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Fetal Origins of Personality: Effects of early life circumstances on adult personality traits*

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Abstract

Personality traits are highly predictive of life outcomes and successes. However, little is known about their formation and what can hamper their development. There is ample evidence that conditions in early-life can have persistent influence on health and cognitive skills. In this paper, we ask whether this is also the case for the formation and development of personality traits. We find strong and robust evidence of persistent impacts among siblings of early-life rainfall fluctuations on measures of a latent personality trait, known as core self-evaluation, in adulthood. The results are driven by females, irrespective of the gender composition of siblings within the household. There is heterogeneity across households likely to have different levels of credit access, suggesting a household wealth mechanism; effects are strongest for households with lowest durable asset holdings. Effects on other outcomes in adulthood suggest that early life rainfall may impact adult core self-evaluation through health, schooling and wealth, although we cannot rule out reverse causality.

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1 Introduction

Little is known about the formation of personality traits, despite their importance for numerous adult-life outcomes (Almlund et al., 2011). While it has been established that early-life (including prenatal) conditions have a remarkable influence on cognitive skills, health and socioeconomic outcomes of adults (Almond and Currie, 2011b; Currie and Vogl, 2013), there is virtually no evidence on whether early-life conditions also influence adult personality traits, and, more generally, what can promote or hamper their development before they stabilize in adulthood (Almlund et al., 2011).

In this paper, we ask whether early-life conditions can have a permanent effect on the formation and development of personality traits that can be detected in adulthood. To do so, we exploit exogenous variation in rainfall in a rural developing country setting where livelihoods of the majority of households are dependent on rain-fed subsistence farming. We build on the empirical set-up used in Maccini and Yang (2009) - and a number of subsequent studies - to identify the causal impact of being exposed to unanticipated deviations from the usual seasonal rainfall patterns in early-life on the formation of personality traits among siblings in adulthood. We control for seasonal, village, district-birth year and sibling fixed effects; the latter in order to address potential endogeneity of fertility behavior. In addition, by using within sibling variation, we also control for unobserved parental characteristics and personality traits, which may influence how parents cope with unexpected rainfall fluctuations and, thus, whether and how such fluctuations translate into impacts on children.

We utilize the Kagera Health and Development Survey (KHDS) from rural Tanzania: an individual level tracking survey spanning 20 years, which provides detailed childhood and young adulthood information and is linked to historical rainfall data collected in nearby rainfall stations¹. To account for measurement error in the rainfall data, we construct a measure based on average rainfall recorded in stations closest to the village where an individual was born, weighted by scaled distance to the village. We use measures of deviations in the two annual rainy seasons relative to the usual patterns for the local

¹The last follow-up survey, which we mainly rely on, was financed by the Rockwool Foundation and the World Bank. For more information, see De Weerd et al. (2012).

area to capture exposure to fluctuations unanticipated by the household. The area is characterized by a bimodal rainfall pattern. We therefore also examine the role of each of the two rainfall periods, *Vuli* and *Masika*, where the former is linked to the main harvest of annual crops.

Our outcome measure is a latent personality trait known as ‘core self-evaluation’, see Judge et al. (2002). It indicates the degree to which one has a generally positive and proactive view of oneself and one’s relationship to the world, Almlund et al (2011:77). It is a composite measure based on three separate measures of self-esteem, self-efficacy and locus of control. Individuals with high core self-evaluation have been found to be more successful in their job careers and better at pursuing further education and maintaining better health (Judge and Hurst, 2008).

We show that variation in rainfall during the in-utero stage has a strong long-term impact on core self-evaluation (CSE) in young adulthood (at 17-28 years of age). The persistence of this effect is striking. In particular, we find that a ten per cent increase (or decrease) in rainfall relative to the long run average results in an increase (decrease) in core self evaluation of 0.08 of a standard deviation. We do not find any evidence that rainfall prior to or after the in-utero period has any permanent significant effects. The results persist when utilizing separate and alternative measures for self-esteem and agency as outcomes and when controlling for past rainfall to account for the possibility of cyclicalities in the rainfall patterns.

Examining the exact timing of exposure to the two rainy seasons, we find that the main results are driven by in-utero exposure to fluctuations in the *Vuli* rains specifically. A ten per cent increase in *Vuli* rains relative to the long term mean results in an increase in CSE by adulthood of 0.1 of a standard deviation. This pattern of effects suggests that one plausible explanation for the impacts is nutritional deprivation during the weaning period. Fluctuations in *Vuli* rains affect the subsequent *Vuli* harvest and, therefore, the severity of the subsequent hunger period when food stocks are depleted. Children who experience *Vuli* rains in-utero are 4-12 months of age and likely to be weaning during this subsequent hunger season. This explanation is also consistent with the findings in Bengtsson (2010), who uses the same data-set to show a significant correlation between

rainfall and body-weight of household members, especially children age 0-9. Alternative mechanisms are plausible, however, the results could also be driven by adverse effects of in-utero exposure to maternal physical or mental stress during pregnancy as a direct and immediate consequence of shortfalls in *Vuli* rains.

As often found in similar studies, the impact in our sample is driven by girls. This is consistent both with the presence of gender differences in parental response to an impairment caused by early-life shocks and with selective male mortality (Currie and Vogl, 2013). We further show that households with low holdings of durable assets are least able to shield their children against impacts of rainfall fluctuations. Finally, in line with existing evidence, we find indications that early life rainfall in this setting also affects other key outcomes, even after controlling for sibling fixed effects, including self-reported health, schooling and household wealth

Our study is related to two strands of literature in economics. First of all, it adds to the research examining the fetal origins hypothesis and the relationship between early-life conditions and adult outcomes. The ‘fetal origins hypothesis’ from the epidemiological literature posits that adverse health conditions in adulthood may be triggered by adverse conditions in-utero. Almond and Currie (2011b) review this and the associated economic literature and argue that there is a wealth of evidence in its support. Similarly, there is also substantial evidence of the importance of how postnatal ‘early influences’ can affect not only later health outcomes, but also non-health outcomes such as socio-economic status in adulthood, labor force outcome, and cognitive skills or educational outcomes as reviewed by Almond and Currie (2011a) and Currie and Vogl (2013).

Our study is also related to the research on non-cognitive skills and personality traits, showing a strong association with life outcomes and successes. Almlund et al. (2011) provide an excellent overview of how personality and non-cognitive skills measures are often as strong predictors of later academic and economic success, health and risky behavior (e.g. criminal activity, smoking or teenage pregnancy) as typical cognitive measures, such as IQ or achievement test scores. Further, Conti and Heckman (2014) emphasize that there is now ample evidence of the importance of early childhood in

shaping children’s capabilities as initial endowment of skills matter for how productive further investments into these and complementary skills are.

Finally, our study also relates to the studies of the impact of early life exposure to famine on adult personality disorder or mental distress. Based on the Dutch WWII famine and the later Great Leap Forward Chinese famine, there is evidence that prenatal exposure to famine increases the risk of antisocial personality disorder (Neugebauer R et al., 1999), of schizophrenia (St Clair D et al., 2005; Xu et al., 2009; Susser et al., 1998), and of a broad spectrum of mental illnesses (Stein et al., 2009; Huang et al., 2013) in adulthood. The Dutch studies look at men only, while the Chinese studies show strong sex-specific findings with negative impacts mainly being detected among women. This could be driven by higher male vulnerability and early-life selective male mortality, as argued by e.g. Huang et al. (2013); Currie and Vogl (2013). Most recently, Adhvaryu et al. (2014) have shown that in cocoa producing provinces of Ghana early life exposure to transitional but high global cocoa price variations increases the relative risk of severe mental distress in adulthood. This suggests that even shorter and potentially less severe (given a certain degree of smoothing) early life exposure to transitory income or nutrition fluctuations can have long term consequences on adult mental health.

In this paper, we generalize this evidence further by looking at the impact of unanticipated transitory rainfall fluctuations in early life on a broad and general personality trait, core self evaluation, in the normal adult population.

The paper is organized as follows; in Section 2 we present the empirical model and in Section 3 we take a careful look at the data used. Results are presented in Section 4, Section 5 concludes.

2 Conceptual Framework & Empirical Model

Identifying long-term impact of early life environment is challenging for a number of reasons including the difficulty of observing the relevant dimensions and accounting for the non-random nature of the setting into which an individual is born. We study a

sample of households in which the livelihoods of the great majority is highly dependent on rain-fed agriculture; here rainfall patterns in-utero and the first few years of life are a key dimension of the child’s early life circumstances. It can be difficult to disentangle the effects of early-life conditions from unobservable factors correlated with these conditions as well as the outcome of interest. However, by utilizing exogenous measures of unanticipated rainfall fluctuations (as opposed to, for instance, self-reported shocks), we reduce concerns about various unobservable confounders.

