Climate risk and state-contingent technology adoption: The role of risk preferences and probability weighting

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Introduction

- **State-Contingent Framework**
  - We study «*ex ante*» input use decisions given preferences, endowments, past shock exposure and expectations/perceptions of alternative technologies
  - Input use decisions are «ex ante» in the sense that the weather conditions are not yet revealed
  - Input use decisions are also «ex post» in the sense that past shocks have been revealed and may affect perceptions/knowledge about technology performance, expectation formation, and possibly preferences

Background

- Climate risk represents an increasing threat to poor and vulnerable farmers in drought-prone areas of Africa.
- This study assesses the maize and fertilizer adoption responses of food insecure farmers in Malawi, where Drought Tolerant (DT) maize was recently introduced.

Risk Preferences, Shocks and Technology Adoption

- Some studies have found that more risk averse people are likely to be late adopters of new technologies
  - E.g. Liu (2013) found that more risk averse farmers adopted BT cotton (pest resistant variety) later in China
- Can risk aversion therefore hinder efficient adaptation to climate change?
- How does risk aversion affect adoption of new technologies that are better adapted to drought conditions?
- How does past exposure to drought shocks affect adoption of more Drought Tolerant crops/varieties?

Setting: Small Farmers in Malawi

- Farm sizes: 0.25 ha – 5 ha
- Rain-fed agriculture
- Rainfall variability: Drought in form of dry spells in the rainy season are common
- Main staple crop: Maize planted on most of the land
- Majority are net buyers of maize (deficit producers)
- Large input subsidy program (FISP) provides subsidized fertilizer and maize seeds
- 2011/12: Drought year (70% of sample affected)
  - Combined hh farm survey and experiments (to elicit risk preferences)

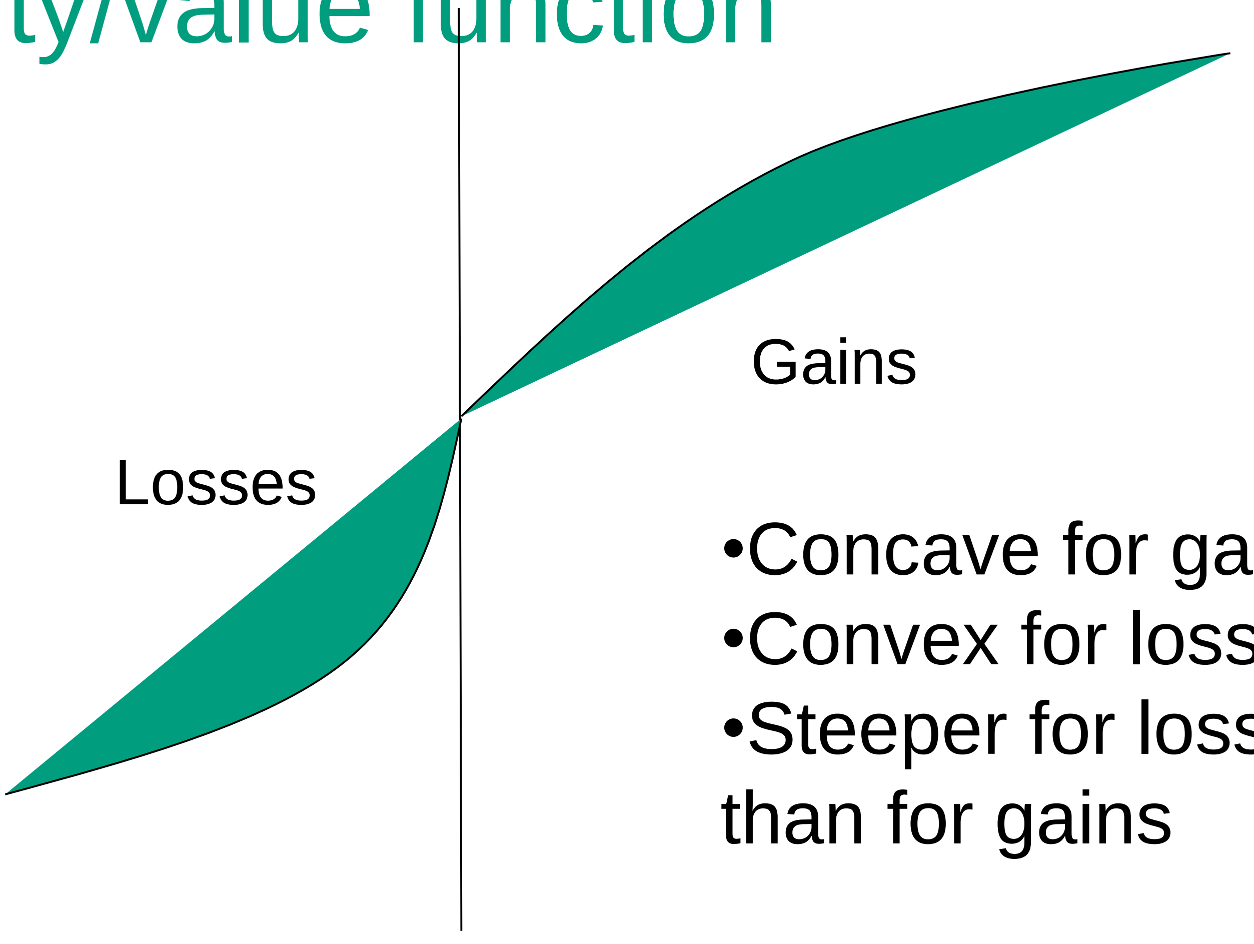
How to measure technology adoption?

