point differences in the likelihood of attaining better than compulsory education.

VARIABLES	(1) City size	(2) East/West of Rhine	(3) SBZ/West Germany
Urban × born Mar 45-Aug 45	-0.013*		
	(0.007)		
Urban × born Nov 45-Apr 46	-0.024**		
	(0.007)		
East of Rhine × born Mar 45-Aug 45		-0.002	
		(0.008)	
East of Rhine × born Nov 45-Apr 46		-0.018**	
		(0.008)	
SBZ × born Mar 45-Aug 45			0.013
			(0.011)
SBZ × born Nov 45-Apr 46			-0.030**
			(0.013)
Sex dummy	yes	yes	yes
Cohort dummies	yes	yes	yes
City size dummies	yes	yes	yes
State dummies	yes	yes	yes
City-size specific trend	yes	no	no
State specific trend	no	yes	yes

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

Another interesting region is the former Soviet occupation zone (SBZ). There are two reasons why food for civilians might have been scarcer than in other parts of Germany. First, it was among the last German regions to be occupied. Second, given the previous atrocities of the German army in the USSR, the Soviet military was arguably less concerned with feeding German civilians than U.S. or even British military.[13] For these two reasons, I 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. Again, this is analyzed by differences-in-differences regression (Table 2, Column 3). Among those born November 1945 to April 1946, I find again significantly lower educational attainment (by about 3 percentage points) in the region that I suspect to have been hit harder by the food crisis.

3.2 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 expulsed after the war. One explanation for the post-war education dip is that the affected cohorts were born to mothers who fled or were expulsed 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 (Jochims and Doerks, 1947).

The census contains information where the family of the individuals lived on September 1st, 1939, i.e. when the Second World War began. If adverse effects of flight and expulsion rather than widespread malnutrition account for the disadvantage of immediate post-war cohorts, one expects that only those whose parents lived in the former Eastern Provinces of Germany are affected and not those who always lived within the current (1990) borders of Germany. Figure 7 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. The first group are those whose parents lived within the 1990 borders (i.e. former East and West Germany) and who are thus *not* refugees. Clearly, members of this group have suffered the by now familiar post-war education dip. Although not shown in the graph, the dip is statistically significant. Thus flight and expulsion are not the only and not even the main reason for our findings.

The second 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 third group are those whose parents lived in Sudetenland, a part of Czechoslovakia. These individuals were ethnic Germans who were expulsed 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).

[13] Roughly 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.

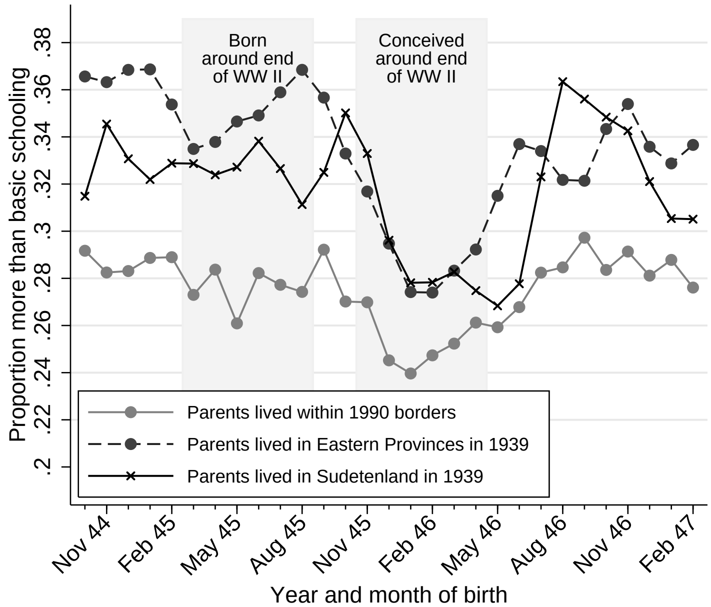

Figure 7: Educational attainment, by month of birth, and parental place of residence in 1939.

Figure 7 shows that a larger share of the individuals in the two refugee 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 importantly, consistent with the idea that flight or expulsion are harmful to the fetus, the educational attainment dip is much 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 expulsed after the end of the war.

