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Civil War, Crop Failure, and Child Stunting in Rwanda *

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Abstract

Economic shocks at birth have lasting impacts on children's health several years after the shock. We calculate height for age z-scores for children under age five using data from a Rwandan nationally representative household survey conducted in 1992. We exploit district and time variation in crop failure and civil conflict to measure the impact of exogenous shocks that children experience at birth on their height several years later. We find that boys and girls born after the shock in regions experiencing civil conflict are both negatively impacted with height for age z-scores 0.30 and 0.72 standard deviations lower, respectively. Conversely, only girls are negatively impacted by crop failure, with these girls exhibiting 0.41 standard deviation lower height for age z-scores and the impact is worse for girls in poor households. Results are robust to using sibling difference estimators, household level production, and rainfall shocks as alternative measures of crop failure.

Keywords: Child health, economic shocks, civil war, rainfall shocks, Africa
JEL classification: I12, J13, O12, O15

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1. Introduction

There is growing concern among economists and practitioners that economic conditions prevailing in early childhood may have a persistent effect on child health and socioeconomic outcomes later in life. The shock's effect may be such that children cannot catch up even if they experience subsequent good years at later ages. Policy makers are aware of the distressing link between early childhood and adult well-being, making it one reason why the World Bank and non-governmental organizations view improvements in child health as a top priority.

In this paper, we focus on how exogenous shocks at birth lead to worse health outcomes in the short-run several years after the shock. In particular, we look at the effect of civil conflicts and crop failures on the health of Rwandan children born between 1987 and 1991. We use an integrated household survey, combining health and agricultural data with event data from reports by non-governmental organizations. We exploit the local nature of the crop failure (confined to provinces in southern Rwanda) and the civil war (confined to provinces in northern Rwanda) to identify the causal effect of these exogenous shocks on child health, and we use the variation across birth cohorts to capture the child's exposure to the shock. Our approach is to estimate the effect of these shocks on height-for-age while controlling for province of residence, month and year of birth as well as household, infant, and mother characteristics. Our results are robust to using sibling difference estimators and for a sub-sample of children, we use rainfall and household production shocks to confirm the robustness of the crop failure results.

There is an extensive literature that attempts to measure the impact of economic shocks on future welfare outcomes.[1] Using Netherlands' birth registry data, Van den Berg, Lindeboom,

[1] This is related to research that explores the association between health and income and the link between childhood conditions and later welfare outcomes (Curry and Hyson, 1999; Case, Lubotsky, and Paxson, 2002). In a paper exploring the role of shocks and income, Frankenberg, Smith, and Thomas (2004) find that richer households are able to smooth consumption and cope with the unanticipated financial crisis that occurred in Indonesia in 1998.

and Portrait (2005) find that poor macroeconomic conditions in infancy lead to higher adult mortality. Almond (2006) finds that individuals who were in utero during the 1918 influenza pandemic experienced as adults lower education attainment, increased rates of physical disability, and lower socioeconomic status compared with other birth cohorts. Alderman, Hoddinott, and Kinsey (2006) use data from Zimbabwe and show that preschool malnutrition has a negative impact on subsequent human capital formation, measured by the number of grades completed. Yamauchi (2006) shows that healthier children in South Africa start school earlier, attain more grades, and repeat fewer classes. Finally, Maccini and Yang (2006) examine the effect of early-life environmental conditions for Indonesians on health and socioeconomic outcomes later in life. They find that higher early-life rainfall leads to improved health, schooling, spousal quality, and socioeconomic status, but the impacts are only for women.

The literature also provides evidence of gender bias in health and socioeconomic outcomes. Rose (1999) shows that when districts experience higher rainfall, the gender bias in infant mortality in India (favoring boys over girls) narrows significantly. Alderman and Gertler (1997) find that demand for girls' medical care is more income and price-elastic than demand for boys' medical care in rural Pakistani households. Behrman (1988) finds bias in favor of boys in the intra-household allocation of nutrition during the lean season in India. Recent work questions the perceived view that gender bias is more of problem in Asia than Africa. Verwimp and Van Bavel (2005) find evidence that the usual sex differential in child survival (more girls than boys survive infancy) observed in Africa as well as elsewhere changes under severe living conditions. Dercon and Krishnan (2000) find that adults in poor Ethiopian households are unable to smooth their consumption and women bear the brunt of adverse shocks.

This paper establishes the mechanism linking shocks at birth and adult welfare outcomes—just a few years after the shock, children already have significantly lower height for age z-scores and this impact may persist into adulthood. By focusing on the short-run impact of these shocks at birth, we are able to pin down more precisely how the shock could translate into adult impacts, something none of the other papers explore. We also explore a type of shock, civil conflicts, that has received surprisingly little attention in the development literature despite the fact that two-thirds of all countries in sub-Saharan Africa experienced armed conflict during the 1980s and 1990s (Miguel, Satyanath, Sergenti, 2004; Guidolin and La Ferrara, 2005; Bellows and Miguel, 2006). We find that both types of shocks, crop failure and civil conflict, negatively impact children's health, but the roles of gender and poverty differ for each shock. With respect to crop failure, girls, from poor households in particular, are severely negatively impacted, but boys (in either poor or rich households) do not experience any negative effects on their height for age z-scores. However, for children that experience a civil conflict, the health status of boys and girls are negatively impacted and children in both rich and poor households suffer these consequences, although the estimates for rich households are not precisely measured.

The remainder of the paper is organized as follows. Section 2 describes the Rwandan setting and how the shock measures are calculated. Section 3 describes the empirical identification strategy and in Section 4, we present the results as well as tests of the robustness of the shock measures. Section 5 concludes.

2. Data and Empirical Setting

2.1 The rural household economy in Rwanda

Table 1 presents an overview of the Rwandan provinces and shows significant regional differences. For instance, the southern prefectures of Butare and Gikongoro and the western

prefectures Kibuye, Cyangugu, and Gisenyi are poorer than the northern, central and eastern prefectures. Previous work has shown that differences in regional and household income can be explained by farm size, soil fertility, suitability of the soil for high yielding crops, rainfall, access to public infrastructure (such as roads and markets), availability of off-farm jobs, and coffee and tea prices for regions growing these crops (Justino and Verwimp, 2006).

Ninety-three percent of Rwanda's population live in rural areas and nearly all rural households are engaged in farming. On average, households cultivate 0.89 hectares of land, with the vast majority of these landholdings being owner operated. Beans, bananas, potatoes and sweet potatoes are the main food staples, although bananas and potatoes are also sold for cash. Coffee is cultivated as a cash crop. Farming is labor intensive, primarily using hoes and machetes, and animal traction is non-existent. Women's labor is particularly important in food crop production, while men's labor is crucial in cash crop production and animal husbandry. For many crops, the ideal growing conditions are between the altitude of 1500 and 1700 meters, which explains the high population densities found at this altitude. The average household derives almost 60 percent of its income from subsistence crop production and 40 percent from beer sales, crop sales, off-farm income, and livestock sales (Clay, Reardon, Kangasniemi, 1998).