- Assess adoption of 3 types of maize:
  - **LM** (Local maize)
  - **DT** (Drought Tolerant) maize varieties
  - **OIMP** (Other improved) maize varieties
- Assess **Adoption** and **Intensity of Adoption** for each type of maize
  - Intensity measured as area planted to each type of maize (measured by GPS)
- Assess **Intensity of Fertilizer Use** on each type of maize (measured as kg Fertilizer by maize type)

Poor producer-consumer households as decision-makers: Different Theoretical Perspectives):

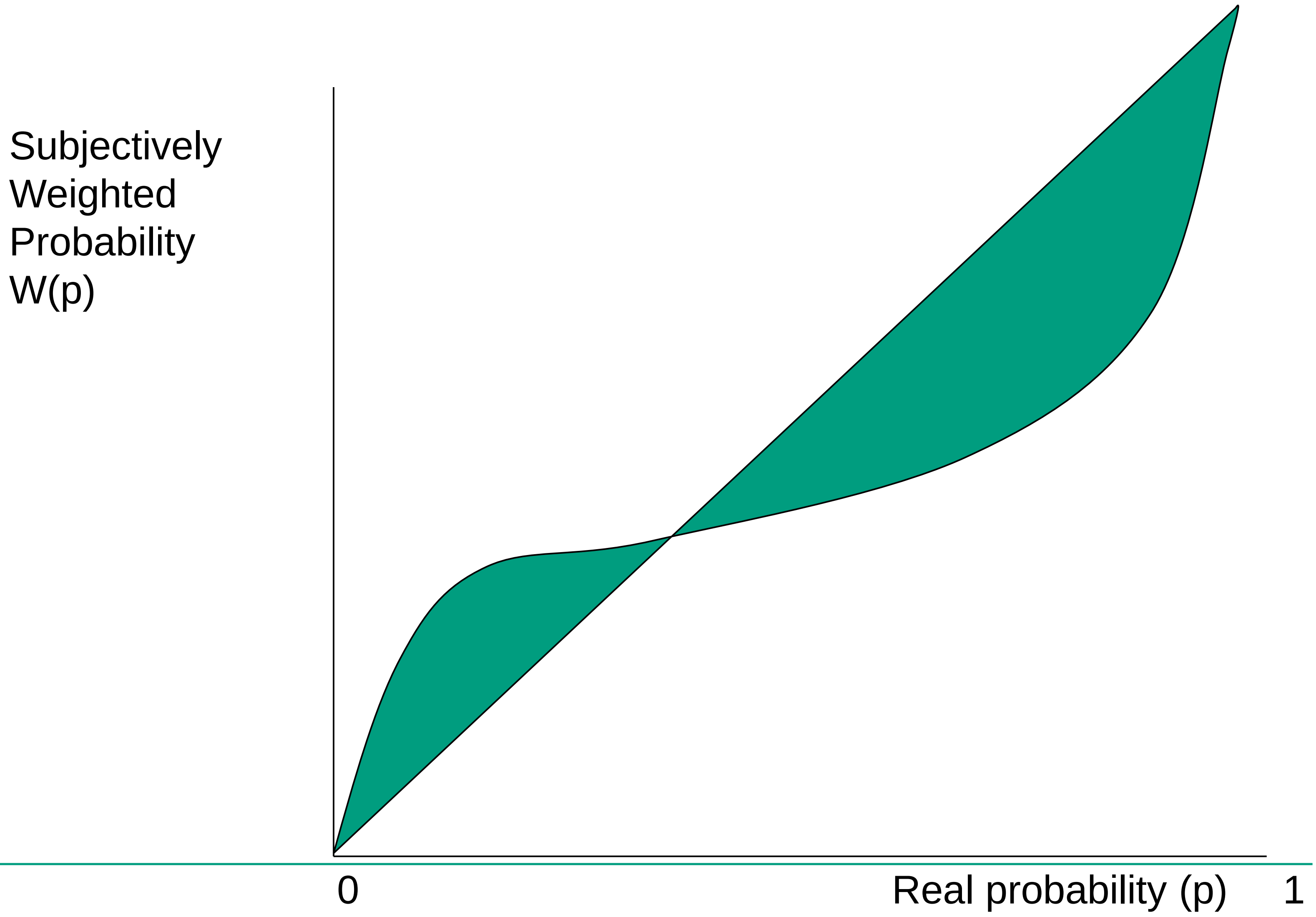
- "Poor but Efficient"(Theodore Schultz 1965) or
- "Too Poor to be Efficient" or simply
- "Irrational and In-efficient"(Prospect Theory)?
  - (Duflo et al., 2011)
- Decisions under uncertainty and risk: Do poor households living in risky environments behave according to Expected Utility Theory (EUT) or more according to Prospect Theory (PT)?