Regression analyses are shown in Table 3, which contains results of separate difference-in-difference regressions, one for those from the Eastern Provinces and one for those from Sudetenland. Note that I deliberately shifted the definition of the treatment periods. For the former group I shifted the "treatment period" to January-May 1945 and for the latter group to May-September 1945. The purpose of this shift is to capture *additional* effects of hardship during flight and expulsion on educational attainment. This implies assuming that refugee groups were subject to the *general* food crisis at the same time and to the same extent as non-refugees, with the effect of the general food crisis being captured by month-of-birth cohort dummies. The results in Table 3 are quite homogeneous in the sense that men appear to be vulnerable to the additional hardship of flight and expulsion, while no additional effects can be found for women.[14]

Table 3: Effect of being born or conceived during periods of flight or expulsion

VARIABLES	(1) All	(2) Men	(3) Women
Eastern Provinces (treatment periods shifted backwards by two months)			
Born Jan 45-May 45	-0.007	-0.013	-0.001
	(0.013)	(0.018)	(0.018)
Born Oct 45-Feb 46	-0.008	-0.023	0.010
	(0.018)	(0.025)	(0.026)
Sudetenland (treatment periods shifted forward by two months)			
Born May 45-Sep 45	-0.024*	-0.054***	0.008
	(0.013)	(0.018)	(0.019)
Born Feb 46-Jun 46	-0.031	-0.059**	0.002
	(0.020)	(0.026)	(0.029)

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Control variables: sex, cohort dummies, region of residence in 1939, region-specific linear cohort trend.

3.3 Selective fertility

Panel A of Figure 8 shows the number of observations in the 1970 Census of the cohorts born October 1944 to February 1947 (and their average educational attainment). The shaded areas correspond to cohorts born or conceived around the end to World War II. Both cohorts are characterized by a dramatically decreasing number of observations/births (20% and 30%, respectively), whereas the number of observations nearly also doubles within the latter cohort (conceived immediately after the end of war). Apparently, most of the variation in the number of observations is due to directly 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 at the end of the war had a major impact on fertility, for instance, one would *not* observe the steep increase in the number of observations immediately after the war. Still, selective fertility remains a concern, because one can legitimately ask who actually had children in such chaotic and dire circumstances.

In particular, one might be worried about selectivity with respect to social status. 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

[14] Sex differences in vulnerability to intrauterine insults are well documented in the medical literature. For instance, Hansen et al. (1999) document decreased sex-ratios at birth in response to mothers' exposure to severe life events especially around the time of conception. Theoretical support comes from the so-called Trivers-Willard-Hypothesis, which stipulates that evolutionary pressures will lead to more daughters when living conditions are poor (Trivers and Willard, 1973).

nine months after would be of lower average ability. This could happen if, for instance, the better educated officers were kept longer in POW camps, while the rank and file were released soon after the war. However, the steep increase in the number of observations born May to August 1946 (when lower ranks returned home) shown in Figure 8, Panel A, is matched by a slight increase and *not a decline* in educational attainment. Rather, the nadir in educational attainment is reached before the soldiers returned home.

Since the census has no information on parental education or other family background, I use survey data from the German General Social Survey (ALLBUS) and the SOEP.[15] Jointly, these two surveys have biographical information on about 15,000 Germans born between 1939 and 1949, which corresponds to between 60 and 120 observations per month of birth. Figure 8, Panel B, shows these number of observations, and the proportion of respondents with more than basic education as well as the proportion born to at least one parent with more than basic education. Since there is a large degree of variation in all these variables from month to month, I show kernel-smoothed averages. The general development of the number of observations and the proportion of respondents with more than basic schooling matches the development in the census. However, there are differences in education levels across the two data sources. While around 30% of respondents are recorded having more than basic education in the 1970 census, the corresponding figure in the ALLBUS/SOEP is about 50% (and hence in the vicinity of the 1987 census figures, see Table 1). Comparability of the education measures might be an issue. The combined ALLBUS/SOEP data also show a dip in average educational attainment in the first part of 1946, which mirrors the census findings.

Average parental education increases during the war until early 1945 and then declines. Thus cohorts born 1941 to 1947 appear to be positively selected in terms of parental education. Further, there is a dip in parental education around late 1945, which could lend support to the notion that at least some of the low attainment cohorts are a negative selection in terms of parental education. Figure 8 does not tell us, though, whether this drop is significant or sufficient to explain the overall drop in educational attainment among those born in early 1946.

