Cooperation and Adaptation to Natural Risk: Evidence from Ghana

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Abstract

This paper investigates experimentally the causal effect of exposure to flood risk on the inclination to cooperate and on risk aversion among sample of farmers in Ghana. The results show that highly exposed individuals exhibit a pronounced inclination to contribute to a public good as well as higher degree of risk aversion. A strong positive correlation between cooperation and risk aversion also emerges, suggesting that cooperation may act as a form of self-insurance in an environment where classic forms of insurance are not available. However, a causal mediation analysis shows that only a small proportion of the change in the inclination to cooperate is explained by risk aversion. Cooperation can be considered as a spontaneous and relevant adaptation strategy in rural areas of developing countries.

Keywords: Cooperation, Risk Aversion, Natural Disaster, Adaptation Strategy

Résumé

Cet article étudie expérimentalement l'effet causal de l'exposition au risque d'inondation sur la tendance à coopérer et sur l'aversion au risque parmi un échantillon d'agriculteurs au Ghana. Les résultats montrent que les individus très exposés présentent une forte inclinaison à contribuer à un bien public ainsi qu'un degré plus élevé d'aversion au risque. Une forte corrélation positive entre la coopération et l'aversion au risque émerge également, suggérant que la coopération peut agir comme une forme d'auto-assurance dans un environnement où les formes classiques d'assurance ne sont pas disponibles. Cependant, une analyse de la médiation causale montre que seule une faible proportion du changement dans la tendance à coopérer s'explique par l'aversion au risque. La coopération peut être considérée comme une stratégie d'adaptation spontanée et pertinente dans les zones rurales des pays en développement.

Mots-clés : Coopération, Aversion au Risque, Catastrophe Naturelle, Stratégie d'Adaptation.

Introduction

The scale of destruction from natural shocks has increased over the past decades. According to Intergovernmental Panel on Climate Change (IPCC, 2014), these natural shocks are expected to have an even more profound impacts especially in developing countries, where rural livelihoods are inextricably linked to the environment (Mensah & Adu, 2015). In particular, weather shocks such as flood and droughts can exacerbate poverty both directly and indirectly (Carter & Barrett, 2006). Building resilience through adaptation is, therefore, considered as the most important policy option in reducing the impact of natural shocks (IPCC, 2014). In principle, there are several conceivable ways to cope with the risk of natural disasters. Investing in innovative production processes or in new and more resistant crops is one of the possibilities. Alternatively, an effective climate risk management (e.g. through insurance) may improve livelihoods in unfavourable years and enable farmers to take the productive risks necessary to ensure a bountiful return in favourable years (Norton, et al., 2014). While access to financial, human and physical capital is important to foster resilience, these adaptation strategies needs to be consistent with the behavioural traits of the recipient in order to succeed. For instance, risk averse farmers may not be receptive to innovative programs (Boucher, Carter, & Guirkinger, 2008; Dercon & Christiaensen, 2011).

In developing countries the classic indemnity-based insurance is typically unavailable due to problems of adverse selection, moral hazard, and long delays in implementation. Index-based insurance is a theoretically appealing second-best that however turns out to be extremely costly for small farmers (Carter, De Janvry, Sadoulet, & Sarris, 2014). The correlated nature of the risk implied by natural disasters also hinders the use of alternative and informal insurance arrangements, too. Risk such as that of burglary, illness, injury, malfunctioning of equipment affects individuals in an idiosyncratic manner. This type of risk can be pooled even in case of incomplete markets through a variety of informal risk-sharing mechanisms documented in remote rural communities around the world, including gift giving, food sharing, remittances, rotating savings, and unstructured loans (Fafchamps, 2003; Cherry, Howe, & Murphy, 2015). In contrast the risk implied by natural disasters like floods and droughts affects virtually every individual in the community and cannot be pooled locally (Lohse, Robledo, & Schmidt, 2012; Friedl, De Miranda, & Schmidt, 2014). A risks that cannot be avoided, diversified, or insured against has been labelled as background risk in the literature. It has been shown that background risk makes individuals less tolerant towards other, avoidable risks (Pratt & Zeckhauser, 1987; Kimball, 1993; Eeckhoudt, Gollier, & Schlesinger, 1993).

The collective effort of the members of a community constitutes a major strength of rural households in reducing the impact of natural shocks on their livelihoods. Therefore, not only risk aversion but also the inclination to cooperate of farmers is a crucial behavioral trait that needs to be assessed to identify the more appropriate adaptation strategies to the risk of natural disasters. Public goods can even contribute to risk reduction. For example, dams, embankments, and drainage systems can work as a form of insurance against droughts and floods. Therefore, the interplay between the willingness to contribute to a public good and risk aversion also needs to be investigated.

A growing body of research has introduced behavioural hypotheses into public choice theory (Ostrom, 1998; Lohse, Robledo, & Schmidt, 2012; Teyssier, 2012; Friedl, De Miranda, & Schmidt, 2014). For instance, Lohse, et al. (2012) posit that a high risk averse person will

demand more self-insurance to reduce the size of a loss in the wake of idiosyncratic risk. Such a conclusion can be extended to the case of correlated risk as long as the utility function depends on individual's payoff only. Indeed, risk averse individuals display higher demand for self-insurance in the presence of background risk (Konrad & Skaperdas, 1993). The natural question is then to investigate whether the demand for self-insurance also triggers a stronger inclination to cooperate in case of correlated background risk.

Available experimental evidence displays mixed evidence concerning the correlation between individuals' risk preferences and their contributions to public goods. Charness & Villeval (2009) report that older and more risk averse employees are more cooperative than younger and risk averse employees. Sabater-Grande & Georgantzis (2002) find that high risk aversion relates positively with the frequency of collusive outcomes. Other studies find instead that risk aversion reduces individuals' contributions in public goods experiments (Bohnet & Zeckhauser, 2004; Schechter, 2007; Heinemann, Nagel, & Ockenfels, 2009; Teyssier, 2012)[1]. These studies typically assume that preferences are a stable construct. However, there is a growing body of research showing that shocks in the living environment heavily shape individual preferences. For instance, several studies show that the living environment influence risk preferences (Eckel, El-Gamal, & Wilson, 2009; Olbrich, Quaas, Haensler, & Baumgärtner, 2012; Voors, et al., 2012; Cameron & Shah, 2015; Kahsay & Osberghaus, 2018) and time preferences (Bchir & Willinger, 2014; Callen, 2015).

