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ON THE SOURCES OF RISK PREFERENCES IN RURAL VIETNAM

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Abstract

In this paper, I provide new empirical evidence that the natural environment can shape individual risk preferences. By combining historical data on weather variation and contemporary survey questions on risk aversion, I find that risk aversion is significantly different for people who live in areas that have suffered high frequency of natural disasters. In particular, households highly affected by weather volatility show a long-term risk aversion and are more willing to buy insurance to protect crop losses. The finding also supports the hypothesis that when people are used to live in a risky environment, an incremental increase in risk affects their risk preferences less.

JEL classification: D03, Q54, O53
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1. Introduction

Risk preferences play an important role in economics. Studies in experimental economics have tried to examine to the extent to which risk attitudes lead to impacts on economic performance. They find that risk aversion is inversely related to economic outcomes such as investment in physical and human capital and wage growth (Levhari & Weiss 1974; Shaw 1996).

However, most economic analyses assume that the preferences of an individual agent are given and those preferences decide the agent's selection (Stigler & Becker 1977). Based on this assumption, society's economic behaviour is obtained by aggregating the choices of agents in the society. This way of aggregating decisions leaves little room for investigating how the environment in which agents make decisions affects those decisions (Postlewaite 2011). Recent studies, however, suggest that individual experiences can have long-term effects on preferences such as risk and patience. For example, Malmendier and Nagel (2011) investigated whether the experiences of macro-economic shocks, such as after the Great Depression, could affect individuals' long-term risk attitudes. They found that birth cohorts that have experienced high levels of stock market returns throughout their life showed lower risk aversion and tended to participate more in the stock market and invested a higher fraction of their liquid wealth in stocks. Their empirical results also indicated that cohorts that have experienced high inflation are less likely to hold bonds. In another study, Bogan et al. (2012) found that personal traumatic experiences—such as the combat experiences of veterans—have long-term effects on financial decisions. In particular, their findings show that having experienced psychological shocks decreases an individual's willingness to take financial risks.

A few studies have also examined natural environmental influences on shaping preferences and risk attitudes (for example, van den Berg, Fort & Burger 2009; Cameron & Shah 2011; Cassar, Healy & Kessler 2011).[1] All of these studies used field experiments to examine the impact of extreme events, such as tsunamis, floods and

[1]Other papers have investigated the impact of natural disasters on other outcomes such as household welfare (Thomas et al. 2010), macroeconomic output (Noy 2009), income and financial flows (Yang 2008), migration decisions (Halliday 2006; Yang 2008b), fertility and education investments (Baez et al. 2010; Finlay 2009; Portner 2006; Yamauchi, Yisehac & Agnes 2009) and mental health (Frankenberg et al. 2008).

earthquakes, on the risk preferences of village farmers. They found that individuals affected by natural disasters were substantially more risk-averse (Cassar, Healy & Kessler 201; Cameron & Shah 2011). Moreover, Cameron and Shah (2011) showed that both current and historical earthquake events have significant effects on current risk aversion of rural households in Indonesia.

This paper complements the existing studies by examining the effect of the natural environment on individual behaviours. Similar to the other studies, my focus is on rural people who are more vulnerable to unpredictable weather conditions and who depend more on natural resources for survival, when insurance instruments are limited. I ask whether the natural environment can create long-term effects on the risk preferences of rural households in Vietnam. My hypothesis is that people who are heavily exposed to hazardous environments with a high frequency of typhoons, storm and floods tend to be more risk-averse. In addition, I would like to determine whether villagers have different preferences corresponding to different time periods of historical weather variations. In particular, this study tests the hypothesis originally proposed by Kahneman and Tversky (1979) that if the level of risk is high, people may not be particularly concerned about the addition of a small independent risk.

Using data from contemporary individual-level surveys on risk aversion and basing my approach on cumulative prospect and expected utility theories, I calculate different measures of risk aversion of rural households. The use of different questions on willingness to take risks also allows the estimation of whether consistent patterns of risky environments can lead to greater risk aversion.

Combining historical data on weather at the district level and contemporary data on natural disasters at the household level, the empirical results confirm that rural households that have experienced more natural disasters show significantly higher levels of risk aversion. In addition, rural households are more willing to buy insurance to protect themselves from crop losses. The results also support the hypothesis that when people are accustomed to live in a risky environment, an incremental increase in risk does not result in a consistent change in their risk attitudes. Moreover, the results indicate that the importance of historical factors in the current outcomes and risk perception may have evolved over time in this environment and continues to persist to this day.

The remainder of this paper is structured as follows. In the next section, I start with a detailed description of weather volatility and the history of natural disasters in different regions in Vietnam. Section 3 illustrates the mechanism by which natural disasters can affect and frame risk preferences. Section 4 describes data on the main variables and the calculation of different risk aversion parameters. Section 5 presents reduced form model and estimation results, and reports OLS estimates of the relationship between historical weather variations and individual risk attitudes today. In section 6, I then turn examine whether contemporary risk preferences result from current shocks or historical factors. Section 7 offers concluding remarks.

2. Characteristics of Topography and Natural Disasters in Vietnam[2]

Vietnam's mainland stretches from 23°23' to 08°02' north in latitude and widens from 102°08' to 109°28' east in longitude. The country covers relatively complicated terrain: countless mountains, numerous rivers and a stretched and meandering coastline. The entire territory of Vietnam can be divided into three regions with different topography and weather conditions.

The northern region's topography includes mountains and hills in the west, east and north. Its south side is coastline and its centre is plains, primarily the Red River Delta which has consolidated for millions of years. Due to its location in the Southeast Asian monsoon area, North Vietnam is subject to the hot and humid weather from the Pacific and Indian Oceans. Therefore, floods and rains occur frequently in the river basins each year, leading to serious flooding in the Red River Delta and the north midland region. Over the past 50 years, there have been three severe flood events: in 1945, 1969 and 1971, that caused dyke failures in numerous places and inundated hundreds of hectares of land, affecting millions of people.

The central region is sloping and narrow and its plains are close to the coastline. The region is divided by rivers originating from the western mountain ranges and flowing into the South China Sea. Along the coastline are small plains. Between the sloping mountainsides are narrow and deep valleys. Central Vietnam is frequently subjected to

[2] The information from this section is mainly drawn from the National Report on Disaster Reduction in Vietnam, World Conference on Disaster Reduction, Kobe-Hyogo, Japan, 18-22 January, 2005.

flood and storm disasters. The storms affecting the central provinces of Vietnam often originate from typhoons and depressions arriving from the South China Sea, and from tropical and cold fronts. Severe storms with strong winds are often associated with heavy rain, causing the river levels to rise and flooding. Moreover, the typhoons coincide with the monsoon season, while the country's terrain, which includes steep, high mountains and narrow low plains, contributes to a high risk of flash flooding (Benson 1997).

The topography of southern Vietnam is more even and flat, with the Mekong delta, a low-lying region. However, the Mekong Delta region of Vietnam also displays a variety of physical landscapes, ranging from mountains and highlands in the north and west to broad plains in the south. Some regions of this delta are lower than the average sea level. Therefore, this area includes about a million hectares that are covered by flood water for 2–4 months each year.

3. Conceptual Framework

The existing theories are inconclusive about the effects of the natural environment on risk behaviour. Natural disasters affect individuals by many mechanisms.

One possible mechanism could be through a recent large negative shock to wealth or income, resulting in a shift in individual preferences in towards greater risk aversion (Cassar, Healy & Kessler 2011; Cameron & Shah 2011). Thomas et al. (2010) have shown that natural disasters have profound effect on peoples' living conditions. By combining repeated cross-sectional national living standard measurement surveys (in 2002, 2004 and 2006) from Vietnam with a proxy for natural disasters, they showed that the immediate income and wealth losses from floods and hurricanes can be substantial, with floods causing losses of up to 23 per cent and hurricanes reducing consumption of individual households close to urban centres by up to 52 per cent.

Another related explanation is that the experience of recent hazard means that people are more worried about income losses, and that this worry leads to more risk-averse choices (Cassar, Healy & Kessler 2011). An empirical study by Li et al. (2009) supports this in the case of Chinese people affected by an unprecedented snowstorm and a major earthquake. These authors' results, based on data collected one month after the power outages and two months after the earthquake, suggest that people tend to give more weight to low probabilities after a disaster, preferring a sure loss but a probable gain. They also found that participants tended to buy both insurance and lotteries after these events.

A second mechanism could involve an increase in the perceived likelihood that other negative events would occur. Cameron and Shah (2011) provide experimental survey estimates which support the idea that people living in villages that have been recently exposed to earthquakes or floods exhibit more risk aversion than others whose villages did not experience such events. They found that individuals update and increase the probability that another flood will occur in the next year because individuals perceive that they are now facing a greater risk, so they are less inclined to take risks.

A third mechanism explaining for individual risk attitudes is that they could be rooted in past memories on natural disasters. It is possible that risk aversion arises not because of recent events but because the shocks caused by historical natural disasters have created an imprint on rural households that has not yet fully dissipated. This explanation is consistent with the dominant presumption that preferences and norms change slowly (for example, Bisin & Verdier 2001; Alesina & Fuchs-Schundeln 2007; Nunn & Wantchekon 2011).

However, a fourth mechanism is possible. Repeated exposure to a risky environment is likely to build up a high level of preference for risk, as well as patience, which makes the agents more willing to make risky and patient choices (Nguyen 2011). In other words, people's preferences undergo some form of adaption and if the level of risk is high, people may not be particularly concerned about the addition of a small independent risk (Kahneman & Tversky 1979).

4. Data Description

4.1. Risk Aversion

Data for calculating risk aversion parameters is taken from the third wave of Vietnam Access to Resources Household Survey (VARHS), starting from 2006.[3] The VARHSs are longitudinal survey conducted biannually by the Institute of Labour Science and

[3] The pilot survey was carried out in 2002.

Social Affairs of the Ministry of Labour, Invalids and Social Affairs under the technical support from Department of Economics at the University of Copenhagen. The surveys cover more than 3,000 rural households in the rural areas of twelve provinces in Vietnam.[4] These twelve provinces are distributed evenly throughout the country and representatively reflect regional weather and geography throughout the country. The survey also collects detailed information on a wide variety of topics, including information on household demographics, such as gender, age, education, labour market status, income and expenditure as well as social network and political participation. However, the information about household risk aversion is only collected from the fourth wave of VARHS in 2010.[5]

The novelty of this survey is that it has different types of risk measures. There are three questions on individual's risk attitudes that can be used to calculate risk parameters. The first question adopts a simple unpaid lottery experiment.[6] In this question, respondents are asked to choose between six lotteries that differ in payoffs and whether they want to accept or reject them. In each lottery the prize is fixed at 6,000 VND and only the losing price varies (between 2,000 VND and 7,000 VND).[7]

The exact wording of this question is: 'You are given the opportunity of playing a game where you have a 50:50 chance of winning or losing (for example, a coin is tossed so that you have an equal chance of it turning up either heads or tails). In each case choose whether you would accept or reject the option of playing:

[4] Figure 1 presents the location distribution of these respondents in the twelve provinces, in which Ha Tay in Red River Delta; Lao Cai and Phu Tho in Northeast; Lai Chau and Dien Bien in Northwest; Nghe An in North Central Coast; Quang Nam and Khanh Hoa in South Central Coast; Dac Lac, Dac Nong and Lam Dong in Central Highland; and Long An in Mekong River Delta. The VARHS included 1,314 rural households in the 2004 Vietnam Household Living Standards Survey, a nationally representative, socio-economic survey, carried out biannually by the General Statistics Office (GSO). In addition to the 1,314 resurveyed VHLSS-2004 households, the survey contained two other main groups of households. First, 820 rural households were resurveyed from the 2002 VHLSS in Ha Tay, Phu Tho, Quang Nam and Long An provinces. Second, the sample included 945 additional households from the five provinces covered by the Agricultural and Development Program (ARD-SPS), including Lao Cai, Dien Bien, Lai Chau, Dak Lak and Dak Nong. These households were surveyed specifically for the purpose of generating a baseline study for the ARD-SPS program.

