Thailand Vietnam Socio Economic Panel

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2022

TVSEP Working Paper

WP-024

Gefördert durch DFG Deutsche Forschungsgemeinschaft

Leibniz Universität Hannover

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

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

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Long-term behavioral responses to man-made disasters: Insights from the Agent Orange experiment in Vietnam

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Abstract

Do man-made disasters induce permanent behavioral changes? While the temporary link between negative shocks and risk aversion has been analysed, the *evolution* of risk profiles over time in response to a negative shock remains unexplored. Using panel data from Agent Orange affected areas in Vietnam, we explore (i) whether individuals in a disaster-prone area are more risk tolerant vis-à-vis those who are unaffected, (ii) whether risk tolerance declines and the willingness to invest increases, with the decreasing intensity of the harm in the disaster affected area, and (iii) what factors influence individuals' residency within disaster affected areas. We find that individuals living within an Agent Orange affected area are relatively more risk loving but this risk tolerance decreases with the decreasing intensity of harm over time. Residency within the disaster area is influenced by the level of human capital and ownership of physical capital.

Keywords: Vietnam, Agent Orange, Risk Profiles, Propensity Score Matching

JEL: C93, D1, Q51

RePEc:tvs:wpaper:wp-024

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1. Introduction

An increasingly prolific area of social science research concerns the behavioral response of individuals to natural and man-made disasters. As the frequency of disasters increases - from climate change induced droughts, floods, hurricanes and earthquakes to environmental disasters involving oil spills and nuclear accidents to man-made disasters like wars – two aspects of human behavior are under increasing scrutiny. First, how are behavioral preferences of individuals, especially risk profiles, affected by unanticipated shocks? Second, aside from humanitarian interventions and risk preferences, what intrinsic factors contribute to the residency of individuals within the disaster-prone area? It is now well-established that risk preferences of individuals do change in the face of man-made and natural disasters with a tilt towards more risk tolerance in some cases and a tilt towards risk aversion in others. But what is unknown is whether this observed change in risk preferences is temporary or whether this change tends to persist over the long run. The central question in this paper involves the analysis of the evolution of risk preferences of individuals residing in areas affected by a large-scale man-made disaster – the spraying of Agent Orange during the Vietnam War. Our central finding is that indeed, risk preferences of individuals residing in a disaster-prone area evolve, mirroring the decay of contaminants embedded in soil and water over time. The second issue we analyse are the factors that contribute to an individual's continued residency within a disaster zone in a developing country. Not surprising perhaps, we find that the level of human capital and ownership of physical capital play important roles in the residency decision. Our paper is the first to both track the *evolution* of risk preferences subsequent to a disaster and establish a framework to analyse the issue of residency within disaster affected areas.

We leverage a unique panel dataset with negligible attrition: the Thailand-Vietnam Socio-Economic Panel (TVSEP), undertaken over the 2008-2017 period. The panel tracks over time experimentally elicited behavioral responses and socio-economic indicators of approximately 2000 individuals residing in three provinces of Vietnam – one heavily sprayed and the other two with minimal exposure to Agent Orange. Beyond an analysis of the risk preferences, and its trend over time, we are interested in exploring the conceptual link between risk preferences and the motive for self-insurance. Specifically, we explore the idea that staying out of a disaster afflicted area is a self-insurance mechanism, with self-insurance in turn being negatively correlated with the individual's level of risk tolerance. In addition, we explore whether the differential risk tolerance across the treatment (heavily sprayed by Agent Orange) and the control (minimally affected by Agent Orange) provinces in Vietnam is robust to a matching test that aims to resolve observed differences in an individual's

potential to sort into or out of the disaster afflicted province and whether and how it changes over time in line with the reduction of the threat.

Our results indicate that individuals in the province affected by Agent Orange exhibit more risk tolerance, consistently with their lower degree of preference for self-insurance against risks for health and life. Their risk tolerance decreases over time, in line with the gradual dissipation of the risk, but their willingness to invest continues to decline compared to individuals in areas not affected by the disaster. Sorting of individuals across affected and unaffected areas is a function of the level of education and land holdings.

2. Relevant literature

Our paper contributes to three broad debates that analyse the behavior of individuals exposed to potential adverse health and loss of life risks due to man-made and natural disasters. The first group looks exclusively at the risk profiles of individuals affected by civil wars in developing countries. The second provides a conceptual framework for the findings of the first, by examining risk profiles and residential prices (which reflects demand for housing) of individuals affected by the building of nuclear power plants, transportation and storage of radioactive waste and the presence of water contaminants due to a variety of reasons. A third group looks at outmigration from areas of natural and man-made catastrophes. These three strands in the literature are described in the following.

