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

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Abstract

This paper studies how transitory income shocks affect abortion and generate unintended demographic consequences under son preference. I focus on rural Vietnam, where low rainfall induces a short-run downturn through a reduction in rice yields, and sex-selective abortion is widely available at a low cost. Linking rich microdata on fertility with local rainfall shocks, I find that affected mothers were 30 percent more likely to get abortions. Most abortions occurred during the pre-harvest season, suggesting that mothers postpone births through abortion to smooth consumption. The affected birth cohort exhibits a more male-skewed sex ratio at birth: 6 female fetuses were aborted to every 1 male fetus, explaining approximately 3 percent of the sex imbalance in rural Vietnam in 2004-2013. I find no effect on abortion for mothers in urban or triple-cropping provinces, indicating that income diversification can alleviate the adverse impacts. This study provides new evidence that transitory shocks can exacerbate the "missing girls" phenomenon in developing countries that are vulnerable to extreme weather events.

JEL Codes: D1, I15, J13, J16, Q54
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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, 2017). 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 also can ensure the sex of a child once paired with ultrasound, having far-reaching demographic implications in the long run.

This paper aims to examine how negative aggregate shocks affect childbearing through abortion and 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 a low cost and serves as one of the 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 the 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

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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 pre-emptive 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 also is 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,[2] 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 data (CHIRPS).[3]

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

[2]Here, I assume the health cost of abortion is minimal given safe abortion practices in Vietnam, and that the psychological cost is also not significant, which I discuss in Section 2.1.

[3]The Vietnamese administrative levels have the following structure: Region $\supset$ Province $\supset$ District $\supset$ Commune. There are 674 districts in Vietnam, and 629 districts are used for the analyses in this paper.

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. 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 more likely to get abortion by approximately 30 percent in the following year after the 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 linear 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, indicating that most abortions occurred in the pre-harvest season of the next rice crop when affected rural households exhibit the inability to smooth consumption. Furthermore, I find no effects on abortion among urban mothers, and substantially muted impacts on abortion for mothers living in provinces where one more rice crop can be harvested. I also find that neither the opportunity cost of a woman's labor nor the direct health impact of droughts appears dominant

The remaining districts are mostly urban districts within major cities. The average geographic area of rural districts in my sample is 457.7 km^2.

factors to drive the effects on abortion because of weak evidence on differential responses in a woman's labor market participation and infant mortality rates.

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 sub-sample surveyed when the ultrasound scans for fetal sex determination were 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, but at the same time, 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 the adjustment and skews the sex ratio by abortion, 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 the previous studies focusing on developing countries, infant mortality should be taken into consideration to understand 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 leverage 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 re-

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cent developing country contexts where pre-emptive 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 include 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, which 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 against weather-induced aggregate shocks (Dell et al., 2014). If adverse weather shocks occur, and credit and insurance markets are incomplete, poor households smooth consumption not only by changing their usual diet (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 the most liberal laws, which allow 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). The user fees for the two main 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).[4] The rapid expansion of the public health system has also lowered the barrier to abortion; not only does every rural commune have its own health clinic where early-stage abortions are provided, but 73 percent of rural residents can also pay a visit to district health centers less than a half-hour away for later-stage procedures.[5]

Abortion for married women is socially well-accepted throughout Vietnam (Whittaker, ed, 2010). This anti-natalist social atmosphere has largely been established by the family planning program—the one-or-two child policy—that intensely promoted abortions along with intrauterine devices (IUDs) as the primary birth control options. Other

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[4]There are a number of ways for rural married women to get abortions at subsidized prices or free of charge. For example, she will not be charged if she subscribes to the family planning program, reports a malfunction in contraceptive methods or is subject to the poverty alleviation program by localities (Teerawichitchainan and Amin, 2010).

[5]Based on the author's calculation using the commune survey section of the VHLSS 2004.

modern contraceptives, particularly temporary methods such as condoms and pills, were frequently unavailable, and their use was discouraged by local family planning officials (Teerawichitchainan and Amin, 2010; Figure A.2). These very limited options in birth control have been deemed to be the main culprits for the high abortion rates in Vietnam because abortion has replaced other modern contraceptives (Whittaker, ed, 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). Having at least one son can be of primary importance because he will be responsible for the rituals to worship his ancestors, support his elderly parents and inherit family properties (Pham et al., 2008). Meanwhile, ultrasound scans, which were first introduced as part of reproductive health services, rapidly increased approximately 10-fold from 1998 to 2007 (Guilmoto et al., 2009). This rapid adoption stemmed not only from supply-side factors, such as a very low cost (20,000 VND or US$1.30 per scan) and numerous providers, 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 1). This widespread availability of ultrasound scans undoubtedly plays a crucial role in the recent male-biased sex ratio at birth in the 2000s (Figure 2 and Figure A.1). This demographic transformation is common among countries of India and East Asia with son preference, especially when ultrasound scans become widespread and the cost of abortion is low (Das Gupta et al., 2003).[6]

Last but not least, other relevant environments affecting aggregate fertility have been steady in the 2000s. Infant mortality rates have been relatively low in Vietnam in the 2000s

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[6]Alarmed by abnormally male-skewed sex ratio in the early 2000s, the Vietnamese government has issued several official decrees to ban 'sex-selective' abortion since 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 abortions for family planning (Pham et al., 2008).

in comparison with other neighboring countries or those with a comparable income level (Figure A.3a). While total fertility and relevant population policies exhibit little change, the excess male infant mortality has been stable and close to the ratio found in countries without son preference in the 2000s (Figure A.3b), suggesting that there was neither an immediate fertility squeeze to have a son nor active substitution between pre- and post-natal discrimination against female births in the sample period (Goodkind, 1996).

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.[7] 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.[8] I pool nine waves of the PCS from 2004-2008 and 2010-13, which report abortion, giving me a sample size of approximately 1 million mothers from almost every rural district across Vietnam.[9]

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,

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[7]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 trends for January-March in year n and April-December in year $n-1$. (Figure 3)

[8]The Demographic and Health Surveys (DHS) Vietnam 2002 has more extensive information about fertility, including complete pregnancy histories, miscarriages, and abortion, but the sample size is only 5,665 women of reproductive age (Committee for Population, Family and Children [Vietnam] and ORC Macro, 2003). I use these data to understand the timing of abortion in Section 4.5.

[9]There is no PCS 2009 due to the census in the same year.

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. Due to inconsistency in the sampling and the change of the recall period for consumption from yearly to monthly, I use the first three waves (i.e., 2004, 2006, 2008) to examine the effects on yearly expenditure and the latter three waves (i.e., 2010, 2012, 2014) to analyze the effects on monthly expenditure and labor participation. 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 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 population in a province.[10] 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 using the birth order controls.

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), while they are more likely to use contraceptives. Conditional on childbirth in the last year, approximately 79 percent of mothers knew the fetal

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[10]Using the 2009 Census of Vietnam, I chose 10 provinces where more than 50 percent of the heads of household were not ethnically Kinh. The 10 provinces are Cao Bang, Bac Kan, Ha Giang, Lang Son, Lai Chau, Son La, Dien Bien, Hoa Binh, Lao Cai, Tuyen Quang, and the locations are mapped in Figure A.6. Not only are these provinces 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.2 Panel B.

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, Rainfall Data and Construction of 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. 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 is also the main staple for the population by supplying more than 50 percent of the people's daily calorie intake (Jaffee et al., 2016). 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 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 (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 3), and thus, rainfall is the most important weather variation affecting rural incomes if irrigation is ineffective (Lobell and Field, 2007).[11]

I create season-specific rainfall shocks for each district using CHIRPS version 2.0. CHIRPS incorporates 0.05-degree resolution satellite imagery with station readings to provide monthly estimates of precipitation beginning in 1981.[12] 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). To match those estimates

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[11]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.

[12]0.05 degrees is equivalent to approximately 5 kilometers at the equator.

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. 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). I collapse monthly rainfall to create a season-year measure of precipitation, e.g., 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-run 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 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 of drought assumes that fertility decisions are intrinsically conservative and discreet, and thus, they would respond to economic shocks in a nonlinear fashion. However, in Section 5.5, I will carefully verify the validity of the empirical specification using binned indicators for given percentiles or restricted cubic splines to explain the marginal effects be-

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[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 to be a single meaningful weather variable for proxying economic shocks, due not only to the complicated hydrologic and climatic conditions that cause flood but also to its nonlinear relationship with crop yield (Guiteras et al., 2015).

tween rainfall levels and abortion decisions. Figure A.6 plots the districts that experienced droughts in the sample period, 2004-2013. Districts that were afflicted with droughts are relatively evenly dispersed across the country.

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:

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

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 pregnancy, abortion, contraceptive use, birth 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 rainfall distribution from 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 3).[14]

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.[15] X_{it} is a vector of covariates, which consist of a mother-specific observable characteristics that are age in year t and its quadratic, and two indicator variables for 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, the baseline) to account for the birth order of current conception in 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.[16] 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 abortion but only asked whether a mother had an abortion in the last 12 months from the reference date, I include survey year fixed effects in lieu of the calendar year fixed effects to capture any sampling difference across waves over ten years. 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

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

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

[16]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.

productivity, etc. by district level over time.

As robustness checks, I also include two sets of control variables pertaining to a woman's fertility: the birth spacing and the age at the first birth[17] and spousal characteristics, such as his educational attainment and age for the subsample.[18] 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 her 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 in 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

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[17]To be precise, I construct the variable of birth spacing by calculating the interval between the baseline of the survey (one year before the reference date) and the year and month of the previous birth that occurred before the baseline instead of the period between the most recent live birth that occurred in the present survey year and the previous birth. This avoids the bad control problem because the concurrent live birth that occurred in the present survey is also affected by weather shocks (Angrist and Pischke, 2009). For a married woman who had no first child as of the reference date, I use the months elapsed since the year and month of her marriage.

[18]Spousal information 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.

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 rainfalls and define droughts analogously at the province level in lieu of the district level because the province is the unit of analysis for agricultural statistics from the GSO, and the VHLSS has the smaller sample size of households per district in comparison with the PCS.

Figure 4 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 4 (a) and Figure 4 (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 4 (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 4 (e)), but the impacts of poor rainfall to the extent of total expenditure (Figure 4 (c)) and food expenditure (Figure 4 (d)) are muted.

In Table 2, I provide the regression results using the drought indicator to examine how the drought measure 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

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

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 is difficult to anticipate and 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), but the effects are not precisely estimated for the other expenditure measures (columns 3 and 4), as shown in Figure 4, primarily because droughts result not only in slumps in agricultural income but also potentially in price surges of food, which constitute approximately half of households' real expenditure (Vu and Glewwe, 2011). These findings are also supported by Figure 4 (f), which shows a slight increase in the ratio of expenditure on food to total expenditure in the context of low levels of rain, suggesting that rural households allocate relatively more resources to purchasing food after droughts.

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 permits an immediate substitution between current consumption and childbearing.

I estimate the effects of droughts on monthly expenditure using the VHLSS 2010, 2012, and 2014, which collect consumption information over the month preceding the date of the interviews, which occurred over the year. In addition, I examine the effects

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[20]The reduction in rice production is estimated by similar magnitudes. If the outcome is the log of province-year level production in thousand tons, the point estimates for the spring rice and all rice production are -0.055 ($p < 0.05$), and -0.031 ($p < 0.1$), respectively.

on province-level prices using the monthly CPIs of 12 provinces provided by the Vietnam GSO in 2005-2014. I estimate the impact of droughts using the following specification:

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

where Y_{ipt} is the log of the 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 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 the drought, 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 5 (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 5 (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.3), affected

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households maintain their consumption of rice and pork (columns 8 and 9 of Table B.3), the two main food categories, by substituting away from consuming some daily non-food items (the 3rd quarter (Oct-Dec) of Figure 5 (b)) and toward the consumption of cheaper items, such as maize, cassava and potato (column 11 of Table B.4).

Figure 3 shows 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.[21] Furthermore, Figure A.11 shows that the adverse effects of droughts on consumption smoothing become attenuated in the triple-cropping provinces where autumn rice is also harvested between the harvests of spring and winter rice crops. 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 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 improved by here including mother-level abortion and current pregnancy to live birth, which has been a proxy for conception in the prior literature.[22] The indicator for conception in each survey year becomes one if a woman reported one of three cases: 1) she gave birth between September

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[21]I find the results discussed thus far are consistent with the findings of Wainwright and Newman (2011) that existing risk-coping strategies of rural Vietnamese households are ineffective in protecting consumption against aggregate shocks. For example, rural Vietnamese households do not have large-scale facilities to store rice, which limit 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).

[22]Since 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 5.5.

and March,[23] 2) she had an induced abortion, and/or 3) she was pregnant at the time of the survey. Figure 3 explains the time frame of each variable. 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 on outcomes. 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 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 economically sizable 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

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[23]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.

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 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 also 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 5 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. 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, whereas the effects of droughts in $t-1$ are robust to the distributed lagged specification in Table B.1.

The point estimates on the effects of droughts ($t-1$) are also invariably robust to employing a wide range of control covariates. First, this specific measure of droughts 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 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 depending on her expected payoff from having an extra child or son; thus, the effect of droughts is robust to unobservable changes in the composition of the mothers who conceived.

These results suggest that economic shocks can also have substantial effects, even to the extent of impacting a woman's decision regarding her current pregnancy, which not only reveals another onerous coping strategy when aggregate shocks befall poor rural households but also supports 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 over 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 discrimination against a female child.[24] 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 a survey year y and Q is a dummy variable that becomes one if a district is j quarters $(-3 \leq J \leq 8)$ before or after a drought.[25] 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 the province-specific crop calendar (λ_{pq}) and national-level trends in fertility (λ_{qy}). Therefore, 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 6 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 pre-trends 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 (Figure 8). Table 6 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

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[24]It is also important to minimize the duration of potential postnatal discrimination because this infant sample will also be analyzed to calculate the sex ratio at birth in Section 4.5.

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

year.

Importantly, Figure 6 shows that the effects of droughts on births are not evenly distributed across quarters; instead, they are concentrated in a particular quarter, suggesting that an affected mother is very likely to terminate her pregnancy in that specific quarter of the year. Given that conception occurs 9 months before the date of birth and most abortions are performed between 8-12 weeks of pregnancy, affected mothers get abortions particularly 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 5. Taken together, the income channel would indeed be the pivotal pathway for an increase in abortion after droughts. However, I will further investigate additional channels to explain more abortions in that quarter by examining labor participation and biological mechanisms in Section 5.5.

4.5 Effect on the Sex Ratio at Birth

Having the results 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 affected mothers are less likely to terminate their 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 sex ratio at birth.[26] I include region-quarter-year fixed effects (λ_{rqy}) to flexibly control for trends in the sex ratio at birth.

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

Figure 7 (a) presents the results. I find the effect is statistically significant only in the 5th quarter after droughts when significantly fewer births are found (Figure 8 (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 7 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.