Prospect theory: Shape of utility/value function



- Concave for gains
- Convex for losses
- Steeper for losses than for gains

Subjective probability weighting



Methods and data

- Holt and Laury (2002) approach: Expected Utility Theory
- Relative risk aversion parameter
  - → CRRA-parameter ($U = (1-crra)^{-1}\left(Y^{1-crra}-1\right)$
- Tanaka et al. (2010) Prospect Theory series:
  - 3 series to derive 3 parameters:
    - Loss aversion (lambda):
      - Gains: $v(x) = x^{\sigma}$ Losses: $v(x) = -\lambda(-x)^{\sigma}$
    - Subjective probability weighting (alpha)

$$w(p) = 1/\exp\left(\ln(1/p)\right)^{\alpha}$$

    - Curvature of value function (sigma)(not used)

Hypotheses

- H1) Relative risk aversion is associated with a higher probability and a higher intensity of adoption of DT and LM maize and the opposite for OIMP maize.
- H2) Loss aversion is associated with a higher probability of DT maize adoption and a lower probability of OIMP maize adoption.
- H3) Subjective overweighting of low probability extreme events is associated with less adoption of OIMP maize and of fertilizer on OIMP and local maize.
- H4) Shock exposure in the form of droughts in previous years is associated with increased adoption of DT maize and dis-adoption of LM maize.
- H5) Access to subsidized inputs enhances adoption of DT maize and intensity of fertilizer use for all types of maize.

Methods

- Household farm panel survey in Malawi
- Natural experiment: 2012 Drought
- Framed Field Experiment/Artefactual Field Experiment:
  - 2012 for EUT/PT parameters