[5] The respondents for this question were mainly the head of the household (76.6 per cent) and their spouse (19.7 per cent).

[6] A drawback of survey questions compared to real payment experiments is that because they are not incentive compatible and various factors, including self-serving biases, inattention, and strategic motives could cause respondents to distort their reported risk attitudes (Dohmen et al 2011).

[7] These amount are equivalent to U$ 0.10 - 0.30. Some previous studies, such as Rabin (2000), Schmidt and Zank (2005), Köbberling and Wakker (2005) suggested that for small-stake lottery may measures loss aversion rather than risk aversion.

Lottery	Accept	Reject
a. You have a 50 per cent chance of losing 2,000 VND and a 50 per cent chance of winning 6,000 VND	O	O
b. You have a 50 per cent chance of losing 3,000 VND and a 50 per cent chance of winning 6,000 VND	O	O
c. You have a 50 per cent chance of losing 4,000 VND and a 50 per cent chance of winning 6,000 VND	O	O
d. You have a 50 per cent chance of losing 5,000 VND and a 50 per cent chance of winning 6,000 VND	O	O
e. You have a 50 per cent chance of losing 6,000 VND and a 50 per cent chance of winning 6,000 VND	O	O
f. You have a 50 per cent chance of losing 7,000 VND and a 50 per cent chance of winning 6,000 VND	O	O

Based on this question, risk aversion can be calculated by applying cumulative prospect theory (Tversky & Kahneman, 1992). A household will be indifferent between accepting and rejecting the lottery if $w^{+}(0.5)v(G) = w^{-}(0.5)\lambda^{risk}\, v(L)$, where L denotes the loss amount in a given lottery and G the gain; $v(x)$ is the utility of the outcome $x \in \{G, L\}$, λ^{risk} represents the coefficient of risk aversion in the choice task; and $w^{+}(0.5)$ and $w^{-}(0.5)$ denote the probability weights for the chance of gaining G or losing L, respectively (Gächter et al, 2010).

Two other following questions can also be used to calculate the coefficient of absolute risk aversion: 'Consider an imaginary situation where you are given the chance of entering a state-run lottery where only 10 people can enter and 1 person will win the prize. How much would you be willing to pay for a 1 in 10 chance of winning a prize of 2,000,000 VND?' and 'How much would you be willing to pay for a 1 in 10 chance of winning a prize of 20,000,000 VND?'[8] The answers to these questions are regarded as reservation prices above which households reject the lottery. I rely on the expected utility theory to construct formal measures of absolute risk aversion. [9]

4.2. Risk Aversion Coefficient Distribution

The results from calculating the risk coefficients show that most households are risk averse, as expected given the high levels of poverty and the particularly large number of natural disaster on agricultural activities (Cameron & Shah 2011).

[8] These amount are equivalent to U$ 100 and $US 1,000, respectively.
[9] See Appendix A for the detailed calculation of the risk aversion parameters.

According to Table 1, only 0.6 per cent of our respondents accept all lotteries and 1.49 per cent accepts all lotteries with a non-negative expected value. Most participants reject gambles with a positive expected value. A lot of respondents (66.14 per cent) reject all six lotteries. For these people they have highest risk-averse coefficient.

The distributions of the risk aversion coefficients calculated by prospect and expected utility are right-skewed with a substantial proportion of rural households being very risk-averse. This proportion is substantially higher than that of other studies that have carried out real payment experiments to investigate individual risk attitudes, such as those of Binswanger (1980) in India and Cameron and Shah (2011) in Indonesia.[10] This creates a concern that the surveyed results may be biased because a large proportion of respondents may not understand the questions. Therefore, people may simply choose to reject all lotteries, leading to bias in our results. However, I believe that this is unlikely to be the case due to two reasons. First, the risk aversion coefficients calculated from both prospect and expected utility show similar distributions as observed in Figure 2[11] although the first group of questions based on prospect theory was more difficult for the respondents to understand. Second, the actual payment experiment implemented by Nielsen and Keil (2012) in 2011 in Son La province demonstrated a similar pattern.[12] Of 300 rural households, they found that 70 per cent of respondents are risk-averse with 15 per cent of households being classified as extremely risk-averse. However, to strengthen the above argument, some formal sensitivity tests will be discussed in detail in subsequent sections.

4.3. Insurance

To investigate the relationship between weather variation and insurance, my analysis relies on data from two questions that ask respondents' views about buying insurance. The first question asks about whether households have insurance in general and the second question asks how much the households would like to buy insurance for crop losses. The exact wording of two questions is as following: "Does your household have any type of insurance?" and "If insurance against loss or damage of crop were available, how much would you be willing to pay for it?" For the first question, respondents can choose to answer 'Yes' or 'No'. I create a dummy variable that takes the value of 1 if

[10] These studies have played risk games with different settings.
[11] As also shown in Table 2, the correlation between risk aversion from two approaches is 0.5.
[12] Nielsen and Keil (2012) play an experimental risk game which is similar to that of Holt and Laury (2002).

respondents choose to answer ‘Yes’ and 0 if ‘No’. For the second, respondents can provide an amount of insurance they would like to buy per year or answer “Not interested”. I created a continuous variable and code the observations for which the respondents answer “Not interested” as 0.

4.4. Weather and Geographic Variables

Rural households in Vietnam are exposed to many natural risks that could potentially threaten their livelihoods and incomes. For example, since the majority of households in rural areas rely on agricultural activities, they will experience fluctuations in agriculturally derived income from exogenous natural shocks such as drought, floods, pest infestation and livestock disease (CIEM, DOE, ILSSA & IPSARD 2007).

To investigate these effects on risk attitudes of village people, I employ two datasets that cover different time periods. For historical natural condition, I pay attention to highest rainfall and rainfall variation at station level for the period from 1927 to 1995. These two variables are expected to have a considerable impact on household incomes from agriculture and other natural resource-dependent activities. They also are highly associated with other important natural phenomenon such as floods, landslides, typhoons, storms that could result in negative effects on household incomes in Vietnam (Benson 1997). For contemporary conditions, I use information from the questions in VARHSs that ask about whether households have suffered any natural shocks and losses due to extreme events over the past eight years. This information allows me to observe the effects of recent shocks on risk preferences at household levels. Moreover, by using both historical and current data, I can examine whether risk aversion correlates more closely with recent events or historical variability.

A. Historical Weather Variables

The historical data on weather variability was obtained from weather stations in 45 districts produced by the Institute of Meteorology and Hydrology.[13] These stations were allocated to capture the best variation of weather within regions.

[13]On average, there are nearly 12 districts in one province. The area of each district ranges from 27.8 to 3677.4 square kilometres and the mean is 660 square kilometres. For the period 1975–2006, the data is taken from Thomas et al. ‘Natural disasters and household welfare: evidence from Vietnam’, Policy Research Working Paper, 2010, World Bank.

For the remaining 97 districts without stations, the weather conditions were assumed to be similar to districts sharing the same borders with them but have a weather station. The reason for this strategy was that stations were expected to gauge significant weather variations in different regions. Therefore, weather data from one station could be used to measure neighbouring districts with similar conditions. The distribution of the weather stations is shown in Figure 3.

There were two data series I used to proxy for historical weather variability.

First, monthly rainfall observations (from January to December) were available over 20 years for each station from 1975 to 1995. For each month, I calculated the standard deviation over the 20 years for each station, and obtained the average rainfall deviation of each station over 12 months to investigate year-to-year rainfall fluctuations.[14]

Second, for longer period, another data series was also available. For each station, I obtained data for the highest rainfall in 58 years for each month during the period from 1927 to 1985. The Institute of Meteorology and Hydrology reported for each station the highest rainfall event for each month over the period from 1927 to 1985. Thus, each station had 12 observations that reported the highest rainfall of that month over 58 years. I calculated the standard deviation over 12 months for that period as a proxy for extreme rainfall variations.

A possible concern regarding these two proxies is whether the measure of rainfall variation can be a good proxy for the riskiness of natural environment. There are reasons to believe that the construction of year-to-year rainfall and extreme rainfall variations capture the effects of hazardous natural environment such as floods, typhoons and storms in Vietnam reasonably well. For example, Benson (1997) shows that typhoons are typically associated with heavy rainfall and strong winds. Each typhoon accounts for about 10 to 15 per cent, and sometimes even more, of annual rainfall and causes flash floods and landslides. In addition, heavy rainfall causes rivers to fill and

[14] A possible concern is whether the measure of rainfall in the 1990s is a good proxy for historical weather variation a hundred years ago. The construction of rainfall variation does not give any cause for concern. In fact, the measure of rainfall variation for each station was very similar when I used the period from 1975 to 2006 instead. Therefore, it is reasonable to assume that the historical variation of rainfall in each region has not changed significantly compared to the past.

potentially results in flooding. Therefore, I expect the more typhoons and storms one region suffers from, the more rainfall volatility it has.

B. Contemporary Natural Disasters

The data on current natural disasters was taken from three rounds of the VARHS (in 2006, 2008 and 2010) at the household level. In the 2008 and 2010 waves, households were asked to select from a list of 12 natural, biological and economic shocks that the household may have suffered if they had experienced any loss due to these shocks in the past two years. The exact wording of the question is: 'Since xxxx, did the household suffer from an unexpected loss from any of the following shocks? 1. Floods, landslides, typhoons, storms, droughts; 2. Pest infestation and crop diseases; 3. Avian flu…' Since respondents could choose many shocks for this question, I constructed a measure that counted the number of natural disasters that the household suffered in the past two years. I also considered the second measure asking about income losses based on the following question: 'Please list how much you lost due to this event (000 VND)'. The amount of loss for any household was accumulated over two years.[15] Table 2 shows that historical rainfall variations correlate positively with more recent natural disasters in the period from 2006 to 2010.[16]

C. Other Geographic Variables

Other variables may be important for this analysis. Rainfall, flood, and landslides may harm production, depending on land type and plot slope. Floods affect only low-lying fields, whereas landslides destroy fields on or below steep or unstable slopes. General weather indicators such as average rainfall or the passage of a storm or a typhoon

[15] In the 2006 survey, households were instead asked an open ended question: 'In which years during the last 5 years did your household suffer an unexpected loss of income? And how much did you lose?' Following the same strategy, I calculated the number of natural hazards over five years for each respondent and the total income losses. Having the longitudinal dataset, I could construct a measure of the number of disasters that each rural household had experienced in the period 2002–2010. However, since households were asked about the number of natural disasters and losses over the last 5 years in 2006 compared with those in the last 2 years in either of the 2008 or 2010 surveys, I expected the figures to be larger in 2006 than those in 2008 and 2010. Fortunately, the question asks about the number of disasters and income losses separately for each year, so I could decompose the number of natural shocks and losses in the 2006 round into two periods to make them comparable to the different periods. Therefore, four sets of variables measuring the impacts of recent natural disasters were created: the number of natural disasters and income losses in 2002–2004, 2005–2006, 2006–2008 and 2008–2010. The income losses were adjusted for inflation to make the figures comparable across years.

