Weather Shocks and Sex-Selective Abortion: Evidence from Rural Vietnam

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Abstract

Negative weather shocks have various detrimental impacts on credit-constrained rural households in poor countries. Coupled with son preference, it could lead to excess female infant mortality in the short run and also worse adult female outcomes in the long run. With widely available sex-selection technologies, parents now can make simultaneous decisions on quantity and sex of child. In this project, I investigate a household's decisions on fertility and a child's gender by exploiting exogenous variations in rainfall across years within a detailed geographic unit in rural Vietnam. Those decisions can be directly observed by using rare household-level datasets on prenatal sex determinations and abortions. I find a 25 percent increase in the abortion rate after negative rainfall shocks, and it is mostly due to mothers who already have at least one son in the previous births. There is no change in the aggregate-level sex ratio at birth and no differential response in contraceptive use after rainfall shocks. Well-designed public safety nets and family planning programs would play an important role to prevent households from engaging in this costly measure to smooth consumption.

(*JEL Codes*: D1, I1, I15, J13, J16, O12, O13)
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1 Introduction

Households in poor countries are exposed to various types of economic shocks. It is so deleterious sometimes that households resort to onerous measures to smooth consumption; poor households facing aggregate income shocks would not only change their usual diet (Subramanian and Deaton, 1996; Jensen and Miller, 2008), but also migrate (Groeger and Zylberberg, 2016), allocate resources only to male infants (Rose, 1999; Maccini and Yang, 2009; Duflo, 2012; Anttila-Hughes and Hsiang, 2013), or engage in risky sexual behaviors while seeking for extra income (Burke et al., 2015).

In this paper, I suggest that terminating the current pregnancy can be another strategy that households might consider to mitigate aggregate shocks. One of most critical challenges posed to empirical investigations on the income-fertility relationship is to find exogenous variations in income while holding constant other key determinants such as underlying preferences for fertility. By exploiting variations in rainfall within a fine geographic unit, which proves to be a valid proxy for rural income, I examine how income shocks affect reproductive behavior and demand for a child of a poor rural household in Vietnam.

Vietnam has an ideal setting to study this; abortion is legal, widely available and also regarded as one of common birth control methods. In addition, its cultural preference for son offers an interesting dimension to exploit by allowing for extra marginal utility of having a boy in her offspring. In particular, I can identify this rather extreme copping strategy of a poor household by analyzing unusually rich dataset on reproductive and fertility behaviors of married women. Most remarkably, this dataset contains approximately one million mothers' decision on abortion from almost every rural district in Vietnam from 2004-2013.

In addition to adding new evidence to the research on arduous coping mechanisms for a poor household after income losses, this paper contributes to a host of literature which delve into the fertility response to changes in income. A series of Becker's seminal works are devoted to reconcile the well-known negative correlation between income and fertility with the theoretical prediction that a child is a normal consumption good due to the unavailability of immediate substitutes for children. To be specific, Becker incorporates additional determinants to decipher the puzzle within a neoclassical model of fertility; first by introducing parental demand for quality of children as well as the income gradient in contraceptive use (Becker, 1960; Becker and Lewis, 1973), and by adopting the opportunity cost of parental time, which disentangles the substitution effect from an increase in household income (Becker, 1965). However, the lack of exogenous variations to a household or a mother-specific source of income has served as main threats to infer causal implications from empirical studies on theoretical models of fertility. Thus, a few notable previous works on this subject are mainly about how to find compelling natural experiment settings to distinguish income effects while other factors are held constant.

The early examples include research by Schultz (1985) and Heckman and Walker (1990) in Sweden, and both show that the negative relationship between female income and fertility, which suggests the existence of substitution effects. On the contrary, based on the theoretical assumption that male income would be associated more with the income effect from the specialization of household production, other body of papers try to show that positive (negative) shocks to male labor market contributes to an increase (decrease) in fertility (Lindo, 2010; Black et al., 2013). The other host of studies draw on aggregate income shocks to explore the income effect on fertility; Dehejia and Lleras-Muney (2004) use the business cycle in the US to show that fertility is pro-cyclical, Cohen et al. (2013) find that a reduction in child subsidies in Israel leads to a decrease in the likelihood of having an extra child, and Lovenheim and Mumford (2013) and Dettling and Kearney (2014) both suggest a positive impact of an increase in housing price on fertility in the US.

However, there is scant literature in a poor country setting[1], whereas a majority of existing literature is based on the analysis of households in developed countries. As explained by Bhalotra and Rocha (2012), the scope of investigation is substantially limited in developing countries because of the unavailability of credible mother-level datasets and appropriate income measures. But, as long as there exists a credible micro-level dataset on fertility in poor countries, researchers might be able to seize better opportunities to test for the income effects on fertility because the opportunity cost of mothers' time would not be a dominant factor in developing countries where female labor market participation and marginal product of labor are substantially low (Bhalotra and Rocha, 2012).

[1] A few examples include; Adsera and Menendez (2011) use DHS datasets to show economic downturns are related to a reduction in fertility in ten Latin American countries, Bhalotra and Rocha (2012) show a positive association between per capita income and fertility in India, and Palermo et al. (2016) find little impact of unconditional cash transfer on fertility in Zambia.

Thus, although this study is relevant to all aspects of Becker's arguments, this paper is more closely related to an empirical investigation of the income effect on a mother's decision on abortion or carrying the current pregnancy to full term, while assuming the substitution effect is not a crucial pathway to explain those outcomes of interest. To be specific, this paper attempts to link the exogenous rainfall shocks which are mostly translated into income effects not only with the abortion decision but also with a wide array of other reproductive and fertility characteristics of mothers using unique datasets in Vietnam. In addition, I also can explore heterogeneity by using differential price of a marginal child depending on the gender composition of previous children and parental educational attainment to better shed light on the income-fertility relationship in poor countries.

The main results in this paper again corroborate evidence that "children are normal"; there is an increase in the abortion rate after negative rainfall shocks, i.e., negative impact on income, but on the contrary, mother are less likely to get abortion after positive rainfall shocks for poor households in rural Vietnam. These results are significant both statistically and economically, and robust to a variety of controls including fertility histories and district-specific time trends. I observe the gender composition of previous births plays an important role to explain heterogeneous responses in abortion. To be specific, this result is primarily driven by mothers who already have at least one son. It implies that sonless mothers face lower marginal cost of having an additional child (if a newborn is a son) than mothers with a son. However, I cannot find any change in the birth rates, though, because extra or less abortions offset changes in the conception rate. The sex ratio at birth is also not responding to rainfall shocks in the aggregate level.

The paper proceeds as follows. I present relevant institutional background of Vietnam and datasets used in this study in Section 2. Section 3 discusses the empirical strategy I employ. Results are presented in Section 4, and Section 5 concludes.

2 Background and Data

Section 2.1. provides institutional information focusing on family planning policies and reproductive health practices in Vietnam. Section 2.2 describes datasets which are used to create main outcome variables and control covariates, and provide relevant summary statistics. Section 3.3

discusses background on agriculture in Vietnam and the construction of rainfall shocks.

2.1 Abortion, Contraceptive Use and Sex-selection

Abortion is legal in Vietnam up to 22 weeks of pregnancy[2]. Approximately 26 abortions per 1,000 women aged 15-49 report her experience of voluntary abortion in 2003, which one of the world's highest rates (Sedgh et al., 2007). Fees for abortion services vary by the types of hospital, e.g., administrative level, public or private[3] and pregnancy weeks when the procedure occurs: from 40,000 Vietnamese dong (VND) (US$2) at public and about 120,000-150,000 VND (US$8-10) in private clinics for a first-trimester abortion to 1.5 million VND (US$78) for a second-trimester procedure[4] (Reproductive Health Department, 2006; Teerawichitchainan and Amin, 2010; Pham et al., 2011). Second trimester abortion at public hospitals is not easily accessible than early abortion within six weeks not only because of cost but also due to the unavailability of the procedure at commune health centers (Hoang et al., 2008). However, second trimester abortion is not uncommon especially in rural areas; first antenatal visit takes place in the late first trimester, and it would take some time for mothers to decide on abortion (Gallo and Nghia, 2007).

Coupled with lowering barriers to abortion, aggressive promotions of IUD[5] have contributed to a rapid decline in the fertility level in Vietnam in the 1990s after the introduction of the one-or two-child policy in 1988 (Goodkind, 1994)[6]. Favored as one of most cost-effective birth control methods for resource-poor communist countries, Vietnam's family planning strategy has advocated IUDs over other modern contraceptive methods until very recently (Nguyen and Budiharsana,

[2]Two kinds of pregnancy termination procedures are primarily performed in Vietnam. Menstrual regulation is a manual vacuum aspiration procedure conducted within 12 weeks of pregnancy. It is available at all levels of public health institutions, but the most basic level hospital, commune health centers provide the procedure only up to seven weeks of pregnancy (Ngo et al., 2014). On the other hand, the other procedure, dilation and curettage is performed at district and higher level public health centers. It is used for late-stage pregnancy termination when menstrual regulation is not possible (Reproductive Health Department, 2006)

[3]The number of abortions performed at private hospitals rapidly increased following Vietnam's economic reforms in the late 1980s; in the early 1990s, they account for about 15 percent of total abortions (Teerawichitchainan and Amin, 2010).

[4]There are a number of ways for rural households to get abortions for free of charge. For example, there will be no cost in case that they are family planning program subscribers, report a malfunction of contraceptive method, or are subject to the poverty alleviation program by localities (Reproductive Health Department, 2006; Teerawichitchainan and Amin, 2010; Pham et al., 2011).

