Farmer's Adaptation to Climate Change: Evidence from Vietnamese Rural Households

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1. Introduction

Vietnam is among the countries that are most vulnerable to climate change. The agricultural sector was shown to be worst affected by abnormal weather patterns with an estimated decrease in productivity of about 2 – 15 percent. This study will examine the impacts of climate change on crop production and the adjustment of farm management practices among Vietnamese farmers as an adaptation strategy.

Our contributions to the literature are as follows. Firstly, we focus on a wide variety of farming practices, some of which are understudied in previous literature (e.g., agroforestry). These practices work in various ways to help mitigate the adverse effects of temperature rise and rainfall shocks. In addition to the binary indicator for adopting each practice, we follow Anderson (2008) and construct a summary index that groups the studied conservation practices, which are possibly mutually correlated. This method helps avoid concerns about multiple testing and optimistic family-wise rejection rates to which insufficient attention is paid in the literature.

Secondly, previous studies found little evidence about how individual and household characteristics affect the heterogeneity of farmer responses to shocks. Thus, we contribute to the literature meaningful findings for the heterogeneity by farmer age, farm size, access to extension service, and farmer union membership.

2. Data and Methodology

The data in this analysis come from the Vietnam Access to Resources Household Survey during the 2008-2016 period. This survey covers a representative sample of rural households in 12 provinces in North, South, and Central Vietnam. We use the sub-sample of annual crop-producing households (N=8966), which account for about 80 percent of the total sample. Focusing on the effects of temperature rise and rainfall shocks, we formulate two different model specifications for crop production and conservation practice adoption analyses. The equation for the crop production model is constructed as follows.

$$Crop_{it} = \beta_1 GDD\_below_{it} + \beta_2 GDD\_above_{it} + \beta_3 Pos\_rainshock_{it} + \beta_4 Neg\_rainshock_{it} + \beta_5 Disaster_{it}$$
$$+\gamma X'_{it} + t * \tau_p + \mu_i + \varepsilon_{it} \quad (1)$$

where *i* and *t* denote the individual and the survey year, respectively. $Crop_{it}$ corresponds to the annual crop production value of household *i* in year *t*. GDD_below_{it} (GDD_above_{it}) is the growing degree days of temperature below (above) a harmful threshold that captures the impact of cold (hot) temperatures. $Pos\_rainshock_{it}$ ($Neg\_rainshock_{it}$) is a dummy variable indicating a positive (negative) rainfall shock year, defined as 2SD above (below) the 30-year average. Weather variables are calculated for the survey year to examine crop production's responsiveness to short-term weather shocks. $Disaster_{it}$ represents a dummy variable for the household's self-reported disaster experience in the past two years. X'_{it} is a vector of household's characteristics. $t * \tau_p$ is time by province fixed effects. μ_i is individual fixed effect. $\varepsilon_{i,t}$ is a random error term.

Regarding conservation practice adoption model, we employ weather variables in the past six years to study farmer adaptation to weather shocks in the medium term. We categorize temperatures into discrete ranges (below 18ºC, 18-23ºC, and above 23ºC) and set the temperature bin below 18ºC as the benchmark. Coefficients of temperature bins capture the impacts of the average number of days during a year that fall in each bin over the previous six years. To figure out how repetitive rainfall shocks in the recent past trigger farmers' adaptation, we incorporate the number of shocks experienced over the past six years. Accordingly, the equation for this analysis is formulated as follows.

$$Practice_{it} = \sum_{n=1}^{2} \beta_n Temp\_bin_{it} + \beta_3 Pos\_rainshock_{it} + \beta_4 Neg\_rainshock_{it} + \beta_5 Disaster_{it}$$
$$+\gamma X'_{it} + t * \tau_p + \mu_i + \varepsilon_{it} \quad (2)$$

where $Practice_{it}$ represents the conservation practices composite index and the dummy variables for the conservation practices that household *i* adopted in year *t*. We use different control variables X'_{it} from those in crop production model.

To capture the potentially heterogeneous effects, we augment Equations (1) and (2) by adding the interaction terms of temperature and rainfall shock variables with the dummy variables for the selected household factors, including farmer age, farm size, access to extension service, and farmer union membership.