2.1 Risk tolerance in the face of natural and man-made disasters

The most popular direct consequence of the impact of man-made disasters on risk preferences is in the context of civil wars. Empirical evidence is mixed, with studies finding both a positive association in some cases and a negative one in others. Individuals exposed to terrorist attack(s) in Afghanistan displayed more risk loving behavior[1]. Similarly, individuals in Sri Lanka who were affected the civil war displayed lower aversion to risk[2]. While Burundians directly affected by the civil war (1993-2003) displayed less risk aversion to gains, they did not show significant differences in losses compared to individuals unaffected by the war[3]. In contrast, there is evidence that people affected by post-election violence in Kenya and drug-related serious violence in Colombia display higher levels of risk aversion[4,5].

2.2 The Willingness to Pay to avoid a risk for health or life

A relative shortcoming of the literature examining the link between natural and man-made disasters is that it does not provide a unifying conceptual framework to reconcile the differences in results.

One of the most interesting conceptualisations of the behavioral response to man-made disasters comes from the literature on the Willingness to Pay (WTP) for self-insurance against risk associated with residing near nuclear power plants and radioactive waste disposal sites. A popular way to assess this WTP is via observing residential prices at different radii from the hot spot. Theoretically, an individual's choice of residential location reveals their risk profile as follows: greater distance reduces the exposure to a nuclear accident – and individuals locating further away should exhibit a higher WTP to insure against this eventuality. Thus, location is a proxy for self-insurance and individuals further away from a potential disaster zone should show greater risk aversion. There is a host of empirical evidence in support of this hypothesis. For instance, research based on a series of publicly known shipments of spent nuclear fuel in the US state of South Carolina found that real estate values near densely populated urban areas at high risk of exposure have fallen substantially, while real estate values were unaffected in areas with lower risk perception[6]. However, the problem with analyses based on residential prices is that disaster risk is one of many factors that determine an individual's choice of where to reside. A further complication is the fact that the cost of sorting in and out of an affected area is not necessarily trivial[7]. A preferable alternative would be to either estimate directly the WTP to avoid the health risk associated with an exposure to radiation or to assess individuals' subjective assessment of the risk. Research on the WTP to cover the financial risks of a potential nuclear accident in Switzerland shows that distance from an environmental disaster could have a nuanced effect on the WTP for risk reduction[8]. Distance is a significant predictor of marginal WTP for insurance coverage, but not WTP for solving the waste disposal problem. Controlling for attitudes towards nuclear energy and nuclear sorting in space, the distance gradient with regards to the marginal WTP for increased insurance coverage is significantly negative. Surprisingly though, distance is not a relevant predictor for WTP to solve nuclear-related risk issues in South Africa[9]. On the subjective risk assessment side, there is a small literature that relates to the controversy surrounding the 1987 US Congress decision to ship nuclear waste from 33 states across the US over a 24-year period to the Yucca Mountain nuclear waste repository in the State of Nevada. Based on a survey of mortality risk from exposure to radioactive waste along some transport routes, research shows that distance from the transport route has a negative and significant effect on the perceived mortality risk[10]. More recent studies on risk assessment related to locations near nuclear power plants conducted after the Fukushima nuclear accident in Japan show that individuals WTP to avoid risks in East Asian countries are high. Specifically, individuals in China are willing to pay higher electricity prices to avoid nuclear power plants in the neighborhood[11].

2.3 Migration in the face of natural and man-made disasters

Our conceptual framework indirectly touches on a third popular theme, that of out-migration from areas affected by man-made disasters. Estimates suggest that at the end of 2019, there were 50.8 million internally displaced people; 45.7 million as a result of conflict and violence and 5.1 million as a result of natural and man-made disasters[12]. An important factor, other than risk perceptions based on either imperfect information regarding the true potential for harm or an underestimation of the potential losses to be incurred, relates to ownership of immovable assets like land. The situation is particularly complex with regards to ill-defined property rights in less developed economies. Research in Ethiopia has shown that people do not migrate out of fear that their property rights will be dissipated in their absence[13]. Thus, the decision to flee an area affected by natural or man-made disasters is compounded by weak institutional and governance frameworks in developing countries[14]. Not surprising, therefore, are the observed differences in WTP estimates for risk avoidance across developed versus developing countries.