We estimate the following equation:

$$\begin{aligned}
 PT_{ijvt} = & \beta_0 + \beta_1 Rainfall_{ijv,t-1} + \beta_3 S_{ijv} + \beta_4 Male_{ijv} \\
 & + \mu_v + k_{dt} + \varepsilon_{ijv2010}
 \end{aligned} \tag{1}$$

Where PT_{ijvt} are the adult personality traits for individual i , born in household j in village v , year t , $Rainfall_{ijv,t-1}$ is a measure of in-utero rainfall during the rainy seasons in the 12 months before birth, S_i controls for season of birth (rainy versus dry), μ_v is the village fixed effect, and k_{dt} is a district-year of birth fixed effect. We discuss measurement of PT and $Rainfall$ in detail below. Year of birth and season fixed effects control for any cohort specific effects allowing these to vary over districts and possible seasonality in fertility; village fixed effects control for any unobservable correlates of weather patterns and local levels of human capital accumulation. It may be, for instance, that villages which are more likely to experience unstable weather are on average worse-off and have less infrastructure such as schools, or that more apt individuals predominantly locate in villages with more stable weather conditions; we, therefore, restrict our comparison to within village.

It is possible, that there may be systematic differences between households in the way that they cope with rainfall fluctuations. Say, all else equal, that parents with certain personality traits (e.g. higher core self-evaluation) are better able to shield their children from adverse effects of unanticipated rainfall fluctuations than parents with lower core self-evaluation. Furthermore, some parents may also incorporate observed

weather patterns into their fertility decisions, such as more educated households putting off having children during years of less favorable weather conditions. In this case the children who experienced the largest rainfall fluctuations in-utero are also children of less educated parents with low core self-evaluation, who are themselves likely to have lower self-evaluation. Our preferred specification, therefore, includes controls for sibling fixed effects² which alleviate these concerns, especially if the fertility decision-making process is similar across children of the same parents.

3 Data

3.1 Survey

The Kagera Health and Development Survey (KHDS) in Tanzania is one of the longest running African panel surveys designed to study long-run and inter-generational trends in and mechanisms of poverty persistence and economic growth in rural households. Kagera region lies at the shores of Lake Victoria and shares a border with Uganda, Rwanda and Burundi. The 2012 census estimated a population of just under 2.5 million. More than 80 per cent of the households rely on agricultural production as their main source of income (National Bureau of Statistics and Ministry of Finance, 2013). The first round of interviews was held in 1991-1994 with 915 households originating from 51 villages and urban areas across Kagera interviewed up to four times (World Bank, 2004). The first follow-up survey was organized in 2004 with the aim of re-interviewing all individuals ever interviewed at the baseline (1991-94). This involved tracking individuals who had migrated away from the village to other parts of the region, elsewhere in Tanzania or to neighboring Uganda. More than 93 per cent of the baseline households were re-contacted after a 10-year period (Beegle et al., 2006a).³ Due to migration and other reasons for household partitions, the 2004 sample expanded to more than 2,700 households. The second follow-up survey was organized in 2010. This time the tracking rate was 92 per cent yielding a sample of more than 3,300 households (De Weerd et al.,

²We define siblings as individuals who have at least one parent in common.

³This excludes 17 households in which all previous household members were deceased.

2012). Relative to comparable panel surveys, these household level attrition rates are exceptionally low (Alderman et al., 2001). At the individual level, the re-interview rates among survivors were 82 per cent in 2004 and 85 per cent in 2010.

At each round of the survey a multi-topic household survey was administered to all split-off households containing individuals who had resided in the original baseline sample of households. Topics covered range from education, health, employment and migration of individual household members, to household asset ownership, consumption expenditure, formal and informal networks, remittances, history of economic shocks, and more (see De Weerd et al. (2012) for a detailed description). An innovative addition to the last round of the survey in 2010 was a module to measure some core individual personality traits including self-esteem, self-efficacy and locus of control of those who were observed as children in the baseline 1991-1994 rounds, and were adults (age 17-28) by the 2010 follow-up round. These personality traits data are used to construct the outcomes of interest in this paper.

3.2 Rainfall

The annual rainfall patterns in the districts of Kagera are shown in Figure 1. Combined with Table 2, Figure 1 further shows that across the districts there is noticeable fluctuation in rainfall over the time covered by the available rainfall data, ranging between nearly 2,000 mm in the High Rainfall Zone (where parts of Bukoba and Bukoba Rural Districts are located) to about half of that in Ngara Region, where households rely on swampy valleys for farming during the extensive dry seasons.

Kagera is a region subject to bimodal rains, the *Masika* rains from March to May, and the *Vuli* rains from September to December. Figure 2 shows that this pattern holds quite consistently across the baseline districts. According to two agricultural censuses from Kagera, the main annual crops are beans and maize (National Bureau of Statistics, 2007, 2012). These can be harvested twice, but the main harvest follows the *Vuli* rains. Annual crop production is the main source of food production and it relies heavily on the rainfall patterns, whereas the perennial crops, such as coffee and cooking banana

Figure 1: Total annual rainfall and total rainy season rainfall in KHDS baseline districts (1980-2004)

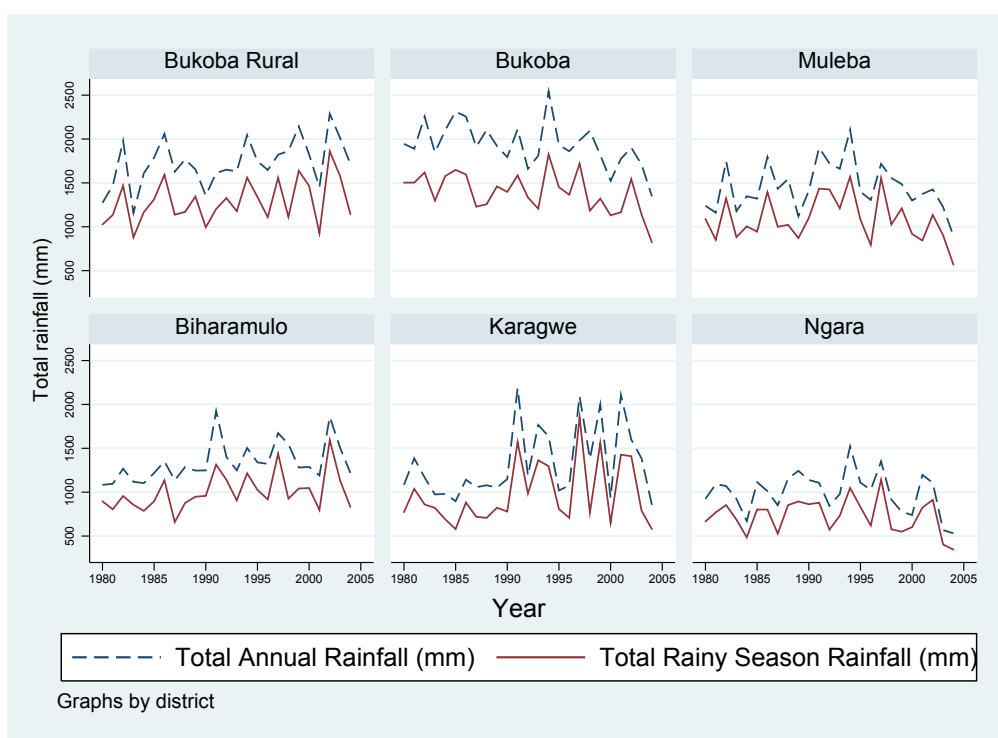
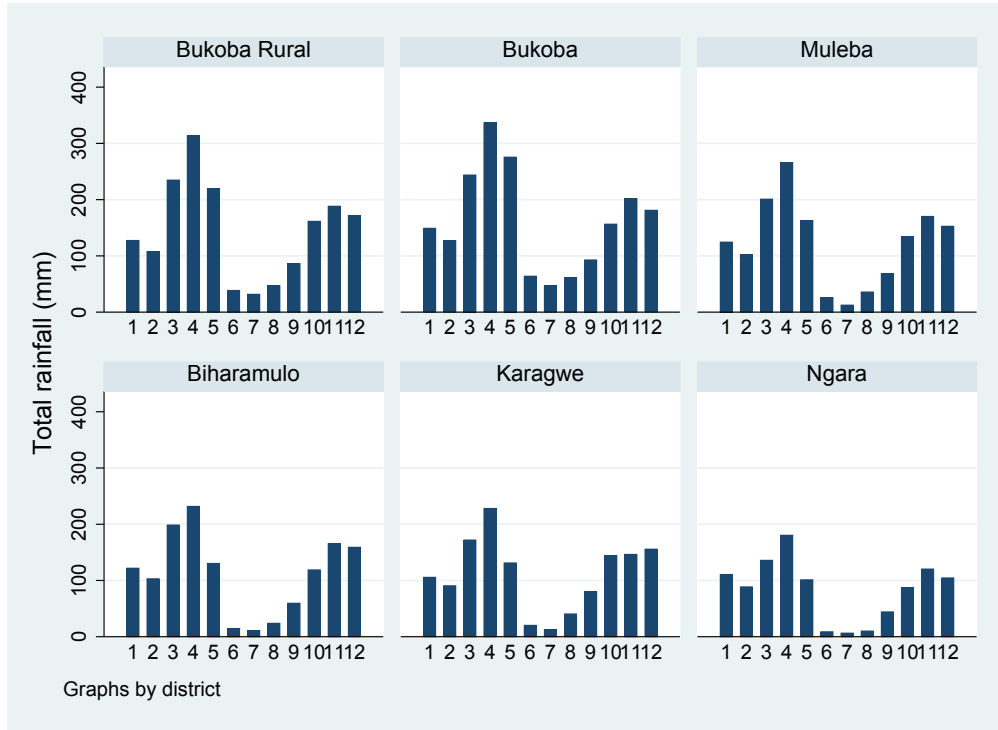


Figure 2: Monthly rainfall in KHDS baseline districts (1980-2004 average)



Source: KHDS rainfall data from 23 local rainfall stations

are more resistant to rainfall fluctuations. The top half of Figure 3 shows points in the year when the rainy seasons, the subsequent harvest periods and the hunger season typically set in (adapted from the famine early warning system network, FEWS NET, for Tanzania and Mitti et al. (2007)). This shows that the lean season sets in prior to the main harvest which follows the *Vuli* rains. The harvested beans and maize from the previous *Vuli* harvest are only somewhat supplemented by additional maize or tuber crops from the *Masika* harvest; the last few months before the main *Vuli* harvest (October - December) are, therefore, the leanest of the year. The start of the lean period is thus determined by the *Masika* rains and harvest, whereas its length and severity is determined by the *Vuli* rains and harvest.

