Thailand Vietnam Socio Economic Panel

Rainfall shocks and risk aversion: Evidence from Southeast Asia

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The Thailand Vietnam Socio Economic Panel (TVSEP) is a long-term research project for data collection and scientific analysis funded by the Deutsche Forschungsgemeinschaft (DFG). The high quality panel data sets have been collected in rural areas of Thailand and Vietnam since 2007. The panels cover many important aspects of living standard measures, demography, geography, shocks, risks, expectations and behavioural traits of individuals. TVSEP data is available for scientific research purposes free of charge.

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Rainfall Shocks and Risk Aversion:

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Abstract

Empirical studies advocating the temporal variability of risk attitudes suggest that adverse covariate shocks significantly alter risk attitudes over time, but there is no consensus on the direction. In this paper, we investigate whether risk aversion increases or decreases in response to shocks. To do so, we combine individual-level panel data with historical rainfall data for rural Thailand and Vietnam. Our econometric analysis shows that temporal variability in risk attitudes is driven by rainfall shocks. Both severe shortages and excesses appear to increase individuals' risk aversion. Contrary to expectations, we find that this impact is lower for farmers than for non-farmers. We can explain this result by the heterogeneous composition of non-farmers and by farmers' ability to mitigate rainfall shocks. Our findings have potentially important implications especially for developing countries in that adverse shocks can increase poor people's risk aversion and may lead to decisions that perpetuate their lives in poverty.

Key words: Rainfall, Risk attitudes, Risk mitigation

JEL: C23, D9, Q54

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Section 1: Introduction

Risk attitudes play a fundamental role in individual economic decision-making processes, such as decisions on consumption, investments and savings and are, hence, an important determinant of individual-level wealth. The current literature suggests that poverty and risk aversion are interlinked. More precisely, poorer people, who are more exposed to adverse risks and unprotected by dysfunctional market and government institutions, are more risk averse than wealthier people (Haushofer and Fehr 2014). In turn, risk averse individuals are less likely to adopt new technologies since they involve uncertain returns. As a consequence, chances of higher returns are forgone and abilities to manage risks further deteriorate, increasing the likelihood that the individual will remain below the poverty line (Rosenzweig and Binswanger 1993; Morduch 1994; Mosley and Verschoor 2005; Dercon and Christiaensen 2011).

In standard economic theories, risk attitudes are assumed to be persistent individual characteristics and should not be altered by changes in individual circumstances such as shocks (Stigler and Becker, 1977). A recent review of empirical studies by Chuang and Schechter (2015) confirms the temporal stability of risk attitudes in the absence of shocks. In the presence of shocks, however, evidence suggests that one needs to distinguish between the individual and the aggregate impact level of shocks (Liebenehm 2018). More specifically, risk attitudes seem to be unaffected by idiosyncratic shocks, such as sudden unemployment, health impairments, or changes in income, assets, or wealth (Brunnermeier and Nagel 2008; Chiappori and Paiella 2011; Sahm 2012). In contrast, covariate shocks such as natural disasters, economic crises or social conflicts seem to significantly affect risk attitudes[1].

A closer look at current studies reveals that there is little consensus as to whether covariate shocks induce individuals to become more or less risk averse. For example, empirical studies that investigate the impact of natural disasters find evidence for increasing risk aversion (Cameron and Shah 2015; Chantarat et al. 2015; Cassar, Healy, and Kessler 2017), decreasing risk aversion (Bchir and Willinger 2013; Hanaoka, Shigeoka, and Watanabe 2014; Kahsay and Osberghaus 2017), or an inconsistent effect (Eckel, El-Gamal, and Wilson 2009; Willinger, Bchir, and Heitz

[1]See Appendix Table A1 for an overview of the empirical studies.

2013).[2] However, an important problem with concluding from the existing literature is the difficulty of identification. In this regard, most studies rely on cross-sectional data collected after shock occurrence and, hence, inference may lead to biased results. Among the few extant studies using representative panel data is the study by Hanaoka et al. (2014) which investigates the impact of the great East Japan earthquake in 2011 and the study by Kahsay and Osberghaus (2017) which investigates the impact of storm damage during 2012 and 2014 in Germany. Both studies reveal that individuals that were exposed to the adverse events showed lower levels of risk aversion.

In this paper, we use a representative individual-level panel data set from rural Thailand and Vietnam and combine it with historical rainfall data to overcome the identification problem inherent in most studies. We investigate whether and in which direction variations in risk attitudes can be explained by variations in rainfall risk. To identify the effect of rainfall risk on risk attitudes we use the village-specific Standardized Precipitation Index (SPI), recommended by the World Meteorological Organization (WMO) to monitor abnormal rainfall patterns. We are able to control for time fixed effects, district-specific time trends, and other time-varying control variables, arguably allowing us to capture exogenous rainfall shocks. In addition, we examine different channels at work that may affect the impact of rainfall risk on risk attitudes such as risk mitigating strategies.

Our econometric results show that rainfall risks, both severe shortages and severe excesses, increase respondents' risk aversion. We find that this impact of rainfall risk is lower for farmers than for non-farmers, contrary to a priori expectations. Further analyses of differences between farmers and non-farmers indicate that farmers may benefit from irrigation and ex-post coping measures. Such strategies proved to be effective in mitigating adverse rainfall shocks.

Our finding that rainfall shocks increase risk aversion is consistent with other studies that particularly investigated weather shocks in Southeast Asia (Cameron and Shah 2015; Chantarat et

[2] A similar pattern is echoed in the research on social conflict. While Voors et al. (2012) suggest that violent conflict decreases risk aversion of rural Burundis, Callen et al. (2014) and Kim and Lee (2014) find the opposite effect of violence during the wars in Afghanistan and Korea, respectively.

al. 2015; Cassar, Healy, and Kessler 2017), but contradicts results from the few extant panel studies from the developed world (Hanaoka et al. 2014; Kahsay and Osberghaus 2017).

The remainder of the paper is organized as follows. In the next section, we describe our two data sources. In Section three, we introduce the empirical strategy and present main results. In Section four, we test the robustness of results, and we finally draw conclusions in Section five.

Section 2: Data

We use two different data sources, i.e., (i) individual-level panel data and (ii) historical rainfall data at the village level. Individual-level panel data come from "Impact of shocks on the vulnerability to poverty: Consequences for development of emerging Southeast Asian economies" project funded by the German Research Foundation (TVSEP). The survey covers 4,212 representative households in rural areas in Thailand and Vietnam that were interviewed in 2008, 2010, and 2013. We use a reduced sample of 1,844 identical respondents across the three survey waves with comprehensive socio-economic and behavioral information available at the individual level. More specifically, we draw information on age, education, health, income generating activities, and risk attitudes. We measure risk attitudes using the survey-based measure of Dohmen et al. (2011) in which respondents are asked to classify themselves on an eleven-point Likert scale. The survey question reads, "Are you generally a person who is fully prepared to take risks, or do you try to avoid taking risks? Please choose a number on a scale from zero (unwilling to take risks) to ten (fully prepared to take risks)". The survey-based measure is not a perfect measure of risk aversion because it does not reflect risk aversion in the concavity of the utility function (Arrow 1971; Pratt 1966). Nonetheless, the survey-based measure has been validated in several countries and several contexts and is generally found to be less noisy than other experimental measures (Wölbert and Riedl 2013; Guiso, Sapienza, and

Zingales 2013; Chuang and Schechter 2015; Lönnqvist et al. 2015). Furthermore, Hardeweg, Menkhoff and Waibel (2013) validated the survey-based measure in an incentive-compatible experiment using a sub-sample of the current paper's sample. In the following we define this variable as the respondent's willingness to take risk (WTR).

Our source for rainfall data is the satellite derived TRMM-adjusted merged-infrared precipitation (3B42 V7) product. It provides daily rainfall data for the period 1998 to 2014 for every village. These 3 hourly precipitation estimates were generated by first using the TRMM VIRS and TMI orbit data (TRMM products 1B01 and 2A12) and the TMI/TRMM Combined Instrument (TCI) calibration parameters (from TRMM product 3B31) to produce IR calibration parameters. The derived IR calibration parameters were then employed to adjust the merged-IR precipitation data, which consists of GMS, GOES-E, GOES-W, Meteosat-7, Meteosat-5, and NOAA-12 data. The final gridded, adjusted merged-IR precipitation (mm/hr) have a 3 hourly temporal resolution and a 0.25-degree by 0.25-degree spatial resolution and extend from 50 degrees south to 50 degrees north latitude. We calculated monthly average rainfall for each village using the TRMM data series, to which we fitted a two-parameter gamma distribution to obtain the Standardized Precipitation Index (SPI) (Edwards and McKee 1997).