[5]IUD means an intrauterine device which is inserted in a woman's uterus for pregnancy prevention. It is long-acting up to three years and reversible, and one of the most common methods adopted by married women especially in Asia (United Nations, Department of Economic and Social Affairs, Population Division, 2015)

[6]The rapid decrease in fertility in Vietnam after this population policy concurrently occurred with *doi moi*, the movement for a free-market economy from a socialist system since 1986. Thus, this demographic transition can be attributable also to the country's rapid economic and social development.

2012); more than half of women in reproductive age reported that they had ever used the method (Teerawichitchainan and Amin, 2010). But this leads to one puzzling fact about Vietnam that high contraceptives use is observed with high abortion rates compared to its fertility level (Haughton, 1997). One plausible explanation is the unavailability of short-term, reversible modern method such as condoms and pills despite the high prevalence of IUD which is more suited for women who completed fertility. This can, in turn, imply that abortion serves as an alternative to modern contraceptives methods (Teerawichitchainan and Amin, 2010), as also supported by the fact that repeated abortions are very commonly witnessed among married women (Goodkind, 1994)[7].

More recently, abortion in Vietnam should be understood with the interaction between long-held son preference and widely available ultrasound technology, which are two key drivers to cause demographic transitions in East Asia and India. Vietnam is a son preference county influenced by Confucianism like East Asian countries (Belanger, 2002). Thus, Vietnamese households face the imperative to have at least one son who will be responsible for worship rituals, old age support of parents and inheritance of family properties (Pham et al., 2008). First introduced as a part of the reproductive health, ultrasound scan services rapidly increased about tenfold from 1998 to 2007 (Guilmoto et al., 2009). This exceptionally rapid take-up is not only due to the supply side factors such as very low cost (40,000-50,000 VND per scan, or US$2.50-3.50) and numerous public and private providers but also due to its easy and reliable identification of fetal sex as early as 12 weeks of pregnancy (Gammeltoft and Nguyn, 2007). This widely available technology for determining sex of fetus undoubtedly plays a crucial role for a recent male-biased sex ratio at birth in the 2000s (Figure 1 and Figure 2). This is a common demographic transformation among son preference countries, especially when ultrasound is widespread and legally available abortion is conducted for terminating unwanted female births (Guilmoto et al., 2009; Bhalotra and Cochrane, 2010; Lin et al., 2014; Almond et al., 2015). Alarmed by abnormally male-skewed sex ratio in the early 2000s, Vietnamese government has issued several official decrees to ban the 'sex-selective' abortion since 2003 (Pham et al., 2011). But like the previous cases in India and China those bans have little impact because its sex-selective motive is rarely discernible from other reasons (Pham et al. (2008);

[7]Another evidence that abortion as one of contraceptive methods can be found in Eastern Europe in the 1980s (Levine and Staiger, 2004), in the legalizing states in the US (Ananat et al., 2009). And Miller and Valente (2016) conduct an investigation on the substitution between other modern contraceptives and abortion by using a natural experiment in Bangladesh.

Anukriti et al. (2016)).

Last but not the least, Vietnam has been successful in reducing the infant mortality rate. Thanks to rapid economic development from the mid 1990s and investment in the primary health care system, Vietnam witnessed low infant mortality rates in the 2000s relative to other neighboring countries or those in the comparable income level (Graner et al., 2010) (Figure 3). Especially, while total fertility and relevant population policies exhibit little change, the sex ratios of infant mortality have been stable in the 2000s, which convince us that there is no immediate fertility squeeze to have a son nor active substitution between pre- and postnatal discrimination against female births in my study period (Figure 4).

2.2 PCS and VHLSS

I use the Population Change and Family Planning Survey (PCS) to construct fertility and reproductive behavior outcome variables. These are repeated cross-sectional surveys based on three percent sample of the census, conducted every year from 2000 by the General Statistics Office in Vietnam[8]. These datasets report basic socio-demographic information of all usual residents of a household, and the birth history of all married women of childbearing age from 15-49, which includes a child's month, year of birth and sex. Most notably, in 2004-2013, this survey asked a married woman whether she had an induced abortion last year in addition to requesting extensive information on contraceptive use, visits to antenatal care and fetal sex determination[9]. This makes the PCS a unique individual-level dataset regarding fertility and reproductive characteristics of mothers, which is usually unavailable not only in developing but also in developed countries[10]. I pool nine waves of PCS from 2004-2008 and 2010-13[11] which contain abortion information, giving me the sample size of about one million mothers from almost every rural district across Vietnam[12].

[8]The reference date for this survey is April 1st of the current year, and the survey asks events in the preceding 12 months. As a result, the survey conducted in the year of n describes demographic trends for January-March in year n and April-December in year $n-1$.

[9]Two categories of pregnancy termination, menstrual regulation and induced (surgical) abortion are reported respectively in early rounds of the survey (2004-2008). I do not distinguish one from the other in my main analysis primarily because this is a self-report rather than a hospital report.

[10]PCSs are not the only nationally representative survey with abortion information in developing countries. Kim (2005) uses the Korean National Fertility and Family Health Surveys, but there were only two waves in 1988 and 1991, and its sample size is much smaller than the PCS.

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

[12]There are 674 districts in Vietnam, and 629 districts are used for the analysis in this paper. The remaining districts are mostly urban districts within major cities.

I use the Vietnamese household living standard survey (VHLSS) to explore the link between weather shocks and a household's income and expenditure. This biannual survey has been conducted since 2000, and thus I use five rounds from 2004 to 2012 to match the periods of PCS datasets. Since 50 percent of households were revisited in the next round of survey, this sample design allows me to exploit a panel structure of income and expenditure of a particular household.

Since my empirical strategy hinges on the relationship between rainfall and economic condition of a household, I primarily rely on the sample consisting of married women in rural areas, where the link is presumed to be starkly significant than urban regions. In addition, to make parental preference and cultural settings for fertility and family planning comparable across districts, I exclude ten mountainous provinces of the Northwest region where Kinh, the major ethnicity in Vietnam makes up less than half of population in a province[13]. Not only are these provinces different in terms of ethnic composition, but they also are in fact the ten poorest provinces, thereby exhibiting lower socio-economic development, higher fertility and infant mortality rates (World Bank, 2004). I further limit my analysis to include mothers with up to four children and a single childbirth at a time to have comparable results in the birth order analysis.

Table 1 provides summary statistics of married women aged 15-49 in my sample. I present urban women's statistics to show how rural mothers are different relative to urban counterparts. More than half of rural mothers have completed only primary or lower secondary school, and about 73 percent of mothers have at least one son now. Rural mothers are less likely to get abortion, while more like to use contraceptive relative to urban mothers. Conditional on her childbirth last year, about 79 percent mothers knew their sex of child before birth, and they knew the sex when about 20 weeks of pregnancy. This is evidence of a late visit to hospital for antenatal care, considering the fact that the sex can be revealed as early as 12 weeks of pregnancy; in fact, rural mothers are less likely to pay her first antenatal care visit during the first trimester than urban mothers (Tran et al., 2011). This is mainly due to financial and time constraints when she travels to health centers (Graner et al., 2010). On rural household characteristics from the VHLSS, more than half of rural households grew rice, which shows that their economic conditions are substantively dependent on the rice yield.

[13]The ten provinces are chosen if more than 50 percent of the head of household's ethnicity is not Kinh in a province using the 2009 Census of Vietnam.

2.3 Agriculture in Vietnam and Rainfall Data

This paper aims to examine how economic shocks affect rural mothers' decision on her current pregnancy. Due to the unavailability of household-level datasets which ideally include both complete fertility information and economic performance measures, I draw on variations in local economic conditions from year-to-year rainfall realizations within a geographic unit, as fine as district level. To obtain exogenous and meaningful variations in a household's economic productivity, we need to understand what agricultural activities constitute a primary portion of income for rural households, and its interaction with rainfall levels.

In Vietnam, rice is the most important crop; not only being the primary staple produced across all regions, it is also considered as a key source of income for a majority of rural households since Vietnam became a leading rice exporter in the 2000s (USDA report 2014). Especially in case of rice, its variation in yield is better explained by precipitation rather than temperature (Lobell and Field, 2007). Therefore, we would expect rainfall to be an important determinant of rural incomes, as other research also use rainfall as the most important factor of weather variation (Jayachandran, 2006; Maccini and Yang, 2009; Kaur, 2014; Shah and Steinberg, 2017). Vietnam's climate is characterized by one wet season from April to November and one dry season December to April (Figure A.1). Thanks to favorable weather conditions, rice can be grown twice a year in the northern regions and up to three times in the southern regions. Accordingly, rice production can be divided into three cropping seasons: winter-spring, summer-autumn, and autumn-winter. Of these three crops, the winter-spring crop (or spring crop)is planted across all regions and is more productive than the other two (Viet Khoa et al., 2012). Although the crop calendars vary across regions, the length of spring crop approximately overlaps the dry season, and its harvest takes place before a new wet season starts (Le, 2016). Drought and extreme rainfall both can negatively affect rice yield, but drought in particular has more harmful impacts on agricultural productivity than flood does (Maccini and Yang, 2009; Auffhammer et al., 2012). Therefore, abnormally low level of rainfall during the dry season can be directly translated into poor yields of the most productive spring crop, and thus it would constitute meaningful economic variations for rural households in Vietnam[14].