A few contributions consider how the environment shapes the inclination to cooperate, but without providing clean evidence on their relationship with risk attitudes. Afzal, et al. (2015) show that frequent floods of relatively low intensity have a positive significant effect on cooperation, while single disastrous floods negatively affects cooperation. However, no clear pattern emerges as far as the relationship with risk aversion is concerned. A possible interpretation of this result is that the sample in Afzal, et al. (2015) is large but characterized by substantial heterogeneity. Voors, et al. (2012) investigate the effect of exposure to the risk of conflict on both cooperation and risk preferences, but separately. Belfor (2014) report no significant relationship between exposure to disaster and prosocial preferences. However, exposure to a natural disaster in the past year was found to significantly decrease contribution amounts towards public goods (Belfor, 2014).

The main goal of this paper is to fill this gap by investigating the causal effect of exposure to flood risk on the inclination to cooperate, on risk aversion, and their interplay. In particular, our main research question is to assess whether farmers exposed to higher degree of risk exhibit a more/less pro-social behaviour and how much of the change is due to a change in their risk preferences. Toward this goal we consider communities that are more exposed to the risk of flood as our treated group and those less susceptible to floods as our control group. We believe that our approach improves upon the existing literature, as it constitutes the first attempt to assess the impact of exposure to background risk on risk preferences and cooperation in a comprehensive manner.

We find that preferences are affected by a different exposure to the risk of natural disaster. In particular, more exposed individuals display a more pronounced inclination to cooperate as well as higher degrees of risk aversion. While the result about risk aversion confirms a well-known effect of background risk, our paper provides interesting insights concerning its effect

[1] Entitlement may also play a relevant role in this relationship. Wunsch & Strobl (2018) show that individuals who choose a risky option are less likely to share their income than subjects who receive their income by pure chance

on cooperation, something that is less established in the literature. On the one hand, our results show that exposure to the risk of natural disasters clearly increase the inclination to cooperate. On the other hand, we also find a positive and strong correlation between cooperation and risk aversion. At first glance, the fact that more risk averse individuals contribute more to the public good lends support to cooperation as a form of self-insurance, in line with Lohse, et al. (2012) and Konrad & Skaperdas (1993). According to this interpretation, individuals react to the exposure to background risk by increasing their risk aversion and then using cooperation as a form of self-insurance in an environment where classic forms of insurance are not available. However, a causal mediation analysis shows that, only a small fraction 6.3% of the change in cooperation may be ascribed to the increased level of risk aversion, while the bulk of the effect is direct. According to our findings cooperation, therefore, emerges as a crucial adaptation strategy in rural areas of developing countries, something that should be taken in due consideration to design effective policies.

The structure of the paper is as follow. Section 2 describes the experimental design and procedure, while the results of the paper are presented in Section 3. Section 4 concludes with potential policy implications and directions for future research.

1. Design

The loss of control implicit in exploiting natural events in the field requires particular attention in the design of the experiment along two dimensions: *a)* ensuring that the event under investigation representing the risk of natural disaster properly mimics the intended treatment; *b)* avoiding confounding factors across experimental conditions.

From the first point of view we exploit floods in the North of Ghana as the treatment meant to capture a different exposure to the risk of natural disasters. The Ministry of Food and Agriculture has estimated that, in this region, the 2007 flood affected about 70500 hectares of farmlands, resulting in an estimated loss of 144000 metric tonnes of food crops including maize, rice, millet, sorghum, yam, cassava and groundnuts (Armah, et al., 2011). There has been an increase in the occurrence of flood in this part of the country in the last decades. In 2012, for instance, floods destroyed a total of 1725 farmlands in the northern region alone while temporary displacing about 3152 persons. In all, approximately 22008 people were affected by the flood resulting in the death of 3 persons.[2]

The area where the experiment took place is the Tolon-Kumbungu district, where floods are a recurrent but not systematic phenomenon. Severe floods occurred in this area during the months of July to September in 1995, 1997, 2004, 2007, 2008, 2009, 2010 and 2012 (Musah & Oloruntoba, 2013; Jakpa, 2015). The worst flood was that in August 2007, which resulted in the loss of 6 human lives, loss of property, and temporary rendering more than 1300 households homeless. Over 3000 hectares of farmlands were destroyed in this district with many buildings submerged. In addition, the floods also caused outbreak of water-borne diseases including diarrhoea, cholera and malaria, particularly among children (Musah & Oloruntoba, 2013). More recently severe floods have devastated communities along the White Volta in the northern region of Ghana in 2017[3], when the experiment took

[2] https://www.modernghana.com/news/419147/floods-kill-three-affect-22008-people-in-northern-upper-e.html

[3] https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Northern-Region-floods-unprecedented-Minster-562928

place, and in 2018 temporary displacing about 100,000 people[4]. Less destructive floods are a recurrent phenomenon, occurring more often than what reported in the news. The precipitation pattern in this part of the country is not easily predicted, with flood being potentially very destructive to crops leaving households in the wake of famine. As such, people in this area face an impending risk of dealing with natural disasters.

From the second point of view mentioned above, uniformity across treatments is a necessary condition to properly infer causal relationships. In the laboratory, confounding factors in the ex-ante characteristics of the subjects across experimental conditions are ruled out through the randomization of the treatment. In our case, the hypothesis of random assignment to the probability of natural disasters is clearly violated. As explained by Guala (2005), however, uniformity in experimental subjects can also be achieved through matching with the explicit aim of achieving groups that are as similar as possible ex ante. Guala (2005) also argues that matching should take into consideration both the characteristics of the subjects and the experimental environment. In our setting, uniformity through matching requires to find groups that are similar in all domains except for their exposure to risk.

