Conception and Contraceptives in Times of Drought

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Abstract

Poor economic conditions at timing of birth can have damaging impacts on both children and their parents, particularly in less developed countries. Ability to adjust birth timing away from negative shocks by delaying conception therefore has important welfare consequences. Recent work has shown that parents in less developed countries delay conception following economic downturns, but evidence that this response is causal, that it is deliberate, and the importance of different underlying mechanisms all remain thin. Using data from 147,215 women in agriculture dependent households in 29 Sub-Saharan African countries and 545,363 births, this paper shows that recently experienced droughts reduce the likelihood of conception by 1-2%. While overall levels of contraceptive use remain stable, women shift towards more modern contraceptive methods following droughts, suggesting that reduction in fertility is, at least partly, the result of deliberate fertility adjustments. Responses for conception are strongest among the wealthy, while responses on contraceptive use are strongest among the poor, raising open questions about additional mechanisms and contraceptive adjustments on the intensive margin that may not be well captured in existing data.

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1 Introduction

Poor economic conditions at time of birth or early childhood can have considerable negative impacts on children's development and health, while having an additional mouth to feed imposes substantial demands on both family resources and household labor.[1] Meanwhile, households in less developed countries are frequently exposed to high income volatility with myriad factors impeding their ability to smooth income over time (Dercon, 2002; Morduch, 1995). Households' ability to shift births away from times of economic hardship therefore has considerable implications for the welfare of both children and their families.

This paper contributes to a growing literature on income shocks and birth timing by analyzing conception and contraceptive use in response to droughts among rural farmers across Africa, the world's region with the highest levels of fertility and fastest population growth. I examine the impact of droughts as a proxy for negative income shocks on conception likelihood to assess whether people are able to shift births away from times of financial hardship. I look for heterogeneous responses along three dimensions frequently been linked to fertility outcomes in the literature: education, attained fertility at the time of drought, and wealth. Even showing a response of conception timing to droughts, the mechanisms remain unclear and may not necessarily be due to intentional reduction in conception but instead an unintended consequence of other responses to the shock such as lower coital frequency due to temporary migration (Timaeus and Graham,

[1]Existing literature shows robust linkages between early life production or income shocks and early life health, nutrition, and mortality (Baird et al., 2011; Hirvonen and Hoddinott, 2017; Benshaul-Tolonen, 2018). other work links early life nutrition with long-run human capital, health, and labor outcomes (Alderman et al., 2006; Hoddinott et al., 2013). A third group goes straight from early life or pre-natal shocks to long-term outcomes (Jensen, 2000; Maccini and Yang, 2009; Banerjee et al., 2010; Shah and Millet Steinberg, 2017). In addition to concern for the well-being of their children, parents incur high costs associated with contraception. An additional mouth to feed can stretch scarce resources even tighter (Pörtner, 2018) and having an infant in the household imposes additional labor demands on household members that may have otherwise been put towards productive, income-generating activities (Kochar, 1999). While these factors all suggest an optimal response to shift conception away from times of scarcity, other work has also argued that droughts can reduce the opportunity costs of female labor, making conception at these times preferable (Pitt and Sigle, 1998).

1989) or lower fecundity from worse nutrition (Bongaarts, 1980). To make progress on whether this response is intentional, I look at the impact of droughts on contraceptive use as an indicator of deliberate actions taken to affect conception. Finally, I examine whether droughts early in marriage affect total fertility outcomes.

This paper uses data from 53 Demographic and Household Surveys (DHS) from 29 African countries. This includes information on 545,363 births from 147,215 rural farming women. I convert this data into a woman-year panel of conceptions. Given the dependence of this population on agricultural production, I expect that droughts have a first order impact on families' income and livelihoods. I therefore use historical rainfall data from the University of Delaware and follow a definition of drought established elsewhere in the literature to create a panel of local droughts.[2] Using GPS data in both the DHS surveys and the weather data, I can then link these droughts to the panel of conceptions in the respondent's area. For the analyses of contraceptive use and total fertility outcomes, data structure of the DHS force me to switch to a cross-sectional estimation strategy, but I maintain the same definition of drought used for the effects on conception. For all analyses, I rely on the plausible exogeneity of the timing of droughts to other household characteristics and preferences and other local factors influencing conception, contraceptive, and total fertility decisions and assess the reduced form impact of droughts on these outcomes.

My results show that recent droughts lower the average likelihood of conception by 1-2%. These results are robust to an array of alternative specification choices and definitions of drought. I also show that results are not driven by spurious correlations resulting from migration and, in a placebo test, that there are no significant impacts on non-farming households in these same areas, adding credence to the economic channel. The effects of drought are muted for households with higher levels of education, while attainment of fertility targets also lowers responsiveness to droughts. Effects of drought are, however,

[2]The rainfall data come from (Matsuura and Willmott, 2018) while the definition of droughts is from Burke et al. (2014). Both are discussed in more detail in the next section.

stronger on wealthier families, suggesting that economic vulnerability does not tell the entire story.

Next, I present evidence that droughts impact contraceptive use as well, suggesting that at least part of the response we see in likelihood of conception is the result of deliberate actions made by parents to reduce pregnancies. An additional drought in the three preceding years increases use of modern contraceptives by 0.7 percentage points from a base of 15 percent. I also see a nearly identical fall in usage of traditional methods. Impacts are stronger among women who do not yet have a son and among the poor. This second result appears in tension with the heterogeneous responses by wealth on conception whereby the relatively wealthy adjusted *more* than the poor. This apparent contradiction may, however, be the result of all wealth groups reducing conception, and the analysis being unable to incorporate meaningful variation in the intensivity or care of contraceptive use that is unobserved in the data. Finally, using a different sample of women, likely to have completed their overall fertility attainment, I show that droughts during early years of marriage do not decrease completed fertility totals and do not extend the duration of women's years of fertility.

These results speak directly to a growing literature on income shocks and fertility. There has been a considerable body of evidence showing that families in developed countries adjust fertility towards times of relative abundance (Black et al., 2013; Lovenheim and Mumford, 2015; Brueckner and Schwandt, 2014; Dettling and Kearney, 2014). Until recently, the evidence in less developed countries has been very thin. However, in a broad analysis of births from over two million women in less developed countries across the world, Chatterjee and Vogl (2018) recently showed the critical role that economic shifts have on fertility outcomes. They find that long-run economic growth leads to lower overall fertility levels, while short-run shocks result in procyclical fertility patterns. Their paper is a breakthrough, resolving what had been an unresolved tension in the literature between apparently contradictory responses to econonomic conditions in the short and long run. However, their use of macro-economic downturns prevents them from making claims about causality and their data prevent them from saying whether fertility responses are deliberate or the result of other shock coping strategies. My paper builds directly on their work and fills a gap in evidence on the causal connection between short-run economic shocks and fertility as well as the mechanisms underlying this response.

A handful of other papers have also spoken to these themes, linking income shocks to fertility and contraceptive use in developing countries. Notably, Alam and Pörtner (2018) use data from Tanzania and find that crop loss lowers the likelihood of birth in that location alongside an increase in use of traditional (but not modern) contraceptive methods. Jones (2015) looks at fertility outcomes and contraceptive usage in response to shocks on the prices of contraceptives in Ghana. She finds that reduced supply of condoms resulting from the gag rule, which impedes international non-governmental organizations' ability to distribute free or heavily subsidized contraceptives, leads to a reduction in contraceptive use, greater incidence of abortion, and higher levels of fertility. These papers both provide important insights on the dynamics of shocks, contraceptive use, and fertility that directly inform my analysis. They are both, however, limited in their external validity due small geographic coverage and my paper's results do not always match their core findings. My paper therefore provides a link between work done on these topics at the national or sub-national level, and the broader, multi-country analysis done by Chaterjee and Vogl.

Additional work has looked at income shocks, sexual behavior, and contraceptive use, without necessarily focusing on fertility outcomes. Robinson and Yeh (2011) demonstrate a linkage between income shocks and contraceptive usage among prostitutes in Kenya, showing willingness to expose themselves to greater risks by foregoing usage of condoms in pursuit of higher pay following negative economic shocks. Burke et al. (2014) show that droughts cause an increase in the prevalence of HIV, which they posit is the result of economic vulnerability and engagement with riskier sexual behaviors. Also related is a paper by Corno et al. (2017) on the impact of droughts on timing of marriage and bride price traditions. Using an identical definition of droughts, they find that droughts in Africa, where bride prices are typically paid from the husband to the wife's side of the family, increase the likelihood of early marriage for young women. This in turn advances the age at which women begin having children and increases their total fertility outcomes. My paper complements the these papers by focusing on fertility and contraceptive decisions *within* marriages, *after* marriages have already been formed, where dynamics of vulnerability and decision-making are likely to be very different from those surrounding transactional sex and prostitution.