[14] Flood is also one of main natural disasters and has deleterious impacts on rural households especially in the Red River and Mekong Deltas (Arouri et al., 2015). However, excessive rainfall is not adequate to be a single meaningful

I create season-specific rainfall shocks for each district by using Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) version 2.0. The CHIRPS incorporates 0.05 degree resolution satellite imagery with station readings to provide monthly estimates of precipitation from 1981[15]. In particular, the 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 of precipitation with outcome variables of interest, I spatially aggregate them up to a district level by taking land-area weighted average of monthly rainfall for each district. The resolution of CHIRPS is fine enough (0.05 x 0.05 degree) for each overlaid administrative boundary to include several grids within a narrow geographic area to produce a weighted average. This allows me to address a potential threat to the unbiased estimation of the effects, which can be an issue particularly when projecting coarser grids having precipitation estimates to smaller geographic units (Dell et al., 2014). Monthly rainfalls then temporally collapse to create a season-year measure of precipitation, i.e., dry (December-March) and wet (April-November) season rainfall for each district. This is a common approach to precisely match rainfall to agricultural cycles, rather than using calendar-year rainfall, which is employed by Paxson (1992), Jayachandran (2006), Maccini and Yang (2009) and Kaur (2014). Finally, to determine rainfall shocks that capture unusually high and low rainfall realizations relative to what is typically experienced in a district, I define shocks at the district-season-year level, using the district level rainfall distribution in 1984-2013. To be specific, for each district in my sample, I define a positive shock if seasonal rainfall occurs above the 80th percentile, and a negative shock if it does below the 20th percentile of the district-specific long-run rainfall distribution of 1984-2013. As widely adopted by a host of recent studies with minor alterations (Kaur, 2014; Burke et al., 2015; Shah and Steinberg, 2017), this measure of weather shocks allows me to capture significant economic impacts on a rural household, while holding constant other determinants of fertility and reproductive behaviors of a married woman. Furthermore, since this study design exploits a panel setup rather than relying on cross-sectional comparisons, my estimates are not biased due to the correlations between unobservable characteristics of different locations and their mean levels of rainfalls (Dell et al., 2014; Hsiang, 2016). In addition, I employ indicator variables to allow a mother to simply have a positive or a

weather variable for proxying economic shocks. This is not only due to its complicated hydrologic and climatic conditions to cause flood, but also because of its nonlinear relationship with crop yield (Viet Khoa et al., 2012).

[15] 0.05 degrees is equivalent to about 5 kilometers at the equator.

negative rainfall shock or not, instead of using continuous measures such as deviations from the mean. This relatively nonparametric specification is based on the assumption that fertility decisions are intrinsically conservative and discreet, and thus they would respond to economic shocks in a nonlinear fashion, as suggested by Lindo (2010) and Black et al. (2013) who focus on layoffs and a substantial increase in male income induced by coal price shocks. In Figure A.3a and Figure A.3a I plot those districts which experienced negative or positive rainfall shocks in my study period, 2004-2008 and 2010-2013. Lastly, I do not find serial correlation of rainfall shocks measures in this study. This is to guarantee that my empirical estimates are presenting contemporaneous impacts of negative or positive rainfall on fertility and reproductive decisions, rather than estimates of cumulative shocks of rainfall.

2.4 Rainfall Shocks, Crop Yield and Expenditure

To corroborate evidence on the causal link between rainfall shocks and crop (mainly rice) yields, first I measure the effect of rainfall shocks on agricultural yields in Table B.1. This exercise is also worthwhile because there has been scant empirical literature in the context of Vietnam despite a myriad of studies in economics exploring the relationship between weather shocks and agricultural yields in India and Africa. I use province-level yield data from the General Statistics Office of Vietnam from 1995 to 2013 on all cereals, three kinds of rice crops and maize which shows the highest yield following rice. I create provincial level shocks for each season analogously, instead of district-level shocks for fertility outcomes, and show estimates from regressions of crop yields on two rainfall shock dummies in Table B.1[16]. In column (1)-(3), we can see that negative impact of excessively low rainfall during the dry season on those yields of all cereal, all rice and spring rice. If there is a negative rainfall shock in the dry season, the most fragile crop would be spring rice, as the dry season rainfall is most closely related with spring crop production. And since the spring crop is the most productive crop among all cereals grown in Vietnam, the total rice yield including three types of rice crop would decrease if there was drought in the dry season. The impacts of positive rainfall shocks in the dry season are imprecisely estimated in general, except for its negative impact

[16]There has been a rapid increase, about 25 percent in the yield of rice in the 2000s. I include province-specific linear time trends to account for substantial heterogeneity in agricultural production by provincial level, motivated by diverse provincial level implementations on distributing high-yielding varieties and fertilizers (Viet Khoa et al., 2012)

on the yield of fall rice. I also check whether rainfall shocks in other season-year have greater impacts on rice yields, but the shocks constructed using the rainfall in the dry season give the most significant results on the yield of all cereal and all types of rice.

In addition, I present a local linear regression to describe the relationship between rainfall and rice yields in Figure A.4 and Figure A.4b. Now the crop yield responses are plotted on continuous measures of rainfall percentile instead of binary indicators, after controlling for province specific linear time trends as well as year and province fixed effects. The positive relationship between rainfall realizations and crop yield is clearly evident; unusually low rainfall leads to a decrease in rice yields, but this monotonic relationship diminishes when rainfall is above a certain level.

In Table B.2, I provide the estimates on the relationship between rainfall levels for each season and various measures of household expenditure using the panel structure of VHLSS. We can see the positive association between rainfall levels and a rural household's total and food expenditure (column (1), (2)), whereas the coefficients on the wet-season rainfall are not precisely estimated. This analysis supports that the rainfall shock, especially rainfall shocks in the dry season are more relevant proxies for general economic conditions for rural households in Vietnam than the other measures of shock defined by other season or calendar year rainfalls.

3 Estimation Strategy

The goal of my empirical analysis is to estimate the causal effect of economic shock on decisions on abortion or giving birth to a child. By exploiting arguably random year-to-year variations within a district, I make comparisons of mothers who share similar underlying preferences for completed fertility and the gender composition of children. This is a reduced-from approach relying on straightforward identification assumptions, thereby warranting the causal interpretation of the discovered relationship(Dell et al., 2014). I determine the impact of economic shocks on various outcomes of interest using the following regression:

$$Y_{idt} = \alpha_1 Neg_{d,t-1} + \alpha_2 Pos_{d,t-1} + \sum_{s \in S, l \in L} \beta_{s,l} R_{s,t+l} + \mathbf{X}_i' \gamma + \tau_t + \mu_d + \theta_d t + \varepsilon_{idt} \tag{1}$$

where i, d, t and s denote mother, district, year and season (dry/wet), respectively.

The outcome includes a wide array of variables related to a married woman's reproductive and fertility behavior such as pregnancy, abortion, contraceptive use, giving birth and prenatal sex determination, and prenatal investment such as the number of prenatal check-ups. Most variables are binary; for example, 'abortion' is coded one if a mother terminated the pregnancy within the survey year. The main coefficients of interest are α_1 and α_2 on $Neg_{d,t-1}$ and $Pos_{d,t-1}$ respectively, which become one if rainfall in the last dry season occurs below the 20th percentile ('negative rainfall shock') or above the 80th percentile ('positive rainfall shock') of the district-specific rainfall distribution from 1984-2013. These two coefficients capture the impacts of positive and negative rainfall shocks compared to what would be normally observed after the usual levels of rainfall, i.e., the average impact of 2nd, 3rd and 4th quintile of historical rainfall distribution on various outcomes.

A vector of $R_{s,t+l}$'s, which are log values of dry and wet season-year rainfall up to two year lags $(L = 0, 1, 2)$ enter the equation to account for potential effects of previous rainfall realizations[17]. $\mathbf{X}_i$ is a vector of covariates consists of a mother-specific observable characteristics which are age in year t and its quadratic, and two indicator variables for woman is educational attainment and the relationship to the household head. These covariates would potentially control not only for differential opportunity costs of childbearing, but also for marginal utility of having an extra child (Kim, 2005). In my main specification, I also include the number of children one year before the reference date of the survey to account for the birth order of current conception in the survey year. I further control for higher or lower marginal utility of having a specific sex of child by replacing the indicators of parity by dummies for the gender composition of previous births. In particular, the inclusion of the gender composition in my specification, especially whether a mother has at least one son or not, is imperative because it serves as a main determinant of marginal utility thus demand for an additional child of specific sex by sex-selective abortion (Almond et al. (2015); Jayachandran (2017)). Since PCS does not report the month of abortion and only asked whether a mother had an abortion in the last 12 months from the reference date, I include a vector of survey year fixed effects instead of calendar year fixed effect in my specification.

In addition to a full set of district and year fixed effects which are to ensure the panel structure

[17] The results do not change if I replace those log values with raw precipitation values or logs of deviation from the mean.

rather than cross-sectional comparisons, I include district-specific linear trends to absorb differential trends by districts. This can be crucial not to have biased estimates due to unobservable variables because it purges the effects from differential expansion of public health service and an increase in agricultural productivity by district level over time.

Lastly, for the purpose of robustness check, I additionally include two sets of control variables describing fertility information, birth spacing and age at first birth[18] , and spousal characteristics such as educational attainment and age in my preferred specification for the subsample which have a husband information[19]. These are another important dimension in conjunction with the gender composition of previous births to determine incentives to get abortion or carry the current pregnancy to full term (Prtner, 2015).