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.[27] Furthermore, I find that an approximately 3 percent increase in the sex imbalance observed in PCS 2004-2013 is attributable to the sex-selective abortions in the period before the next harvest after droughts.[28] While the effect of drought-induced 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)

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[27] 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 $130.4 (= 115.5 \times 1.129)$, 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, while $0.055 (= 2.687 - 2.632)$ boys were aborted in the affected districts in the 5th quarter after droughts.

[28] 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.

for each subsample. Since sex-selective abortion can be performed at a low cost after the availability of ultrasound scans has spread across rural areas, the effects on sex selection would be more conspicuous in the later periods. In Figure 7, Panels (b) and (c) show that the results are consistent with the prediction: the effects on the sex ratio of the full sample in Figure 7 (a) are mostly driven by the effects found in the later periods.

Second, given that the most plausible timing of the sex-selective abortion is 12-16 pregnancy weeks,[29] if mothers want to sex-select to have a boy, the weeks of prenatal sex determination by ultrasound should be more likely to fall within 12-16 weeks of pregnancy, which should be particularly true if a mother exposed to droughts gives birth to a boy in the 5th quarter because having a boy can compensate the forgone consumption in the pre-harvest season. In Figure 9a (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 9a (b), I do not find any difference in the weeks of sex determination for unaffected mothers. 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)).

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[29]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) Table 1 shows that a rural mother knew the sex of child at an average of 20 weeks of pregnancy conditional on the childbirth in the survey year.

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 10 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 statistically significant in the pre-harvest season ($p < 0.05$) but is not economically large. Furthermore, Figure A.13 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.3, I first find little evidence of detrimental effects on the consumed quantity of rice and pork, the two main food categories of rural households.

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.

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 7 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.12, I find no evidence of the effects of droughts on recent illness by estimating Equation (2) on an indicator for any illness or injuries among household members in the past 4 weeks using the VHLSS 2004-2008.[30]

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.[31] Table 8 reveals that droughts are not associated 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.

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

[31]Bharadwaj and Lakdawala (2013) argue that there can be other forms of prenatal discrimination, such as lower 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 is tested in this section.

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.2 shows the imprecisely estimated effects on abortion of urban women whose income is 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.6 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; they cannot grow autumn rice, which allows one extra income flow to mothers in the triple-cropping provinces. 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-run effects, i.e., delaying births, than to the long-term effects on a woman's completed fertility.[32] Figure 11 provides the results from estimating Equation (3) after adding the interaction terms between indicators for quarters and droughts up to six lags. After the first slump in the 5th quarter

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[32]In contrast, Currie and Schwandt (2014) find that the effect of unemployment on a young woman in the US can have long-run impacts on her lifetime fertility. However, its long-run effect is driven primarily by women who remain childless, which indicates unemployment has negative impacts on her marriage markets.

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 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 every 10th percentile of historical distribution and zero otherwise while making the 5th indicator the omitted category.[33] Panel (f) of Figure A.10 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.8 shows consistent results with Panel (f) of Figure A.10 using the historical rainfall realizations in the main analysis.

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

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

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.9 shows that rainfall levels below the 20th percentile have consistent and significant effects on abortion, giving confidence in using my definition of drought 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.7 presents that the drought defined using either the wet season rainfall in t (Panel A) or the calendar year rainfall in t (Panel B) do not have statistically significant effects on the rice yields and yearly household expenditure measures. Next, Figure A.10 shows that the coefficients resulting from repeating the estimation in Figure A.10 Panel (f) using all of the combinations of other season-year-rainfall distributions. I find the drought shocks defined by rainfall levels in the preceding dry season have the largest impacts on abortion (Figure A.10 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.8 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 4 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 mea-

surement 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 in lieu of 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.9, 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-run 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. While a full rebound in births in 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-run demographic conse-

quences, 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 child-bearing 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.

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Figures

Figure 1: Rate of Ultrasound Scan Use for Prenatal Sex Determination
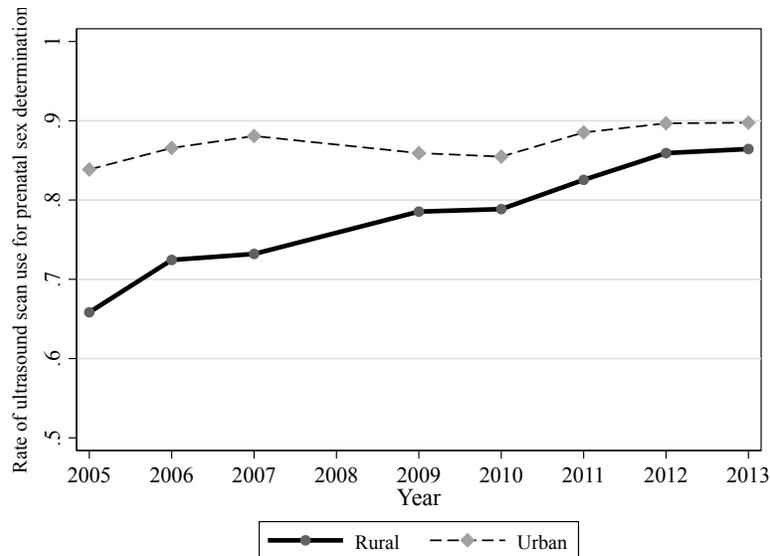
Data: PCS 2006, 2007, 2010-2013
Notes: This figure plots the rate of mothers who used ultrasound scans for prenatal sex determination given their childbirth in the survey year. The information about the ultrasound scan use is only available in the PCS 2006, 2007, and 2010-2013.

Figure 2: Sex Ratio at Birth in Vietnam
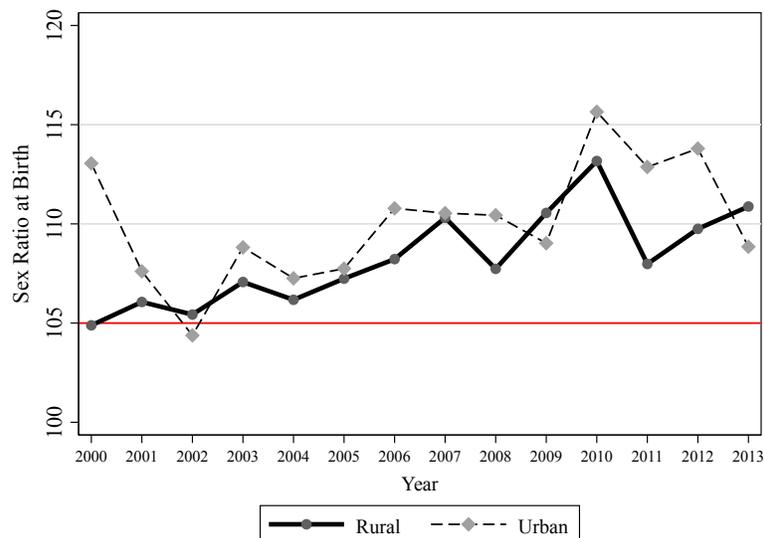
Data: PCS 2000-2008, 2010-2013, Census 2009
Notes: The figure plots the sex ratio at birth, i.e., the number of infant boys (≤ 1 year old) born to one hundred infant girls in each survey year in rural and urban areas, respectively. The red horizontal line denotes the biological normal sex ratio at birth, approximately 105 male newborns to 100 female newborns.

Figure 3: Rice Crop Calendar and Time Frame of Drought Shocks and Fertility Variables
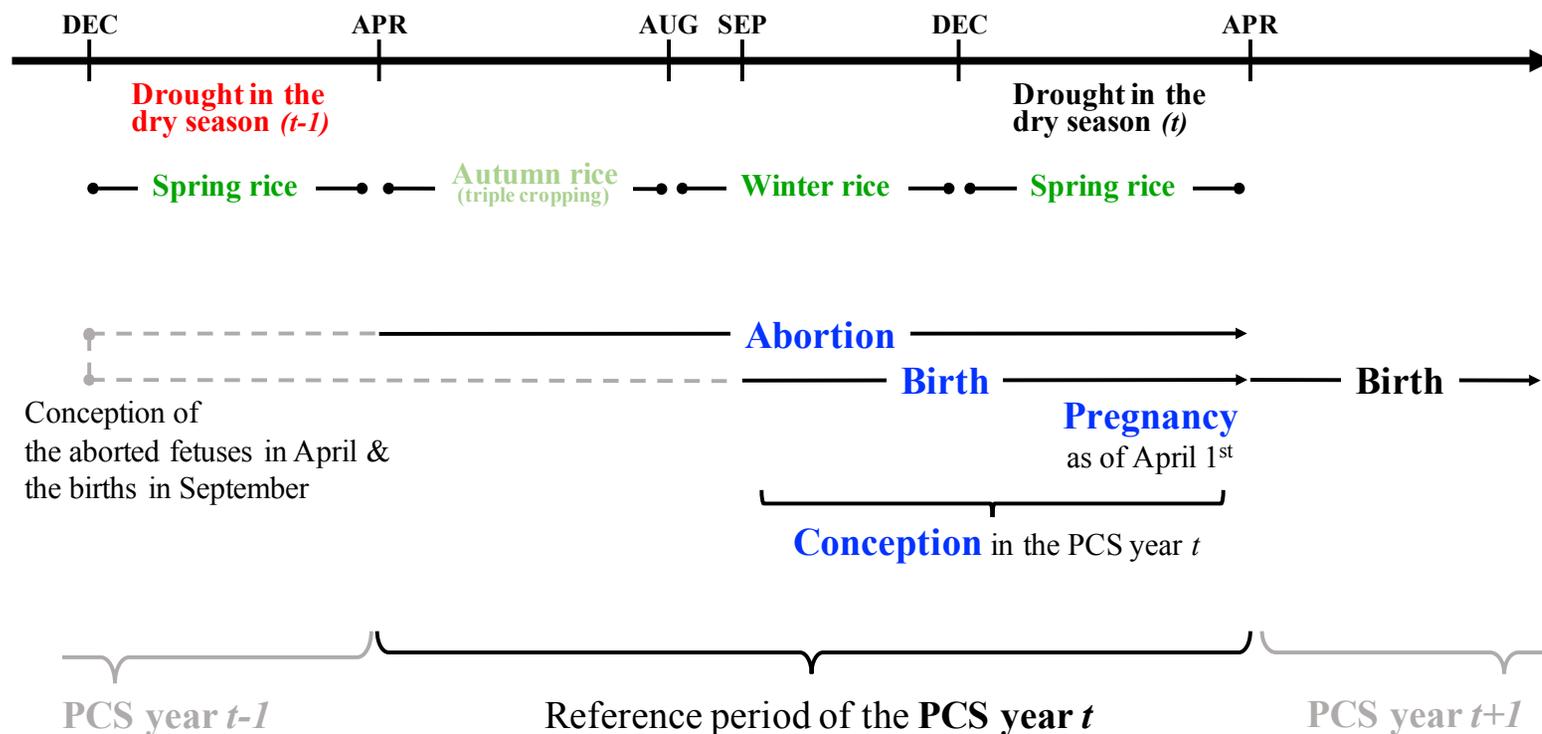
Notes: This plot describes the rice crop calendar across Vietnam from the FAO, and the timeframe of the drought shocks in the dry season (Dec-Apr) and fertility outcomes from the PCS. The reference period of the PCS is from April to March. Accordingly, the drought occurring right before the reference 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 asked 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 from 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 4: Rainfall Percentiles and Yearly Rice Yields, Expenditure

(a) Yield of Spring Rice

(b) Yields of All Rice Crops

(c) Total Expenditure

(d) Expenditure on Food

(e) Expenditure on Daily Non-food

(f) Ratio of Food Exp. to Tot. Exp.
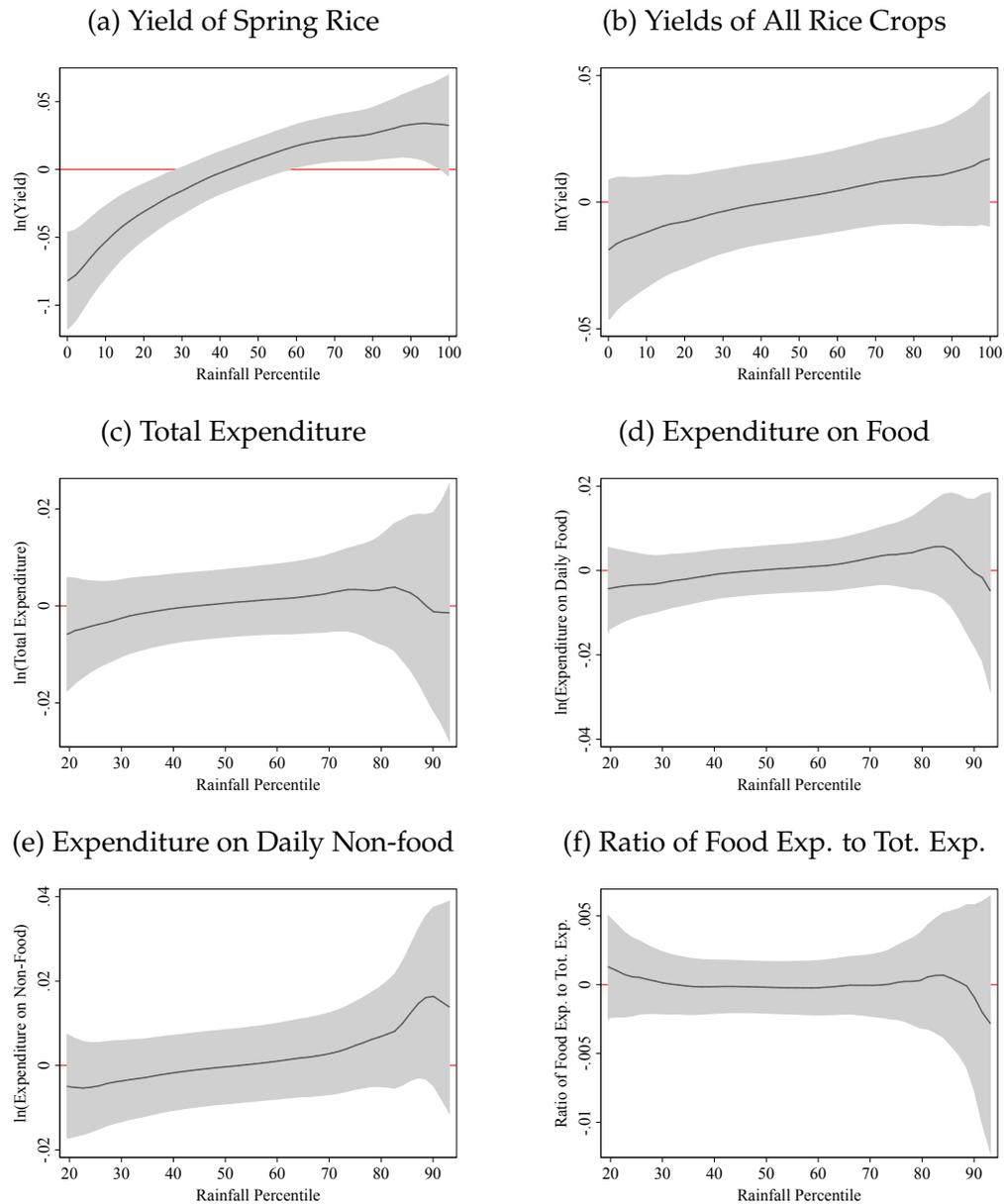
Data: Province-level rice yields in 1995-2014 from the GSO; Yearly household expenditure from the VHLSS 2004, 2006, 2008