The use of SPI is recommended by the World Meteorological Organization (WMO) for monitoring dry spells. More specifically, it measures the number of standard deviations from the long-term precipitation average after the long-term precipitation has been normalized (Edwards and McKee 1997; Trenberth et al. 2014). For interpretation, a severe shortage occurs when the SPI value is below -1.0; a severe excess occurs when the SPI value is above 1.0 (Hayes 2000). Here we use a 12 month timescale for the SPI data and combine it with the retrospective individual survey data for three survey years in 2008, 2010, and 2013 covering the same reference period from May_{year-1} to $April_{year}$. Figures 1 and 2 show the average WTR and the SPI at the district level, for the years 2008, 2010 and 2013 for Thailand and Vietnam, respectively. Finally, we use general village information such as infrastructure, employment and agriculture, obtained from the village head men. Table 1 shows summary statistics of our sample[3].

[3] There was no village head interview in the survey wave 2008, we use the information provided by the village head men in 2007.

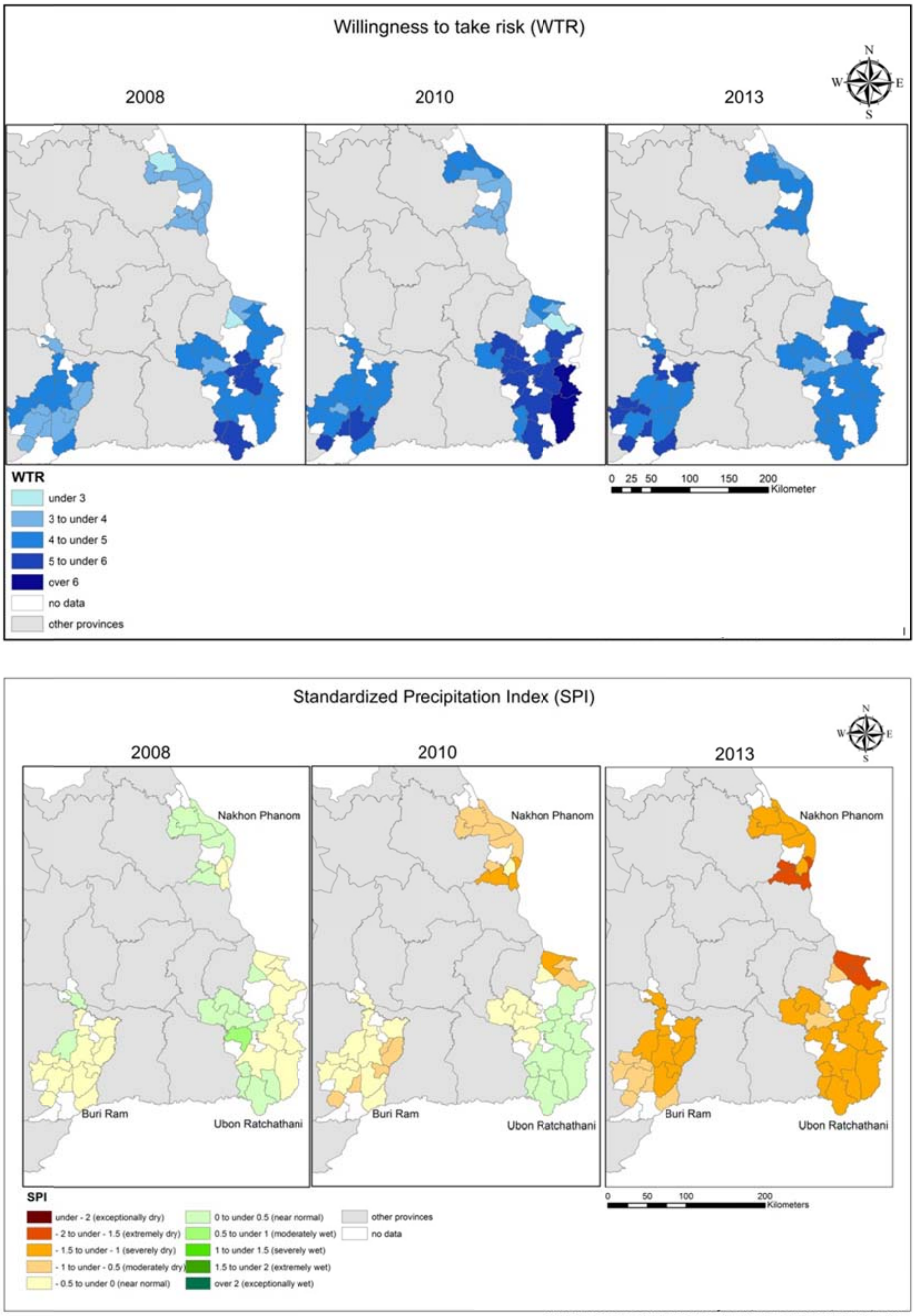

Figure 1: WTR and SPI Thailand
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

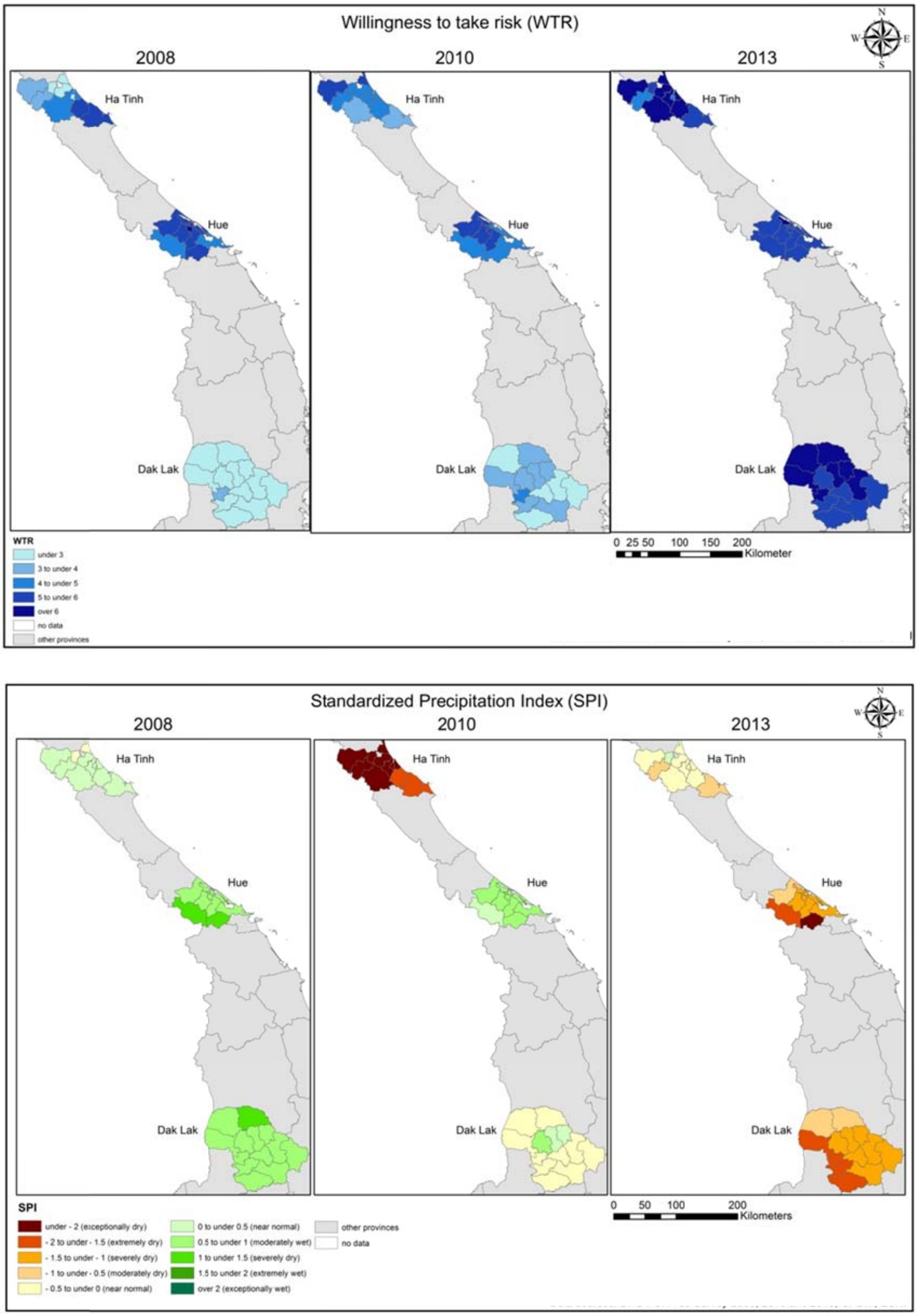

Figure 2: WTR and SPI Vietnam
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

