Spatial Externalities, Policy Interventions, and Private Wildfire Risk Mitigation
An Experimental Study

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1. Background

Reducing wildfire risk to wildland-urban interface (WUI) homeowners has been a growing major issue in the United States. Successful wildfire management in the WUI involves homeowners' voluntary mitigation actions. However, individual homeowners fail to take sufficient risk mitigation due to risk externalities (known as "the mitigation paradox"). Do policy interventions facilitate private mitigation efforts and increase the efficiency? We use a laboratory experiment wherein spatial-risk externalities exist to investigate whether financial interventions promote private mitigation efforts and increase the efficiency

2. Experimental Design

We develop a public good game that models the WUI owners' risk mitigation, where in we construct hierarchical groupings containing three local groups of three members nested in a nine members global group. This group structure captures the features of spatial risk externalities. For each player, there are two neighbors in the same local group and six players in the different local groups. Each players decides whether to conduct fuel reduction ($d_i = 1$) or not ($d_i = 0$). Player *i*'s expected payoff function is defined as $\pi_i = Y - c \cdot d_i - L \cdot P(\sum d_j, \sum d_k | W)$. *Y*, *c*, and *L* are income, private cost of fuel reduction, and loss caused by wildfire, respectively. *P* is the probability of wildfire occurrence, which is the function of the sum of risk mitigation efforts in the player's own local group ($\sum d_j$) and those in the other local groups ($\sum d_k$). The vector *W* puts different weights between their own group and outside groups: 1 on $\sum d_j$ and 1/3 on $\sum d_k$One control and two treatments were used in the experiment: the no intervention group (CONTROL), the low intervention group (LOW), and the high intervention group (HIGH). The LOW (HIGH) intervention mandatory involves mild (high) risk mitigation efforts, financed by tax deducted from all players' income. In the LOW (HIGH), 20% (40%) of total maximum risk mitigation is mandatory conducted. In each treatment, players made a decision ten times and received feedback about other players' decisions after each round.

We conducted a laboratory experiment at Kyoto University in 2016. A hundred and eight undergraduate and graduate students were participated.

3. Results

The likelihood of individual fuel reduction (i.e. *d=1)* was highest in the LOW (see Figure 1). The likelihood of risk mitigation is higher for older, male, and more risk averse participants (see Table 1). In order to analyze how financial interventions influence the total amount of mitigation, we calculate how much intervention substitutes voluntary risk mitigation. We find that the LOW intervention incompletely crowds in voluntary mitigation and the

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HIGH intervention incompletely crowds out voluntary mitigation. We also analyze how intervention influences on players' incentives. The intervention changes the expected payoff given other players' decisions in the previous round (ΔE). We assume that the influence of ΔE through the intervention is the economic incentive of interventions and the other influences of interventions are intrinsic incentives. We analyze these effects using the logit model. We find that players in the treatment groups have lower economic incentives than those in the control groups. Players in the LOW have higher intrinsic incentives, but players in the HIGH show no significant difference in intrinsic incentives from players in the CONTROL (see Table 2). The total amount of mitigation in the treatment groups is stable near the social optimal amount of mitigation (see Figure 2) and the efficiency of the treatment groups is higher than the control groups (see Figure 3)

4. Conclusion

The socially optimal intervention cannot be expected because most of the WUI is private. However, we find that even low level of interventions can crowd in the likelihood of risk mitigation and improve the efficiency. When we raise the level of interventions, the incentive of voluntary fuel reduction is crowding out, but the efficiency stays at the socially optimal level. We also find that older, male, and more risk averse players are more likely to mitigate the risk.

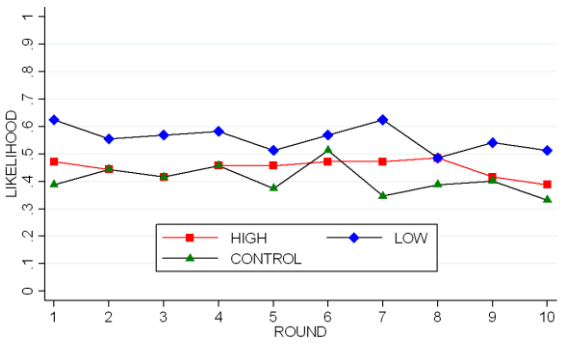

Figure 1: Likelihood of fuel reduction

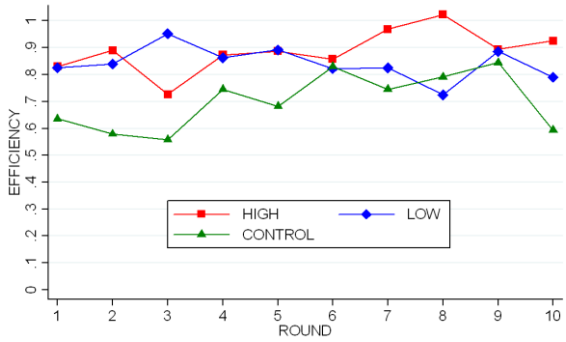

Figure 2: Efficiency

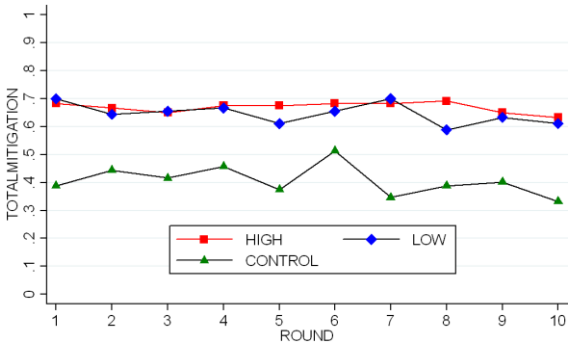

Figure 3: Total amount of risk mitigation

Table 1: Logit Model 1 (Individual characteristics)

Variables	Coef.	p-value
HIGH	0.184	0.089
LOW	0.590	0.000
Age	0.071	0.000
Female	−0.293	0.004
CRRA	0.210	0.008
Round Dummy	✓	
Stage Dummy	✓	
Constant	−1.775	0.000

Table 2: Logit Model (History variables)

Variables	Coef.	p-value
Δ E	3.761	0.000
HIGH	−0.625	0.699
LOW	−0.432	0.008
HIGH* Δ E	−2.809	0.000
LOW* Δ E	−1.704	0.027
Round Dummy	✓	
Stage Dummy	✓	
Constant	−0.069	0.789