We measure rainfall using historical rainfall data that were collected as an additional component of the 2004 and 2010 KHDS follow-up surveys; the aim was to collect records from all of the weather stations located closest to the baseline villages. An extensive effort was made to collect data from more weather stations than captured in publicly available data-sources, such as the National Oceanic and Atmospheric Administration (NOAA). Data were collected for 23 weather stations; in some cases only paper copies of the records were available and had to be entered. The available records span from 1980 until 2010 and include monthly recordings of total precipitation, as well as the altitude, longitude and latitude of the station location.

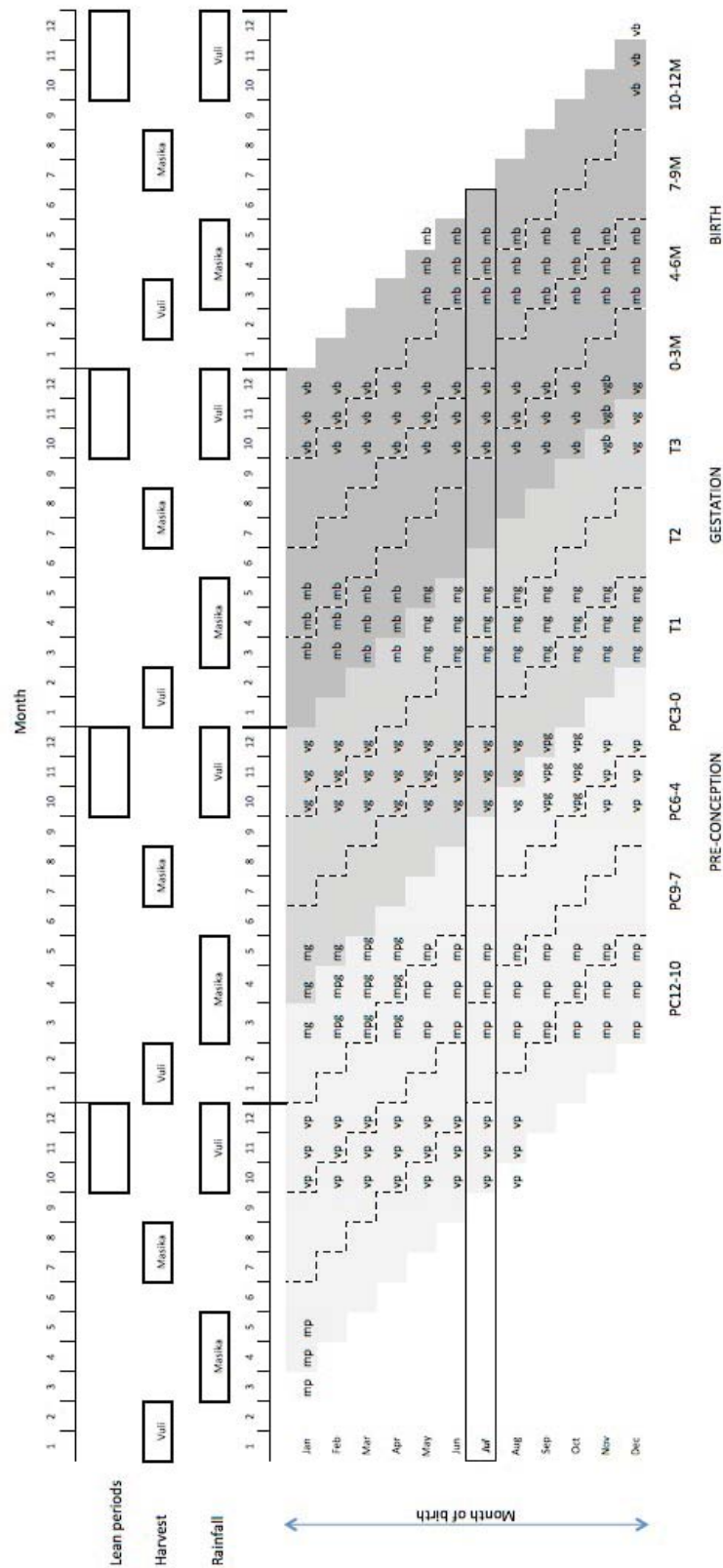
In order to construct a village specific rainfall measure, we apply an inverse distance weighted (IDW) interpolation procedure using data from three closest nearby stations.⁴ The interpolation procedure generates a measure which gives greater weight to values from stations located more closely.⁵ Relative to alternative measures, such as rainfall from the closest station, this one increases the chances that the most relevant rainfall is captured. Often the closest and second closest stations, for instance, are only a few kilometers apart and it may well be the case that it is the second station that captures the rainfall that is most relevant for a given village.

To measure early-life environment, we link the rainfall data to individual's month of birth. We define the main period of interest as rainfall in the two rainy seasons in the 12 months preceding the birth; we also look at effects of rainfall in the 12 months after the birth and 12 months after that. The rainfall measure used in the analysis is constructed as the deviation of the natural log of early childhood rainfall over the relevant period from the natural log of the average over ten years around the time of birth (1980 to 1990). Bottom panel of Figure 3 shows exactly how the linking was done. The vertical axis displays the month of birth, while exposure to different rainy seasons in early life is captured in the step-wise shaded areas. For instance, for an individual born in July, the mother is exposed to *Vuli* rains 10-12 months prior to conception, she is then exposure to *Masika* rains 5-7 months prior to conception, in pregnancy she is experiences *Vuli*

⁴An alternative approach would be to define a maximum distance within which all data would be used. Taking all stations within a 100km radius does not change the main findings, though the estimates are less precise as the measure is more noisy.

⁵For a more specialized discussion of this method see for instance Chen and Liu (2012).

Figure 3: Tanzania seasonal calendar for bimodal rains, hunger seasons and early-life exposure



Note: PC12-10: 12-10 months pre-conception, PC9-7: 9-7 months pre-conception, PC3-0: 3-0 months pre-conception, T1: first trimester in-utero, T2: second trimester in-utero, T3: third trimester in-utero, 0-3M: 0-3 months old, 4-6M: 4-6 months old, 7-9M: 7-9 months old, 10-12M: 10-12 months old. Timing of exposure labels: m: Masika, v: Vuli, p: pre-conception, g: gestation, b: birth or after, e.g. 'vg' show exposure to Vuli rains during gestation and 'mb' shows exposure to Masika rains after birth.

rains again in the first trimester and *Masika* rains mainly in the third trimester. During the next *Vuli* rains the infant is 4-6 months old and he/she is 9-11 months during the next *Masika* rains.

Table 1 shows the correlation between lagged rainfall measures going back two years (four rainy seasons) that will be used in the analysis in this paper and household consumption⁶ and income. The estimates suggest that consumption and income increase by more than 2 percent in response to 10 per cent increase in rainfall during the previous rainy season. As expected the biggest effect is on food consumption. Further, there is some evidence of longer-term effects of rainfall on non-food consumption and income: rainfall from two rainy seasons before the interview has even slightly larger effects than rainfall from the previous rainy season, which could be driven by savings.⁷

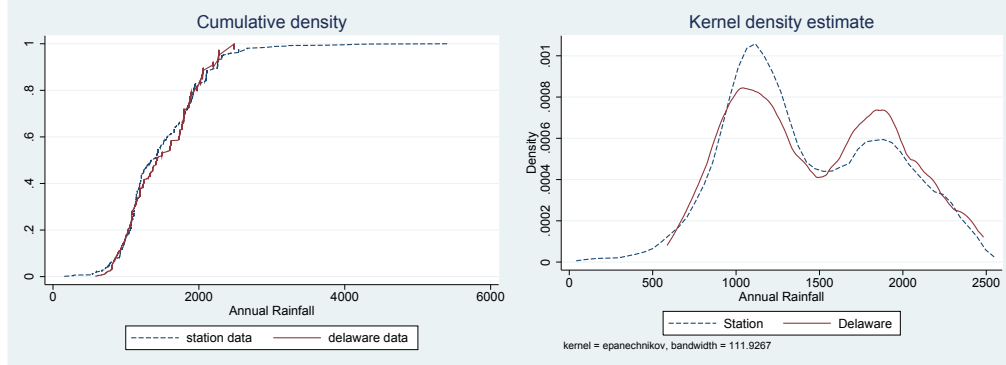
As a robustness and validity check of our rainfall data, we have compared them with the widely used and trusted source of monthly gridded rainfall data from the University of Delaware, version 3.02, available for the years 1900-2010. Figure 4 shows the cumulative distribution function and kernel probability density estimates of long-term average annual rainfall using the Delaware gridded and station rainfall data for the years during which the analysis sample could have been in-utero (1980-1992), linking closest points in both data-sets to the KHDS villages. Visually there is a clear similarity. Further, the means are remarkably close and not significantly different from each-other (difference of 0.06 mm)⁸. Despite these similarities there are two important reasons why the rainfall station data are more appropriate for the analysis we undertake. Firstly, the points in the gridded Delaware data-set are on average nearly twice as far from the KHDS villages as location of the rainfall stations from which station level data are available (at 21.2 and 12.8 km respectively). Secondly, gridded rainfall data (as well as satellite rainfall

⁶Note that consumption expenditure includes the values of goods consumed from home production.

