Can Abortion Mitigate Transitory Shocks?: Demographic Consequences under Son Preference*

Jaehyun Jung†

January 16, 2019

Abstract

This paper studies how transitory income shocks affect fertility timing via abortion and exacerbate the 'missing girls' phenomenon under son preference. After linking rich microdata on fertility with local rainfall shocks in rural Vietnam, I find that affected mothers were 30 percent more likely to get abortions. Six female fetuses were aborted to every 1 male fetus, leading to a more male-skewed sex ratio at birth. Most abortions occurred during the pre-harvest season, suggesting that mothers postpone births via abortion to smooth consumption.

JEL Codes: D1, I15, J13, J16, Q54
Keywords: Abortion, Fertility, Weather shock, Consumption smoothing, Son preference, Sex selection

*I am deeply grateful to Douglas Almond, Cristian Pop-Eleches and Rodrigo Soares for their invaluable advice and support. I thank So Yoon Ahn, Michael Best, Eyal Frank, Jonas Hjort, Bryant Hyuncheol Kim, Anouch Missirian, John Mutter, Wolfram Schlenker, Eric Verhoogen, and the participants at the sustainable development seminar and the development workshop at Columbia University. I also thank Thy Le for excellent research assistance. This project received financial support from the Center for Development Economics and Policy at Columbia University. All errors are my own.

†Korea Institute of Public Finance, Sejong, South Korea (e-mail: jj2521@columbia.edu)

1 Introduction

Credit-constrained households in poor countries employ various coping strategies to mitigate negative aggregate shocks (Dercon, 2002). Childbearing can be subject to such arrangements in light of Becker's characterization of children as normal goods (Becker, 1960) and the observed decline in birth rates after economic recessions in both developed and developing countries (Sobotka et al., 2011; Chatterjee and Vogl, 2018). However, empirical research on how women adjust fertility to smooth consumption, particularly through abortion, has remained scarce. In fact, abortion merits careful consideration in comparison with other birth control methods; abortion not only is increasing in developing countries (Sedgh et al., 2016) but can also ensure the sex of a child once paired with ultrasound, thereby having far-reaching demographic implications in the long run.

This paper aims to examine how negative aggregate shocks affect childbearing through abortion and manipulation of the sex ratio at birth under son preference. I attempt to link adverse rainfall shocks, which credibly translate into transitory economic downturns, with a unique mother-level dataset on abortion in Vietnam. Rural Vietnam may be an ideal setting to shed light on this connection. Droughts inflict sizable damage on rural households' economic conditions through reduced rice yields, and abortion is widely available at low cost and serves as a common birth control methods. Importantly, son preference in Vietnam can play a crucial role in generating differential fertility responses if the sex of a fetus is ascertained via ultrasound. By exploiting approximately 1 million rural mothers' decisions on abortion and prenatal sex determination in almost every rural district in Vietnam from 2004-2013, I provide reduced-form estimates for the effect of droughts on how rural mothers adjust fertility using abortion and whether such abortions become more sex-selective.

How do rainfall-induced aggregate shocks affect childbearing, particularly through abortion? If this procedure occurs under son preference, would it exacerbate the imbalance in the sex ratio at birth? Although the relationship between income and fertility can be diversely characterized depending on time horizons on both sides—e.g., permanent or transitory shocks on income, completed fertility or timing of childbearing—negative rainfall shocks can shed light on the effect of *transitory* income shocks on the *timing* of fertility, while holding other shadow prices constant. This is because 1) rainfall-induced economic shocks are transitory;[1] 2) transitory shocks have no effects on childbearing when credit markets are perfect (Dehejia and Lleras-Muney, 2004), but credit constraints are commonly faced by the poor, especially after aggregate shocks (Dercon, 2002); and 3) the low skill and low participation of female labor in agrarian economies plausibly limit the scope of influence exerted by the opportunity cost of childbearing (Bhalotra and Rocha, 2012).

The decision of credit-constrained rural parents facing transitory rainfall shocks is thus essentially reduced to a comparison of benefits from current consumption with those from childbearing. Choosing to give birth by forgoing current consumption would hardly be the optimal choice, especially if delaying is not costly. In particular, abortion can be preferred to other preemptive measures to avoid pregnancy because abortion not only allows for extra months to update the expected payoff of giving birth (Ananat et al., 2009) but is also the only method to ensure the sex of a child when used with ultrasound. Thus, if the cost of 'sex-selective' abortion is sufficiently low and a mother expects extra marginal utility by having a long-awaited son, she would rather choose to give birth to a child only if the revealed sex of a fetus is male.

To test the intertemporal substitution effects on childbearing, I draw on exogenous variations in local economic conditions by exploiting year-to-year variations in rainfall realizations. Specifically, I define droughts as seasonal rainfall occurring below the 20th percentile of the district-specific long-run rainfall distribution in 1984-2013 using Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data.

To confirm that the constructed drought shocks translate into negative economic shocks, I first combine rainfall with yearly rice yields. Then, I demonstrate a more direct effect on household consumption using detailed expenditure surveys. My drought measure leads to an approximately 2 percent decrease in the yield of the main rice crop and lower expenditure of non-food items by approximately 8 percent.

[1] Rainfall shocks are assumed to be short-term and transitory by previous studies in the economic literature (Paxson, 1992; Townsend, 1994; Jayachandran, 2006; Kaur, 2014).

To identify a specific time window when parents are faced with a stark trade-off between childbearing and current consumption, I further examine monthly household expenditure and find that affected households are unable to smooth consumption, especially in the pre-harvest season of the next rice crop.

To derive reduced-form estimates on fertility outcomes sequentially from conception to abortion, birth, and finally the sex ratio at birth, I link droughts with the 9 rounds of the Population Change and Family Planning Surveys (PCSs) from 2004-2013. The PCS contains rich information on fertility; in particular, it reports approximately 1 million rural mothers' decisions on abortion from almost every rural district in Vietnam.

The first main result indicates that a married woman is approximately 30 percent more likely to get an abortion in the year following a drought event. The effect is significant both statistically and economically and remains robust to a variety of controls, including a mother's fertility history and district-specific time trends.

I show that the income effect is the primary pathway for explaining the abortion responses. With no changes in the number and composition of mothers who conceive, I find the birth rate drops significantly in a specific quarter of a year, indicating that most abortions occurred in the pre-harvest season of the next rice crop when affected rural households appear unable to smooth consumption. I also find no effects on abortion among urban mothers, and substantially muted impacts on abortion for mothers living in provinces where an additional rice crop can be harvested. Furthermore, I find weak evidence of the effects of droughts on a woman's labor market participation and infant mortality rates, suggesting neither the opportunity cost of a woman's labor nor the direct health impact of droughts appears to be a dominant factor driving the effects on abortion.

Importantly, droughts lead abortion to be more sex-selective, e.g., 6 female fetuses were aborted to every 1 male fetus, contributing to approximately 3 percent of the sex imbalance witnessed in rural Vietnam in 2004-2013. The evidence on sex selection can be corroborated by two further results. First, the effect of droughts on the sex ratio at birth is primarily driven by the subsample surveyed when ultrasound scans for fetal sex determination are more prevalent. Second, the ultrasound scan, particularly during the 12-16 weeks of pregnancy—an essential prerequisite for sex-selective abortions—was more likely to be conducted for mothers who gave birth to a son after droughts.

I argue that abortion can be considered as a coping strategy to address aggregate shocks; at the same time, however, it worsened the sex imbalance to be more male-skewed. I find a rebound of fertility approximately 2 years after the shortfall in birth rates, which implies that the effects of droughts on fertility are more pertinent to the timing of fertility rather than lifetime fertility. However, if son preference interacts with such adjustments via abortion and skews the sex ratio at birth, the resulting demographic consequences can persist in the long run.

This paper builds on and contributes to three strands of the literature. First, this paper speaks to the effects of income on fertility, particularly the fertility response to transitory economic downturns. In previous studies focusing on developing countries, infant mortality has been implicated as an important factor in understanding how negative income shocks affect childbearing and determine lifetime fertility (Dyson, 1993; Pitt and Sigle, 1997; Artadi, 2005). Furthermore, due to a dearth of credible mother-level data, there is scant literature providing micro-level evidence, whereas a number of studies in the US have leveraged exogenous variations in household-level permanent income to show its positive association with fertility (Lindo, 2010; Black et al., 2013; Lovenheim and Mumford, 2013 Dettling and Kearney, 2014). This study attempts to fill this substantial gap in the literature in recent developing-country contexts where preemptive measures to adjust fertility become more available. Specifically, I highlight abortion as the main mechanism for adjustment in childbearing to mitigate transitory income shocks.

Second, my findings are complementary to the literature regarding how economic determinants interact with traditional cultural norms, e.g., son preference through prenatal sex selection. The influential factors discussed thus far have included a decline in fertility given the importance of having at least one son (Ebenstein, 2010; Jayachandran, 2017), the availability of cheap sex-selective technologies (Bhalotra and Cochrane, 2010; Chen et al., 2013), and an increase in income when the cost of sex selection is high (Almond et al., 2017). This paper presents a new case study exploring how prenatal sex selection can be driven by short-run economic downturns. I find low-cost sex selection technologies make female 'fetuses' bear a disproportionate burden of aggregate shocks during the lean season, a phenomenon that used to befall female infants (Behrman, 1988).

Third, this study contributes to an emerging strand of the literature on the various coping strategies of credit-constrained households employed against weather-induced aggregate shocks (Dell et al., 2014). If an adverse weather shock occurs, and if credit and insurance markets are incomplete, poor households smooth consumption not only by changing their usual diets (Bhattacharya et al., 2003; Hou, 2010; Lohmann and Lechtenfeld, 2015), but also by migrating to urban areas (Groeger and Zylberberg, 2016), by investing less in a female infant's health (Rose, 1999; Maccini and Yang, 2009; Anttila-Hughes and Hsiang, 2013), or by gaining cash transfers through engaging in risky sexual behaviors (Burke et al., 2015) or adjusting the timing of child marriage (Corno et al., 2017). In this paper, I suggest that delaying the timing of fertility through abortion can also be a margin of adjustment to smooth consumption for poor households to cope with adverse rainfall shocks.

The remainder of the paper proceeds as follows. I describe the relevant empirical context of Vietnam and the data in Section 2. Section 3 introduces the empirical strategy I employ. The results are presented in Section 4, and additional outcomes are further discussed in Section 5. After showing the robustness of the main results in Section 5.5, Section 6 concludes the paper.

2 Background and Data

2.1 Abortion, Son Preference and Sex Selection

Vietnam has one of the highest abortion rates in the world: approximately 26 abortions per 1,000 women of reproductive age or 0.6 induced abortions per woman during her lifetime in the early 2000s (Committee for Population, Family and Children [Vietnam] and ORC Macro, 2003; Sedgh et al., 2007). In addition to very liberal laws allowing abortion up to 22 weeks of pregnancy, this high rate is primarily attributable to the procedure's very low cost and widespread availability across all levels of public and private health facilities (Whittaker, ed, 2010).[2]

Abortion for married women is socially well-accepted throughout Vietnam (Whittaker, ed, 2010). This antinatalist social atmosphere has largely been established by the family planning program—the one-or-two child policy—that has intensely promoted abortions along with intrauterine devices (IUDs) as the primary birth control options. Other modern contraceptives, particularly temporary methods such as condoms and pills, have frequently been unavailable, and their use has been discouraged by local family planning officials (Teerawichitchainan and Amin, 2010).

The recent proliferation of ultrasound in the 2000s has led to the use of abortion to selectively terminate female fetuses. Vietnam has a strong son preference, influenced by Confucianism (Belanger, 2002). Meanwhile, ultrasound scans, which were first introduced as part of the reproductive health services, rapidly increased approximately 10-fold from 1998 to 2007 (Guilmoto et al., 2009). This rapid adoption stemmed not only from a very low cost (20,000 VND or US$1.30 per scan) but also from the easy and reliable identification of fetal sex as early as 12 weeks of pregnancy (Gammeltoft and Nguyen, 2007). Whereas prenatal sex determination using ultrasound was already prevalent in the 2000s for urban mothers, ultrasound was still expanding across rural regions in the mid-2000s; thus, the rate surpassed 80 percent for rural mothers in the late 2000s (Figure A.1). This widespread availability of ultrasound scans undoubtedly has played a crucial role in the recent male-biased sex ratio at birth in the 2000s (Figure A.2 and Figure A.3). This demographic transformation has been common among countries of India and East Asia with son preference, especially when ultrasound scans has become widespread and the cost of abortion is low (Das Gupta et al., 2003).[3][4]

[2] The user fees for the two main abortion procedures performed in rural districts are considerably low: approximately US$2 and US$6.1 for early-stage (up to 8 weeks) and for later-stage abortions (up to 16 weeks), respectively (PATH and Reproductive Health Department, 2006).

[3] Alarmed by an abnormally male-skewed sex ratio in the early 2000s, the Vietnamese government has issued several official decrees to ban ‘sex-selective’ abortion starting in 2003 (Pham et al., 2011). However, similar to the previous cases in India and China, those bans had little impact, because sex selection was hardly discernible from other abortions for family planning (Pham et al., 2008).