3. Overview of Agent Orange

Over the period 1965-1972 during the Vietnam War, the US military sprayed 80 million liters (or roughly 21.6 million gallons) of the defoliant Agent Orange on rainforests, wetland mangroves, agricultural land, rivers and streams with the twin objectives of improving visibility for military operations and disruption of food supply for the VietCong. A number of other defoliants, some without or with low levels of dioxin concentration, named after the color of the band on the containers such as Agent White, Agent Pink, Agent Blue and Agent Purple were also used at various stages of the war, Agent Orange was the deadliest and consisted of equal amounts of two herbicides 2,4-dichloro phenoxyacetic acid C8H6Cl2O3 (2,4-D) and 2,4,5-trichlorophenoxyacetic acid C8H5Cl3O3 (2,4,5-T) and dioxin, 2,3,7,8-tetrachlorodibenzodioxin (C12H4Cl4O2) – commonly known as TCDD. While the half-life of the herbicides in Agent Orange is days and weeks after application to vegetation, the half-life of the dioxin TCDD depends on where it is deposited and varies from 1 to 3 years on soil surfaces that have been fully exposed to sunlight, to as long as 20 to 50 years or more when buried in tropical subsoils, and more than 100 years in river and sea sediments[15]. Given that the levels of TCDD in Agent Orange was 50 times the level found in commercial weed killers sold in the US, it continues to have significant adverse health impacts from birth defects to cancer and premature deaths in the more heavily sprayed areas of Vietnam even 50 years after the end of the war[16]. Figure 1 shows the gradual increase of the use of Agent Orange over the 1965-1970 phase of the war, with some studies estimating an even higher use of this defoliant[17].

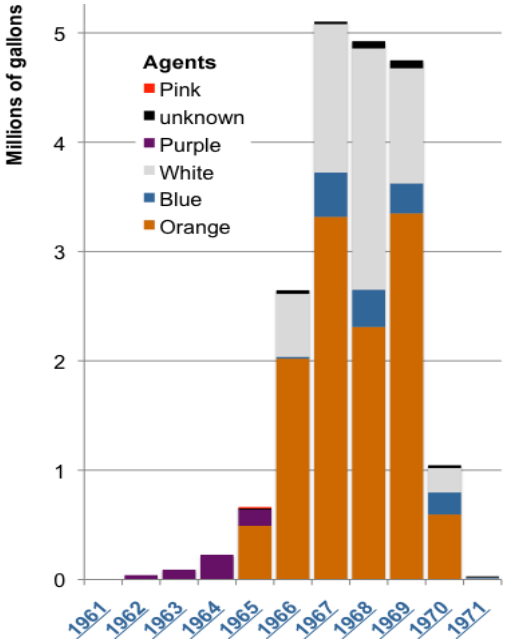


Figure 1: Millions of Gallons of Agent Orange used between 1961-1971 in Vietnam.

Source: The Chicago Tribune, Jul 17, 2014

4. Data and choice of treatment and control areas

The socioeconomic panel survey in Vietnam was conducted in three provinces over five rounds between 2008-2017. Of these three provinces, two, Thua Thien Hue and Dak Lak are in South Vietnam (below the 17th parallel) while Ha Tinh is in North Vietnam, which was less severely affected by Agent Orange spraying. Thua Thien Hue is one of the more heavily sprayed provinces and ranks third in terms of the most heavily sprayed provinces during the war. A total of 920,497 gallons of herbicides was sprayed over 1,244 square kilometers or over 25% of the province. However, the Dak Lak and Ha Tinh provinces were minimally affected by Agent Orange. We thus define Thua Thien Hue as the treatment area and Ha Tinh and Dak Lak as the control areas. Figures 2 and 3 show the survey provinces and the intensity of herbicide spraying below the 17th parallel.