Lastly, the ε_{idt} represents mother-specific idiosyncratic factors for each outcome variable, and I assume it to be orthogonal to all observable and unobservable determinants. And standard errors are clustered at the district level.

4 Results

4.1 Main Results

I start by discussing the main outcome of this study: a married woman's decision on abortion. To examine other pathways in fertility, I also investigate how a married woman uses contraceptives differentially after rainfall shocks. Lastly, I will look into whether those abortions are sex-selective and thus lead to male-skewed sex ratios at birth.

In Table 2 I present the results from Equation (1) estimating the impact of rainfall shocks on the abortion rates of married women in reproductive age 15-49 from the nine rounds of annual PCS in 2004-2008 and 2010-2013. Negative and positive rainfall shocks in the dry season have the opposite effects for the rural sample (Panel A); the overall effect of negative shock shows an increase in the

[18]To be precise, I construct the variable of birth spacing by calculating the interval between the reference date of the survey and the year and month of previous birth which happened before the reference date, instead of the period between the recent livebirth occurred in the present survey year and the previous birth. This is to avoid the bad control problem because the recent livebirth which happened 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.

[19]Spousal information can be merged only if a married woman is the head of household or the spouse of household head, and the educational attainment of a husband is reported only after 2006 in the PCS.

likelihood of abortion by about 0.2 percentage point (column 1-8), but on the contrary a positive shock reduces abortion by 0.2 percentage point (column 4-8) at the 1 percent statistical significance level for both estimates[20]. The magnitude of impact is substantively large; married women in rural are more(less) likely to get abortion by about 25 percent given a mean of 0.8 percent if there was unusually low (high) rainfall realization in the last dry season, relative to years after normal rainfall realizations. The size of coefficients and statistical significance of those estimates especially on negative rainfall shock are robust to employing various control covariates. To be specific, the effect of rainfall is robust to the compositional changes of mothers who select into conception. It does not change the size of coefficient and statistical significance to include not only a mother's and her spousal characteristics but also the number of parity and the gender indicators of previous births and other fertility characteristics, which would control for differential incentives to select into conception and to give birth (column 6-8). Furthermore, the main findings are robust to including district-specific time trends, suggesting that my shock measures are not collinear with the time trends as shown by consistent standard errors (Mazumder, 2008). And differential developments of relevant factors to affect the outcomes do not bias these estimates, either.

The causal link between income shock and decision on terminating pregnancy can be once more warranted by investigating those urban mothers, who are presumed to be exposed to much mitigated impacts of rainfall on income. As shown in Table 2 Panel B, I cannot reject the hypothesis that the point estimates are statistically different from zero. And the rainfall shocks in the last dry season have the largest impacts on the outcome, which also limit the concern regarding spurious correlation between rainfall shocks and abortion Table B.3.

Lastly, my results are also robust to a more flexible specification. When there are more than two dummy categories for rainfall realizations, compared to previous two indicators for negative and positive rainfalls, we can expect that normal rainfall realizations which fall within middle categories would give little response in the abortion rate, while the lowest level of rainfall would result in the highest rate of abortion. By just replacing two indicators for negative and positive rainfall shocks with ten dummy variables which become one if rainfall in a district falls within each decile range and zero otherwise, Figure 5 plots those coefficients on each decile dummy, making the 5th decile

[20]Since the analysis in this section is based on the full sample including both mothers who conceived and did not in the survey period, the outcome, the probability of abortion can be understood as the general abortion rate that is the number of abortion per 100 women when it is presented in percentage points.

the omitted category. Indeed, at the first decile which corresponds to the 10 percent level of rainfall, the abortion rate is highest and statistically significant, and not significantly different from zero from the 2nd to 8th decile, and it flips to be negative (less abortion) at the 9th decile. The effect on the 10th decile is not different from what one can conjecture because the excessive rainfall can be understood as floods, rather than positive income shocks if it is above a certain threshold.

The main conclusion from this analysis is that income shocks can have contemporaneous impacts on a pregnant woman's decision on the current pregnancy, which is not only a new piece of evidence on numerous coping strategies for poor households, but also supports the theoretical prediction that demand for a child increases as income increases.

Even though those abortion results come from the full sample, after controlling for differential incentives to select into pregnancy by including an extensive set of observable characteristics, it is important to check whether the initial conception responds to economic shocks. If we can find more or less conceptions after negative or positive rainfall shocks, and if they take place selectively, it can suggest that my previous results on abortion would be biased because some unobservable characteristics of households might covary with rainfall shocks other than the income channel.

First, since the experience of abortion, pregnancy or giving a birth is reported by a mother level, I can define an 'actual conception'; if a woman reports one of these three cases in the survey year: 1) she had a livebirth between August and March, 2) she had an induced abortion, or 3) she is currently pregnant as of April 1st which is the reference date of the PCS survey. The exclusion of livebirths in the first five months of the survey from April to July results from the fact that have an aborted pregnancy been carried to full term the earliest possible month of birth starts from August because abortion after 22 weeks is prohibited by law[21]. In Table 3 column (1), (2) I report conception response using the full rural sample. In these two specifications, the estimates of rainfall shocks are not statistically different from zero at any conventional level. Once assured by the fact that there are no differential incentives to become pregnant after rainfall shocks, thus no change in the likelihood of conception, I can further present the abortion result conditional on pregnancy. If I maintain a similar assumption by PopEleches (2006) that baseline maternal characteristic variables

[21] To be specific, all impacts from rainfall shocks in the last dry season (December-March) would be reflected in those abortion decisions starting from April 1st. Thus, corresponding livebirth cohorts to those aborted pregnancies would start as early as August 5th (=April 1st-22 weeks+40 weeks), then the conception cohort will be all those births from August 5th to March 31st, and current pregnancies as of the reference date of the survey.

can control for the composition of mothers who become pregnant in my study period and that any unobservable determinants for pregnancy are orthogonal to my constructed measures of rainfall shocks, my estimates on abortion are still suggesting the casual link between economic shock and the demand for a child.

Table 3 column (3), (4) provide the abortion results conditional on pregnancy. I can find statistically significant and sizeable estimates of two dummies for negative and positive shocks using the preferred set of controls (column (1)), and additional paternal and fertility characteristics controls (column (4)). We can find that mothers are 19 percent more likely to get abortion once she gets pregnant after negative rainfall shocks. On the contrary, if there was positive rainfall shock in the last dry season, those pregnancies are 19 percent more likely to result in livebirths, compared to 6.2 percent of abortion after normal rainfalls.

We then need to see how those income shocks would be translated into actual birth rates. I estimate Equation (1) by using the outcome as a dummy for giving birth to a child within the survey year, which only includes a newborn who is less than a year old from each wave of survey. To be consistent with the previous results, I use births only in the months of August to March, but the results are largely consistent across alternative definitions of the probability of giving birth by differing periods of months of births. Table 3 column (5), (6) present estimates of the effect of negative and positive rainfall shocks on the likelihood of births. Like those results on the conception, I do not find those points estimates are statistically different from zero.

Following on the results on birth rates, one can come up with a question that why mothers would choose to get abortion which are much more expensive and detrimental to health instead of avoiding unwanted pregnancies in advance by using modern contraceptives. Table 4 provides the results when I conduct the same analysis for outcomes on contraceptive use. For each definition of contraceptive use, I present the estimate using my preferred specification which controls up to the gender composition of previous births. I present the results on contraceptive use by using two kinds of samples; first I exclude those mothers if she reports that she is currently pregnant and not using any contraceptive methods (Panel A), and further restrict the sample to include only those mothers who have not had livebirths or abortion in the survey year. One notable fact about the results in Table 4 is that those results are not significantly different from zero in general, and the magnitude of significantly estimated coefficients are not large, either (Panel A column (2), (3) and Panel B column (3)). To be specific, in column (1), I cannot find any effects of rainfall shocks on the usage of any kinds of contraception which include traditional methods like withdrawal or abstinence as well as modern contraceptive measures. And in column (3)-(5), the outcome variables describe the reasons why a woman does not use any contraceptives, but these analyses do not show any statistically significant relationship with income shocks. Furthermore, the take-up of two most frequently used modern contraceptives do not respond to rainfall shocks (column (6)-(7)).

Statistically significant results are only found in column (2), which show the effect of income shocks on the take-up of modern contraceptives which include IUDs, condoms, pills and male/female sterilization. The sign of coefficient on negative rainfall shocks is consistent with the theoretical prediction that negative income shocks are associated with less demand for children, but the magnitude of the coefficient is considerably small compared to its mean (about 1-2 percent in Panel A and B), which in turn lead to an increase in the abortion rates eventually. These are quite contrary results compared to the previous research conducted in poor countries; negative agricultural yields are associated with an increase in contraceptive use in order to prevent a new childbirth in Tanzania (Alam and Prtner, 2016) and in Uganda (Abiona, 2017). One plausible explanation for this response in Vietnam can be found in the different trends in contraceptive use between these countries. To be specific, male condoms or other short-term and reversible methods have been adopted as the primary tool for birth controls in African countries, but Asian countries, notably Vietnam, have favored to promote IUD and sterilizations as their main contraceptive methods (United Nations, Department of Economic and Social Affairs, Population Division, 2015). This might have created unmet needs for couples who temporarily want to avoid unwanted pregnancies by using short-term and convenient methods such as male condoms or pills after unexpected and short-run income losses. Furthermore, there is also evidence that family planning program is not functioning in Vietnam. For example, the take-up of voluntary family planning services did not lead to a reduction in the likelihood of getting abortion (Nguyen and Budiharsana, 2012), and couples frequently discontinue using modern methods and return to traditional methods (Do and Koenig, 2007).