Finally, this paper links to a broader set of work on the impact of weather shocks and income risk. Where households are unable to perfectly smooth income across time periods, they may engage in different coping strategies such as migration (Morten, 2016; Kleemans and Magruder, 2017; Kleemans, 2014), sale of household assets or bufferstocks (Fafchamps et al., 1998), temporary employment (Jayachandran, 2006), or even conflict and violence (Burke et al., 2015; Miguel et al., 2004). Birth timing is another way in which households, unable to smooth consumption across time periods, adjust in response to uninsurable economic shocks.

The remainder of the paper is organized as follows. Section 2 details the sources and treatment of the data. Section 3 explains the paper's main empirical and identification strategy. Section 4 provides the empirical results of the paper. Section 5 concludes.

2 Data Treatment

This paper uses data from 53 Demographic and Health Surveys conducted in 29 African countries. This constitutes all DHS surveys in Africa from version 4 through 7 (the most recent) that include GPS locations of survey enumeration areas and household wealth measures, both central to the analysis. For each DHS, households are randomly sampled within the country to be representative of the national population. In sampled households, all women between 15-49 are interviewed on a range of topics including, personal background, household background, health, family planning practices, and a full listing of the respondent's live births.

The analysis sample consists of women in rural areas whose husbands' primary source of income is from farming as these are the households for whom droughts should have a first order impact on household finances. In addition, I restrict the sample to married women who have only been married once and have never been separated, in order to focus on conception decisions within a partnership and avoid confounding decisions about marriage formation or dissolution that may also be impacted by income shocks.[3] These additional restrictions were chosen in order to focus on households whose livelihoods are reliant on agricultural production and for whom droughts should have a first order impact on household finances. The remaining data include a total of 147,215 women and 545,363 births. Table A.1 lists each DHS survey along with the number of geographic survey clusters, eligible women, and births included in the main analysis.

Adapting an approach used by Maccini and Yang (2009), I use women's age at the time of interview and dates from their birth history, to convert the cross-sectional data in the DHS into an unbalanced, woman-year panel of conceptions.[4] I drop woman-years prior to, and including, her first year of marriage, and women married before the age of 15.[5]

Next, I must find a way to link this panel of conceptions to a source of income shocks. Given this population's dependence on agricultural production, I use drought as a proxy

[3] The impact of droughts on marriage has been demonstrated by Corno et al. (2017).

[4] I assume that conception typically takes place nine months before the date of reported birth. Deviations from this assumption may lead to occasional mis-attribution of year of conception for babies born before reaching full term. In these, likely rare, cases, the year of conception may be assumed to be in the year prior to when it actually took place. To the extent that this noise in the data impacts the estimated results, they are likely to bias detection of an impact of droughts on conception towards zero.

[5] There are some, but very few women married below the age of 15. This trimming is made given that these households are likely very different from those married in thicker parts of the marriage distribution and may not be comparable across many observable and unobservable dimensions.

for negative shocks to income. Latitude and longitude markers for each DHS survey cluster allow me to link these geographic areas to historical weather data generated by climatologists at the University of Delaware (UDel) (Matsuura and Willmott, 2018). The current version (v4.01) contains monthly historical precipitation estimates from 1900-2014 at a "grid-cell" level of 0.5×0.5 degree (approximately 50×50 kilometers).

To determine years of drought, I follow the definition and coding of droughts developed by Burke et al. (2014). For each location, I calculate annual yearly rainfall and then estimate a gamma distribution of rainfall between the dates of 1970 and 2014. Droughts are defined as rainfall that falls at or below the 15th percentile of this local distribution. Coding these shocks at a fixed percentile of the local historical distribution of rainfall realizations results in each location-year having an equal possibility of experiencing drought.[6] In their paper, Burke et al. (2014) estimate that these droughts lead to a nine percent reduction in cereal yields while Corno et al. (2017), following the same definition of a drought but using a broader pool of data, estimate these losses at twelve percent.[7] Using latitude and longitude coordinates contained in both data sets, I link this historical panel of droughts to the panel of women's births.

3 Empirical Strategy

To measure the impact of droughts on birth timing, I estimate the following linear probability model:

$$Conception_{i,g,t} = \beta_0 + \beta_1 Drought(s)_{g,t-1} + (\gamma_r \times \delta_t) + (\phi_{i,t} \times \psi_c) + \omega_i + \epsilon_{i,g,t} \quad (1)$$

[6] Using absolute rainfall thresholds across geographic areas to define droughts would systematically skew the likelihood of droughts towards drier regions and thus bias the analysis towards responses in these areas.

[7] Another estimate using longitudinal household data from the Nigerian Living Standards Measurement Survey by Amare et al. (2018) uses the rainfall anomaly index and finds that rainfall one standard deviation (approximately in the 15th percentile) below the historical mean caused a reduction of farm yields and household consumption by approximately 37%.

Where $Conception_{i,g,t}$ is a binary indicator for whether individual, i, from survey cluster in location (grid-cell), g, conceived a child in year, t. $Drought_{g,t-1}$ is an indicator for whether grid-cell, g, experienced a drought in the preceding year. I also frequently use an aggregate count of total droughts experienced in location, g, in the three prior years. $(\gamma_r \times \delta_t)$ are a set of year by geographical region fixed effects included to flexibly control for fertility dynamics within a region. Geographical regions are Western, Southern, Eastern, and Central Africa. ω_i are individual woman fixed effects which control for her (and her partner's) fertility preferences. $(\phi_{i,t} \times \psi_c)$ are additional age by country and current number of children by country fixed effects that control for country level norms surrounding maternal age and overall fertility levels, respectively. I estimate regressions with standard errors clustered at the grid-cell level to allow for serial correlation in the error terms for women in the same geographic area.

I implement variations of this preferred specification to show robustness of the main results to choice of specification. The identifying assumption needed for this model to result in a valid causal effect of drought on conception is that the timing of drought in a given location in a given year is random with respect to an individual's overall fertility preferences and local norms.

In the analysis of contraceptive usage, I am forced to switch to a cross-sectional estimation strategy. The DHS surveys ask respondents about current contraceptive use and categorize these responses as either modern or traditional methods.[8] However, current contraceptive methods may have been adopted prior to the year of interview and without a fixed window of recall on contraceptive approaches over time, it is not possible to create a panel of prior contraceptive use similar to that created for conceptions. Instead, I rely on the orthogonality of droughts to the timing of the survey as an identifying assumption to examine the impact of droughts in the three previous years on current contraceptive

[8]The DHS also includes a category for "folkloric" methods, but due to very low incidence of this category, I include them with traditional methods.

use using the following linear probability model:

$$Contraceptive_{i,g} = \beta_0 + \beta_1 Droughts_{g,t-1} + (\phi_i \times \psi_c) + \epsilon_{i,g} \tag{2}$$

Where $Contraceptive_i$ is a binary indicator for whether respondent, i, interviewed in grid-cell, g, reports current usage of a given type of contraceptive (any, modern, or traditional). $Droughts_{g,t-1}$ are the number of droughts experienced in that grid-cell location, g, in the three years preceding the interview. $(\phi_i \times \psi_c)$ are a set of individual characteristics by survey fixed effects.[9] They include, wealth level, education attainment, current number of children, and current age. Standard errors are clustered at the grid-cell level.

4 Results

4.1 Main Effect of Drought on Likelihood of Conception

Table 1 presents the paper's main result: drought reduces likelihood of conception. Panel (a) uses a binary indicator of whether a drought was experienced in the previous year while Panel (b) switches to a count of the number of droughts experienced over the preceding three years. Magnitudes fall between columns (1) and (3) as I use increasingly stringent sets of geographic controls and geographic by year fixed effects. However, the effects remain highly statistically significant. Column (4) switches from grid-cell to individual woman fixed effects, capturing time invariant unobservable characteristics unique to that woman (and her partner) such as household fertility preferences. Column (5) includes country by age and country by current children fixed effects, controlling for local fertility and maternal age norms. This is the preferred specification detailed in equation (1). With this specification, panel (a) shows that a drought in the previous year reduces the likelihood of conception by 0.55 percentage points, or 2%. Panel (b) shows that an ad-

[9]Many countries have had multiple rounds of the DHS and all available rounds are included, as discussed in the previous section. For a list of surveys, see Appendix Table A.1.

ditional drought in one of the three prior years reduces likelihood of conception by 0.41 percentage points, or 1.5%.