⁷A more extensive investigation of the link between rainfall and household welfare can be found in a paper by Bengtsson, who uses the same KHDS data to show strong correlation between rainfall and household income, expenditure and profits, as well as body weight of household members (especially children age 0-9), (Bengtsson, 2010). He finds an increase in body weight for female children as a result of an increase in household income induced by rainfall fluctuations, whereas the body weight of adolescents and young adults is virtually invariant to income changes.

⁸The differences in the middles of the distributions, however, do result in a rejection of the Kolmogorov-Smirnov test for equality of distributions (which is particularly sensitive to differences in the middle rather than tails of distributions).

Figure 4: Annual rainfall patterns in KHDS villages using rainfall station and Delaware gridded data



Sources: KHDS rainfall data from 23 local weather stations and University of Delaware gridded rainfall data, version 3.02

data) are generally considered less suitable for analysis of a specific, relatively small, geographic area and are more suited for analysis at country or higher levels.⁹

3.3 Personality Traits

The data collected inform on three personality traits; self-esteem, self-efficacy and locus of control. Self-esteem reflects a person's overall evaluation of his own worth, in the sense of self-worth, self-respect, and self-acceptance (Rosenberg, 1989). Self-efficacy captures a belief about the link between one's own behavior and its consequences and one's capability to behave or act to achieve desired outcomes (Bandura, 1977). Locus of control is closely linked to self-efficacy relating more to whether individuals believe that they can control events in their lives (Rotter, 1966); both are related to the broader concept of individual agency.

Although less is known about the formation of these traits, than, for instance, verbal and mathematics skills, there is evidence to suggest that they are positively affected by parental support and a nurturing home environment and negatively affected by adverse childhood events (e.g. Carton and Nowicki, 1994). More generally, Trzesniewski's study of twins suggests that while self-esteem has a moderate genetic component, a

⁹Source: personal correspondence with Kenji Matsuura, Department of Geography, University of Delaware

substantial amount of variance is due to environmental factors (Trzesniewski et al., 2003). Consistently with this, there is evidence to suggest that there is a link between socio-economic status and development of locus of control, which becomes detectable in children as young as four (Stephens and Delys, 1973).

The literature suggests that these traits matter because individuals with a more internal locus of control and higher self-efficacy and self-esteem are generally more active in improving their lives and work out ways of exercising some measure of control even in the face of limited opportunities (Bandura, 1977; Rotter, 1966; Judge et al., 1998). The psychology literature presents ample evidence of the link between these traits and academic and occupational achievement, as well as general physical and mental well-being, and antisocial behavior (e.g. Schwarzer and Fuchs, 1996; Donnellan et al., 2005). A number of studies in economics have also established a link with education, employment and socioeconomic outcomes (Carneiro et al., 2007; Goldsmith et al., 1997; Heckman et al., 2006).

In order to measure the personality traits of interest we followed the established practice of aggregating responses to sets of statements relating to a range of beliefs reflecting the traits of interest to construct measures of these traits. In selecting scales appropriate for rural Tanzania, we relied on a combination of well-established scales as well as measures used in other studies in similar settings. Self-esteem was measured using the Rosenberg scale (Rosenberg, 1989), which has been applied in a large variety of diverse settings; locus of control was measured using a culturally appropriate sub-set of statements from the Rotter scale (Rotter, 1966); and self-efficacy was measured using a set of items from a number of existing scales collated into a culturally appropriate measure for use with adolescents and young adults in Sub-Saharan Africa.¹⁰ In total KHDS respondents were asked to indicate the degree of agreement with a set of 22 statements. Response choices are on a four point scale ranging from total disagreement to total agreement. Table A.2 in the Appendix shows each of the statements with corresponding distribution of responses and raw average scores for each; statements relating to locus of control are split by whether they reflect an internal or external locus of control.

¹⁰The selection was based on the questions used in the Young Lives Longitudinal Study across four countries including Ethiopia (<http://www.younglives.org.uk>). This is a large-scale longitudinal study of two cohorts of children currently 12 and 19 years of age.

There is a long-standing literature in psychology questioning the independence of some of the most common concepts including self-esteem, self-efficacy and locus of control from each-other (Judge et al., 2002). A number of studies in different contexts found that there is a strong connection between these measures (Saadat et al., 2012) and that behaviors of individuals with external locus of control and low self-efficacy is consistent with behaviors of those with low self-esteem and vice versa (Brockner, 1979). As a consequence many studies caution against investigating related concepts in isolation (Watson and Clark, 1984; Block, 1995). Our data are consistent with this connection. Firstly there are statistically significant positive correlations between the three measures ranging between 0.36 and 0.42¹¹ (i.e. those with higher self-esteem also have a more internal locus of control and higher self-efficacy). Further, using iterated principal factor analysis we find that the statements with the highest factor loadings for the first factor, which has an eigenvalue of 1.6, come from all of the three scales. Below we report the items with the highest loading (more than 0.25), see Table 3.¹²

In the psychology literature the higher level core construct that contains related elements of self-esteem, self-efficacy and locus of control (as well as related measures of neuroticism) is termed “core self-evaluations” (CSE) - a trait that reflects an individual’s evaluation of their abilities and own control (Judge et al., 1998). This definition is consistent with the statements from the three scales that have the highest loading in the first factor (Table 3), such as *“At times I think I am no good at all”* and *“There is not much opportunity for me to decide for myself how to do things in my daily life”*. We, therefore, use this term to describe the latent personality traits measured by the first factor and use it as the main outcome in our analysis. To construct the outcome we standardize the factor so that it has a mean of zero and standard deviation of one; a higher score reflects a more positive CSE.¹³

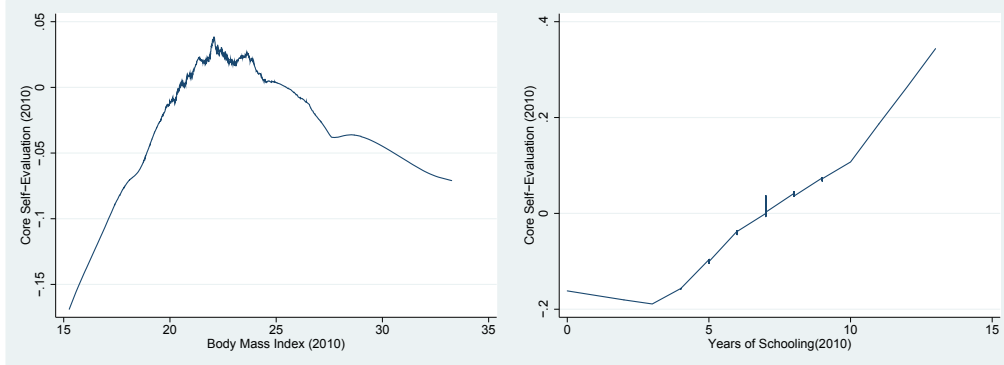
Correlations between our CSE measure and contemporaneous individual characteristics, health and schooling are consistent with the literature. Judge et al, for instance, find that in the National Longitudinal Surveys of Youth (NLSY79), individuals with higher

¹¹With the scores for the negative items reversed.

¹²The complete set of factor loadings for the first factor can be found in Appendix Table A.2.

¹³We also present the main results using disaggregated principal components and raw measures in the robustness checks.

Figure 5: Correlations between Core Self-evaluation and other adult outcomes



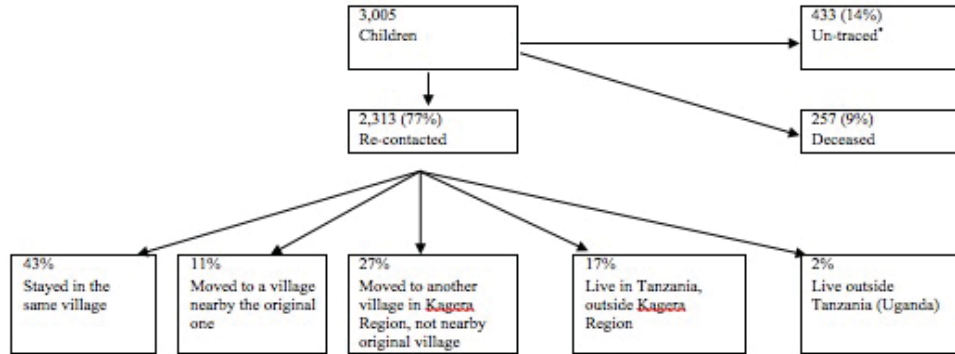
CSE were also more successful at work, paid more, had more education and better health (Judge and Hurst, 2008). In line with this evidence, the two-way lowess graphs in Figure 5 show that individuals in the healthy Body Mass Index range (18-25) have the highest CSE and that CSE increases with schooling. While we have no direct way of testing the validity of our main outcome measure, the consistency of its behavior with the main body of evidence is reassuring.