[16] The number of observations for natural shocks is significantly smaller than those of weather rainfall variation, which raises a concern about a difference on risk preferences between peoples who reported whether they suffered from natural disasters and peoples who have missing data. However, I found that the difference on the average risk preferences between people who reported and the people who had missing data is statistically insignificant.

therefore obscure differences in risk exposure among households. I therefore used household-level questionnaires to gather information on these risk exposures.

Average climatic conditions are likely to have a considerable impact on agriculture and income. For example, even regions without much weather variation but with low (or high) average rainfall within a year are also subject to risks of drought and flood. To account for these effects, I controlled for the average level of rainfall at the district level. These measures were constructed from the same dataset described above, taking their average over 12 months and over the entire period.

Land terrain and elevation may also be correlated with weather variability. For example, the presence of a mountain can lead to different climatic condition and micro-ecosystems on either side (Durante 2009). This may reduce or increase the risk of negative effects of weather variation on agricultural activities. To control for the relationship between weather variability and topography, I included a plot dummy variable to measure agricultural land terrain in the regressions. The information for land terrain was drawn from the question to household heads on the topography of their household's land plot: 'In general, what is the slope of this plot? Flat, slight slope, moderate slope or steep slope?' The measure of land slope took the value of 1 if all plots were flat and 0 otherwise. As presented in Table 3, nearly 50 per cent of land plots were in slight to steep slope conditions.

Land quality could affect the risk of crop failure and household income. To account for this aspect, I included land area and a dummy variable to measure land quality in the regressions. The land area was calculated by summing the area of all the plots for each household. Information on land quality was taken from the question: 'Do you experience problems with any of following conditions on this plot? Erosion, dry land, low-lying land, sedimentation, landslide, stone soils/clay, other or no problem?" I constructed a measure of land quality that takes a value 1 if households do not have any plots that suffer from any of the above problems and 0 otherwise. Only 2 per cent of households reported a large quantity of land without any of these problems.

D. Migration

The survey provides some useful information on how long households have lived in the commune and location that people were born. I use them to restrict the sample to households whose head, spouse or both of them are currently living in the region where they were born. The reason for this restriction is twofold. From the historical point of view, in a rural region in a developing country, the longer people live in one place, the more likely their parents lived in the same place, and the more likely their risk preference is adapted to the social norm, which was formed partly by the historical weather variation. Similarly, from the contemporary view point, the longer people live in one place, the more likely they themselves are exposed to the current weather condition, and the more likely their risk attitudes adapt to the current weather condition.

As shown in Table 3, the average age of household heads who are born locally is above 50 years old. This implies that weather variation has affected their life for a long time. Their living strategies and behaviour are more likely to be adapted to the weather pattern. In addition, assuming that culture is resistant and transmitted through the generations, people are likely to inherit their risk preferences from their forebears who lived in the same settings.

Table 4 displays the characteristics of the rural households in the full and restricted samples. The two groups are similar in almost all indicators. However, immigrants have larger land areas and larger social networks. They also live in the areas that suffer less from weather variations.

5. Empirical Strategies and Results

5.1. Empirical Strategies

The relationship between historical weather variability and current parameter of risk aversion can be estimated from following equation:[17]

$$Risk\_aversion_{i,d,p} = \alpha_p + \beta Weather\_Var_d + X'_{i,d}\Gamma + Z'_{i,d}\Phi + \varepsilon_{i,d,p} \qquad (1)$$

where subscripts *i*, *d* and *p* represent household, district and province, respectively. The variable $Risk\_aversion_{i,d,p}$ denotes measures of risk aversion coefficients, which vary

[17]Because the distribution of the highest rainfall and rainfall variations are highly right skewed, with a small number of observations taking on large values, I report estimates using the natural log of the weather measures.

across households. $Weather\_Var_d$ represents the degree of variability of the weather (log of extreme rainfall variation or log of year-to-year rainfall variation) across stations. β is the coefficient of my main measures that indicates the relationship between the weather variation in a district and the individual's current level of risk aversion. I expect β to be positive and statistically significant. α_p indicates province fixed effects, which are included to capture provincial specific factors, such as the effectiveness of local regulations and other time invariant factors at provincial level that may affect risk aversion.

The vector $X'_{i,d,p}$ controls a set of household and individual-level covariates, which includes the characteristics of household head, such as age, age squared/100, years of education, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects and household income, variables that reflects whether rural households ask for monetary help in case of emergency from neighbor and relatives. The vector $Z'_{i,d,p}$ consists of other geographic variables, such as log of average rainfall and land terrain, land quality and land area.

In addition, the main explanatory variable, $Weather\_Var_d$, in Equation (1) does not vary across individuals, but at the station level. Weather variation may have similar effects on people measured by the same station. Given the potential for within-group correlation of the residuals, I clustered the standard errors for a potentially arbitrary correlation between households in the same station.

5.2. Empirical Results

I first investigate the impacts of weather variation on the risk aversion coefficients.

The results from the OLS estimation of Equation (1) are reported in Table 5.[18] The main independent variable presented in this table is the log of extreme rainfall variation over 58 years. The estimates, which are reported in Columns 1 - 4, show substantial evidence that the log of extreme rainfall variation is positively correlated with risk-averse indicators. However, the coefficient could be biased because time-invariant omitted variables at provincial levels may correlate with both rainfall variation and individual

[18]The main reason to use OLS rather other estimators such as ordered logit is that the coefficients estimated by OLS are easier to be interpreted.

risk attitudes. Therefore, in the estimates in Columns 4 - 8, I include provincial fixed effects to control for this possibility. In all cases with and without provincial fixed effects, the estimated coefficient for rainfall variation, β, was positive and statistically significant, indicating that historical weather variability positively associates with average risk aversion at the household level.[19]

Columns 1 - 4 of Table 6 report the same estimation using the log of rainfall variation over the period 1975-1995 as the measure of weather condition. The results also indicate that the estimates of the log of rainfall variation positively correlate with risk aversion and are highly statistically significant. In addition, the estimates of β with provincial fixed effects are higher than those without fixed effects. The estimates are stable and fall between 0.60 and 0.86 in Columns 5 - 8. Intuitively, one standard deviation increase in log of rainfall variation causes an increase in risk aversion that ranges from 16 to 23 per cent of standard deviation of different risk aversion coefficients.[20]

The risk aversion coefficients may vary systematically across groups. For example, many studies have shown that the willingness to take risk increases with education (e.g., Dohmen et al. 2011; Donkers et al. 2001; Hartog, Carbonell & Jonker 2002; Miyata 2003). Other empirical studies indicate that the levels of risky activities are expected to increase with wealth and income. Wealthier individuals are found to be more likely to undertake risky activities (Rosenzweig & Binswanger 1993; Miyata 2003; Cohen & Einav 2007). In addition, it is possible that wealthier households choose to stay in regions that do not experience flooding and are more likely to choose the riskier option (Cameron & Shah 2011).

Risk-taking behaviour can change as people age. In earlier studies on risk experiments, it was found that older people tend to be more risk-averse than younger people. In addition, single individuals were found to be less risk-averse than married individuals, though having more children did not seem to increase risk aversion. In general, women are more risk-averse than men (Byrnes et al. 1999; Cohen & Einav 2007; Dohmen et al. 2011; Donkers et al. 2001; Hartog, Carbonell & Jonker 2002). A number of studies have

[19] Because the variation of extreme rainfall covers the period from 1927 to 1985, the findings may partly reflect the effects of the transmission of risk preferences from generations to generations.

[20] Including both the log of rainfall variation and the log of average rainfall is equivalent to investigating the effect of the log of coefficient of variation on individual risk aversion. The magnitude is calculated as (0.3*0.6)/1.13=0.16 or 16 per cent.

shown that less risk-averse agents are more likely to choose higher risk jobs for better compensation (Viscusi & Hersch 2001). For instance, Cramer et al. (2002) show that less risk-averse agents are attracted to entrepreneurship, a more risky occupation. King (1974) finds that individuals from wealthier families choose riskier occupations.

The results in Tables 5 and 6 show a similar trend of other variables compared to those of previous studies. The coefficients of household and individual characteristics have their expected signs although they are not statistically significant. For example, women seem to be more risk-averse than men. Richer households appear to be less risk-averse. Married people are more risk-averse.

To control for the potential problem that weather variation may be contaminated by the effects of other geographic variables as discussed in the section 5.4.C, I include the vector of the geographic controls. I also control for two variables that proxy for the potential effects of social networks. The first variable is the number of relatives from whom households ask for monetary help in the case of emergency and the second variable is number of same village members from whom households ask for monetary help. Cameron and Shah (2011) show that informal insurance, such as remittances, partially reduces risk aversion of households in the face of natural disasters. The results in Table 7 show that including these variables does not change the estimated results.

5.3. Robustness Tests

Table 8 repeats the same estimation with two measures of absolute risk aversion. The results of the effects of the weather variation estimates on absolute risk aversion are marginally significant in some cases. Nevertheless, the results have a same sign as those presented in Table 7.

I undertake a number of other robustness checks. First, I separately investigate the impact of weather variation on each gender group of the population. The results, which are reported in Tables 9 and 10, are more robust for the male subsample. One possible explanation is that men in rural Vietnam, on average, must take more responsibility for their families during unexpected natural disasters, which in turn makes them more risk-averse

Second, I check for robustness to alternative estimation method. Because the risk coefficients calculated by the prospect theory are restricted in range, they may not be normally distributed. Therefore, rather than using OLS estimators, I used ordered logit estimator instead. Using ordered logit models produces estimates that are qualitatively[21] identical to the baseline OLS estimates (Appendix B) and stable over a range of regressions.

Finally, I test the robustness of the results by excluding some of the households who responded to reject any lottery choices. Given the extremely high proportion of the households who rejected all the lottery choices, there is a possibility that some of the individuals may have not understood the questions. If so, the results may be biased. To address this concern, I conducted some inference tests to determine how the results may change if those who could have misunderstood the question are excluded. To do so, I randomly selected some individuals who rejected any lottery choices to be excluded from the estimation so that the total proportion of the households selecting no lottery is similar to that of other studies. If all results became statistically insignificant, this would lead to concerns that the results were driven by a large number of people who had not understood the questions.