[4] Other environments relevant to fertility have been steady in the 2000s. For example, infant mortality rates have been relatively low in Vietnam in the 2000s (Figure A.4a). While total fertility and relevant population policies have exhibited little change, excess male infant mortality rates in

2.2 Data

I use the PCS to construct fertility measures. The Vietnam General Statistics Office (GSO) and the United Nations Population Fund designed the survey and have conducted it every year since 2000, providing repeated cross-sectional and nationally representative 3% samples. In addition to socio-demographic information for all usual residents of a household, the survey asked all married women of childbearing age from 15-49 whether they had an 'induced' abortion in the last year along with requesting extensive information about contraceptive use, antenatal care, and fetal sex determination. This line of questioning makes the PCS a unique dataset containing comprehensive fertility characteristics of mothers that are representative at the national level, which is rarely available in developing countries. The reference date of the PCS is April 1st of the current year. The survey asks about events that occurred in the 12 months preceding the reference date. As a result, the survey conducted in the year n describes demographic events in Jan-Mar in year n and Apr-Dec in year $n-1$. (Figure 1) Nine waves of the PCS from 2004-2008 and 2010-13 are pooled to yield a sample size of approximately 1 million mothers from almost every rural district across Vietnam.[5]

To explore the effects of adverse rainfall shocks on the economic conditions of rural households, I supplement expenditure information, which is not available in the PCS, using the Vietnamese Household Living Standard Survey (VHLSS). This biennial survey has been conducted since 2000, and I use six rounds from 2004 to 2014 to match the sample period of the PCS data.[6] I also collect several province-level statistics from the GSO to examine the effects of droughts on yearly crop yields, monthly CPIs, and infant mortality rates.

Since my empirical strategy hinges on the relationship between rainfall and the economic condition of a household, I rely on the sample that consists of married

---

the 2000s have been stable and close to the ratio found in countries without son preference (Figure A.4b), suggesting that there was neither an immediate fertility squeeze to demand a son nor active substitution between pre- and postnatal discrimination against female births in the sample period (Goodkind, 1996).

[5]There was no PCS 2009 due to the census in the same year.

[6]Since the recall period for consumption has changed from yearly to monthly starting in 2010, I use the first three waves to examine the effects on yearly expenditure and the latter three waves to analyze the effects on monthly expenditure and labor participation.

women in rural areas, where the association is presumed to be more pronounced than urban regions. In addition, to make parental preference and cultural settings for fertility and family planning comparable across districts, I focus on those 54 provinces out of 64 where the Kinh, the major ethnicity in Vietnam, account for more than half of the population in a province.[7] I further limit the sample to include mothers who had up to three children at the baseline, which is a year before the reference date of the survey, and a single childbirth at a time to have comparable results after controlling for the birth order.

Table 1 provides the summary statistics of married women aged 15-49 in the main sample. I present urban women's statistics to show how rural mothers differ from their urban counterparts. More than half of rural mothers have completed only primary or lower secondary school, and approximately 73 percent of mothers had at least one son at the time of the survey. Rural mothers are less likely to get abortions than urban mothers (0.7 percent vs. 0.8 percent), whereas they are more likely to use contraceptives. Conditional on childbirth in the last year, approximately 79 percent of mothers knew the fetal sex by ultrasound at approximately 20 weeks gestation. Turning to household characteristics collected from the VHLSS 2004-2008, more than half of rural households grew rice, suggesting that their economic conditions depend substantively on rice yields.

2.3 Agriculture in Vietnam and Construction of Rainfall Shocks

Agriculture in Vietnam is an important sector, and rice is of particular importance as the main source of income for a majority of rural households.[8] Thanks to the favorable climate, double-cropping of rice is common across the country except in the northern mountainous provinces, and triple-cropping is even possible, especially in

[7] Using the 2009 Census of Vietnam, I chose 10 provinces where more than 50 percent of the heads of household were not ethnically Kinh. Not only are these northern provinces (mapped in Figure A.5) different in terms of ethnic composition, but they are also the 10 poorest provinces, thereby exhibiting lower socio-economic development and higher fertility and infant mortality rates (Glewwe et al., eds, 2004). I run the falsification test for this sample in Table B.7 Panel B.

[8] Rice is cultivated in more than 50 percent of the annual crop land and accounts for more than 50 percent of the annual crop production, positioning Vietnam as the second-largest rice-exporting country. Furthermore, rice also serves as the main staple for the population by supplying more than 50 percent of the people's daily calorie intake (Jaffee et al., 2016).

the Mekong Delta region. Accordingly, the cropping season is defined by three rice crops: winter-spring rice, summer-autumn rice, and autumn-winter rice. The winter-spring crop (hereafter, spring rice) is most productive and is planted across all regions, accounting for approximately 30 percent of the total annual crop production. The cropping cycles are largely determined by the rainfall patterns rather than temperature (Figure 1), and thus, rainfall is the most important weather variation affecting rural incomes if irrigation is ineffective (Lobell and Field, 2007).[9]

I create season-specific rainfall shocks for each district using CHIRPS version 2.0.[10] CHIRPS incorporates 0.05-degree resolution satellite imagery with station readings to provide monthly estimates of precipitation beginning in 1981.[11] To match those estimates of precipitation with the outcome variables of interest, I spatially aggregate the estimates up to the district level by taking the land area-weighted average of monthly rainfall for each district.[12] I collapse monthly rainfall to create a season-year measure of precipitation, i.e., dry (December-March) and wet (April-November) season rainfall for each district, to precisely match rainfall realizations to agricultural cycles.

To determine rainfall shocks that capture unusually low rainfall realizations relative to a district's typical experience, I define a drought as seasonal rainfall occurring below the 20th percentile of the district-specific long-term rainfall distribution of 1984-2013. Since this study design exploits a panel structure instead of relying on cross-sectional comparisons, my estimates are not biased due to the correlations between the unobservable characteristics of different locations and their mean levels of rainfall (Dell et al., 2014).[13] As widely adopted by a host of recent studies

[9]In fact, according to the VHLSS 2004, only 35 percent of communes responded that their annual crop lands are fully irrigated, and only 69 percent of the land is irrigated across the country.

[10]In particular, CHIRPS is well-suited for the purpose of this study in that it is explicitly tailored for monitoring agricultural drought across the globe (Funk et al., 2015).

[11]0.05 degrees is equivalent to approximately 5 kilometers at the equator.

[12]The resolution of CHIRPS is fine enough (0.05×0.05 degree) for each overlaid administrative boundary to include several grids within a narrow geographic area to produce a weighted average, addressing potential measurement errors arising from projecting coarser grids with precipitation estimates onto smaller geographic units (Dell et al., 2014).

[13]Drought and excessive rainfall can both adversely affect rice yields, but drought, in particular, inflicts heavier damage on productivity than flood does (Auffhammer et al., 2012). In addition, excessive rainfall is not adequate as a single meaningful weather variable for proxying economic shocks, due not only to the complicated hydrologic and climatic conditions that cause flood but also

using rainfall shocks in India and Africa (Jayachandran, 2006; Kaur, 2014; Burke et al., 2015; Shah and Steinberg, 2017; Corno et al., 2017), this measure enables me to capture significant economic impacts on a rural household while holding constant the other determinants of fertility and reproductive behaviors of a married woman. This simple specification employing one indicator variable for drought assumes that fertility decisions are intrinsically conservative and discrete; thus, they would respond to economic shocks in a nonlinear fashion.[14] Figure A.5 plots the districts that experienced droughts in the sample period, 2004-2013.

3 Empirical Strategy

This study aims to estimate the causal impact of economic shocks on the fertility decisions of rural married women. By exploiting arguably random year-to-year variations in seasonal rainfall within a district, I compare the childbearing decisions of mothers who are affected by droughts with those of mothers who are not affected but share similar underlying preferences for completed fertility and the gender composition of their children. I estimate the effects of droughts on various outcomes of interest using the following regression:

$$Y_{idt} = \alpha + \beta Drought_{dt} + \sum_{s}^{S}\sum_{l}^{L}\gamma_{sl}R_{s,t-l} + X_{it}'\delta + \tau_t + \mu_d + \theta_d * t + \varepsilon_{idt} \quad (1)$$

where i, d, t, and s denote mother, district, year and season, respectively.

The outcome Y_{idt} includes a wide array of variables related to a married woman's fertility, such as contraceptive use, pregnancy, abortion, childbirth and prenatal sex determination. Most variables are binary; for example, 'abortion' is coded one if a mother terminated her pregnancy within the survey year. The main coefficient of interest is β on $Drought_{d,t}$, which becomes one if the dry- or wet-season rainfall occurs below the 20th percentile ('drought') of the district-specific seasonal rain-

to its nonlinear relationship with crop yield (Guiteras et al., 2015).

[14] In Section 5.5, I will carefully verify the validity of this empirical specification using binned indicators for given percentiles or restricted cubic splines to display the marginal effects between rainfall levels and abortion decisions.

fall distribution during the period 1984-2013. This coefficient captures the effect of negative rainfall shocks (1st quintile) compared to what would be typically observed after the other realizations of rainfall, i.e., the average effects of seasonal rainfall in the 2nd, 3rd, 4th and 5th quintiles of the historical rainfall distribution.

I primarily focus on the effect of droughts in the last dry season, $Drought_{d,t-1}$. The reference period of the PCS starts right after the realization of $Drought_{d,t-1}$; additionally, abnormally low dry-season rainfall also most clearly translates into the economic conditions of rural households at that time because the crop cycle of the most productive spring rice approximately overlaps the dry season (Figure 1).[15]

To focus on the contemporaneous effects of $Drought_{d,t-1}$, a vector of $R_{s,t+l}$, which represent the deviations of other season-year rainfalls from the local median up to two-year lags ($L = \{0,1,2\}$), enters the equation to control for the potential effects of wet and previous dry-season rainfalls.[16] X_{it} is a vector of covariates, which consist of mother-specific observable characteristics that include age in year t, its quadratic term, and two indicator variables representing a woman i's educational attainment and her relationship to the household head. These covariates would potentially control not only for the diverse opportunity costs of childbearing but also for the marginal utility of having an extra child.

The main specification also includes indicators for the number of children one year before the reference date of the survey (hereafter, 'baseline') to account for the birth order of the current conception for the survey year. I further control for the demand for a son by replacing the indicators of parity with the dummies for the gender composition of living children.[17] In particular, the inclusion of the gender composition, i.e., whether a mother has at least one son, is useful because it serves as one of the key determinants of demand for a son through sex-selective abortion. Since the PCS does not report the month of the abortion but asks only whether a mother has had an abortion in 12 months preceding the reference date, I include survey-year fixed effects in lieu of calendar year fixed effects to capture any sam-

[15] I will show that the effects of other season-year rainfalls are not significant in Section 5.5.

[16] The results are robust to the inclusion of raw precipitation values, the logs of seasonal rainfalls, and the quintile indicators.

[17] This would give me a total of 15 cases by considering all of the possible combinations of the birth order (e.g., 0 to 3) and the sex of the children at the baseline.

pling difference across ten-year waves. In addition to the full set of district fixed effects, I include district-specific linear time trends to purge the effects from differential expansions of public health services, increases in agricultural productivity, etc. by district level over time.

As robustness checks, I additionally include control variables pertaining to spousal characteristics[18] and a woman's fertility, e.g., birth spacing, age at the first birth. Lastly, the ε_{idt} represents mother-specific idiosyncratic factors for each outcome variable. Robust standard errors are clustered at the district level because I define rainfall shocks using district-specific rainfall distributions over 30 years.

4 Results

This section is organized as follows. Section 4.1 investigates how the drought shocks affect rice outputs and the expenditure of rural households. Then, I present in sequence the fertility results: the effect of droughts on a rural woman's conception, abortion, birth, and newborn's sex.

4.1 Effects on Crop Yield and Expenditure

4.1.1 Effects on Yearly Yield and Expenditure

I first assess the effects of droughts on yearly yield and expenditure using province-level yield data from the Vietnam GSO during the period 1995-2014 and yearly expenditure data from the three waves of the VHLSS in 2004, 2006 and 2008. The log yield of spring rice and all rice crops, which also include winter and autumn rice yields, are the outcomes for the analyses of the effects on crop outputs. For the analyses of expenditure, I use the log of total yearly expenditure and the logs of yearly expenditure on subcategories such as food items and non-food items. I aggregate the dry-season rainfall and define droughts analogously at the province level rather than at the district level because the province is the unit of analysis for

[18] The spouse's educational attainment and age can be merged only if a married woman is the head of household or the spouse of the household head; additionally, the husband's educational attainment is reported only after 2006 in the PCS.

agricultural statistics from the GSO, and the VHLSS has the smaller sample size of households per district in comparison with the PCS.

Figure 2 presents local linear regression results that describe how crop yields and various expenditure measures are associated with rainfall levels in the dry season. Spring rice and all rice yields are plotted on rainfall percentiles after controlling for province-specific linear time trends and year and province fixed effects in Figure 2 (a) and Figure 2 (b). I find positive associations between the dry-season rainfall and rice yields, but low rainfall levels in the dry season have unambiguously detrimental impacts on the yield of spring rice, particularly if rainfall is below approximately the 20th percentile. However, this correlation is weakened once rainfall is above the median, providing confidence in employing the 20th percentile cut-off as the drought indicator in the following analyses.