Let us thus turn to a regression analysis. Table 4 shows regression results from regressions of parental and own schooling on a "treatment period" dummy, a fourth-order polynomial time trend, and month of birth dummies. Each parameter is from a different regression. I estimated four sets of regression with four different treatment windows. The first window contains birth before the end of the war, the second window contains births during the end of the war, the third window contains cohorts conceived around the end of the war and the fourth window contains cohorts conceived after the height of the food crisis. These windows have between 355 and 637

[15] Briefly, ALLBUS and SOEP are the German analogues of the U.S. GSS and the PSID with about the same subjects and scope. Detailed descriptions can be found in Terwey (2000) and Wagner et al. (2007), respectively.

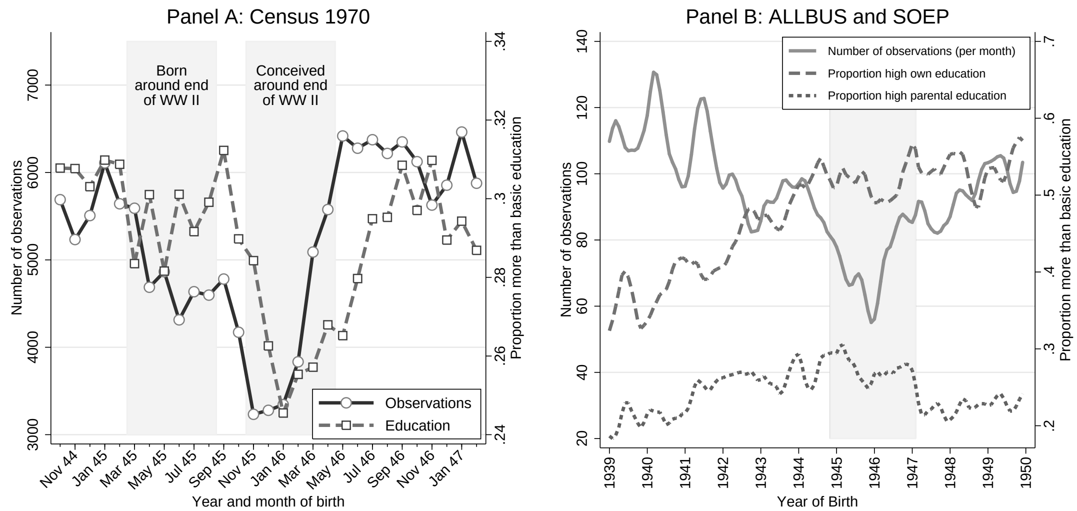

Figure 8: Panel A: Number of observations and average educational attainment, by month of birth, October 1944 to February 1947 (1970 Census); Panel B: Number of observation, average respondents' education level, and average parental education level, by month of birth. Due to the low number of observations, I show smoothed averages obtained by local polynomial regression (Epanechnikov kernel, bandwidth=1.5). The shaded area indicates the Panel A observation period.

observations. For each treatment window, I estimated five regressions; one for parental education and four for the respondents own educational attainment, first without controlling for parental education, then controlling for parental education, and then two separate models for individuals with low and high parental education.

The most important finding is in Column (1): there is no significant drop in parental education among those born nor among those conceived around the end of the war. The point estimates are practically zero. Moreover, standard errors are reasonably small. Further, the results with respect to the individuals' education in Column (2) reflect the findings from both censuses: those born in late 1945/early 1946 are roughly 5 percentage points less likely to have obtained more than compulsory schooling. If selective fertility with respect to parental education was the explanation behind this drop, controlling for parental education should eliminate the drop in own education. This does not happen, although parental education has a huge effect on one's own education. The point estimate (very precisely estimated, not shown in the table) is about 0.44, i.e. having a parent with more than compulsory schooling increases one's own chances of attaining more than compulsory schooling by 44 percentage points. The education dip of late 1945/early 1946 does not vanish when controlling for parental education because in the present data, these cohorts are not different with respect to parental education. In fact, given the 44 percentage point effect, a parental education gap of more than 10 percentage points would be needed to fully explain the 4.6 percentage point drop in attainment. A 5 percentage point gap – which is the lower bound of

Table 4: Parental and own educational attainment (measured as having more than compulsory schooling) difference between those born about nine months after the end of WWII (five different time windows) and adjacent cohorts. Data are from German SOEP and General Social Survey (Allbus), various waves.