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 5: Effects of Droughts on Monthly CPI, Expenditure and Birth
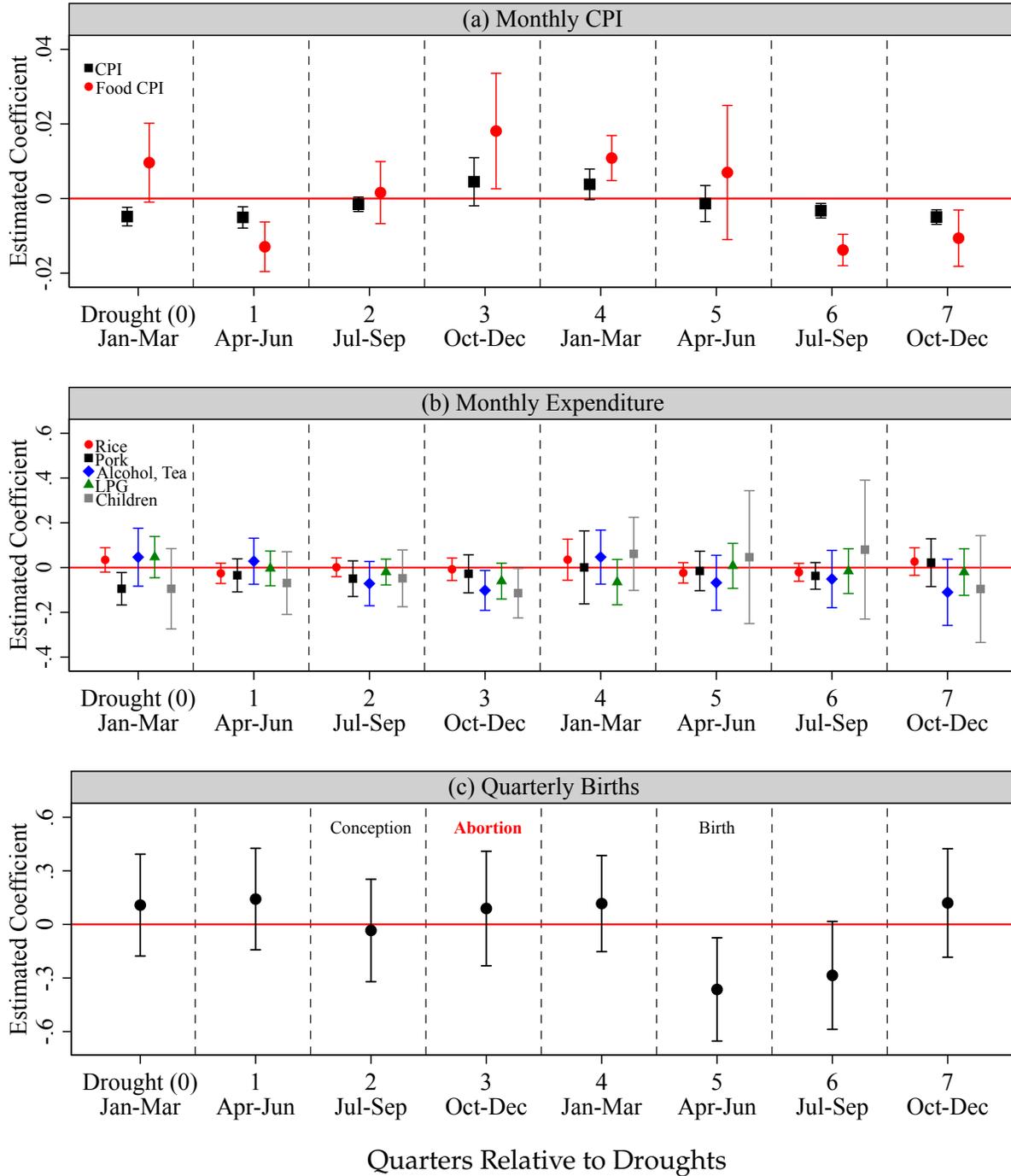
Data: Province-level monthly CPI from the GSO; Monthly expenditure from the VHLSS 2010, 2012, 2014; Births from the PCS 2004-2008, 2010-2013

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 6: Effect of Droughts on Births
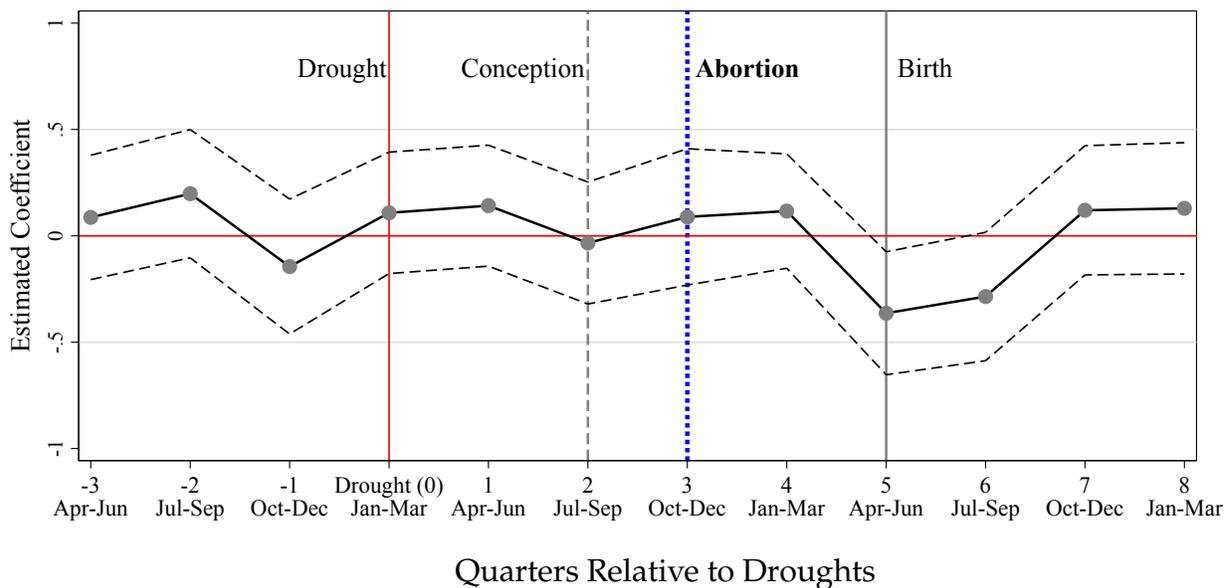
Quarters Relative to Droughts

Data: PCS 2004-2008, 2010-2013

Notes: This figure plots the coefficients on the indicators for *n* quarters away from the drought occurring at *n* = 0 in the regression estimating the effect on the district-quarter level number of births. The dashed black lines refer to the 95 percent confidence intervals. The gray solid line denotes the quarter when the effect on birth is statistically significant at the 5% level. Two vertical lines are additionally plotted for the birth cohort in the 5th quarter: the gray dashed line denotes the timing of conception, i.e., nine months before the birth in the 5th quarter, and the blue dotted line denotes the timing of abortion, i.e., about one quarter after the conception.

Figure 7: Effects of Droughts on the Sex Ratio at Birth

(a) Sex ratio at birth (Full sample)

(b) Sex ratio at birth (PCS 2004-2007)

(c) Sex ratio at birth (PCS 2008, 2010-2013)

Quarters Relative to Droughts
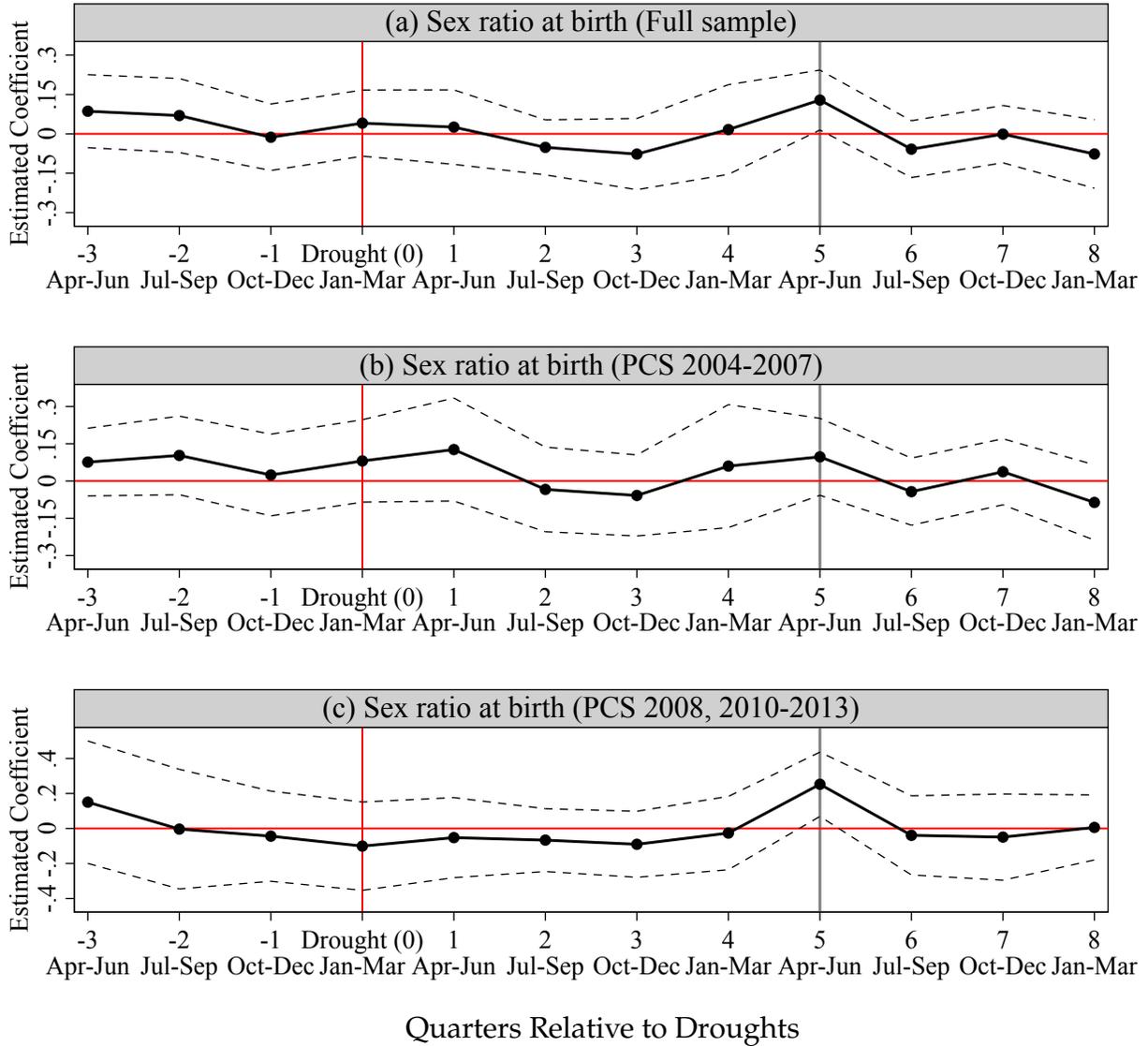
Data: PCS 2004-2008, 2010-2013

Notes: Panel (a) plots the coefficients on the indicators for *n* quarters away from the drought occurring at $n = 0$ in the regression estimating the effect on the log of province-quarter level sex ratio at birth using the full PCS sample. Panel (b) and (c) plot the coefficients from repeating the same regression of Panel (a) using the first four and the latter five rounds of the PCS, respectively. 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 dashed black lines refer to the 95 percent confidence intervals. The gray vertical line denotes the quarter when droughts have significant effects on births as shown in Figure 6.

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Figure 8: Effects of Droughts on Conception, Abortion, Birth and the Sex Ratio at Birth

Quarters Relative to Droughts
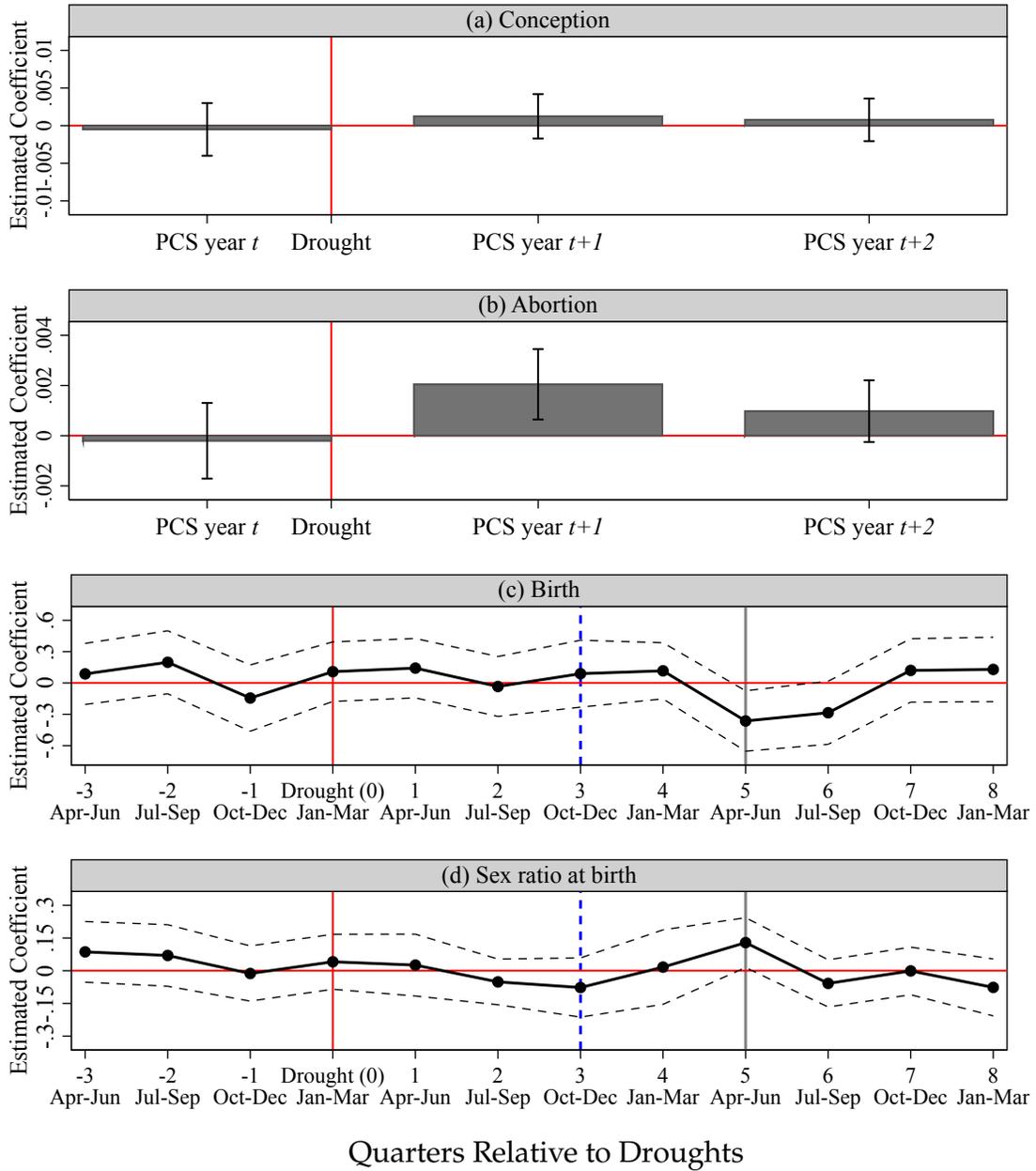
Data: PCS 2004-2008, 2010-2013