Table 1 Descriptive statistics

	Thailand			Vietnam		
	2008	**2010**	**2013**	**2008**	**2010**	**2013**
Individual level						
WTR	3.992	4.541	4.561	3.374	4.113	5.653
Age (years)	52.075	54.097	57.137	48.82	50.826	53.993
Education (years)	5.093	5.114	5.167	7.503	7.509	7.511
Main occupation						
Farmer	0.7	0.669	0.644	0.748	0.69	0.686
Non-farm self-employed	0.09	0.095	0.079	0.09	0.098	0.097
Civil servant	0.018	0.012	0.02	0.02	0.027	0.016
Unemployed	0.033	0.023	0.086	0.037	0.031	0.02
Health status						
Healthy	0.534	0.551	0.51	0.143	0.215	0.098
Can manage	0.315	0.324	0.338	0.626	0.508	0.56
Sick	0.15	0.124	0.152	0.232	0.277	0.342
Born in the village	0.671	0.676	0.678	0.62	0.617	0.617
Village level						
Main road						
Two-lane made road	0.53	0.511	0.755	0.404	0.624	0.514
Single-lane made road	0.317	0.399	0.224	0.068	0.011	0.095
All-season dirt road	0.075	0.078	0.021	0.481	0.327	0.384
Seasonally not viable	0.078	0.012	0	0.047	0.038	0.007
Average share of crop farmers	0.861	0.846	0.827	0.929	0.892	0.894
Average land size owned (ha)	1.816	1.361	2.484	0.732	0.749	0.773
Area share of HHs that irrigate	0.111	0.118	0.09	0.722	0.712	0.761
Average share of HHs that cope with rainfall shocks *ex-post*	0.232	0.184	0.305	0.406	0.297	0.331
Average share of HHs that prevent rainfall risks *ex-ante*	0.109	0.071	0.109	0.14	0.255	0.277
Average SPI	-0.027	-0.362	-1.196	0.547	-0.7	-0.91
Average number of shortages	n.a.	0.051	0.766	n.a.	0.397	0.545
Average number of excesses	n.a.	n.a.	n.a.	0.082	0.034	n.a.
N	**892**	**892**	**892**	**950**	**950**	**950**

Source: TVSEP Survey 2008, 2010 and 2013, own calculations.
Notes: Means are calculated by survey weights. Village level information reported for 2008 come from the village head survey in 2007.

Section 3: Empirical strategy and main results

3.1 Empirical strategy

To identify the effect of rainfall risk on risk attitudes we use village-specific SPI to explain individual willingness to take risk (*WTR*), controlling for time-varying individual and village level characteristics in each survey year. Our underlying rationale is that abnormal rainfall should directly affect individuals whose major income generating activity is agricultural production on their own farm. We therefore interact *SPI* with *Farmer* to investigate whether the effect of rainfall risk is different for farmers and non-farmers. Furthermore, we add a third interaction term, i.e., time (*T*) to examine whether the effects may have varied over time. Our first specification is as follows:

$$\text{(1)} \quad \begin{aligned} WTR_{ivdt} &= \beta_0 + \beta_1 (SPI_{vdt} \;\; x \;\; Farmer_{ivdt}) + \beta_2 (SPI_{vdt} \;\; x \;\; Farmer_{ivdt} \; x \;\; T_t) \\ &+ X'_{ivdt}\,\gamma + V'_{vdt}\,\delta + \theta_v + \theta_{dt} + \varepsilon_{ivdt}, \end{aligned}$$

where the matrix *X* contains individual characteristics, namely, age, education, and health, and the matrix *V* represents village level control variables, i.e., the quality of roads, the average share of crop production, and the average land size owned. In addition, we include village fixed effects, θ_v, and district-specific time trends, θ_{dt}.

A priori one should expect β_1 to be positive: abundant rainfall improves agricultural production and, hence, increases farmers' WTR, whereas insufficient rainfall worsens agricultural production and, hence, decreases farmers' WTR. β_2 is likely to be negative as the effect of insufficient rainfall that decreases agricultural production should decrease over time due to learning and adaption processes.

3.2 Main results

Table 2 contains the main results of estimating equation (1) using six different specifications to show the sensitivity of results with respect to different sets of controls. The main effect of rainfall risk on respondents' willingness to take risk is positive, but not significant (column 1). However, column 2 shows that the effect of rainfall risk is significantly negative for a farmer. The p-value reported on the interaction term between *SPI_12* and *Farmer* in column 2 tests whether the effect of rainfall risk is different between farmers and non-farmers. This hypothesis cannot be rejected at the 5% significance level (p-value < 0.05). More specifically, if exposed to severe rainfall excesses, i.e., SPI is larger than 1, a farmer's WTR is 0.236 points lower than a non-farmer's WTR. In contrast, if a farmer is exposed to severe shortages, i.e., SPI is below -1, her WTR is 0.259 points larger than a non-farmer's WTR (Figure 3). Comparing the marginal effect of SPI to the effect of other variables illustrates the quantitative effect of rainfall risk on farmers' risk aversion. For example, marginal effects of an additional year in age and an extra year of schooling are 0.07 and 0.1 points, respectively, but are not significantly different between farmers and non-farmers (see Appendix Figure A1).

So far the results show that rainfall risk does not matter for respondents' risk attitudes on average in our sample. But, as expected, rainfall risk matters for those who are directly dependent on it, i.e., farmers, who make a living from their own agricultural fields. However, the sign of the rainfall risk effect on farmers' risk attitude is negative and not in line with our expectations. Before we investigate this seemingly counter-intuitive finding further, we first investigate the dynamics of the SPI effect in Column 3.

Table 2 Rainfall risk and risk aversion

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Basic	Farmer interaction	Year interaction	District-time interaction	Shortage and excess (binary indicators)	Shortage and excess (threshold indicators)
Individual level						
Age	0.151***	0.117***	0.114***	0.101***	0.115***	0.114***
Age²	-0.002***	-0.001***	-0.001***	-0.001***	-0.001**	-0.001***
Education						
Secondary education	0.49***	0.256***	0.251*	0.238*	0.25**	0.253**
Tertiary education	0.121	0.048	0.055	0.024	0.043	0.047
Sick	-0.466***	-0.477***	-0.502***	-0.518***	-0.489***	-0.484***
Farmer	-0.061	-0.168	0.138	0.201	-0.167	-0.122
Village level						
SPI_12	0.085	0.172	-0.056	0.232	-0.282**	-0.267**
Shortage					-0.982***	0.476***
Excess					-1.829***	-1.677***
Main road						
Single-lane	-0.059	-0.103	-0.077	0.003	-0.113	-0.14
All-season dirt	-0.742***	-0.185	-0.142	0.054	-0.139	-0.162
Seasonally not viable	-0.594*	-0.216	-0.457	0.05	-0.304	-0.348
Average share of crop farmers	0.176	0.843*	0.863*	1.007**	0.692	0.682
Average land size owned (ha)	-0.045	-0.154**	-0.133**	0.014	-0.125**	-0.125*
Interactions						
SPI_12 x Farmer		-0.248**	-1.261***	-1.021***		
SPI_12 x Farmer x 2010			1.306***	0.997***		
SPI_12 x Farmer x 2013			1.12**	0.859*		
Shortage x Farmer					0.406*	-0.165
Excess x Farmer					0.391	0.36
Year effects	Yes	Yes	No	No	Yes	Yes
Village fixed effects	No	Yes	Yes	Yes	Yes	Yes
District-specific time effects	No	No	No	Yes	No	No
R^2	0.074	0.179	0.188	0.254	0.185	0.184
N	5442	5442	5442	5442	5442	5442

Source: TVSEP Survey 2008, 2010 and 2013, own calculations.
Notes: OLS with survey weights. The dependent variable is willingness to take risk (WTR). Single, double, and triple asterisks (*, **, ***) denote p < 0.10, 0.05, and 0.01, respectively.

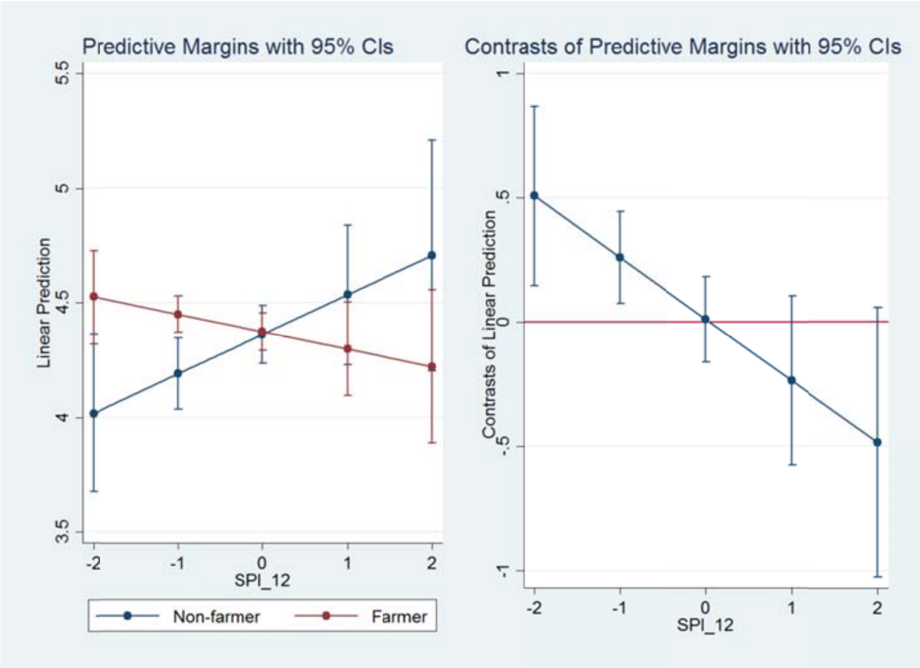

Figure 3: Difference in rainfall risk effect between farmers and non-farmers
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

Column 3 introduces a three-way interaction between rainfall risk, farmer, and time. It shows that the negative effect of rainfall risk on farmers' WTR is reduced over time. In 2008, an increase in rainfall risk by one standard deviation decreased a farmer's WTR by 1.32 points, while by 2010 this negative marginal effect was reduced to 0.05 points. By 2013, however, the negative effect turned positive (Figure 4). This implies that rainfall excesses increase farmers' risk aversion in 2008, to a lesser extent in 2010, and in 2013 it is rainfall shortages that increase farmers' risk aversion. This time trend remains statistically robust when we include district-specific time trends in column 4.