Nielsen and Keil (2012) conducted a risk experiment using Vietnamese rural households as subject and in their study, the proportion of rural households who are extremely risk averse is 15 per cent. I used this as a benchmark and randomly excluded 51 per cent of the households from those who reject all lottery choices and re-estimated the risk aversion coefficients on weather variation with the same specifications used above. I repeated this procedure 100 times.[22] Figure 4 presents the distribution of the results after 100 simulations. The upper panel shows the distribution of weather variation coefficients with the outcome variables risk aversion and absolute risk aversion. The lower panel presents the t-statistics of the weather variation coefficients generated by the same regressions. The results are robust to variation in the log of

[21] Appendix B.1 re-estimates the specifications from Table 7 of the paper using an ordered logit model. The estimated coefficients reported in the top panel of the table are positive and statistically significant. Marginal effects are reported in the bottom panel. Each row of the panel reports the marginal effect for each of the seven possible responses to the risk coefficients. The estimates show that if rural households were more heavily impacted by the weather variation, then they are more likely to choose rejecting all lotteries, and less likely to choose risky games.

[22] The results are very similar when I change this proportion to another value such as 10 per cent (Binswanger 1980).

rainfall and indicate that log of rainfall variation has a positive and significant effect on rural household risk aversion.

As a second more conservative sensitivity test I excluded all households who rejected all lotteries and replicated the estimation with a subsample that included only households who had accepted at least one lottery.[23] The results represented in Table 11 indicate that even in the most cautious scenario, the log of rainfall variation still positively and significantly affects household risk aversion. Moreover, the results from these two robustness tests indicate that it is less likely that the estimated effect of the rainfall variation is completely driven by bias in self-reported risk attitudes.

5.4. Potential Issues

The results from Equation (1) may suffer from omitted variables. For example, uncontrolled other geographic variations and local regulation changes may correlate with both weather variation and risk preferences. Although including provincial fixed effects and other geographical factors can mitigate the omitted variable bias to some extent, this does not completely solve this problem because these omitted variables may change overtime and may be correlated with both changes in weather variables and in individual risk aversion in each district.

There may be other problems as well. The first one is that OLS estimator may yield biased estimates due to measurement error on measure of weather variables. If the measurement errors in extreme rainfall and rainfall variation are correlated with the error term in the risk equation, the estimates will suffer from an attenuation bias.

Another possible problem is selection bias. It is possible that only a selected group of people stay in regions where there are more natural hazards. If this group of villagers happen to be more risk-averse, thus tend to stay in the same place where they were born even this place is not ideal for living, the OLS results will be overestimated. Conversely, if the selected group is more risk-loving, then the results may be underestimated.

[23] In a similar risk game in Germany, Gächter et al (2010) report that only 1.84 per cent of people reject all lotteries.

5.5. Sensitivity Test for Unobservable Bias

As mentioned above, although I try to control for observable factors, such as individual controls and other geographic variables, the estimates reported in Table 7 may still be biased by unobservable omitted variables and selection problems.

In this part, I assess the likelihood that the estimates are biased by unobservables. I follow the approach initiated by Altonji et al. (2005) and Bellows and Miguel (2008) that selection on observables can be used to assess the potential bias from unobservables. Their ideas are to measure the strength of the likely bias arising from unobservables. In other words, how much higher selection on unobservables, relative to selection on observables, must be to explain away the full estimated effect (Nunn & Wantchekon 2011). Specifically, to gauge this bias, the ratio of the estimated coefficient for the variable of interest from the unrestricted regression over the difference between the estimated coefficient for the variable of interest from the restricted and unrestricted regression is calculated. Then, the higher this ratio, the greater is the effect that needs to be explained away by selection on unobservables.

I consider two sets of restricted control variables: one with only log average rainfall and another with a group of individual controls that includes age, age squared, and married, gender, ethnicity and log average rainfall variable. The full set covariates include group of controls from the equation in Table 7.

Given our two restricted and one set of full covariates, there are two combinations of restricted and unrestricted controls that can be used to calculate the ratios. The ratios, for each of two measures of risk aversions from the prospect theory, are reported in Appendix B.2.

Of the eight ratios are reported in Appendix B.2, none are less than one. The ratios range from 11.4 to 66.5, with a median ratio of 24.7. Therefore, to make the entire OLS estimate to be from selection effects, selection on unobservables would have to be eleven times greater than selection on observables, and on average, over 24 times greater. In my view, these results make it less likely that the estimated effect of the rainfall variation is completely driven by unobservables.

6. Persistent Impacts of Natural Environment

To this point, I have shown that historical weather variations are associated with a greater risk aversion in rural households today. This relationship suggests long-term persistence of the effects of the natural environment on people's preferences.

In this section, I tested the hypothesis advanced by Kahneman and Tversky (1979), who suggest that people's preferences are adaptive in the sense that if the level of risk is high, people may not be concerned about the addition of a small independent risk. To test this hypothesis, I first replicated the analysis using only current natural disasters and then controlled for both historical weather variation and variables that reflect the impacts of natural disasters that household have experienced recently. If the hypothesis by Kahneman and Tversky holds, I expected that the impacts of current natural disasters will be small, regardless of controlling for historical weather variation.

Tables 12 and 13 present the results using lottery measures of risk aversion and absolute risk aversion as dependent variables, respectively. All regressions had the same specification as before and include provincial fixed effects and the full set of control variables.[24] The main explanatory variables are different measures of recent natural disasters generated from the survey data for each period from 2002 to 2010 as discussed in the section 5.4.B. In Table 12, I found that the coefficient of number of natural disasters in 2005-2006 is significant and positively correlated with risk aversion. This suggests that people who experienced natural disasters in 2005-2006 exhibit higher level of risk aversion. However, the number of natural disasters in 2002-2004 and 2006-2010 do not show significant effects on current household's risk aversion. To better investigate the impacts of natural hazards, I replace number of natural disasters by share of losses caused by disasters over household incomes in Table 13. The results from these estimations provide a similar pattern: only the share of losses over incomes in 2005-2006 has significant effects on risk aversion. When I control for all recent periods, the coefficient of share of losses over income 2008-2010 becomes statistically significant and positively correlate with risk aversion. However, the interpretation of

[24] Two main explanatory variables in this estimation do not vary at the same level. Rather, they vary at either the household level (contemporary natural disasters) or the station level (historical weather variation). Therefore, I replicated the estimations to obtain standard errors which were adjusted for two-way clustering within station and commune. The reason for clustering standard errors at the commune level was to correct for potential correlation of residuals between households who suffered the same current natural disasters in the same commune. The results show that this method produces standard errors that are essentially identical to the original one-way clustering at the station level.

this estimation should be made with caution because a significant decrease in the sample size.

In Tables 14 and 15, I control for both historical weather variations and recent natural disaster variables. For each of measure of risk aversion, the rainfall variation coefficients were quite stable and had statistically significant effects. The effects of current natural disasters were small, although their signs were consistent with expectations in almost every case. The magnitude of the effect is largest and statistically significant in the period 2005–2006. The effects of natural disasters were not statistically significant during the periods between 2002-2004 and 2006-2010. The qualitative results for absolute risk aversion are similar: in almost all cases, greater historical weather variability corresponds to higher risk aversion but contemporary natural disasters do not show statistically significant effects.[25] Columns 5 and 10 present the results when the number of natural disasters was controlled for all periods simultaneously. The point estimates of historical weather variation remain positive and significant in both cases. The effects of recent natural disasters are only significant in the period 2005-2006.[26]

I replicate the regression with similar measures of risk aversion but other measures of current natural disasters such as share of losses due to the disasters over household incomes (see Tables 16 and 17). The results of historical weather variation are similar to those presented in Tables 14 and 15. The severity of the effect on household incomes due to natural disasters in 2005–2006 correlates positively with the risk aversion parameters and the coefficient is statistically significant. However, experiencing a high share of income losses from natural disasters in 2006–2008 and 2008–2010 does not reveal a consistent pattern of current natural disasters on risk coefficients.

The results which indicate that both current natural disasters and historical weather variations have significant effects on current risk aversion are almost consistent with the findings in the other existing empirical study such as Cameron and Shah (2011). However, the findings here seem to suggest that historical natural disasters leave a deep

[25]Moreover, these findings are not much different compared to those in the estimations that I include only contemporary natural disasters. This may reflect the low level of correlation between two variables.
[26] Due to the significant attrition of observations when including simultaneously all recent disasters, the interpretation of this estimation should be made with caution.

and lasting imprint on people' risk attitudes and current natural disasters do not create significant impacts compared to those in the past.[27]

7. Weather Variation and Insurance

Economic theory suggests that due to the lack of insurance markets households will accumulate precautionary savings and assets in order to protect themselves against uncertainty in future income (Marshall 1920). However, precautionary savings are inefficient because they divert resources from productive investments and from consumption. If risk can be insured through formal insurance contracts, then risk-averse households may choose to purchase insurance to protect themselves against future income fluctuation and smooth their consumption (Newman & Wainwright 2011). Therefore, if I assume that weather variation has a negative impact on households' wealth and income and thus makes them more risk-averse, then I expect to find a positive correlation between weather variation and householders' decisions to buy insurance.[28]

Table 18 reports the OLS estimates of the relationship between weather variation and householders' decisions on buying insurance. Along with historical weather variation, I also controlled for the number of natural disasters in 2008–2010 and the share of losses over household incomes caused by natural disasters in the same period. These variables capture the possibility that householders will buy insurance to prevent unexpected income losses due to recent natural disasters.

The estimated coefficients of the weather variation from Columns 1 to 6 are of the expected sign although they are not statistically significant. The results indicate that income losses due to natural disasters during 2008- 2010 have significant impacts on household's decisions on buying insurance in 2010. Columns 7 - 12 report estimates with the dependent variable being the share of insurance that households are willing to

[27]The difference in the findings compared to those in Cameron and Shah (2011) may come from the differences in proxies for natural disasters and specific characteristics in each country.

[28] Another way to investigate the impacts of historical weather variations on insurance is to use IV estimation with an assumption that historical weather variations only affect the farmer's decisions to buy insurance through their effects on risk preferences. However, this assumption may not be hold if historical weather variations may directly impacts on current decisions to buy insurance. For example, farmers may adjust their production decisions and the willingness to pay for crop losses based on changes on weather hazards even if their risk aversion may not change. Therefore, I restrict my analysis to reduced form effects of weather variations on insurance.

buy to protect their crop over crop values. The coefficients of rainfall variation are negative but statistically insignificant. The log of highest rainfall variation coefficient is becomes positive when I control for either number of natural disaster or share of income losses in 2008 – 2010.[29]

8. Conclusion

The frequency and damages created by weather variation and natural hazards have increased substantially over the past century and will probably continue to do so in the near future, especially in developing countries. This study adds to a recent line of research which has emphasised the relevance of historical factors as important determinants underlying the persistent differences in cultural norms and preferences across and within societies. Using historical and contemporary data on weather variation and natural disasters and a survey on rural households in Vietnam, this paper has formally tested the hypothesis that individuals living in villages that have experienced frequent natural disasters behave in a more risk-averse manner than individuals in those that have not. The results strongly support the hypothesis that experiencing natural shocks in the past makes rural households more risk-averse and more willing to buy insurance to protect their crop losses. These findings also provide evidence that recent natural disasters may have moderate impacts on forming the risk preferences of rural households.