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 9: Distribution of the Pregnancy Weeks of Fetal Sex Determination

(a) By the sex of newborns born to affected mothers
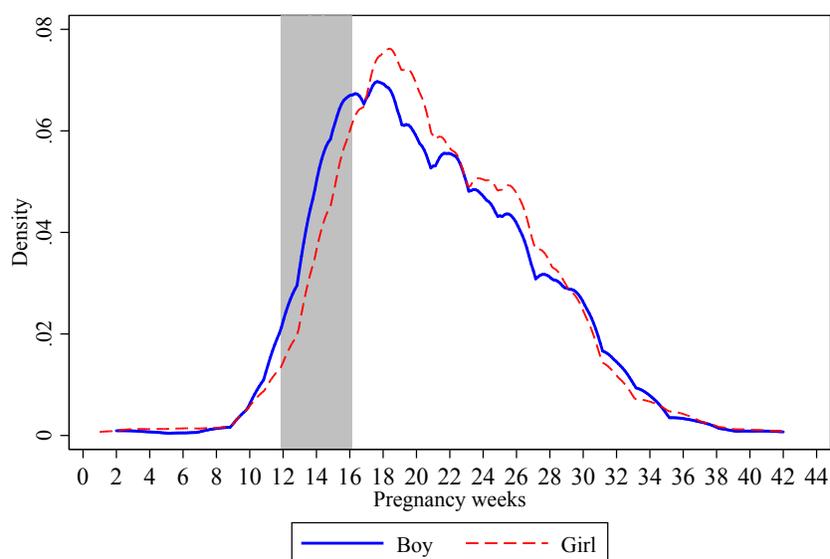
p-value of two-sample Kolmogorov–Smirnov test: .112

(b) By the sex of newborns born to unaffected mothers
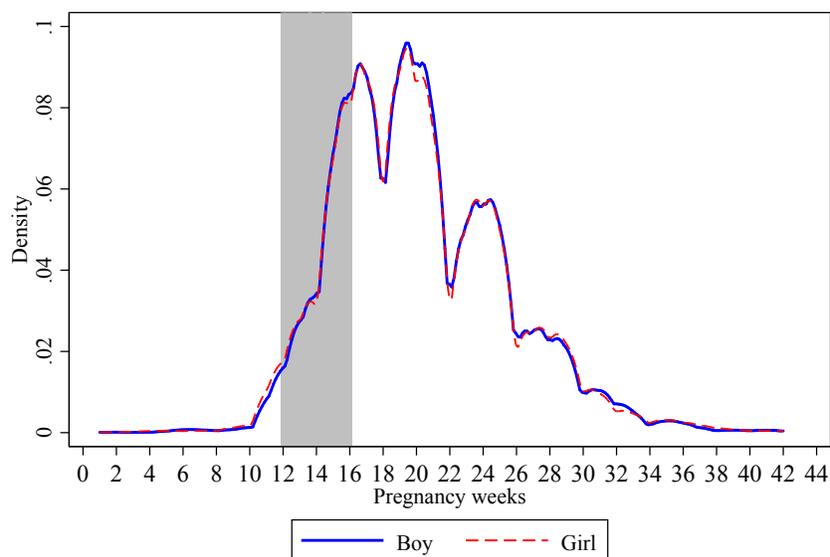
p-value of two-sample Kolmogorov–Smirnov test: .999

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, while 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 6.

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Figure 10: Effects of Droughts on Labor Market Participation
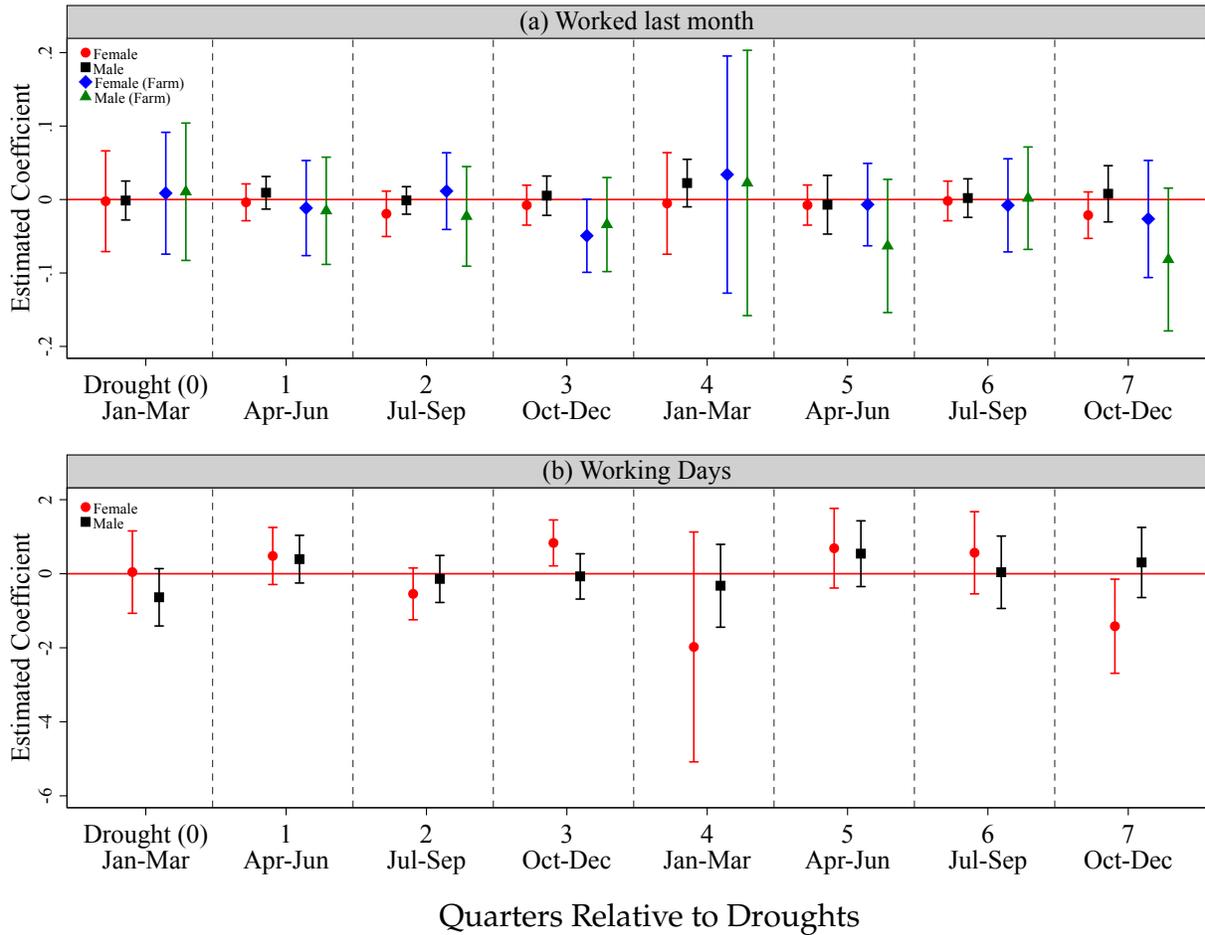
Data: VHLSS 2010, 2012, 2014

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 whether a married woman/man worked last month (Panel (a)) and the working days conditional on her/his labor market participation last month (Panel (b)). Colored bars represent the 95% confidence intervals of the estimated coefficients. Each regression includes quarter FEs, province FEs, region×year FEs, the logs of other season-year rainfalls and household-level controls such as 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 are clustered for the province level.

Figure 11: Effect of Droughts on Births in the Medium Term
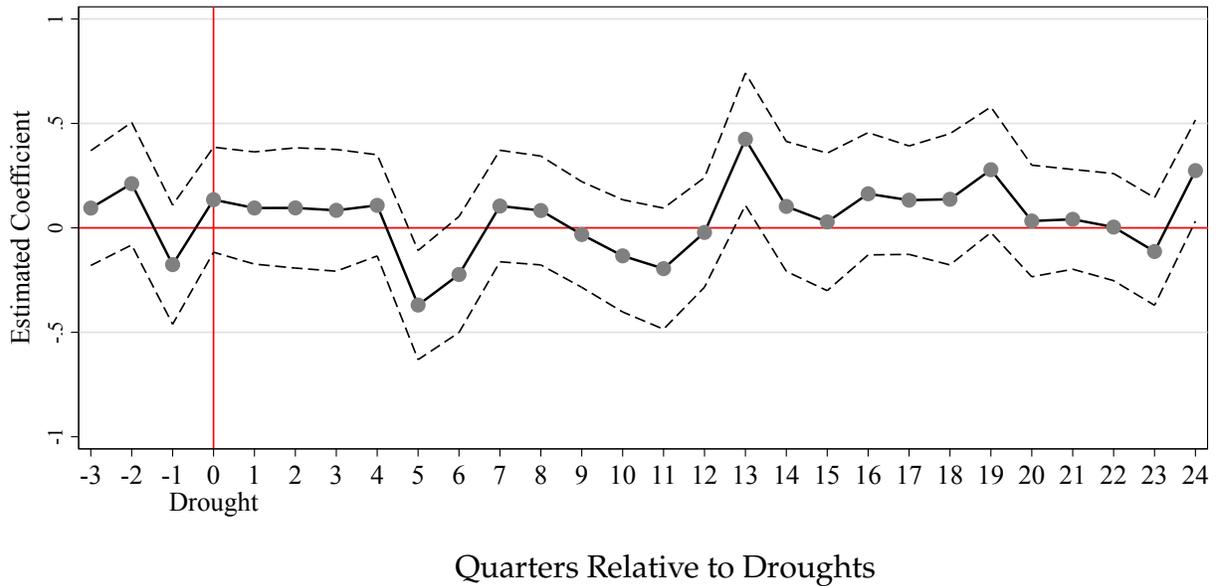
Quarters Relative to Droughts

Data: PCS 2004-2008, 2010-2013

Notes: This figure plots the coefficients on the interaction terms between quarters and droughts from t to $t-6$ from the regression estimating the effect on the number of quarter-district-level births. Each point estimate refers to the effect on births in n quarters away from the drought occurring at $n = 0$. The dashed lines refer to the 95 percent confidence intervals. The regression includes the same controls in Equation (3), district FEs, province×quarter FEs, quarter×year FEs, and district-level linear time trends. Robust standard errors are clustered for the district level.

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 between the 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.6) 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 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. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent 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 occurred 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, diaphragm, foam or sterilization. Robust standard errors are shown in parentheses clustered at the district level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 4: Test for Balance in Characteristics of Affected and Unaffected Mothers

Dependent Vars.	Full Sample		By Parity							
			1st		2nd		3rd		4th	
	Mean/(SD) (1)	Diff. (2)	Mean/(SD) (3)	Diff. (4)	Mean/(SD) (5)	Diff. (6)	Mean/(SD) (7)	Diff. (8)	Mean/(SD) (9)	Diff. (10)
Panel A. Mother's characteristics										
Age (Year)	26.181	-0.104	22.689	-0.335	26.722	-0.611	31.716	0.268	34.347	0.428
	(5.632)		(3.803)		(4.249)		(4.914)		(5.110)	
Being the household head	0.039	-0.008	0.018	-0.009	0.056	-0.009**	0.052	-0.008	0.055	0.003
	(0.193)		(0.133)		(0.229)		(0.222)		(0.228)	
Educ. Attain.: Primary or none	0.284	-0.199	0.210	-0.197	0.303	-0.201	0.376	-0.217	0.487	-0.211
	(0.451)		(0.408)		(0.460)		(0.484)		(0.500)	
Educ. Attain.: Lower secondary	0.493	0.166	0.480	0.143	0.506	0.182	0.513	0.184	0.455	0.195
	(0.500)		(0.500)		(0.500)		(0.500)		(0.498)	
Educ. Attain.: Higher secondary or above	0.223	0.033	0.310	0.053	0.191	0.019	0.111	0.032	0.058	0.016
	(0.416)		(0.463)		(0.393)		(0.314)		(0.233)	
Age at the first birth (Year)	22.035	-0.289	-	-	22.243	-0.365	21.719	-0.147	21.626	0.116
	(3.190)		-		(3.320)		(2.932)		(2.955)	
Number of children ever born	0.887	0.016	-	-	-	-	-	-	-	-
	(0.902)		-		-		-		-	
Having the first child	0.434	-0.012	-	-	-	-	-	-	-	-
	(0.496)		-		-		-		-	
Have at least one son	0.576	0.006	-	-	0.530	0.016	0.649	-0.013	0.657	-0.081
	(0.494)		-		(0.499)		(0.477)		(0.475)	
Panel B. Spouse's characteristics										
Age (Year)	31.843	0.196	27.589	0.020	30.537	-0.456	35.013	0.420	37.186	0.656
	(6.018)		(5.761)		(4.859)		(5.342)		(5.188)	
Educ. Attain.: Primary or none	0.311	-0.154	0.237	-0.151	0.296	-0.155	0.348	-0.166	0.432	-0.193
	(0.463)		(0.426)		(0.457)		(0.477)		(0.496)	
Educ. Attain.: Lower secondary	0.493	0.150	0.470	0.126	0.491	0.152	0.515	0.151	0.484	0.178
	(0.500)		(0.499)		(0.500)		(0.500)		(0.500)	
Educ. Attain.: Higher secondary or above	0.196	0.004	0.292	0.025	0.213	0.002**	0.137	0.016	0.084	0.015
	(0.397)		(0.455)		(0.410)		(0.344)		(0.278)	
Observations	14,373	94,995	6,241	42,239	5,024	34,227	2,396	14,298	712	4,231

Data: PCS 2004-2008, 2010-2013
Notes: This table is to test for balance between affected and unaffected mothers who had abortion, gave birth or were pregnant at the time of the survey. The statistics of affected mothers are presented in columns (1), (3), (5), (7) and (9). The number of observation in every first column for the full sample and for each parity refers to the number of affected mothers, while the number of unaffected mothers is presented in every second column. After regressing each dependent variable on the indicator of drought, the statistical significance of the coefficient is marked on the difference in the means between the two samples of mothers. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 5: Effect of Droughts on Abortion