In this respect, the Tolon-Kumbungu district provides an environment with the necessary features for several reasons. In this rural area, the population relies almost entirely upon agriculture for their survival, implying that the risk cannot be avoided. Furthermore, this district is homogeneous from a cultural perspective, as about 95% of the inhabitants are Muslim. The communities in this district follow a patrilineal system of inheritance and the land used for farming is typically acquired through inheritance. To make sure to avoid problems of self-selection through mobility only farmers who have stayed in the communities for more than 20 years are considered for the experiment. In order to further reduce potential heterogeneity and confounds, participants in each community are randomly selected only among male Muslim farmers. Maize and cassava are the predominant crops, cultivated to be sold, while other crops (sorghum, rice, millet, yam, groundnut, cowpea) represent a low share of total production and are typically used for subsistence reasons (GSS, 2012).

1.1 Treatment

Even though the whole district is a flood-prone area, the degree of exposure to such a risk is not homogeneous, with communities closer to the White Volta being more exposed than communities that are far from the river. The communities that are more prone to flood are known to suffer larger losses and are therefore considered as the treated group. Out of the 22 flood prone communities identified in this district, 5 communities (Kuli, Sheegbuni, Nawumi Afayili, and Tampia) are selected as our treated group based on their proximity to the river and easy access. A total of 5 communities (Wantugu, Gummon, Koblimahigu, Tali and Sabiegu), which are least susceptible to flood are instead selected as control groups (see Figure 1).

[4] http://floodlist.com/africa/ghana-floods-northern-regions-september-2018

Figure 1: Study area (Black squares represent treated groups; white squares represent control groups).

1.2 Experimental tasks

1.2.1 Public Good

Public goods are defined by two well-known properties of non-excludability (individuals cannot be excluded from the consumption of the good irrespective of their contribution to its production) and non-rivalry (individual consumption does not reduce the amount available to others). In the experimental literature the conflict between the selfish option to free ride and the socially desirable outcome represented by full cooperation has been extensively investigated mostly using the linear Voluntary Contribution Mechanism (VCM). A very robust result of this experiment is that a large majority of individuals voluntarily cooperate even though the Nash equilibrium is to contribute nothing to the public good. However, this rate of cooperation declines as the game is repeated (Isaac, et al., 1985; Andreoni, 1988; Ledyard, 1994; Anderson, 2001; Teyssier, 2012, among others).

The level of contribution is commonly interpreted as the inclination to cooperate in order to achieve a common goal. In the communities considered the provision of a public good could be represented for instance by the construction of an embankment, which would be effective only if protecting all the farmlands from floods. The benefits would accrue to everyone regardless of the level of the individual contribution. Given the relevance of cooperation in rural communities, particularly when exposed to the risk of natural disasters, we administer a public good game in its VCM incarnation.

Groups of four participants are formed randomly before the start of the experiment. Each member of the group is given an envelope containing an endowment of 10 tokens, with

each token worth 1 Ghana cedi[5]. Each participant then decides individually how many tokens to keep for himself and how many to leave in the envelope. The tokens left in the envelope represent his contribution to the group (c_i). Participants are told that the tokens they keep directly represent a private payoff. In contrast, the tokens in all the four envelopes are then put in a box, doubled by the experimenter, and then shared equally among the four members of the group regardless of whether someone contributed or not. The resulting payoff function is therefore

$$\pi_i = (10 - c_i) + 0.4\left(c_i + \sum_{j \neq i} c_j\right) \qquad (1)$$

The game is repeated 10 times, and the total contribution of the group in every round is shown to the members before the subsequent round. Participants are instructed that in case this is the task selected for the final payment one round will be chosen randomly at the end of the experiment to determine the individual payoff. The research goal is to test whether higher exposure to the risk of natural disasters shapes the individual inclination to cooperate. Since cooperation may indeed represent a form of collective insurance (e.g. building an embankment can be seen as a premium paid to reduce the risk) in the experiment we also elicit farmers' risk attitudes.

1.2.2 Risk Preferences

The measurement of risk preferences is a problematic endeavour in general because a low consistency and a weak external validity of the answers have been extensively documented (Isaac & James, 2000; Dave, Eckel, Johnson, & Rojas, 2010; Crosetto & Filippin, 2016; Charness, Garcia, Offerman, & Villeval, 2019). These problems can only be exacerbated in rural areas of developing countries due to the lower numeracy of the subjects involved. Therefore, the choice of a simple and comprehensible task is of utmost importance (Charness & Viceisza, 2016). For this reason we administer a further simplified version of the Bomb Risk Elicitation Task (Crosetto & Filippin, 2013).

In this task, participants are presented a winding road (as shown in Figure 2) in which participants earn 0.5 Ghana cedi for every step taken in numerical order. A time bomb is hidden behind one of the 100 steps. If a participant steps on the bomb all the earnings are wiped out. The bomb can be behind any of the 100 steps with the same probability, but its position is unknown to the participants and to the experimenters. The location of the bomb is blindly determined by each participant at the end of the experiment drawing a number from a bowl containing 100 numbered and folded pieces of paper. Participants have to indicate every step they take by crossing all the numbers until they reach the step where they want to stop. They also have to confirm their choice writing the number of steps that they decide to take in the box below the winding road.

If the number drawn from the bowl, which represents the position of the time bomb, is greater than the number of steps the participant decides to take it means that the participant did not step on the bomb. Therefore, he earns 0.5 Ghana cedi for each step taken. Conversely, if the number drawn from the bowl is lower than or equal to the number of steps chosen, the participant does not earn anything. In this risk elicitation task the higher the number chosen, the larger the potential earnings but also the probability of getting zero. The choice reveals

[5] The exchange rate at the time of the experiment was 1 Ghana cedi = $0.225.

the respondent's risk preferences, with 50 corresponding to a risk neutral decision, and lower numbers representing higher degrees of risk aversion.