3.4 Sample

Due to time constraints it was not possible to collect data on personality traits for all panel respondents. Interviewers were instructed to sample those individuals for whom there is childhood baseline data.¹⁴ If more than one of the individuals from this 'eligible' group were found in a household in 2010, one was randomly selected to be the respondent for the personality traits module. In total the personality traits module was administered to 49 percent of those who were "eligible". Since members of the original 915 households had formed 3,300 households by 2010, this strategy ensured that the data includes personality traits of siblings who were growing up together in 1991-1994 and had moved apart by 2010. Additional restrictions to the analysis sample are dictated by availability of rainfall data and information about the respondents' place of birth. The earliest year for which we have rainfall data is 1980; to capture in-utero conditions

¹⁴This design was intended to facilitate analysis of the impact of childhood conditions (measured in the 1991-1994 baseline rounds) on personality traits in adulthood (measured in 2010).

Figure 6: Tracking of analysis sample



Note: Figure shows how all children from baseline sample (KHDS 1991-94) were tracked in the second follow-up round (KHDS 2010).

we, therefore, have to restrict the sample to those born after 1980. Finally, just under 20 per cent of those who fulfill all these criteria were not born in the baseline village so early life rainfall data is missing for them. Conditional on all of these restrictions, the final analysis sample consists of 897 individuals.

The relevant group for assessing attrition is among this “eligible” group (those who were under the age of 15 in the 1991-1994 baseline rounds). As shown in Figure 6, overall 77 percent of those who were under the age of 15 during the baseline were re-interviewed in 2010, 9 percent had passed away and 14 percent were not found.¹⁵

To investigate the nature of attrition between the baseline and 2010 surveys, we estimate an OLS model using an indicator of whether an individual is in the sample in 2010 as the outcome on some key individual and household level characteristics. The results, presented in Appendix Table A.1 show significant correlates between inclusion in the 2010 sample and orphanhood, parental education, land ownership and household size, but no significant correlates with individual level characteristics, which would be more of a concern since we can only control for fixed effects at the sibling or parental level.

While concerns about unobservable correlates of attrition remain, it is reassuring that

¹⁵Notably, the distribution of those who were found by new location shows that had the thorough tracking component of the survey not been undertaken, the attrition rate would have been more than twice as high.

at least based on observables, there is no evidence of systematic differences in individual characteristics of those who were re-surveyed in 2010 and those who were not.

Table 4 shows some basic baseline characteristics for the 897 individuals included in the analysis sub-sample. Just under half are male, average age at baseline was 4.4 years and only 8 percent of the children had started school. They tend to have been living in quite large households (around 8 members) with 5.3 acres of land at their disposal; 7 percent of the children were already maternal orphans, and 13 percent paternal. On average the deviation of natural log of rainfall from the 25 year average in the *Masika* and *Vuli* rainy seasons in the 12 months preceding the month of birth was 0.07, ranging from -0.56 to 0.87.

4 Results

4.1 Main Estimates

The main estimates are presented in Table 5; all standard errors are clustered at the village level. The first two columns show estimates of β_1 , the coefficient on the weighted rainfall deviation of natural log of total rainfall in the *Masika* and *Vuli* rains during the in-utero period from the long-run average, and β_4 , the coefficient on the male dummy in Equation 1. In the first column we control for village, district-birth year and birth season fixed effects; the second column also includes controls for sibling fixed effects and is our preferred model. The main outcome - core self-evaluation - is the first principal factor from iterated principal factor analysis combining items from the self-esteem, self-efficacy and locus of control scales. The results suggest that rainfall during the in-utero period has a positive impact on core self-evaluation in adulthood. This effect is statistically significant once sibling fixed effects are controlled for; estimates in Col (2) suggest that a 10 per cent increase in the deviation of rainfall during the year preceding birth from the long-term average leads to an 8 per cent of a standard deviation increase in core self-evaluation in adulthood. Further, estimates in Col (3) suggest that it is the very early life environment that has such long-term effects: we find no significant effects

of rainfall during the first or the second year of life. There do not appear to be any systematic differences in core self-evaluation between boys and girls; the male dummy remains insignificant throughout.

In the last two columns we disaggregate the core self-evaluation measure into the constituent traits and show estimates using first principal factor measures for self-esteem and agency separately. Agency combines measures of locus of control and self-efficacy; we do not separate these as there are too few items in each to ensure construction of reliable measures.¹⁶ The pattern of estimates in Cols (4) and (5) is similar, though with a p-value of 0.12 the effect on self-esteem is not quite statistically significant.

4.2 Robustness

We test the robustness of the main estimates in a number of ways. Firstly, in the presence of strong correlation in rainfall over time the estimates may be misleading, suffering from omitted variable bias. The stability of the estimated in-utero effect to the inclusion of rainfall in subsequent two years (Table 5, Col (3)) offers some reassurance that this is indeed an independent effect. To check this further, we add rainfall for two years prior to the in-utero period.¹⁷ Estimates in Table 6, Col(1) show that none of the coefficients on rainfall prior to or after the in-utero period are statistically significant or comparable in size to the coefficient on in-utero rainfall, suggesting that correlation in rainfall over time is not driving the results.

Next we check sensitivity of the results to the method used to construct the outcome measures. Of the three scales administered to measure personality traits, the one used to measure self-efficacy is least well-validated as it is made up of items from a number of different scales. We, therefore, re-estimate the main model using the first factor from combining only the items from the self-esteem and locus of control scales. Results in Col (2) of Table 6 show that the effect is comparable in size to the main estimate

¹⁶Due to time constraints, only a few items of the locus of control and self-efficacy scales could be administered. The first principal factor of these individually has an eigenvalue around 0.5, much lower than the agreed “rule of thumb” cut-off of one.

¹⁷Note that 61 individuals are omitted from this analysis as they were born before 1983 and so rainfall data for the years preceding the in-utero period is not available (since 1980 is the earliest year for which we have station rainfall data).

(0.7 compared to 0.8 of a standard deviation), but is only significant at 10 per cent (compared to 1 per cent for the main estimate). The loss of precision is unsurprising since constructing the outcome measure using fewer items is likely to introduce more measurement error.

Finally, we show the main estimates using standardized raw z-scores rather than principal components measures for the main outcomes (core self-evaluation, self-esteem and agency). The estimates in Col(3-5) Table 6 show that the pattern of results does not change, though the effects are somewhat smaller. Again, this is to be expected as by weighting all items that comprise the score equally, the raw score is a noisier measure of the latent trait.

4.3 Mechanisms

We now explore heterogeneity in the main results in timing of effects, gender and wealth to learn about mechanisms.

4.3.1 Timing

To understand the identified effects better, we want to know more precisely whether there are periods in-utero, which are more critical than others in terms of exposure to rainfall deviations and whether the two annual rainfall seasons are equally strong in driving the results. We split early-life into three month intervals, or quarters, from nine months before conception to nine months after birth and look at the effects of deviations in *Vuli* and *Masika* rainfall separately. This allows us to identify which of the *Masika/Vuli* ('m'/'v') - preconception/gestation/birth ('p'/'g'/'b') combinations of timing of exposure to rainfall deviations in Figure 3 are important for the formation of core self-evaluation.

We plot the estimated quarterly β_1 coefficients of experiencing deviations in *Vuli* and *Masika* rains in Figures 7 & 8, respectively. Each estimate is based on a sub-sample of individuals born in the same quarter, who, therefore, experienced *Vuli* or *Masika* rains

during the specified months. For instance, estimates of impact of deviations in *Vuli* rains during first trimester of gestation and in months 4-6 of first year of life are based on a sub-sample of individuals born June-August, as can be seen in Figure 3.

Figures 7 & 8 suggest that the formation of CSE is particularly sensitive to exposure to deviations in *Vuli* rains while in-utero, irrespective of which trimester the exposure happens; the effect is largest in the first trimester of pregnancy. Focusing on Figure 7, the estimated effects in the first two gestation trimesters are an increase in CSE of around 0.1 of a standard deviation as a result of a 10 per cent increase in *Vuli* rains; the third trimester effect is slightly lower at 0.08 of a standard deviation.¹⁸

To understand what may be the mechanism behind this strong effect of *Vuli* rains during gestation, we return to Figure 3. Deviations in *Vuli* rains directly affect the subsequent *Vuli* harvest; this is the main harvest of the year, when food stocks are built. A poor *Vuli* harvest results in earlier onset and thus prolonging of the subsequent hunger period; a good *Vuli* harvest provides households with more food buffer stocks. As can be seen from Figure 3, children who were in-utero during *Vuli* rains are 4-12 months of age when the subsequent hunger season sets in. According to the 1991/92 Demographic and Health Survey (the earliest available for Tanzania), the median duration of full breastfeeding¹⁹ in Kagera region was 3.2 months (DHS and National Bureau of Statistics, 1993), after which they enter the weaning stage. The effects of deviations in *Vuli* rains may, therefore, reflect the impact of the subsequent hunger season, which sets in during the weaning period. The weaning period is a time when children's nutrition ceases to depend entirely on protective maternal milk, and intake of a variety of foods as part of a balanced healthy diet becomes increasingly important for children's development. This suggests that nutrition in the first year of life may be a mechanism through which adult personality traits are affected.²⁰ Consistently with this pathway, Table 1 shows that household food consumption in Kagera region is sensitive to the most recent rainfall,

¹⁸These are estimates from specifications controlling for village and year of birth-district fixed effects, with robust standard errors clustered at the village level. We are not controlling for sibling fixed effects as our sample size is not big enough to include sufficient number of siblings born in the same 3 month period in different years to identify within sibling effects of rainfall fluctuations in a given trimester.