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Abortion=1							
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 characteristics control consists of her age at the first birth and the birth spacing referred to as the months between the most recent childbirth and the starting month of the survey period. Spouse characteristics include her spouse age, age squared and his educational attainment. The mean of dependent variable is the mean abortion rate of mothers living in the districts that were not inflicted with droughts. Robust standard errors are shown in parentheses clustered at the district level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 6: Effects of Droughts on Childbirth

	Dependent variable: Giving Birth=1			
	Birth in Apr-Jun (1)	Birth in Jul-Sep (2)	Birth in Oct-Dec (3)	Birth in Jan-Mar (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 show 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. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 7: Effects of Droughts on a Child's Sex

	Dependent variable: Newborn is a boy=1			
	Born in Apr-Jun (1)	Born in Jul-Sep (2)	Born in Oct-Dec (3)	Born in Jan-Mar (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. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 8: Effects of Droughts on Infant Mortality

	Dependent variable					
	Newborn is dead=1					ln(IMR)
	Born in Apr-Mar	Born in Apr-Jun	Born in Jul-Sep	Born in Oct-Nov	Born in Dec-Mar	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Drought in the dry season (t)						
Drought	-0.0010	0.0032	0.0005	-0.0047	-0.0026	-0.0057
	(0.0014)	(0.0030)	(0.0029)	(0.0032)	(0.0029)	(0.0144)
Observations	85,691	20,683	22,791	23,212	19,005	477
R-squared	0.008	0.014	0.013	0.014	0.017	0.789
Mean of Dep. Var.	0.0081	0.0083	0.0081	0.0084	0.0077	2.7273
Panel B. Drought in the dry season (t − 1)						
Drought	-0.0001	-0.0043	0.0018	0.0044	-0.0047*	-0.0045
	(0.0014)	(0.0026)	(0.0029)	(0.0028)	(0.0024)	(0.0201)
Observations	85,691	20,683	22,791	23,212	19,005	477
R-squared	0.008	0.014	0.013	0.014	0.017	0.789
Mean of Dep. Var.	0.0082	0.0082	0.0090	0.0079	0.0081	2.7245
Panel C. Drought in the dry season (t − 2)						
Drought	-0.0006	-0.0024	-0.0025	0.0002	0.0026	-0.0066
	(0.0013)	(0.0023)	(0.0026)	(0.0032)	(0.0023)	(0.0161)
Observations	85,691	20,683	22,791	23,212	19,005	477
R-squared	0.008	0.014	0.013	0.014	0.017	0.788
Mean of Dep. Var.	0.0082	0.0082	0.0084	0.0082	0.0086	2.7309
Controls						
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Region×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes
Mother characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Province-specific linear time trend	Yes	Yes	Yes	Yes	Yes	Yes
Birth parity FE	Yes	Yes	Yes	Yes	Yes	Yes
Gender composition FE	Yes	Yes	Yes	Yes	Yes	Yes

Data: PCS 2004-2008, 2010-2013; Province-level IMR from the GSO
Notes: This table presents the results from regressions estimating the effect of droughts on infant mortality. Columns (1)-(5) report the effect on the likelihood that a newborn is dead in the survey year (column (1)) and in a given quarter in the survey year (columns (2)-(5)) from the PCS. Column (6) presents the effect on the log of province-level infant mortality rates from the GSO. Robust standard errors are shown in parentheses clustered at the province level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Appendix. Figures

Figure A.1: Sex Ratio at Birth by Birth Parity
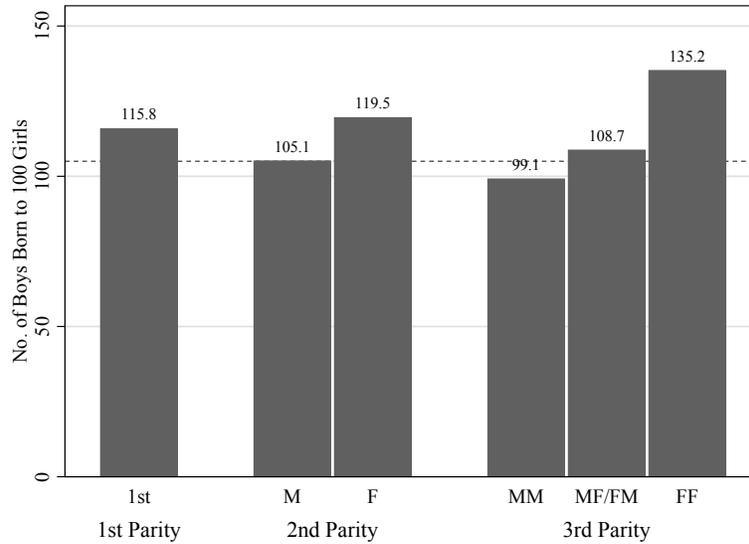
Data: Census 2009
Notes: This figure describes the sex ratio at birth by birth parity depending on the sex of previous births. 'M' of the 2nd parity means the firstborn is son, and 'F' means a daughter. Likewise, for the third parity, 'MM' means the first two births are boys, whereas 'FF' means there is no son in the previous two births.

Figure A.2: Contraceptive Use
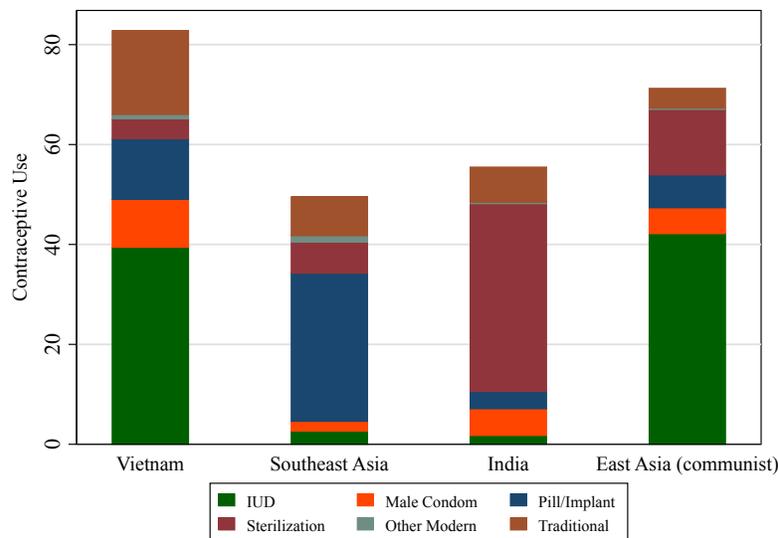
Data: The World Contraceptive Use 2016, the United Nations
Notes: This figure describes average contraceptive use by methods across region and country in 2004-2013. Communist East Asian countries include China, North Korea and Mongolia. Southeast Asia statistics exclude Vietnam.

Figure A.3: Infant Mortality Rate

(a) Infant Mortality Rate by Country
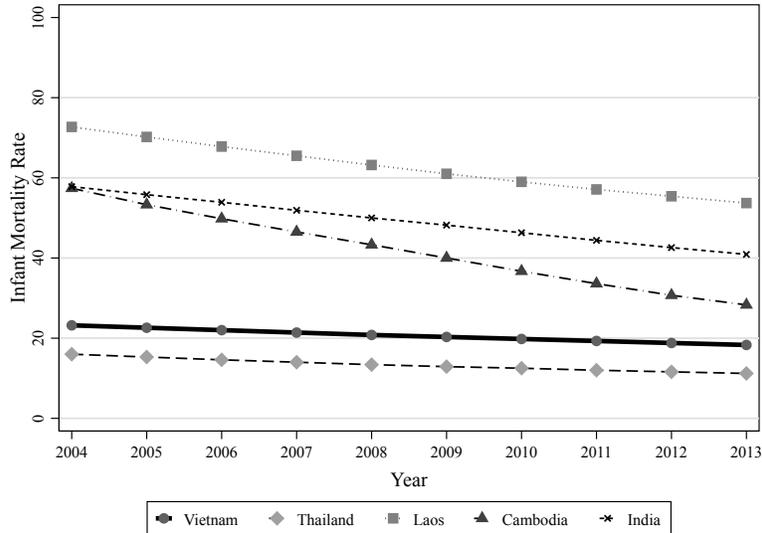
Notes: This figure describes the infant mortality rates of Vietnam and neighboring countries in Southeast Asia using the official statistics from the World Bank.

(b) Infant Mortality Rate by Sex
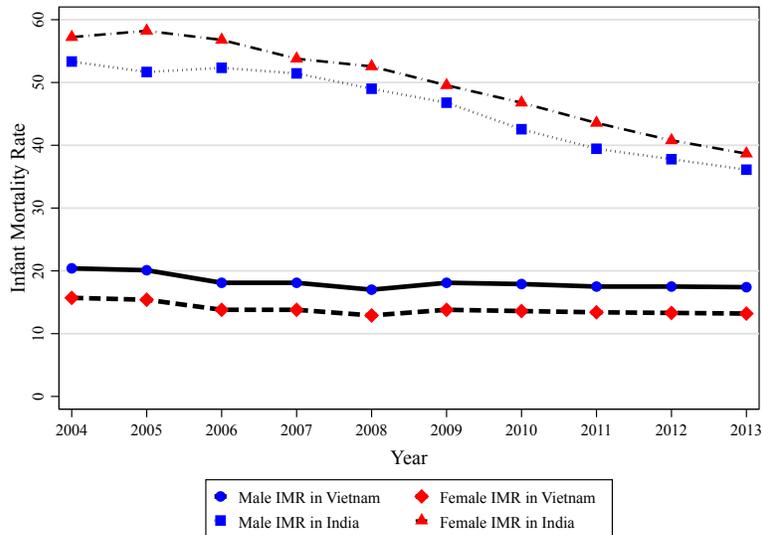
Notes: This figure describes infant mortality rates by sex using the official statistics from the Vietnam GSO. For the IMR in India, I choose nine states in northwestern India showing strong son preference (Anukriti (2017)). They consist of Rajasthan, Himachal Pradesh, Delhi, Gujarat, Uttar Pradesh, Madhya Pradesh, Maharashtra and Haryana.

Figure A.4: Monthly Precipitation by Region
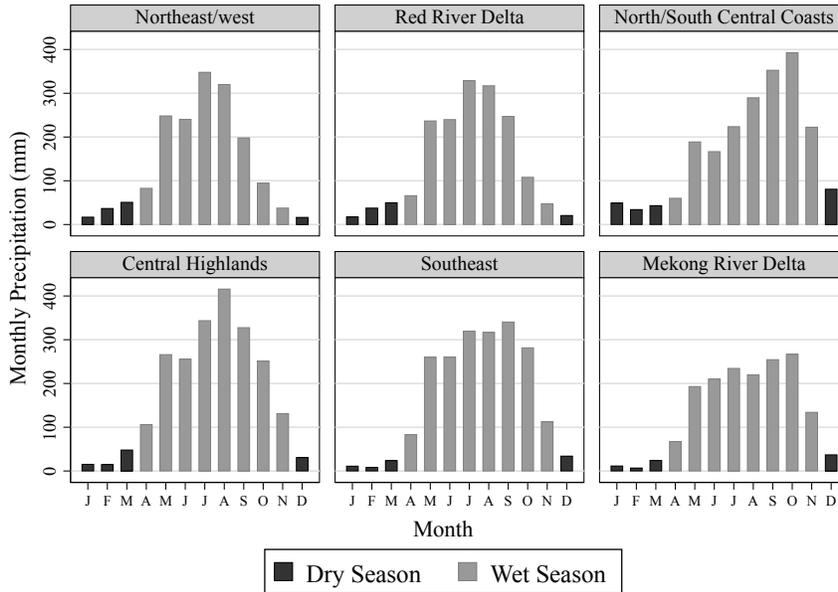
Notes: The figure describes the monthly precipitation averaged over the years in 1984-2013 by region. The dry season is from December to March.

Figure A.5: Rainfall Deviation to 30-Year Median by Region
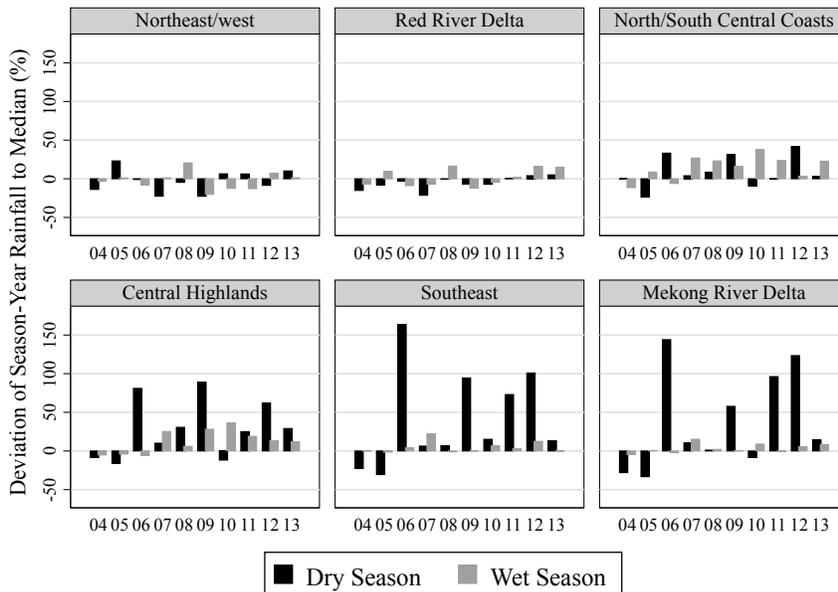
Notes: This figure provides the rainfall deviation (in percentage) relative to the long-run average season-year rainfall for each region.