All in all, poorly designed and ineffective family planning programs in Vietnam have been partly responsible for an increase in the abortion rate after negative income shocks by failing to provide a household with appropriate measures to prevent unwanted pregnancies.

However, we also need to consider recent new motivations for Vietnamese parents to opt for abortions, rather than using any contraceptive methods. As suggested by Ananat et al. (2009), getting abortion after pregnancy might be the outcome of completely different decision process relative to avoiding unwanted pregnancies using contraceptives. That is, after 12 weeks of pregnancies when ultrasound can reveal the fetal sex, the expected payoff from carrying the current pregnancy to full term can be higher or lower than the initial expected payoff at the time of pregnancy. Not only does the outlook for agricultural yields become more precise in about two months, the fetal sex can serve as a key factor to increase or reduce the expected payoff from keeping the pregnancy in the context of son preference.

To investigate the existence of this pathway to abortion, I show the results on the likelihood that a newborn is male. If abortions after rainfall shocks become more or less sex-selective, we would expect that the sex ratio at birth is more or less male-skewed. Especially after negative rainfall shocks, the increased price of having a child is only compensated by higher marginal utility from having a boy, thereby increasing the sex ratio at birth. Furthermore, this pattern would be more visible if a mother does not have a son in the previous births.

The results on the sex of a newborn are presented in Table 3 column (7)-(8). I restrict the sample of mothers who had a livebirth in the survey year not to suffer from potential biases due to postnatal discrimination, which lead to differential infant mortality rates depending on the infant's sex (Anukriti et al., 2016). In my preferred specification and adding more control covariates do not change the results that negative or positive rainfall shocks are not associated with the likelihood of having a boy. This might suggest that those abortions after income shocks are not more or less likely to be sex-selective relative to those being done after normal rainfall realizations, or opposite signs of estimates from various subsamples would offset each other to result in no effects in the aggregate analysis.

4.2 Heterogeneous Analysis

I provide two heterogeneous analyses for two outcomes of abortion and the probability of having a son.

4.2.1 by demand for at least on son

Table 5 provides the results on the impact of rainfall shocks on the abortion rates by birth parities. In column (2), (5), (7) and (9), I add an indicator of 'Have no son' which becomes one if a mother did not have a son in the previous births and its interaction terms with two rainfall shocks in Equation (1). For example, column (6)-(7) present the response in the abortion rates of mothers who expect the third child conditional on pregnancy for a given survey year. One can predict that under son preference, mothers are more likely to have lower demand for an extra child if she already has a son in the previous births. Thus, we would expect that a negative sign on the indicator for having no son, and it is supported by those estimates on 'have no son' indicator in column (2), (5), (7) and (9). In addition, if we assume marginal utility from a child is diminishing as the number of children increases, a mother would be more likely to get abortion on pregnancies of higher parity after income losses. And this prediction is also empirically supported by an increase in magnitude of coefficients on negative rainfall shocks from column (3) to (9). Lastly, it is theoretically ambiguous to predict whether a mother without son is more or less likely to get abortion after rainfall shocks because she wants to give birth to a child to have a son, but the price of having a boy increases after negative rainfall shocks. In column (7) and (9) the point estimates on the interaction term between 'Have no son' and 'Negative shock' are negative, which might suggest that the demand for a son outweighs increased cost to have a son after negative rainfall shocks.

When we turn to the results on the likelihood of having a boy in Table 6, we observe little heterogeneous response here, except for mothers who are more likely to have a son if there was no son in the previous births in column (2) and (7). These results can imply that abortions which occur after rainfall shocks are not more or less sex-selective compared to those happening after normal levels of rainfall. However, I cannot rule out the possibility that it is imprecisely estimated due to improper matching livebirth cohorts to the abortion samples which do not report the pregnancy weeks when the procedure was performed.

5 Conclusion

This paper finds another onerous coping strategy which poor households might adopt if they are not able to smooth consumption after aggregate economic shocks. I suggest compelling evidence that poor households might need to terminate the current pregnancy if they have negative rainfall shocks in the last dry season which serves as a valid proxy for negative income shocks. On the contrary, they are less likely to get abortion if they have positive rainfall shocks than after usual rainfall realizations. These findings are also connected to a host of literature on linking income shocks with demand for a child. The response of abortion is contemporaneous and short-run rather than long-term consequences of income on a woman's complete fertility, but as Heckman and Walker (1990) suggested, economic shocks may affect other fertility variables such as birth spacing while holding completed fertility unchanged. Furthermore, this short-run response which delays a childbirth by abortion can result in negative long-run effects on poor households like the case in the US that women hit by negative economic shock in their early 20s eventually have much lower fertility in the long run (Currie and Schwandt, 2014). Households who face negative income shocks would have been able to prevent unwanted pregnancies if they had various options of contraceptives and had easy access to them. Furthermore, considering the habit-forming aspect of contraceptive use, family planning program needs to be carefully designed.

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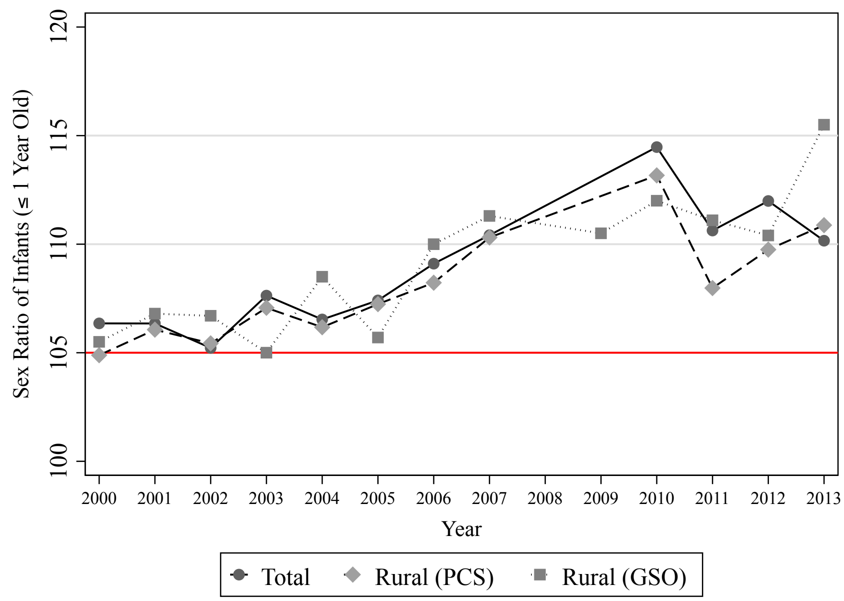
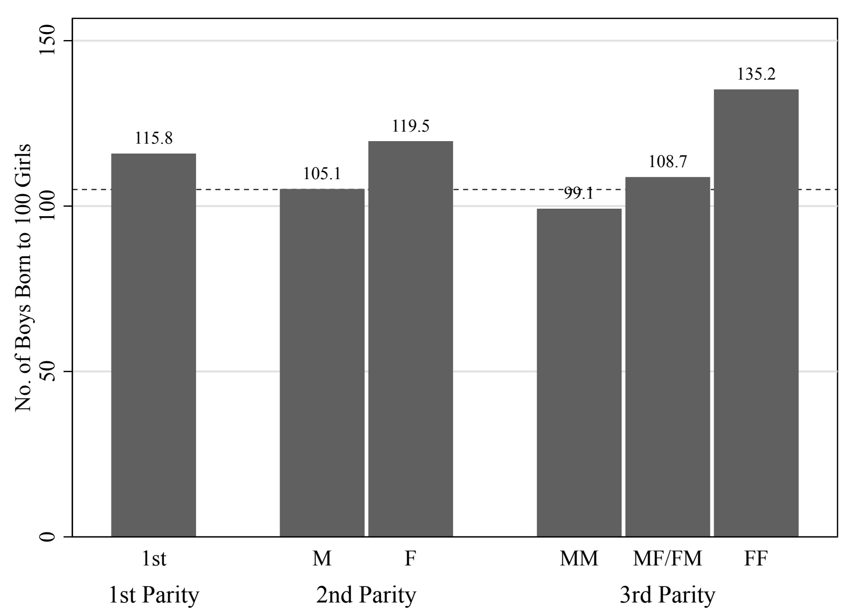
Figures

Figure 1: Sex Ratio at Birth by Year



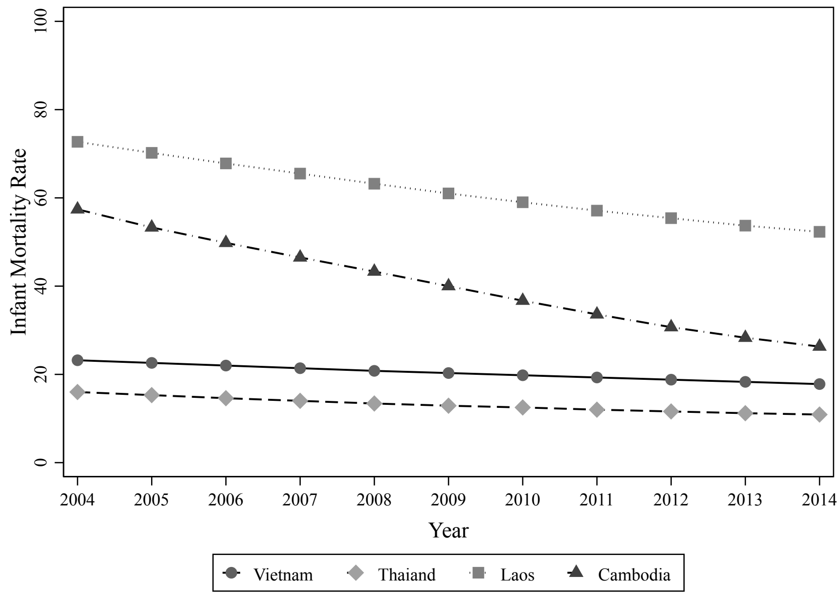
Notes: The figure plots the sex ratio at birth, the number of newborn boys born to one hundred girls, using two data sources: PCS by the author's calculation and the official statistics from GSO. 'Total' means the sex ratio at birth using all births in urban and rural regions reported in PCS. The red horizontal line marks the biological normal sex ratio at birth, which is about 105.