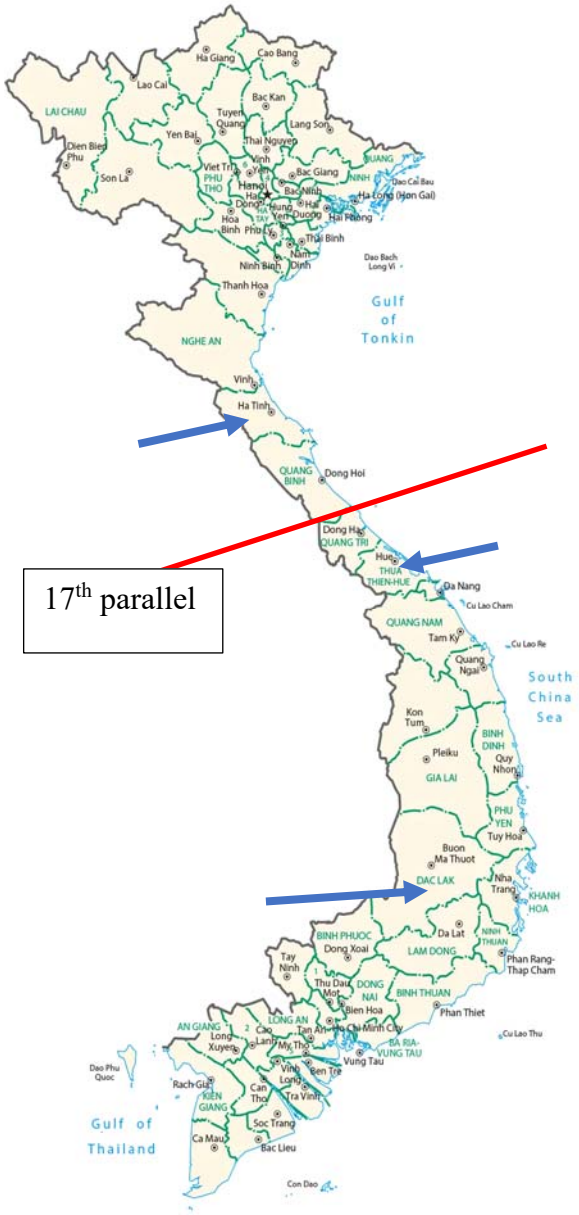


Figure 2: TVSEP Survey Provinces

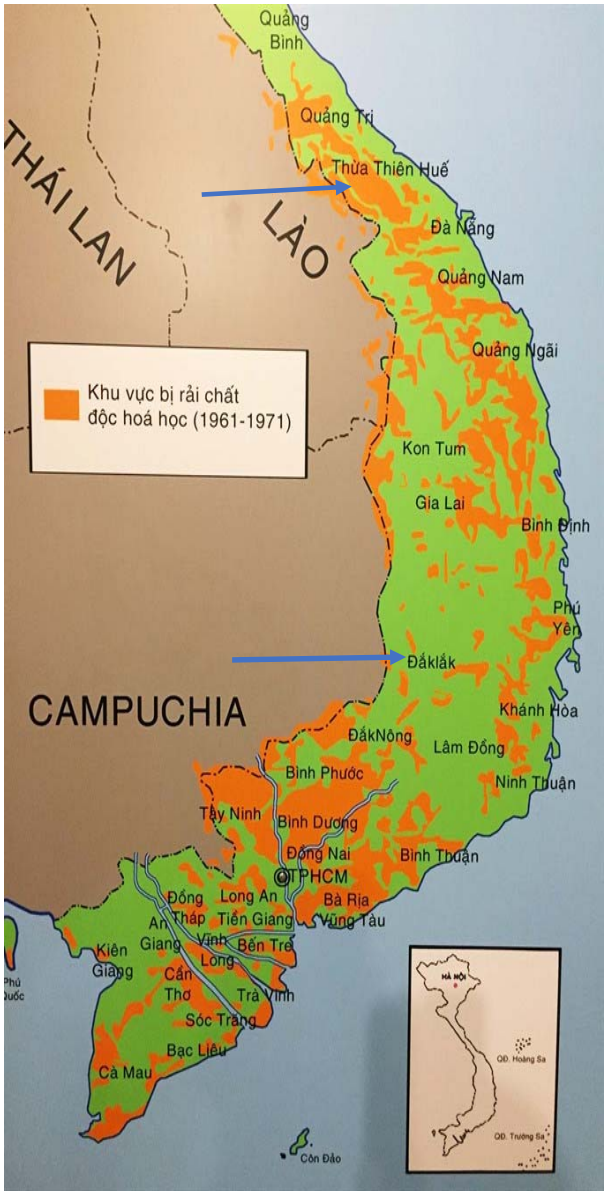


Figure 3: Intensity of Herbicide Spraying by Province

Descriptive statistics for the treatment and control provinces are shown in Table 1. Individuals residing within the province affected by Agent Orange display a greater level of risk tolerance and a lower willingness to invest as compared to their peers in non-Agent Orange provinces. Individuals in the Agent Orange province are also less educated and with higher dependency ratios. They are less likely to be farmers and more likely to have a permanent non-farming job than individuals in non-Agent Orange provinces. It is also interesting to note that there is no statistically significant difference between the number of household shocks experienced, and the age and gender of individuals belonging to the treatment and control provinces. However, individuals belonging to the non-Agent

Orange provinces are more likely to report correlated shocks, namely shocks affecting households other than their own in the neighbourhood.

Table 1: Descriptive statistics across provinces

	Non-Agent Orange Provinces			Agent Orange Province			T-test
	N	mean	sd	N	mean	sd	t-stats
Age	5459	48.661	11.863	2342	48.233	12.699	-1.7028
Years education	5459	8.177	3.375	2342	7.056	3.884	13.2208
Healthy	5459	.251	0.434	2342	.309	0.462	-4.9211
Farmer	5459	.747	0.435	2342	.61	0.488	11.5879
Non-agro job	5459	.039	0.193	2342	.07	0.255	-4.7215
Married	5459	.857	0.350	2342	.887	0.316	1.5164
Female	5459	.43	0.495	2342	.398	0.490	-1.0302
Household size	5459	4.755	1.683	2342	5.135	1.717	-6.9316
Dependency ratio	5459	1.48	0.679	2342	1.546	0.690	-4.0172
Household shock	5459	.537	0.687	2342	.527	0.730	0.0163
Covariate shock	5459	.737	0.731	2342	.667	0.792	3.1757
Risk tolerance	5459	5.178	2.938	2342	5.623	2.604	-4.8838
Investment/10000	5459	1.671	1.910	2342	1.529	1.675	5.5824

Risk tolerance is measured via an 11-point Likert scale, via the question, "Are you generally a person who is fully prepared to take risks, or do you try to avoid taking risks? Please choose a number on a scale from 0 (unwilling to take risks) to 10 (fully prepared to take risks)." Thus, higher values of the variable indicate higher levels of tolerance to risk. Investment is based on the question "If you won 60 Mio. Dong how much would you invest". Household shock stands for the number of self-assessed shocks affecting the households, while Correlated shocks capture self-assessed shocks affecting more than one household in the neighbourhood. The rest of the variables are self-explanatory of either continuous nature (age, years of education, household size and dependency ratio) or dummy variables related to self-assessed health status, gender, employment and marital status.