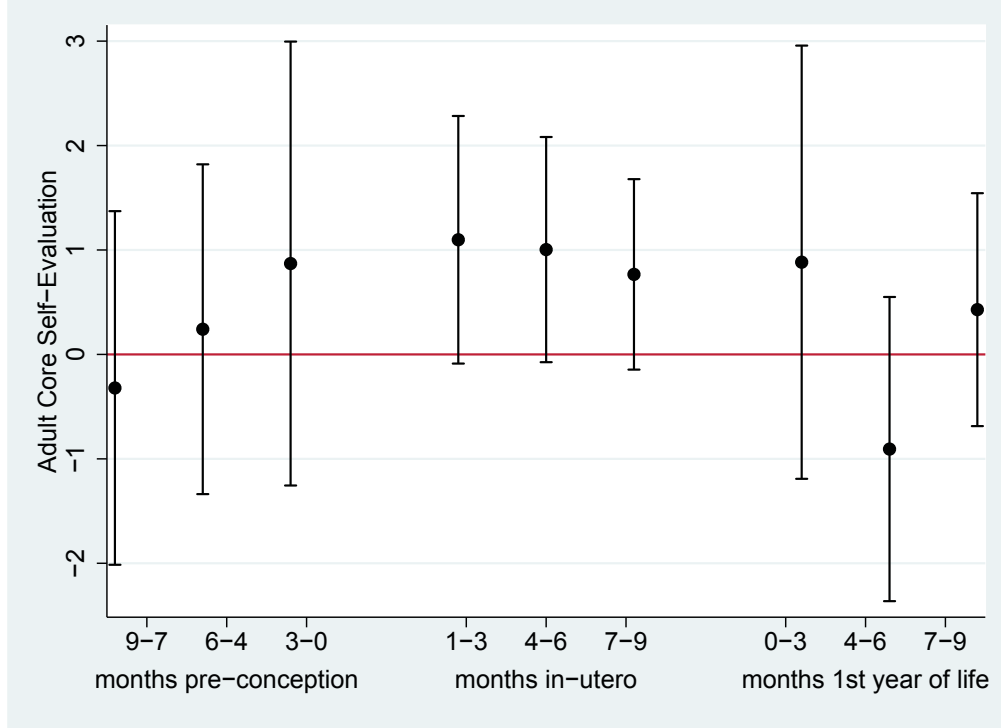
¹⁹Defined as either exclusive breastfeeding or breastfeeding and plain water only.

²⁰It should be noted that if the failure of the *Vuli* harvest is particularly severe, food stocks may not even last until the subsequent *Masika* harvest which could introduce nutritional deficiencies already towards the end of the third trimester.

while income and non-food consumption are correlated with historical rainfall over a longer period.

Alternative mechanisms cannot be ruled out, however. For instance, the results are also consistent with adverse effects of maternal physical or mental stress during pregnancy, as a direct and immediate consequence of shortfalls in *Vuli* rains. Women in this area carry the main responsibility for feeding the household; their emotional/mental stress levels may, therefore, be sensitive to fluctuations in harvest conditions. There is growing evidence that maternal stress during pregnancy can have adverse effects on infant physical and psychological health through raised fetal cortisol (Baibazarova et al., 2013). Poor rainfall may also raise physical stress levels if it leads to a diversification of women's income earning activities away from agriculture to more strenuous work. While it is beyond the scope of this work to test these hypotheses, they do suggest areas of focus for future research.

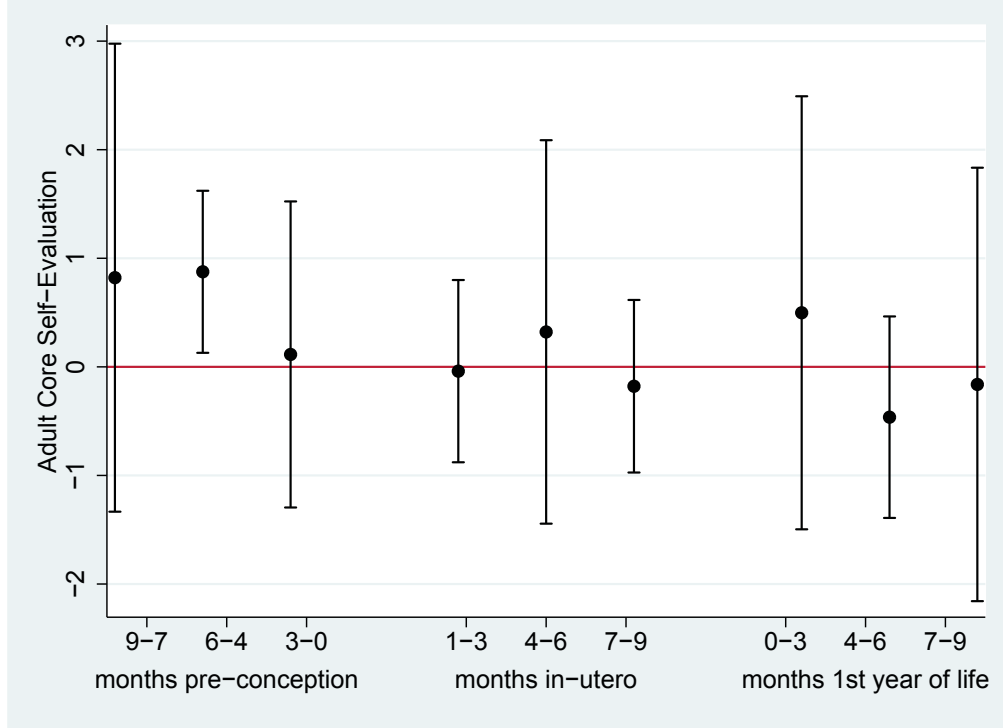
Figure 7: Effects of Deviations in *Vuli* Rains on Adult Core Self-Evaluation by Timing



Note: This figure shows coefficient estimates for the main OLS specification, using rainfall in *Vuli* rainy season only, with 95 per cent confidence intervals, controlling for village and district-year of birth fixed effects and with robust standard errors clustered at the village level. Each estimate is for the sub-sample of individuals who experienced *Vuli* rains during the specified months, which depends on the birth month. For instance, estimates of impact of *Vuli* rains during first trimester of gestation and in months 4-6 of first year of life are based on a sub-sample of individuals born June-August as can be seen in Figure 3, where for these individuals pre-conception *Vuli* (vp) and first year of life *Vuli* (vb) overlap with these specific periods.

The pattern of *Masika* rains effects in Figure 8 is much less distinctive than that of *Vuli* rains. There is no evidence that fluctuations in *Masika* rains during the in-utero period or in the first year of life have any long-term effects on CSE. While noisy, estimates from the pre-conception period are more suggestive of an effect. The agricultural calendar in Figure 3 shows that failure of pre-conception *Masika* rains will anticipate and deepen the following hunger season, which will set in around the time of conception and in the first trimester of pregnancy. Given the lack of precision or consistency in the pattern of the *Masika* timing effects, however, we do not want to overstate their significance.

Figure 8: Effects of Deviations in *Masika* Rains on Adult Core Self-Evaluation by Timing



Note: This figure shows coefficient estimates for the main OLS specification, using rainfall in *Masika* rainy season only, with 95 per cent confidence intervals, controlling for village and district-year of birth fixed effects and with robust standard errors clustered at the village level. Each estimate is for the sub-sample of individuals who experienced *Masika* rains during the specified months, which depends on the birth month. For instance, estimates of impact of *Masika* rains during 9-7 months pre-conception and in months 7-9 of first year of life are based on a sub-sample of individuals born August-October as can be seen in Figure 3, where for these individuals pre-conception *Masika* (mp) and first year of life *Masika* (mb) overlap with these specific periods.

4.3.2 Gender

It is often found in the existing literature that the impact of early-life conditions differ by gender, with girls experiencing stronger effects e.g. Maccini and Yang (2009); Adhvaryu et al. (2014) and Huang et al. (2013). This is consistent with more general evidence that individual characteristics such as gender and birth-order are important determinants of investment into children and the role of children within the household (e.g. Ejrnæs and Pörtner, 2004; Vogl, 2013).