Figure 2: Sex Ratio at Birth by Birth Parity



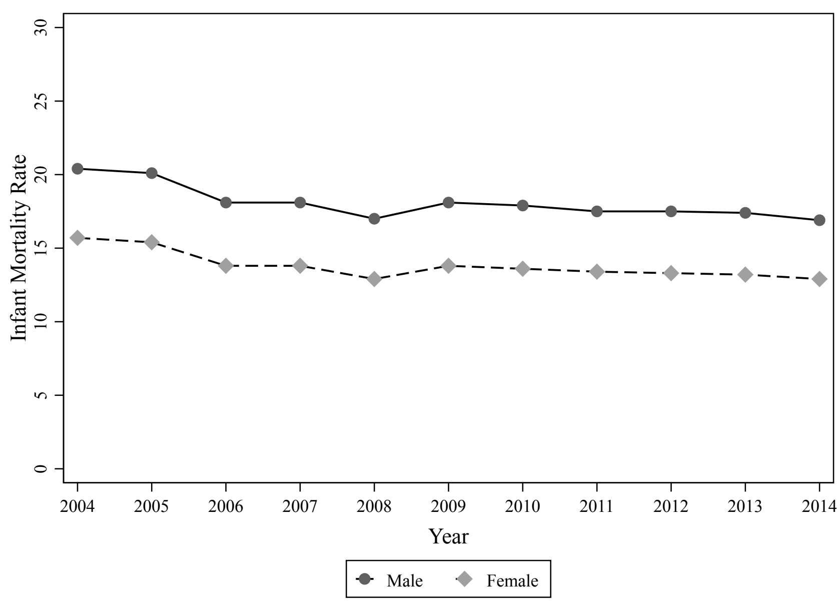
Notes: This figure plots the sex ratio at birth by birth parity, depending on the sex of previous births. 'M' of the 2nd parity means the firstborn is son, and 'F' means a daughter. Likewise for the third parity, 'MM' means the first two births are boys, whereas 'FF' means there is no son in the previous two births.

Figure 3: Infant Mortality Rate by Country



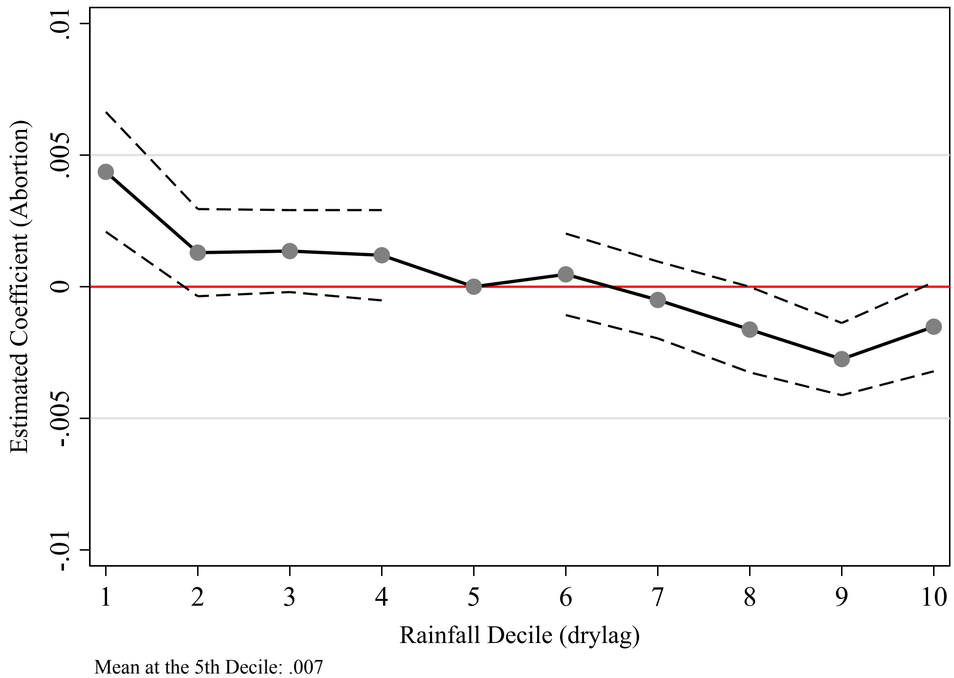
Notes: This figure plots infant mortality rates of Vietnam and neighboring countries in Southeast Asia using the official statistics from the World Bank.

Figure 4: Infant Mortality Rate by Sex



Notes: This figure plots infant mortality rates by sex using the official statistics from the GSO.

Figure 5: Effects of Rainfall Levels on Abortion



Notes: The figure plots coefficients and 95% confidence intervals from a regression of abortion on dummies for each decile of the rainfall distribution in the last dry season. The omitted category is the fifth decile.

Tables

Table 1: Summary Statistics

	Rural		Urban		Diff.
	Mean	SD	Mean	SD	
	(1)	(2)	(3)	(4)	(5)
Panel A. Full Sample					
Age (year)	31.962	(7.394)	33.771	(7.427)	-1.809
Education Attainment: Primary or lower	0.500	(0.500)	0.284	(0.451)	0.216
Educ Attainment: Higher secondary or above	0.144	(0.351)	0.423	(0.494)	-0.279
Age at the fi rst birth	22.606	(3.662)	24.074	(3.939)	-1.468
Number of children ever born	1.839	(0.829)	1.699	(0.740)	0.14
Number of children ever died	0.024	(0.154)	0.014	(0.116)	0.01
Have at least one boy	0.726	(0.446)	0.676	(0.468)	0.05
Gave birth last year	0.104	(0.305)	0.093	(0.290)	0.011
Currently pregnant	0.039	(0.195)	0.038	(0.191)	0.001
Had abortion last year	0.007	(0.085)	0.008	(0.087)	-0.001
Currently using any contraceptives	0.768	(0.422)	0.757	(0.429)	0.011
Panel B. Conditional on childbirth last year					
Checked pregnancy	0.949	(0.221)	0.982	(0.134)	-0.033
Number of prenatal check	3.697	(1.830)	4.574	(2.066)	-0.877
Knew the child's sex before birth	0.794	(0.404)	0.890	(0.313)	-0.096
Gestational weeks when you knew child's sex	20.121	(5.092)	18.967	(4.602)	1.154
Knew the child's sex by ultrasound	0.989	(0.105)	0.991	(0.093)	-0.002
Facility delivery	0.937	(0.243)	0.985	(0.121)	-0.048
Panel C. Spouse Characteristics					
Age (year)	36.622	(7.104)	39.049	(7.214)	-2.427
Educ. Attain.: Primary or lower	0.455	(0.498)	0.249	(0.432)	0.206
Educ. Attain.: Higher secondary or above	0.165	(0.371)	0.447	(0.497)	-0.282
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)	830,398		819,474		
Observations (VHLSS)	22,253		8,207		

Data: PCS 2004-2008, 2010-2013
Notes: This table provides the summary statistics of mothers included in the main analysis. VHLSS datasets are only used to find the relationship between rainfall levels and expenditure of rural households.

Table 2: Effects of Rainfall Shocks on Abortion

	Dependent var.: Abortion=1							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Rural								
Negative rainfall shock	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Positive rainfall shock	-0.000	-0.000	-0.000	-0.002***	-0.002***	-0.002***	-0.002***	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	830,398	830,398	829,324	829,324	829,324	829,324	822,003	452,298
R-squared	0.008	0.008	0.009	0.012	0.012	0.012	0.012	0.013
Mean of Dep. Var.	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Panel B. Urban								
Negative rainfall shock	0.002*	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Positive rainfall shock	0.001***	0.001**	0.001**	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	819,474	819,474	818,223	818,223	818,223	818,223	813,227	478,714
R-squared	0.008	0.009	0.009	0.012	0.013	0.013	0.013	0.014
Mean of Dep. Var.	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
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: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 3: Effects of Rainfall Shocks on Conception, Abortion, Birth and Male

	Dependent variables							
	Conception		Abortion| Conception		Giving birth		Newborn is Male	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Negative rainfall shock	0.002	0.001	0.012***	0.020**	-0.000	-0.001	-0.003	-0.001
	(0.002)	(0.002)	(0.004)	(0.008)	(0.001)	(0.002)	(0.007)	(0.013)
Positive rainfall shock	-0.001	-0.002	-0.012***	-0.019***	0.001	-0.001	-0.002	0.004
	(0.002)	(0.002)	(0.003)	(0.006)	(0.002)	(0.002)	(0.008)	(0.013)
Observations	829,324	452,298	97,299	36,066	829,324	452,298	68,251	26,370
R-squared	0.188	0.136	0.239	0.272	0.202	0.146	0.018	0.047
Mean of Dep. Var.	0.119	0.119	0.062	0.062	0.111	0.111	0.523	0.523
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: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 4: Effects of Rainfall Shocks on Contraception