The statistics indicate the possibility for sorting of individuals across the treatment and control provinces. On the one hand, characteristics like the lower level of education make individuals less geographically mobile and hence less likely to escape a disaster area. On the other hand, farmers in the Agent Orange affected province in Vietnam are most vulnerable to the negative effects of TCDD and hence logically less likely to stay in that area. Interestingly, individuals from the Agent Orange province are reportedly healthier than individuals in the non-Agent Orange provinces, which is an additional sign of potential self-selection. Sorting of individuals across areas is consistent with the presence of individual heterogeneity, including non-trivial differences in the ability of covering the cost of relocating which we aim to address via matching, based on observed characteristics correlated with the propensity of individuals to migrate in and out of the Agent Orange affected province.

5. Methodology

Following the discussion in the preceding section, we define Thua Thien Hue as a treatment area and Ha Tinh and Dak Lak as control areas and estimate the following model:

$$Y_{it} = \alpha_0 + \alpha_1 AgentOrangeArea + \alpha_2 AgentOrangeArea * Trend + X'_{it} + \varepsilon_{it} \quad [1]$$

Y_{it} captures the respondent's behavioral response to a man-made disaster, which we measure with three different proxies related to risk tolerance or willingness to invest for avoiding the risk, described in the main body of the paper. X'_{it}contains a set of typical individual and household characteristics, used in the literature on risk preferences. Risk tolerance in TVSEP is measured via an 11-point Likert scale, via the question, "Are you generally a person who is fully prepared to take risks, or do you try to avoid taking risks? Please choose a number on a scale from 0 (unwilling to take risks) to 10 (fully prepared to take risks). Although this is not a perfect risk measure, it has been validated in several contexts and has generally been found to be less noisy than certain experimental measures[18,19,20]. In our analysis we use both the ordinal measure of risk tolerance and a dummy variable that takes the value of 1 if the respondent situated him/herself in categories 0-4. An additional survey question asks, "If you won 60 Mio. Dong how much would you invest". Following the intuition of the literature on willingness to pay to avoid the risk to health and life, we hypothesise that $\alpha_1>0$ in the case of our ordinal risk tolerance outcome variable and $\alpha_1<0$ in the case of our binary risk aversion variable. We add the additional hypothesis that risk tolerance should go down over time, with the decreasing intensity of the harm, namely, $\alpha_2<0$.

To purge the sample of heterogeneity that could among other things be correlated with the ability of individuals to sort themselves out of the region affected by a man-made disaster, we perform propensity score matching across the two types of provinces and re-run the regressions for the matched sample. To achieve good balancing, we only include those variables that influence simultaneously the treatment decision (residence within the Agent Orange affected province) and the outcome variable of interest (risk tolerance, risk aversion dummy and willingness to invest) as variables that are unaffected by the participation in (or anticipation of) the treatment should be included in the model. To ensure this, one should prioritise variables that are largely unchanged [21]. We experimented with characteristics that influence both the participation and outcome variables, such as age, gender, marital status, household composition and wealth, measured in the first year of our panel. The results from the probit estimation in the first stage of the propensity score matching methodology (Table 2) indicate that variables such as asset ownership (in the form of both land and other durable goods) and low educational attainment are the factors reducing the capacity of individuals to sort themselves out of the area affected by Agent Orange. Table S1 and Figure S1 in the supplementary section attest to the good balancing achieved with the chosen indicators. The Variance Ratios of all variables other than land ownership, reported in Table S1 are close to one, but even in the case of land ownership, matching leads to a reduction from 8 to 4. Only two observations remain outside of the common support. We keep the first- year observations that share a common

support and apply the matching rule to the rest of the sample. This leaves us with a balanced panel of individuals that share a common support. The method allows us to account for non-random selection of individuals in the disaster affected area, based on observed characteristics. Unfortunately, we are not able to resolve the additional potential problem of unobserved heterogeneity, given that our treatment variable is time invariant and would be wiped out in a fixed effects model.

6. Results

The Probit results from the first stage of this analysis aims at identifying observed correlates associated with the willingness and capacity of individuals to sort themselves in and out of the affected area (Table 2). Human capital and resource endowments are found to play an interesting role. Importantly, years of education have a strong negative association with the propensity to reside in the affected province, while large acreage of owned land and other durable assets have a positive association. The influence of dependency ratios is also positive, while older individuals are less likely to reside in the disaster affected area.