Column (6) switches from year by region to year by country fixed effects. These may capture local dynamic factors affecting peoples' conception decisions more closely than the broader, region by year fixed effects. However, given the high spatial correlation of rainfall, restricting estimation to only within country variation in a given year means that drought areas are being compared to "non-drought" areas that are also likely to be below their normal rainfall levels. This would lead to an underestimation of the impact of droughts. As expected, these estimates have smaller magnitudes (and lose statistical significance for the binary lagged indicator) but are largely consistent with the preferred specification in column (5). As an alternative approach to address concerns about dynamic factors at the national level, column (7) reverts to year by region fixed effects, but also includes a set of both linear and quadratic country time trends. The magnitudes of these effects are even stronger than those shown in column (5).

Figure 1 shows droughts in an event study format. Notably, the impact of drought appears negative and significant for the preceding three years. This motivates a focus on drought in the previous year as well as the number of droughts in the previous three years. Appendix Table A.3 shows this event study in regression form. Column (3) focuses on the first two lags while including an interaction for droughts in both years. The results suggest that the effect of the first lag is bigger than that in the second period. The positive (although not statistically significant) interaction of the two droughts suggests that consecutive droughts do not compound one another (and may not even be additive). Families may delay conception in response to a single drought but be unwilling or unable to delay indefinitely following further droughts.

4.2 Robustness of Main Result

Figure 2 shows robustness of the main effects to different thresholds in defining droughts. The x-axis shows the percentile threshold used to define drought in a locally estimated gamma distribution. The y-axis shows the point estimate from estimation of equation (1) with either a single lagged shock, in Panel (a), or for the total number of shocks in the last three years, in Panel (b). The vertical lines represent 95% confidence intervals around the point estimates. Impacts of drought get bigger with more stringent criteria for inclusion and as would be expected to result from more severe droughts. Standard errors get larger with lower incidence of these events. Effects are significant and negative for all thresholds below the 45th percentile.

Next, Appendix Table A.2 shows robustness to the choice of distribution used while defining droughts. Column (1) reproduces the original results. Instead of using a locally estimated gamma distribution, column (2) uses a locally estimated normal distribution, and defines drought as rainfall below negative one standard deviation. This cutoff should lead to a similar incidence of drought (≈14%) as the original estimates (15%). Results are slightly stronger and remain highly statistically significant. Column (3) does not impose any assumptions about the local distribution and defines drought as rainfall at or below the 15th percentile of locally realized rainfall. Estimated magnitudes are slightly smaller than those using the gamma distribution, but remain highly statistically significant with confidence intervals that contain the original estimates.

Aside from definition of droughts, a separate potential threat to the validity of the results is that respondents are linked to historical rainfall based on the location of their interview. Although most movements in rural Africa are likely to cover only small distances, where exposure to drought is similar in both origin and destination, longer moves linked to weather patterns could still bias the results. To account for this concern, I use data from the DHS on duration of a woman's presence in their current location. Unfortunately, this question was not asked in all surveys. For this robustness check, I drop any observation where data on duration of current location is missing as well as woman-years pre-dating a woman's known location. These restrictions cut the sample by over 50%. Results are presented in column (4). As expected from the loss of sample, there is a loss of precision, however highly statistically significant negative point estimates persist, with confidence intervals that contain the original estimates.

Finally, this paper suggests that the first order effect of drought is on the finances of rural farming households. As a placebo, I look at the impact of droughts on rural households for whom the husband is not a farmer. Point estimates fall by more than 80% for the single lag and go nearly to zero for the total lags. Both confidence intervals comfortably contain zero. The strong impacts on farmers and lack of effects on non-farmers provide corroborating evidence that the impact of droughts operate through a financial channel and are not the result of an otherwise spurious correlation.

4.3 Heterogeneous Responses to Drought

The previous section showed that droughts reduce conception likelihood. However, average impacts may mask meaningful heterogeneity that is important in its own rite for our understanding who does and does not respond to droughts, while providing clues to the mechanisms behind these responses. A challenging part of interpreting impacts is that responsiveness to drought captures (at least) two factors which frequently push in opposite directions. They capture who is most impacted by income fluctuations from droughts, but also reflect peoples' ability to adjust fertility timing. Compounding matters further, people may be aware of vulnerability to droughts and actively try and mitigate these risks. Because any given dimension of heterogeneity could push these different responses in different directions, predictions are generally ambiguous.

In this section, I explore three broad groups of heterogeneity: 1) education, 2) existing fertility measures, and 3) wealth. To do this, I estimate equation (1) while adding a binary indicator for one dimension of heterogeneity at a time, interacted with the measure of lagged drought or droughts.[10]

Farmers with higher education levels may be better able to adjust behavior and reduce likelihood of conception, suggesting greater response to droughts than those with less education (Ainsworth et al., 1996; Angeles et al., 2005). However, education may facilitate ones ability to either smooth income or implement less vulnerable farming practices, either of which would mute the negative impacts of a drought and lead to smaller fertility responses. The net impact of these two opposing dynamics is therefore ambiguous. Panel (a) of Table 2 suggests that those with higher levels of education respond significantly less to droughts over the preceding three years than those with lower levels of education.

Panel (b) examines a different dimension of heterogeneity: fertility attainment at the time of conception. Parents may have strong preferences over the number or gender composition of their children. Recent work has shown that son preference in particular affects weaning behavior in India (Jayachandran and Kuziemko, 2011) and is also an important factor leading to a height gradient in birth order among children in both India and Africa (Jayachandran and Pande, 2017). Desire to secure at least one boy (or girl) may therefore reduce parents' willingness to delay conception in response to droughts until a woman has had her first son (or daughter). Results for already having a boy are shown in column (1) and for a girl in column (2). More generally, mothers could be more willing to delay conception once they've had one or two children, as shown in columns (3) and (4). On a sample of women who were 40 or above at the time of their interview, column (5) shows heterogeneity by women who had already achieved half of their fertility totals. And column (6) looks at heterogeneity by whether its early in a woman's marriage (first ten years) or relatively later, with a sample of women who had been married for at least 20 years. For all of these dimensions, one might expect that having achieved or approached different fertility targets, women would be more willing to delay further conception following droughts. While lacking statistical significance at conventional levels, point estimates

[10] With the inclusion of individual fixed effects, I do not need to also include the non-interacted measure of heterogeneity in the regression since it would be constant within individual.

are consistently in the opposite direction from that hypothesized response. These results would instead be consistent with parents giving preference to early children while also being sophisticated about the vulnerability of children born in times of financial hardship. Appendix Table A.4 shows these results using the single lagged drought treatment instead of the total from the three preceding years and are very similar across both groups of heterogeneity.

Finally, I examine heterogeneity by levels of wealth. Each DHS categorizes households into wealth based on reported assets. Unsurprisingly, rural farming households are less well off than their national averages. With just 2% of the population falling in the top wealth quintile, I combine the top two quintiles, leaving four wealth groupings: very poor, poor, medium, and wealthy. Table 3 presents these results.

Columns (1) and (4) show heterogeneity by being in the top two wealth groups for lagged drought and total lagged droughts, respectively. Columns (2) and (5) show heterogeneity by being in the top wealth group. All point estimates for the interaction term are negative. The estimate in column (5) for heterogeneity by the top wealth group is statistically significant at the 95% level. For all four of these estimates, the estimated effect on the wealthier group is statistically significantly different from zero ($p < .001$). Columns (3) and (6) use a fully saturated set of interactions of drought and the four wealth groups. The magnitude of the estimated interactions generally get larger for higher levels of wealth. In the more precise estimates in column (6), the wealthy are significantly more responsive to droughts than two of the three other wealth groups. If wealthier families were more exposed to the impact of shocks, they may be expected to respond more to droughts. Greater resources could mean that they, in fact, experience greater absolute variability of income in response to shocks. However, having higher level of assets would also suggest a bigger buffer to potentially mitigate the impact of these shocks, leading us to expect less responsiveness. Alternatively, if material resources are needed in order to take advantage of family planning, then we would expect to see bigger impacts of droughts on conception among the relatively wealthy, as we saw in the estimates.