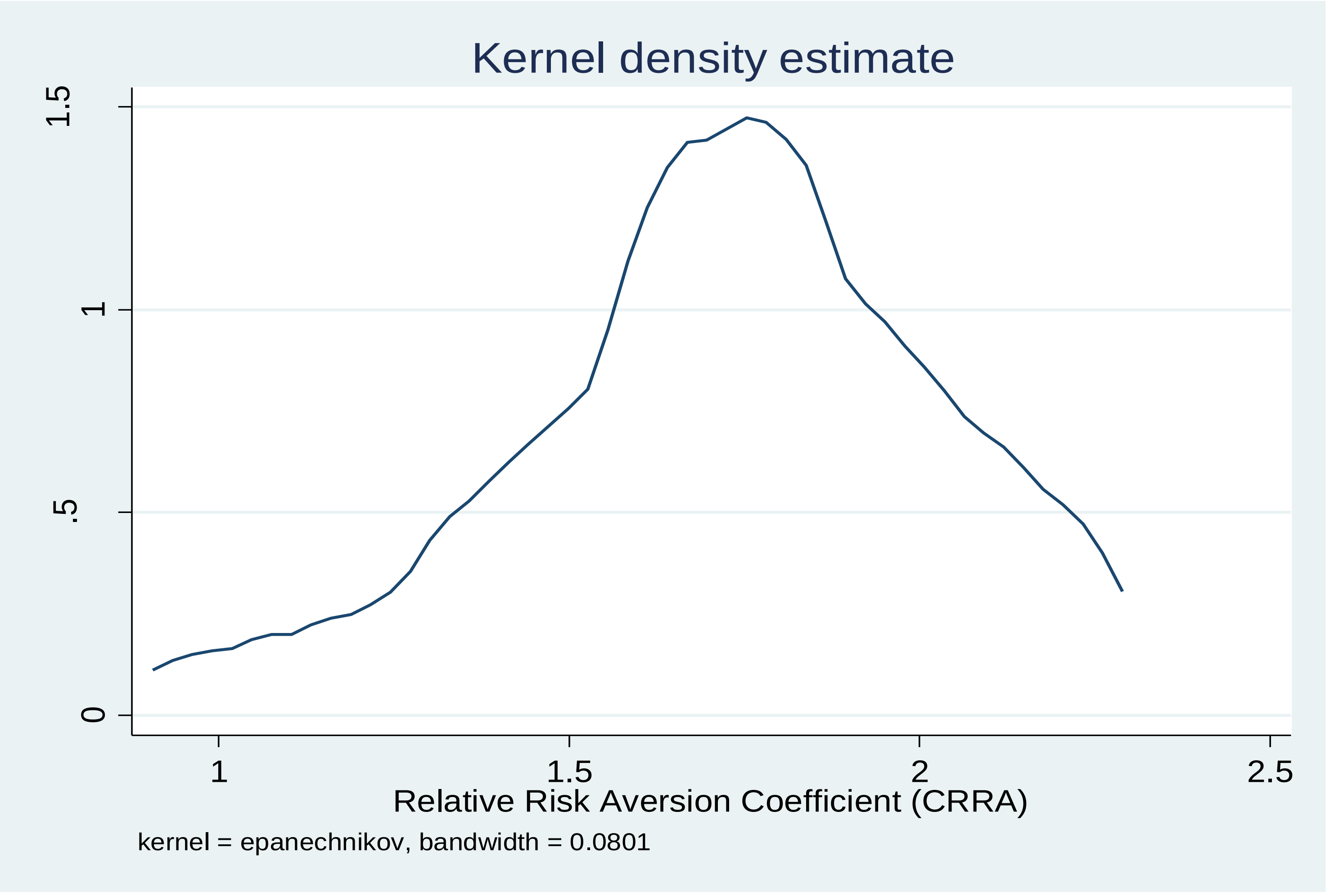
- Econometric analysis
  - Double hurdle (Demand for maize technologies)
  - Censored Tobit (Demand for fertilizer by MZ-technology)