The temporal changes in farmers' risk attitudes match with the temporal distribution of severe rainfall excesses and shortages displayed in Figures 1 and 2. In 2008, there were severe rainfall excesses, especially in Vietnam. In 2010, we observe a mixed picture of extreme dry spells in Ha Tinh (Vietnam), moderately to severe dry spells in Nakhon Phanom (Thailand) as well as severe excesses in Hue (Vietnam). 2013 is characterized as severely to extremely dry in both countries. Hence, extreme deviations in rainfall on either side, such as excesses in 2008 or shortages in

2013, seem to increase farmers' risk aversion. Considering these patterns in conjunction with the change in coefficient sign over time is indicative of a non-linear relationship between SPI and risk aversion, in particular at its extreme values.

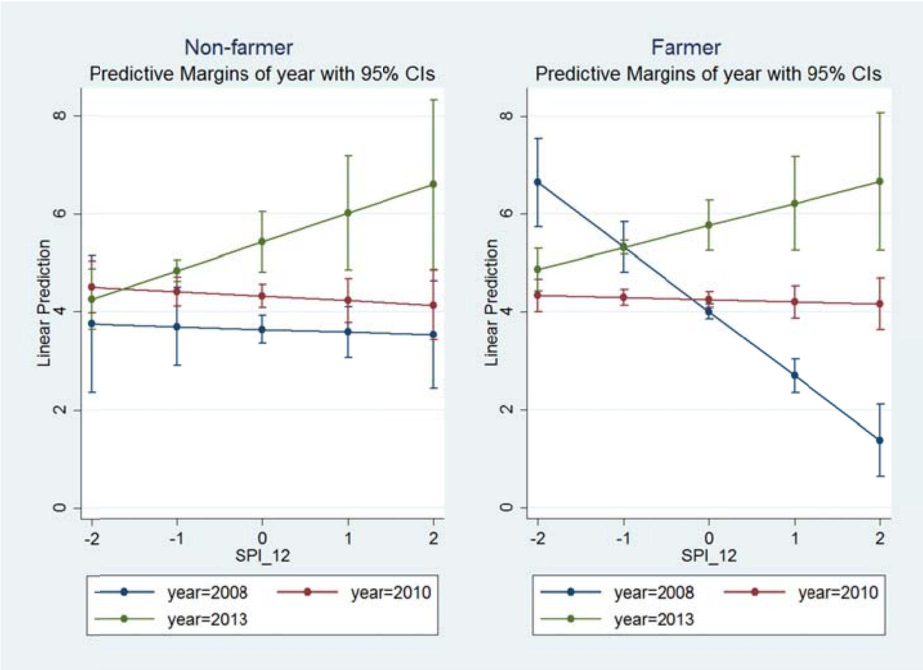

Figure 4: Rainfall risk effect on respondents' WTR for farmers and non-farmers across years
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

In order to allow for different effects of severe deviations from the long-term rainfall mean, we include excess and shortage indicators in column 5, defined as dummy variables that take on the value of 1 when SPI is greater than or equal to 1 and less than or equal to negative 1, respectively, and zero otherwise. One finds that the main effect of both events is negative. A severe rainfall shortage significantly reduces respondents' WTR by 0.71 points on the Likert scale, whereas a severe rainfall excess reduces respondents' WTR by 1.56 points. Moreover, in contrast to what we expected, both negative effects are lower for farmers than for non-farmers, albeit not statistically significant (Figure 5).

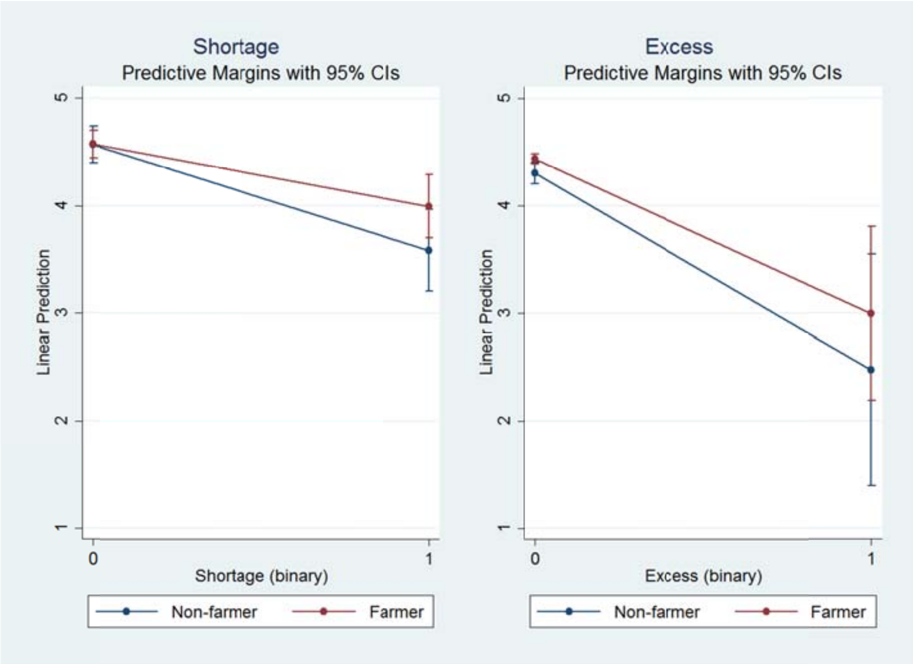

Figure 5: Effects of shortages and excesses on farmers' and non-farmers' WTR (binary specification)
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

These results remain statistically robust to when we define rainfall shortage and excess as threshold variables that take on the SPI value if the SPI is greater than or equal to 1 in the case of excess rainfall, less than or equal to negative 1 in case of shortages, and zero otherwise (column 6). As shown in Figure 6, if the SPI value is below negative one, i.e., a severe shortage, respondents' WTR decreases by 0.364 points on the Likert scale. Similarly, if the SPI value is above 1, i.e., a severe rainfall excess, a respondent's WTR is 1.431 points lower than if the SPI would be 0. As before, both negative effects are lower for farmers than for non-farmers, albeit the difference is not statistically significant.

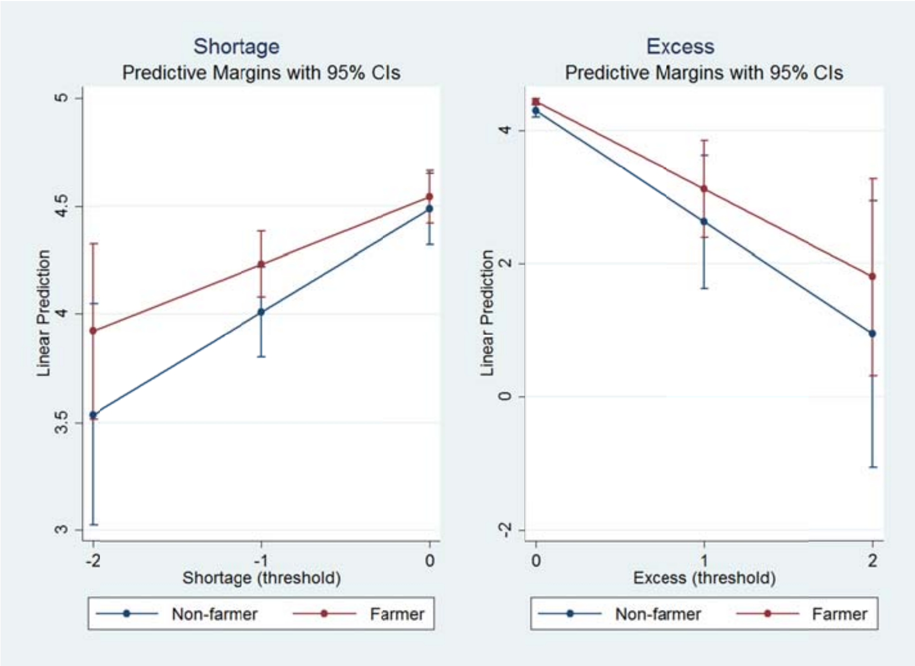

Figure 6: Effects of shortages and excesses on farmers' and non-farmers' WTR (threshold specification)
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

To summarize the results at this stage, we find that any deviation from the long-term mean of rainfall, both a severe shortage and a severe excess, increases respondents' risk aversion. The impact of both rainfall shock types on respondents' risk attitudes is, however, lower for farmers than for non-farmers – although farmers may be more sensitive to changes in rainfall patterns than non-farmers.