Table 2: Observed characteristics associated with self-sorting in and out of the man-made disaster province

	Agent Orange Province
Age	-.008***
	(.003)
Years education	-.063***
	(.012)
Female	-.095
	(.073)
Married	-.052
	(.12)
Household size	.026
	(.023)
Dependency ratio	.124**
	(.049)
Acres land owned	.054***
	(.021)
Assets index	.107***
	(.024)
_cons	-.029
	(.269)
Observations	1599
Pseudo R^2	.045

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1* The variables used are self-explanatory and of either a continuous nature (age, years of education, dependency ratio, household size and acres of owned land; asset index including durable goods such types of transportation, number of rooms in the residence, access to water and electricity and type of cooking fuel) or a discrete nature (gender, marital status).

Table 3: Empirical analysis

	Full Sample			Matched Sample		
	Risk tolerance	Risk averse dummy	Willingness to invest	Risk tolerance	Risk averse dummy	Willingness to invest
Agent orange area	2.911***	-.353***	-.047	3.055***	-.378***	.01
	(.166)	(.027)	(.055)	(.175)	(.029)	(.057)
Trend	.888***	-.135***	.844***	.898***	-.135***	.831***
	(.027)	(.004)	(.015)	(.029)	(.005)	(.016)
Agent orange area*trend	-.825***	.104***	-.067***	-.86***	.11***	-.086***
	(.048)	(.008)	(.023)	(.052)	(.009)	(.026)
Age	.007**	0	-.007***	.008***	0	-.008***
	(.003)	(0)	(.001)	(.003)	(.001)	(.001)
Years of education	.077***	-.01***	.001	.075***	-.01***	0
	(.009)	(.001)	(.004)	(.009)	(.002)	(.005)
Healthy	.233***	-.016	.388***	.26***	-.018	.368***
	(.069)	(.012)	(.04)	(.075)	(.013)	(.043)
Farmer	-.111	.033***	.034	-.08	.028**	.03
	(.074)	(.012)	(.038)	(.082)	(.013)	(.041)
Non-agro employee	-.074	.001	.142	0	-.001	.148
	(.15)	(.023)	(.088)	(.163)	(.025)	(.094)
Married	.571***	-.071***	.011	.604***	-.069***	-.027
	(.097)	(.016)	(.05)	(.11)	(.018)	(.056)
Female	-.124*	.027**	-.443***	-.123*	.029**	-.435***
	(.066)	(.011)	(.032)	(.071)	(.012)	(.034)
Household size	-.016	.004	-.01	-.025	.005	-.011
	(.018)	(.003)	(.009)	(.02)	(.003)	(.01)
Dependency ratio	-.147***	.029***	-.128***	-.136***	.027***	-.113***
	(.049)	(.008)	(.024)	(.053)	(.008)	(.025)
Household shock	.136***	-.01	-.226***	.125**	-.009	-.241***
	(.044)	(.007)	(.02)	(.049)	(.008)	(.022)
Correlated shock	.076*	-.003	-.164***	.107**	-.006	-.16***
	(.042)	(.007)	(.02)	(.046)	(.008)	(.022)
Constant	1.383***	.797***	.098	1.26***	.805***	.205
	(.261)	(.043)	(.126)	(.287)	(.047)	(.137)
Observations	7801	7801	7801	6750	6750	6750
R-squared	.172	.141	.463	.183	.148	.461

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

Detailed empirical analysis on the determinants of risk preferences and willingness to invest across the treatment and control provinces is presented for the whole sample, as well as for the matched sample accounting for the potential of individuals to self-sort across these provinces (Table 3). The results are consistent both across the two sets of estimates and with common intuition. Importantly, as indicated by the results reported in columns 1 and 2 of each set, individuals in the province affected by Agent Orange are characterised by significantly greater levels of risk tolerance, even though their willingness to invest is not significantly different from that of the individuals in non-Agent Orange provinces at least in a conventional statistical sense. The interaction between the treatment area and the trend variable indicates a decrease in the tolerance to risk but a continually lower willingness to invest of individuals belonging to the Agent Orange province compared to their non-Agent Orange peers. The rest of the results are broadly consistent with intuition. Risk tolerance is an increasing function of education and health, females are less risk tolerant and less willing to invest, dependency ratios decrease the tolerance to risk, and shocks of both idiosyncratic and covariate nature tends to increase risk tolerance.

7. Conclusion

To the best of our knowledge, this is the first paper to analyse the risk preferences of individuals residing in a province heavily affected by the spraying of Agent Orange during the Vietnam War, while trying to develop a conceptual framework of behavioral responses to man-made disasters and tracking behavioral changes over time.