Figure 2 (c)-(f) provide local linear regression estimates of the four measures of expenditure on the dry-season rainfall percentile after controlling for province, year and survey quarter fixed effects and household-level covariates.[19] Non-food item expenditure has a strong positive association with rainfall levels (Figure 2 (e)), but the impacts of poor rainfall on the extent of total expenditure (Figure 2 (c)) and food expenditure (Figure 2 (d)) are muted.

In Table 2, I provide the regression results to examine how the drought indicator I create determines rice yield and expenditure. Columns 1 and 2 show that adverse rainfall shocks in the dry season have negative effects on yields; there is a 2.4 percent reduction in the spring rice yield (column 1, $p < 0.01$), and a 1.3 percent reduction in all rice yields (column 2, $p < 0.05$).[20] Given that annual rice production in Vietnam has shown robust growth at a rate of approximately 4 percent in the 2000s (Jaffee et al., 2016), a rainfall-induced decline in rice yield can have substantive impacts on rural households. Droughts are also associated with lower non-food expenditure by 8.5 percent ($p < 0.01$, column 4). However, the effects on the other expenditure measures are not precisely estimated (columns 3 and 4) mainly because droughts also result in price surges of food that constitutes

[19]The household-level control covariates include the size of the household, the household head's age, sex, ethnicity and educational attainment and the log of total expenditure.

[20]The reduction in rice production is estimated by similar magnitudes. The point estimates for the spring rice and all rice production are -0.055 ($p < 0.05$), and -0.031 ($p < 0.1$), respectively.

approximately half of households' real expenditure (Vu and Glewwe, 2011).[21]

4.1.2 Effect on Monthly Expenditure

To examine how negative aggregate shocks have intertemporal substitution effects on childbearing—e.g., postponing births by abortion—for credit-constrained parents, it is crucial to understand how lower income would affect consumption smoothing. Furthermore, describing how consumption is determined by variations in prices after droughts is of primary importance, because the consumption of a rural household can be more responsive to seasonal prices than to seasonal income (Paxson, 1993; Khandker, 2012). In particular, high-frequency data on consumption is needed because low-cost abortion can permit an immediate substitution between current consumption and childbearing.

I estimate the effects of droughts on monthly expenditure using the VHLSSs of 2010, 2012, and 2014, which collect consumption information over the month preceding the date of the interviews. In addition, I examine the effects on province-level prices using the monthly CPIs of 12 provinces provided by the Vietnam GSO during 2005-2014. I estimate the impact of droughts using the following equation:

$$\begin{aligned} Y_{ipt} &= \alpha + \sum_{q}^{Q}\sum_{k}^{K}\beta_{qk} Drought_{p,t-k} \times Quarter_q + \sum_{q}^{Q}\theta_q Quarter_q \\ &\quad + \sum_{s}^{S}\sum_{l}^{L}\gamma_{sl} R_{s,t+l} + X_{it}'\delta + \tau_{rt} + \mu_p + \varepsilon_{ipt} \end{aligned} \tag{2}$$

where Y_{ipt} is the log of monthly expenditure of household i in province p in year t.

Since enumerators' visits to rural households were mostly arranged at the end of each quarter, I include indicators for quarters, $Quarter_q$, that equal one if a household was visited in quarter q. To observe the lagged impacts of droughts on consumption, I interact the quarter indicators with the lagged droughts ($Drought_{p,t-1}$) and with the current drought ($Drought_{p,t}$). While maintaining the same household-level control covariates (X_{it}) and fixed effects used in the estimation of the effects

[21] These findings are also supported by Figure 2 (f), which shows a slight increase in the ratio of expenditure on food to total expenditure after low levels of rain, suggesting that rural households allocate relatively more resources to purchasing food after droughts.

on yearly expenditure, I replace the year fixed effects with region-year fixed effects (τ_{rt}) to control for different market structures and prices across regions. The main coefficient of interest β_{qk} represents the average effect of droughts on monthly expenditure surveyed 0-7 quarters away from a drought event, relative to the usual level of monthly expenditure in the unaffected provinces.

I first estimate the effects on price levels using Equation (2) after replacing monthly expenditure with province-month-level CPI as the outcome variable. Figure 3 (a) plots the coefficients on the interaction terms, β_{qk}'s, with their 95 percent confidence intervals. Statistically significant positive point estimates on the overall CPI ($p < 0.1$) and food CPI ($p < 0.05$) are initially observed in the 3rd quarter (October-December) after droughts in the dry season, indicating that droughts have lagged effects on local prices.

Figure 3 (b) displays the effects of droughts on monthly expenditure in subcategories using Equation (2), suggesting that price surges during the 3rd quarter are associated with lower expenditure on some non-food daily items in the same quarter. To be specific, while holding the total monthly expenditure constant (columns 1-3 of Table B.1), affected households maintain their consumption of rice and pork (columns 8 and 9 of Table B.1), the two main food categories, by substituting away from consuming some daily non-food items (the 3rd quarter (Oct-Dec) of Figure 3 (b)) and toward the consumption of cheaper items, such as maize, cassava and potato (column 11 of Table B.2).

Importantly, I find that the 3rd quarter after droughts (October-December), when price hikes and the corresponding adjustment of consumption are conspicuous, is the pre-harvest season of winter rice, the next rice crop after spring rice for two-cropping regions (Figure 1).[22] Therefore, to examine whether parents want to delay childbearing to smooth consumption after droughts, this pre-harvest season would be the most likely timing for observing the intertemporal substitution effects on

[22] I find the results discussed thus far are consistent with the findings of Wainwright and Newman (2011): existing risk-coping strategies in rural Vietnam are ineffective in protecting consumption against aggregate shocks. For example, rural Vietnamese households do not have large-scale facilities for storing rice, which limits their capability to smooth consumption using rice as precautionary savings (Vu and Glewwe, 2011; Wainwright and Newman, 2011). The failure of perfect consumption smoothing in the pre-harvest season is also found in Bangladesh (Khandker, 2012).

childbearing, which is illustrated as an increase in abortion.

4.2 Effect on Conceptions

I begin the analysis of the effect on fertility by examining how conception responds to adverse rainfall shocks. The measurement of conceptions is here improved by including mother-level data on abortion as well as live birth, which has been a single proxy for conception in the prior literature.[23] The indicator for conception in each survey year becomes one if a woman reported one of three cases: 1) she gave birth between September and March,[24] 2) she had an induced abortion, and/or 3) she was pregnant at the time of the survey (Figure 1). In addition, since the PCS asks married women about their current contraceptive use and their reasons for not using any contraceptives, I can ascertain whether rural mothers intend to time their pregnancies in relation to adverse rainfall shocks.

In Table 3, I report the estimation results for the conception and contraception responses using Equation (1). Panel A presents the estimates for the effects of droughts that occurred during the last 4 months of the survey year, and Panels B and C provide the estimates for 1-year and 2-year lagged effects. I expect the drought that occurred right before the start of the reference period ($Drought_{t-1}$ in Panel B) would have the largest impacts. The estimates for the effects on conception are not statistically significant at any conventional level (columns 1-2), suggesting that concurrent or previous droughts do not lead to more or fewer pregnancies.

This finding can be further supported by exploring the effect on contraceptive use. Following the same methodology, I estimate Equation (1) for the outcomes of contraceptive use and report the results in Table 3, columns 3-8. Columns 3 and 4 do not show any significant effects of droughts on the use of any contraceptive

[23] Because the PCS does not provide information on miscarriages, stillbirths or spontaneous abortions, my measure of conception cannot be complete. However, I assume that those cases do not bias the results if droughts do not entail severe malnutrition or alter the disease environment, for which I provide evidence in Section 5.

[24] The exclusion of births from conception in the first 5 months of the survey (April-August) results from the fact that if aborted pregnancies in April were carried to full term, the earliest possible month of childbirth starts in September because abortion after 16 weeks was rarely reported by DHS 2002. I also used the 22-week threshold, which is the number of weeks of pregnancy after which abortion is prohibited by law. The results are consistent with the 16-week threshold.

methods, including both traditional methods such as withdrawal or abstinence, and modern methods, which include IUDs, condoms, the pill, and sterilization. Although the droughts that occurred in the dry season right before the survey year (Panel B, column 5) or a year earlier (Panel C, column 5) have statistically significant effects on the use of modern birth control methods, the estimates are not of economically meaningful magnitude compared with the mean (approximately 1 percent) and are not robust to controlling for spousal characteristics. Columns 7 and 8 present the estimates on an indicator for demand for children, which I construct using a woman's response that no birth control was in use because she wants to have a child. These estimates also do not show any significant association with droughts, implying that contraception or abstinence, which are *ex ante* measures of birth timing, play limited roles for rural mothers.

Next, I test for balance to address the selection bias arising from the compositional changes in those mothers who conceive after droughts. In Table B.4, I first illustrate the socio-economic and fertility characteristics of mothers who conceived after droughts, and the spousal characteristics for the subsample (columns 1,3,5,7 and 9). The balance is presented in columns 2,4,6 and 8 by calculating the differences in the means of those observable characteristics with those of unaffected mothers who conceived. The statistical significance in the difference results from the regressions of the drought indicator and the other control covariates in Equation (1) on those characteristics. I cannot find significant differences in those observable characteristics between the two groups of women, suggesting that the compositional changes of mothers who conceived after being exposed to droughts would not imperil the causal link between drought-induced income shocks and abortion.

4.3 Effect on Abortion

Table 4 presents the main finding of this study from Equation (1) estimating the effect of droughts on the probability of abortion among rural married women of reproductive age (15-49) using the nine rounds of the annual PCS in 2004-2008 and 2010-2013. Married women who experienced droughts in the last dry season are approximately 0.21 percentage points more likely to get an abortion (Panel B, columns 1-8, $p < 0.01$). The magnitude of that impact is economically large; compared with a mean of the likelihood of abortion of unaffected mothers of 0.0066, abortions reported by affected mothers increase by approximately 30 percent.[25] The effect of droughts that are concurrent with the survey period (Panel A) or one year before the reference date (Panel C) are much smaller and statistically insignificant.

The point estimates on the effects of droughts $(t-1)$ are also invariably robust to employing a wide range of control covariates. First, this drought indicator is not collinear with the district-specific time trends, as shown by consistent standard errors (column 4). Furthermore, district-specific developments of relevant factors influencing the accessibility of abortion also do not bias these estimates. Second, it does not change the size of the coefficient nor does it reduce statistical significance to include not only a mother's and her spouse's characteristics but also the indicators for the parity and the gender composition of previous births (columns 5-8). Those covariates would potentially control for the diverse incentives for mothers to select into pregnancy and to give birth to a child or a son; thus, the effect of droughts is robust to unobservable changes in the composition of the mothers who conceived.

These results not only reveal another coping strategy even to the extent of impacting a woman's decision regarding her current pregnancy when aggregate shocks befall poor rural households, but also empirically support the theoretical prediction of the positive relationship between income and demand for children.

4.4 Effect on Births

Since I find no effects on conception, I hypothesize that the effect on abortion necessarily leads to fewer births. However, these effects may be difficult to estimate precisely if the timing of abortions is spread across a year and the number of the missing births is relatively small. To detect the effects on the likelihood of giving birth within a year, I use the district-quarter-level number of births as the outcome variable by counting infants who were born to the mothers in the sample. I restrict the sample to infants aged less than one year because the estimation using the older cohort might suffer from omitted variables bias due to postnatal discrimina-

[25] The effects of droughts in $t-1$ are also robust to the distributed lagged specification (Table B.5).

tion against a female child. I estimate the effect of droughts using the following equation:

$$Y_{dqy} = \alpha + \sum_{j}^{J} \beta_j Q_d^j + \lambda_{pq} + \lambda_{qy} + \lambda_d + \theta_d * t + \varepsilon_{dqy} \tag{3}$$

where Y_{dqy} is the number of infants in each district-quarter cell in survey year y and Q is a dummy variable that becomes one if a district is j quarters before or after a drought ($-3 \leq J \leq 8$).[26] Since I pool the nine waves of cross-sectional surveys, this is equivalent to estimating the effects of the current and up to 2-year lagged events of droughts on the number of births. In addition to district-level linear time trends, a host of fixed effects enter to control for the seasonality of births, which are shaped by province-specific crop calendars (λ_{pq}) and national-level trends in fertility (λ_{qy}). Thus, the coefficients, β_j's, ascertain how the effects of an increase in abortion on births are distributed across quarters conditional on seasonality and trends in childbearing.

Figure 4 (c) plots the point estimates along with their corresponding 95 percent confidence intervals. First, the coefficients before a drought (the red vertical line) tests for parallel pretrends by comparing the number of births born in districts exposed to unusually low levels of dry-season rainfall with those born in unaffected districts. While the effects on births in pre-drought quarters are not significant, the 5th quarter after the droughts (April to June) shows the first statistically significant effect on the number of births. Given the estimate of -0.364 ($p < 0.01$), more abortions in year $t+1$ result in an approximately 7 percent reduction in the number of births, with a mean of 5.087 district-quarter-level number of births. Table 5 reports the consistent results using Equation (1) to estimate the effect if the outcome is an indicator for a woman's childbirth in the survey year.