	(1) Parental education	(2) Own education	(3) Own ed. (controlling for parental ed.)	(4) Own ed. (low parental education)	(5) Own ed. (high parental education)
Born Oct 44 to Mar 45	0.023	-0.002	-0.012	-0.016	0.002
	(0.023)	(0.025)	(0.023)	(0.029)	(0.036)
Cohort size	470	470	470	332	138
Born Apr 45 to Oct 45	-0.001	0.021	0.021	0.016	0.040
	(0.022)	(0.025)	(0.023)	(0.029)	(0.035)
Cohort size	460	460	460	335	125
Born Nov 45 to Apr 46	0.003	-0.046*	-0.048*	-0.059*	-0.012
	(0.025)	(0.028)	(0.026)	(0.032)	(0.043)
Cohort size	355	355	355	258	97
Born May 46 to Dec 46	0.020	-0.014	-0.023	-0.037	0.023
	(0.019)	(0.022)	(0.020)	(0.025)	(0.032)
Cohort size	637	637	637	461	176
Observations	14,756	14,756	14,756	11,232	3,524

Notes: Robust standard errors in parentheses; *p<0.1,**p<0.05. Control variables: fourth-order polynomial trend, month of birth dummy.

the 95%-confidence interval around the estimate for the difference in parental education – would explain just half of that. In other words, even with this comparatively small sample, one can safely rule out that selective fertility with respect to parental education fully explains our findings.

Columns (4) and (5) of Table 4 show the results of separate regression for individuals with parents of low and high education. They contain another interesting finding in support of the malnutrition explanation: children of parents of low education have suffered more in terms of the educational attainment dip (although the difference across equations is not significant). This may be explained by the better ability of high education (or income, respectively) parents to buy food beyond what was allocated on the ration cards, for instance by purchasing more or better food on black markets, or by traveling to the countryside to buy directly from farmers.

3.4 Selective mortality of adjacent cohorts

I now address the concern of potential positive selection in cohorts born just before or after the cohorts that seem to have suffered most from the food crisis. This may be relevant especially for those born during times of high infant mortality, e.g. around the end of the war. If these cohorts are positively selected because inherently "weak" types perished in utero or as infants, the estimated

Table 5: Regression of educational attainment on pre- and post-treatment cohort dummies.

Cohorts	Census 1970 jointly estimated	Census 1970 separately estimated	Census 1987 jointly estimated	Census 1987 separately estimated
Pre-treatment				
Born Jan 1-May 27, 1945	-0.014***	-0.002	-0.009*	-0.0002
	(0.005)	(0.005)	(0.005)	(0.005)
Born May 28-Dec 31, 1945	-0.023***	-0.014***	-0.019***	-0.012***
	(0.004)	(0.004)	(0.005)	(0.004)
Treatment				
Born Jan 1-May 27, 1946	-0.059***	-0.053***	-0.043***	-0.038***
	(0.005)	(0.005)	(0.005)	(0.005)
Post-treatment				
Born May 28-Dec 31, 1946	-0.013***	-0.003	-0.012***	-0.005
	(0.004)	(0.004)	(0.004)	(0.004)
Observations	448,449	448,449	435,685	435,685

Notes: Robust standard errors in parentheses; *p<0.1,**p<0.05,*** p<0.01. Control variables: fourth-order polynomial trend, sex, half-year of birth dummy. The census reference date in 1987 was May 25.

negative effect of the food crisis on the November 45 to April 46 cohorts may be exaggerated. I counter this objection by showing the absence of cohort effects in the cohorts surrounding the "treated" cohorts.[16]. Using the 1970 IPUMS data, I define two "pre-treatment" cohorts (born Jan 1 to May 27, 1945 and born May 28 to Dec 31, 1945) and one "post-treatment" cohort (born May 28 to Dec 31, 1946) along with our treatment cohort (born Jan 1 to May 27, 1945). For the 1987 IPUMS data, I define the same cohorts except that the reference date is May 25. Table 5 shows the coefficients of interest from several regressions. The columns labeled "jointly estimated" contain the coefficients of period dummies that are jointly estimated in one regression model. The columns labeled "separately estimated" contain the coefficients of period dummies from four separate regressions. Control variables are – as before – a fourth-order polynomial birth cohort trend, a sex dummy, and a half-year of birth dummy (where the first half-year lasts until the census reference date).