2.2 Crop Failure in the South and Civil War in the North

In the late 1980s, Rwanda entered a period of economic decline. The country experienced low coffee and tea prices, unfavorable weather conditions, unresolved refugee questions, demographic growth, and mounting corruption. There was also a dramatic drop in yields of all major crops between 1984 and 1991, with the decline for tubers, the main source of calories for poor households, being particularly strong (Clay, 1996). This decline in yields, combined with

population growth, led to an average decline in per capita food production of 25 percent (World Bank, 1998). Two distinct events mark this time period. The first is a local crop failure in southern Rwanda in 1989 and the second is an outbreak of civil conflict in northern Rwanda in October 1990.[2]

Several non-governmental organizations documented the extent and severity of the crop failure. In February 1990, the Center for Cooperative Research and Information (known in Rwanda by the French acronym, IWACU), a non-governmental organization working in rural areas, produced a film "*Haguma Amagara*" meaning "*You Only Live Once*." The film documents the food crisis in the south and was motivated by the Rwandan government's refusal to acknowledge the local famine. The footage depicts peasants in southern Rwanda with nothing to eat, markets without products, residents deconstructing their houses to sell the parts for food, hungry children and mothers, and adult males who tell the filmmaker they are too weak to work. The film clearly documents hunger in southern Rwanda during the 1988 to 1990 period.

Apart from the film, at least three Rwandan organizations published reports on the food crisis. The first report, written by Bureau Social Urbain-Caritas in Kigali (1990), cites administrative and local sources documenting hunger and starvation in several communes of Butare (Nyakizu, Runyinya) and Gikongoro (Nyamagabe, Karama).[3] The report measures the number of deaths due to starvation in those communes and confirmed the withdrawal of children from school. Husbands temporarily migrated in search of income and food, crops were stolen at night, and several cases of suicide were reported. In Gikongoro, the report noted that peasants hoped the next coffee harvest would be good or else they would starve to death. The Caritas

[2] Figure 1 presents a map of Rwanda depicting the crop failure and civil conflict areas.
[3] Before the genocide, Rwanda's territorial administration was organized in prefectures (provinces), communes (municipalities), sectors, and cells. A commune had on average 50,000 inhabitants.

report concluded there was no longer anything to eat in the south, and peasants were already eating the leaves and roots of plants.

The second report was written by another grass-roots organization, Conseil de Concertation des Organisations d'Appui aux Initiatives de Base (CCOAIB), but the authors were unable to get a copy of this report (Twizeyimana and Uwimana, 1989). The third report describes a local agricultural survey of 300 households conducted by the Ministry of Agriculture in several communes in Gikongoro (Gascon, 1992). The report stated that 25 percent of the surveyed households were indigent and female headed households suffered the most. Two of the reports use the term famine to describe the situation in southern Rwanda, and the third speaks of starvation. Factors mentioned that contributed to the crop failure were rainfall variation as well as crop disease.

Kinyamateka, the most prominent independent newspaper in Rwanda, also published information on the food crisis in 1989, making the famine known to the Rwandan public. André Sibomana, editor of the newspaper in 1989, expressed it as follows:

> *"In 1989, a terrible famine struck the south of the country. There was a natural explanation for this phenomenon, but the authorities did nothing to improve the situation. Worse still, I had evidence that part of the government's assistance which was intended for the population at risk had been diverted. It was a scandal. I decided to publish this information. We were threatened and we were called liars, until I published photographs which were overwhelming. This had an immediate effect. Readers wrote in to express their satisfaction: at last the truth was being told."* (Sibomana, 1999)

Based on the film, the non-governmental organizations' reports, and the newspaper articles, we create a variable indicating which regions in Rwanda experienced crop failure during this time period. This crop failure area included all of the communes of Gikongoro province and the communes of Butare province bordering Gikongoro province (see Figure 1).

The civil war is the second crucial event in this period. In October 1990, a group of rebels consisting of Tutsi refugees who left Rwanda during the 1959 to 1962 revolution and their offspring attacked Rwanda from Uganda. What followed was a civil war between the Rwandan armed forces (FAR) and the rebel army (Rwandan Patriotic Front or RPF) in which civilians in the northern provinces of Byumba and Ruhengeri were the main victims. In January 1991, the rebels mounted a surprise attack against the city of Ruhengeri to liberate political prisoners from the government prison (Prunier, 1995). A report by an international group of human rights experts documents the disruption in agricultural production and in the lives of northern villagers (Federation International des Droits de l'Homme, 1993).[4] Battles between both armies were paralleled by peace negotiations and third party interventions. Before the war, relative to other regions in Rwanda, these northern provinces were areas of surplus production providing potatoes to the rest of the country. There are no existing household level data on the extent of the disruption to crop production and income generating activities in the north due to the war.

In a manner analogous to the crop failure measure, we use these reports to create a variable indicating which Rwandan regions experienced armed conflict during this period. The civil war area included parts of the northern provinces of Byumba and Ruhengeri (see Figure 1).

2.3 Data

In January 1992, UNICEF financed a survey on the health status of young children and mothers in Rwanda (UNICEF, 1992). The UNICEF survey was nationally representative and collected detailed information on the exact date of birth and height of every child under age five in 2,496 rural households, yielding 1762 children under age five with complete information in these

[4] In addition, between 1990 and 1993, the Rwandan government organized small-scale, local massacres that targeted Tutsi in regions far from the war front (Fédération Internationale des Droits de l'Homme, 1993).

households.[5] Wealth data, such as the number of livestock, and information about the mother's health and demographic status were also collected.

Height for age is generally accepted as a good indicator of the long-run nutritional status of children (Thomas, Lavy, Strauss, 1996). Children with low height for their age are considered stunted, an indicator of chronic malnutrition. According to Alderman (1993),

> *"Though a stunted child may have some catch up growth, for the most part, a child whose growth has faltered in the first two years of life will be on a different growth trajectory during the rest of his/her life."*

We compute z-scores for each child's height for age, where the z-score is defined as the difference between the value for an individual child and the median value of the reference population (in this case, the United States), divided by the standard deviation of that reference population (Cogill, 2001). On average, across households in all regions of Rwanda, children were two standard deviations below the average height of a child from the United States.