Figure A.6: Distribution of Droughts across Districts in Vietnam
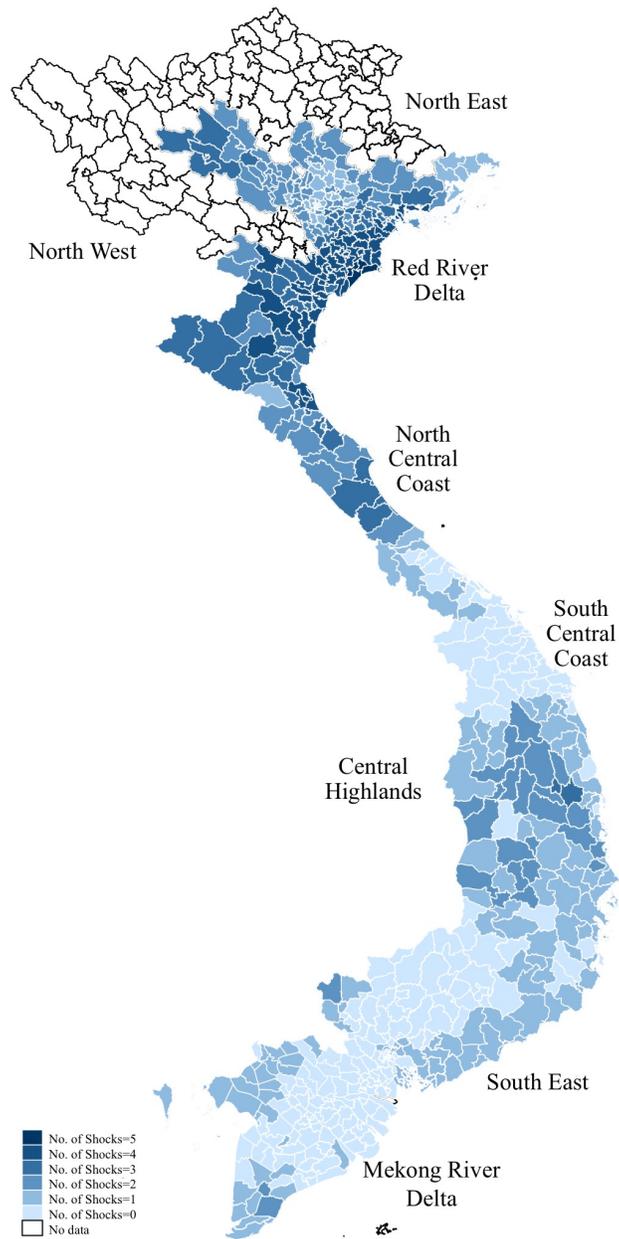
Notes: This map describes the number of droughts experienced by each district in the sample period from 2004-2013. Droughts are defined as seasonal rainfall occurring below the 20th percentile of the district-specific dry season rainfall distribution in 1984-2013 from Climate Hazards Group InfraRed Precipitation with Station version 2.0. The districts with 'No data' are excluded in the analysis because more than 50 percent of the heads of household are not ethnically Kinh in the 10 provinces. The 10 provinces are Cao Bang, Bac Kan, Ha Giang, Lang Son, Lai Chau, Son La, Dien Bien, Hoa Binh, Lao Cai, and Tuyen Quang.

Figure A.7: Distribution of the Weeks of Sex Determination by the Sex of Newborn and by the Birth Order
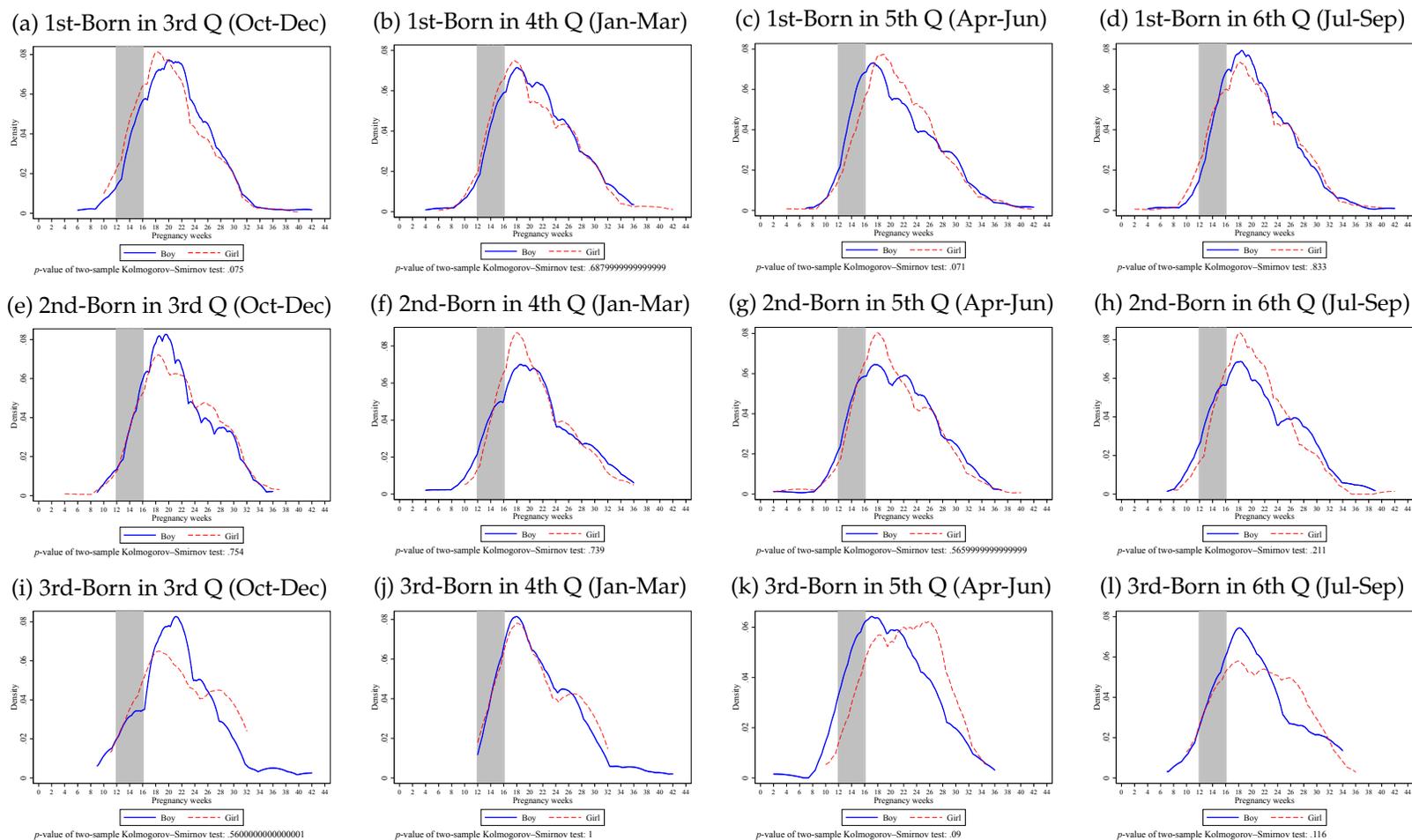
(a) 1st-Born in 3rd Q (Oct-Dec)   (b) 1st-Born in 4th Q (Jan-Mar)   (c) 1st-Born in 5th Q (Apr-Jun)   (d) 1st-Born in 6th Q (Jul-Sep)

(e) 2nd-Born in 3rd Q (Oct-Dec)   (f) 2nd-Born in 4th Q (Jan-Mar)   (g) 2nd-Born in 5th Q (Apr-Jun)   (h) 2nd-Born in 6th Q (Jul-Sep)

(i) 3rd-Born in 3rd Q (Oct-Dec)   (j) 3rd-Born in 4th Q (Jan-Mar)   (k) 3rd-Born in 5th Q (Apr-Jun)   (l) 3rd-Born in 6th Q (Jul-Sep)

Data: PCS 2004-2008, 2010-2013

Notes: Figures plot the kernel density estimation on the distributions of the weeks of fetal sex determination of affected mothers using ultrasound, conditional on the childbirth of each parity from the 3rd (Panel (a), (e), (i)) to the 6th quarter (Panel (d), (h), (l)) after droughts. It is from the 3rd to the 6th quarter after droughts when the aborted fetuses in the PCS (*t*) would have been born otherwise. 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). It is the 5th quarter after droughts (April-June) when the effect of droughts on birth is significant as shown in Figure 6.

Figure A.8: Effects of Rainfall Decile on Abortion

Mean at the 5th Decile: .0088
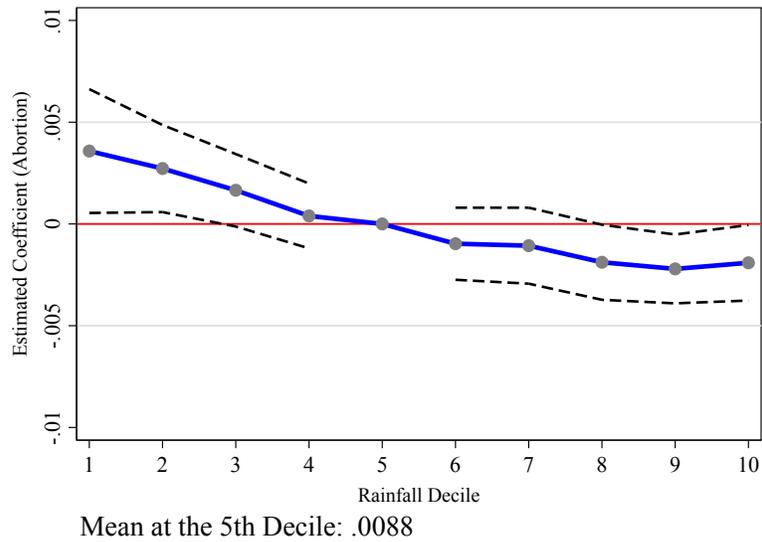
Data: PCS 2004-2008, 2010-2013
Notes: The figure plots coefficients and 95% confidence intervals from a regression of abortion on the dummies for each 10th percentile (decile) of the gamma distribution fitted by the district-specific dry season rainfalls in 1984-2013. The omitted category is the 5th decile.

Figure A.9: Marginal Effects of Rainfall Percentiles on Abortion
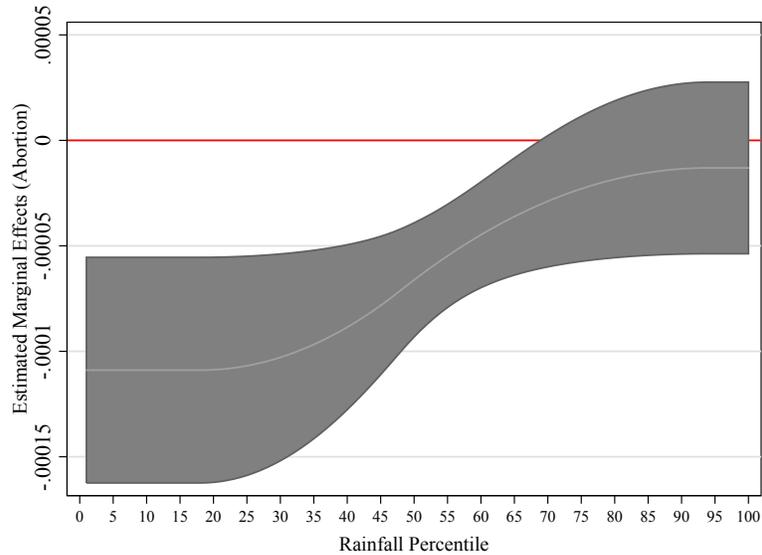
Data: PCS 2004-2008, 2010-2013
Notes: The figure plots marginal effects of rainfall percentile on the indicator for abortion along with its 95% confidence intervals. The marginal effects are estimated using a restricted cubic spline with the knots at 18, 48 and 98 which are chosen by Harrell's procedure.

Figure A.10: Effects of Other Season-Year Rainfalls on Abortion
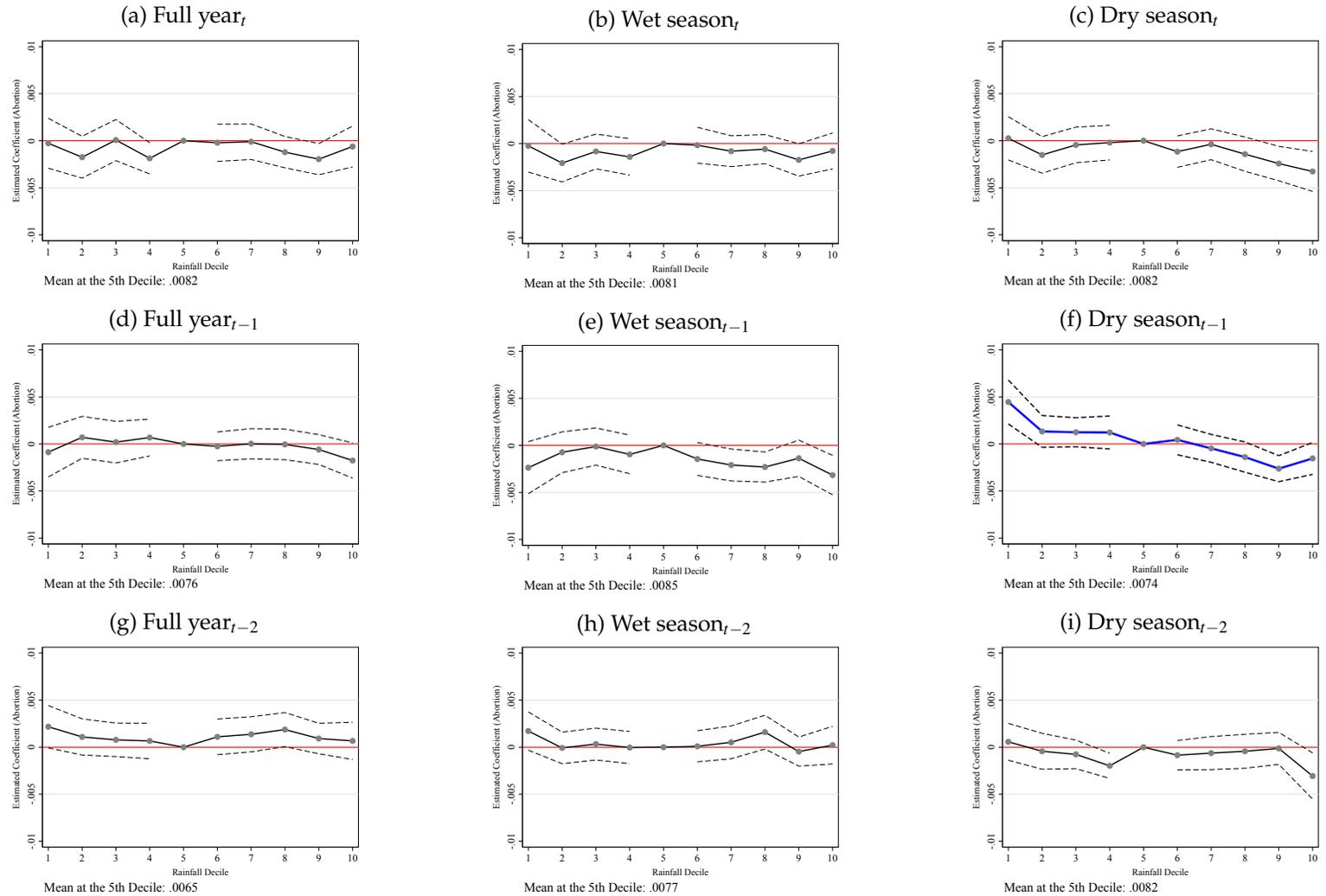
Data: PCS 2004-2008, 2010-2013

Notes: Figures plot coefficients and 95% confidence intervals from regressions of abortion on the dummies for each 10th percentile (decile) of the district-specific rainfalls of the full year (Dec-Nov), dry season (Dec-Mar) and wet season (Apr-Nov) in 1984-2013. The omitted category is the 5th decile. Panel (f) plots the coefficients on each dummy (connected with blue solid lines) that is constructed using the dry season rainfall in $t-1$, the drought shocks used in the main analyses.

