Probability Weighting and Input Use Intensity in a State-Contingent Framework

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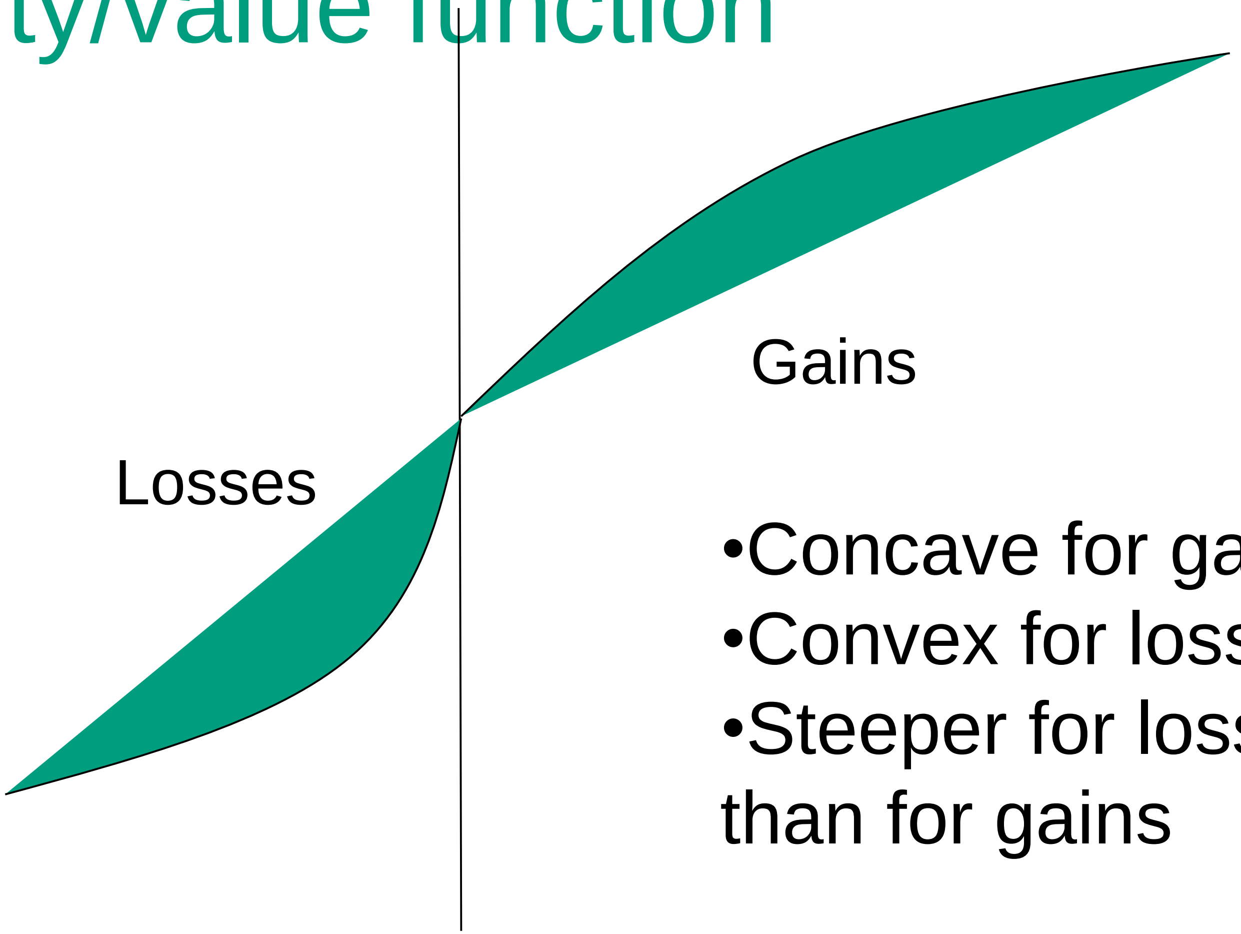
Background