The UNICEF survey was linked to a prior agricultural survey that ran from October 1988 to September 1991 and was organized by the Rwandan Department of Agricultural Statistics (DSA) and Michigan State University.[6] The DSA survey was also nationally representative and collected agricultural and economic data (including household production, land holdings, and labor inputs) from half of the 2,496 rural households (see Clay, 1996 for additional details about the DSA survey).[7] For part of our analysis, we use the agricultural DSA survey to isolate the

[5] We exclude children with height-for-age z-scores less than -6 or greater than 6 due to probable errors in either height or age data.

[6] To ensure survey quality, DSA and UNICEF had one supervisor in the field per prefecture. This supervisor monitored the performance of each of the interviewers in that prefecture. The supervisor collected completed questionnaires, screened for inconsistencies, and went back to the farm households with the interviewers if needed. The office staff made frequent field visits to see how the questionnaires were understood and completed. Data were checked again in the office, both visually for each questionnaire and with the help of data cleaning programs.

[7] There are two caveats on how representative our findings are using the UNICEF data. First, because of the DSA survey's focus on agriculture, households who did not own or cultivate land (mostly young wage laborers no longer living with their parents) were excluded from the sample. Given that these households generally are poorer than average, this may lead to an underestimate of the true effect of poverty on child health. Second, since the UNICEF survey was linked to the prior DSA survey, which was panel data, we are concerned with possible attrition in the

causal mechanism driving the crop failure results seen with the UNICEF data. We examine household level production shocks and their impact on children's height for age z-scores, but given the smaller sampling frame (1, 248 households) and the three-year window of household production information, there are only 473 children under age five in that analysis.

2.4 Ethnicity

Neither the UNICEF nor the DSA survey registered the ethnic affiliation of the survey respondents, so we are unable to test potential ethnic differences, although we do not think these are critical for the following two reasons. First, although Tutsi account for 10 to 15 percent of the Rwandan population, in the northern civil-war-affected provinces, they account for less than three percent. Given the civil war was confined to the north in the period under investigation, we do not expect ethnicity to be a factor influencing our results for the civil war shock.

Second, although Tutsi account for 15 to 20 percent of the population in the southern crop failure provinces, Austin's (1996) review of the literature did not find evidence of inequality between the Hutu and Tutsi ethnic groups. Similarly, Verwimp (2005) did not find systematic differences between the two ethnic groups in income per adult equivalent, land size, or livestock holdings in several southern provinces. In 1990, there existed no exclusively Hutu or Tutsi villages in Rwanda, both lived as neighbors and were dispersed across the territory of

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DSA sample. All households that were in the DSA agricultural survey as of 1990 are in the UNICEF sample. The main concern is households that were in the DSA sample in October 1988 but dropped out before the 1990 survey. Of all households who were interviewed during the first round of the DSA survey (from October 1988 to March 1989), 96.8 percent of them were still in the sample in 1990. In the crop failure region, only 14 out of 256 households (5.4 percent) dropped out, while in the civil war region, 3 out of 239 households (1.3 percent) dropped out. Almost all of the conflict-related migration in the civil war region occurred between 1992 and 1994 after the UNICEF survey was conducted. We did not find any significant differences in observable characteristics between the 17 dropped households and the remaining households in the crop failure and civil war regions. Given the low overall attrition rate and the lack of observable differences, we believe the UNICEF data are representative of the Rwandan population.

the southern provinces. Thus, we have no a priori reason to believe or expect that Hutu children would be differentially affected by crop failure compared to Tutsi children. In fact, part of the political economy of Rwanda under the Second Republic is that the southern region as a whole, Hutu as well as Tutsi, were disfavored by the government, whose leaders came from the north of Rwanda (Prunier, 1995). This is also the main reason why the government did not deliver aid to the population affected by the crop failure.

3. Empirical Identification Strategy

To measure the causal impact of economic shocks on children's health, we exploit two sources of variation. The first is district-wide variation in which regions experienced the different types of shocks. As discussed in Section 2.2 above, Gikongoro and parts of Butare province in southern Rwanda experienced severe crop failure in 1988. However, other regions of the country remained unaffected. Likewise, beginning in October 1990, the rebel army under the command of the RPF attacked Rwanda from Uganda and occupied part of the northern region of the country. In the time-frame of the survey, the civil conflict was confined to the northern provinces. The second source of variation is by birth cohort and measures the child's potential exposure to the shock. Children born before the shock will be impacted differently than children born afterwards.

The identification strategy can be illustrated using a two-by-two difference-in-differences table. Panel A in Table 2 shows average height for age z-scores for children born before and after the civil conflict in affected and unaffected regions. The cross sectional results show that children born prior to October 1990 in the civil war regions exhibited a statistically insignificant 0.251 standard deviations lower height for age z-scores than children in the rest of the country,

which is evidence that children's health in this region is similar to the rest of the country.[8] Children from the civil war region born after the war began have improved height for age z-scores, but they do not improve as much as children born after October 1990 in the rest of the country. Relative to children in the civil war region born before the conflict started, height for age z-scores improve by 0.724 standard deviations. This is in contrast to the rest of the country, which experienced an increase in children's heights of 1.145 standard deviations.[9] Calculating the difference-in-differences estimator shows that children born after 1990 in the civil war region have 0.421 standard deviations lower height for age z-scores compared to children in the rest of the country, a result that is significant at the one percent level. The difference-in-differences result can be interpreted as the impact of the civil war on children's height for age z-scores under the assumption that, without the war, children in the civil war region born after October 1990 would have experienced the same change in average height for age z-scores as children in the rest of the country.

Panels B and C in Table 2 further explore these preliminary results by examining whether the conflict impact depends on the child's gender. Panel B presents the results for the 750 boys and Panel C for the 806 girls. Boys and girls born after October 1990 in the rest of the country experience similar improvements in average height for age z-scores relative to children born before that date with an increase of 1.222 and 1.073 standard deviations for boys and girls, respectively. In the civil war region, boys born after the conflict have a similar improvement in height for age z-score as girls born after the conflict (0.788 and 0.677 standard deviations higher, respectively). The difference-in-differences estimate shows that the impact of the armed conflict

[8] In all of the tables and figures, "rest of the country" is defined to exclude the crop failure and civil war regions.
[9] In developing countries, height for age z-scores decline with child age because the child continues to accumulate additional deficits compared to a well-nourished child (Duflo, 2003).

for boys is a 0.434 standard deviation reduction in height for age z-scores and for girls is a 0.396 standard deviation reduction and both results are significant at the five percent level.

The results in Table 3 analyzing the impact of crop failure contrast with those for civil wars. With respect to armed conflict, both boys and girls are negatively impacted by the shock, but only girls appear to suffer the negative consequences of a crop failure. Children born in the crop failure region prior to the October 1988 have better height for age z-scores on average than children in the rest of the country (0.229 standard deviations higher). Children from the crop failure region born after the crop failure have improved height for age z-scores but they do not improve as much as children born after October 1988 in the rest of the country. The difference-in-differences result indicates that children born after October 1988 in the crop failure region have 0.323 standard deviations lower height for age z-scores than children in the rest of the country, but the difference is not statistically significant. The results for all children are an average of the difference-in-difference result for boys and girls. Panel B and C examine the impact of crop failure by gender. The difference-in-differences results indicated that boys experience no impact from the crop failure, while girls have 0.545 standard deviations lower height for age z-scores due to the crop failure.