The question I seek to answer is whether the low educational attainment measured among those born early in 1946 can be explained by relatively high educational attainment in adjacent cohorts. If that was the case, I would see positive coefficients (deviations from the long-term trend) for pre- and post-treatment cohorts and perhaps zero or even slightly positive effects for the treatment cohorts. This is clearly not what Table 5 shows. In contrast, negative coefficients in the 4 to 6 percentage point range remain for those born January to May 1946. For adjacent cohorts one

[16] I am grateful to the anonymous referee who has suggested this analysis

either finds negative coefficients as well (in the jointly estimated case) or even fairly precisely estimated zeros (in the separately estimated case). In sum, there is no evidence compatible with the view that positive selection in adjacent cohorts, e.g. due to high infant mortality, is responsible for our main findings.

4 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 fought 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. U.S. troops reached Austrian territory 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 expulsed persons, under- and malnutrition as well as mass rape.

I replicate the 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, I 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). The total number of observations is 433,000. The development of the number of observations across the years (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 immediately after the war. In fact, the correlation between the German and Austrian time series is 0.90 for men and 0.92 for women.

I use the Austrian data to test again the hypothesis that intrauterine malnutrition around the end of the war had long-term effects on educational attainment and labor market outcome. This cannot only be viewed as testing my prediction out-of-sample, but also as a way to exclude changes in the education system as a rivaling explanation. If I 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 consequences.

Using the analogue specification that I used with the German 1987 census data, I 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 6. I 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. 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)

Table 6: 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	College degree	Unemployed	Blue-collar
			Men	
Mean dep. variable	0.752	0.063	0.035	0.522
Born in 1946/I	-0.024***	-0.007**	-0.001	0.029***
	(0.006)	(0.005)	(0.003)	(0.008)
Observations	213,941	213,941	186,680	185,926
			Women	
Mean dep. variable	0.541	0.025	0.044	0.330
Born in 1946/I	-0.057***	-0.005***	0.027***	0.039***
	(0.007)	(0.003)	(0.002)	(0.009)
Observations	219,018	219,018	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.

I use the Austrian data also to study whether the post-war birth "penalty" varies along the rural-urban dimension. I 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 7 shows the estimation results of linear probability models of educational attainment—with general specifications as before. 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. I find that all parameters are negative, that is, there is a the post-war birth penalty and it increases with city size. I 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, I 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.

Overall, the results for Austria provide evidence in support of the malnutrition hypothesis, in particular because they rule out a competing explanation discussed above. Although some insti-

Table 7: 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	-0.020***	-0.011	-0.029***
	(0.006)	(0.009)	(0.010)
Born in 1946/I × Urban	-0.017	-0.004	-0.029*
	(0.011)	(0.014)	(0.016)
Born in 1946/I × Vienna|Urban	-0.0345***	-0.035**	-0.035*
	(0.013)	(0.017)	(0.020)
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).

tutional 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.

5 Economic consequences

The purpose of this short section is to provide some rough back-of-the-envelope calculations of the economic consequences of the educational decline among the post-war cohorts. First, I estimate the number of individuals who have not gone past compulsory education because they were affected by the food crisis in utero. This estimate is equal to the number of children born in West Germany between January and May 1946 times the percentage point reduction in educational attainment as estimated above. The numbers are shown in Table 8. The first row shows that, according to official statistics, about 340,000 boys and girls were born during the "treatment period". Of these, 5.31 percent or 18,051 individuals have not completed more than compulsory education due to the food crisis. Second, I use German SOEP data to estimate the net present value of real life-time earnings for 1946 cohort members, by sex and educational attainment, as follows:

$$NPV(y) = \sum_{a=17}^{37} \frac{y_a^{1967}}{1.03^a} \cdot \frac{\bar{y}_{1946+a}}{\bar{y}_{1967+a}} \cdot \frac{p_{2010}}{p_{1946+a}} + \sum_{a=38}^{64} \frac{y_a^{1946}}{1.03^a} \cdot \frac{p_{2010}}{p_{1946+a}} \tag{3}$$