	Dependent variables						
	Use Any Contraceptives (1)	Use Modern Contraceptives (2)	Want More Child (3)	Lack of Knowledge (4)	Expensive (5)	IUD (6)	Pills/ Condoms (7)
Full Sample (except for the current pregnancy)							
Negative rainfall shock	0.001	0.007**	0.000	0.000	0.000	0.004	0.002
	(0.002)	(0.003)	(0.002)	(0.000)	(0.000)	(0.004)	(0.003)
Positive rainfall shock	0.003	0.001	-0.006**	0.001	0.000	-0.004	0.003
	(0.003)	(0.004)	(0.002)	(0.000)	(0.000)	(0.005)	(0.004)
Observations	795,774	795,582	794,554	794,554	794,554	794,362	794,362
R-squared	0.326	0.222	0.312	0.017	0.003	0.149	0.077
Mean of Dep. Var.	0.787	0.671	0.124	0.001	0.000	0.406	0.231
Panel B. No Conception Sample							
Negative rainfall shock	0.001	0.006**	-0.000	0.000	0.000	0.003	0.002
	(0.002)	(0.003)	(0.002)	(0.000)	(0.000)	(0.004)	(0.003)
Positive rainfall shock	0.002	-0.002	-0.004	0.000	0.000	-0.006	0.001
	(0.003)	(0.004)	(0.002)	(0.000)	(0.000)	(0.005)	(0.004)
Observations	704,406	704,229	703,299	703,299	703,299	703,122	703,122
R-squared	0.390	0.246	0.464	0.015	0.003	0.152	0.084
Mean of Dep. Var.	0.810	0.696	0.130	0.001	0.000	0.430	0.229
Controls							
District and year FE	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	Yes
District-specific linear time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth parity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gender composition FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data: PCS 2004-2008, 2010-2013
Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 5: Effects of Rainfall Shocks on Abortion by Parity (Conditional on Conception)

	Dependent var.: Abortion=1								
	Full Sample		**By Parity**						
			1st	2nd		3rd		4th	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Negative rainfall shock	0.012***	0.037***	0.004***	0.014***	0.009*	0.026*	0.045***	0.036	0.056*
	(0.004)	(0.010)	(0.002)	(0.005)	(0.006)	(0.015)	(0.017)	(0.030)	(0.034)
Positive rainfall shock	-0.012***	-0.064***	-0.002	-0.010**	-0.013***	-0.056***	-0.094***	-0.014	-0.057**
	(0.003)	(0.006)	(0.002)	(0.004)	(0.005)	(0.013)	(0.014)	(0.025)	(0.027)
Have no son		-0.086***			-0.011***		-0.174***		-0.185***
		(0.004)			(0.002)		(0.012)		(0.022)
Negative × Have no son		-0.038***			0.009		-0.062***		-0.074*
		(0.010)			(0.006)		(0.020)		(0.043)
Positive × Have no son		0.074***			0.006		0.114***		0.162***
		(0.006)			(0.004)		(0.015)		(0.033)
Observations	97,299	97,299	43,227	35,147	35,147	14,646	14,646	4,279	4,279
R-squared	0.239	0.194	0.035	0.084	0.085	0.344	0.380	0.530	0.556
Mean of Dep. Var.	0.062	0.147	0.005	0.038	0.043	0.228	0.286	0.253	0.308
Controls									
District and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mother characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District-specific linear time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth parity FE	Yes								
Gender composition FE	Yes								

Data: PCS 2004-2008, 2010-2013
Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 6: Effects of Rainfall Shocks on Pr(Newborn is Male)

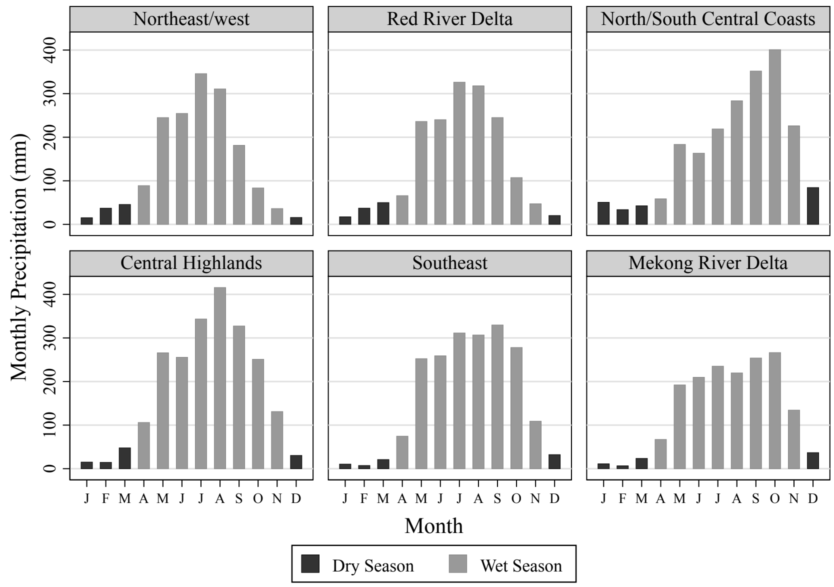
	Dependent var.: Newborn is Male=1									
	Full Sample		**By Parity**							
			1st	2nd		3rd			4th	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	(9)
Negative rainfall shock	-0.003	-0.001	-0.004	-0.002	0.001	-0.005	-0.010		-0.005	0.030
	(0.007)	(0.012)	(0.011)	(0.013)	(0.015)	(0.023)	(0.029)		(0.049)	(0.058)
Positive rainfall shock	-0.002	0.002	-0.003	-0.001	-0.002	-0.017	-0.010		0.007	0.013
	(0.008)	(0.011)	(0.012)	(0.013)	(0.017)	(0.022)	(0.026)		(0.061)	(0.063)
Have no son		0.016***			0.012		0.027*			0.038
		(0.006)			(0.008)		(0.016)			(0.042)
Negative × Have no son		-0.003			-0.006		0.014			-0.112
		(0.013)			(0.020)		(0.036)			(0.088)
Positive × Have no son		-0.005			0.003		-0.017			-0.021
		(0.011)			(0.018)		(0.037)			(0.088)
Observations	68,251	68,251	31,286	25,064	25,064	9,163	9,163		2,738	2,738
R-squared	0.018	0.018	0.035	0.049	0.050	0.125	0.125		0.305	0.306
Mean of Dep. Var.	0.523	0.524	0.517	0.530	0.541	0.513	0.510		0.517	0.520
Controls										
District and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Mother characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
District-specific linear time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Birth parity FE	Yes									
Gender composition FE	Yes									

Data: PCS 2004-2008, 2010-2013

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

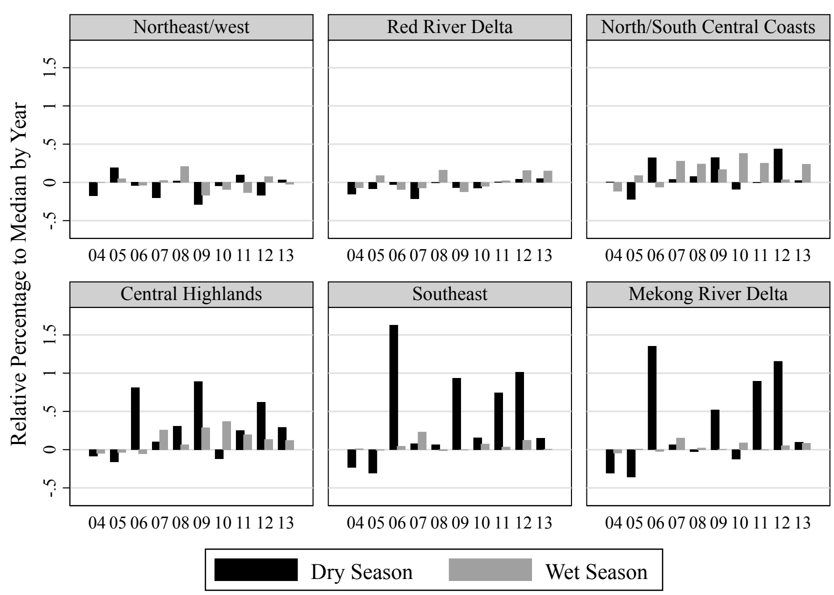
A Appendix. Figures

Figure A.1: Monthly Precipitation by Region



Notes: The figure plots the monthly precipitation averaged over the years in 1984-2013 by region. The dry season rainfall occurs from December to March.