We draw our central hypothesis from the literature on individuals living close to nuclear waste storage facilities. Specifically, we explore the idea that staying out of a disaster afflicted area is a self-insurance mechanism, with self-insurance in turn being negatively correlated with the individual's level of risk tolerance. This logic provides some structure to the large body of empirical literature aiming to identify the impact of negative natural and man-made shocks on risk preferences, without necessarily linking the results to a theoretical framework.

Our finding that residence in a man-made disaster zone is positively associated with greater risk tolerance is similar to existing studies that have evaluated risk profiles of individuals living close to nuclear waste storage facilities or being exposed to civil wars. The finding that changes in the risk profiles of individuals residing within the disaster zone mirror the decreasing impact of Agent Orange over time is novel and provides one of the first examples of risk profiles adapting to changes in the physical environment. We are also able to identify the self-insurance motive behind the choice of residential location via a matching model to show that lower levels of education and large land

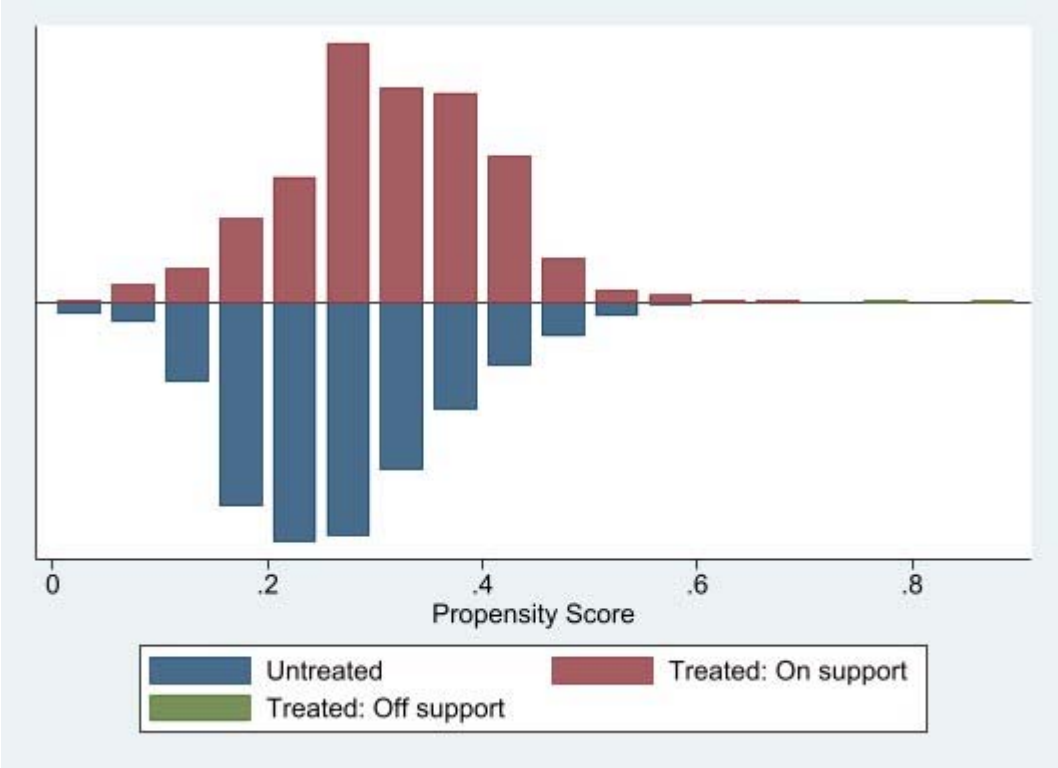
holdings prevent individuals from sorting out of the Agent Orange affected province. Finally, we shed light on some interesting behavioral responses to man-made disasters such as the fact that while risk tolerance might fall over time, the willingness to invest continues to fall within the Agent Orange province, compared to alternative areas. While we only indirectly touch upon the debate on migration from areas affected by natural or man-made disasters, our results highlight the complexities of this choice and its connection to current and future socio-economic inequalities. Importantly, while assets such as education increase the chances that better-off individuals will live outside the affected area, physical wealth (particularly in the context of poorly functioning property rights) can be a major barrier to re-settling in a disaster free area. As the interactions between man-made disasters, natural disasters and human displacement become more important in the context of climate change, careful analyses of the nuanced role of these socio-economic inequalities and behavioral responses to crises require further research.

Supplementary robustness check materials

Table S1: Balancing test one

	Standardized	differences	Variance	ratio
	Raw	Matched	Raw	Matched
Age	-0.159	-0.110	1.047	1.099
Female	-0.025	0.004	0.993	1.002
married	0.065	-0.026	0.847	1.066
Years of education	-0.337	0.042	1.187	1.427
Household size	0.203	0.020	0.995	1.015
Dependency ratio	0.196	-0.028	1.187	0.949
Acres land owned	0.134	0.053	8.444	4.345
Asset index	0.150	-0.002	1.282	1.132

Figure S1: Balancing test 2



References

[1] Callen, M., Isaqzadeh, M., Long, J. and Sprenger C. "Violence and risk preference: Experimental evidence from afghanistan". American Economic Review, 104, 123-48.