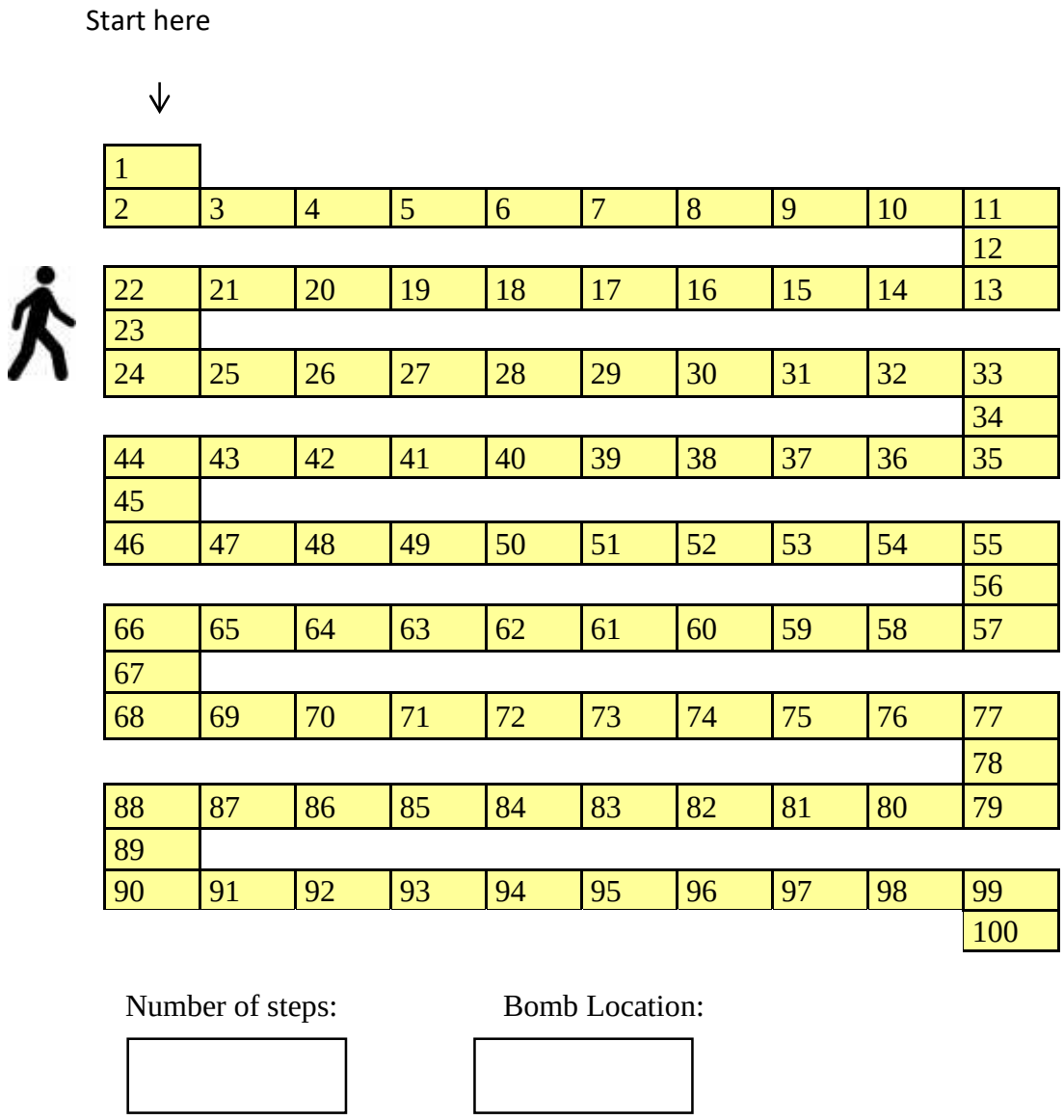

Figure 2: Picture Card for Risk Experiment

1.3 Experimental procedure

The experiment took place in September 2017 in the Tolon-Kumbungu district, in the Northern part of Ghana, involving 200 participants. A total of 10 experimental sessions were organised in 10 different communities, 5 closer to the White Volta river (Kuli, Sheegbuni, Nawumi, Afayili, and Tampia), which constitutes our treatment group, and 5 further away used as controls (Wantugu, Gummon, Koblimahigu, Tali and Sabiegu). A recognizance visit to the study area was made in February 2017. The first contact was the regional director of the Ministry of Food and Agriculture. The district director then instructed an officer to

accompany an experimenter to the villages. Among the villages visited during the recognizance visit were Afayili, Nawumi, Kuli, Wantugu, Tampia, Gummon, Sabiegu, Koblimahigu, Sheegbuni and Tali. The first contact in the villages was the community head, who after listening the description of the experiment gave us the permission to hold a session in the village.

To grant a clear understanding of the experiment, the tasks and the questionnaire were administered in the local language (Dagbani). Two district officers of the Ministry of Food and Agriculture were thus trained on how to administer the tasks and the questionnaire. The community head was informed in advance about the timing of the experiment and asked to gather the male farmers in the community telling them that the participation was limited to 20 people. Before the beginning of the experiment we asked each farmer whether he has been staying in that community for more than 20 years, something that indeed characterized everybody. We then put in a bowl numbered and folded pieces of papers corresponding to the total number of people gathered, and then asked the farmers to draw one number at random. Those drawing the numbers from 1 to 20 were selected as the participants to the experiment in that community.

In each session, the public good game was administered first. The groups were formed putting 20 folded pieces of paper numbered from 1 to 5 (each number 4 times) in a bowl. The participants randomly selecting the same number were grouped together. Subject then played the Bomb task[6]. Finally, an exit questionnaire was administered in a face-to-face interview format to obtain the socio-economic characteristics of the respondents, as well as their self-reported willingness to pay for different goods (insurance, investment in drainage systems and fertilizers).