«Lab-in-the-field» experiments in Malawi

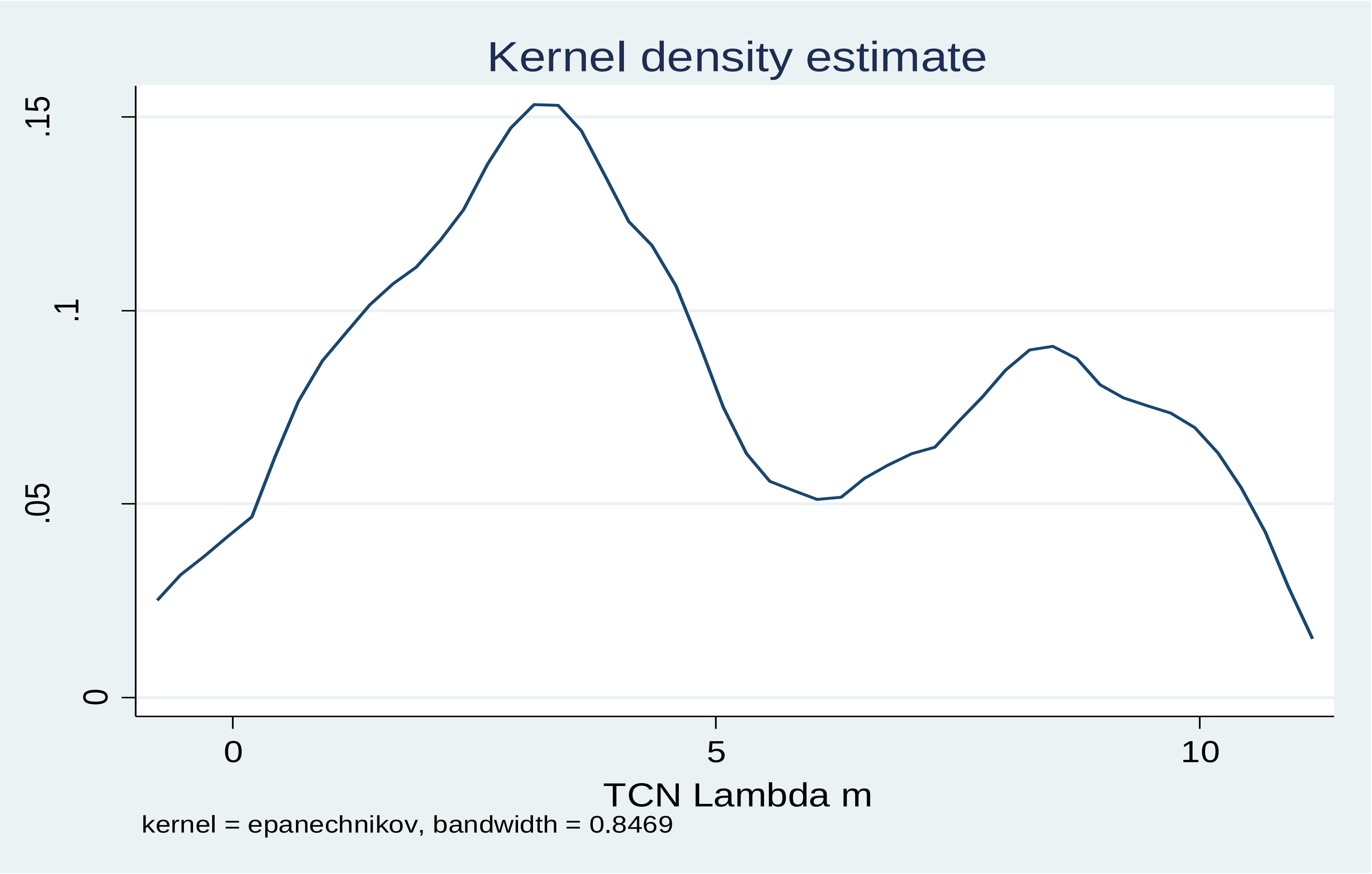
Holden, S. T. and Fischer, M. (2015). Can Adoption of Improved Maize Varieties Help Smallholder Farmers Adapt to Drought? Evidence from Malawi.

Year		Local maize	**DT maize**	OIMP maize	Total
2006	No of plots	295	**20**	525	840
	% of plots	35.1	**2.4**	62.5	100.0
2009	No of plots	273	**130**	225	628
	% of plots	43.5	**20.7**	35.8	100.0
2012	No of plots	143	**249**	163	555
	% of plots	25.8	**44.9**	29.4	100.0
Total	No of plots	711	**399**	913	2,023
	% of plots	35.2	**19.7**	45.1	100.0