Importantly, Figure 4 (c) shows that the effects of droughts on births are not evenly distributed across quarters; instead, they are concentrated in a particular quarter. Given that conception occurs 9 months before the date of birth and most abortions are performed between 8-12 weeks of pregnancy (Committee for Pop-

[26] The births in January to March in a survey year y would have $j = 0$. If there were a drought in survey year y, then $Q_d^0 = 1$ would be matched to the number of births in January to March of the survey year.

ulation, Family and Children [Vietnam] and ORC Macro, 2003), affected mothers principally get abortions in the 3rd quarter after droughts (October-December). Note that this quarter corresponds to the pre-harvest season of the next rice crop, when a rural household's consumption smoothing is particularly difficult, as shown in Figure 3 (c). Taken together, the income channel would indeed be the pivotal pathway for an increase in abortion after droughts. However, in Section 5.5, I will further investigate additional channels to explain the finding of more abortions in that quarter by examining labor participation and biological mechanisms.

4.5 Effect on the Sex Ratio at Birth

Having reviewed the effects on birth, I now turn to investigate the sex ratio at birth to understand whether abortion becomes more or less sex-selective. I predict that an affected mother is less likely to terminate her pregnancy if the fetus is male, given the availability of low-cost sex-selective abortion. I repeat the estimation using Equation (3), but to have reliable estimates on the sex ratio at birth, I aggregate the numbers of male and female infants in each district up to the province-quarter level and combine them with the province-level droughts:

$$Y_{pqy} = \alpha + \sum_{n=-3}^{8} \beta_n Q_p^n + \lambda_{rqy} + \lambda_p + \varepsilon_{pqy} \tag{4}$$

where Y_{pqy} is the log of the sex ratio at birth.[27] I include region-quarter-year fixed effects (λ_{rqy}) to flexibly control for trends in the sex ratio at birth.

Figure 4 (d) presents the results. I find the effect is statistically significant only in the 5th quarter after droughts, when significantly fewer births are found in Figure 4 (c). The sex ratio at birth increases by 12.9 percent ($p < 0.05$), implying that abortions conducted in the 3rd quarter after droughts not only increase, and thus reduce the size of the birth cohort, but also become more sex-selective against female fetuses. Table 6 reports the consistent results using Equation (1) to estimate the effect when the outcome is a dummy indicator for a newborn being a boy conditional on being born in each quarter of the survey year.

[27] The sex ratio at birth here is the number of male infants born to 100 female infants.

To explain the more male-skewed sex ratio within the reduced birth cohort in the 5th quarter, a back-of-the-envelope calculation indicates that 6 more female fetuses were aborted for every 1 male fetus that was aborted.[28] Furthermore, I find that an approximately 3 percent increase in the sex imbalance observed in the PCSs 2004-2013 is attributable to the sex-selective abortions in the period before the next harvest after droughts.[29] While the effect of transitory income shocks might be more relevant to the timing of fertility than lifetime fertility, son preference can regulate the way mothers postpone births, and thus has far-reaching and long-term implications on demographics by worsening the sex imbalances at birth.

Here, I provide two more pieces of corroborating evidence that drought-induced abortions become more sex-selective. First, since ultrasound scans for fetal sex determination became more prevalent in rural areas in the late 2000s, I split the PCS sample roughly in half, e.g., before and after the PCS 2007, and I run the same regression of Equation (4) for each subsample. The effects on the sex ratio at birth would be more conspicuous in later periods because sex-selective abortion can be performed at a low cost due to the wide availability of ultrasound scans across rural areas. In Figure A.6, Panels (b) and (c) show the results that are consistent with the prediction: the effects on the sex ratio of the full sample in Figure A.6 (a) are mostly driven by the effects found in the later periods.

Second, by exploiting that the most plausible timing of ultrasound scans for the purpose of 'sex-selective' abortions (12-16 pregnancy weeks) can be earlier

[28] Given that the mean number of quarterly births in the unaffected districts is 5.014, the numbers of boys and girls should be 2.687 and 2.327, respectively, to explain the mean sex ratio of 115.5 at birth. In the 5th quarter after droughts, the number of births in the affected districts decreases to $4.65(=5.014-0.364)$, and the corresponding sex ratio at birth increases to $130.4(=115.5\times1.129)$, implying the numbers of boys and girls in that quarter should be 2.632 and 2.018, respectively. Thus, $0.309(=2.327-2.018)$ more girls were aborted, whereas $0.055(=2.687-2.632)$ boys were aborted in the affected districts in the 5th quarter after droughts.

[29] The mean sex ratio at birth found in all 1,856 quarter-province cells in the sample is 115.775. I find the mean sex ratio at birth in the 1,806 unaffected quarter-province cells to be 115.483. Thus, the 50 affected provinces in the 5th quarter after droughts increased the mean sex ratio at birth by 0.293 (= 115.775 – 115.483). Given the normal rate at birth is 105 boys born to 100 girls, this suggests the drought-induced sex selection explains approximately 3 percent of the sex imbalances found in rural Vietnam in 2004-2013. $(0.293/(115.775-105)=0.027)$. All of the mean sex ratios at birth are weighted by the number of mothers in each province.

than that for the usual childbirths (approximately 20 weeks in Table 1),[30] I can ascertain whether a mother had her prenatal sex determination via ultrasound earlier if she gave birth to a boy after income shocks. In Figure 5 (a), I find that affected mothers who gave birth to sons in the 5th quarter were more likely to know the fetal sex between 12-16 weeks of her pregnancy, which is earlier than the period when mothers who gave birth to daughters knew the fetal sex. However, in Figure 5 (b), I do not find any difference in the weeks of sex determination for unaffected mothers.[31]

5 Additional Results and Robustness Checks

5.1 Opportunity Cost of a Mother's Labor

The demand for a mother's labor also exerts considerable influence on the decision regarding when to time fertility. On the one hand, a woman wants to postpone childbearing when the opportunity cost of her parental time is high (Schultz, 1985; Heckman and Walker, 1990). On the other hand, low demand for female labor can have ambiguous effects because it reduces the substitution effect, thereby increasing fertility; however, it can also further depress income (Dehejia and Lleras-Muney, 2004).

Figure A.8 presents the estimated coefficients on the effects on labor participation of married women and men using Equation (2) on the extensive margin (e.g., whether a respondent worked last month, Panel A) and on the intensive margin (e.g., working days conditional on having worked last month, Panel B). Overall, the results suggest that droughts are not associated with higher labor participation for women and men (Panel A) although the point estimate for female working days is

[30]Ultrasound can credibly detect the fetal sex as early as 12 weeks, and abortion in Vietnam is rarely performed after 16 weeks of pregnancy (Committee for Population, Family and Children [Vietnam] and ORC Macro, 2003).

[31]Furthermore, Figure A.7 shows that the effect on the weeks of prenatal sex determination does not depend on the seasonality of births because the distribution is not significantly different across the quarters of births; it is only the 5th quarter after droughts when the distributions are significantly different, i.e., a mother who gave birth to a son is more likely to know the fetal sex in the 12-16 pregnancy weeks (Panel (c) and (k)).

statistically significant in the pre-harvest season ($p < 0.05$) but is not economically large. Furthermore, Figure A.9 shows little evidence of recent migration of married women or men (within 6 months), suggesting labor migration does not bias the estimates of the effect on abortion.

5.2 Biological Channel

Droughts can have direct adverse effects on the health of women or fetuses. Although the PCS specifically asks whether mothers had an 'induced' abortion, mothers might terminate their pregnancy to prevent stillbirths or miscarriages because drought-induced malnutrition or incidence of certain infectious diseases makes fetuses too feeble to be carried to term.

In columns 8 and 9 of Table B.1, I first find little evidence of detrimental effects on the consumed quantity of rice and pork, the two main food categories of rural households.[32] The nutritional channel can be further dismissed by examining its effects on the sex ratio at birth; poor nutritional intake at the preconception stage increases the probability of giving birth to a daughter (Cameron, 2004; Mathews et al., 2008). Table 6 reports no significant effects on the sex ratio at birth between droughts (column 4 of Panel A) and the 4th quarter after droughts (columns 1-4 of Panel B). In addition, in Figure A.10, I find no evidence of the effects of droughts on recent illness by estimating Equation (2) on an indicator for any illness or injury across household members in the past 4 weeks using the VHLSSs 2004-2008.[33]

Finally, I examine the effect of droughts on infant mortality. This investigation is doubly important because it can test not only for fetal exposure to malnutrition or drought-related diseases, which increase the risk of infant mortality, but also for postnatal discrimination against female infants after aggregate shocks. I assume that the effect of negative income shocks would be fully reflected in the margin of prenatal discrimination, e.g., sex-selective abortion, and not postnatal discrimination, such as infanticide or neglect.[34] Table B.6 reveals that droughts are not associated

[32] This inelastic calorie consumption with respect to food price can be further supported by Gibson and Kim (2013), who find that a 10 percent increase in the price of rice is associated with a less than 2 percent decrease in calorie intake.

[33] There are no monthly reports of illness in the VHLSS from 2010.

[34] Bharadwaj and Lakdawala (2013) argue that there can be other forms of prenatal discrimination,

with an increase in infant mortality from the estimation of Equation (1) for infant deaths reported in the PCS and the province-level infant mortality rate from the GSO.

5.3 Additional Evidence on the Income Channel

To corroborate the causal link between income shocks and pregnancy terminations, I investigate heterogeneous effects on abortion using local conditions that variably determine income vulnerability to adverse rainfall shocks. Panel A of Table B.7 shows the imprecisely estimated effects on abortions of urban women whose incomes are presumably invariant to rainfall fluctuations.

Furthermore, triple-cropping, the availability of irrigation and wealth level are other proxies that are correlated with district-level income variability to the fluctuations of the rainfall in the dry season. Table B.8 reports the results from estimating Equation (1) after augmenting it with indicators for the three proxies. Column 1 shows that the effect on abortion is mostly driven by the rural mothers living in the double-cropping provinces, whereas mothers in the triple-cropping provinces can have one extra income flow by growing autumn rice. Column 2 reveals that most effects are found in the districts with the lowest coverage of irrigation, suggesting that higher volatility in the yield of rice can translate into larger effects on abortion. In column 3, I find that the coefficients for the two indicators for wealthier districts are not statistically significant, but the negative signs imply that mothers in wealthier districts are less likely to get abortions after droughts in the dry season.

5.4 Effect on Lifetime Fertility

I hypothesize that the effect on births is more relevant to short-term effects, i.e., delaying births, than to the long-term effects on a woman's completed fertility.[35]

---

such as less antenatal care, once the sex of a fetus is revealed. However, I assume here that the cost of abortion is not prohibitively higher than the cost of discrimination in prenatal investment, and if it is, part of that lower investment in female fetuses would result in higher female infant mortality, which can be tested in this section.

[35] In contrast, Currie and Schwandt (2014) find that the effect of unemployment on a young woman in the US can have long-term impacts on her lifetime fertility. However, its long-term effect is driven

Figure A.11 provides the results from estimating Equation (3) after adding the interaction terms between indicators for quarters and droughts for up to six lag periods. After the first slump in the 5th quarter after droughts, the rebound in the 13th quarter is statistically significant ($p < 0.01$), and the size of the coefficient is comparable to the coefficient found in the 5th quarter. This full rebound in Figure A.11 confirms my hypothesis: rainfall-induced transitory income shocks primarily affect the timing of childbearing while holding lifetime fertility unchanged. In addition, the young age of rural mothers (on average 23 years old at her first childbirth, from Table 1) would allow for more time for the temporary decline in fertility to recuperate.

5.5 Robustness Checks

5.5.1 Alternative Empirical Specifications

The main result on abortion remains intact to more flexible specifications. To test for nonlinearities, I replace the indicator for drought in Equation (1) with multiple binned indicators which become one if rainfall falls within each 10th percentile interval of the historical distribution and zero otherwise while making the 5th indicator the omitted category.[36] Panel (f) of Figure A.12 plots the coefficients on each dummy that is constructed using the dry-season rainfall in $t-1$. I find that the lowest level of the dry-season rainfall in $t-1$, i.e., the 1st decile, leads to the highest rate of abortion compared to the effect of rainfall in the 5th decile. The point estimates for the other decile indicators are close to zero.

In addition, I further show that the main results are robust to replacing the rainfall estimates from CHIRPS with the modified distributions that result from fitting the historical rainfall realizations to a district-specific gamma distribution, as suggested by Burke et al. (2015) and Corno et al. (2017). Figure A.13 shows consistent results with Panel (f) of Figure A.12 using the historical rainfall realizations in the main analysis.

---

primarily by women who remain childless, which indicates that unemployment has negative impacts on her marriage prospects.

[36] $Y_{idt} = \alpha + \sum_{k\in K} \beta_k \widetilde{R}^k_{d,t} + \sum_s^S \sum_l^L \gamma_{sl} R_{s,t-l} + X'_{it}\delta + \tau_t + \mu_d + \theta_d * t + \varepsilon_{idt}$ where $\widetilde{R}^k_{d,t}$ are the dummies for every 10th percentile.

Finally, to further examine the relationship between rainfall and abortion, it is important to estimate the marginal effects of rainfall levels on the likelihood of abortion. Using restricted cubic splines with three knots, I present the estimated marginal effects of an additional unit increase in the dry-season rainfall percentile on the probability of abortion. Figure A.14 shows that rainfall levels below the 20th percentile have consistent and significant effects on abortion, lending credence to my definition of drought in the main analysis as that occurring below the 20th percentile in the main analysis.