Subjects were told in advance that the experiment involved a pay-one-at-random protocol among the tasks, on top of a show up fee of 10 Ghana cedis. In every session, the choice of the task relevant for payment was determined by one participant who selected randomly from a bowl a numbered and folded piece of paper. To ensure a good understanding the tasks were explained very carefully, and therefore the experiment was quite long (3 and half hours on average), but was adequately rewarded. In fact, subjects earned on average 21.23 Ghana cedis, equivalent to $4.78 and about two and a half times the daily minimum wage at the time (8.80)[7].

2. Results

In this section we first provide evidence supporting the goodness of the experimental design, in terms of the ex-ante socio-economic characteristics of treated and control groups as well as concerning the effectiveness of the intended treatment represented by the proximity to the White Volta river. We then present the experimental results capturing the effect of the

[6] The experimental protocol involved then the elicitation of loss aversion and time preferences. These tasks, however, are not analysed in what follows. The reason is that the choices in the loss aversion task turn out to be highly collinear with those in the risk elicitation task. Given that risk aversion also affects the choices in the lotteries with negative payoffs, we find no evidence of an additional role played by loss aversion. As far as time preferences is concerned, impatience does not significantly correlate with the inclination to cooperate.

[7] http://www.myjoyonline.com/news/2017/july-11th/daily-minimum-wage-goes-up-by-10.php

different degree of exposure to the risk of floods on farmers' inclination to cooperate, risk attitudes, and the interaction between these behavioural traits.

2.1 Goodness of the experimental design

Crucially for a field experiment based on equality via matching, we first test whether the treated and control groups are similar ex ante, except for their exposure to the risk of floods. Table 1 includes the descriptive statistics of a wide range of socio-economic characteristics that turn out to be balanced across experimental conditions. In particular, a battery of Mann-Whitney tests shows that there is no significance difference in the average age of participants, in the household size, in the number of adults in the households, as well as in the dependency ratio (total number of household members over number of members working in the household). A non-parametric Fisher exact test of proportions shows a similar distribution of educational levels. Farmers are similar across experimental groups also in terms of crop area cultivated and in the number of years of experience. Confirming the effectiveness of the selection procedures, all the participants confirmed in the questionnaire that they have spent their entire lifetime in the current community, indicating that there was no migration issue between the two experimental groups.

Table 1: Socio-economic characteristics of treated and control groups

Variable	Control	Treated	Mann-Whitney Z	p-value
Age	44.17	43.05	1.030	0.3032
	(7.58)	(8.59)		
Household Size	5.96	6.27	-1.164	0.2443
	(1.71)	(1.84)		
Number of Adults	2.32	2.37	-0.627	0.5307
	(0.57)	(0.60)		
Dependency[8]	2.60	2.66	-0.925	0.3549
	(0.60)	(0.55)		
Education: (Fisher Test)				
No Education	58%	66%		
Basic Education	19%	16%		0.530
Secondary Education	23%	18%		
Farm Size	5.07	4.82	1.273	0.2031
	(1.44)	(1.33)		
Farming Years	23.52	22.44	0.991	0.3219
	(8.14)	(8.31)		
Migrant	0	0		
	(0)	(0)		

Note: Standard deviation in parenthesis

The following question to answer is whether the choice of the communities based on their proximity to the White Volta river effectively captures a different exposure to the risk of the natural disaster represented by floods. The experiment took place in September 2017 at the end of a harvest season in which severe floods occurred (see above Footnote 3).

Participants are asked to report in the questionnaire the amount of crop losses suffered. Table 2 shows that farmers in the treated group lost about 5.19 bags of maize in the last growing

[8] Note: The dependency ratio is the ratio of total household members over the number of household members actively working.

season on average, more than twice the amount of the controls (2.39 bags). A Mann-Whitney test shows that the difference is highly significant ($p < 0.001$). The results also show a significant difference in the amount of cassava output lost, with the treated group losing about 1.7 bags more (Mann-Whitney test $p < 0.001$).

Using the price at which the respondents report to have sold their maize and cassava output in the market we compute the total monetary value of the losses. This value ranges from a minimum of $68.06 to a maximum of $322.88 in the whole sample, with an average of about $169.4. The treated group lost about $218.44 on average, significantly more than the $120.36 of the controls (Mann-Whitney test $p < 0.001$). Farmers are also asked to indicate how the losses. In 2017 compare with the average in the previous five years. 91% and 85% of the respondents in the treated and the control group, respectively, report a similar pattern. Floods are not a one-off occurrence as they represent an impending risk borne by treated and control communities to a different degree on a regular basis. As such, the identification of the communities in the experimental design seems to properly represent the intended treatment, i.e. a different exposure to the risk of natural disasters.

Table 2: Analysis of the outcome of the exposure to risk ex-ante

Variable	Control	Treated	Mann-Whitney Z	p-value
Maize Loss (Bags)	2.39	5.19	-12.11	< 0.001
	(0.88)	(0.87)		
Cassava Loss (Bags)	3.51	5.16	-10.15	< 0.001
	(0.70)	(1.05)		
Value of Crop Loss ($)	120.34	218.44	-12.07	< 0.001
	(26.46)	(34.35)		
Losses: (2017 vs 2012-16)				
Different	15%	9%	Fisher	0.276
Similar	85%	91%		
Maize Output (Bags)	23.25	22.71	1.229	0.2192
	(3.15)	(3.16)		
Cassava Output (Bags)	18.45	17.8	1.578	0.1146
	(2.67)	(2.00)		
Maize Productivity	5.32	6.06	-5.061	< 0.001
	(1.03)	(1.05)		
Cassava Productivity	4.58	5.05	-3.004	0.0027
	(1.05)	(1.13)		
WTP for Drainage System	5.57	13.60	-11.225	< 0.001
	(2.38)	(3.92)		
WTP for Fertilizer	6.72	5.31	4.735	< 0.001
	(2.35)	(1.84)		

Note: Standard deviation in parenthesis

Two things deserve to be stressed. First, the controls also face some risk of natural disaster, although with significantly less severe consequences. Hence, the results in Section 3 should not be interpreted quantitatively as the absolute effect of exposure to background risk, but rather in relative terms as the effect of a higher exposure. Second, Table 2 also shows that summing up the output brought to the market and the amount lost, we find that the productivity per acre is significantly higher in the treated communities for both crops. Hence, living closer to the river represents a lottery with a potentially higher reward but also a higher

risk. The combined effect using the 2017 data displays that the output brought to the market is not significantly different.