To look at gender heterogeneity in effects of early-life conditions on formation of personality traits, we focus on the *Vuli* rains, shown above to be driving the main estimates of in-utero rainfall effects. In line with other studies, the results suggest that the effect of early life rainfall is much stronger for girls than boys Col (1), Table 7; in fact the effect for boys is close to zero. As noted by Currie and Vogl (2013) and Adhvaryu et al. (2014), such a gender difference may be explained by differential parental investments, but could also be a result of selective male mortality, as male fetuses and infants tend to be more vulnerable to adverse conditions. In our case, one would expect that if the heterogeneous gender effect reflects differential parental investment in favor of sons, rainfall effects should be larger for girls with older brothers than those without. However, focusing only on girls in Col (2) of Table 7, the results suggest that in fact the impact is equally strong for both types of girls.²¹ While this evidence does not allow us to rule out differential parental investment as the explanation for gender heterogeneity, it does suggest that for this to be the mechanism the differences should exist irrespective of the gender composition of children within the household.

4.3.3 Wealth

Finally, we show that the effect of early life rainfall is larger for households that are less likely to be able to protect themselves from adverse effects of transitory income shocks.

Motivated by findings in Beegle et al. (2006b), who use the same data to show that durable assets²² can mitigate the impact of transitory agricultural income shocks through improved access to credit, we use durable asset holdings as a proxy for household capacity to protect themselves against transitory income shocks. We compare the effect of early life rainfall on individuals from households that were in the bottom tercile of durable-asset holdings during the baseline (1991-1994) to those in the top two terciles. We similarly find that that individuals who are most effected by early life rainfall are those from households in the bottom tercile of durable asset holdings; these are the

²¹Due to small sample size, the models in Cols (1) and (2) of Table 7 are estimated without controls for sibling fixed effects. A comparison of the village and sibling fixed effects estimates in Cols (1) and (2) 5, however, suggests, that if anything, this may bias the coefficients downwards.

²²Value of durable asset holdings includes the value of durable goods, such as radios, bicycles, fans, lamps and pots.

households that are least likely to have access to credit reducing their ability to mitigate impacts of income shocks, see Table 7, Col (3)²³

4.4 Other Outcomes in Adulthood

Before concluding we examine the effect of early life rainfall on other outcomes in adulthood. As reviewed above, a growing body of evidence points to the importance of both early-life circumstances as well as personality traits for adult outcomes, such as health, cognitive skills and socio-economic status. We, therefore, extend our analysis to look at whether early life rainfall, found to impact adult personality traits, also affects adult health (measured in terms of height and self-reported chronic illness), human capital (proxied by years of schooling), and socio-economic status (measured using consumption levels in 2010).

Results in Table 8 show effects of *Vuli* rainfall in-utero and in the first two years of life, controlling for sibling, district-birth year and birth-season fixed effects. While we do not find any significant impact on height. Rainfall during the in-utero rainfall does appear to be inversely associated with the probability of reporting chronic illness, though this effect is estimated imprecisely (with a p-value of 0.18). There is further some evidence that favorable rainfall conditions in the first year of life have a large and statistically significant positive impact on the number of years of schooling an individual attains. Finally, though again imprecisely estimated (p-value of 0.17), it appears that those experiencing more rainfall during the in-utero period also have higher consumption in adulthood. Based on these results, it is plausible that, at least in part, the effect of early life rainfall on core self-evaluation in adulthood is driven by better health and socio-economic status as well as, higher schooling. However, it may, of course, also be the case that effects of rainfall on these outcomes are partly driven by higher core self-evaluation.

²³This finding may, however, reflect some unobserved parental heterogeneity; if, say, parents with certain personality traits such as high CSE are also more wealthy and have more assets, while at the same time being better at shielding their children against adverse events.

5 Conclusion

Currently, not much is known about how personality traits are formed or what can hamper their development. While there is empirical evidence of interventions successfully altering personality traits of young children, there is virtually no evidence on what influences their early formation and development.

In this paper we offer new empirical evidence that personality traits in adulthood are sensitive to early life circumstances, as has been found to be the case for other forms of human capital such as cognitive skills, and, physical and mental health. We find that unanticipated rainfall fluctuations that affect livelihood conditions in early childhood have a persistent impact on the stock of core self-evaluation in adulthood. We measure early life circumstances by linking information on the date and place of birth of respondents followed as part of Kagera Health and Development Survey, a 20 year tracking study in Kagera region (Tanzania), to historical rainfall data. Our measure of personality traits (core self-evaluation) in adulthood combines measures of self-esteem, self-efficacy and locus of control collected in the last follow-up round of the survey (in 2010).

We find that in-utero exposure to a 10 per cent increase in rainfall deviation from the long run average results in 0.08 of a standard deviation increase in the core self-evaluation measure relative to siblings. Our estimation method passes the placebo test of no impact of rainfall deviations two or three years prior to birth. We also find no indication that rainfall during the first two years of life have any impact. This suggests that the formation of personality traits is not purely genetic, but that it is influenced by the early-life environment.

When examining the timing of the two main rainy seasons more closely relative to pre-conception, gestation and early infancy stages, we find that the impact is driven by exposure to deviations in the *Vuli* rains during each of the three trimesters in-utero. Since deviations in *Vuli* rains directly affect the main harvest of annual food crops, crucial for building food stocks, a poor *Vuli* harvest can significantly increase the severity of the subsequent annual hunger period. Children exposed to *Vuli* rains in-utero will be

4-12 months of age during the subsequent hunger period and, therefore, likely to have begun weaning, a stage at which intake of a varied diet becomes increasingly important for children’s development. This suggests that nutrition in the first year of life could be a mechanism through which adult personality traits are affected. Alternative pathways could also be at play; for instance, we cannot rule out adverse effects of maternal physical or mental stress during pregnancy due to rainfall deviations.

The impact is only significant for girls: experiencing deviations in *Vuli* rainfall results in an increase in core self-evaluation of 0.07 of a standard deviation. The strong gender heterogeneity in the effects is both consistent with selective male mortality and with the presence of gender related differences in parental response to impairment caused by early-life shocks. With the data at hand, we cannot test for the former, and find no evidence in support of the latter explanation.

There are differences across households in how well they are able to shield their children against rainfall deviations. Children from households with low durable asset holdings are much more sensitive to rainfall fluctuations than the rest.

Our findings of remarkable persistence of effects of very early childhood events into adulthood are also consistent with the existence of dynamic complementarities between initial endowments of a skill and subsequent investments, as suggested by Heckman and colleagues, see Almlund et al (2011) for an introduction to their theoretical framework. If skill acquisition is a cumulative process, starting out with lower (or higher) endowments will determine the path for future skills acquisition and could explain why initial endowment shocks translate into persistent effects on outcomes in adulthood, including key personality traits, as we show in this paper.

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Table 1: Household welfare and rainfall in first wave of baseline

	Total consumption	Food consumption	Non-food consumption	Income
Log of total rainfall during rainy seasons:				
1 season before interview	0.206** (0.098)	0.247** (0.103)	0.234* (0.133)	0.239* (0.144)
2 seasons before interview	0.108 (0.102)	0.064 (0.107)	0.257* (0.138)	0.268* (0.150)
3 seasons before interview	-0.061 (0.114)	-0.110 (0.119)	0.061 (0.155)	0.040 (0.167)
4 seasons before interview	-0.022 (0.112)	0.001 (0.118)	-0.021 (0.152)	-0.062 (0.165)
Number of observations	874	899	889	908

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; variation in number of observations due to missing values; all specification include district-season interaction terms and year of interview dummies, as well as basic controls for household characteristics (age, gender and education of household head; amount of land owned; household composition). Consumption measured as natural log of total annual consumption expenditure per capita. Income measured as natural log of total annual household income.

Table 2: Mean annual rainfall in KHDS baseline districts 1980-2004

District	Mean Total Annual Rainfall	
Bukoba Rural	1727.71	(270.84)
Bukoba	1936.34	(255.71)
Muleba	1454.87	(274.09)
Biharamulo	1338.49	(222.55)
Karagwe	1327.92	(413.79)
Ngara	998.87	(232.63)

Note: Standard deviations in parentheses

Table 3: Statements with factor loadings > 0.25 for first factor

<i>General Self-Esteem</i>		
I certainly feel useless at times		
At times I think I am no good at all		
All in all I am inclined to feel that I am a failure		
I feel I do not have much to be proud of		
<i>Locus of Control</i>		
I have often found that what is going to happen will happen		
Many times I feel that I have little influence over the things that happen to me		
It is not always wise to plan ahead because many things turn out to be a matter of luck anyway		
<i>Self-Efficacy</i>		
I have no choice about the work I do, I must work		
There is not much opportunity for me to decide for myself how to do things in my daily life		

Table 4: Sample Descriptives

Baseline Characteristics	Mean	Standard dev
Age	4.4	3.2
Male	0.49	0.5
In school	0.08	0.3
Maternal Orphan	0.07	0.3
Paternal Orphan	0.13	0.3
Mother: Years of schooling	4.3	2.9
Father: Years of schooling	5.5	2.8
Household size	8.1	3.8
Land ownership (acres)	5.3	4.4
Household head: male	0.81	0.4
Household head: age	45.4	15.1
Household head: years of schooling	4.5	2.9
Deviation of natural log rainfall from natural log 1980-1990 mean in rainy seasons in 12 months preceding month of birth	0.07	0.22
Total Observations	897	

Source: KHDS 1991

Table 5: Main Results

	(1) CSE	(2) CSE	(3) CSE	(4) Self-esteem	(5) Agency
Rainfall deviation in-utero	0.308 (0.233)	0.808** (0.384)	0.828** (0.377)	0.588 (0.372)	0.894** (0.371)
Rainfall deviation age 0-1			-0.109 (0.404)	-0.083 (0.398)	-0.123 (0.359)
Rainfall deviation age 1-2			-0.266 (0.326)	-0.413 (0.370)	-0.189 (0.282)
Male	0.019 (0.072)	0.021 (0.127)	0.019 (0.125)	0.029 (0.130)	0.055 (0.113)
Number of observations	897	741	741	741	741
Sibling fixed effects	No	Yes	Yes	Yes	Yes
Village fixed effects	Yes	No	No	No	No
District * birth year fixed effects	Yes	Yes	Yes	Yes	Yes
Season of birth dummy	Yes	Yes	Yes	Yes	Yes

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; robust standard errors in parentheses clustered at village level. Rainfall deviation is defined as the difference between natural log of 10-year average total rainfall during the two main rainy seasons (*Musika* and *Vuli*) 1980-1990 and natural log of total rainfall during the two main rainy seasons in the period of interest (in-utero, ages 0-1 and 1-2).