One possible explanation for the unexpected result that the negative effects of shortages and excesses are lower for farmers than for non-farmers is the heterogeneous composition of the non-farmer group and the divergent distribution of their average WTR. For example, approximately 30% of non-farmers are non-farm self-employed and their average WTR is 4.979. Approximately 26% are engaged in occasional and light work or cannot work and their WTR is 3.725 and 3.368, respectively. The overall average WTR of the non-farmer group is 0.2 points lower than farmers' average WTR (Appendix Table A2). In other words, non-farmers are more risk averse than farmers in the absence of negative rainfall shocks (predictive margins of non-farmers are below predictive margins of farmers). Also, the negative effect of shortages and excesses is possibly more severe for unfortunate respondents engaged in occasional work or respondents who are unable to work because of sickness or high age than for farmers engaged in their own agricultural fields (predictive margins of non-farmers are steeper than predictive margins of farmers) [4].

Section 4: Robustness

We now examine other channels through which rainfall shocks might affect individuals' risk attitudes. First, we investigate regional differences in the effects of rainfall shortages and excesses. Second, we explore to what extent different mitigating strategies can reduce the negative effects of rainfall shortages and excesses.

4.1 Regional effects

To test whether the negative effects of rainfall shortages and excesses on individuals' WTR remain across different regions, we separately re-estimate Model 5 for each province in Thailand and Vietnam (Table 3). In Thailand, severe shortages appear to reduce respondents' WTR in all three provinces, where in Ubon Ratchathani, the largest province which has seen severe to extreme shortages in 2013, the decrease in WTR is significant at the 10% level[5].

[4] To further investigate the unexpected result, we re-define the variable *Farmer* in three different ways comparing the effects of shortages and excesses between (*i*) farmers engaged on their own fields and non-farm self-employed respondents, (*ii*) agricultural occupations and non-agricultural occupations (both self-employed and employed), and (*iii*) agricultural, non-agricultural occupations and non-working respondents. Results are according to expectation, i.e., predictive margins of respondents engaged in agriculture are below predictive margins of respondents engaged in non-agriculture. Further, the slope of a severe rainfall excess is steeper for agricultural-related occupations than for non-agricultural occupations (see Appendix Figures A2-A4).

[5] There are no incidences of severe rainfall excesses (i.e. SPI > 1) in Thailand.

Table 3 Average marginal effects of shortages and excesses on risk aversion, by province

	Thailand			**Vietnam**		
	Buriram	**Ubon Ratchathani**	**Nakhon Phanom**	**Ha Tinh**	**Hue**	**Dak Lak**
Shortage	-0.682	-0.554*	-1.0	-1.17	0.312	-1.573**
Shortage x Farmer	0.135	0.299	0.704	-0.205	1.277*	0.262
Excess	n.a.	n.a.	n.a.	n.a.	-0.658	-1.35**
Excess x Farmer	n.a.	n.a.	n.a.	n.a.	1.251**	1.423***
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Village fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
District-specific time effects	No	No	No	No	No	No
R^2	0.121	0.15	0.132	0.268	0.204	0.458
N	1049	1135	449	975	891	943

Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

Notes: OLS with survey weights. The dependent variable is willingness to take risk (WTR). n.a. indicates that the incidence of rainfall shortage or excess is not available in the province. Single, double, and triple asterisks (*, **, ***) denote p < 0.10, 0.05, and 0.01, respectively.

The picture in Vietnam is more diverse. In the southern province of Dak Lak, that was both exposed to severe excesses in 2008 and to severe shortages in 2013, we obtain significant negative main effects of shortages and excesses. However, a farmer in Dak Lak that is exposed to rainfall excesses shows a WTR that is 1.423 points higher than a non-farmer in the same situation. The main effects of shortages and excesses are not significant in Vietnam's central province Hue, although there were excesses in 2008 and 2010 and a dry spell in 2013. However, the interaction terms with the variable *Farmer* are positive and significant. That means, in the incidence of a severe shortage, a farmer's WTR is 1.277 points larger than a non-farmer's WTR, whereas in the presence of a severe rainfall, a farmer's WTR is 1.251 points larger. Finally, Ha Tinh – characterized by an exceptional dry spell in 2013 – does not show a significant main effect nor a significant difference between farmers and non-farmers.

Albeit not significant in every region, we find that the main results remain robust, i.e., a severe shortage and a severe excess are associated with an increase in respondents' risk aversion and the negative effect of both rainfall shock types is lower for farmers than for non-farmers.

4.2 Effects of risk mitigating strategies

Possible strategies that we expect to mitigate negative effects of rainfall shocks are (i) the share of households who irrigate their agricultural land in the village, (ii) the share of households who coped with rainfall shocks *ex-post*, and (iii) the share of households who *ex-ante* applied strategies to mitigate rainfall risks. We re-estimate Model 5 from Table 1 as follows:

$$
\begin{aligned}
(2) \quad WTR_{ivdt} = {} & \beta_0 + \beta_1 (Shortage_{vdt} \ \ x \ \ Farmer_{ivdt}) + \beta_2 (Excess_{vdt} \ \ x \ \ Farmer_{ivdt}) \\
& + \phi (Shortage_{vdt} \ \ x \ \ Farmer_{ivdt} \ x \ \ Mitigation_{vdt}) + \psi (Excess_{vdt} \ \ x \ \ Farmer_{ivdt} \ x \ \ Mitigation_{vdt}) \\
& + X'_{ivdt} \gamma + V'_{vdt} \delta + \theta_v + \theta_{dt} + \varepsilon_{ivdt},
\end{aligned}
$$

where all three mitigation strategies captured by the vector $Mitigation_{vdt}$ are simultaneously estimated. ϕ and ψ should then be positive if the respective strategy is effective in reducing the negative effect of rainfall shortages and excesses on individuals' WTR.

Figure 7 plots average marginal effects (AMEs) of shortages and excesses on farmers' and non-farmers' WTR for different shares of households that irrigate their agricultural land at village level. In villages where there is no irrigation, a severe shortage appears to decrease farmers' WTR by 1.17 points on the Likert scale. In the counterfactual scenario, i.e., in villages where all households irrigate their agricultural land, the marginal effect of rainfall shortage on farmers' WTR is significantly positive (0.91). As one would expect, the larger the share of land under irrigation is, the smaller is the negative impact of dry spells for farmers. For non-farmers, one can also find the mitigating effect of irrigation, but – as indicated by the drop of the 95% confidence interval below the zero-effect-threshold – it is not statistically significant.

Furthermore, the right panel of Figure 7 shows that irrigation is not effective in mitigating negative effects of severe rainfall excesses.

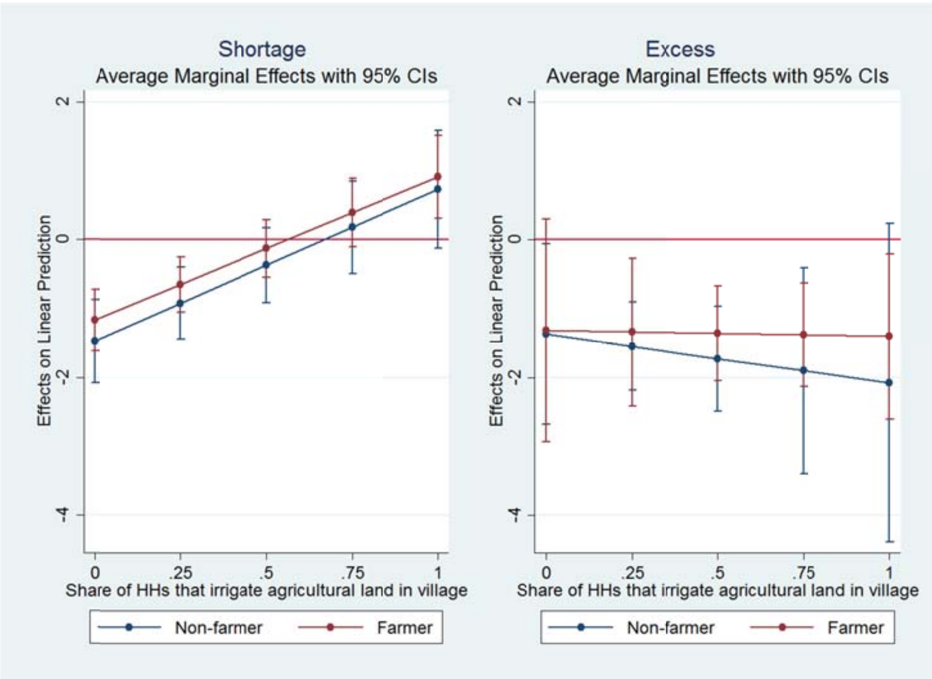

Figure 7: Effects of shortages and excesses on farmers' and non-farmers' WTR mitigated by irrigation

Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

Ex-post coping strategies applied after the experience of severe rainfall shocks include, for example, the adjustment of income generating activities, official help from governmental or non-governmental institutions, or informal help from friends or relatives within respondents' social networks[6]. The left panel of Figure 8 shows AMEs of shortages on farmers' and non-farmers' WTR for different shares of households that reported having undertaken a coping measure after experiencing a dry spell. As in the case of drought mitigation by irrigation, it appears that *ex-post* coping significantly decreases the negative effect of rainfall shortages on farmers' WTR from -0.699 to 1.07. Non-farmers follow the same trend, but the mitigating effect of *ex-post* coping is not statistically significant.