Additional evidence supporting the effectiveness of the treatment comes from the elicitation of the farmers' Willingness to Pay (WTP) for different goods. In particular, respondents were asked to indicate the maximum amount they are willing to pay *a)* in building a drainage system around farmlands; *b)* to buy a bag of fertilizer[9]. Farmers in the treated group are willing to pay $13.60 per year on average for a drainage system, while this amount drops to $5.57 on among the controls. The difference is highly significant (Mann-Whitney test $p < 0.001$) indicating that the farmers in the communities close to the river attach a higher value to the protection against the impact of floods. The WTP for a bag of fertilizer is instead significantly lower for the treated, confirming that the soil is more fertile close to the river.

In all, the evidence in this section shows that the two experimental groups are comparable in terms of their ex ante socio-economic and cultural characteristics. At the same time, they differ significantly in terms of exposure to flood risk and of the consequent impact on their activity. Given that we can exclude self-selection into the treatment, this setting allows us to identify the causal effect of a higher exposure to the risk of floods on the behavioural traits under investigation.

2.2 Experimental results

This section analyses the participants' risk attitudes and inclination to cooperate, as well as the interaction between these preferences for different levels of exposure to the risk of natural disaster.

3.2.1 Risk Preferences

The effect of the environment on individual risk preferences is in line with the literature stating that background risk makes individuals less tolerant to other avoidable risks (see Table 3, top panel). Subjects in the treated group chose on average 18.3 boxes, against 30.5 of the controls (Mann-Whitney test $p < 0.001$) displaying a significantly higher degree of risk aversion. A Fisher exact test confirms that there is a significantly higher fraction of risk averse subjects among the treated (92% Vs. 80%, $p = 0.024$). This finding is consistent with Cameron & Shah (2015), who report that respondents exposed to flood and earthquake in Indonesia exhibit higher levels of risk aversion compared to unexposed respondents.

The respondents from both groups display a remarkably strong degree of risk aversion, a result that at first glance is at odds with the finding that subjects in developing countries are generally risk tolerant (l'Haridon & Vieider, 2019).This purported contradiction can be rationalized by the fact that respondents in both groups face a high (though different) risk of natural disasters, which makes the whole sample more risk averse.

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[9] These amounts are elicited using a dichotomous Contingent Valuation Method (CVM) on hypothetical scenarios. Respondents are first asked whether they are willing to pay more or less than an initial value. According to their answer, a second (higher or lower) value is proposed, and finally the respondents report the exact amount they attach to the good. Five different initial values are proposed, in order to minimize possible anchoring effects. Indeed, there is no correlation between the initial value and the final WTP for the two goods ($\rho = -0.0174; p - value = 0.8065$), which implies that there is no starting point biases in the CVM. A correlation between the initial bid and the final WTP would have mean the respondents' final WTP was influenced by the initial bid.

A regression of the choice in the BRET controlling for the socio-economic characteristics of the subjects confirms the robustness of the effect of exposure to risk (see Table 4, Column 1). Results display decreasing absolute risk aversion, something typically observed also in the literature concerning developing countries, both in Asia (Liu, 2013; Tanaka, Camerer, & Nguyen, 2010) and in Africa (Yesuf & Bluffstone, 2009; Liebenehm & Waibel, 2014). The higher risk aversion of poorer farmers suggests that they are even less willing to undertake risky endeavours such as investments and therefore could be trapped in poverty. Education also makes subjects less risk averse, similarly to what found by Liebenehm & Waibel (2014) among cattle farmers in West Africa[10].

Table 3: Descriptive statistics of experimental tasks results

Variable	Control	Treated	Mann-Whitney Z	p-value
Risk Tolerance (Number of Steps)	30.47	18.26	5.764	< 0.001
	(20.46)	(18.42)		
Risk Attitudes:				
Risk Averse	80%	92%	Fisher	0.024
Risk Loving	20%	8%		
Average Contribution	3.38	5.16	-6.026	< 0.001
	(0.36)	(0.52)		

Notes: Standard deviation in parenthesis.
The test of the average contribution is based on the average group choices, i.e. 25 independent observations per treatment

The positive relationship between education and risk tolerance suggests a channel that policies may exploit to foster the adoption of more rewarding methods of production that require investments perceived as risky. Finally, the classic positive correlation between age and risk aversion also emerges. These significant correlations also corroborate the goodness of the elicitation of risk preferences with experimental tasks, something not obvious in general and even less so in developing countries (Charness & Viceisza, Three Risk-elicitation Methods in the Field-Evidence from Rural Senegal, 2016).

2.2.2 Cooperation

The results clearly show that exposure to flood risk increases cooperation substantially (see Table 3, bottom panel). The average contribution to the public good is 51.6% of the endowment in the treated group and 33.8% among the controls. Using the average contribution of each group across the ten period as an independent observation, a Mann-Whitney test detects that differences are highly significant despite the low number of observations ($p < 0.001$). The same pattern emerge analysing the contributions period by period (see Figure 3). In both groups we observe the classic decay in the contributions over time (Isaac, McCue, & Plott, Public goods provision in an experimental environment, 1985; Andreoni, 1988; Ledyard, 1994), but the treated contribute steadily and significantly more. This result seems to extend the findings of Afzal, et al. (2015) also to the case of devastating floods.