4.4 Effect of Drought on Contraceptive Use

The previous sections showed negative responses of conception to droughts. However, they can not determine whether these responses are the result of active family planning choices or are the unintended byproduct of other impacts of the shock or shock-coping behaviors such as seasonal migration in pursuit of additional income or lower fecundity resulting from worse nutrition. In this section, I examine the effect of drought on usage of family planning methods to provide evidence of plausibly intentional efforts to reduce conception. As discussed in section 3, the structure of the available data prevent me from creating a retrospective panel of contraceptive usage as I did with conceptions. Instead, I follow a cross-sectional estimation approach and rely on the orthogonality of droughts to the timing of the surveys as a source of exogenous variation in exposure to droughts.

In the DHS, respondents were asked if they are currently using any form of family planning. 21% of respondents report that they are currently trying to follow some form of strategy to lower likelihood of conception. These responses are categorized as modern (17.2%), traditional (3.3%), or folkloric (0.5%). If they list multiple methods, then the more "advanced" approach is prioritized and recorded. Due to their low level of incidence, I combine traditional and folkloric methods under the "traditional" heading.[11] Estimation is based off a set of cross-sections that capture current contraceptive use while controlling for survey (survey number and country) by current number of kids, survey by age, survey by wealth group, and survey by education attainment fixed effects. Because a respondent's current contraceptive strategy may have begun years before the time of interview, I look at the effect of total droughts in the previous three years on current contraceptive

[11] Modern contraceptive approaches include female or male sterilization, intrauterine devices, injectables, implants, pills, male or female condoms, foam, or jelly. Traditional contraceptives include the standard days method (beads to count days), rhythm method, lactational amenorrhea, and withdrawal. Folkloric methods were all categorized based off of an "other, specify" option in the survey that is not included in the publicly available data.

usage instead of the single lagged drought, which may have occurred after the current contraceptive strategy began. Results using the single lagged drought are included in the appendix.

Table 4 presents these results. Panel (a) shows the effect of an additional drought in the preceding thee years on current utilization of any, modern, or traditional methods of contraception. Notably, while there does not appear to be any change in overall contraceptive usage, there is a sizable reduction in usage of traditional methods as the primary mode of contraception and an increase in usage of more modern forms of contraception.[12] This would be consistent with women knowing that modern methods of contraception are more effective at preventing conception than traditional methods and being more likely to take up modern methods following recent times of drought. Appendix Table A.5 shows robustness of these results to alternative specifications.[13] [14]

Panels (b), (c), and (d) examine the same dimensions of heterogeneity as show in the main results in the previous section in Tables 2 and 3. To economize space and given their relatively stronger estimated heterogeneity, I focus on primary education for wives and whether the respondent already has a son in panels (b) and (c) respectively. The estimates for wife's education are unfortunately too noisy to make strong claims about differential response to droughts. The point estimates appear stronger for primary educated women, but I can not reject that educated and uneducated women respond the same or a net effect of zero.

Panel (c) shows some differences for women who do not yet have a son. Women without a son are significantly more likely to use modern and less likely to use traditional

[12]Because the DHS prioritizes categorization of the most modern form of contraception, I can not tell if there is actually a reduction of usage of traditional methods or if people are adding more modern methods to their traditional ones.

[13]While the gap in response to droughts between modern and traditional methods persists across specifications, Appendix Table A.5 also contains a puzzle. Droughts should be effectively random with respect to respondents in a country interviewed in the same year. Despite this, adding additional controls lowers the estimates for both outcomes.

[14]Appendix Table A.6 shows specification robustness using the single drought lag while Appendix Table A.7 shows all results on contraceptives using the single drought lag.

methods of contraception. Although the difference was not statistically significant, this would be consistent with the direction of heterogeneity seen in the last section, whereby women without a son reduce conception more than those who have a son.

Finally, Panel (d) shows strong differential responses to shocks by levels of wealth. Notably, people who are very poor respond to droughts significantly more than those who are wealthy. These differences are statistically significant for takeup of any contraceptive and for traditional methods. Although it lacks statistical significance, the magnitude of the estimates on modern methods are nearly three times bigger than those for the wealthy. This appears inconsistent with the heterogeneity by wealth discussed in the previous section whereby wealthier women were more likely to decrease conception following droughts than the relatively less well off. However, it should be noted that despite differing magnitudes of response, all wealth groups significantly reduced conception.

There are a number of possible ways in which these inconsistencies could be reconciled. First, the bottom of panel (d) shows that for both modern and traditional methods, average usage rates of contraception increase with wealth. The estimated effects only capture changes in variation on the extensive margin, but do not capture intensivity or carefulness when following a given contraceptive strategy. If the relatively wealthy are better at adhering to different methods of contraception when they want to (following a drought), then the intensive margin may capture more meaningful variation than what I am able to observe in the DHS data on the extensive margin. Second, adjustments within category may mask meaningful changes in contraceptive strategy that are lost when aggregating to larger categories. Understanding choice of contraceptive strategies as well as adherence in these settings is therefore an important topic for future research.

4.5 Effect of Drought on Fertility Totals

While the results in section 4.1 showed that droughts cause delays in conception timing, this does not necessarily mean that they affect eventual fertility totals. To explore this, I focus on a sample of women likely to have completed their fertility. In addition to the existing sample restrictions, I further limit the sample to women who have been married for at least 20 years and who have not had a child in the previous 10 years. I focus on the number of droughts that they experienced in the first ten years of their marriage. Panel (a) of Table 5 shows these results. The estimates in the most stringent specification, in column (6), have a confidence interval that includes zero as well as an effect size of roughly -0.024 standard deviations in total children. I can therefore reject that droughts early in ones marriage have a large effect on total fertility.

Panel (b) finds a statistically significant reduction in age of final birth. Point estimates suggest that an additional drought in the first ten years of marriage reduces age at final birth by 0.0371 standard deviations. While precisely estimated, this magnitude appears only marginally economically meaningful. What is clear, however, is that women are not pushing out their time horizon for additional births after experiencing droughts in the early years of their marriage.

5 Discussion

This paper has analyzed the effect of droughts on conception and contraception use among rural, agriculture-dependent, households in Africa. I find a 1-2% reduction in likelihood of conception following recent droughts. Early droughts do not impact completed fertility levels. Conception responses to drought are muted by education but heightened by wealth. And droughts appear to increase usage of modern methods of contraceptive usage.

This paper builds on recent work by Chatterjee and Vogl (2018) which showed positive correlations between fluctuations in economic growth and fertility responses in less developed countries. By using a separate, and plausibly exogenous, source of income shock to assess impacts on conception, I can make stronger causal claims about these effects on conception. However, given the broad coverage of data in the analysis, my results also have greater claim to external validity than much of the rest of the existing literature on income shocks, fertility, and contraceptives that rely national or sub-national samples.

The magnitudes of my effects are more modest than those identified in other settings. Alam and Pörtner (2018) showed that crop-loss, equal to the 5th percentile of household savings, reduced pregnancy by nearly 60%, a near total collapse in fertility. While estimates from the United States by Lovenheim and Mumford (2015) show that a 65% increase in housing value lead to a 19% increase in likelihood of conception. My estimates of a 1-2% reduction in likelihood of conception following droughts (estimated by others to constitute output losses of roughly 10%) are considerably more modest. It is difficult, or even impossible, to compare responses across different settings with different fertility norms. However, observing that fertility adjustments in Africa are smaller than those in the United States, despite greater potential consequences in terms of infant health and survival in Africa suggests that improving access to and understanding of modern contraceptive methods may have substantial welfare benefits.

I also provide further evidence that droughts impact choice of contraceptive strategy, corroborating a mechanism of deliberate effort by rural farmers to reduce conception in times of economic hardship. Contrary to Alam and Pörtner (2018) with their work in Tanzania, I find a significant increase in use of *modern* contraceptive methods, with a reduction in usage of traditional methods as ones primary contraceptive method. Also, I find that contraceptive take up in response to droughts is strongest among the poor, a finding that appears to contrast work by Jones (2015) showing a reduction in contraceptive usage following reduction in contraceptive availability and increased contraceptive prices in Ghana. Developing a deeper understanding of when, where, and why different responses prevail in different settings is an important area of future research central to understanding takeup and usage of contraception and household fertility decisions.