My focus on the long-term historical determinants of risk perceptions does not disregard the importance of short-term effects of natural disasters. There is substantial evidence that current experiences of natural shocks are also important in shaping risk attitudes. However, even accounting for these short-term effects, there remains a strong persistent impact of historical weather variation. This indicates that such disasters not only have short-term effects on individual risk attitudes but also shape their long-term preferences and survival strategies.

[29] However, the interpretation of results should be made with caution due to substantial reduction in the number of observations.

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Appendix A

Calculating parameters of risk aversion

For the first question, risk aversion in the risky choice task can be identified by applying cumulative prospect theory (Tversky and Kahneman, 1992). A village household will be indifferent between accepting and rejecting the lottery if $w^{+}(0.5)v(G) = w^{-}(0.5)\lambda^{risk}\, v(L)$, where L denotes the loss in a given lottery and G the gain; $v(x)$ is the utility of the outcome $x \in \{G, L\}$, λ^{risk} represents the coefficient of risk aversion in the choice task; and $w^{+}(0.5)$ and $w^{-}(0.5)$ denote the probability weights for the chance of gaining G or losing L, respectively (Gächter et al, 2010).

If I assume that the same weighting function is used for gains and losses, $w^{+} = w^{-}$, the ratio $v(G)/v(L) = \lambda^{risk}$ will define a household's implied risk aversion in the lottery choice task. I assume that $v(x)$ is linear ($v(x) = x$) for small amounts, which gives us a simple measure of risk aversion: $\lambda^{risk} = G/L$. I will relax some of these assumptions later.

In my lottery choice task $\lambda^{risk} = \boldsymbol{\omega}(v(G)/v(L))$, where $\boldsymbol{\omega}=w^{+}(0.5)/w^{-}(0.5)$ is probability weight. I only consider monotonic acceptance decisions (99 percent of respondents exhibit monotonicity). Table 1 represents the results of risk parameters with different assumptions on probability weights and functional forms for gains and losses. The benchmark case (model (1)) is that both probability weighting and sensitivity are set to be equal to one. Model (2) assumes that differential probability weighting for gains and losses is unimportant (that is, $w^{+}(0.5)/w^{-}(0.5) = 1$) but allows for changing in the functional form for gains and losses. Model (3) assumes the functional form is unimportant but allows for differences in probability weights for gains and losses. I follow Gächter et al (2010) to take the estimates of Abdellaoui (2000) who reports that $w^{+}(0.5) = 0.394$ and $w^{-}(0.5) = 0.456$ for the median individual (implying $\boldsymbol{\omega} = 0.86$). It therefore provides an upper bound for the importance of differential probability weightings of gains and losses for the median individual in our context. Model (4) assumes that both probability weighting and the functional power matter.

For the second and third question, I can rely on Pratt (1964) and Arrow (1965), who used a concave utility function U which is defined over income (or wealth), to construct formal measures of absolute risk aversion.

I assume that households are initially endowed with income of ***w*** and have a twice differentiable, state independent utility function *U*, such that $U^{'}(w) > 0$ and $U^{"}(w) < 0$. Denote by **z** the prize of the lottery, **α** the probability of winning the prize and **λ** the maximum price that the individual is willing to pay for the lottery ticket, which is the reservation price. The initial wealth will drop to **w- λ** after buying the lottery ticket and increase to **w+z - λ** in case of winning the prize.

Suppose that the household's behaviour can be described by the maximization of expected utility, and then the expected utility theory implies that the utility of wealth w, without participation into the lottery, is equal to utility when participating at reservation price **λ**:

$$U(w) \equiv (1-\alpha)U(w-\lambda) + \alpha U(w-\lambda+z) \quad (1)$$

A second order of Taylor series expansion of the right-hand side of Equation 1 around an income of w gives:

$$U(w) \equiv U(w) + \alpha z U^{'}(w) - \lambda U^{'}(w) + 0.5U^{"}(w)[(1-\alpha)\lambda^2 + \alpha(z-\lambda)^2]$$

After rearranging, we yield the Pratt-Arrow measure of absolute risk aversion as[30]:

$$A(w) = -\frac{U^{"}(w)}{U^{'}(w)} = \frac{\alpha z - \lambda}{0.5\lambda^2 + 0.5\alpha z^2 - \alpha\lambda z}$$

An appealing characteristic of the two calculations of subjective risk variables is that they provide measures of the risk values based on different theories. However, I expect

[30] For α=0.1, z_1=2 and z_2=20 the measures of absolute risk aversion from the two question are represented by: $A_1(w) = -\frac{U^{"}(w)}{U^{'}(w)} = \frac{0.2-\lambda}{0.5\lambda^2 + 0.2 - 0.2\lambda}$ and

$$A_2(w) = -\frac{U^{"}(w)}{U^{'}(w)} = \frac{2-\lambda}{0.5\lambda^2 + 20 - 2\lambda}$$

that there is a close relationship between the objective measures from two approaches. The pairwise correlation between difference risk parameters is represented in Table 2. As is apparent, there is a strong correlation between the risk parameters calculated by prospect and expected utility theories.

Table 1 Risk behaviour from different lotteries (Risk aversion)

Risk behavior (lottery choice category)	Percent	Implied Acceptable loss	Implied λ^{risk} under different assumptions of probability weights and sensitivities for gains and losses			
		(thous. VND)	**(1)**	**(2)**	**(3)**	**(4)**
Parameters:			ω=1 α=1 β=1	ω=1 α=0.95 β=0.92	ω=0.86 α=1 β=1	ω=0.86 α=0.95 β=0.92
1. Reject all lotteries	**66.14**	< 2	**> 3.00**	**>2.90**	**>2.49**	**>2.58**
2. Accept lottery **a**, reject lotteries **b** to **f**	**4.04**	2	**3.00**	**2.90**	**2.49**	**2.58**
3. Accept lotteries **a** and **b**, reject lotteries **c** to **f**	**13.53**	3	**2.00**	**2.00**	**1.72**	**1.72**
4. Accept lotteries **a** to **c**, reject lotteries **d** to **f**	**9.44**	4	**1.50**	**1.53**	**1.32**	**1.29**
5. Accept lotteries **a** to **d**, reject lotteries **e** to **f**	**4.76**	5	**1.20**	**1.25**	**1.07**	**1.03**
6. Accept lotteries **a** to **e**, reject lotteries **f**	**1.49**	6	**1.00**	**1.06**	**0.91**	**0.86**
7. Accept all lotteries	**0.60**	≥ 7	**≤ 0.87**	**≤0.92**	**≤0.79**	**≤0.73**
Median			**1.50**	**1.53**	**1.32**	**1.29**

Note: I follow the same strategy of Gächter et al (2010) in identifying sensitivity parameter. (1) benchmark parameters: no probability weighting, and no diminishing sensitivity. (2) no probability weighting, but sensitivity. (3) Probability weighting, but no sensitivity. (4) Probability weighting and sensitivity. Parameters on sensitivity are taken from Booij and van de Kuilen (2009); parameters on ω taken from Abdellaoui (2000).

Table 2 Bivariate correlation

	Risk 1	Risk 2	Risk 3	Risk 4	ARA C1	ARA C2	No of shock 02-04	No of shock 05-06	No of shock 06-08	No of shock 08-10	Log highest rainfall variation	Log rainfall variation
Risk 1 (ω=1; α=1; β=1)	1											
Risk 2 (ω=1; α=0.95; β=0.92)	1.00 *	1										
Risk 3 (ω=0.86; α=1; β=1)	1.00*	1.00*	1									
Risk 4 (ω=0.86; α=0.95; β=0.92)	1.00*	1.00*	1.00*	1								
Absolute risk aversion coeff 1	0.50*	0.50*	0.50*	0.50*	1							
Absolute risk aversion coeff 2	0.44*	0.44*	0.44*	0.44*	0.81*	1						
No of natural shocks 2002 – 04	0.04	0.04	0.04	0.04	0.03	0.05	1					
No of natural shocks 2005 – 06	0.04	0.04	0.04	0.04	0.04	0.06*	0.5*	1				
No of natural shocks 2006 – 08	0.12*	0.12*	0.12*	0.12*	0.09*	0.09*	0.07*	0.01	1			
No of natural shocks 2008 - 10	0.02	0.02	0.02	0.02	-0.05	-0.07*	0.03	0.05	0.19*	1		
Log highest rainfall variation	0.20*	0.20*	0.20*	0.20*	0.08*	0.08*	-0.03	-0.01	0.17*	0.09*	1	
Log rainfall variation	0.09*	0.09*	0.09*	0.09*	0.003	0.08*	0.02	0.005	0.20*	0.16*	0.08*	1

Note: * Statistically significant at 5 per cent.

Table 3 Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Risk aversion 1	2351	3.32	1.13	0.87	4.10
Risk aversion 2	2351	3.19	1.03	0.92	3.90
Risk aversion 3	2351	2.58	0.77	0.79	3.10
Risk aversion 4	2351	2.84	0.96	0.73	3.50
Absolute risk aversion coefficient 1	2364	0.37	0.65	-1.6	1.0
Absolute risk aversion coefficient 2	2364	0.02	0.09	-0.16	0.1
Number of natural shocks in 2002 - 2004	1602	0.05	0.28	0	3
Number of natural shocks in 2005 - 2006	1602	0.04	0.22	0	2
Number of natural shocks in 2006 - 2008	1219	0.41	0.57	0	3
Number of natural shocks in 2008 - 2010	1205	0.54	0.58	0	2
Share of losses over income in 2005 - 2006	1602	0.02	0.22	0	6.97
Share of losses over income in 2006 - 2008	1219	0.06	0.23	0	4.16
Share of losses over income in 2008 - 2010	1205	0.05	0.30	0	7.45
Log highest rainfall variation over 1927 - 1985 (mm)	2364	4.40	0.52	3.35	5.33
Log rainfall variation over 1975 - 1995 (mm)	2364	4.55	0.30	3.97	5.37
Log average monthly rainfall (mm)	2364	5.01	0.35	2.96	5.70
Age of head	2364	50.99	14.17	20	109
Age of head, squared/100	2364	28.01	15.79	4	118.81
Year of schooling of head	2364	8.21	3.65	0	13
Gender (Male=1)	2364	0.84	0.37	0	1
Married	2364	0.85	0.36	0	1
Minority	2364	0.41	0.49	0	1
Log household income in 2010 (mil VND)	2364	70.73	120.66	-381.00	2711.16
Area of land (1000m2)	2364	8.25	11.76	0.02	154.37
Land terrain (Flat=1)	2364	0.48	0.50	0	1
Land quality (Good=1)	2364	0.02	0.15	0	1
Borrowing money from neighbours	2231	1.59	1.04	0	3
Borrowing money from relatives	2231	1.47	1.00	0	3
Buying insurance	2364	0.91	0.28	0	1

Note: The summary statistics are calculated based on VARHS survey data.