5.5.2 Other Seasonal Rainfall

I examine whether the drought shock I construct using the dry-season rainfall in $t-1$ is the most crucial shock to determine economic conditions and fertility outcomes in the main analyses. Table B.9 presents that the drought, as defined using either the wet-season rainfall in t (Panel A) or the calendar-year rainfall in t (Panel B), does not have statistically significant effects on the rice yields nor on yearly household expenditure measures. Next, Figure A.12 shows that the coefficients resulting from repeating the estimation in Figure A.12 Panel (f) using all of the combinations of other season-year-rainfall distributions. I find that the drought shocks defined by rainfall levels in the preceding dry season have the largest impacts on abortion (Figure A.12 Panel (f)), whereas the effects of the other drought shocks are imprecisely estimated in general. Finally, I examine whether consecutive rainfall shocks would amplify or mitigate the effect of droughts in the dry season in $t-1$ by augmenting Equation (1) with the indicators for positive (8th and 9th deciles) or negative shocks (1st and 2nd deciles) of the wet-season rainfall in t and $t-1$. Table B.10 shows that the effect of droughts in the dry season in $t-1$ remains robust and the interaction terms are not statistically significant.

5.5.3 Measurement Error

I calculate the average effect on yearly births by summing up the four point estimates from the 3rd to the 6th quarters after droughts (or, equivalently, from October to September) and compare it to the point estimate for yearly abortion. This exercise checks the measurement error in the reporting of abortion because mothers might be reluctant to provide their true experience of abortion if those abortions were particularly sex-selective. The average effect of droughts on the yearly birthrate is -0.0023, which is almost identical to the point estimate on yearly abortion in Table 5, implying that the under-reporting of abortion should be less of a concern.

5.5.4 Spatial and Serial Correlation

I investigate whether the estimates of standard errors are biased due to spatial correlation of drought indicators. I attempt to correct for the spatial correlation by clustering the standard errors at the province level rather than at the district level. I also show the p-values from clustering on both district and year to further account for serial correlation in rainfall realizations over time within districts. In Table B.11, I still find that the main estimates are statistically significant at the 95 percent significance level, although alternative clustering slightly reduces the significance.

6 Conclusion

In this paper, I examine how abortion responds to drought-induced transitory income shocks and how son preference regulates such adjustments. I provide reduced-form estimates for the effects of droughts, which serve as a valid proxy for short-term slumps in agricultural income, on a series of fertility outcomes of credit-constrained rural mothers. I find that affected mothers postpone fertility using abortion when they are unable to smooth consumption in the pre-harvest season. Importantly, droughts are associated with disproportionately more abortions of female fetuses, which exacerbates the problem of the skewed sex ratio at birth. While a full rebound in births after approximately 2 years appears more consistent with the effect on the timing of fertility, the effect on the sex ratio at birth emphasizes that even transitory income shocks can have long-term demographic consequences, which can shed light on how the gender gap can persist during the economic development process (Jayachandran, 2015).

Abortion allows parents to maximize lifetime utility by arranging the timing of childbearing at a low cost; thus, parents avoid giving birth to an unwanted child, who otherwise faces lower pre- and postnatal investment (Pop-Eleches, 2006). However, at the same time, if paired with son preference, abortion may have demographic consequences by exacerbating the 'missing girls' phenomenon, which can have a detrimental influence on female human capital accumulation (Jayachandran, 2015), and can relate to social problems, such as an increase in crime by unmarried young men in the long run (Edlund et al., 2013).

My findings provide timely evidence for policy designs in developing countries. Although I focus on rural Vietnam, sex-selective abortions are increasing in the developing world (Bongaarts and Guilmoto, 2015). Furthermore, climate change would make extreme weather events more frequent, which essentially translate into transitory economic shocks to which poor economies relying on agricultural yields are especially vulnerable (IPCC, 2014). The effect on prenatal sex discrimination should be incorporated in assessing the damage functions that estimate the potential economic implications of climate change. Expanding the social safety nets or effective credit markets that help the poor mitigate aggregate shocks might minimize the resulting fertility response and therefore, the bias in sex ratios at birth.

References

Almond, Douglas, Hongbin Li, and Shuang Zhang, "Land Reform and Sex Selection in China," *Journal of Political Economy*, November 2017, *Forthcoming*.

Ananat, Elizabeth Oltmans, Jonathan Gruber, Phillip B Levine, and Douglas Staiger, "Abortion and Selection," *Review of Economics and Statistics*, February 2009, *91* (1), 124–136.

Anttila-Hughes, Jesse Keith and Solomon M. Hsiang, "Destruction, Disinvestment, and Death: Economic and Human Losses Following Environmental Disaster," *SSRN Electronic Journal*, 2013.

Artadi, Elsa V., "Going into Labor: Earnings vs. Infant Survival in Rural Africa." Working Paper, Harvard University November 2005.

Auffhammer, Maximilian, V. Ramanathan, and Jeffrey R. Vincent, "Climate change, the monsoon, and rice yield in India," *Climatic Change*, March 2012, *111* (2), 411–424.

Becker, Gary S., *An Economic Analysis of Fertility* number no. c2387. In 'NBER book chapter series.', Cambridge, Mass: National Bureau of Economic Research, 1960.

Behrman, Jere R., "Intrahousehold Allocation of Nutrients in Rural India: Are Boys Favored? Do Parents Exhibit Inequality Aversion?," *Oxford Economic Papers*, 1988, *40* (1), 32–54.

Belanger, Daniele, "Son Preference in a Rural Village in North Vietnam," *Studies in Family Planning*, December 2002, *33* (4), 321–334.

Bhalotra, Sonia and Rudi Rocha, "The Timing of Fertility in Response to Income Shocks." Unpublished Manuscript, University of Bristol 2012.

— **and Tom Cochrane**, "Where Have All the Young Girls Gone? Identification of Sex Selection in India," Technical Report IZA Discussion Paper No. 5381 December 2010.

Bharadwaj, Prashant and Leah K. Lakdawala, “Discrimination Begins in the Womb: Evidence of Sex-Selective Prenatal Investments,” *Journal of Human Resources*, 2013, *48* (1), 71–113.

Bhattacharya, Jayanta, Thomas DeLeire, Steven Haider, and Janet Currie, “Heat or Eat? Cold-Weather Shocks and Nutrition in Poor American Families,” *American Journal of Public Health*, July 2003, *93* (7), 1149–1154.

Black, Dan A., Natalia Kolesnikova, Seth G. Sanders, and Lowell J. Taylor, “Are Children “Normal”?,” *Review of Economics and Statistics*, March 2013, *95* (1), 21–33.

Bongaarts, John and Christophe Z. Guilmoto, “How Many More Missing Women? Excess Female Mortality and Prenatal Sex Selection, 1970-2050,” *Population and Development Review*, June 2015, *41* (2), 241–269.

Burke, Marshall, Erick Gong, and Kelly Jones, “Income Shocks and HIV in Africa,” *The Economic Journal*, June 2015, *125* (585), 1157–1189.

Cameron, Elissa Z., “Facultative adjustment of mammalian sex ratios in support of the Trivers-Willard hypothesis: evidence for a mechanism,” *Proceedings of the Royal Society B: Biological Sciences*, August 2004, *271* (1549), 1723–1728.

Chatterjee, Shoumitro and Tom Vogl, “Escaping Malthus: Economic Growth and Fertility Change in the Developing World,” *American Economic Review*, June 2018, *108* (6), 1440–1467.

Chen, Yuyu, Hongbin Li, and Lingsheng Meng, “Prenatal Sex Selection and Missing Girls in China: Evidence from the Diffusion of Diagnostic Ultrasound,” *Journal of Human Resources*, January 2013, *48* (1), 36–70.

Committee for Population, Family and Children [Vietnam] and ORC Macro, “Vietnam Demographic and Health Survey 2002,” Technical Report, Committee for Population, Family and Children and ORC Macro, Calverton, Maryland, USA September 2003.

Corno, Lucia, Nicole Hildebrandt, and Alessandra Voena, “Age of Marriage, Weather Shocks, and the Direction of Marriage Payments.” NBER Working Paper No. 23604, National Bureau of Economic Research, Cambridge, MA July 2017.

Currie, Janet and Hannes Schwandt, “Short- and long-term effects of unemployment on fertility,” *Proceedings of the National Academy of Sciences*, October 2014, *111* (41), 14734–14739.

Dehejia, Rajeev and Adriana Lleras-Muney, “Booms, Busts, and Babies’ Health,” *The Quarterly Journal of Economics*, August 2004, *119* (3), 1091–1130.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken, “What Do We Learn from the Weather? The New Climate-Economy Literature,” *Journal of Economic Literature*, September 2014, *52* (3), 740–798.

Dercon, Stefan, “Income Risk, Coping Strategies, and Safety Nets,” *The World Bank Research Observer*, 2002, *17* (2), 141–166.

Dettling, Lisa J. and Melissa S. Kearney, “House prices and birth rates: The impact of the real estate market on the decision to have a baby,” *Journal of Public Economics*, February 2014, *110*, 82–100.

Dyson, Tim, “Demographic Responses To Famines In South Asia,” *IDS Bulletin*, October 1993, *24* (4), 17–26.

Ebenstein, Avraham, “The "Missing Girls" of China and the Unintended Consequences of the One Child Policy,” *Journal of Human Resources*, 2010, *45* (1).

Edlund, Lena, Hongbin Li, Junjian Yi, and Junsen Zhang, “Sex Ratios and Crime: Evidence from China,” *Review of Economics and Statistics*, December 2013, *95* (5), 1520–1534.

Funk, Chris, Pete Peterson, Martin Landsfeld, Diego Pedreros, James Verdin, Shraddhanand Shukla, Gregory Husak, James Rowland, Laura Harrison, Andrew Hoell, and Joel Michaelsen, “The climate hazards infrared precipitation with stations-a new environmental record for monitoring extremes,” *Scientific Data*, December 2015, *2*, 150066.

Gammeltoft, Tine and Hanh Thi Thuy Nguyen, “The Commodification of Obstetric Ultrasound Scanning in Hanoi, Viet Nam,” *Reproductive Health Matters*, January 2007, *15* (29), 163–171.

Gibson, John and Bonggeun Kim, “Quality, Quantity, and Nutritional Impacts of Rice Price

Changes in Vietnam," *World Development*, March 2013, *43*, 329–340.

Glewwe, Paul, Nisha Agrawal, and David Dollar, eds, *Economic growth, poverty, and household welfare in Vietnam* World Bank regional and sectoral studies, Washington, DC: World Bank, 2004.

Goodkind, Daniel, "On Substituting Sex Preference Strategies in East Asia: Does Prenatal Sex Selection Reduce Postnatal Discrimination?," *Population and Development Review*, 1996, *22* (1), 111–125.

Groeger, Andre and Yanos Zylberberg, "Internal Labor Migration as a Shock Coping Strategy: Evidence from a Typhoon," *American Economic Journal: Applied Economics*, April 2016, *8* (2), 123–153.

Guilmoto, Christophe Z., Xuyen Hoang, and Toan Ngo Van, "Recent Increase in Sex Ratio at Birth in Viet Nam," *PLoS ONE*, February 2009, *4* (2), e4624.

Guiteras, Raymond, Amir Jina, and A. Mushfiq Mobarak, "Satellites, Self-reports, and Submersion: Exposure to Floods in Bangladesh," *American Economic Review*, May 2015, *105* (5), 232–236.

Gupta, Monica Das, Jiang Zhenghua, Li Bohua, Xie Zhenming, Woojin Chung, and Bae Hwa-Ok, "Why is Son preference so persistent in East and South Asia? a cross-country study of China, India and the Republic of Korea," *Journal of Development Studies*, December 2003, *40* (2), 153–187.

Heckman, James J. and James R. Walker, "The Relationship Between Wages and Income and the Timing and Spacing of Births: Evidence from Swedish Longitudinal Data," *Econometrica*, November 1990, *58* (6), 1411.

Hou, Xiaohui, "Can Drought Increase Total Calorie Availability? The Impact of Drought on Food Consumption and the Mitigating Effects of a Conditional Cash Transfer Program," *Economic Development and Cultural Change*, July 2010, *58* (4), 713–737.

IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]*, Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2014.

Jaffee, Steven M., Son Kim Dang, Do Anh Tuan Nguyen, Emilie Cassou, Trang Thi Thu Truong, Nguyen Thi Thuy, Mateo Ambrosio Albala, Donald F. Larson, and Bernardita Ledesma, "Vietnam-Agricultural modernization transforming Vietnamese agriculture: Gaining more for less," Technical Report AUS15856, World Bank Group, Washington, D.C. April 2016.

Jayachandran, Seema, "Selling Labor Low: Wage Responses to Productivity Shocks in Developing Countries," *Journal of Political Economy*, 2006, *114* (3), 538–575.

—, "The Roots of Gender Inequality in Developing Countries," *Annual Review of Economics*, August 2015, *7* (1), 63–88.

—, "Fertility Decline and Missing Women," *American Economic Journal: Applied Economics*, January 2017, *9* (1), 118–139.