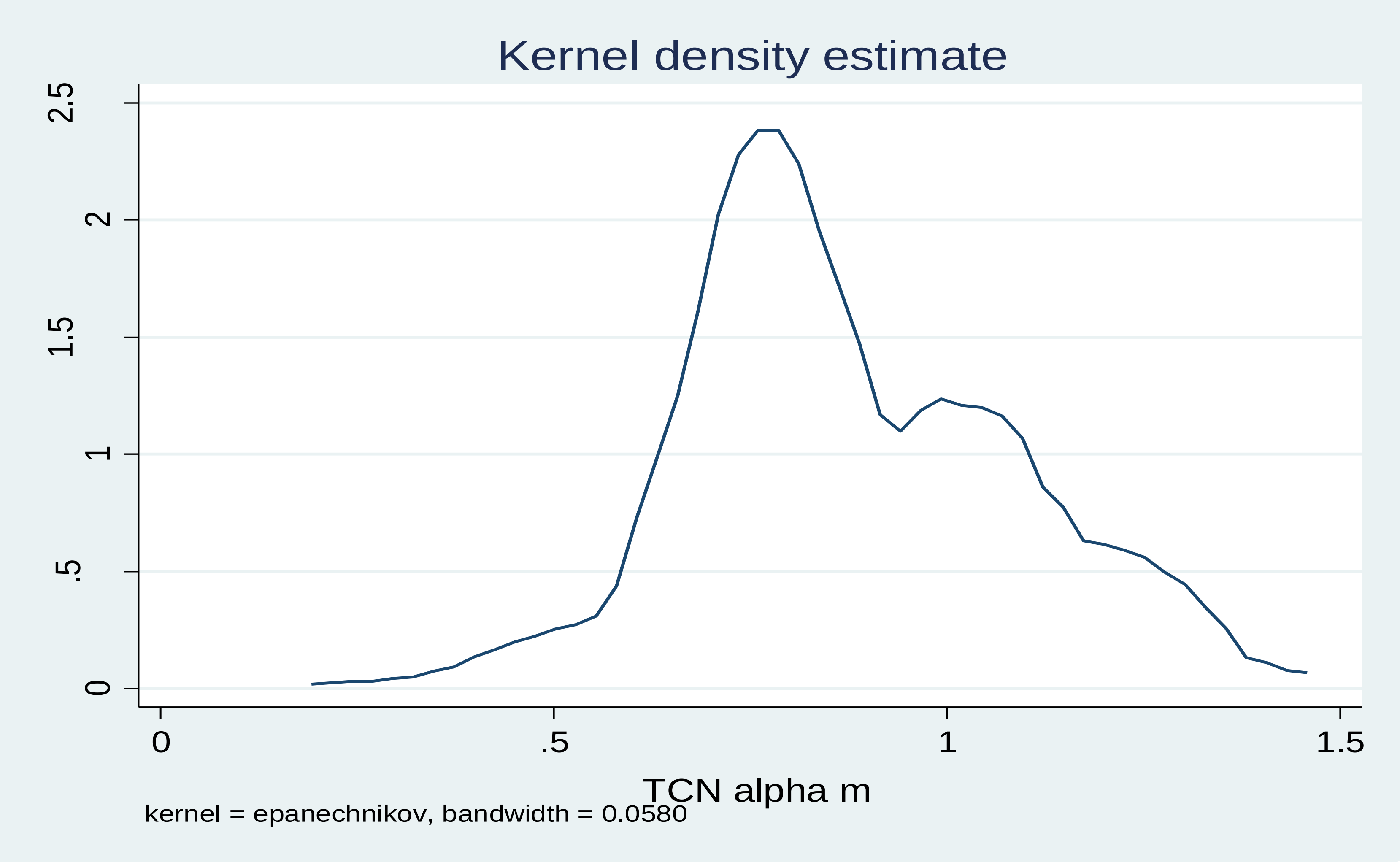
Relative risk aversion (**CRRA**) distributions