Column 2 of Table 4 reports the analysis of the degree of cooperation controlling for the main socio-economic characteristics of individuals in a standard linear regression. The treatment dummy display a very strong and significant effect, while only age displays a weakly significant correlation with the average individual level of the contributions. Poorer subjects are also those who display a higher risk aversion, thereby suggesting that the

[10] Tanaka, et al. (2010) and Nguyen (2011) find instead the opposite relationship in Asia.

correlation of age with cooperation is likely spurious. In fact, the significance of this correlation disappears when individuals' risk preferences are controlled for.

Table 4: Factors influencing farmers' economic preferences.

Variables	(1) Risk (Steps)	(2) Cooperation	(3) Cooperation
Treated	-10.875***	1.7674***	1.6528***
	(2.028)	(0.1215)	(0.1268)
Risk Tolerance			-0.0105***
			(0.0033)
Income	0.094***	-0.0011*	-0.0001
	(0.015)	(0.0007)	(0.0007)
Age	-0.517***	0.0109	0.0054
	(0.126)	(0.0084)	(0.0081)
Education			
No Education	Reference	Reference	Reference
Basic Education	9.677***	-0.0641	0.0379
	(2.714)	(0.1340)	(0.1336)
Secondary	17.346***	-0.0434	0.1393
	(3.361)	(0.1430)	(0.1365)
Farm Size	0.951	-0.0345	-0.0245
	(0.770)	(0.0388)	(0.0378)
Dependency	2.614	0.0319	0.0595
	(1.587)	(0.0773)	(0.0815)
Constant	-29.770***	3.7923***	3.4789***
	(8.959)	(0.4697)	(0.4804)
R-squared	0.6711	0.7316	0.7449

Standard errors in parentheses () are clustered at the group level

$*p < 0.1, **p < 0.05, ***p < 0.01$

Risk tolerance turns out to be negatively and strongly correlated with cooperation (Table 4, Column 3), showing that the interplay between these two behavioural traits needs to be analysed carefully. The fact that risk aversion increases cooperation suggests that cooperation may indeed work as a form of self-insurance. This result is in line with Lohse, et al. (2012), who report that a highly risk averse person will demand more self-insurance to reduce the size of a loss. If cooperation was only driven by self-insurance purposes the change in cooperation should be entirely linked to the change in risk aversion. However, greater exposure to natural risk likely has a direct effect, too. The interesting question is therefore to disentangle how much of the stronger inclination to cooperate is directly driven by exposure to risk from what is due to higher risk aversion, which is in turn affected by the treatment.

2.2.3 Cooperation as self-insurance?

In general terms, risk aversion plays the role of an intermediate variable that lies in the causal path between the treatment (exposure to risk of disaster) and the outcome (inclination to cooperate). In our data we observe the level of cooperation and risk aversion under the two separate conditions (treated vs. control). What cannot be observed is the counterfactual level of cooperation for the controls when the level of risk aversion is equal to that of the treated. This measure would represent the indirect effect of exposure to flood on cooperation, i.e. the fraction of the total effect that can be attributed to the increase in risk aversion. In what follows we identify this indirect effect using the Average Causal Mediation Effect (ACME) proposed by Imai, et al., 2010a,b; Hicks & Tingley, 2011). The ACME estimator applies to continuous mediation and outcome variables, as in our experiment, and

requires less parametric assumptions than the linear structural equation model. Once the mediation effect is inferred, we can then identify how much of the total effect is driven by the so-called natural direct effect of the treatment on cooperation and how much by the mediating role of risk-aversion.

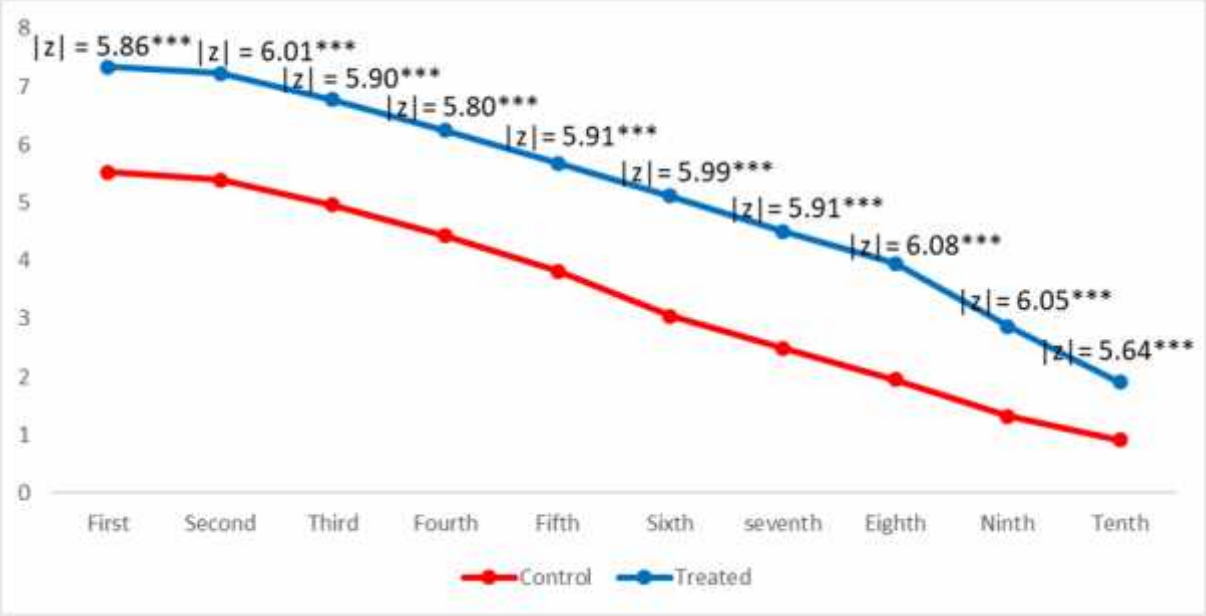

Figure 3: Average group contributions by location

The mediation effect turns out to be only 6.3% of the overall impact of the treatment, showing that the bulk of the effect of exposure to the risk of flood on cooperation is direct. The identification of ACME relies upon the sequential ignorability assumption. In particular, while the two groups display similar observable characteristics, we cannot exclude that there may exist unmeasured covariates that confound the relationship between the mediator and the outcome. For example, the sequential ignorability assumption would be violated if cooperation responded to risk aversion differently depending on whether it was directly assigned or occurred as a natural response to the treatment. Sensitivity analysis show that the mediation effect remains of a small order of magnitude for reasonable departures from the identification assumption (see Figure 4).