Finally, this paper revealed what appears to be an important puzzle: Wealthier people respond more dramatically to droughts, suggesting that the effect of droughts on conception may have more to do with access and ability to use contraceptives than it does with vulnerability to shocks, insights consistent with Alam and Pörtner (2018); Jones (2015). And yet, heterogeneity of response in contraceptive usage does match that of conception. This suggests that there may be other unobserved responses on the intensive margin of contraceptive usage or choice of particular method that influence fertility outcomes and are associated with different wealth levels. Or, other channels entirely may be at play unrelated to usage of contraceptives. In particular, a better understanding of intensivity, carefulness, and mixed strategies of contraceptive use are all areas that could reveal important insights with first order implications on fertility outcomes that current data, focused on the extensive margin of contraceptive use, misses.

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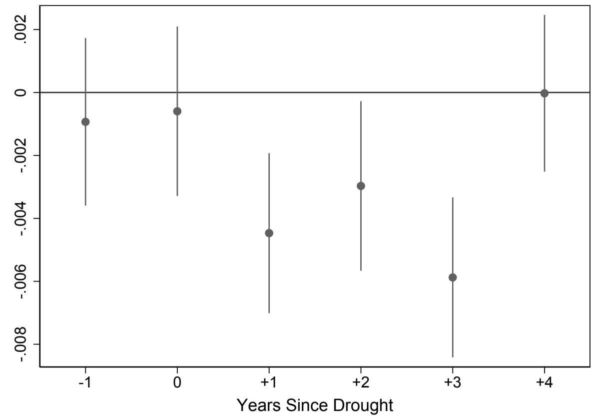
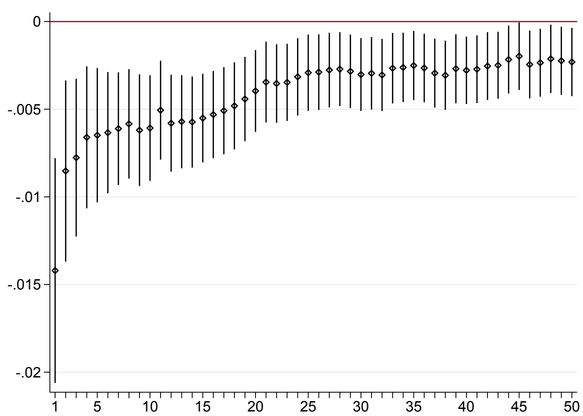
Tables and Figures

Figure 1: Timing of Drought and Conception Likelihood

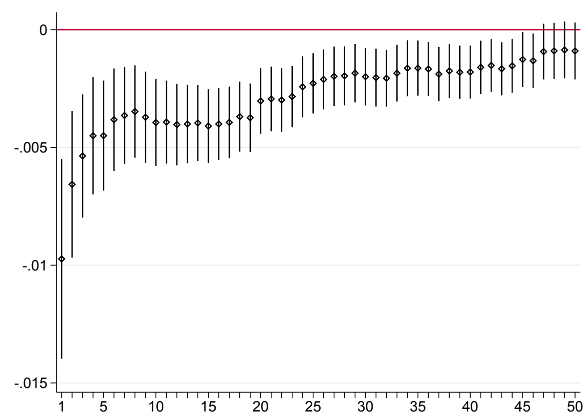


Notes: This figure shows point estimates of the effects of droughts on likelihood of conception along with 95% confidence intervals. The lead and lagged droughts were jointly estimated using equation (1).

Figure 2: Effect of Drought on Conception with Different Thresholds



(a) Drought Last Year



(b) Droughts in Last Three Years

Notes: These figures show robustness of the main effects of droughts on likelihood of conception using different thresholds as cutoffs for the definition of droughts. The x-axis indicates the percentile cutoff of the gamma distribution used to define a drought. Each percentile threshold on the x-axis is analyzed with a separate estimation of equation (1). Diamonds represent the point estimate, while the vertical lines show 95% confidence intervals. The paper's main tables use a cutoff at the 15th percentile.

Table 1: Effect of Drought(s) on Conception Likelihood

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel (a): Lagged Drought							
Drought Last Year (0/1)	-0.0075***	-0.0068***	-0.0050***	-0.0038***	-0.0055***	-0.0021	-0.0057***
	(0.0014)	(0.0014)	(0.0014)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
Mean Outcome	0.2731	0.2731	0.2731	0.2741	0.2741	0.2741	0.2741
Beta/Mean	-0.0276	-0.0249	-0.0184	-0.0138	-0.0202	-0.0076	-0.0209
Individuals	136657	136657	136657	136657	136657	136657	136657
Observations	1680975	1680975	1680970	1674185	1674176	1674173	1674176
Adjusted R2	0.0193	0.0228	0.0262	0.0103	0.0236	0.0308	0.0247
Panel (b): Lagged Droughts	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Droughts Last Three Years (0-3)	-0.0046***	-0.0040***	-0.0025***	-0.0020**	-0.0041***	-0.0027***	-0.0047***
	(0.0010)	(0.0009)	(0.0009)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Mean Outcome	0.2602	0.2602	0.2602	0.2614	0.2614	0.2614	0.2614
Beta/Mean	-0.0168	-0.0146	-0.0090	-0.0073	-0.0150	-0.0097	-0.0171
Individuals	136657	136657	136657	136657	136657	136657	136657
Observations	1308049	1308049	1308043	1301293	1301283	1301266	1301284
Adjusted R2	0.0220	0.0253	0.0292	0.0146	0.0292	0.0362	0.0303
Specification:							
Country FEs	Yes	Yes	No	No	No	No	No
Cluster FEs	No	No	Yes	No	No	No	No
Indiv FEs	No	No	No	Yes	Yes	Yes	Yes
Year FEs	Yes	No	No	No	No	No	No
Year x Region FEs	No	Yes	Yes	Yes	Yes	No	Yes
Year x Country FEs	No	No	No	No	No	Yes	No
Age FEs	No	No	No	No	No	No	Yes
Country x Kids FEs	No	No	No	No	Yes	Yes	Yes
Country x Age FEs	No	No	No	No	Yes	Yes	No
Country Time Trends	No	No	No	No	No	No	Yes

Notes: Droughts defined as rainfall at or below the 15th percentile of the estimated gamma distribution of local rainfall. Country time trends, included in column (7), include both linear and quadratic time trends for each country. Standard errors in parentheses, clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Heterogneous Impacts of Recent Droughts on Conception Timing

Panel (a) Education	(1) Wife Primary	(2) Wife Secondary	(3) Husband Primary	(4) Husband Secondary		
Droughts Last Three Years (0-3)	-0.0047***	-0.0043***	-0.0054***	-0.0043***		
	(0.0009)	(0.0008)	(0.0010)	(0.0008)		
Droughts Last Three Years x Het	0.0025*	0.0050*	0.0032**	0.0013		
	(0.0014)	(0.0025)	(0.0013)	(0.0018)		
Mean (Het=0)	0.2757	0.2752	0.2739	0.2750		
Mean (Het=1)	0.2686	0.2361	0.2722	0.2608		
Scaled (Het=0)	-0.0171	-0.0156	-0.0197	-0.0157		
Scaled (Het=1)	-0.0083	0.0029	-0.0081	-0.0117		
P-val: B1+B2	0.0738	0.7783	0.0431	0.0649		
Individuals	136692	136692	134842	136695		
Observations	1301246	1301203	1284762	1301261		
Adjusted R2	0.0294	0.0292	0.0294	0.0293		
Panel (b) Current Fertility	(1) Has Boys	(2) Has Girls	(3) Any Kids	(4) Two Kids	(5) Half Kids	(6) Late Years
Droughts Last Three Years (0-3)	-0.0053***	-0.0043***	-0.0044*	-0.0043***	-0.0033***	-0.0044***
	(0.0013)	(0.0013)	(0.0023)	(0.0013)	(0.0011)	(0.0016)
Droughts Last Three Years x Het	0.0016	0.0002	0.0004	0.0004	0.0006	0.0031
	(0.0014)	(0.0014)	(0.0024)	(0.0015)	(0.0015)	(0.0020)
Mean (Het=0)	0.2915	0.2900	0.2774	0.2980	0.3392	0.3276
Mean (Het=1)	0.2643	0.2645	0.2723	0.2592	0.1927	0.2687
Scaled (Het=0)	-0.0182	-0.0147	-0.0158	-0.0145	-0.0097	-0.0133
Scaled (Het=1)	-0.0140	-0.0152	-0.0146	-0.0153	-0.0138	-0.0045
P-val: B1+B2	0.0000	0.0000	0.0000	0.0000	0.0069	0.3069
Individuals	136695	136695	136695	136695	41957	24627
Observations	1301270	1301274	1301233	1301270	764367	493059
Adjusted R2	0.0294	0.0294	0.0292	0.0299	0.0558	0.0240