The identification strategy can also be illustrated by examining the nonparametric relationship between height for age z-scores and children's birth cohort. We estimate a kernel-weighted local polynomial regression of height for age z-score on birth cohort using an Epanechnikov kernel. Figure 2 compares children in the civil war region with children in the rest of the country. In the regressions, we use precise information on the exact month and year of birth. In the figures, a vertical line is drawn at October 1990, representing the start of the armed conflict in the civil war regions. It is evident that children in the civil war regions born

after the conflict started experience a significant negative drop in height for age z-scores, which is consistent with the difference-in-differences results in Table 2.[10] Figure 3 compares children in the crop failure regions with children in the rest of the country. We observe that for children born after October 1988, there is a slight drop in height for age z-scores among children in the crop failure region but not in the rest of the country and in results not shown, this impact is larger for women.

4. Empirical Results

4.1 Effect of Civil War and Crop Failure Shocks

While the difference-in-differences results and figures are revealing and informative, they do not incorporate all available information and they do not control for other factors that might influence children's health status. To address this issue, we estimate a province and birth cohort fixed effects regression which is comparable to the difference-in-differences estimator. In the simplest specification (additional child and maternal controls are added later), we estimate the following regression:

$$HAZ_{ijt} = \alpha_j + \beta_1 (ShockRegion_j * BornAfterShock_t) + \delta_t + \varepsilon_{ijt} \qquad (1)$$

where HAZ_{ijt} is the height for age z-score for child i in region j who was born in time period t, α_j are the province fixed effects, δ_t are the cohort of birth (year and month) fixed effects, $ShockRegion_j * BornAfterShock_t$ indicates children born in a region that experienced a crop failure or civil war after the economic shock occurred, and ε_{ijt} is a random, idiosyncratic error term. The coefficient β_1 measures the impact of civil conflict or crop failure on children's health status for children born after the shock in regions experiencing these events. Identification of the

[10] The figure also provides some evidence there might be a negative impact on height for age z-scores for children who are aged six to nine months at the start of the conflict. Future work will explore this possibility.

impact comes from comparing children born before and after the shock occurred and from comparing regions impacted by the shock to the rest of Rwanda.[11]

In Table 4, we present results from estimating variations of equation 1. All regressions include province and birth cohort (month and year of birth) controls. Column 1 uses a shock variable that measures a child's exposure to the civil war (similar to Table 2). Children born after the civil war affected their region have 0.676 standard deviations lower height for age z-scores, a reduction that is statistically significant at the one percent level. Column 2 shows that both boys and girls born after the civil war impacted their region are worse off, with girls having an additional 0.718 standard deviations lower height for age z-scores. In columns 3 and 4, results indicate that only the health status of girls is negatively affected by the crop failure consistent with the Table 3 findings.[12] In columns 5 and 6, we combine the two types of shocks into a single variable, indicating children born in periods after a shock occurred in those regions that experienced either a crop failure (southern region) or a civil conflict (northern region).[13] Results show that girls impacted by the shock have 0.440 standard deviations lower height for age z-scores and the result is significant at the one percent level.[14]

[11] Correlation among the error terms of children in a given province experiencing the same shocks might bias the OLS standard errors downward, so in all regressions we cluster the standard errors by birth province (Moulton, 1986; Bertrand, Duflo, and Mullainathan, 2004).

[12] These reported effects are likely to be lower bounds of the total impact of the shocks since we do not have data on children in these households who died prior to the 1992 UNICEF survey (Rose, 1999). Our results should be interpreted as, conditional on a child surviving until the survey, civil wars negatively impact boys and girls height for age z-scores while crop failures negatively impact only girls.

[13] As an additional robustness check, we estimated a more refined regression that used year of birth interacted with the shock region (either civil war or crop failure), instead of using born after the shock interacted with the shock region. Results (not shown) are consistent with the Table 4 outcomes, with children born in the year following the shock experiencing the brunt of the impact.

[14] The onset of the civil war in October 1990 in the northern regions of Rwanda was sudden and unexpected, which could explain why boys and girls were both negatively impacted by the conflict. Parents could not protect the health status of any of their children from this type of event. In contrast, the crop failure results indicate households were able to shield boys from experiencing the negative impacts of the shock. Due to survey limitations, we do not have household production data covering the civil war time period, so we are unable to compare the magnitudes of these different shocks. Therefore, we cannot rule out that the civil war shock was larger in magnitude and this explains why boys were negatively impacted in those regions, while a potentially smaller crop failure shock did not impact them, although the coefficient estimates for girls in the two shock regressions (column 2 and 4) are similar. Future

In all regressions, we included controls measuring characteristics about the mother and these variables all have the expected sign. Regression results are similar (not shown) when these mother's characteristics are not included. A child whose mother received prenatal care has an increase of between 0.188 and 0.301 standard deviations in their height for age z-score, while mothers who are literate have children who are 0.11 to 0.14 standard deviations higher in terms of height for age z-scores.

Although we find a negative impact of civil war and crop failure, not all children experience these shocks equally. We already saw girls are more susceptible to the shocks' negative impacts than boys, and in Table 5 we extend the analysis to examine how wealth might mitigate the negative impacts of these shocks on children's health. As owning livestock in this environment is an asset and a sign of wealth, we measure wealth in terms of tropical livestock units (TLU) owned by the household.[15] Households owning less than or equal to one TLU, which is a cumulative measure of the number of cattle, pigs, sheep, and goats, are considered to be poor and approximately 77 percent of households are classified this way.

Results in panel A of Table 5 show that a child in a poor household born in the civil war region after the war experiences 0.468 standard deviations lower height for age z-scores due to the conflict, and the result is significant at the one percent level. Children in wealthier households are also negatively impacted by the civil conflict (column 3), although the coefficient is not significant at standard levels. We do not find an additional statistically significant negative impact for girls in the poor households, indicating both boys and girls are negatively affected. The civil war results contrast with those in panel B that examine the crop failure. It appears that

work, including data collection in conflict zones, should attempt to more precisely measure the differences between these types of shocks and how households manage to respond to them.