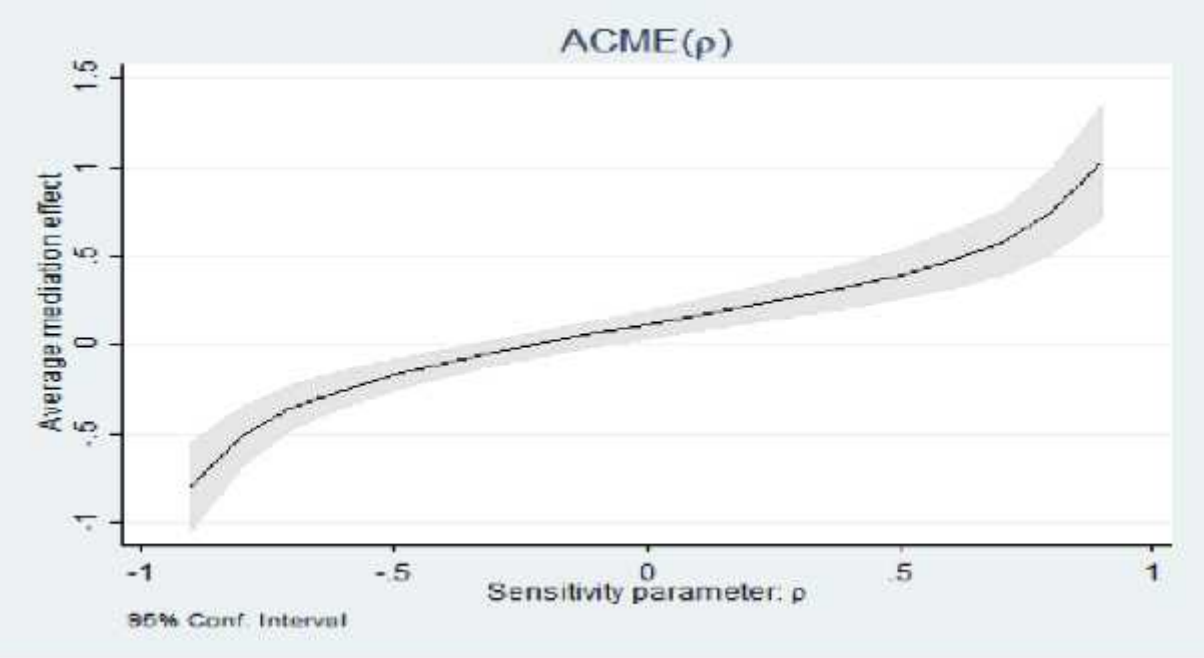

Figure 4: Sensitivity analysis of causal mediation analysis around the identification assumption $\rho = 0$

Conclusion

The growing risk of natural disasters has a profound impact especially in developing countries, where rural livelihoods are inextricably linked with the environment. The difficulty to insure this type of risk magnifies the role played by individual behavioural traits when dealing with the severe consequences of these unfavourable events as well as in shaping appropriate adaptation strategies. This paper studies the causal effect of a different exposure to flood risk on the inclination to cooperate, on risk aversion, and their interplay. While the role of risk aversion is intuitive, we also investigate the effect of background risk on cooperation, something not established in the literature. The idea is that the collective effort of the members of a community constitute a major strength of rural households in reducing the impact of natural shocks on their livelihood. In particular, given that cooperation may be seen as a form of self-insurance at the local level, the goal is to assess how much of the change in pro-social behaviour is a direct effect of exposure to risk, and how much is instead mediated by the effect on risk preferences.

Our experiment confirms that preferences are significantly affected by the environment. As regards risk aversion, we find that highly exposed individuals exhibit a significantly higher level of risk aversion, an effect of background risk that is well-known in the literature. The average degree of risk aversion is higher than what commonly found in developing countries, possibly because respondents in both the treated and the control group face a significant (though different) risk of natural disaster. This treatment effect is robust to the inclusion of socio-economic characteristics in a multivariate analysis. Besides the classic positive correlation with age, we find evidence of decreasing absolute risk aversion, suggesting that poorer farmer may be less willing to adopt more rewarding methods of production involving risky investments and therefore be trapped in poverty. However, risk aversion decreases with education suggesting a channel that policies may exploit to foster the adoption of rewarding but risky innovations.

Our results show that a higher exposure to the risk of natural disaster significantly increases the inclination to cooperate. The results also reveal a strong and positive correlation between cooperation and risk aversion. At first glance, the fact that more risk averse individuals contribute more to the public good lends support to the interpretation of cooperation as a form of self-insurance in an environment where classic forms of insurance are not available. We therefore perform a causal mediation analysis to test whether risk aversion acts as an intermediate variable in the causal path between background risk and individuals' inclination to cooperate. We find that risk aversion does play a role, but that only a small proportion (6.3%) of the change in cooperation may be ascribed to the increase in the level of risk aversion, with the bulk of the effect being direct. In other words, the increase in the farmers' inclination to cooperate is to a great extent directly driven by the higher exposure to natural disaster.

While cooperation seems to emerge as a spontaneous and relevant adaptation strategy, the results of our experiment also provide suggestive evidence for policy implications. The take-up of innovative but risky methods of production could be fostered by policies aimed at increasing farmers' income and education, given their negative relationship with risk aversion. The results of our paper also provide interesting insight for future research. Understanding the exact shape of the relationship between different levels of exposure to risk of natural disaster and cooperation, as well as discovering other and more relevant mediating variables (e.g. altruism, trust and trustworthiness) looks like two promising endeavours in our opinion.

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