Notes: Heading of each column indicates dimension of heterogeneity interacted with treatment. All regressions include individual, time by region by heterogeneity, country by age by heterogeneity, and country by number of kids, by heterogeneity fixed effects. Standard errors show in parentheses, clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Conception Timing Heterogeneity by Wealth

	Drought Previous Period (0/1)			**Droughts Previous Three Periods (0-3)**		
	(1)	(2)	(3)	(4)	(5)	(6)
Drought(s)	-0.0057***	-0.0065***		-0.0038***	-0.0038***	
	(0.0016)	(0.0014)		(0.0009)	(0.0009)	
Drought(s) x (Middle or Wealthy)	-0.0030			-0.0012		
	(0.0024)			(0.0013)		
Drought(s) x Wealthy		-0.0036			-0.0035**	
		(0.0031)			(0.0016)	
Drought(s) x Very Poor			-0.0059***			-0.0044***
			(0.0021)			(0.0012)
Drought(s) x Poor			-0.0050**			-0.0028**
			(0.0022)			(0.0012)
Drought(s) x Middle			-0.0077***			-0.0034**
			(0.0024)			(0.0014)
Drought(s) x Wealthy			-0.0102***			-0.0074***
			(0.0029)			(0.0016)
Mean: Very Poor	.	.	0.2795	.	.	0.2795
Mean: Poor	.	.	0.2720	.	.	0.2720
Mean: Middle	.	.	0.2648	.	.	0.2648
Mean: Wealthy	.	.	0.2614	.	.	0.2614
P-val: B1+B2=0	0.0000	0.0004	.	0.0000	0.0000	.
P-val: B1=B4			0.2215			0.1147
P-val: B2=B4			0.1522			0.0151
P-val: B3=B4			0.4976			0.0452
Individuals	120944	120944	120944	120944	120944	120944
Observations	1485521	1485494	1485474	1154260	1154220	1154194
Adjusted R2	0.0143	0.0143	0.0142	0.0179	0.0177	0.0176

Notes: Regressions include individual, country by kids, country by age, and region by year fixed effects. Standard errors in parentheses, clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Impact of Droughts on Contraceptive Use

Panel (a): Overall Effect	(1) Any	(2) Modern	(3) Traditional
Droughts Last Three Years (0-3)	0.0001	0.0069**	-0.0068***
	(0.0039)	(0.0029)	(0.0026)
Mean Outcome	0.1900	0.1507	0.0393
Beta/Mean	0.0005	0.0403	-0.1807
Observations	98653	98653	98653
Adjusted R2	0.2202	0.2290	0.0489

Panel (b): Heterogeneity by Wife's Primary Education	(1) Any	(2) Modern	(3) Traditional
Droughts Last Three Years (0-3)	-0.0018	0.0055**	-0.0073**
	(0.0044)	(0.0027)	(0.0033)
Droughts x Primary	0.0056	0.0017	0.0039
	(0.0054)	(0.0044)	(0.0035)
Wife Finished Primary	0.0837***	0.0635***	0.0203***
	(0.0043)	(0.0038)	(0.0023)
Non-Primary Mean	0.1687	0.1357	0.0330
With Primary Mean	0.2865	0.2398	0.0467
P-val: B1+B2	0.4767	0.1318	0.2413
Observations	98658	98658	98658
Adjusted R2	0.2168	0.2259	0.0461

Panel (c): Effects by Attainment of Son	(1) Any	(2) Modern	(3) Traditional
Droughts Last Three Years (0-3)	0.0014	0.0111***	-0.0097***
	(0.0043)	(0.0032)	(0.0028)
Droughts x Has Son	-0.0019	-0.0058**	0.0039**
	(0.0032)	(0.0026)	(0.0019)
Has Son	0.0119***	0.0135***	-0.0016
	(0.0039)	(0.0034)	(0.0021)
Non-Son Mean	0.1687	0.1357	0.0330
Has Son Mean	0.2865	0.2398	0.0467
P-val: B1+B2	0.9172	0.0908	0.0394
Adjusted R2	0.2202	0.2291	0.0489

Panel (d): Effects by Wealth Level	(1) Any	(2) Modern	(3) Traditional
Droughts x Very Poor	0.0205***	0.0144***	0.0061*
	(0.0060)	(0.0050)	(0.0037)
Droughts x Poor	0.0170**	0.0124**	0.0046
	(0.0068)	(0.0059)	(0.0040)
Droughts x Middle	-0.0004	0.0092	-0.0095*
	(0.0081)	(0.0070)	(0.0049)
Droughts x Wealthy	-0.0039	0.0049	-0.0087***
	(0.0058)	(0.0054)	(0.0032)
Mean: Very Poor	0.1428	0.1139	0.0289
Mean: Poor	0.2009	0.1627	0.0382
Mean: Medium	0.2537	0.2080	0.0456
Mean: Wealthy	0.3389	0.2904	0.0485
P-val: B1=B4	0.0021	0.1558	0.0022
P-val: B2=B3	0.0397	0.6369	0.0080
Observations	98653	98653	98653
Adjusted R2	0.2204	0.2290	0.0489

Notes: All regressions include Survey x Current Kids, Survey x Age, Survey x Wealth Group, and Survey by Education Attainment fixed effects. Standard errors clustered at the survey cluster geographic level. Regressions in Panel (b) are fully saturated so that every respondent is categorized in one of four wealth groups (quintiles four and five are combined into wealthy because the incidence of highly wealthy rural farmers is so low). Standard errors in parentheses, clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Effect of Shocks Fertility Duration and Total

Panel (a): Age of Final Birth	(1)	(2)	(3)	(4)	(5)	(6)
Droughts First 10 Years	-0.1265*	-0.1763***	-0.2634***	-0.2354***	-0.2294***	-0.2024***
	(0.0650)	(0.0603)	(0.0755)	(0.0742)	(0.0738)	(0.0751)
Mean Outcome	29.1274	29.1274	29.1319	29.1319	29.1319	29.1327
Beta/SD	-0.0232	-0.0323	-0.0483	-0.0431	-0.0420	-0.0371
Observations	5848	5848	5747	5747	5747	5705
Adjusted R2	0.0274	0.1534	0.1614	0.1650	0.1660	0.1739
Panel (a): Total Children	(1)	(2)	(3)	(4)	(5)	(6)
Droughts First 10 Years	0.0188	-0.0060	-0.0383	-0.0336	-0.0330	-0.0310
	(0.0302)	(0.0256)	(0.0324)	(0.0322)	(0.0323)	(0.0328)
Mean Outcome	5.1575	5.1575	5.1507	5.1507	5.1507	5.1569
Beta/SD	0.0076	-0.0024	-0.0154	-0.0135	-0.0133	-0.0125
Observations	5848	5848	5747	5747	5747	5705
Adjusted R2	0.0309	0.2405	0.2311	0.2314	0.2318	0.2380
Specification:						
Survey FEs	Yes	Yes	No	No	No	No
Year of Marriage (YoM) FEs	No	Yes	No	No	No	No
Survey x YoM FEs	No	No	Yes	Yes	Yes	Yes
Education FEs	No	No	No	Yes	Yes	xCtry
Wealth Group FEs	No	No	No	No	Yes	xCtry

Notes: Sample is constructed of women who have been married for at least 20 years and who have not had a child in the past ten years. Robust standard errors in parentheses. “xCtry” indicates that either Education or Wealth Group fixed effects are interacted with the country. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendices

Table A.1: Survey Stats and Sample

	DHS	Year	Clusters	Births	Women	Woman-Years
Angola	7	2016	158	5085	1408	16535
Burkina Faso	4	2003	34	21211	5595	73398
Burkina Faso	6	2010	49	27357	6800	91466
Benin	4	2001	9	6254	1620	20023
Benin	6	2012	29	14706	4049	55997
Burundi	6	2010	11	9974	2673	30037
Cameroon	4	2004	54	6324	1804	21602
Cameroon	6	2011	68	8608	2293	29286
Democratic Republic of Congo	5	2007	89	7297	2034	23946
Democratic Republic of Congo	6	2013	215	17100	4566	53359
Ethiopia	4	1997	107	35420	9012	116420
Ethiopia	6	2003	82	19353	4926	63871
Ethiopia	7	2008	66	14866	3704	49474
Gabon	6	2012	47	1095	286	3936
Ghana	4	2003	32	4609	1300	16617
Ghana	6	2014	30	5537	1455	20716
Guinea	4	2005	30	10179	2602	39003
Guinea	6	2012	25	10142	2594	36805
Ivory Coast	6	2012	83	8525	2454	31473
Kenya	4	2003	47	4880	1295	16598
Kenya	5	2009	55	4351	1150	15641
Lesotho	4	2004	11	2214	876	8836
Lesotho	6	2014	7	1169	518	5360
Liberia	5	2007	21	4313	1295	16948
Liberia	6	2013	12	5262	1428	18760
Madagascar	5	2009	149	16818	5054	59245
Malawi	4	2000	12	10138	2952	32852
Malawi	5	2010	30	18843	5230	63437
Malawi	7	2015	8	12982	4013	48594
Mali	4	2001	127	21035	5177	70072
Mozambique	6	2011	146	7223	2201	25085
Namibia	4	2000	45	1016	402	4371
Namibia	5	2007	81	1188	485	5201
Nigeria	4	2003	29	4625	1239	16115
Nigeria	5	2008	150	29750	7876	101482
Nigeria	6	2013	100	27263	6999	94804
Rwanda	6	2011	11	23231	6818	79966
Senegal	4	2005	30	8176	2067	27679
Senegal	6	2011	47	14904	3782	50357
Sierra Leone	5	2008	10	5967	1986	25357
Sierra Leone	6	2013	15	13309	3888	50938
Swaziland	5	2006	10	371	153	1538
Tanzania	5	2010	98	9868	2629	33821
Tanzania	7	2015	110	11357	3084	38166
Togo	6	2014	10	8917	2197	31176
Uganda	4	2001	20	6267	1560	18606
Uganda	5	2006	52	10005	2308	29386
Zambia	5	2007	72	5155	1359	16243
Zambia	6	2013	128	12930	3173	40871
Zimbabwe	4	1999	13	1541	533	5729
Zimbabwe	5	2005	60	3161	1059	12440
Zimbabwe	6	2011	26	2067	749	8760
Zimbabwe	7	2015	23	1425	505	6084
TOTAL			**2983**	**545363**	**147215**	**1874482**

Table A.2: Robustness of Drought Impacts: Alternative Thresholds, Migration, and Non-Farmers

Panel (a): Drought Last Year	(1)	(2)	(3)	(4)	(5)
Drought Last Year (0/1)	-0.0048***	-0.0055***	-0.0045***	-0.0036**	-0.0006
	(0.0013)	(0.0013)	(0.0013)	(0.0018)	(0.0016)
Drought Definition	Gamma-15	$Z < -1$	15 p-tile	Gamma-15	Gamma-15
Sample	Sample	Sample	Sample	In Location Farmers	Non-Farmers
Mean Outcome	0.2740	0.2741	0.2741	0.2848	0.2551
Beta/Mean	-0.0177	-0.0202	-0.0163	-0.0126	-0.0024
Individuals	136494	136641	136641	67628	100548
Observations	1671645	1674176	1674176	822454	1110788
Adjusted R2	0.0236	0.0236	0.0235	0.0180	0.0320
Panel (b): Drought Last Three Years	(1)	(2)	(3)	(4)	(5)
Droughts Last Three Years (0-3)	-0.0038***	-0.0041***	-0.0032***	-0.0035***	-0.0001
	(0.0008)	(0.0008)	(0.0008)	(0.0011)	(0.0009)
Drought Definition	Gamma-15	$Z < -1$	15 p-tile	Gamma-15	Gamma-15
Sample	Sample	Sample	Sample	In Location Farmers	Non-Farmers
Mean Outcome	0.2614	0.2614	0.2614	0.2726	0.2409
Beta/Mean	-0.0140	-0.0150	-0.0117	-0.0125	-0.0005
Individuals	136494	136641	136641	67628	100548
Observations	1301283	1301283	1301283	620574	838684
Adjusted R2	0.0292	0.0292	0.0292	0.0240	0.0395

Notes: Specifications in column (1) of both panels match those in Table 1 column (5) using the sample of farmers and defining droughts as rainfall falling at or below the 15th percentile of a locally estimated gamma distribution. Column (2) estimates a local normal distribution and sets a drought threshold of z-scores below -1. Column (3) uses the non-fitted local distribution of historical rainfall and sets the threshold at the 15th percentile of rainfall. Column (4) and (5) both use the 15th percentile of the gamma distribution definition for droughts on different samples of the data. Column (4) checks for robustness of the results against a possibility of historical weather patterns not matching households in the data and restricts the main analysis sample to only observations where the woman confirms that was in the location of the survey in that year. Column (5) serves as a placebo by using a different sample of rural *non*-farmers. Regressions include individual, region by year, country by kids, and country by age fixed effects as detailed in equation (1). Standard errors are reported in parentheses and clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Event Study and Dynamic Effects of Droughts on Conception

	(1)	(2)	(3)	(4)
Drought, Lead 1		-0.0009		
		(0.0014)		
Drought, Current Year		-0.0006		
		(0.0014)		
Drought, Lag 1	-0.0055***	-0.0045***	-0.0060***	
	(0.0013)	(0.0013)	(0.0015)	
Drought, Lag 2		-0.0030**	-0.0032**	
		(0.0014)	(0.0015)	
Drought, Lag 3		-0.0059***		
		(0.0013)		
Drought, Lag 4		-0.0000		
		(0.0013)		
Drought, Lag 1 x Lag 2			0.0020	
			(0.0030)	
Droughts Last Three Years (0-3)				-0.0041***
				(0.0008)
Mean Outcome	0.2741	0.2755	0.2740	0.2614
Individuals	136657	136657	136657	136657
Observations	1674176	1652969	1673073	1301283
Adjusted R2	0.0236	0.0220	0.0235	0.0292

Notes: Regressions include individual, country by kids, country by age, and region by year fixed effects. Column (1) is the same as the estimate in Column (5) of Table 1. Standard errors in parentheses, clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.4: Heterogneous Impacts of Prior Year Drought on Conception Timing

Panel (a) Education	(1) Wife Primary	(2) Wife Secondary	(3) Husband Primary	(4) Husband Secondary		
Drought Last Year (0/1)	-0.0065***	-0.0060***	-0.0078***	-0.0062***		
	(0.0016)	(0.0013)	(0.0017)	(0.0014)		
Drought Last Year x Het	0.0034	0.0087**	0.0055**	0.0047		
	(0.0023)	(0.0044)	(0.0023)	(0.0031)		
Mean (Het=0)	0.2757	0.2752	0.2739	0.2750		
Mean (Het=1)	0.2686	0.2361	0.2722	0.2608		
Scaled (Het=0)	-0.0235	-0.0217	-0.0286	-0.0227		
Scaled (Het=1)	-0.0115	0.0118	-0.0087	-0.0059		
P-val: B1+B2	0.1055	0.5147	0.1785	0.6037		
Individuals	136692	136692	134842	136695		
Observations	1674138	1674111	1652597	1674158		
Adjusted R2	0.0239	0.0236	0.0239	0.0237		
Panel (b) Current Fertility	(1) Has Boys	(2) Has Girls	(3) Any Kids	(4) Two Kids	(5) Half Kids	(6) Late Years
Drought Last Year (0/1)	-0.0080***	-0.0061***	-0.0086***	-0.0078***	-0.0052**	-0.0073***
	(0.0020)	(0.0019)	(0.0028)	(0.0019)	(0.0022)	(0.0027)
Drought Last Year x Het	0.0037	0.0010	0.0038	0.0035	0.0008	0.0047
	(0.0023)	(0.0023)	(0.0030)	(0.0023)	(0.0030)	(0.0037)
Mean (Het=0)	0.2915	0.2900	0.2774	0.2980	0.3392	0.3276
Mean (Het=1)	0.2643	0.2645	0.2723	0.2592	0.1927	0.2687
Scaled (Het=0)	-0.0274	-0.0210	-0.0310	-0.0262	-0.0154	-0.0224
Scaled (Het=1)	-0.0163	-0.0193	-0.0175	-0.0166	-0.0232	-0.0096
P-val: B1+B2	0.0038	0.0012	0.0006	0.0061	0.0162	0.2737
Individuals	136695	136695	136695	136695	41957	24627
Observations	1674167	1674169	1674139	1674165	884011	571639
Adjusted R2	0.0242	0.0242	0.0244	0.0247	0.0519	0.0237