The right panel of Figure 8 illustrates AMEs of rainfall excesses for different shares of households that applied coping measures after excesses. In this case we obtain a different picture, i.e., non-farmers can significantly decrease the negative effect of rainfall excesses from -2.43, where nobody would apply any coping measure, to 5.07 , where all households would apply *ex-post* coping in the village. In contrast, farmers barely achieve the zero-effect-threshold.

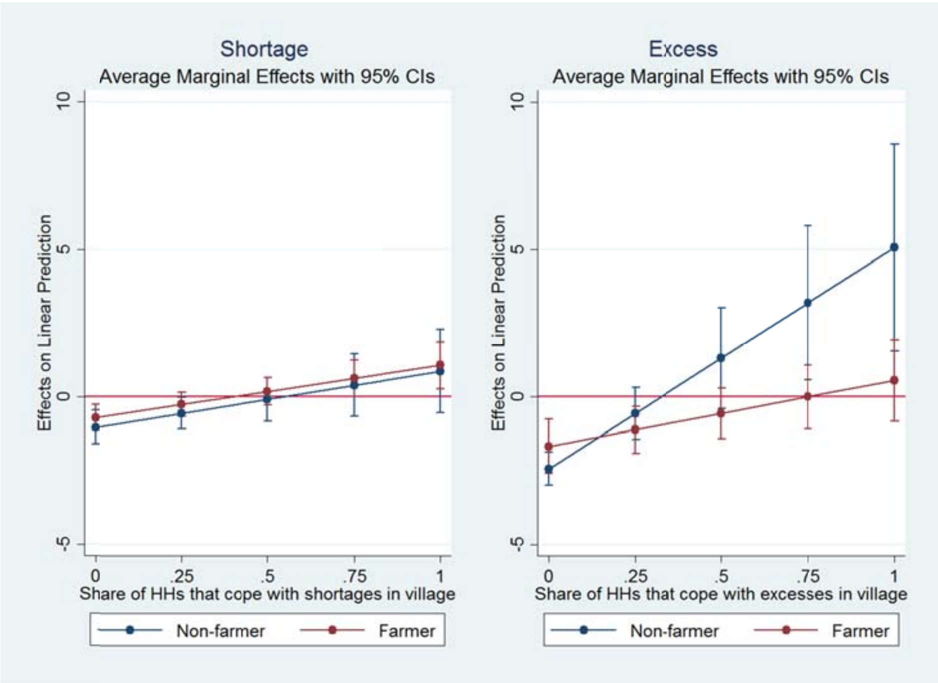

Figure 8: Effects of shortages and excesses on farmers' and non-farmers' WTR mitigated by coping strategies applied *ex-post*
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

[6] The interested reader can find a detailed summary of *ex-post* coping measures applied after shortages and excesses in the Appendix (Figure A5).

Finally, preventive measures *ex-ante* shock occurrence involve, for example, smoothing assets, investing in physical and human capital or contracting insurances[7]. We excluded collective preventive strategies, such as improving infrastructure or building dikes, or terraces, because of strong correlation with the share of households that irrigated agricultural land in the village. Figure 9, hence, shows AMEs of shortages and excesses on farmers' and non-farmers' WTR for different shares of households that reported individual strategies to prevent rainfall risks. In case of rainfall shortages, *ex-ante* risk prevention does not show a mitigating effect on respondents' WTR, neither for farmers, nor for non-farmers. In case of rainfall excesses, effects are different between farmers and non-farmers. The larger the share of households that apply preventive measure is, the smaller is the negative effect of rainfall excesses for farmers. For non-farmers, ex-ante risk prevention appears to even increase the negative effect of excesses. However, as indicated by the 95% confidence intervals in the right panel of Figure 9, mitigating effects in case of rainfall excesses are not statistically significant.

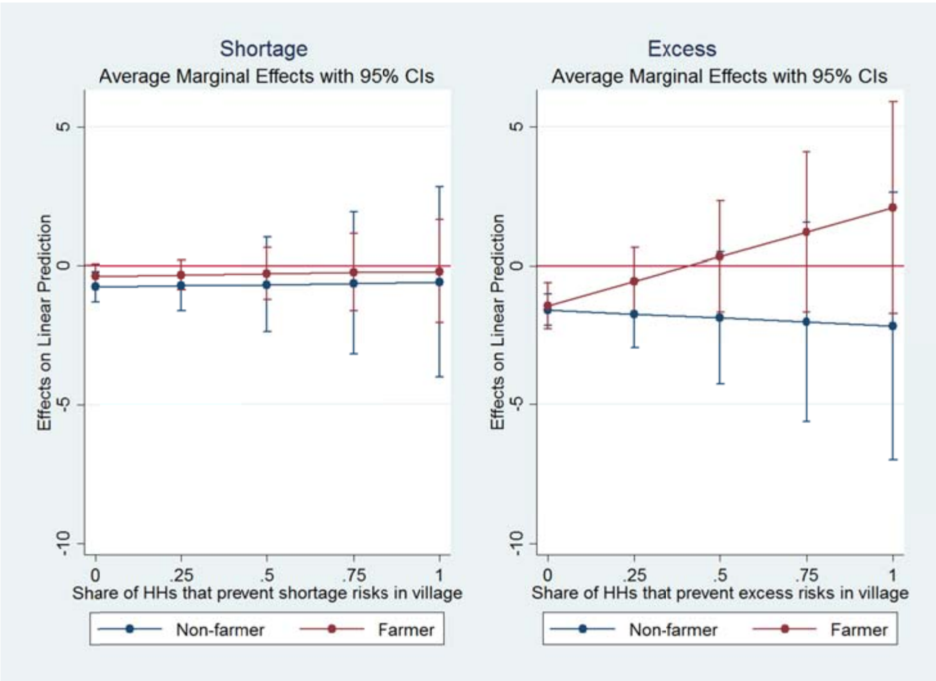

Figure 9: Effects of shortages and excesses on farmers' and non-farmers' WTR mitigated by individual preventing strategies applied
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

[7] The interested reader can find a detailed summary of *ex-ante* strategies applied to prevent shortages and excesses in the Appendix (Figure A6).

Comparing the effects of the three mitigation strategies among farmers and non-farmers, we find significant positive mitigating effects of rainfall shortages through irrigation and *ex-post* coping for farmers, but not for non-farmers. For non-farmers, however, we find significant mitigating effects of rainfall excesses associated with *ex-post* coping.

In other words, farmers seem to be better than non-farmers in alleviating negative effects of droughts by means of irrigation systems that are an inherent component of agricultural production in dry areas and during abnormal rainfall periods. Farmers also seem to be better than non-farmers in coping with droughts *ex-post*. Comparing farmers' coping strategies with non-farmers' coping strategies shows no significant differences except that farmers sell more assets after droughts (Appendix Figure A5). Probably it is farmers' ability to sacrifice assets to smooth negative effects of droughts. In case of floods, however, a non-farmer can reduce the negative effects through *ex-post* coping, whereas a farmer cannot. Figure A5 shows no differences in coping strategies associated with floods between farmers and non-farmers. The dominant strategies of both groups are the adjustment of income generating activities, external help from governmental or non-governmental institutions and external help from friends and relatives. In this context it is probably the nature of coping strategy that matters. For example, a non-farmer may find it easier to take up additional occupation or to change her employment, whereas a farmer may find it difficult to give up her agricultural self-employment.

Section 5: Summary and conclusions

In this paper we aimed to shed light on the controversy in the literature of whether and – in which direction – do adverse events such, as natural disasters, conflicts, or crises alter risk attitudes over time. To this end, we combined a representative individual-level panel data set from rural Thailand and Vietnam with historical rainfall data and tested if variations in risk attitudes can be explained by deviations from long-term rainfall averages.

Our results showed that a severe deviation from the long-term mean of rainfall, both a severe shortage and a severe excess, appear to increase individuals' risk aversion. In contrast to our expectations, we found that this negative impact is lower for farmers than for non-farmers. We, therefore, further analyzed differences between farmers' and non-farmers' risk mitigation strategies. Results indicate that farmers have an advantage in smoothing negative effects of severe shortages by means of irrigation techniques and by *ex-post* coping abilities of sacrificing assets in comparison to non-farmers.

Comparing our results with results from other studies that investigated the temporal stability of risk attitudes and the impact of covariate shocks, we find similarities and differences. For example, our finding that rainfall shocks increase risk aversion of respondents from rural Thailand and Vietnam is consistent with other studies that investigated natural disasters, and weather shocks in particular, in Southeast Asia (Cameron and Shah 2015; Chantarat et al. 2015; Cassar, Healy, and Kessler 2017). It, however, contradicts results from the few extant panel studies from Japan (Hanaoka et al. 2014) and Germany (Kahsay and Osberghaus 2017).