[15] The conversion from different types of livestock to Tropical Livestock Units is calculated as follows: 1 cow = 1 tlu; 1 pig= 0.25 tlu; 1 sheep = 0.17 tlu; and 1 goat=0.17 tlu.

girls in poor households bear the brunt of the crop failure shock, experiencing 0.657 standard deviations lower height for age z-scores. Boys in poor households and all children in rich households are not impacted by the crop failure shock.[16]

4.2 Robustness Tests: Sibling Differences Estimator, Household Production, and Rainfall Shocks

To this point in the analysis, we have relied on regional-level measures of the shock variables that were derived from the reports produced at the time of these crises by various non-governmental organizations or by academic authors. In this section, we use three alternative strategies to test the robustness of these results. Measuring the shock variables at the regional-level leads to the possibility that province-specific time trends are driving the health results. While we argued earlier that the provinces across Rwanda were similar in terms of child health trends prior to the specific shocks occurring (see discussion of Table 2 and 3), we now estimate a household fixed effects or sibling differences estimator in which we control for observable and unobservable household level factors that are constant across multiple children in a given household. The sibling differences estimator compares siblings within a given household who are born before or after a shock, and identification is driven by the 1081 children in multiple-child households. Using this empirical strategy, results in Table 6 indicate that the impact of the shocks is even larger compared to the earlier tables. Controlling for household and birth cohort fixed effects, we find that siblings born after the shock, in the civil war as well as in the crop failure regions are worse off compared to their siblings born before the shock. For both types of

[16] Unfortunately, the survey data on household asset and livestock holdings was collected in 1991, which is subsequent to the civil conflict that started in October 1990 and the crop failure in 1988, and households might have adjusted their asset holdings in response to the shocks. To address this potential issue, we use the educational attainment of the household head as an alternative wealth measure. Education is highly correlated with wealth but cannot change in response to these shocks as household heads have all completed their schooling. Data on education are only available for the households surveyed in the DSA survey, reducing the regression sample size roughly in half. Results (not shown) are consistent with those in Table 5.

shocks, the household fixed effects results indicate that boys and girls are negatively impacted and there is no additional statistically significant negative impact for girls, although the number of households with children born before and after the shock and of each sex is limited.

Next, we test the robustness of the crop failure results using household-level agricultural production and rainfall data.[17] We use the DSA agricultural survey, which was administered to a subset of the UNICEF households, and which contains household-level production information for October 1988 to September 1991. Using this production information, we can estimate the direct impact of a production shock experienced at the time of birth by a child's household on the child's health. Since the production data only cover three years, we exclude children born outside the three year time interval. Of the 921 children under age five in the DSA households, there were 534 born between October 1988 and September 1991. An additional 61 children could not be included in the regressions due to missing data on household production in the year of the child's birth. The smaller sample of households in the DSA survey, the reduced number of birth cohorts to examine, and missing production data for some households reduce the sample of children we can use in the regressions to 473 children. This smaller, but still nationally representative sample of children provides insight into the mechanism driving the earlier crop failure results seen using province-level variation. Finally, we use rainfall data collected by the Rwandan Meteorological Service, which are available on a monthly basis for each province until December 1991.

In Table 7, we present these robustness tests. We define the household production shock as the difference between the value of farm output during the year the child is born and the three

[17] To our knowledge, no household-level measures of the impact of the civil war in the north of Rwanda in the 1990 to 1991 period exist that cover the entire region and are sufficiently disaggregated (i.e. number of casualties, property damaged).

year average of farm output. A positive value for this variable indicates production in the year of the child's birth is higher than the three year average production (i.e. a positive production shock). Results in column 1 indicate that households that experienced positive production shocks at the time a child was born have children with better height for age z-scores (measured several years after the shock), and the coefficient is significant at the one percent level.

In column 2, we estimate a reduced form specification using dummy variables for the rain shock (large negative, normal (somewhat negative or somewhat positive), and large positive), and we find that child health improves when the rainfall shock is average or very positive.[18] Compared to a large negative rainfall shock, children born in years experiencing normal rainfall exhibit 0.272 standard deviations higher height for age z-scores (significant at the five percent level) and children born in years with large positive rainfall shocks show 0.427 standard deviations higher height for age z-scores (significant at the one percent level). Column 3 presents the result of an instrumental variables specification where we use the rainfall shocks as an instrument for our crop failure shock variable. The result further strengthens our previous findings. Variation in rainfall is the exogenous shock explaining crop failure which in turn affects child health.

5. Conclusion

An extensive literature in labor and development economics finds that economic shocks around the time of birth generally have significant negative long-run impacts on adult welfare outcomes. In this paper, by focusing on the short-run impact of these shocks, we try to understand the mechanism by which shocks at birth impact future adult outcomes. We specifically focus on the

[18] We use the deviation of annual rainfall from the historical 30 year long-run province average as our shock measure. Approximately half of the children experience rainfall shocks categorized as normal and approximately a

height for age of children under five years old and find that these economic shocks have lasting impacts several years after the event. Using nationally representative household survey data collected in January 1992 in Rwanda (prior to the 1994 genocide), we exploit variation in the timing and location of localized crop failure and civil conflict across regions of the country and variation in the birth cohort of children who are exposed to the shock. This exogenous variation allows us to measure the causal impact of the shocks these children experience at birth on their height several years later. We find that rural households in areas affected by either civil conflict or crop failure are unable to protect their offspring from the impact of these shocks. All children exposed to the civil war shock are negatively impacted, although the estimates for rich children are not precisely measured. Girls are particularly vulnerable in regions that experience crop failure, with girls in poor households bearing the brunt of the impact. We find no evidence of a negative impact of crop failure on the health status of boys or children in rich households. Results are robust to using a sibling differences estimator to control for household level factors that might influence a child's health status.

We also test the robustness of the crop failure results using two alternative measures. First, using alternative survey data on household level agricultural production for a sub-sample of these households, we confirm that positive crop production shocks improve a child's height for age z-score. Second, we use the deviation of rainfall from the long-run province average to show that positive rainfall shocks are correlated with improved height for age z-scores. We also use an instrumental variables approach to demonstrate the causal mechanism running from rainfall shocks to crop failure to child health. The findings are robust to these alternative specifications.

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quarter experience large negative or large positive rainfall shocks, respectively.

These results have direct policy implications as they indicate the importance of a quick response to economic crises on the part of governments and non-governmental organizations. Children, in particular girls, are at risk of a worsened health status only a few years after birth due to their household experiencing an economic shock when they were born. Evidence in the literature suggests that a child who has shorter than normal height by age five will not be able to catch up later in life. The negative shock experienced at birth will likely have long-run consequences for these affected children, leading to worse adult outcomes in terms of health, education, and socioeconomic status. The evidence suggests that helping these children with early interventions may have a larger payoff than the present benefit to only short-run health.