Kaur, Supreet, "Nominal Wage Rigidity in Village Labor Markets." NBER Working Paper No. 20770, National Bureau of Economic Research, Cambridge, MA December 2014.

Khandker, Shahidur R., "Seasonality of income and poverty in Bangladesh," *Journal of Development Economics*, March 2012, *97* (2), 244–256.

Lindo, Jason M., "Are Children Really Inferior Goods?: Evidence from Displacement-Driven Income Shocks," *Journal of Human Resources*, March 2010, *45* (2), 301–327.

Lobell, David B and Christopher B Field, "Global scale climate-crop yield relationships and the impacts of recent warming," *Environmental Research Letters*, March 2007, *2* (1), 014002.

Lohmann, Steffen and Tobias Lechtenfeld, "The Effect of Drought on Health Outcomes and Health Expenditures in Rural Vietnam," *World Development*, August 2015, *72*, 432–448.

Lovenheim, Michael F. and Kevin J. Mumford, "Do Family Wealth Shocks Affect Fertility

Choices? Evidence from the Housing Market," *Review of Economics and Statistics*, May 2013, *95* (2), 464–475.

Maccini, Sharon and Dean Yang, "Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall," *American Economic Review*, May 2009, *99* (3), 1006–1026.

Mathews, F., P. J Johnson, and A. Neil, "You are what your mother eats: evidence for maternal preconception diet influencing foetal sex in humans," *Proceedings of the Royal Society B: Biological Sciences*, July 2008, *275* (1643), 1661–1668.

PATH and Reproductive Health Department, "Examining the Cost of Providing Medical Abortion in Vietnam," Technical Report, Ministry of Health, Hanoi, Vietnam August 2006.

Paxson, Christina H., "Using Weather Variability to Estimate the Response of Savings to Transitory Income in Thailand," *The American Economic Review*, 1992, *82* (1), 15–33.

__ , "Consumption and Income Seasonality in Thailand," *Journal of Political Economy*, February 1993, *101* (1), 39–72.

Pham, Bang Nguyen, Wayne Hall, and Peter Stewart Hill, "Indirect evidence of the contribution of prenatal sex selection practices to the high sex ratio at birth in Vietnam," *Journal of Population Research*, 2011, *28* (4), 293–299.

__ , __ , Peter S Hill, and Chalapati Rao, "Analysis of socio-political and health practices influencing sex ratio at birth in Viet Nam," *Reproductive Health Matters*, January 2008, *16* (32), 176–184.

Pitt, Mark M. and Wendy Sigle, "Seasonality, Weather Shocks and the Timing of Births and Child Mortality in Senegal." Working Paper, Brown University April 1997.

Pop-Eleches, Cristian, "The Impact of an Abortion Ban on Socioeconomic Outcomes of Children: Evidence from Romania," *Journal of Political Economy*, August 2006, *114* (4), 744–773.

Rose, Elaina, "Consumption Smoothing and Excess Female Mortality in Rural India," *The Review of Economics and Statistics*, 1999, *81* (1), 41–49.

Schultz, T. Paul, "Changing World Prices, Women's Wages, and the Fertility Transition: Sweden, 1860-1910," *Journal of Political Economy*, December 1985, *93* (6), 1126–1154.

Sedgh, Gilda, Jonathan Bearak, Susheela Singh, Akinrinola Bankole, Anna Popinchalk, Bela Ganatra, Clementine Rossier, Caitlin Gerdts, Ozge Tuncalp, Brooke Ronald Johnson, Heidi Bart Johnston, and Leontine Alkema, "Abortion incidence between 1990 and 2014: global, regional, and subregional levels and trends," *The Lancet*, July 2016, *388* (10041), 258–267.

__ , Stanley K. Henshaw, Susheela Singh, Akinrinola Bankole, and Joanna Drescher, "Legal Abortion Worldwide: Incidence and Recent Trends," *Perspectives on Sexual and Reproductive Health*, 2007, *39* (4), 216–225.

Shah, Manisha and Bryce Millett Steinberg, "Drought of Opportunities: Contemporaneous and Long-Term Impacts of Rainfall Shocks on Human Capital," *Journal of Political Economy*, March 2017, *125* (2), 527–561.

Sobotka, Tomas, Vegard Skirbekk, and Dimiter Philipov, "Economic Recession and Fertility in the Developed World," *Population and Development Review*, June 2011, *37* (2), 267–306.

Teerawichitchainan, Bussarawan and Sajeda Amin, "The Role of Abortion in the Last Stage of Fertility Decline in Vietnam," *International Perspectives on Sexual and Reproductive Health*, June 2010, *36* (2), 80–82.

Townsend, Robert M., "Risk and Insurance in Village India," *Econometrica*, May 1994, *62* (3), 539.

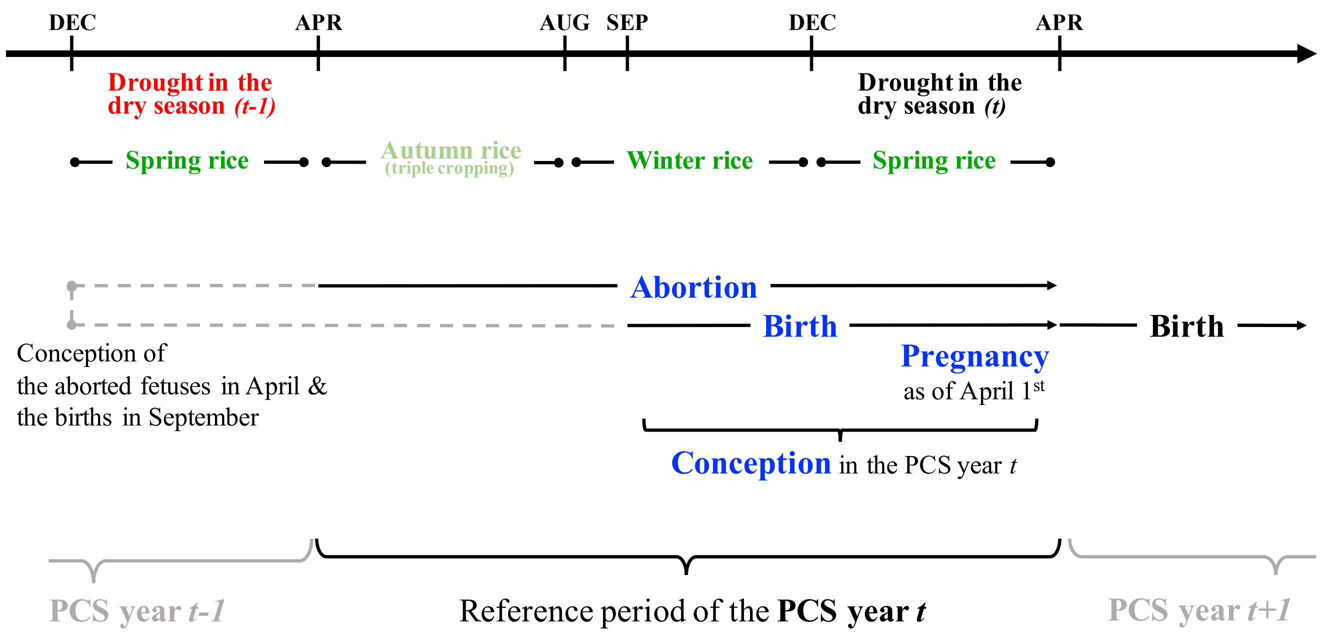
Vu, Linh and Paul Glewwe, "Impacts of Rising Food Prices on Poverty and Welfare in Vietnam," *Journal of Agricultural and Resource Economics*, 2011, *36* (1), 14–27.

Wainwright, Fiona and Carol Newman, "Income shocks and household risk-coping strategies: evidence from rural Vietnam," *Institute for International Integration Studies Discussion paper*, 2011, (358).

Whittaker, Andrea, ed., *Abortion in Asia: local dilemmas, global politics* number v. 20. In 'Fertility, reproduction, and sexuality.', New York: Berghahn Books, 2010.

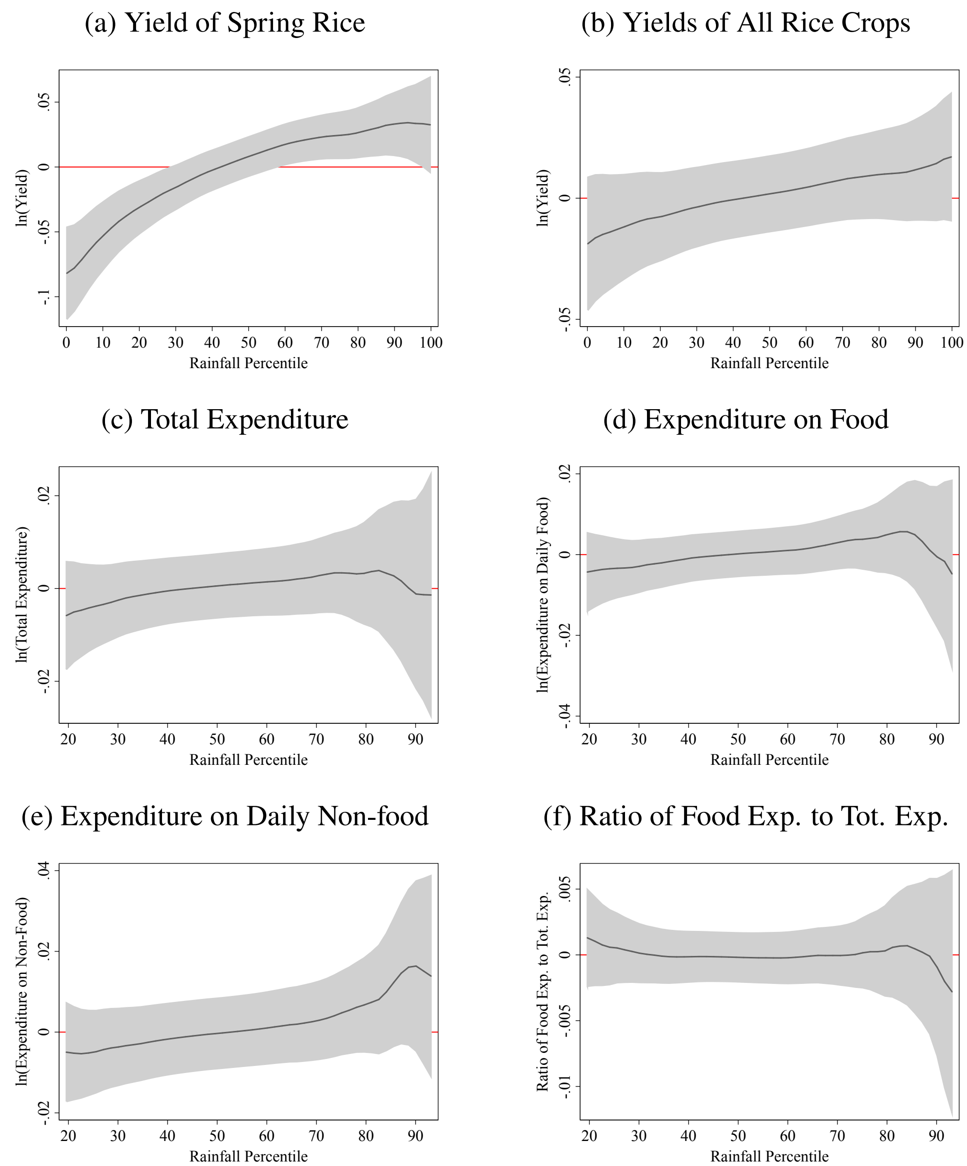
Figures

Figure 1: Rice Crop Calendar and Time Frame of Drought Shocks and Fertility Variables



Notes: This plot describes the rice-crop calendar across Vietnam from the FAO, and the timeframe of the drought shocks in the dry season (Dec-Apr) and fertility outcomes from the PCS. The reference period of the PCS is from April to March. Accordingly, the drought occurring right before the reference period of the PCS, $Drought_{t-1}$ written in red, would be the most relevant shock to the fertility outcomes created using the PCS in t. In the PCS, abortion is reported by year, and the current pregnancy is queried as of April 1st, which is the enumeration date of the PCS. The variable 'conception' denotes all the conceptions for fetuses to be potentially subject to abortion surveyed in the PCS t. Thus, the indicator for conception in the PCS year t is coded one if a mother reports 1) abortion; 2) childbirth; or 3) pregnancy as of April 1st. In particular, a childbirth is considered as conception if it occurs starting in September, because if aborted fetuses would otherwise have been carried to term, the earliest possible childbirth would happen in September given that abortion is rarely performed after 16 weeks of pregnancy.