Figure A.11: Effects of droughts on monthly expenditure by rice-cropping patterns
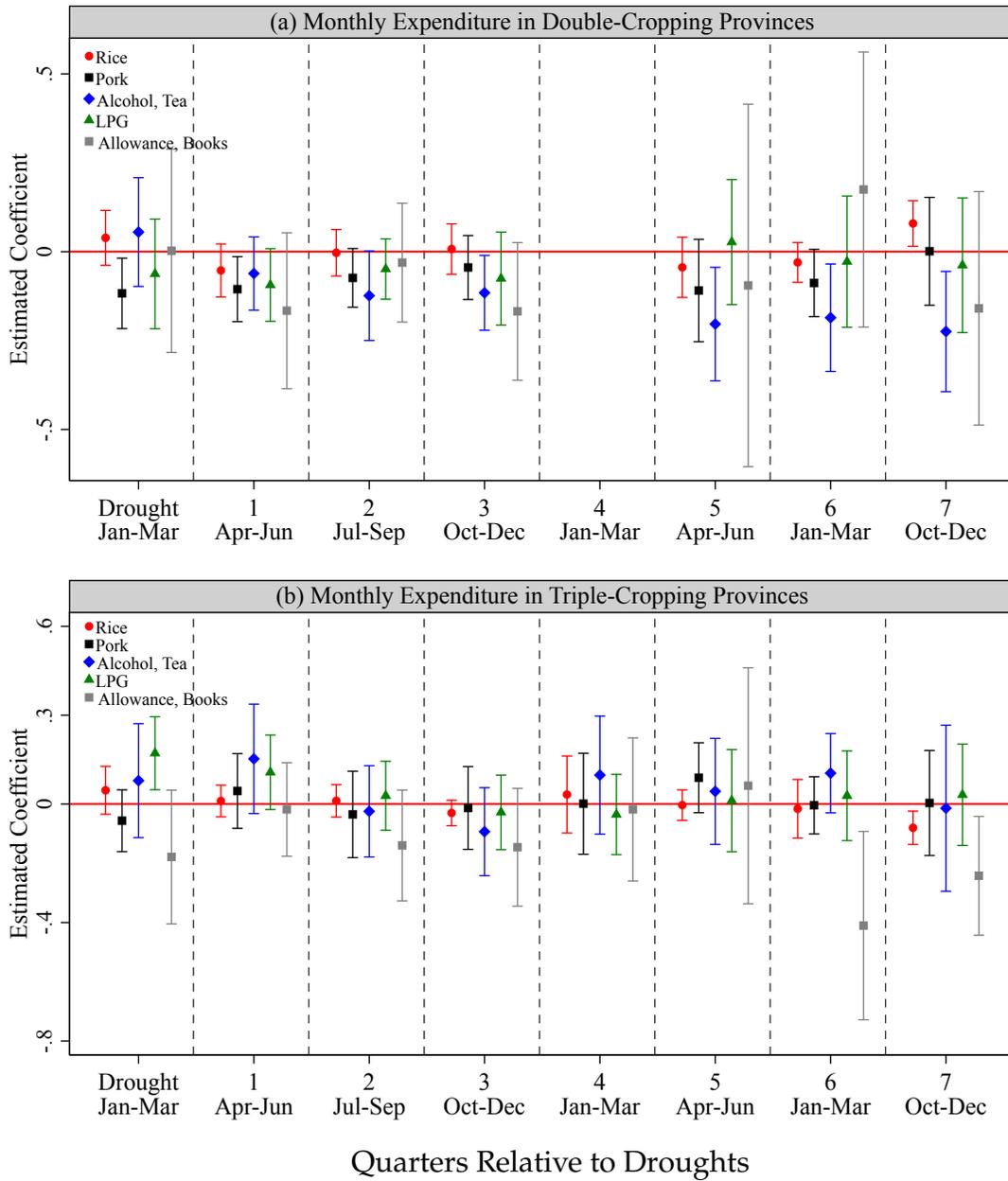
(a) Monthly Expenditure in Double-Cropping Provinces

(b) Monthly Expenditure in Triple-Cropping Provinces

Quarters Relative to Droughts

Data: VHLSS 2010,2012,2014

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 log of monthly household expenditures in the double-cropping provinces (Panel (a)) and in the triple-cropping provinces (Panel (b)). Colored bars represent the 95% confidence intervals of the estimated coefficients. There are no point estimates in the 4th quarter after droughts in Panel (a) due to no observations of households surveyed in that quarter in the double-cropping provinces.

Figure A.12: Effect of Droughts on Recent Illness

Quarters Relative to Droughts
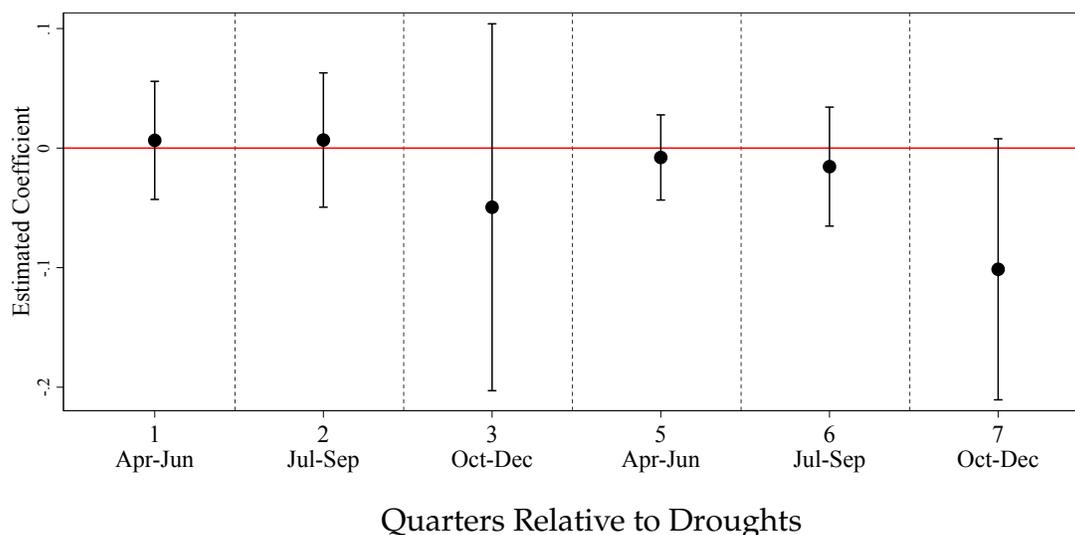
Data: VHLSS 2004, 2006, 2008

Notes: This figure plots the coefficients on the interaction terms between quarters and droughts in t and $t-1$ from the regression estimating the effect on recent illness of any rural household member. The indicator for the recent illness becomes one if any household members suffered from any illness or injuries for the past 4 weeks from the date of the survey. The regression includes quarter FEs, province FEs, region×year FEs, the logs of other season-year rainfalls and household-level controls such as 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 are clustered for the province level. There are no point estimates in the quarter with droughts, and the 4th quarter after droughts due to no observations of households surveyed in that quarters.

Figure A.13: Effect of Droughts on Recent Migration

Quarters Relative to Droughts
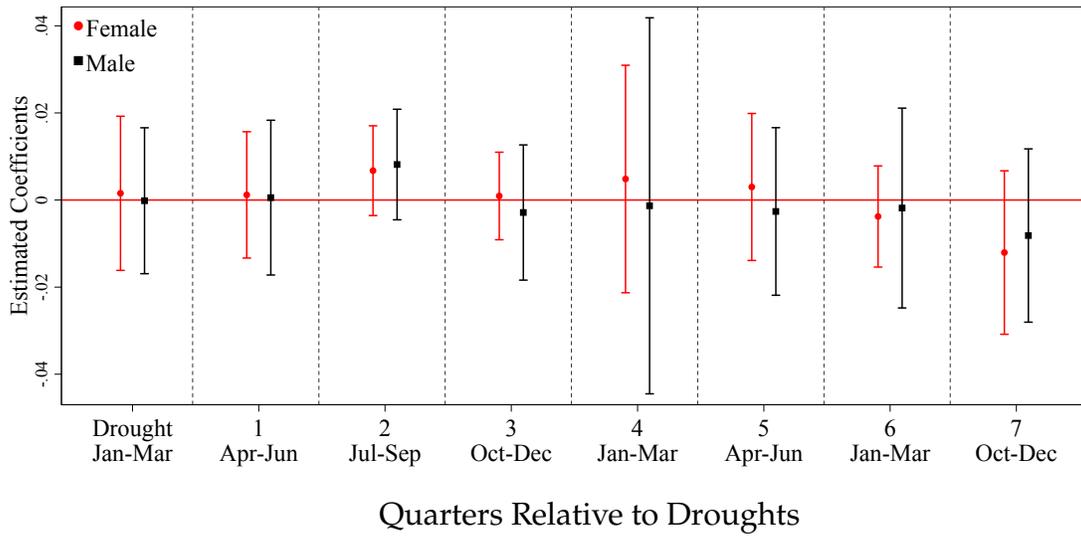
Data: VHLSS 2010, 2012, 2014

Notes: This figure plots the coefficients on the interaction terms between quarters and droughts in *t* and *t* − 1 from the regression estimating the effect on recent migration of a rural household. The indicator for the recent migration becomes one if a married woman or man had been away from home for less than 6 months at the time of the survey. Black bars represent the 95% confidence intervals of the estimated coefficients. The regression includes quarter FEs, province FEs, region×year FEs, the logs of other season-year rainfalls and household-level controls such as 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 are clustered for the province level.

Appendix. Tables

Table B.1: Effect of Droughts on Abortion using Distributed Lagged Model

	Dependent variable: Abortion=1						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Low rainfall in the dry season (t)	0.0008	0.0008	0.0006	0.0006	0.0006	0.0006	0.0006
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0012)
Low rainfall in the dry season ($t-1$)	0.0022***	0.0023***	0.0021***	0.0021***	0.0021***	0.0021***	0.0030**
	(0.0007)	(0.0007)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0012)
Low rainfall in the dry season ($t-2$)	0.0013**	0.0013**	0.0013*	0.0013*	0.0013*	0.0013*	0.0016
	(0.0006)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0011)
Low rainfall in the wet season (t)	-0.0006	-0.0006	-0.0008	-0.0008	-0.0008	-0.0007	0.0007
	(0.0007)	(0.0007)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0013)
Low rainfall in the wet season ($t-1$)	-0.0007	-0.0006	-0.0009	-0.0009	-0.0009	-0.0009	-0.0007
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0014)
Low rainfall in the wet season ($t-2$)	-0.0004	-0.0004	-0.0002	-0.0002	-0.0002	-0.0002	-0.0000
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0011)
Observations	811,092	810,144	810,144	810,144	810,144	802,589	441,789
R-squared	0.008	0.009	0.012	0.012	0.012	0.012	0.013
Mean of Dep. Var.				0.0066			
Controls							
District and year FE	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: Low rainfall shocks refer to the realization of rainfall in the wet season (April-November) or in the dry season (December-March) below the 20th percentile of historical distribution of district-specific seasonal rainfall in 1984-2013. The dependent variable is the indicator for the experience of abortion during the survey year. Fertility characteristics control consists of her age at the first birth and the birth spacing referred to as the months between the most recent childbirth and the starting month of the survey period. Spouse characteristics include her spouse age, age squared and his educational attainment. The mean of dependent variable is the mean abortion rate of mothers living in the districts that were not inflicted with droughts. Robust standard errors are shown in parentheses clustered at the district level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.2: Effect of Droughts on Abortion of Women in Urban and 10 Northern Provinces

	Dependent variable: Abortion=1							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Urban Sample								
Drought	0.0016*	0.0014	0.0014	0.0013	0.0013	0.0013	0.0012	0.0008
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0010)
Observations	840,836	840,836	839,551	839,551	839,551	839,551	834,191	490,732
R-squared	0.008	0.008	0.009	0.012	0.012	0.012	0.013	0.014
Mean of Dep. Var.	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069
Panel B. 10 Northern Provinces								
Drought	-0.0008	-0.0012	-0.0012	-0.0009	-0.0009	-0.0009	-0.0009	0.0007
	(0.0017)	(0.0018)	(0.0018)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0021)
Observations	169,410	169,410	169,196	169,196	169,196	169,196	167,805	93,159
R-squared	0.014	0.015	0.016	0.020	0.021	0.021	0.021	0.019
Mean of Dep. Var.	0.0129	0.0129	0.0129	0.0129	0.0129	0.0129	0.0129	0.0129
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: This table reports the results of regressions for the urban and the 10 northern-province samples. In the 10 provinces, more than 50 percent of the heads of household are not ethnically Kinh. The 10 provinces are Cao Bang, Bac Kan, Ha Giang, Lang Son, Lai Chau, Son La, Dien Bien, Hoa Binh, Lao Cai, Tuyen Quang, and the locations are mapped in Figure A.6. The dependent variable is the indicator for the experience of abortion in the survey year. Fertility characteristics control consists of her age at the first birth and the birth spacing referred to as the months between the most recent childbirth and the starting month of the survey period. Spouse characteristics include her spouse age, age squared and his educational attainment. The mean of dependent variable is the mean abortion rate of mothers living in the districts that were not inflicted with droughts. Robust standard errors are shown in parentheses clustered at the district level. *** Significant at the 1 percent level.