Arguably our findings may be especially detrimental for the poor in developing countries. If adverse shocks, such as severe floods or droughts, increase risk aversion then poor, risk-averse people are likely to invest in low-risk and low-return activities, further increasing the likelihood that they will remain below the poverty line.

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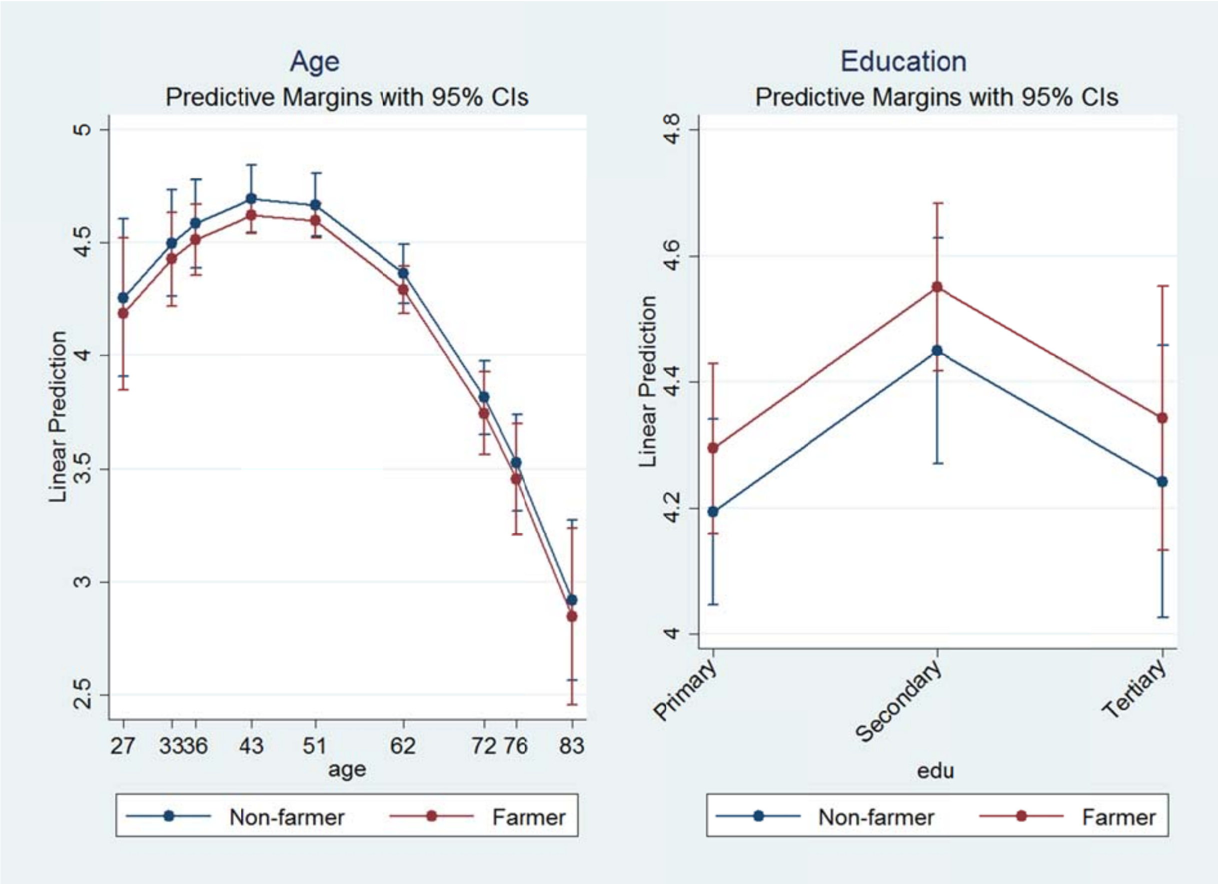
Appendix Table A1 Overview of studies that investigated temporal stability of risk attitudes and the impact of covariate shocks

Shock type	Authors	Shock description	Sample	Time horizon	Measurement of risk aversion	+/- in risk aversion
	Kahsay & Osberghaus (2017)	Storm	4496 German	2012 and 2014	Survey measure (Dohmen et al. 2011)	-
	Cassar et al. (2017)	2004 Tsunami	334 Thai	4.5 years after the Tsunami	Choice task (Holt and Laury 2002)	+
	Hanaoka et al. (2015)	2011 Earthquake	3,221 Japanese	2011 and 2012	Hypothetical lottery question	-
	Chantarat et al. (2015)	2011 flood	256 Cambodian rice farmers	2014	Choice task (Binswanger 1980)	+
Natural disaster	Willinger et al. (2013)	2011 Volcano eruption	160 Indonesian	Jan 2011 and July 2011)	Choice task (Gneezy & Potters 1997)	+/-
	Bchir and Willinger (2013)	Volcano eruption	309 Peruvians	Ex-ante exposure	Choice task (Binswanger 1980)	-
	Cameron and Shah (2015)	Flood or earthquake	1,550 Indonesian	2008	Choice task (Binswanger 1980)	+
	Eckel et al. (2009)	2005 Hurricane	352 US citizen in 2005 and 362 in 2006	2005 and 2006	Choice task (Eckel and Grossman 2002,2006)	- in short run; constant in long run
Economic distress	Guiso et al. (2013)	2008 Financial crisis	666 investors	2007 and 2009	Choice task	+
	Malmendier & Nagel (2011)	Great Depression	51,204 US citizen	1960 - 2007	Survey measure and observed risk behavior	+
Social conflict	Voors et al. (2012)	Violence	300 Burundi	2009	Choice task (Harbaugh et al. 2002)	-
	Callen et al. (2014)	Violence	1,127 Afghani	2002 - 2010	Choice task (Adreoni and Sprenger 2011)	+
	Kim & Lee (2014)	1950-1953 Korean War	7,047 Koreans	2004	Choice task (Holt and Laury 2002)	+

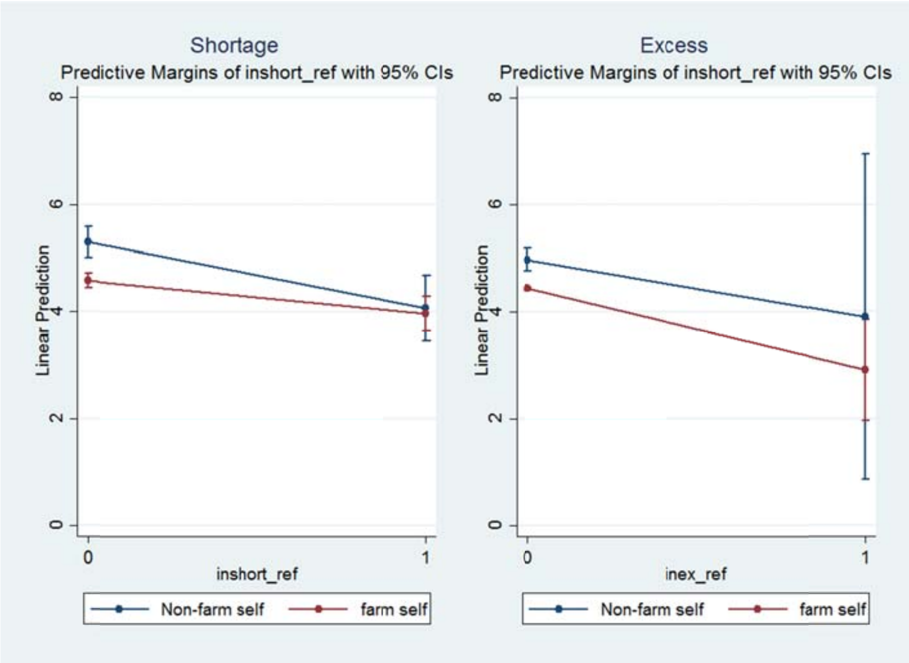


Appendix Figure A1: Effects of age and education between farmers and non-farmers
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.