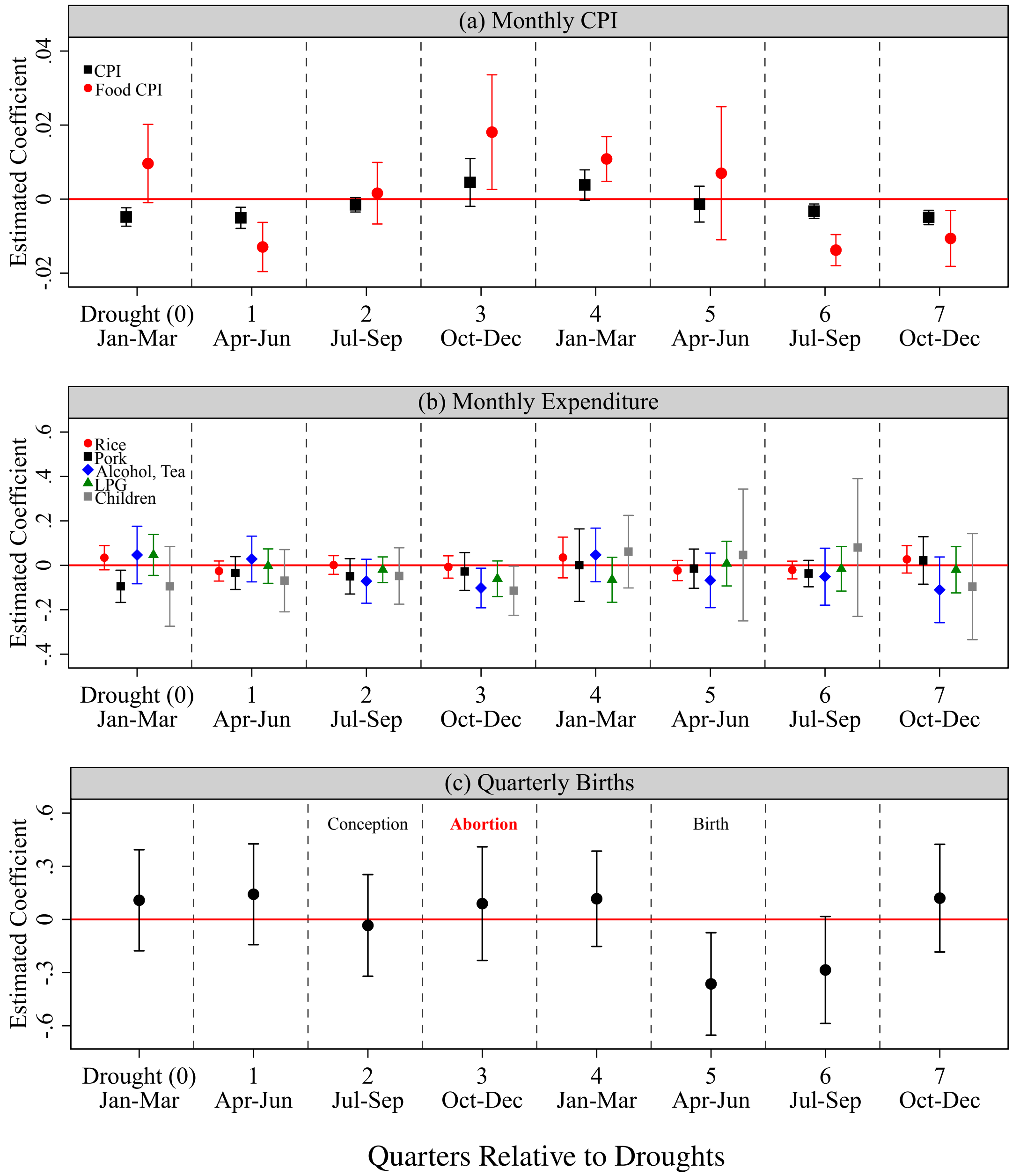
Figure 2: Rainfall Percentiles and Yearly Rice Yields, Expenditure



Data: Province-level rice yields in 1995-2014 from the GSO; Yearly household expenditure from the VHLSS 2004, 2006, 2008

Notes: Figures provide the point estimates (line) and the corresponding 95 percent confidence intervals (shaded area) from local linear regressions of the log of yield (Quintal/Ha) and the log of rural households' yearly expenditure ('000 VND) on the percentiles of the dry season rainfall in a given year, relative to the long-run rainfall distribution in a province. The regressions for crop yields include the logs of other season-year rainfalls, province-level linear time trends, year and province fixed effects. The regressions for expenditure include household-level characteristics, survey-quarter fixed effects, year and province fixed effects. All rice crops refer to spring, autumn and winter rice crops. Daily non-food items include petroleum, cooking fuels, detergent, etc.

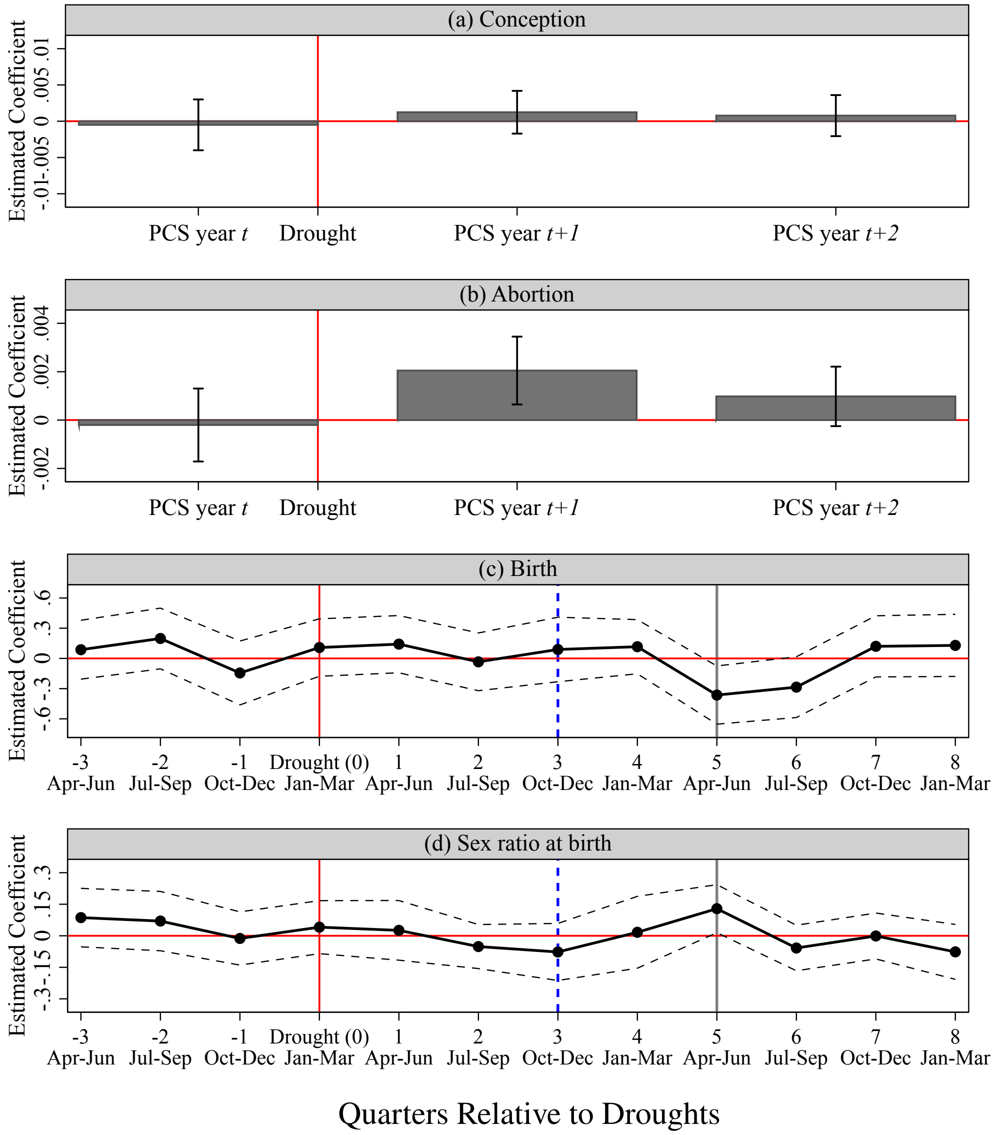
Figure 3: Effects of Droughts on Monthly CPI, Expenditure and Birth



Data: Province-level monthly CPI from the GSO; Monthly expenditure from the VHLSS 2010, 2012, 2014; Births from the PCS 2004-2008, 2010-2013

Notes: Figures plot the coefficients on the interaction terms between quarters and droughts in t and $t-1$ from the regressions estimating the effect on the province-level monthly CPIs (Panel (a)), the log of monthly expenditures (Panel (b)) and the district-quarter level number of births (Panel (c)). Colored bars represent the 95% confidence intervals of the estimated coefficients. The 'Conception' and 'Abortion' in Panel (c) denote the timing of conception and abortion of the birth cohort in the 5th quarter after droughts.

Figure 4: Effects of Droughts on Conception, Abortion, Birth and the Sex Ratio at Birth

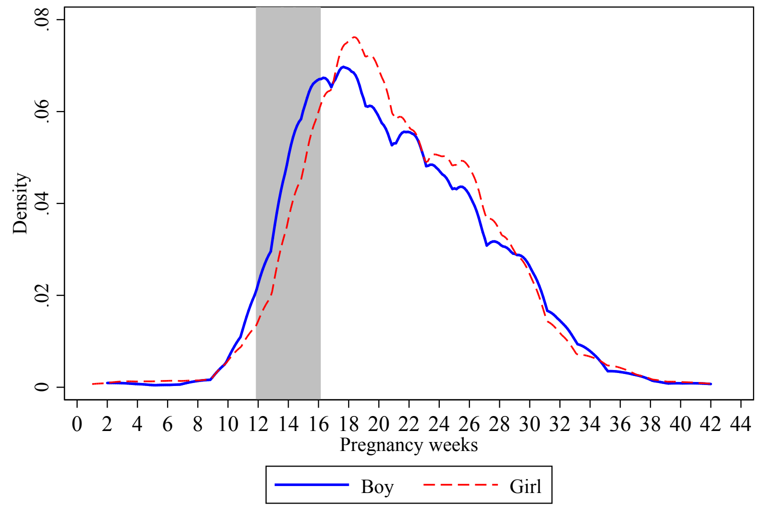


Data: PCS 2004-2008, 2010-2013

Notes: Panel (a) and (b) display the effects of droughts in the dry season in t, $t-1$ and $t-2$ on the mother-level likelihood of yearly conception and abortion. Panel (c) and (d) plot the coefficients on the indicators for n quarters away from the drought occurring at $n = 0$ in the regression estimating the effects on the district-quarter level number of births and the log of province-quarter level sex ratio at birth. The sex ratio at birth is defined by the number of infant boys (≤ 1 year old) born to one hundred infant girls in each survey year. The black bars (Panel (a) and (b)) and dashed lines (Panel (c) and (d)) refer to the 95 percent confidence intervals. The gray vertical lines in Panel (c) and (d) denote the quarter when the effect on births is significant at the 95% level. The blue dashed lines refer to the timing of abortion for the conception of the birth cohort in the 5th quarter (Apr-Jun) after droughts.

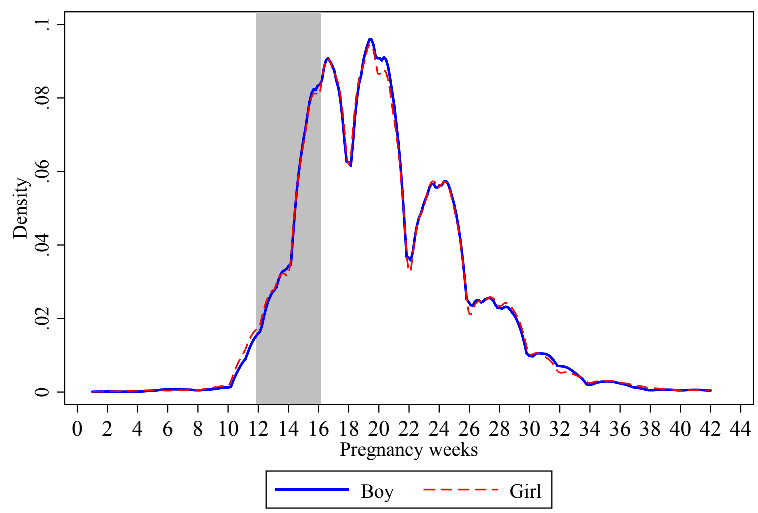
Figure 5: Distribution of the Pregnancy Weeks of Fetal Sex Determination

(a) By the sex of newborns born to affected mothers



p-value of two-sample Kolmogorov–Smirnov test: .112

(b) By the sex of newborns born to unaffected mothers



p-value of two-sample Kolmogorov–Smirnov test: .999

Data: PCS 2006, 2007, 2010-2013

Notes: Figures plot the kernel density estimation on the distributions of the weeks of fetal sex determination using ultrasound, conditional on the childbirth in April-June. The gray vertical bands denote the pregnancy weeks when sex-selective abortion can be performed; the 12th week is the earliest possible week when the fetal sex can be determined by ultrasound, and the 16th weeks is the latest possible week when abortion can be performed from the DHS 2002 (Committee for Population, Family and Children [Vietnam] and ORC Macro, 2003). Panel (a) plots the pregnancy weeks of fetal sex determination of affected mothers by the sex of a newborn, whereas Panel (b) plots those of unaffected mothers, conditional on giving births to a child in the 5th quarter after droughts (April-June) when the effect of droughts on birth is significant as shown in Figure 4 (c).