[2] Kettlewell, N., F. Rijsdijk, S. Siribaddana, A. Sumathipala, A. Tymula, H. Zavos and N. Glozier "Civil War, Natural Disaster and Risk Preferences: Evidence from Sri Lankan Twins"; IZA Discussion Paper No. 11901, Bonn, Germany (2018).

[3] Voors, M., Nillesen, E., Verwimp, P., Bulte, E., Lensink, R., and van Soest, D. "Violent Conflict and Behavior: A Field Experiment in Burundi"; American Economic Review, 102, 41-64. DOI: 10.1257/aer.102.2.941, (2012).

[4] Jakiela, P., and Ozier, O. 2016. The Impact of Violence on Individual Risk Preferences: Evidence from a Natural Experiment"; *The Review of Economics and Statistics*, 101(3), 547-559.

[5] Moya, A., "Violence, Psychological Trauma, and Risk Attitudes: Evidence from Victims of Violence in Columbia"; *Journal of Development Economics*, 131, pp. 15-27 (2018).

[6] Gawande, K. and H. Jenkins-Smith, 2001. "Nuclear Waste Transport and Residential Property Values: Estimating the Effects of Perceived Risks"; *Journal of Environmental Economics and Management*, 42, 207-233.

[7] Davis, L., 2004. "The Effect of Health Risk on Housing Values: Evidence from a Cancer Cluster"; *American Economic Review*, 94, 1693-1704.

[8] Zweifel, P., Schneider, Y., Wyss, C., 2005. "Spatial effects in Willingness-to-Pay: The Case of Nuclear Risks". http://www.energiestiftung.ch/Öles/downloads/energiethemen-atomenergie-kosten/2uni_zh_zweifel-schneider-2007.pdf .

[9] Nkosi, N.P., and Dikgang, J, 2018. "South African Attitudes about Nuclear Power: The Case of the Nuclear Energy Expansion"; Economic Research Southern Africa (ERSA) Working Paper 276.

[10] Riddel, M., 2009. "Risk Perception, Ambiguity, and Nuclear-Waste Transport"; *Southern Economic Journal*, 75, 781-797.

[11] Sun, C., Lyu, N. and Ouyang, X. 2014. "Chinese Public Willingness to Pay to Avoid Having Nuclear Power Plants in the Neighborhood"; *Sustainability*, *6*, pp 7197-7223; doi:10.3390/su6107197.

[12] Internal Displacement Monitoring Centre (IDMC). 2020: Global Report on Internal Displacement https://www.internal-displacement.org/global-report/grid2020/.

[13] De Brouw, A. and Mueller, V. 2016. Do limitations in land rights transferability influence mobility rates in Ethiopia? *Journal of African Economies*, 548-579.

[14] Kaufman, D. and Penciakova, V. 2011. Japan's triple disaster: Governance and the earthquake, Tsunami and nuclear crises. Brookings: https://www.brookings.edu/opinions/japans-triple-disaster-governance-and-the-earthquake-tsunami-and-nuclear-crises/.

[15] Olson, K.R. and Morton, L.W. 2019. "Long-Term Fate of Agent Orange and Dioxin TCDD Contaminated Soils and Sediments in Vietnam Hotspots"; *Open Journal of Soil Science*, 9, pp. 1-34. https://doi.org/10.4236/ojss.2019.91001

[16] Le D. T., Pham, T. M. and Polachek, S. 2021. "The Long-Term Health Impact of Agent Orange: Evidence from the Vietnam War"; IZA Discussion Paper No. 14782, Bonn, Germany.

[17] Stellman, J., Steven D. Stellman, S., Christian, R., Weber, T. and Tomasallo, C. 2003. "The extent and patterns of usage of Agent Orange and other herbicides in Vietnam"; *NATURE*, 422, pp. 682-687.

[18] Chuang, Y. and Schechter, L., 2015. "Stability of Experimental and Survey Measures of Risk, Time, and Social Preferences: A Review and Some New Results"; *Journal of Development Economics*, 117, pp 151-170.

[19] Liebenehm, S., 2018. "Temporal Stability of Risk Attitudes and the Impact of Adverse Shocks - A Panel Data Analysis from Thailand and Vietnam"; *World Development*, 102, 262-274.

[20] Wölbert, E. and Reidl, A., 2013. "Measuring Time and Risk Preferences: Reliability, Stability, Domain Specificity"; SSRN Electronic Journal, DOI:10.2139/ssrn.2354907.

[21] Caliendo, M., and Kopeinig, S., 2008. "Some Practical Guidance for the Implementation of Propensity Score Matching"; *Journal of Economic Surveys*, 22, 31-72.