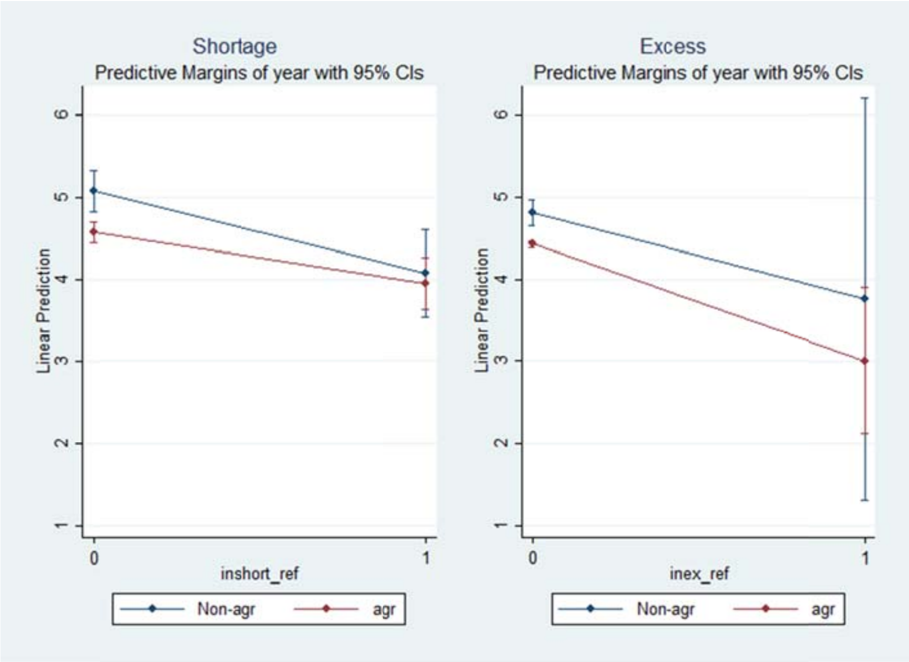
Appendix Table A2 Composition of non-farmer groups and their WTR

	Mean WTR		
	Farmer	**Non-farmer**	$N_{\text{non-farm subpopulation}}$
	4.408	4.291	
Non-farm self-employed		4.979	505
Occasional and light work		3.725	268
Cannot work		3.368	187
Housewife		4.09	151
Civil servant		5.074	121
Casual labor in non-agriculture		4.392	121
Permanently employed in non-agriculture		4.385	120
Unemployed		3.893	101
Casual off-farm labor in agriculture		3.908	87
Fishing, hunting		4.037	44
Permanently employed in agriculture		4.865	26
Other		2.662	7
N	3781	1745	

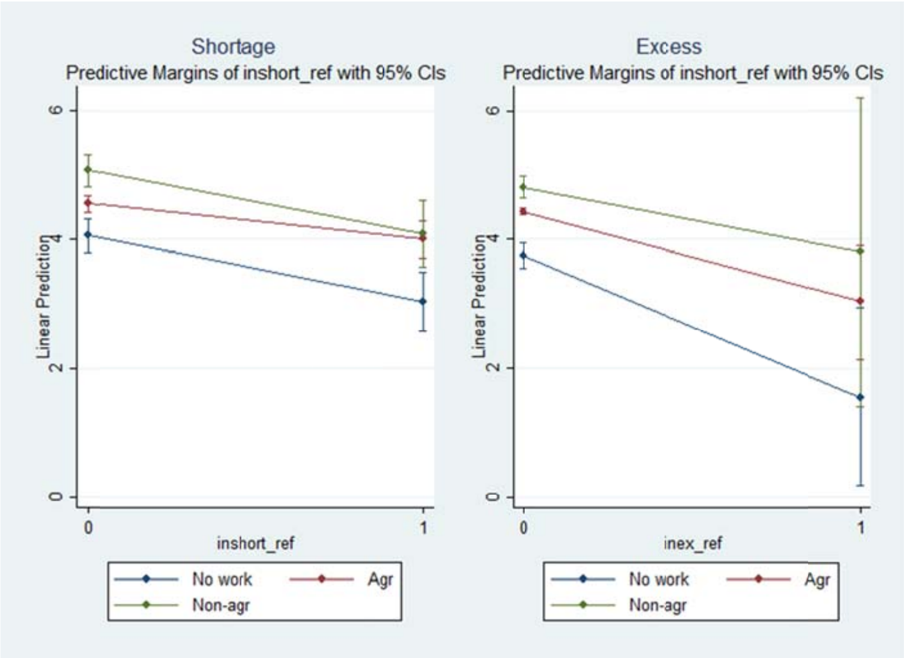
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.
Notes: Other includes respondents who are students, monks and soldiers.



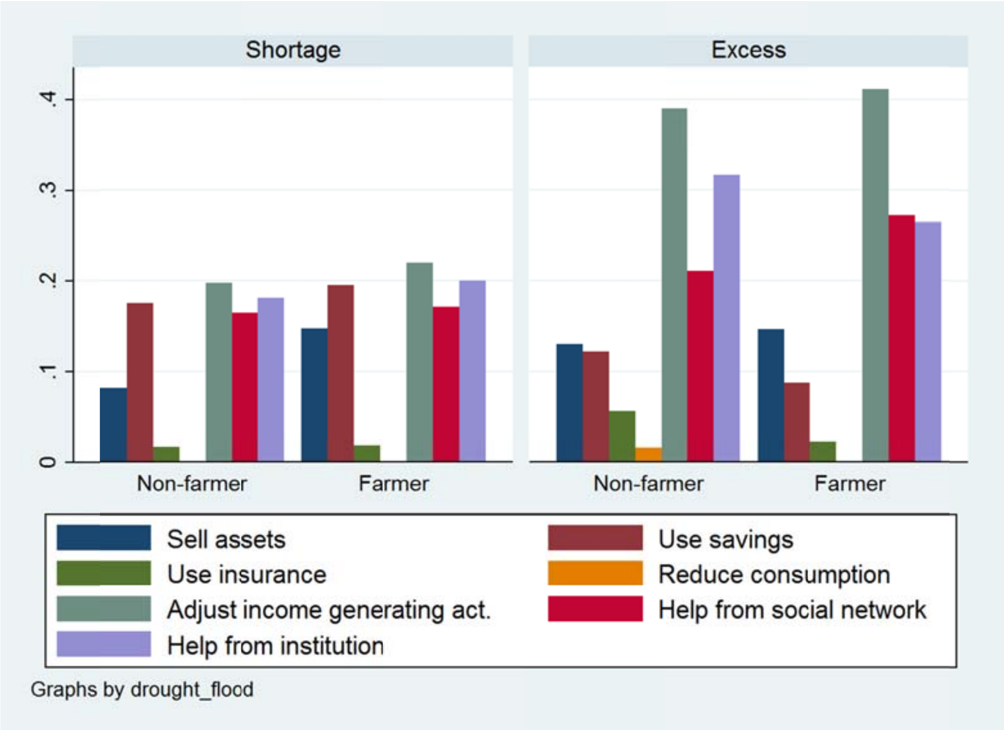
Appendix Figure A2: Effects of shortages and excesses: farmers engaged on their own fields and non-farm self-employed respondents (binary specification)
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.



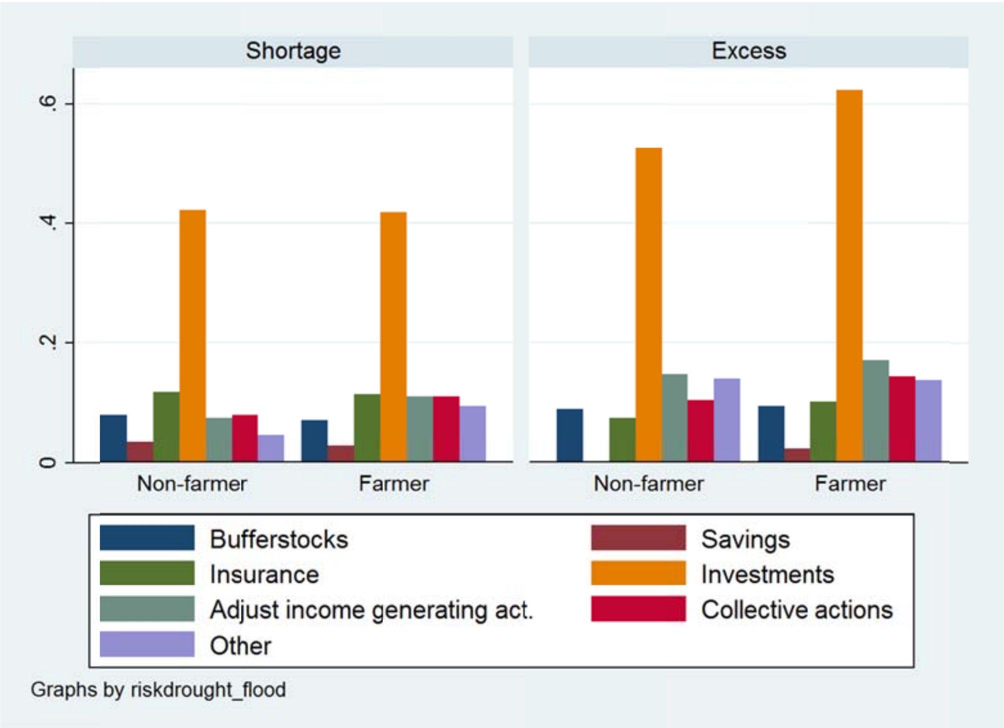
Appendix Figure A3: Effects of shortages and excesses: agricultural occupations and non-agricultural occupations (binary specification)
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.



Appendix Figure A4: Effects of shortages and excesses: non-agricultural, agricultural occupations and non-working respondents
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.



Appendix Figure A5 Ex-post coping strategies associated with rainfall shocks experience
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.



Appendix Figure A6 Ex-ante preventive strategies associated with rainfall risks expected
Source: TVSEP Survey 2008, 2010 and 2013, own calculations.