To explain, let us begin with the second term on the right hand side. It shows the sum of the nominal annual earnings of an individual SOEP sample member born in 1946 at age a, y_a^{1946}, discounted (at 3%) and inflated to 2010 prices. Thus age-earnings profiles of the 1946 cohort between age 38 (in year 1984) and age 64 (in year 2010) are obtained directly from the SOEP survey data. Since zero earnings are included in this computation, non-participation, early retirement or unemployment are taken into account as economic consequences of lower education attainment. Earnings profiles between age 17 (year 1963) and age 37 (year 1983) are not directly observed in the SOEP data and are imputed using the nominal age-earnings profiles of the 1967 cohort (who were aged 17 in 1984 and aged 37 in 2004), y_a^{1967}, adjusted for real income growth between $1946+a$ and $1967 + a$, $\bar{y}_{1946+a}/\bar{y}_{1967+a}$, discounted (at 3%) and inflated to 2010 prices. This procedure assumes that the productivity and price adjusted age-earnings profile between age 17 and 37 was the same for the 1967 as for the 1946 cohort.

Table 8: Estimating the effect of the food crisis on lifetime earnings (West Germany)

	Men	Women	Total
Number of individuals born January to May 1946	170,043	169,583	339,626
Food crisis effect on educational attainment (percentage points)	0.0526	0.0537	0.0531
Number of individuals with low education due to food crisis	8,944	9,107	18,051
Individual NPV lifetime income, low education (2010 Euro)	385,716	166,904	
Individual NPV lifetime income, high education (2010 Euro)	556,303	271,600	
Individual difference (2010 Euro)	170,587	104,696	
Sum across all affected individuals (2010 Euro)	1.526bn	0.953bn	2.479bn

The average net present values of real life-time income is shown, by sex and education, in Table 8. Men born in 1946 with only basic schooling had a NPV of 385,716 Euro. With more than basic schooling, the NPV was 556,303 Euro. Part of this 44% difference should be due to differences in ability, part should be returns to schooling. The amounts for women are smaller, due to lower labor market participation and lower earnings. Multiplying the difference in lifetime earnings between low and high education individuals with the number of 1946 cohort members whose educational attainment was affected by the food crisis yields an aggregate loss in life-time earnings of about 2.5bn Euro or 0.1 percent of the GDP in 2010. Obviously, there are many uncertainties in this calculation. For instance, I did not account for possible excess mortality of the affected cohorts. Accounting for mortality would increase the estimate of lost earnings. Further, due to the long time horizon, the choice of discount factor makes a huge difference. Discounting at 5% reduces the estimated overall loss to 1bn Euro. Still, the rough calculations presented in this section suggest that the food crisis around the end to the war had substantial economic consequences.

6 Summary and conclusion

The aim of this paper was to study 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 fetal origins of adult outcomes, I hypothesized that cohorts in utero immediately after the war (and born in early 1946) 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, I found a remarkably sharp negative dent in outcomes among cohorts *conceived* at the end of the war (around May 1945) and born between December 1945 and May 1946. These 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 my 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 for Germany.

In order to support the claim that this novel finding is indeed a consequence of intrauterine malnutrition, I examined a number of empirical implications emanating from our theory. For instance, I analyzed how average educational outcomes by month-of-birth cohort are related to data on daily caloric intake across Germany. I found that quantitative and qualitative malnutrition around the time of conception has the strongest correlation (compared to late pregnancy or infancy) with the level of completed education. I was also able to show that regional variation in food availability is related to the post-war education dip. Further, I have extended the analysis in time and space. First, using data from the German 1987 census to look at education and economic outcomes another 17 years onward, I was able to confirm the findings from the analysis of the 1970 data. Second, I 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.

Further, I studied alternative 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. Being exposed to flight-related stress in utero was found to inflict some *additional* damage on unborn children. Moreover, there was no evidence that selective fertility (if children born immediately post war had less educated parents), selective mortality, or coincidental changes to the education system (unrelated to the events in 1945) might explain our findings.

Finally, several directions for future research come to mind, both into the fetal origins hypothesis and into the long-term consequences of the Second World War for German and Austrian war and post-war children. First, it would be important to replicate the analysis in this paper with other large scale data sets. Second, 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, the current analysis has the potential to spark an exciting line of future inter-disciplinary research.

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