Loss aversion (**Lambda**) parameter distribution



Subjective probability weight (**Alpha**) distribution



Double hurdle model: Maize adoption: First hurdle: **Average Partial Effects**

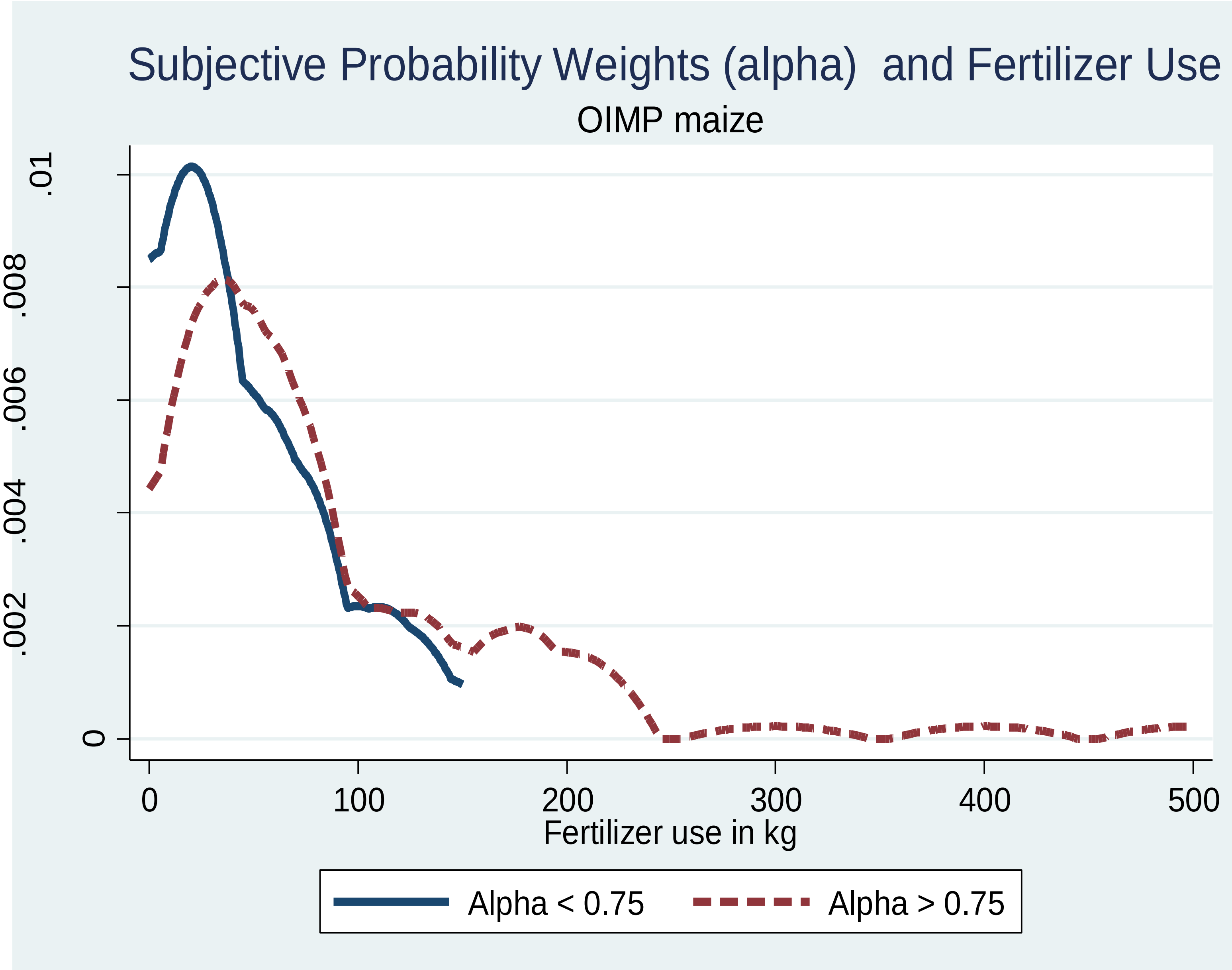
Maize type	DT		OIMP		LM	
Hurdle 1: Growing maize type	APE	Bootstr. SE	APE	Bootstr. SE	APE	Bootstr. SE
Relative risk aversion coefficient	**0 .329****	0.132	**-0.288****	0.132	**0.363****	0.146
Subjective probabilty weight (alpha)	-0.160	0.125	0.039	0.126	-0.035	0.135
Loss aversion coefficient (lambda)	**0.020****	0.009	0.006	0.009	-0.007	0.011
Number of shocks last 3 years	**0.051***	0.031	0.030	0.031	**-0.104*****	0.034
Drought 2011, dummy	**0.246****	0.100	-0.099	0.092	-0.121	0.102
Drought 2010, dummy	0.232	0.383	-0.147	0.189	-0.005	0.117
Age of household head	**-0.003***	0.002	-0.001	0.002	**0.007******	0.002
Received subsidized seed voucher	**0.180*****	0.061	0.032	0.067	-0.027	0.073
Non-agricultural business, dummy	-0.072	0.055	0.098*	0.055	-0.014	0.059

Double hurdle model: Intensity of Maize Adoption: Second hurdle: Average Partial Effects