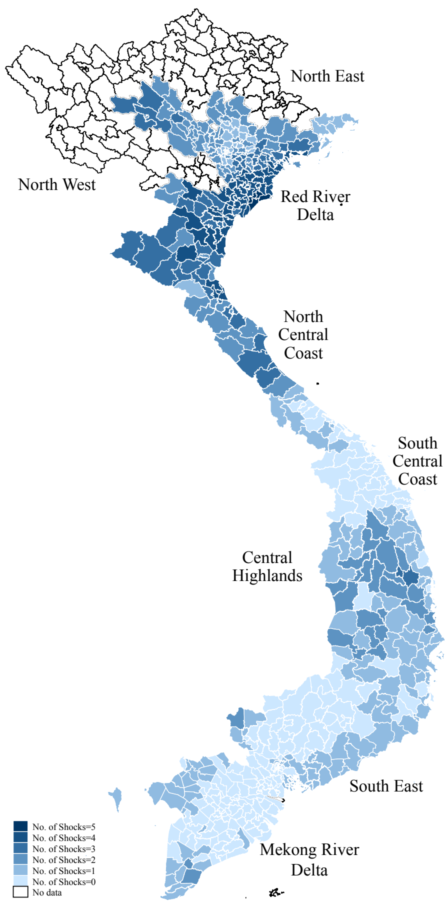
Figure A.2: Rainfall Deviation to 30-Year Median by Region



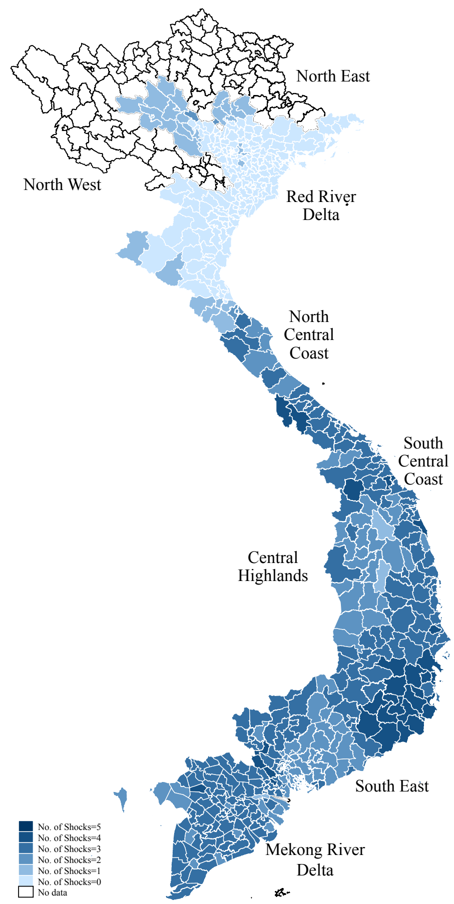
Notes: This figure provides the rainfall deviation in percentage relative to the long-term average season-year rainfall for each region.

Figure A.3: Distribution of Rainfall Shocks across Districts in Vietnam

(a) Negative Rainfall Shocks



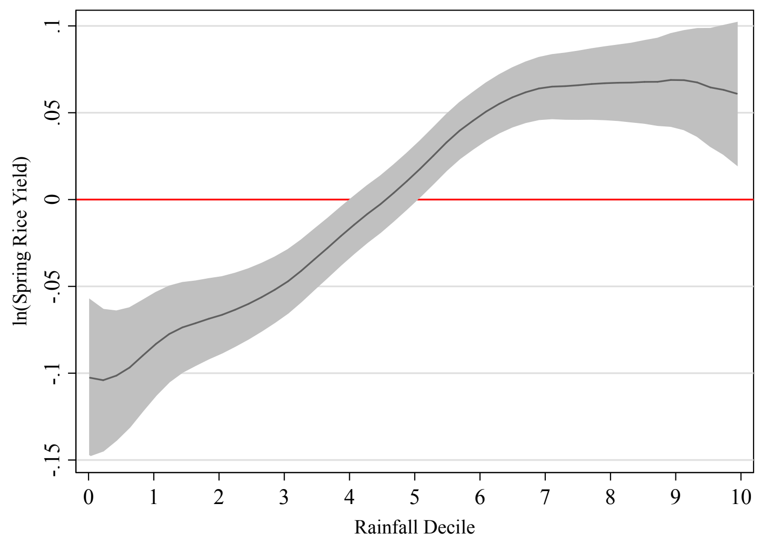
(b) Positive Rainfall Shocks



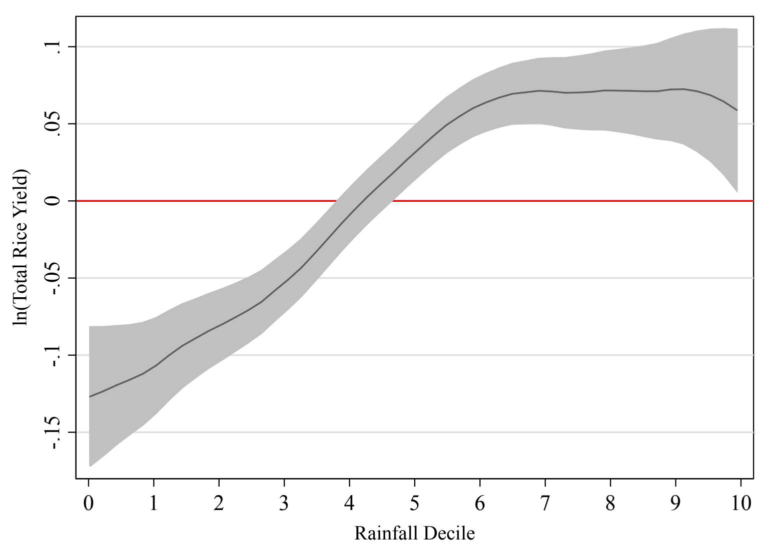
Notes: These plots describe the number of negative (a) and positive (b) rainfall shocks experienced by each district in Vietnam. The districts with ‘No data’ are excluded in the analysis because the major ethnicity is not Kinh in those districts.

Figure A.4: Effect of Rainfall on Crop Yields in Vietnam

(a) Spring Rice Yield



(b) Total Rice Yield



Notes: These plots provides estimates (line) and its 95 percent confidence intervals (shaded area) from a local linear regression of crop yield on rainfall percentile. The dependent variable is the log of yield (Quintal/Ha) of spring rice (a) and total rice (b) using the agricultural statistics from GSO.

B Appendix. Tables

Table B.1: Effects of Rainfall Shocks on Crop Yields

	Dependent variables					
	All Cereal	All Rice	Spring Rice	Fall Rice	Winter Rice	Maize
	(1)	(2)	(3)	(4)	(5)	(6)
Negative rainfall shock	-0.022**	-0.013***	-0.024***	-0.006	0.008	-0.015
	(0.008)	(0.003)	(0.004)	(0.008)	(0.015)	(0.013)
Positive rainfall shock	0.016	-0.010	-0.002	-0.021**	0.016	-0.001
	(0.012)	(0.007)	(0.009)	(0.005)	(0.027)	(0.031)
Observations	1,055	1,055	1,045	608	987	1,045
R-squared	0.832	0.901	0.804	0.783	0.644	0.771
Mean of Dep. Var.	5.885	3.794	3.930	3.733	3.517	3.507
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	Yes	Yes	Yes	Yes

Data: Vietnam GSO Agricultural Statistics in 1995-2014
Notes: The outcome variables are all log values of yield (Quintal/Ha) for each corp. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.2: Effects of Rainfall Shocks on Expenditure

	Dependent variables			
	Total	Food	Protein	FAFH
	(1)	(2)	(3)	(4)
ln(rainfall in dry season)	0.048**	0.059**	0.033	0.160
	(0.022)	(0.028)	(0.048)	(0.102)
ln(rainfall in wet season)	0.056	-0.047	0.005	-0.099
	(0.065)	(0.083)	(0.121)	(0.256)
Observations	16,756	16,742	16,533	11,960
R-squared	0.907	0.913	0.791	0.868
Mean of Dep. Var.	10.097	8.951	4.200	6.834
Controls				
District and year FE	Yes	Yes	Yes	Yes
Survey Month FE	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes

Source: VHLSS 2004-2012
Note: Dependent variables are all log values of expenditure in the last 12 months in thousands VND. Protein represents expenditure on pork, beef and chicken of a household. FAFH means Food away from home *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table B.3: Effects on Abortion by Alternative Definitions of Rainfall Shocks

	Dependent var.: Abortion=1								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Negative rainfall shock in dry season (t)	-0.000								
	(0.001)								
Positive rainfall shock in dry season (t)	-0.002***								
	(0.001)								
Negative rainfall shock in dry season (t-1)		0.002***							
		(0.001)							
Positive rainfall shock in dry season (t-1)		-0.002***							
		(0.000)							
Negative rainfall shock in dry season (t-2)			0.001						
			(0.001)						
Positive rainfall shock in dry season (t-2)			-0.001						
			(0.001)						
Negative rainfall shock in wet season (t)				-0.001					
				(0.001)					
Positive rainfall shock in wet season (t)				-0.001					
				(0.001)					
Negative rainfall shock in wet season (t-1)					-0.000				
					(0.001)				
Positive rainfall shock in wet season (t-1)					-0.001				
					(0.001)				
Negative rainfall shock in wet season (t-2)						0.000			
						(0.001)			
Positive rainfall shock in wet season (t-2)						-0.001			
						(0.001)			
Negative rainfall shock in yeat t							-0.001		
							(0.001)		
Positive rainfall shock in year t							-0.001		
							(0.001)		
Negative rainfall shock in year t-1								0.000	
								(0.001)	
Positive rainfall shock in year t-1								-0.001**	
								(0.001)	
Negative rainfall shock in year t-2									0.001
									(0.001)
Positive rainfall shock in yeart t-2									-0.000
									(0.001)
Observations	829,324	829,324	829,324	829,324	829,324	829,324	829,324	829,324	829,324
R-squared	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Mean of Dep. Var.	0.008	0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Controls									
District and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall in other season-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mother characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District-specific linear time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth parity FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gender composition FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Data: PCS 2004-2008, 2010-2013
Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.