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3. Empirical Results

Firstly, estimation results in Table 1 confirm that hot temperatures and rainfall shocks negatively affect annual crop production. Compared with the threshold temperatures, we find a negative responsiveness of crop production value to the temperature above the threshold but no response to the temperature below the threshold. Our estimates also reveal that a year of abnormally high rainfall (i.e., flood) decreases annual crop production during that year. However, we do not find any crop effect of negative rainfall shocks (i.e., drought). These results are quite consistent across different threshold temperatures reported in Table 1.

Secondly, our results indicate that farmers adapt to temperature rises and rainfall shocks by increasing the application of conservation practices. This finding is supported by the significantly positive coefficients for temperature bins and rainfall shock variables in the conservation practice index model in Table 2. Regarding each conservation practice, we find that higher temperatures result in more farmers employing agroforestry, crop diversity, and crop rotation. On the other hand, farmers decide to apply different conservation practices based on the specific types of rainfall shocks. Farmers are more likely to adopt agroforestry, crop diversity, soil conservation infrastructure, and soil conservation tree as the number of flood years in the past six years, while only increasing agroforestry in response to more drought years in the same period.

Thirdly, we find evidence for the heterogeneity of farmer responses to abnormal weather events by farmer age, farm size, access to extension service, and farmer union membership. Our unreported results show that farmers' age has an inverted U-shaped relationship with annual crop response to temperatures. We also find the same relationship in the adoption of crop diversity in response to higher temperatures. In addition, farmers with larger farmland sizes, access to extension services, or membership in farmer unions tend to experience less crop loss due to temperature rises. This can be explained by the higher adoption rate of agroforestry, crop diversity, and crop rotation among these farmers to cope with temperature rises.

Table 1. Effect of Temperatures and Rainfall Shocks on Annual Crop Production (thousand USD)

Threshold temperature	**18ºC**	**20ºC**	**22ºC**	**24ºC**	**26ºC**
GDD below threshold	0.0001	0.0000	0.0000	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
GDD above threshold	-0.0006***	-0.0006***	-0.0008***	-0.0008***	-0.0010***
	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.0003)
Negative rain shock	0.0565	0.0552	0.0505	0.0531	0.0603
	(0.2462)	(0.2454)	(0.2451)	(0.2470)	(0.2463)
Positive rain shock	-0.1071*	-0.1035*	-0.0957*	-0.0999*	-0.1088*
	(0.0581)	(0.0571)	(0.0557)	(0.0548)	(0.0551)
R-squared	0.4558	0.4559	0.4561	0.4560	0.4561
F statistic	16.50***	16.71***	19.95***	15.82***	14.89***

Notes: ***, ** and * indicate 1%, 5% and 10% significant level, respectively. The values in parentheses are standard errors clustered at the district level.

Table 2. Effect of Temperatures and Rainfall Shocks on the Adoption of Conservation Practices

	Conservation practices index	**Agroforestry**	**Crop diversity**	**Crop rotation**	**Soil conservation infrastructure**	**Soil conservation tree**
18-23ºC	0.053***	0.006*	0.010**	0.017***		
	(0.015)	(0.003)	(0.004)	(0.006)		
>23ºC	0.045***	0.007**	0.006	0.016***		
	(0.014)	(0.003)	(0.004)	(0.006)		
Negative rain shock	0.093*	0.030***	0.019	0.013	-0.014	0.003
	(0.048)	(0.009)	(0.015)	(0.030)	(0.011)	(0.008)
Positive rain shock	0.173***	0.019*	0.034*	0.033	0.042**	0.011*
	(0.044)	(0.011)	(0.018)	(0.022)	(0.017)	(0.007)
R-squared	0.086	0.022	0.085	0.146	0.051	0.014
F-statistics	19.43***	6.86***	19.01***	10.91***	11.24***	2.70***

Notes: ***, ** and * indicate 1%, 5% and 10% significant level, respectively. The values in parentheses are standard errors clustered at the district level. Based on the purpose of each conservation practice, we only consider the effects of rainfall shocks on soil conservation infrastructure and soil conservation tree.

References

Anderson, Michael L. (2008). Multiple Inference and Gender Differences in the Effects of Early Intervention: A Reevaluation of the Abecedarian, Perry Preschool, and Early Training Projects. *J Am Stat Assoc*, 103(484), 1481–95.