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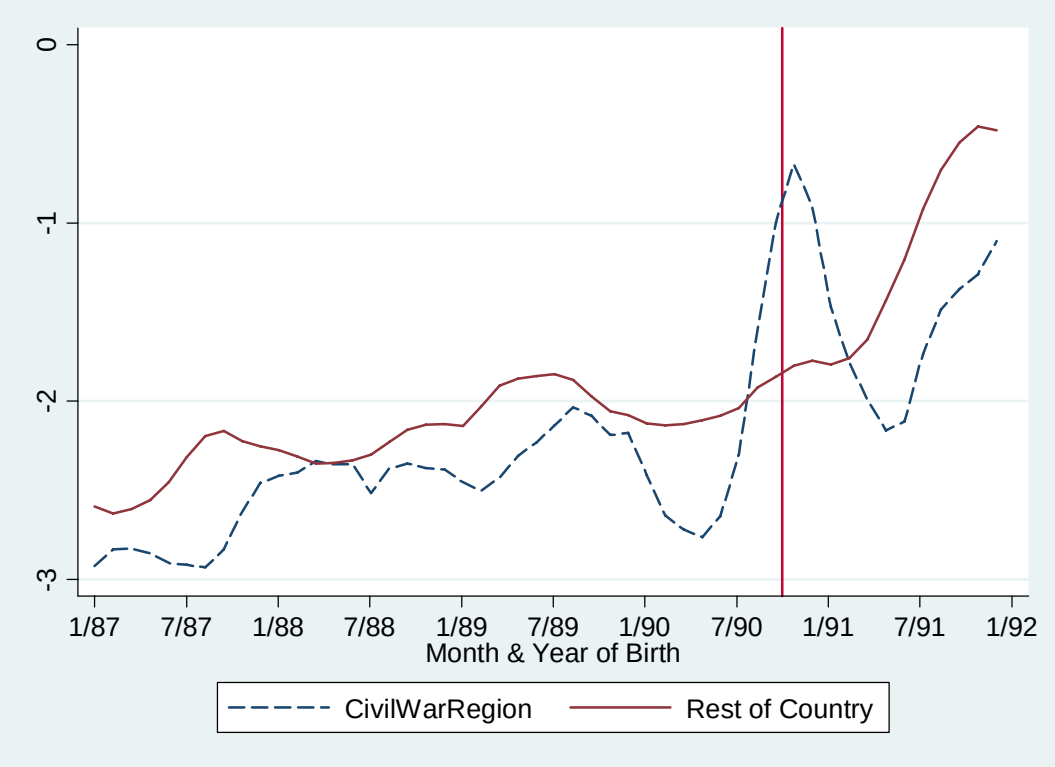
Figure 1: Map of Rwanda Indicating Civil War and Crop Failure Regions

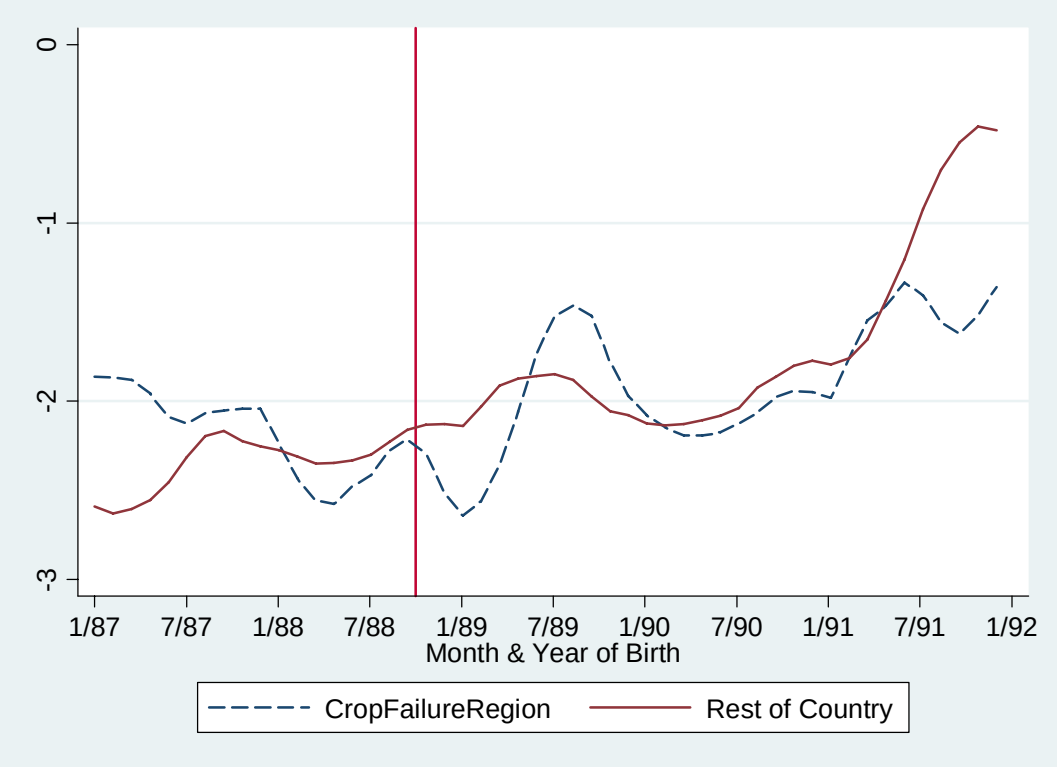
Note: The shaded area in the south, which includes Gikongoro prefecture and the part of Butare prefecture bordering Gikongoro, was affected by a crop failure that started in October 1988. Information sources for this are the NGO reports discussed in the text. The shaded region in the north, bordering Uganda, was affected by the civil war in the period October 1990 to December 1991. Information source for this is Reyntjens (1994). We remark that the latter area expanded in the 1992-1994 period as the RPF troops advanced their positions in Byumba prefecture. That advance however took place after the collection of the UNICEF data which we use in our study.

Figure 2: Height for Age Z-Scores By Civil War Region and Birth Cohort



Notes: Kernel-weighted local polynomial regression (using Epanechnikov kernel) of height for age z-score on birth cohort. Precise information on exact month and year of birth is used in the regressions, although for exposition clarity only January and July are marked on the graph. Vertical line drawn at October 1990, start of armed conflict in civil war regions. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics, and Michigan State University.

Figure 3: Height for Age Z-Scores By Crop Failure Region and Birth Cohort



Notes: Kernel-weighted local polynomial regression (using Epanechnikov kernel) of height for age z-score on birth cohort. Precise information on exact month and year of birth is used in the regressions, although for exposition clarity only January and July are marked on the graph. Vertical line drawn at October 1988, start of crop failure in crop failure regions. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics, and Michigan State University.