Hurdle 2: Log of planted area to maize type	DT APE	Boot S.E.	OIMP APE	Boot S.E.	LM APE	Boot S.E.
Relative risk aversion coefficient	0.080	0.061	**-0.235*** **	0.075	**0.164** **	0.065
Subjective probabilty weight (alpha)	0.046	0.062	0.090	0.072	0.010	0.064
Loss aversion coefficient (lambda)	0.005	0.005	0.010*	0.005	-0.003	0.005
Number of shocks last 3 years	0.021	0.015	0.009	0.018	**-0.052*** **	0.018
Drought 2011, dummy	0.039	0.040	0.003	0.044	-0.039	0.045
Drought 2010, dummy	-0.009	0.125	-0.012	0.111	-0.018	0.054
Log of Farm size in ha	0.202***	0.066	0.218***	0.064	0.208****	0.043
Age of household head	-0.001	0.001	-0.0004	0.001	**0.004**** **	0.001
Received subsidized seed voucher	0.027	0.035	-0.034	0.040	-0.024	0.033
Non-agricultural business, dummy	-0.009	0.027	0.032	0.030	-0.029	0.027

Censored tobit models for intensity of fertilizer use Dependent variable: log(kg Fertilizer+1).

	Models without endogenous variables			Models with endogenous variables		
RHS variables	Fertilizer on DT	Fertilizer on OIMP	Fertilizer on LM	Fertilizer on DT	Fertilizer on OIMP	Fertilizer on LM
Relative risk aversion coefficient	-0.433	**-3.235*** **	-0.587	-0.811	-1.413	-0.761
	(0.816)	(1.063)	(0.904)	(0.653)	(0.973)	(0.776)
Subjective probabilty weight	**2.054*** **	**3.613*** **	1.297	**2.082**** **	**2.912** **	**1.292* **
	(0.754)	(1.192)	(0.818)	(0.571)	(1.126)	(0.736)
Loss aversion coefficient	-0.022	0.051	0.010	0.012	0.004	-0.009
	(0.065)	(0.066)	(0.067)	(0.055)	(0.056)	(0.059)
Number of shocks last 3 years	-0.018	-0.254	-0.304	0.222	-0.101	0.047
	(0.158)	(0.250)	(0.270)	(0.140)	(0.232)	(0.246)
Drought 2012, dummy	0.109	-0.740	0.017	-0.171	-0.841	-0.207
	(0.662)	(0.684)	(0.615)	(0.512)	(0.563)	(0.593)
Drought 2011, dummy	-0.262	1.011*	0.157	-0.220	0.598	0.527
	(0.434)	(0.583)	(0.625)	(0.313)	(0.559)	(0.573)
Drought 2010, dummy	0.220	-0.959	-0.591	0.266	-0.748	-0.562
	(0.334)	(0.817)	(0.711)	(0.319)	(0.878)	(0.583)
Average rainfall, mm	**-0.009** **	**0.011*** **	-0.003	**-0.009*** **	**0.007** **	-0.003
	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
Received subsidized fertilizer voucher				**1.958**** **	**1.254*** **	**1.920**** **
				(0.331)	(0.473)	(0.427)
Received subsidized seed voucher				-0.475	-0.519	-0.104
				(0.351)	(0.473)	(0.384)
Log of savings for fertilizer purchase				**0.078** **	-0.004	**0.074* **
				(0.030)	(0.054)	(0.044)


Subjective Probability Weights (alpha) and Fertilizer Use
OIMP maize
0
.002
.004
.006
.008
.01
0
100
200
300
400
500
Fertilizer use in kg
Alpha < 0.75
Alpha > 0.75

Summary of findings

- Perceptions matter!
- Perceived relative riskiness of technologies affects how risk aversion affects their adoption
  - More risk averse households are more likely to adopt technologies that **are perceived to be** less risky (such as DT maize) (**risk averse hhs may not necessarily be late adopters**: Liu, 2013!)
- Subjective probability weighting (**over-weighting of low probabilities reduce intensity of fertilizer use**)
- Exposure to shocks may stimulate adoption of less risky technologies

Implications for policy

- **Extreme weather events may be used to promote promising technologies** (e.g. DT maize) as well as test the performance of alternative technologies
- Adoption of DT maize was associated with the **input subsidy program** (FISP): **Input subsidies have contributed to more rapid adoption/adaptation**
- **Impact studies that use survey data and do not control for the effects of risk preferences and subjective probability weighting** on adoption and intensity of adoption of the maize varieties as well as fertilizer use **will get biased estimates** of these impacts

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