Table B.3: Effect of Droughts on Monthly Household Expenditure

	ln(Exp. in '000VND)			**1**(Expenditure>0)				ln(Quantity in Kg)	
	Total	Excl. gift	Excl. gift & self	Rice	Pork	Gas	Child	Rice	Pork
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Q1 (Jan-Mar)×Drought(t)	-0.017	-0.017	-0.035	0.000	-0.006	-0.047	0.019	0.074***	-0.062*
	(0.029)	(0.030)	(0.036)	(0.005)	(0.011)	(0.029)	(0.018)	(0.026)	(0.037)
Q2 (Apr-Jun)×Drought(t)	0.021	0.023	0.022	0.005	0.009	-0.006	0.017	-0.001	-0.017
	(0.020)	(0.020)	(0.024)	(0.004)	(0.008)	(0.021)	(0.017)	(0.017)	(0.036)
Q3 (Jul-Sep)× Drought(t)	0.031	0.033	0.028	0.006	0.017	-0.028	-0.013	0.013	-0.046
	(0.021)	(0.020)	(0.025)	(0.004)	(0.011)	(0.021)	(0.018)	(0.022)	(0.039)
Q4 (Oct-Dec)× Drought(t)	0.014	0.020	0.015	0.002	-0.014	-0.036*	0.021	0.029	-0.054
	(0.022)	(0.022)	(0.027)	(0.006)	(0.011)	(0.019)	(0.017)	(0.022)	(0.037)
Q1 (Jan-Mar)× Drought($t-1$)	0.017	0.020	0.071	0.002	0.002	-0.028	0.001	0.053	0.012
	(0.036)	(0.035)	(0.054)	(0.017)	(0.017)	(0.054)	(0.055)	(0.046)	(0.077)
Q2 (Apr-Jun)× Drought($t-1$)	-0.029	-0.028	-0.057	0.011*	0.003	-0.054*	-0.013	0.017	0.007
	(0.041)	(0.042)	(0.051)	(0.006)	(0.010)	(0.028)	(0.026)	(0.019)	(0.042)
Q3 (Jul-Sep)× Drought($t-1$)	-0.011	-0.008	-0.016	0.009	0.024**	-0.009	-0.028	-0.009	-0.007
	(0.033)	(0.033)	(0.044)	(0.008)	(0.011)	(0.030)	(0.025)	(0.021)	(0.027)
Q4 (Oct-Dec)× Drought($t-1$)	0.023	0.030	0.017	0.011	-0.000	-0.004	-0.064***	-0.003	-0.056
	(0.030)	(0.029)	(0.049)	(0.007)	(0.011)	(0.031)	(0.022)	(0.021)	(0.050)
Observations	17,448	17,433	17,432	17,448	17,448	17,448	17,448	17,297	16,665
R-squared	0.536	0.531	0.499	0.016	0.063	0.287	0.217	0.591	0.350
Mean of Dep. Var.	7.860	7.834	7.654	0.991	0.948	0.590	0.367	3.545	1.058
Controls									
Province and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region × Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ln(Total Expenditure)				Yes	Yes	Yes	Yes	Yes	Yes

Data: VHLSS 2010, 2012, 2014

Notes: This table presents the coefficients on the interaction terms between quarters and droughts in t and $t-1$ from the regressions estimating the effect on the log of total expenditure (column (1)-(3)), the indicator for the consumption of each good (columns (4)-(7)), and the log of consumed quantity (columns (8)-(9)). Column (2) excludes the consumption of gifts from total expenditure, and column (3) further excludes the consumption of self-generated goods. Robust standard errors are shown in parentheses clustered at the province level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.4: Effect of Droughts on Monthly Household Expenditure on Food Items

	Dependent vars. (ln(Expenditure in '000 VND))											
	FAFH	Rice	Pork	Veget., Fruit	Other Meat	Seafood	Dairy	Alcohol Tea	Other Starch	Tobacco	Staple	ETC
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Q1 (Jan-Mar)×Drought(t)	0.027	0.036	-0.091**	-0.056	0.014	-0.114**	-0.101*	0.047	0.087	0.100*	0.056	-0.065**
	(0.065)	(0.027)	(0.036)	(0.037)	(0.054)	(0.048)	(0.057)	(0.063)	(0.054)	(0.053)	(0.065)	(0.031)
Q2 (Apr-Jun)×Drought(t)	-0.054	-0.023	-0.039	0.056	0.011	0.002	0.073	0.048	0.061	-0.016	0.032	0.078**
	(0.060)	(0.022)	(0.036)	(0.044)	(0.042)	(0.047)	(0.050)	(0.051)	(0.044)	(0.064)	(0.056)	(0.032)
Q3 (Jul-Sep)×Drought(t)	0.068	0.007	-0.046	-0.019	0.066	-0.049	0.065	-0.045	0.058	-0.002	0.046	0.031
	(0.068)	(0.022)	(0.038)	(0.039)	(0.045)	(0.049)	(0.056)	(0.051)	(0.046)	(0.055)	(0.058)	(0.035)
Q4 (Oct-Dec)×Drought(t)	-0.008	-0.005	-0.035	-0.012	0.012	-0.028	0.057	-0.100**	0.078	0.052	0.099*	0.000
	(0.065)	(0.027)	(0.041)	(0.042)	(0.039)	(0.046)	(0.063)	(0.043)	(0.047)	(0.065)	(0.057)	(0.036)
Q1 (Jan-Mar)×Drought($t-1$)	-0.116	0.035	0.002	0.123**	-0.077	-0.103*	-0.200	0.052	-0.152	0.080	0.355*	0.062
	(0.103)	(0.048)	(0.083)	(0.047)	(0.079)	(0.059)	(0.155)	(0.059)	(0.096)	(0.086)	(0.211)	(0.050)
Q2 (Apr-Jun)×Drought($t-1$)	-0.110	-0.024	-0.025	-0.013	0.017	-0.066	-0.022	-0.047	0.118	-0.149*	0.005	-0.068
	(0.078)	(0.023)	(0.045)	(0.056)	(0.077)	(0.043)	(0.063)	(0.058)	(0.080)	(0.082)	(0.099)	(0.056)
Q3 (Jul-Sep)×Drought($t-1$)	-0.070	-0.024	-0.038	-0.032	-0.106**	-0.035	0.042	-0.030	0.054	0.019	-0.087	0.024
	(0.052)	(0.021)	(0.028)	(0.043)	(0.046)	(0.060)	(0.068)	(0.063)	(0.066)	(0.074)	(0.064)	(0.045)
Q4 (Oct-Dec)×Drought($t-1$)	0.106	0.017	0.005	-0.018	-0.007	0.009	0.080	-0.107	0.026	-0.005	-0.051	0.008
	(0.074)	(0.030)	(0.056)	(0.046)	(0.067)	(0.063)	(0.072)	(0.073)	(0.038)	(0.099)	(0.062)	(0.048)
Observations	12,643	17,297	16,665	17,384	13,437	16,827	15,547	14,239	15,373	8,987	6,526	17,422
R-squared	0.317	0.570	0.392	0.378	0.311	0.434	0.274	0.212	0.214	0.380	0.176	0.419
Mean of Dep. Var.	5.721	5.867	5.303	5.205	5.265	5.209	4.242	4.182	4.062	4.407	3.140	5.194
Controls												
Province and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region × Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ln(Total Expenditure)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data: VHLSS 2010, 2012, 2014
Notes: This table presents the coefficients on the interaction terms between quarters and droughts in t and $t-1$ from the regressions estimating the effect on the log of monthly household expenditure on each food category. The regression columns are sorted by the share of expenditure on the item to the total expenditure from the largest to the smallest. FAFH denotes the food away from home. Robust standard errors are shown in parentheses clustered at the province level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.5: Effect of Droughts on Monthly Household Expenditure on Non-food Items

	Petro	Hygiene	Gas (LPG)	Biomass Fuel	Child	Detergent	Female Goods	Coal Kerosene	ETC
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Q1 (Jan-Mar)×Drought(t)	0.015	-0.038	0.043	0.104*	-0.079	-0.040	-0.035	0.118	0.137*
	(0.043)	(0.041)	(0.044)	(0.062)	(0.091)	(0.033)	(0.094)	(0.151)	(0.077)
Q2 (Apr-Jun)×Drought(t)	0.079**	0.045	-0.008	-0.006	-0.065	0.040	0.079	-0.103	0.047
	(0.035)	(0.030)	(0.037)	(0.056)	(0.068)	(0.027)	(0.095)	(0.154)	(0.078)
Q3 (Jul-Sep)× Drought(t)	0.024	-0.005	-0.023	0.060	-0.040	-0.006	-0.036	0.063	0.073
	(0.030)	(0.031)	(0.027)	(0.042)	(0.060)	(0.033)	(0.097)	(0.134)	(0.068)
Q4 (Oct-Dec)× Drought(t)	0.002	-0.000	-0.066*	0.038	-0.103*	0.010	-0.014	-0.010	0.040
	(0.038)	(0.031)	(0.039)	(0.052)	(0.055)	(0.038)	(0.084)	(0.110)	(0.078)
Q1 (Jan-Mar)× Drought($t-1$)	0.109**	0.103	-0.068	0.124	0.065	-0.015	-0.024	0.069	-0.030
	(0.045)	(0.068)	(0.051)	(0.107)	(0.087)	(0.068)	(0.159)	(0.231)	(0.084)
Q2 (Apr-Jun)× Drought($t-1$)	-0.006	-0.047	0.001	-0.044	0.054	-0.040	0.085	0.045	0.013
	(0.058)	(0.037)	(0.049)	(0.076)	(0.148)	(0.038)	(0.137)	(0.142)	(0.073)
Q3 (Jul-Sep)× Drought($t-1$)	0.051	0.010	-0.023	-0.074	0.101	-0.029	0.263***	-0.081	0.092
	(0.047)	(0.037)	(0.049)	(0.076)	(0.152)	(0.033)	(0.096)	(0.131)	(0.099)
Q4 (Oct-Dec)× Drought($t-1$)	0.068	0.066	-0.032	-0.027	-0.085	0.022	0.129	0.081	0.060
	(0.041)	(0.042)	(0.052)	(0.046)	(0.114)	(0.037)	(0.122)	(0.104)	(0.107)
Observations	12,831	17,322	10,117	11,051	5,831	17,399	4,405	2,752	17,068
R-squared	0.253	0.526	0.235	0.216	0.337	0.430	0.226	0.389	0.285
Mean of Dep. Var.	5.340	4.379	4.708	4.200	4.585	3.748	3.612	2.995	4.155
Controls									
Province and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region × Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ln(Total Expenditure)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variables are ln(Expenditure in '000 VND).

Data: VHLSS 2010, 2012, 2014

Notes: This table presents the coefficients on the interaction terms between quarters and droughts in t and $t-1$ from the regressions estimating the effect on the log of monthly household expenditure on each non-food category. The regression columns are sorted by the share of expenditure on the item to the total expenditure from the largest to the smallest. 'Child' denotes the expenditure on allowance and books for children. Robust standard errors are shown in parentheses clustered at the province level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.6: Heterogeneous Effects of Droughts on Abortion

	Dependent variable: Abortion=1		
	(1)	(2)	(3)
Drought	0.0030***	0.0030***	0.0030*
	(0.0010)	(0.0010)	(0.0015)
Drought × Triple cropping	-0.0026**		
	(0.0013)		
Drought × Irrigation (2nd)		-0.0032**	
		(0.0016)	
Drought × Irrigation (3rd)		0.0008	
		(0.0018)	
Drought × Wealth (2nd)			-0.0010
			(0.0019)
Drought × Wealth (3rd)			-0.0016
			(0.0020)
Observations	811,089	811,089	811,089
R-squared	0.012	0.012	0.012
Mean of Dep. Var.	0.0066	0.0066	0.0066
Controls			
District and year FE	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes
Mother characteristics	Yes	Yes	Yes
District-specific linear time trend	Yes	Yes	Yes
Birth parity FE	Yes	Yes	Yes
Gender composition FE	Yes	Yes	Yes

Data: PCS 2004-2008, 2010-2013

Notes: This table presents results from regressions of the dummy for abortion on the interaction terms between the drought in the dry season and the indicator for mothers residing in triple-cropping provinces (column (1)), and the tercile indicators for district-level irrigation coverage (column (2)), and for district-level wealth index (column (3)). Triple-cropping provinces are defined as if a province produces all three rice crops: spring, autumn and winter rice. Irrigation coverage is the area-weighted irrigation coverage found in the VHLSS 2004. The district-level wealth index is created by aggregating the household-level wealth index from the principal component analysis of 16 asset and residence characteristics found in the 2009 census. Robust standard errors, which are reported in parentheses, are clustered for the district level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.7: Effects of Alternative Rainfall Shocks on Yearly Rice Yields and Expenditure

| | **Dependent variables** | | | | | |
	Spring Rice (1)	All Rice (2)	Total Expenditure (3)	Expenditure on Food (4)	Expenditure on Non-food (5)	Ratio (Food/Total) (6)
Panel A. Low rainfall shocks in the wet season						
Low rainfall	0.005	0.001	-0.018	-0.018	0.024	-0.000
	(0.007)	(0.006)	(0.016)	(0.015)	(0.021)	(0.003)
Observations	1,045	1,055	18,128	18,128	18,128	18,128
R-squared	0.8010	.900	0.531	0.610	0.530	0.119
Mean of Dep. Var.	3.922	3.788	9.861	9.060	7.505	0.471
Panel B. Low rainfall shocks in the calendar year						
Low rainfall	0.005	0.003	-0.018	-0.013	0.016	0.002
	(0.006)	(0.006)	(0.015)	(0.014)	(0.021)	(0.003)
Observations	1,045	1,055	18,128	18,128	18,128	18,128
R-squared	0.800	0.898	0.530	0.609	0.529	0.119
Mean of Dep. Var.	3.921	3.787	9.874	9.070	7.516	0.469
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 Vietnam GSO and the VHLSS 2004, 2006, 2008
Notes: This table presents results from regressions of the log of annual crop yields (Quintal/Ha) and the log of expenditure (in '000 VND) on low rainfall shocks in the wet season (Panel A) and in the calendar year (Panel B), respectively. Low rainfall shocks refer to the realization of rainfall in the wet season (April-November) or in the calendar year (January-December) below the 20th percentile of historical distribution of district-specific rainfall in 1984-2013. 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 households. Robust standard errors, which are reported in parentheses, are clustered for the province level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.8: Effects of Multiple Rainfall Shocks on Abortion

	Dependent variable: Abortion=1			
	(1)	(2)	(3)	(4)
Drought$_{(t-1)}$	0.0021**	0.0022***	0.0015*	0.0022***
	(0.0009)	(0.0008)	(0.0008)	(0.0008)
Drought$_{(t-1)}$×Low rainfall in the wet season $(t-1)$	-0.0001			
	(0.0012)			
Drought$_{(t-1)}$×High rainfall in the wet season $(t-1)$		-0.0008		
		(0.0015)		
Drought$_{(t-1)}$×Low rainfall in the wet season (t)			0.0031	
			(0.0022)	
Drought$_{(t-1)}$×High rainfall in the wet season (t)				-0.0009
				(0.0018)
Mean of Dep. Var.	0.0066	0.0066	0.0066	0.0066
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 presents results from regressions of the indicator for abortion on various interaction terms between the drought in the dry season and a high or low level of wet season rainfall. 'Low' and 'high' level rainfall in the wet season refer to the realization of rainfall in the wet season (April-November) below the 20th percentile or in the 8th or 9th decile of historical distribution of district-season-level rainfall in 1984-2013. Robust standard errors, which are reported in parentheses, are clustered for the district level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.9: Robustness for Alternative Clustering of Standard Errors

	Dependent variable: Abortion=1							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drought (coefficient)	0.0020	0.0021	0.0022	0.0020	0.0021	0.0020	0.0021	0.0023
p-value (clustered by district)	0.003	0.001	0.001	0.004	0.004	0.004	0.003	0.024
No. of Clusters (district)				502				
p-value (clustered by province)	0.018	0.007	0.006	0.017	0.017	0.017	0.015	0.056
No. of Clusters (province)				51				
p-value (two-way by district & year)	0.041	0.015	0.014	0.042	0.042	0.042	0.037	0.101
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: This table shows *p*-values from alternative clustering for the regressions reported in Table 5. The first *p*-values in the 2nd row are derived from the standard errors clustered by district. The second series of *p*-values in the 3th row are derived from the standard errors clustered by province. The last series of *p*-values in the 4th row are derived from the two-way clustering of district and year.