Table 6: Robustness

	(1) CSE	(2) CSE*	(3) CSE (z-score)	(4) Self-Esteem (z-score)	(5) Agency (z-score)
Rainfall deviation in-utero	1.114** (0.427)	0.712* (0.396)	0.613** (0.236)	0.469 (0.306)	0.599** (0.242)
Male	0.016 (0.139)	0.031 (0.126)	0.032 (0.081)	0.009 (0.099)	0.049 (0.072)
Rainfall deviation 2 years before conception	-0.280 (0.465)				
Rainfall deviation 1 year before conception	-0.071 (0.472)				
Rainfall deviation age 0-1	-0.189 (0.422)				
Rainfall deviation age 1-2	-0.254 (0.347)				
Number of observations	680	741	741	741	741
Sibling fixed effects	Yes	Yes	Yes	Yes	Yes
Village fixed effects	No	No	No	No	No
District * birth year fixed effects	Yes	Yes	Yes	Yes	Yes
Season of birth dummy	Yes	Yes	Yes	Yes	Yes

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; robust standard errors in parentheses clustered at village level. Rainfall deviation is defined as the difference between natural log of 10-year average total rainfall during the two main rainy seasons (*Musika* and *Vuli*) 1980-1990 and natural log of total rainfall during the two main rainy seasons in the period of interest (in-utero, ages 0-1 and 1-2). Outcome measure in Col (2) (CSE*) is the first factor from iterated principal components analysis which excludes items measuring self-efficacy (our least validated scale). Fewer observations in Col (1) as rainfall data only available from 1980 and full sample of individuals includes those born between 1981 and 1993. Therefore, 2 year pre-conception rainfall not available for those born before 1983 and 1 year pre-conception rainfall not available for those born before 1982.

Table 7: Heterogeneity

	(1) CSE	(2) CSE	(3) CSE
<i>Vuli</i> rainfall deviation in-utero	0.721*** (0.269)	0.846** (0.327)	0.506* (0.258)
<i>Vuli</i> rainfall deviation in-utero * Male	-0.645*** (0.239)		
<i>Vuli</i> rainfall deviation in-utero * Older brother		-0.204 (0.357)	
<i>Vuli</i> rainfall deviation in-utero * top 2 terciles by values of non-land assets			-0.308 (0.277)
Male	0.066 (0.073)		0.037 (0.073)
Older Brother		0.033 (0.117)	
In top 2 terciles by value of non-land assets			0.127* (0.075)
Number of observations	897	466	897
Sibling fixed effects	No	No	No
Village fixed effects	Yes	Yes	Yes
District * birth year fixed effects	Yes	Yes	Yes
Season of birth dummy	Yes	Yes	Yes

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; robust standard errors in parentheses clustered at village level. *Vuli* rainfall deviation is defined as the difference between natural log of 10-year average total rainfall during the *Vuli* rainy seasons 1980-1990 and natural log of total rainfall during the *Vuli* season in the period of interest (in-utero). Non-land assets are defined as . Results in Col (2) are for women only.

Table 8: Other adult outcomes

	(1) Height	(2) Chronic illness	(3) School Years	(4) Ln per capita consumption
<i>Vuli</i> rainfall deviation in-utero	-0.770 (1.914)	-0.164 (0.121)	0.179 (1.031)	0.305 (0.221)
<i>Vuli</i> rainfall deviation age 0-1	-1.459 (2.714)	-0.049 (0.094)	2.253*** (0.792)	0.105 (0.224)
<i>Vuli</i> rainfall deviation age 1-2	1.093 (1.577)	-0.035 (0.074)	-0.678 (0.602)	0.102 (0.194)
Male	9.883*** (0.565)	-0.041 (0.040)	0.594** (0.267)	0.245*** (0.071)
Number of observations	718	741	747	742
Sibling fixed effects	Yes	Yes	Yes	Yes
Village fixed effects	No	No	No	No
District * birth year fixed effects	Yes	Yes	Yes	Yes
Season of birth dummy	Yes	Yes	Yes	Yes

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; robust standard errors in parentheses clustered at village level. *Vuli* rainfall deviation is defined as the difference between natural log of 10-year average total rainfall during the *Vuli* rainy seasons 1980-1990 and natural log of total rainfall during the *Vuli* season in the period of interest (in-utero, age 0-1, age 1-2). All outcomes measured in 2010. Variation in number of observations due to missing values in outcome measures.

A Appendix

Table A.1: Attrition

	In 2010 Sample
Age in years at baseline	0.002 (0.002)
Male	0.006 (0.015)
Attending School in baseline?	0.021 (0.023)
Mother deceased	-0.040* (0.024)
Father deceased	-0.039* (0.022)
Father: Years of education	-0.006* (0.003)
Mother: Years of education	-0.003 (0.003)
Height for age z-score	0.003 (0.003)
Household size	0.005** (0.002)
Acres of land cultivated	0.001 (0.003)
Value of physical assets	0.000 (0.000)
Value of durables	-0.000 (0.000)
Value of land	0.000* (0.000)
Value of livestock	0.000 (0.000)
Sex of household head	-0.056** (0.023)
Age of household head	-0.000 (0.001)
Years of schooling of household head	0.002 (0.004)
Number of observations	3,005
Village fixed effects	Yes

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; robust standard errors in parentheses clustered at village level.

Table A.2: Personality trait measures

	Totally Disagree	Somewhat Disagree	Somewhat Agree	Totally Agree	Mean (SD)	First Factor Loadings
<i>Self-Esteem</i>						
I am able to do things as well as most other people	9.6	8.9	24.1	57.4	3.29 (0.98)	0.0535
I certainly feel useless at times	52.8	12.1	16.9	18.2	2.01 (1.19)	0.4987
The job I do makes me feel proud	24.1	12.2	21.9	41.8	2.81 (1.21)	-0.0359
I take a positive attitude to myself	9.9	10.9	22.6	56.6	3.26 (1.0)	0.1699
At times I think I am no good at all	57.3	13	14.7	15	1.87 (1.14)	0.5778
I wish I could have more respect for myself	3.1	3.7	17.3	76	3.66 (0.69)	0.1467
I feel that I am a person of worth, at least on equal plane with others	8.9	10.8	26.2	54.2	3.26 (0.97)	-0.0633
All in all I am inclined to feel that I am a failure	38.2	20.7	20.5	20.6	2.23 (1.17)	0.4245
I feel I do not have much to be proud of	22.6	19.2	27.8	30.4	2.66 (1.13)	0.3308
I feel that I have a number of good qualities	3.6	3.3	18.1	75	3.65 (0.71)	-0.138
On the whole I am satisfied with myself	18.1	13	15	53.9	3.05 (1.18)	-0.0943
<i>Locus of Control</i>						
<i>Internal</i>						
In the long-run people get the respect they deserve in this world	13.5	15.9	28.8	41.9	2.99 (1.06)	0.0901
Becoming a success is a matter of hard work. Luck has little or nothing to do with it	7	6.6	28.9	57.5	3.37 (0.89)	0.0905
How many friends you have depends on how nice a person you are	8.1	10.5	32.4	49	3.22 (0.93)	0.1107
<i>External</i>						
Many of the unhappy things in people's lives are partly due to bad luck	19.8	13.6	28.6	38	2.85 (1.13)	0.2549
I have often found that what is going to happen will happen	15.4	15.4	23.8	45.4	3 (1.11)	0.2623
It is not always wise to plan ahead because many things turn out to be a matter of luck anyway	22.5	14.9	27.1	35.5	2.76 (1.16)	0.2918
Many times I feel that I have little influence over the things that happen to me	22.2	16.6	33.5	24.6	2.6 (1.09)	0.4383
<i>Self-efficacy</i>						
There is not much opportunity for me to decide for myself how to do things in my daily life	21.7	16.3	30.1	31.9	2.72 (1.13)	0.2767
I choose what I do, instead of being pushed along by life	13	12.1	23.1	51.8	3.14 (1.07)	0.1725
I have no choice about the work I do, I must work	17.5	10.1	21.4	51	3.06 (1.14)	0.3023
If I try hard I can improve my situation in life	0.6	1.7	10.8	87	3.84 (0.45)	0.1058
I like to make plans for my future studies and/or work	1.7	1.8	10.2	86.4	3.81 (0.54)	0.0252