Table 4 Summary statistics by full and restricted samples

Variables	Mean		Difference in mean	
	Restricted Sample	Full Sample	T-statistics	P- value
Risk aversion 1	3.32	3.36	1.06	0.29
Risk aversion 2	3.19	3.22	1.05	0.29
Risk aversion 3	2.56	2.60	1.02	0.31
Risk aversion 4	2.84	2.87	1.06	0.29
Absolute risk aversion coefficient 1	0.37	0.39	1.20	0.23
Absolute risk aversion coefficient 2	0.02	0.02	1.10	0.27
Log highest rainfall variation over 1927 - 1985 (mm)	4.41	4.31	6.90	0.00
Log rainfall variation over 1975 - 1995 (mm)	4.94	4.47	2.68	0.00
Log average monthly rainfall (mm)	5.01	4.97	4.35	0.00
Number of natural shocks in 2002 - 2004	0.48	0.05	0.69	0.49
Number of natural shocks in 2005 - 2006	0.04	0.55	1.47	0.47
Number of natural shocks in 2006 - 2008	0.41	0.44	1.32	0.19
Number of natural shocks in 2008 - 2010	0.54	0.57	1.44	0.15
Share of losses over income in 2005 - 2006	0.02	0.03	1.27	0.21
Share of losses over income in 2006 - 2008	0.06	0.08	2.11	0.03
Share of losses over income in 2008 - 2010	0.05	0.05	0.68	0.50
Age of head	50.99	50.51	1.26	0.21
Age of head, squared/100	28.01	27.41	1.41	0.16
Year of schooling of head	8.21	8.17	0.44	0.66
Gender (Male:=1)	0.84	0.83	0.17	0.86
Married	0.85	0.85	0.18	0.85
Minority	0.41	0.38	2.59	0.01
Log household income in 2010 (mil VND)	70.7	76	1.63	0.10
Area of land (1000m2)	8.25	10.28	5.45	0.00
Land terrain (Flat:=1)	0.48	0.46	1.70	0.09
Land quality (Good:=1)	0.02	0.03	1.05	0.29
Borrowing money from neighbours	1.59	1.51	2.68	0.00
Borrowing money from relatives	1.47	1.38	3.16	0.00
Buying insurance	0.91	0.92	0.66	0.51

Note: The summary statistics are calculated based on VARHS survey data

Table 5 Baseline estimations. Log highest rainfall variation over the period 1927-1985

VARIABLES	(1) Risk aversion 1	(2) Risk aversion 2	(3) Risk aversion 3	(4) Risk aversion 4	(5) Risk aversion 1	(6) Risk aversion 2	(7) Risk aversion 3	(8) Risk aversion 4
Log highest rainfall variation (mm)	0.447***	0.408***	0.305***	0.380***	0.535***	0.488***	0.362***	0.455***
	(0.119)	(0.108)	(0.0810)	(0.101)	(0.133)	(0.121)	(0.0917)	(0.113)
Minority	0.190	0.174	0.130	0.162	0.182**	0.165**	0.119*	0.154**
	(0.197)	(0.179)	(0.134)	(0.167)	(0.0898)	(0.0817)	(0.0602)	(0.0762)
Age of head	-0.0139	-0.0126	-0.00913	-0.0118	-0.00661	-0.00594	-0.00417	-0.00557
	(0.00881)	(0.00803)	(0.00599)	(0.00748)	(0.0133)	(0.0121)	(0.00908)	(0.0113)
Age of head, square/100	0.0188**	0.0170**	0.0126**	0.0160**	0.0130	0.0118	0.00862	0.0110
	(0.00825)	(0.00751)	(0.00558)	(0.00701)	(0.0118)	(0.0107)	(0.00803)	(0.0100)
Year of schooling of head	-0.00272	-0.00244	-0.00152	-0.00229	0.00605	0.00555	0.00442	0.00516
	(0.00777)	(0.00707)	(0.00533)	(0.00660)	(0.00508)	(0.00464)	(0.00351)	(0.00432)
Male	-0.262***	-0.238***	-0.176***	-0.223***	-0.276***	-0.251***	-0.186***	-0.234***
	(0.0791)	(0.0720)	(0.0531)	(0.0672)	(0.0834)	(0.0760)	(0.0563)	(0.0709)
Married	0.00861	0.00764	0.00818	0.00751	0.0682	0.0617	0.0482	0.0581
	(0.0905)	(0.0821)	(0.0597)	(0.0767)	(0.0684)	(0.0620)	(0.0445)	(0.0579)
Household income	-0.000233	-0.000213	-0.000167	-0.000200	-7.62e-05	-7.00e-05	-5.80e-05	-6.61e-05
	(0.000194)	(0.000176)	(0.000130)	(0.000164)	(0.000150)	(0.000135)	(9.70e-05)	(0.000127)
Occupational fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Provincial fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Number of observations	2,351	2,351	2,351	2,351	2,351	2,351	2,351	2,351
Number of station clusters	45	45	45	45	45	45	45	45
R-squared	0.06	0.06	0.06	0.06	0.18	0.18	0.18	0.18

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets.

Table 6 Baseline estimations. Log rainfall variation over the period 1975 - 1995

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Risk aversion 1	Risk aversion 2	Risk aversion 3	Risk aversion 4	Risk aversion 1	Risk aversion 2	Risk aversion 3	Risk aversion 4
Log rainfall variation (mm)	0.460***	0.419***	0.319***	0.391***	0.859**	0.784**	0.598**	0.731**
	(0.134)	(0.122)	(0.0927)	(0.114)	(0.337)	(0.308)	(0.236)	(0.287)
Minority	0.220	0.202	0.152	0.188	0.196**	0.178**	0.129**	0.166**
	(0.211)	(0.193)	(0.144)	(0.180)	(0.0892)	(0.0812)	(0.0601)	(0.0757)
Age of head	-0.00519	-0.00462	-0.00316	-0.00437	-0.00560	-0.00501	-0.00346	-0.00471
	(0.0101)	(0.00921)	(0.00688)	(0.00858)	(0.0125)	(0.0114)	(0.00856)	(0.0106)
Age of head, square/100	0.0109	0.00988	0.00717	0.00927	0.0114	0.0103	0.00754	0.00968
	(0.00936)	(0.00852)	(0.00634)	(0.00795)	(0.0109)	(0.00999)	(0.00746)	(0.00930)
Year of schooling of head	0.00129	0.00121	0.00122	0.00112	0.00521	0.00478	0.00383	0.00445
	(0.00922)	(0.00840)	(0.00631)	(0.00784)	(0.00552)	(0.00504)	(0.00380)	(0.00470)
Male	-0.278***	-0.253***	-0.187***	-0.236***	-0.291***	-0.264***	-0.196***	-0.247***
	(0.0839)	(0.0764)	(0.0564)	(0.0713)	(0.0895)	(0.0815)	(0.0604)	(0.0760)
Married	0.0469	0.0426	0.0343	0.0401	0.0474	0.0427	0.0336	0.0404
	(0.0904)	(0.0820)	(0.0593)	(0.0766)	(0.0766)	(0.0696)	(0.0501)	(0.0649)
Household income	-0.000200	-0.000183	-0.000143	-0.000171	-6.55e-05	-6.02e-05	-5.11e-05	-5.70e-05
	(0.000212)	(0.000192)	(0.000141)	(0.000180)	(0.000162)	(0.000146)	(0.000105)	(0.000137)
Occupational fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Provincial fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Number of observations	2,351	2,351	2,351	2,351	2,351	2,351	2,351	2,351
Number of station clusters	45	45	45	45	45	45	45	45
R-squared	0.04	0.04	0.04	0.04	0.18	0.18	0.18	0.18

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets.

Table 7 Adding geographic and other variables

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
VARIABLES	Risk aversion 1	Risk aversion 2	Risk aversion 3	Risk aversion 4	Risk aversion 1	Risk aversion 2	Risk aversion 3	Risk aversion 4
	Log highest rainfall variation over 1927-1985				Log rainfall variation over 1975 - 1995			
Weather variation	0.489***	0.446***	0.330***	0.416***	0.834**	0.762**	0.580**	0.710**
	(0.115)	(0.105)	(0.0794)	(0.0982)	(0.344)	(0.315)	(0.242)	(0.294)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219
Number of station clusters	45	45	45	45	45	45	45	45
R-squared	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 8 Weather variation and absolute risk aversion coefficients

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
VARIABLES	Absolute risk 1	Absolute risk 1	Absolute risk 2	Absolute risk 2	Absolute risk 1	Absolute risk 1	Absolute risk 2	Absolute risk 2
	Log highest rainfall variation over 1927-1985				Log rainfall variation over 1975 - 1995			
Weather variation	0.134*	0.167**	0.012	0.009	0.136	0.167	0.036**	0.027
	(0.068)	(0.064)	(0.01)	(0.01)	(0.0969)	(0.125)	(0.015)	(0.019)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Occupational fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Provincial fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Number of observations	2,231	2,231	2,231	2,231	2,231	2,231	2,231	2,231
Number of station clusters	45	45	45	45	45	45	45	45
R-squared	0.03	0.15	0.02	0.16	0.02	0.14	0.03	0.16

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 9 Weather variation and risk aversion by sex (female)

VARIABLES	Risk aversion	Absolute risk aversion 1	Absolute risk aversion 2	Risk aversion	Absolute risk aversion 1	Absolute risk aversion 2
	Log highest rainfall variation over 1927-1985			Log rainfall variation over 1975 - 1995		
Weather variation	0.638***	0.227	0.005	0.579	0.0573	-0.002
	(0.197)	(0.170)	(0.0297)	(0.378)	(0.177)	(0.026)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic control	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	351	356	356	351	356	356
Number of station clusters	34	34	34	34	34	34
R-squared	0.17	0.14	0.19	0.17	0.14	0.19

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 10 Weather variation and risk aversion by sex (male)

VARIABLES	Risk aversion	Absolute risk aversion 1	Absolute risk aversion 2	Risk aversion	Absolute risk aversion 1	Absolute risk aversion 2
	Log highest rainfall variation over 1927-1985			Log rainfall variation over 1975 - 1995		
Weather variation	0.473***	0.152**	0.009	0.898**	0.186	0.0348*
	(0.115)	(0.0620)	(0.009)	(0.344)	(0.126)	(0.0187)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic control	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,868	1,875	1,875	1,868	1,875	1,875
Number of station clusters	45	45	45	45	45	45
R-squared	0.2	0.16	0.16	0.2	0.16	0.17

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 11 Sensitivity to a subsample. Excluding households who reject all lotteries

VARIABLES	Risk aversion 1	Absolute risk aversion 1	Risk aversion 1	Absolute risk aversion 1
	Log highest rainfall variation over 1927-1985		Log rainfall variation over 1975 - 1995	
Weather variation	-0.008	-0.02	0.89**	-0.13
	(0.007)	(0.03)	(0.35)	(0.15)
Individual controls	Yes	Yes	Yes	Yes
Geographic control	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes
Number of observations	766	1,179	766	1,179
Number of station clusters	39	41	39	41
R-squared	0.14	0.18	0.19	0.19

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 12 Current natural disasters and risk aversion. Number of natural disasters

