Risk Preferences and Adoption of Climate Smart Agricultural Technologies - *Evidence from India*

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Introduction

Climate smart technologies are touted as the answer to increasing weather variability as a result of climate change.

These technologies claim to both increase the yield and reduce risk.

We study the adoption of three such technologies: Laser Land Leveler, Zero Tillage and Direct seeded rice in the states of Punjab, Haryana and Bihar in India.

This would be one of the first papers to examine the of risk preferences in the adoption of these technologies.

This study also assesses the relevance of Prospect Theory (PT) against Expected Utility Theory (EUT) and shows how PT holds true.

Like any other technology, uncertainty over the outcome of these technologies make the subjective risk preferences of the farmers an important factor defining adoption.

Theoretical Framework

In Expected Utility Theory (EUT), risk aversion is the sole parameter determining the curvature of utility function, while in prospect theory the shape of the utility function is jointly determined by three factors--risk aversion, loss aversion and a non-linear probability weighting measure. **Risk aversion** (σ) determines one's aversion to taking risk when the outcomes are positive. **Loss aversion**(λ) determines one's sensitivity to losses as compared to gains. *(If farmers consider investment in this technology can cause loss.)*

Non-linear probability weighting measure(α) determines ones tendency to overweight small probabilities and underweight large probabilities.*(Farmers around poverty line might overvalue the probability of falling back in poverty trap)*

$$U(x,p;y,q) = \begin{cases} v(y) + w(p)\left(v(x) - v(y)\right) & if \quad x > y > 0 \text{ or } x < y < 0 \\ w(p)v(x) + w(q)v(y) & if \quad x < 0 < y \end{cases}$$

Where

$$v(x) = \begin{cases} x^{\sigma} & for \quad x > 0 \\ -\lambda(-x^{\sigma}) & for \quad x < 0 \end{cases}$$

probability weighting function $w(p) = exp[-(-\ln p)^{\alpha}]$, for $0 < \alpha \leq 1$

x & y are outcomes and p & q are probabilities.

σ = risk aversion coefficient, λ = loss aversion coefficient,

α = non-linear probability weighting measure

** If $\lambda = 1$ and $\alpha = 1$, then the above model reduces to EUT*

Technologies

(+) Reduces water use, better absorption of nutrients
(-)Price INR 250,000($4000)

(+) Reduces labor cost, saves top soil erosion, reduces water use
(-) Price INR 50,000($800)

(+) Reduces labor cost, reduces methane emission
(-) Possibility of higher weed

PT Holds True

Variable	Description	Mean	Std. Dev.
α	Probability weighting function parameter	0.693***	0.253
σ	Curvature of the prospect value function(risk aversion)	0.574***	0.335
λ	Measure of loss aversion	4.194***	4.089

N=918 (Null for λ =1, α=1)

Conceptual Model

We have two lotteries; L^T, which represents the lottery under traditional farming methods and L^L , which represents the lottery under laser land leveler.

$$L^T = \begin{cases} 1 - f(G) \text{ that represents a good year and has a probability of } q \\ 1 - a\,f(G) \text{ that represents a bad year and has a prob. of } (1-q) \end{cases}$$

Where 1= profits per hectare using traditional leveler without the cost of incurred on irrigation.

f(G) is the cost incurred on irrigation and is a function of ground water level G.

$$L^L = \begin{cases} 1 - C - n\,f(G) \text{ that represents a good year and has a probability of } q \\ 1 - C - n\,a\,f(G) \text{with represents bad year and has a prob. of } (1-q) \end{cases}$$

Where the C is the cost of hiring laser land leveler and n is the proportion of water used on irrigation as compared to the traditional method.

We define Prob $(L)^L = f(\,U(L)^L - U(L)^T\,)$

Plugging in the functions for both the Us we have

$$\Pr(L)^L = f\quad \{\exp[-(-\ln q)^{\alpha}](1 - C - nf(G))^{(1-\sigma)} - \lambda \exp[-(-\ln(1-q))^{\alpha}](1 - C - naf(G))^{(1-\sigma)} - \exp[-(-\ln q)^{\alpha}](1 - f(G))^{(1-\sigma)} + \lambda \exp[-(-\ln(1-q))^{\alpha}](1 - af(G))^{(1-\sigma)}\}$$

Plugging the values of C, a,f(G) and q from empirical data we have

$\frac{df}{d\alpha}$ = -ve , i.e Farmers who overvalue smaller probabilities adopt more.

$\frac{df}{d\sigma}$ = -ve i.e. More risk averse farmers adopt more.

$\frac{df}{d\lambda}$ = +ve i.e. More loss averse farmers adopt more.

Econometric Framework and Results

Probit

$$YhL = \beta0 + \beta11Xh' + \beta21Rh' + \mu hL$$

X'= Vector of demographic, socio-economic and plot level variables influencing technologies adoption.

R'= Risk aversion coefficient, loss aversion coefficient , probability weighting measure.

Standard errors are clustered at HH Level.

Analysis at the plot level, only where respondent is also the plot manager.

The following results only show the adoption of LLL as the adoption of other technologies is very low.

Results

VARIABLES	Probit (at means)	LPM (Dist. f.e)
Prob. Weighting Measure	-1.070***	-0.900*
Risk Aversion coefficent	0.392	0.374
Loss Aversion Coefficient	0.116***	0.062*
Age	-0.003	-0.002
Age*alpha	0.0216**	0.018
Age*Sigma	-0.00903	-0.01
Age*lambda	-0.00249***	-0.001*
HH poverty score	0.00253	0.001
Did you or anyone in the household access credit for ag. production	-0.107*	-0.1
Time it takes on average to travel to nearest commercial town	0.000438	0
Formal Education of Main Respondent	0.0121	0.008
Soil Quality(good)	0.304*	0.905***
Soil Type(Sandy)	-0.338**	-0.583***
Soil Type(Sandy Loam)	-0.125	-0.273**
Soil Type(Clay Loam)	-0.122	-0.183**
Soil Salinity(High)	0.315**	0.347***
Soil Salinity(Medium)	0.268***	0.315***
Soil Salinity(low)	0.197**	0.172*
Rsquared/ Pseudo R-squared	0.328	0.376

Conclusions

Farmers who overvalue smaller probabilities tend to adopt more. As α increases probability weighting measure decreases and adoption also decreases. This is likely when farmers who overvalue the small probabilities of loss tend to adopt laser land leveler more.

Farmers with higher loss aversion tend to adopt more. This makes sense as these technologies are thought of as risk and loss reducing.

It is likely that farmers consider these technologies as risk/loss reducing therefore we see farmers who are more loss averse and farmers who want to avoid the smaller probabilities of loss tend to adopt it more.

We do not find any significant results for farmers who are risk averse. Plot characteristics, HH characteristics also seem to explain a major part of the tech adoption as suggested by literature.

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