Table 1: Overview of Rwanda, By Province

Province	Average Land Size per Household (hectares)	Value of Production [a]	Altitude (meters)	Historical Rainfall Average 1960-1987 (in mm/year)	Height for Age Z-score [b]
Butare	0.81	36000	1660	1217	-1.995
Byumba	1.01	45700	1888	1271	-2.192
Cyangugu	0.66	32200	1917	1559	-2.228
Gikongoro	0.89	21400	1917	1436	-2.080
Gisenyi	0.45	33000	1946	1263	-2.005
Gitarama	0.92	50000	1630	1136	-2.116
Kibungo	1.35	65500	1469	1019	-1.795
Kibuye	1.16	25700	2100	1311	-1.569
Kigali	0.95	67500	1581	1088	-1.703
Ruhengeri	0.79	45200	2115	1276	-2.164
Rural Rwanda	0.89	44300	1802	1258	-1.981

Notes: Crop failure occurred in certain districts in Gikongoro and Butare provinces in October 1988. Civil conflicts occurred in certain districts in Byumba and Ruhengeri provinces starting in October 1990. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics and Michigan State University. Rainfall and altitude information collected by Rwandan Meteorological Service.

[a] Average value of household crop production from 1989 to 1991 in Rwandan Francs.

[b] Height for age z-score is averaged across all children born in that particular province between 1987 and 1991.

Table 2: Difference in Differences Comparing Height for Age Z-Scores for Children Born Before and After the Civil War

Panel A: All children			
	Civil War Region (n=147)	Rest of Country (n=1409)	Difference
Born Before Civil War Shock	-2.407 [0.202]	-2.156 [0.075]	-0.251 [0.164]
Born After Civil War Shock	-1.683 [0.102]	-1.011 [0.138]	-0.672*** [0.194]
Difference	0.724*** [0.099]	1.145*** [0.119]	-0.421*** [0.082]
Panel B: Boys			
	Civil War Region (n=71)	Rest of Country (n=679)	Difference
Born Before Civil War Shock	-2.358 [0.105]	-2.222 [0.102]	-0.136 [0.134]
Born After Civil War Shock	-1.570 [0.011]	-1.000 [0.177]	-0.570*** [0.177]
Difference	0.788*** [0.094]	1.222*** [0.156]	-0.434** [0.175]
Panel C: Girls			
	Civil War Region (n=76)	Rest of Country (n=730)	Difference
Born Before Civil War Shock	-2.454 [0.306]	-2.096 [0.062]	-0.358 [0.218]
Born After Civil War Shock	-1.777 [0.177]	-1.023 [0.240]	-0.754** [0.348]
Difference	0.677*** [0.127]	1.073*** [0.238]	-0.396** [0.173]

Notes: Robust standard errors in brackets, clustered at province level. * significant at 10%; ** significant at 5%; *** significant at 1%. Civil war region denotes districts in Byumba and Ruhengeri provinces and the conflict started October 1990. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics and Michigan State University.

Table 3: Difference in Differences Comparing Height for Age Z-Scores for Children Born Before and After the Crop Failure

Panel A: All children			
	Crop Failure Region (n=206)	Rest of Country (n=1409)	Difference
Born Before Crop Failure Shock	-2.107 [0.128]	-2.336 [0.090]	0.229* [0.121]
Born After Crop Failure Shock	-1.822 [0.350]	-1.728 [0.080]	-0.094 [0.288]
Difference	0.285 [0.479]	0.608*** [0.067]	-0.323 [0.366]
Panel B: Boys			
	Crop Failure Region (n=103)	Rest of Country (n=679)	Difference
Born Before Crop Failure Shock	-2.205 [0.186]	-2.356 [0.097]	0.151 [0.174]
Born After Crop Failure Shock	-1.750 [0.366]	-1.788 [0.120]	0.038 [0.322]
Difference	0.455 [0.554]	0.568*** [0.101]	-0.113 [0.456]
Panel C: Girls			
	Crop Failure Region (n=103)	Rest of Country (n=730)	Difference
Born Before Crop Failure Shock	-1.987 [0.021]	-2.318 [0.105]	0.331*** [0.101]
Born After Crop Failure Shock	-1.884 [0.324]	-1.670 [0.061]	-0.214 [0.255]
Difference	0.103 [0.346]	0.648*** [0.089]	-0.545** [0.247]

Notes: Robust standard errors in brackets, clustered at province level. * significant at 10%; ** significant at 5%; *** significant at 1%. Crop failure region denotes districts in Gikongoro and Butare provinces and the crop failure shock occurred in October 1988. Rest of country excludes the region affected by the other shock. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics and Michigan State University.

Table 4: Province-Birth Cohort Fixed Effects Regressions Measuring the Impact of Civil War and Crop Failure on Children's Height for Age Z-Scores

Dependent Variable: Children's Height for Age Z-Score	(1)	(2)	(3)	(4)	(5)	(6)
Civil War Region * Born After Shock	-0.676***	-0.298***				
	[0.243]	[0.113]				
Female * (Civil War Region * Born After Shock)		-0.718**				
		[0.321]				
Crop Failure Region * Born After Shock			0.019	0.235		
			[0.435]	[0.434]		
Female * (Crop Failure Region * Born After Shock)				-0.414***		
				[0.050]		
Shock Region * Born After Shock					-0.164	0.065
					[0.368]	[0.365]
Female * (Shock Region * Born After Shock)						-0.440***
						[0.098]
Female Child		0.077		0.089		0.080
		[0.075]		[0.085]		[0.074]
Mother's Characteristics						
Child Received Prenatal Care	0.206**	0.206**	0.287**	0.301***	0.188*	0.199*
	[0.098]	[0.096]	[0.114]	[0.117]	[0.110]	[0.112]
Mother Literate	0.130	0.138*	0.111	0.116	0.131*	0.137*
	[0.081]	[0.079]	[0.083]	[0.080]	[0.074]	[0.071]
20<= Mother's Age <30	0.245	0.245	0.351	0.336	0.311*	0.303*
	[0.188]	[0.193]	[0.228]	[0.230]	[0.181]	[0.182]
30<= Mother's Age <40	0.321*	0.324*	0.493**	0.480**	0.465**	0.458**
	[0.185]	[0.186]	[0.243]	[0.242]	[0.206]	[0.203]
Mother's Age >=40	0.134	0.138	0.288	0.276	0.297	0.289
	[0.253]	[0.255]	[0.327]	[0.323]	[0.281]	[0.276]
Province Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
Birth Cohort Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
Number of children	1556	1556	1615	1615	1762	1762

Notes: Robust standard errors in brackets, clustered at province level. * significant at 10%; ** significant at 5%; *** significant at 1%. The civil war regressions in columns 1 and 2 exclude the crop failure regions and the crop failure regressions in columns 3 and 4 exclude the civil war regions. The variable Shock Region * Born After Shock indicates children born in periods following when a region experienced either crop failure or civil conflict. The omitted category for mother's age at time of child's birth is less than 20 years old. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics and Michigan State University.