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Risk aversion 1					Absolute risk aversion 1				
Number of natural disasters 2002-2004	0.07				-0.1	0.002				-0.2*
	(0.11)				(0.23)	(0.08)				(0.24)
Number of natural disasters 2005-2006		0.21**			0.41*		0.11			0.15
		(0.11)			(0.21)		(0.08)			(0.09)
Number of natural disasters 2006-2008			0.04		-0.02			0.05		0.03
			(0.08)		(0.11)			(0.08)		(0.05)
Number of natural disasters 2008-2010				0.01	0.16				-0.03	0.10
				(0.1)	(0.10)				(0.06)	(0.08)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,511	1,511	1,158	1,155	457	1,511	1,511	1,158	1,155	457
Number of station clusters	45	45	44	44	38	45	45	44	44	38
R-squared	0.16	0.16	0.20	0.22	0.26	0.12	0.11	0.16	0.18	0.21

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 13 Current natural disaster and risk aversion. Share of losses over income

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Risk aversion 1				Absolute risk aversion 1			
Share of losses 2005-06 over income 2006	0.13**			2.23**	0.06			0.19
	(0.06)			(0.9)	(0.06)			(0.61)
Share of losses 2006-08 over income 2008		-0.25		-0.14		0.03		-0.00
		(0.20)		(0.13)		(0.15)		(0.12)
Share of losses 2008-10 over income 2010			0.20	0.34**			-0.04	0.07
			(0.19)	(0.15)			(0.06)	(0.10)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,522	1,166	1,159	458	1,122	1,166	1,159	458
Number of station clusters	45	44	44	38	45	44	44	38
R-squared	0.16	0.20	0.22	0.26	0.11	0.16	0.18	0.20

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 14 Weather variation and risk aversion

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Risk aversion 1									
	Log highest rainfall variation over 1927-1985					Log rainfall variation over 1975 - 1995				
Weather variation	0.610***	0.612***	0.494***	0.292**	0.339**	1.84***	1.89***	1.64***	1.37**	1.68***
	(0.144)	(0.144)	(0.144)	(0.126)	(0.162)	(0.55)	(0.56)	(0.52)	(0.52)	(0.55)
Number of natural disasters 2002-2004	0.07				-0.08	0.07				-0.09
	(0.11)				(0.24)	(0.11)				(0.24)
Number of natural disasters 2005-2006		0.22**			0.41*		0.26**			0.41*
		(0.11)			(0.21)		(0.11)			(0.21)
Number of natural disasters 2006-2008			0.05		-0.02			0.05		0.004
			(0.08)		(0.11)			(0.08)		(0.09)
Number of natural disasters 2008-2010				0.01	0.14				0.01	0.12
				(0.1)	(0.10)				(0.10)	(0.09)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,511	1,511	1,158	1,155	457	1,511	1,511	1,158	1,155	457
Number of station clusters	45	45	44	44	38	45	45	44	44	38
R-squared	0.19	0.19	0.22	0.23	0.27	0.17	0.17	0.21	0.23	0.29

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 15 Weather variation and absolute risk aversion

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Absolute risk aversion 1									
	Log highest rainfall variation over 1927 - 1985					Log rainfall variation over 1975 - 1995				
Weather variation	0.22**	0.22***	0.13*	0.21***	0.2	0.28	0.28	0.20*	0.063	0.47**
	(0.08)	(0.08)	(0.07)	(0.07)	(0.144)	(0.21)	(0.21)	(0.11)	(0.13)	(0.21)
Number of natural disasters 2002-2004	0.00				-0.19	0.003				-0.19
	(0.08)				(0.12)	(0.08)				(0.12)
Number of natural disasters 2005-2006		0.11			0.15		0.12			0.15
		(0.08)			(0.11)		(0.08)			(0.11)
Number of natural disasters 2006-2008			0.05		0.03			0.05		0.04
			(0.05)		(0.06)			(0.04)		(0.06)
Number of natural disasters 2008-2010				-0.03	0.1				-0.03	0.09
				(0.07)	(0.07)				(0.06)	(0.07)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,522	1,522	1,166	1,159	458	1,522	1,522	1,158	1,159	458
Number of station clusters	45	45	44	44	38	45	45	44	44	38
R-squared	0.12	0.12	0.17	0.19	0.24	0.12	0.12	0.17	0.18	0.22

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 16 Weather variation and risk aversion

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Risk aversion 1							
	Log highest rainfall variation over 1927 - 1985				Log rainfall variation over 1975 - 1995			
Weather variation	0.61***	0.49***	0.29**	0.35**	1.01***	0.89**	0.87**	1.30***
	(0.15)	(0.14)	(0.12)	(0.161)	(0.37)	(0.34)	(0.41)	(0.43)
Share of losses 2005-06 over income 2006	0.15**			2.32**	0.20**			2.22**
	(0.07)			(0.94)	(0.08)			(0.94)
Share of losses 2006-08 over income 2008		-0.22		-0.10		-0.16		-0.14
		(0.20)		(0.19)		(0.20)		(0.22)
Share of losses 2008-10 over income 2010			0.19	0.31**			0.22	0.38**
			(0.18)	(0.14)			(0.17)	(0.14)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,511	1,158	1,155	457	1,511	1,158	1,155	457
Number of station clusters	45	44	44	38	45	44	44	38
R-squared	0.19	0.22	0.23	0.27	0.18	0.21	0.24	0.3

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 17 Weather variation and absolute risk aversion

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Absolute risk aversion 1							
	Log highest rainfall variation over 1927 - 1985				Log rainfall variation over 1975 - 1995			
Weather variation	0.22***	0.13*	0.21***	0.22	0.28	0.19	0.06	0.51**
	(0.08)	(0.07)	(0.08)	(0.14)	(0.21)	(0.12)	(0.13)	(0.21)
Share of losses 2005-06 over income 2006	0.06			0.24	0.06			0.18
	(0.06)			(0.61)	(0.06)			(0.61)
Share of losses 2006-08 over income 2008		0.04		0.02		0.06		-0.00
		(0.15)		(0.13)		(0.15)		(0.12)
Share of losses 2008-10 over income 2010			-0.04	0.061			-0.03	0.08
			(0.06)	(0.10)			(0.06)	(0.10)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,522	1,166	1,159	458	1,122	1,166	1,159	458
Number of station clusters	45	44	44	38	45	44	44	38
R-squared	0.12	0.17	0.19	0.21	0.12	0.17	0.18	0.21

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Table 18 Weather variation and insurance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Buy insurance			Buy insurance			Crop insurance			Crop insurance		
VARIABLES	Log highest rainfall variation over 1927 - 1985			Log rainfall variation over 1975 - 1995			Log highest rainfall variation over 1927 - 1985			Log rainfall variation over 1975 - 1995		
Weather variation	0.04	0.009	0.008	0.029	0.02	0.02	-0.00	0.012*	0.01*	-0.02	-0.01	-0.01
	(0.03)	(0.03)	(0.03)	(0.05)	(0.04)	(0.04)	(0.00)	(0.007)	(0.007)	(0.02)	(0.01)	(0.01)
Number of natural disasters 2008-2010		0.005			0.004			-0.002			-0.002	
		(0.015)			(0.01)			(0.004)			(0.004)	
Share of losses 2008-10 over income 2010			0.04**			0.05**			-0.0002			0.0005
			(0.02)			(0.02)			(0.003)			(0.003)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	2,231	1,159	1,159	2,231	1,159	1,159	1,748	1,007	1,007	1,748	1,007	1,007
Number of station clusters	45	44	44	45	44	44	45	43	43	45	43	43
R-squared	0.11	0.12	0.13	0.11	0.12	0.12	0.02	0.03	0.03	0.02	0.03	0.03

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, a gender variable indicator, a dummy variable for people who are ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall and land terrain, land quality and land area.