Tables

Table 1: Descriptive Statistics

	Rural		Urban		Diff.
	Mean	SD	Mean	SD	
	(1)	(2)	(3)	(4)	(5)
Panel A. Full Sample					
Age (year)	31.9	(7.4)	33.8	(7.4)	-1.9
Educ.: Primary or below	0.506	(0.500)	0.285	(0.452)	0.221
Educ.: Lower secondary	0.355	(0.479)	0.294	(0.456)	0.061
Educ.: Higher secondary or above	0.139	(0.346)	0.420	(0.494)	-0.281
Age at the first birth	22.590	(3.659)	24.051	(3.938)	-1.461
Number of children ever born	1.849	(0.837)	1.703	(0.744)	0.146
Number of children ever died	0.029	(0.180)	0.016	(0.134)	0.013
Have at least one son	0.727	(0.446)	0.677	(0.467)	0.05
Gave birth last year	0.106	(0.308)	0.093	(0.291)	0.013
Currently pregnant	0.040	(0.195)	0.038	(0.192)	0.002
Had abortion last year	0.007	(0.085)	0.008	(0.087)	-0.001
Currently using any contraceptives	0.769	(0.421)	0.758	(0.429)	0.011
Currently using modern contraceptives	0.670	(0.470)	0.628	(0.483)	0.042
Panel B. Conditional on childbirth last year					
Checked pregnancy at clinics	0.946	(0.226)	0.981	(0.135)	-0.035
Number of antenatal check-ups	3.642	(1.789)	4.591	(2.077)	-0.949
Knew the child's sex before birth	0.790	(0.407)	0.888	(0.315)	-0.098
Gestational weeks when a mother knew the fetal sex	20.170	(5.095)	18.962	(4.611)	1.208
Knew the fetal sex by ultrasound	0.989	(0.105)	0.991	(0.093)	-0.002
Facility delivery	0.934	(0.249)	0.985	(0.121)	-0.051
Panel C. Spouse Characteristics					
Age (year)	36.6	(7.1)	39.0	(7.2)	-2.5
Educ.: Primary or below	0.460	(0.498)	0.250	(0.433)	0.21
Educ.: Lower secondary	0.379	(0.485)	0.306	(0.461)	0.073
Educ.: Higher secondary or above	0.161	(0.367)	0.444	(0.497)	-0.283
Panel D. Household Characteristics (VHLSS)					
Unskilled labor worker in agri., aqua., forestry	0.471	(0.499)	0.116	(0.321)	0.355
Grow any paddy	0.586	(0.493)	0.114	(0.318)	0.472
Average monthly expenditure per capita (in '000 VND)	9731.4	(9608.71)	17859.3	(20803.2)	-8127.9
Observations (PCS)	811,117		840,869		
Observations (VHLSS)	22,253		8,207		

Data: PCS 2004-2008, 2010-2013, VHLSS 2004,2006,2008
Notes: This table provides the summary statistics of mothers included in the main analyses from the PCS (Panels A and B), and household characteristics from the VHLSS (Panel D). Panel C displays the spousal characteristics reported from the PCS 2006. Diff. refers to the difference in means between rural and urban mothers. 'Full sample' includes married women of reproductive age 15-49 residing in rural or urban districts as defined in the PCS. The sample from the 10 provinces (Figure A.5) are not considered for the main analyses.

Table 2: Effects of Droughts on Yearly Rice Yields and Expenditure

	Dependent variables					
	Spring Rice (1)	All Rice Crops (2)	Total Expenditure (3)	Expenditure on Food (4)	Expenditure on Non-food (5)	Ratio (Food/Total) (6)
Drought	-0.024	-0.013	0.005	0.007	-0.085	0.002
	(0.008)	(0.006)	(0.018)	(0.021)	(0.028)	(0.006)
Observations	1,045	1,055	18,128	18,128	18,128	18,128
R-squared	0.804	0.901	0.530	0.609	0.530	0.119
Mean of Dep. Var.	3.923	3.783	9.878	9.078	7.564	0.471
Controls						
Province and year FE	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes
Province-specific linear time trend	Yes	Yes				
Household characteristics			Yes	Yes	Yes	Yes
Survey quarter FE			Yes	Yes	Yes	Yes

Data: Agricultural statistics from the GSO; VHLSS 2004, 2006, 2008

Notes: Column (1) and (2) present results from a regression of the log of annual crop yields (Quintal/Ha) on rainfall shocks. The unit of observation for crop yield is a province-year in 1995-2014. Column (3)-(6) present results from a regression of the log of expenditure (in '000 VND) on rainfall shocks. The unit of observation is a household. The sample excludes the 10 poorest provinces to be consistent with the analyses using the PCS. Household characteristics controls include the sex, age, ethnicity (Kinh or not) and years of schooling of the household head, the household size and the dummy for multigenerational household. Robust standard errors, which are reported in parentheses, are clustered for the province level.

Table 3: Effects of Droughts on Conception and Contraceptive Use

	Dependent variables							
	Conception		Use any contraceptives		Use modern contraceptives		No contraception to have a child	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Drought in the dry season (t)								
Drought	-0.0005	-0.0003	-0.0046	-0.0046	-0.0030	-0.0094	0.0021	-0.0013
	(0.0018)	(0.0024)	(0.0029)	(0.0045)	(0.0040)	(0.0063)	(0.0023)	(0.0028)
Observations	810,144	441,789	808,809	441,222	808,809	441,222	808,809	441,222
R-squared	0.148	0.105	0.326	0.224	0.233	0.158	0.237	0.188
Mean of Dep. Var.	0.107	0.107	0.769	0.769	0.666	0.666	0.117	0.117
Panel B. Drought in the dry season ($t-1$)								
Drought	0.0012	0.0012	0.0011	0.0030	0.0070	0.0037	0.0005	0.0001
	(0.0015)	(0.0019)	(0.0024)	(0.0031)	(0.0033)	(0.0046)	(0.0019)	(0.0022)
Observations	810,144	441,789	808,809	441,222	808,809	441,222	808,809	441,222
R-squared	0.148	0.105	0.326	0.224	0.233	0.158	0.237	0.188
Mean of Dep. Var.	0.107	0.107	0.768	0.768	0.665	0.665	0.117	0.117
Panel C. Drought shocks in the dry season ($t-2$)								
Drought	0.0008	0.0022	-0.0003	-0.0031	0.0068	0.0073	0.0033	0.0017
	(0.0015)	(0.0018)	(0.0026)	(0.0033)	(0.0035)	(0.0046)	(0.0020)	(0.0023)
Observations	810,144	441,789	808,809	441,222	808,809	441,222	808,809	441,222
R-squared	0.148	0.105	0.326	0.224	0.233	0.158	0.237	0.188
Mean of Dep. Var.	0.107	0.107	0.770	0.770	0.668	0.668	0.115	0.115
Controls								
District and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mother characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District-specific linear time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth parity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gender composition FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fertility characteristics		Yes		Yes		Yes		Yes
Spouse characteristics		Yes		Yes		Yes		Yes

Data: PCS 2004-2008, 2010-2013

Notes: This table provides the current and the lagged effects of droughts on the conception and various measures of contraceptive use. ‘Conception’ is defined by the abortion occurring in the survey year and the corresponding conception cohort to this abortion, i.e., the births between September and March in the PCS and the current pregnancy. Any contraceptives include traditional methods, such as periodic abstinence or withdrawal, and modern contraceptives describes IUDs, pills, injections, condoms, diaphragms, foam or sterilization. Robust standard errors are shown in parentheses clustered at the district level.

Table 4: Effect of Droughts on Abortion

	Dependent variable: Abortion=1							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Drought in the dry season (t)								
Drought	0.0002	0.0001	0.0001	-0.0002	-0.0002	-0.0002	-0.0003	-0.0012
	(0.0007)	(0.0007)	(0.0007)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0011)
Observations	811,092	811,092	810,144	810,144	810,144	810,144	802,589	441,789
R-squared	0.008	0.008	0.009	0.012	0.012	0.012	0.012	0.013
Mean of Dep. Var.	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066
Panel B. Drought in the dry season ($t-1$)								
Drought	0.0020	0.0021	0.0022	0.0020	0.0021	0.0020	0.0021	0.0023
	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0010)
Observations	811,092	811,092	810,144	810,144	810,144	810,144	802,589	441,789
R-squared	0.008	0.008	0.009	0.012	0.012	0.012	0.012	0.013
Mean of Dep. Var.	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066	0.0066
Panel C. Drought in the dry season ($t-2$)								
Drought	0.0009	0.0009	0.0009	0.0010	0.0010	0.0010	0.0010	0.0008
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0009)
Observations	811,092	811,092	810,144	810,144	810,144	810,144	802,589	441,789
R-squared	0.008	0.008	0.009	0.012	0.012	0.012	0.012	0.013
Mean of Dep. Var.	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069
Controls								
District and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mother characteristics			Yes	Yes	Yes	Yes	Yes	Yes
District-specific linear time trend				Yes	Yes	Yes	Yes	Yes
Birth parity FE					Yes	Yes	Yes	Yes
Gender composition FE						Yes	Yes	Yes
Fertility characteristics							Yes	Yes
Spouse characteristics								Yes

Data: PCS 2004-2008, 2010-2013

Notes: The dependent variable is the indicator for the experience of abortion during the survey year. Fertility characteristic controls consists of the mother's age at her first birth and the birth spacing, measured as months between the most recent childbirth and the starting month of the survey period. Spouse characteristics include the mother's spouse's age, age squared and educational attainment. The mean of the dependent variable is the mean abortion rate of mothers living in those districts that were not inflicted with droughts. Robust standard errors are shown in parentheses clustered at the district level.

Table 5: Effects of Droughts on Childbirth

	Dependent variable: Giving Birth=1			
	Birth in Apr-Jun	Birth in Jul-Sep	Birth in Oct-Dec	Birth in Jan-Mar
	(1)	(2)	(3)	(4)
Panel A. Drought in the dry season (t)				
Drought	0.0003	0.0008	-0.0014	0.0004
	(0.0008)	(0.0008)	(0.0008)	(0.0007)
Observations	810,144	810,144	810,144	810,144
R-squared	0.035	0.040	0.042	0.035
Mean of Dep. Var.	0.0258	0.0281	0.0202	0.0323
Panel B. Drought in the dry season ($t-1$)				
Drought	0.0005	0.0001	0.0002	0.0002
	(0.0007)	(0.0007)	(0.0007)	(0.0006)
Observations	810,144	810,144	810,144	810,144
R-squared	0.035	0.040	0.042	0.035
Mean of Dep. Var.	0.0258	0.0281	0.0201	0.0321
Panel C. Drought in the dry season ($t-2$)				
Drought	-0.0023	-0.0012	0.0010	0.0009
	(0.0006)	(0.0007)	(0.0006)	(0.0006)
Observations	810,144	810,144	810,144	810,144
R-squared	0.035	0.040	0.042	0.035
Mean of Dep. Var.	0.0258	0.0283	0.0200	0.0318
Controls				
District and year FE	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes
Mother characteristics	Yes	Yes	Yes	Yes
District-specific linear time trend	Yes	Yes	Yes	Yes
Birth parity FE	Yes	Yes	Yes	Yes
Gender composition FE	Yes	Yes	Yes	Yes

Data: PCS 2004-2008, 2010-2013
Notes: This table shows OLS regressions for the effects of droughts on the likelihood of giving birth. The outcome is the indicator for giving birth in a given quarter in the survey year. Robust standard errors are shown in parentheses clustered at the district level.

Table 6: Effects of Droughts on a Child's Sex

	Dependent variable: Newborn is a boy=1			
	Born in Apr-Jun	Born in Jul-Sep	Born in Oct-Dec	Born in Jan-Mar
	(1)	(2)	(3)	(4)
Panel A. Drought in the dry season (t)				
Drought	0.0068	0.0143	-0.0071	0.0261
	(0.0182)	(0.0199)	(0.0148)	(0.0181)
Observations	20,683	22,791	23,212	19,005
R-squared	0.009	0.007	0.009	0.010
Mean of Dep. Var.	0.5244	0.5143	0.5267	0.5262
Panel B. Drought in the dry season ($t-1$)				
Drought	0.0006	-0.0271	-0.0156	0.0137
	(0.0153)	(0.0170)	(0.0135)	(0.0197)
Observations	20,683	22,791	23,212	19,005
R-squared	0.009	0.007	0.009	0.010
Mean of Dep. Var.	0.5232	0.5190	0.5267	0.5250
Panel C. Drought in the dry season ($t-2$)				
Drought	0.0234	-0.0046	0.0058	-0.0134
	(0.0134)	(0.0152)	(0.0128)	(0.0157)
Observations	20,683	22,791	23,212	19,005
R-squared	0.009	0.007	0.008	0.010
Mean of Dep. Var.	0.5219	0.5179	0.5272	0.5264
Controls				
District and year FE	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes
Mother characteristics	Yes	Yes	Yes	Yes
District-specific linear time trend	Yes	Yes	Yes	Yes
Birth parity FE	Yes	Yes	Yes	Yes
Gender composition FE	Yes	Yes	Yes	Yes

Data: PCS 2004-2008, 2010-2013

Notes: This table provides the effects of droughts on the likelihood that a newborn is a boy. The outcome is the indicator for a newborn being a boy conditional on being born in each quarter of the survey year. Robust standard errors are shown in parentheses clustered at the district level.