Table 5: Province-Birth Cohort Fixed Effects Regressions Measuring the Impact of Civil War and Crop Failure on Children's Height for Age Z-Scores, By Household Wealth and Gender

Dependent Variable: Children's Height for Age Z-Score	(1)	(2)	(3)	(4)
	Poor Households		Rich Households	
Panel A: Civil War				
Civil War Region * Born After Shock	-0.468***	-0.378**	-1.501	-0.663
	[0.165]	[0.147]	[0.964]	[1.826]
Female * (Civil War Region * Born After Shock)		-0.196		-1.574
		[0.369]		[2.011]
Female Child		0.104		0.008
		[0.104]		[0.110]
Province Fixed Effects?	Yes	Yes	Yes	Yes
Birth Cohort Fixed Effects?	Yes	Yes	Yes	Yes
Mother's Characteristics?	Yes	Yes	Yes	Yes
Number of children [a]	1076	1076	310	310
Panel B: Crop Failure				
Crop Failure Region * Born After Shock	-0.048	0.279	0.204	0.368*
	[0.466]	[0.503]	[0.176]	[0.209]
Female * (Crop Failure Region * Born After Shock)		-0.657***		-0.317
		[0.138]		[0.374]
Female Child		0.110		0.036
		[0.122]		[0.135]
Province Fixed Effects?	Yes	Yes	Yes	Yes
Birth Cohort Fixed Effects?	Yes	Yes	Yes	Yes
Mother's Characteristics?	Yes	Yes	Yes	Yes
Number of children [b]	1107	1107	345	345

Notes: Robust standard errors in brackets, clustered at province level. * significant at 10%; ** significant at 5%; *** significant at 1%. Each column in each panel is a separate regression where the dependent variable is height for age z-score and the independent variables are as listed. The civil war regressions in Panel A exclude the crop failure regions, and the crop failure regressions in Panel B exclude the civil war regions. All regressions also include province and birth cohort controls as well as the following mother's characteristics: child received prenatal care, mother's literacy, and mother's age at time of child's birth. Households that own less than or equal to 1 tropical livestock unit are considered poor (77.6 percent in Panel A and 77.3 percent in Panel B). Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics and Michigan State University.

[a] In Panel A, 170 children are dropped from the 1556-observation regressions because of missing values for household wealth measures. Results for the regressions in previous tables using this restricted observation sample are similar.
[b] In Panel B, 163 children are dropped from the 1615-observation regressions because of missing values for household wealth measures. Results for the regressions in previous tables using this restricted observation sample are similar.

Table 6: Household-Birth Cohort Fixed Effects Regressions Measuring the Impact of Civil War and Crop Failure on Children's Height for Age Z-Scores

Dependent Variable: Children's Height for Age Z-Score	(1)	(2)	(3)	(4)	(5)	(6)
Civil War Region * Born After Shock	-0.855***	-0.969***				
	[0.309]	[0.275]				
Female * (Civil War Region * Born After Shock)		0.177				
		[0.170]				
Crop Failure Region * Born After Shock			-0.834***	-1.035***		
			[0.167]	[0.319]		
Female * (Crop Failure Region * Born After Shock)				0.250		
				[0.285]		
Shock Region * Born After Shock					-0.784***	-0.990***
					[0.167]	[0.264]
Female * (Shock Region * Born After Shock)						0.280
						[0.234]
Female Child		0.040		0.041		0.037
		[0.095]		[0.112]		[0.088]
Mother's Characteristics						
Mother Literate	0.527	0.491	0.223	0.228	0.331	0.278
	[0.416]	[0.380]	[0.625]	[0.606]	[0.507]	[0.470]
20<= Mother's Age <30	0.040	0.025	-0.051	-0.060	0.040	0.022
	[0.183]	[0.182]	[0.195]	[0.190]	[0.167]	[0.168]
30<= Mother's Age <40	0.023	0.006	-0.080	-0.087	-0.031	-0.058
	[0.291]	[0.282]	[0.317]	[0.307]	[0.295]	[0.289]
Mother's Age >=40	-0.310	-0.318	-0.779	-0.778	-0.495	-0.493
	[0.800]	[0.798]	[0.799]	[0.787]	[0.781]	[0.780]
Household Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
Birth Cohort Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes
Number of children	1556	1556	1615	1615	1762	1762

Notes: Robust standard errors in brackets, clustered at province level. * significant at 10%; ** significant at 5%; *** significant at 1%. The civil war regressions in columns 1 and 2 exclude the crop failure regions and the crop failure regressions in columns 3 and 4 exclude the civil war regions. The variable Shock Region * Born After Shock indicates children born in periods following when a region experienced either crop failure or civil conflict. Mother's characteristics are identified from variation across children in multiple wife households. Results are similar if mother's characteristics are excluded in these household fixed effects regressions. Child received prenatal care is dropped from the regressions as there is no variation at the household level. The omitted category for mother's age at time of child's birth is less than 20 years old. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics and Michigan State University.

Table 7: Regressions Measuring the Impact of Alternative Crop Failure Shock Measures on Children's Height for Age Z-Scores

Dependent Variable: Children's Height for Age Z-Score	DSA Agricultural Production Sample (1)	UNICEF Sample All Children (2)	UNICEF Sample All Children IV specification (3)
Household Production Shock	0.012*** [0.004]		
Normal Rainfall Deviation		0.272** [0.129]	
Large Positive Rainfall Deviation		0.427*** [0.154]	
Crop Failure Region*Born After Shock [a]			-1.857** [0.943]
Number of children	473 [b]	1762	1762

Notes: Robust standard errors in brackets, clustered at province level. * significant at 10%; ** significant at 5%; *** significant at 1%. All regressions also include province and birth cohort controls as well as the following mother's characteristics: child received prenatal care, mother's literacy, and mother's age at time of child's birth. Household production shock is defined as the difference between the value of farm output during the year the child is born and the 3-year average farm output. A larger value for this variable indicates production in the year of the child's birth is higher than the 3 year average production (i.e. a positive production shock). In column 2, dummy variables are created to measure whether rainfall deviations (annual rainfall minus the long-run historical province average) were large positive rainfall shocks, large negative rainfall shocks, or normal rainfall years. The omitted category is large negative rainfall shock. Data source: Survey conducted by UNICEF, the Rwandan Department of Agricultural Statistics and Michigan State University.

[a] Crop Failure Region * Born After Shock is treated as endogenous and instrumented for with dummy variables measuring rainfall shock deviations (large positive rainfall shock, normal rainfall year, large negative rainfall shock).

[b] DSA production data were only collected between October 1988 and September 1991 and only for a sub-sample of the UNICEF surveyed households, leaving only 473 children with complete information on the household production shock at the time of birth. Additional details in the text.