Figure 1 Map showing the current locations of respondents

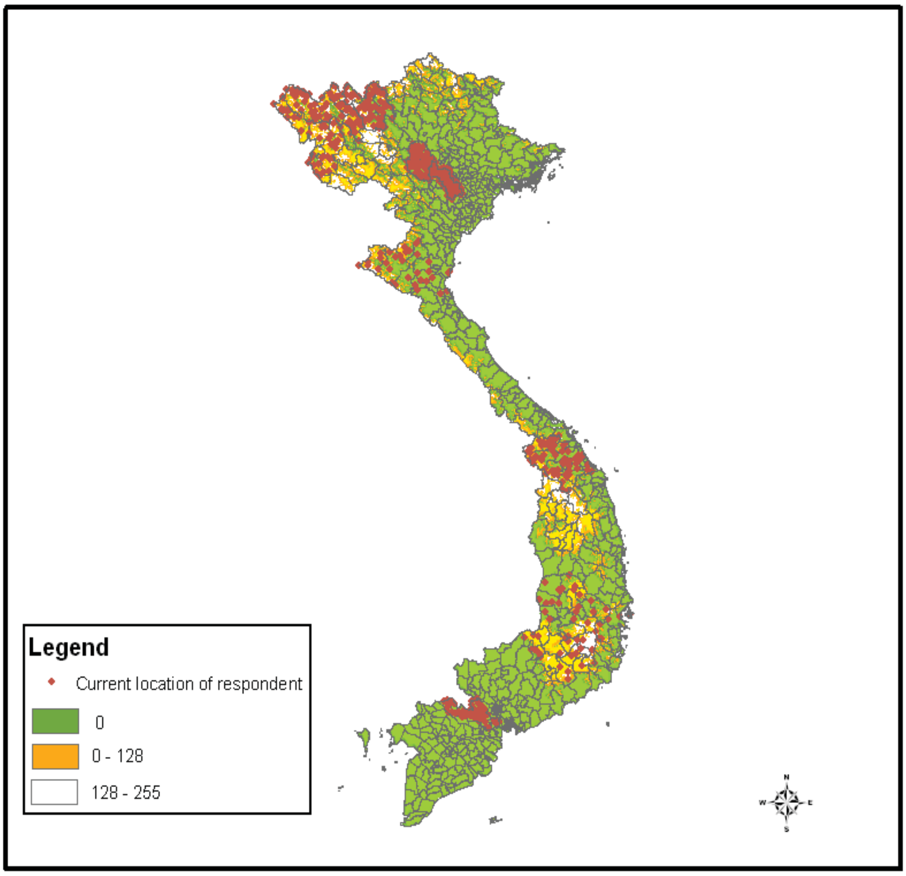


Figure 2 Risk aversion coefficient distribution

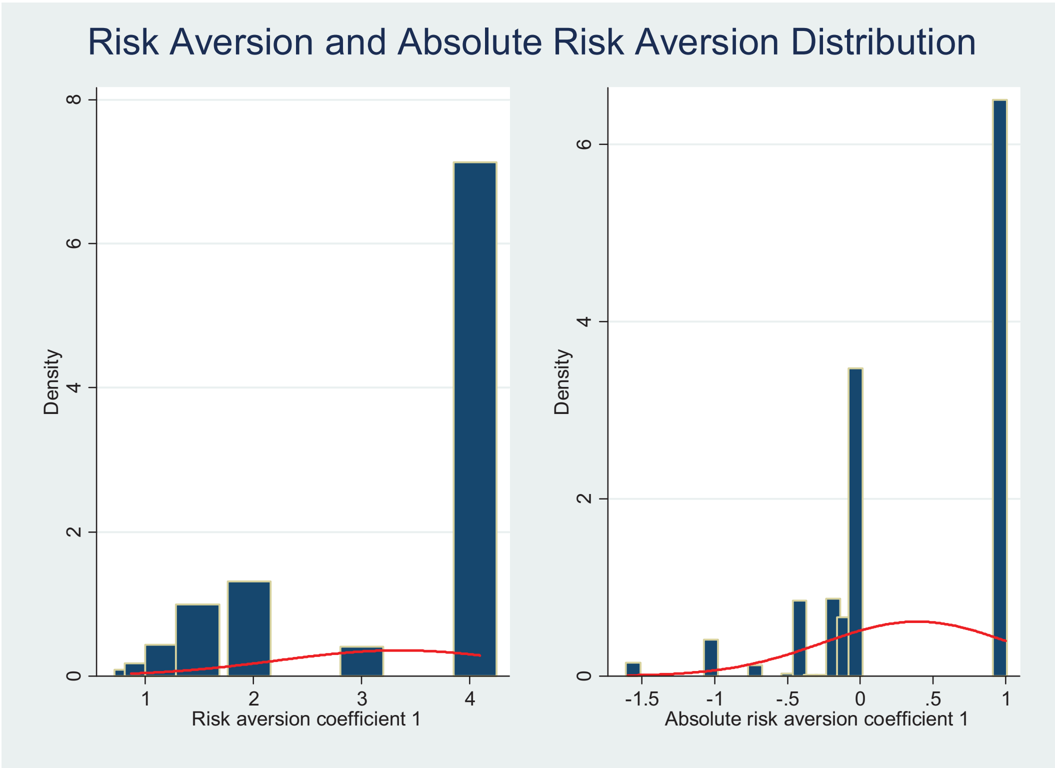


Figure 3 Map showing the distribution of weather stations

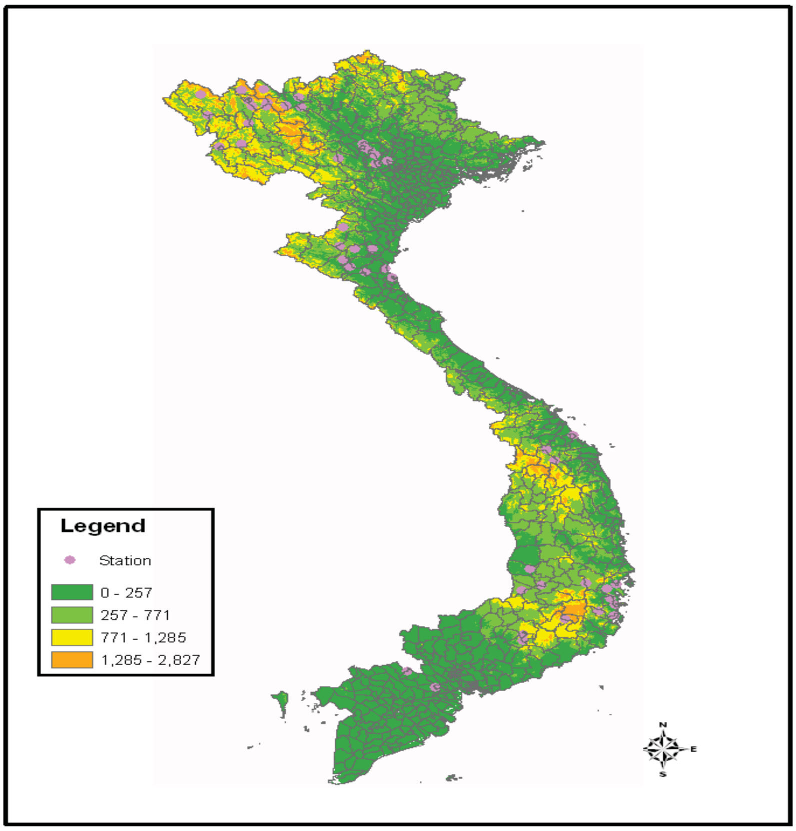
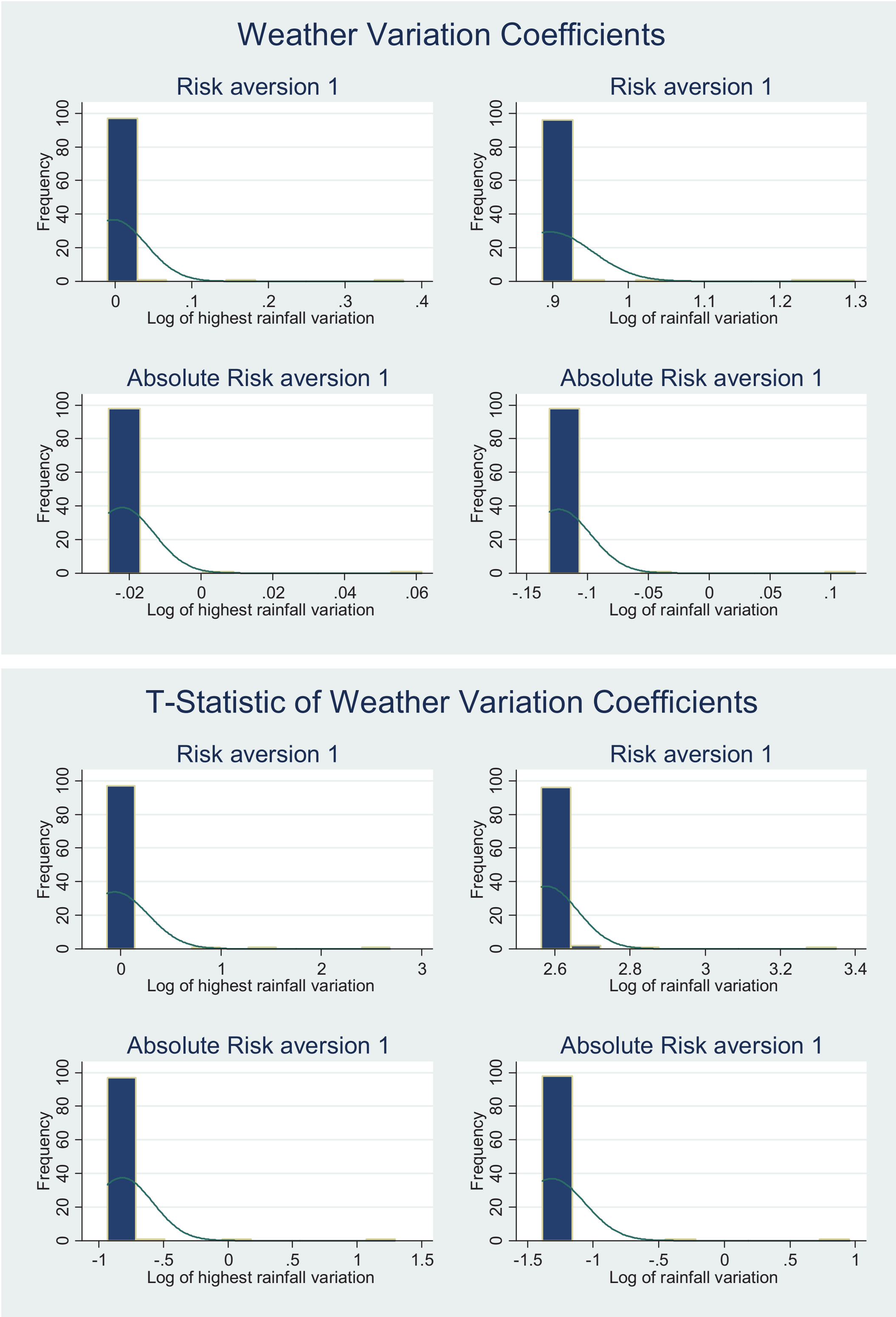


Figure 4 Risk aversion with subsample simulation



Appendix B

B.1. Risk aversion and weather variation. Ordered logit regression

VARIABLES	(1) Risk aversion 1	(2) Risk aversion 2	(3) Risk aversion 3	(4) Risk aversion 4	(1) Risk aversion 1	(2) Risk aversion 2	(3) Risk aversion 3	(4) Risk aversion 4
	Log highest rainfall variation over 1927 - 1985				Log rainfall variation over 1975 - 1985			
Estimated coefficients	0.95***	0.95***	0.95***	0.95***	2.06***	2.06***	2.06***	2.06***
	(0.24)	(0.24)	(0.24)	(0.24)	(0.76)	(0.76)	(0.76)	(0.76)
Response to risk aversion coefficients	Marginal effects, dP/dx							
$\lambda^{risk} > 3.0$	0.173***	0.173***	0.173***	0.173***	0.379***	0.379***	0.379***	0.379***
	(0.042)	(0.042)	(0.042)	(0.042)	(0.134)	(0.134)	(0.134)	(0.134)
$\lambda^{risk} = 3.0$	-0.02***	-0.02***	-0.02***	-0.02***	-0.045***	-0.045***	-0.045***	-0.045***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.014)	(0.014)	(0.014)	(0.014)
$\lambda^{risk} = 2.0$	-0.07***	-0.07***	-0.07***	-0.07***	-0.161**	-0.161**	-0.161**	-0.161**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.064)	(0.064)	(0.064)	(0.064)
$\lambda^{risk} = 1.5$	-0.05***	-0.05***	-0.05***	-0.05***	-0.107***	-0.107***	-0.107***	-0.107***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.038)	(0.038)	(0.038)	(0.038)
$\lambda^{risk} = 1.2$	-0.02***	-0.02***	-0.02***	-0.02***	-0.049**	-0.049**	-0.049**	-0.049**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.022)	(0.022)	(0.022)	(0.022)
$\lambda^{risk} = 1.0$	-0.006**	-0.006**	-0.006**	-0.006**	-0.012**	-0.012**	-0.012**	-0.012**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)	(0.006)	(0.006)
$\lambda^{risk} \leq 0.87$	-0.002*	-0.002*	-0.002*	-0.002*	-0.005	-0.005	-0.005	-0.005
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	2,219	2,219	2,219	2,219	2,219	2,219	2,219	2,219
Number of station clusters	45	45	45	45	45	45	45	45
Pseudo R-squared	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Clustered standard errors are in brackets. The individual controls include age, age squared/100, years of education, household income, gender, ethnic minorities and occupational fixed effects, financial help in case of emergency from neighbor and relatives. The geographic controls are log of average rainfall, land area and dummies for land terrain and land quality

B.2. Using selection on observables to assess the bias from unobservables

Controls in the restricted regression	Controls in the full regression	Log extreme rainfall variation over 1925 - 1985		Log rainfall variation over 1975 - 1995	
		Risk aversion 1	Risk aversion 2	Risk aversion 1	Risk aversion 2
Log average rainfall	Full set of controls from Table 7	36.34	36.67	11.45	11.48
Log average rainfall, age, age square/100, gender, married, ethnicity	Full set of controls from Table 7	65.56	66.51	13.09	13.15

Notes: Each cell of the table reports ratios based on the coefficient for log rainfall variation from household-level regressions. In each regression, provincial fixed effects are included. The reported ratio is calculated as: the coefficient for log rainfall variation (either extreme rainfall variation over 1927 – 1985 or rainfall variation over 1975 – 1995) in full regression/(the coefficient for rainfall variation in restricted regression - the coefficient for rainfall variation in full regression.