Notes: Heading of each column indicates dimension of heterogeneity interacted with treatment. All regressions include individual, time by region by heterogeneity, country by age by heterogeneity, and country by number of kids, by heterogeneity fixed effects. Standard errors show in parentheses, clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: Droughts and Contraceptive Use: Specification Robustness

	(1)	(2)	(3)	(4)	(5)
Panel (a): Any Contraceptives					
Droughts Last Three Years (0-3)	0.0090**	0.0086*	0.0081*	0.0019	0.0001
	(0.0044)	(0.0044)	(0.0043)	(0.0041)	(0.0039)
Mean Outcome	0.1901	0.1901	0.1901	0.1901	0.1900
Beta/Mean	0.0429	0.0407	0.0387	0.0089	0.0005
Adjusted R2	0.1567	0.1853	0.1915	0.2097	0.2202
Panel (b): Modern Contraceptives					
Droughts Last Three Years (0-3)	0.0115***	0.0113***	0.0112***	0.0073**	0.0069**
	(0.0032)	(0.0032)	(0.0032)	(0.0030)	(0.0029)
Mean Outcome	0.1507	0.1507	0.1507	0.1507	0.1507
Beta/Mean	0.0669	0.0657	0.0650	0.0422	0.0403
Adjusted R2	0.1733	0.2005	0.2059	0.2212	0.2290
Panel (c): Traditional Contraceptives					
Droughts Last Three Years (0-3)	-0.0025	-0.0028	-0.0031	-0.0054**	-0.0068***
	(0.0028)	(0.0028)	(0.0028)	(0.0027)	(0.0026)
Mean Outcome	0.0393	0.0393	0.0393	0.0393	0.0393
Beta/Mean	-0.0658	-0.0730	-0.0813	-0.1424	-0.1807
Adjusted R2	0.0309	0.0356	0.0368	0.0442	0.0489
Specification:					
Survey FEs	Yes	No	No	No	No
Survey x Kids FEs	No	Yes	Yes	Yes	Yes
Survey x Age FEs	No	No	Yes	Yes	Yes
Survey x Wealth Quintile FEs	No	No	No	Yes	Yes
Survey x Education FEs	No	No	No	No	Yes
Observations	98679	98662	98658	98658	98653

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Droughts and Contraceptive Use: Specification Robustness

	(1)	(2)	(3)	(4)	(5)
Panel (a): Any Contraceptives					
Drought Last Year	0.0243***	0.0230**	0.0226**	0.0130	0.0091
	(0.0093)	(0.0092)	(0.0090)	(0.0086)	(0.0083)
Mean Outcome	0.1901	0.1901	0.1901	0.1901	0.1900
Beta/Mean	0.1159	0.1095	0.1078	0.0620	0.0433
Adjusted R2	0.1568	0.1854	0.1916	0.2097	0.2202
Panel (b): Modern Contraceptives					
Drought Last Year	0.0194***	0.0186***	0.0186***	0.0125*	0.0115*
	(0.0073)	(0.0072)	(0.0071)	(0.0067)	(0.0064)
Mean Outcome	0.1507	0.1507	0.1507	0.1507	0.1507
Beta/Mean	0.1128	0.1083	0.1082	0.0725	0.0666
Adjusted R2	0.1732	0.2004	0.2058	0.2211	0.2289
Panel (c): Traditional Contraceptives					
Drought Last Year	0.0049	0.0044	0.0040	0.0005	-0.0024
	(0.0056)	(0.0055)	(0.0055)	(0.0054)	(0.0054)
Mean Outcome	0.0393	0.0393	0.0393	0.0393	0.0393
Beta/Mean	0.1299	0.1150	0.1060	0.0142	-0.0629
Adjusted R2	0.0309	0.0356	0.0367	0.0440	0.0486
Specification:					
Survey FEs	Yes	No	No	No	No
Survey x Kids FEs	No	Yes	Yes	Yes	Yes
Survey x Age FEs	No	No	Yes	Yes	Yes
Survey x Wealth Quintile FEs	No	No	No	Yes	Yes
Survey x Education FEs	No	No	No	No	Yes
Observations	98679	98662	98658	98658	98653

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.7: Impact of Droughts on Contraceptive Use

Panel (a): Overall Effect	(1) Any	(2) Modern	(3) Traditional
Drought Last Year (0/1)	0.0091	0.0115*	-0.0024
	(0.0083)	(0.0064)	(0.0054)
Mean Outcome	0.1900	0.1507	0.0393
Beta/Mean	0.0433	0.0666	-0.0629
Observations	98653	98653	98653
Adjusted R2	0.2202	0.2289	0.0486

Panel (b): Heterogeneity by Wife's Primary Education	(1) Any	(2) Modern	(3) Traditional
Drought Last Year (0/1)	0.0071	0.0131*	-0.0060
	(0.0101)	(0.0075)	(0.0068)
Drought x Primary	0.0071	-0.0060	0.0131*
	(0.0101)	(0.0076)	(0.0068)
Wife Finished Primary	0.0851***	0.0650***	0.0201***
	(0.0040)	(0.0036)	(0.0020)
Non-Poor Mean	0.1687	0.1357	0.0330
Poor Mean	0.2865	0.2398	0.0467
P-val: B1+B2	0.1204	0.3476	0.2172
Adjusted R2	0.2168	0.2259	0.0459

Panel (c): Effects by Attainment of Son	(1) Any	(2) Modern	(3) Traditional
Drought Last Year (0/1)	0.0101	0.0172**	-0.0071
	(0.0091)	(0.0073)	(0.0056)
Drought x Has a Son	-0.0014	-0.0079	0.0065
	(0.0075)	(0.0069)	(0.0042)
Has Son	0.0112***	0.0119***	-0.0007
	(0.0037)	(0.0034)	(0.0020)
No Son Mean	0.1687	0.1357	0.0330
Has Son Mean	0.2865	0.2398	0.0467
P-val: B1+B2	0.3244	0.1859	0.9141
Adjusted R2	0.2203	0.2290	0.0486

Panel (d): Effects by Wealth Level	(1) Any	(2) Modern	(3) Traditional
Drought x Very Poor	0.0210**	0.0171**	0.0038
	(0.0091)	(0.0072)	(0.0056)
Drought x Poor	0.0268**	0.0228***	0.0040
	(0.0110)	(0.0085)	(0.0074)
Drought x Middle	-0.0105	0.0033	-0.0138**
	(0.0108)	(0.0091)	(0.0064)
Drought x Wealthy	-0.0235*	-0.0121	-0.0115
	(0.0141)	(0.0122)	(0.0078)
Mean: Very Poor	0.1428	0.1139	0.0289
Mean: Poor	0.2009	0.1627	0.0382
Mean: Medium	0.2537	0.2080	0.0456
Mean: Wealthy	0.3389	0.2904	0.0485
P-val: B1=B4	0.0012	0.0185	0.0356
P-val: B2=B3	0.0010	0.0428	0.0077
Observations	98653	98653	98653
Adjusted R2	0.2204	0.2290	0.0487

Notes: All regressions include Survey x Current Kids, Survey x Age, Survey x Wealth Group, and Survey by Education Attainment fixed effects. Standard errors clustered at the survey cluster geographic level. Regressions in Panel (b) are fully saturated so that every respondent is categorized in one of four wealth groups (quintiles four and five are combined into wealthy because the incidence of highly wealthy rural farmers is so low). Standard errors in parentheses, clustered at the survey enumeration area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$