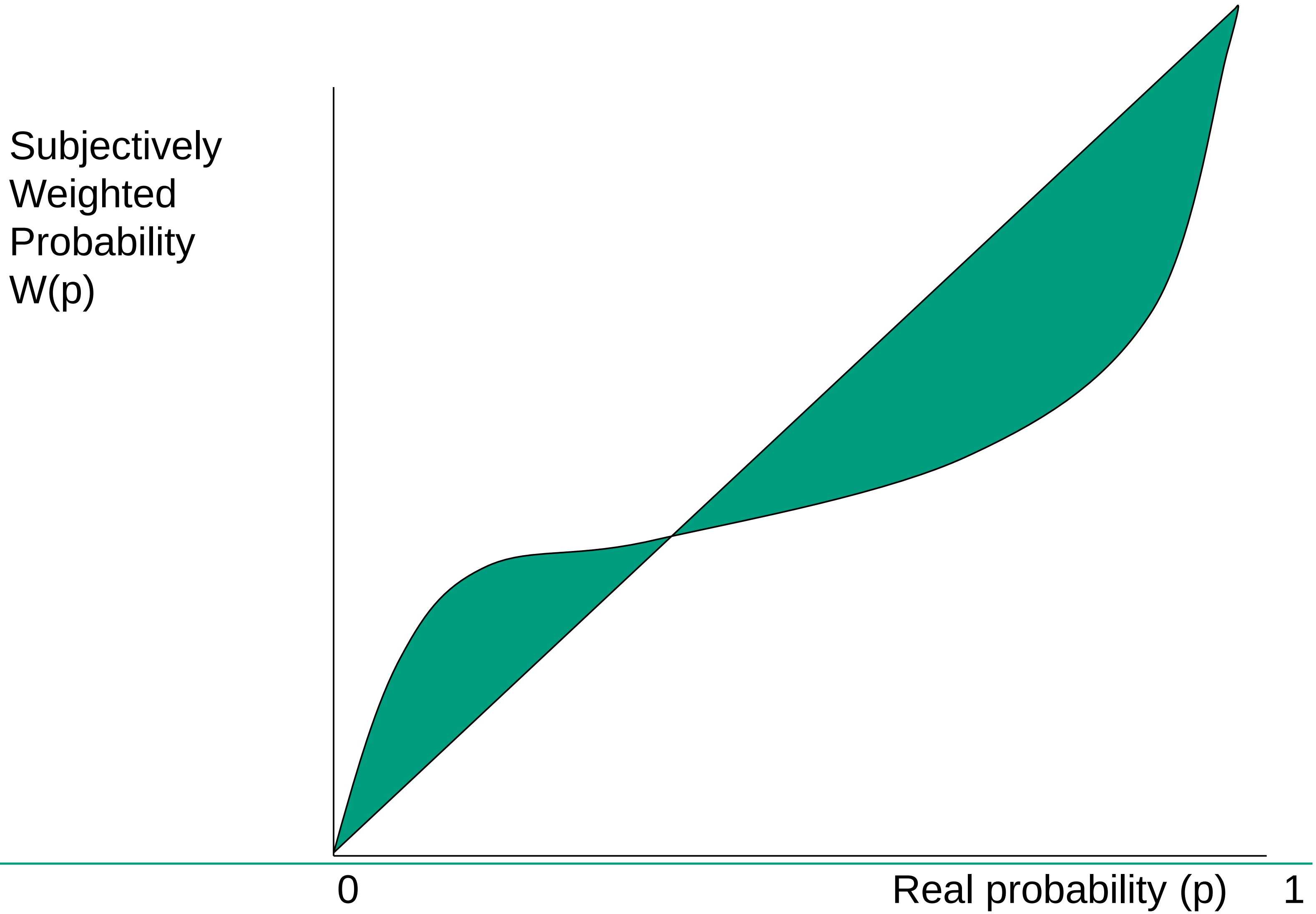
- Climate risk and shocks represent an increasing threat to poor and vulnerable farmers in drought-prone areas of Africa.
- This study assesses the fertilizer adoption responses of food insecure farmers in Malawi, where Drought Tolerant (DT) maize was recently introduced.

Prospect theory: Shape of utility/value function



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

Subjective probability weighting



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

Earlier studies

- Many studies on the relationship between risk attitudes and input use
  - Most studies have been carried out within the Expected Utility (EU) model
- Often combined with a stochastic production function
  - Classifying inputs as risk-increasing or risk-reducing
  - The EU model does not take into account probability weighting or loss aversion

Risk Attitudes, Shocks and Technology Adoption

- We are only aware of one paper applying CPT to input use decisions.
  - Liu and Huang (2013) found that more risk averse farmers use more pesticide on cotton, while more loss averse farmers use less pesticide on cotton.
  - **Over-weighting of small probabilities (alpha<1) was associated with higher pesticide use**
  - Their finding is consistent with farmers placing more emphasis on loss aversion in the health domain than in the profit domain. There is a need for more research to assess the external validity of their findings.

Holden and Quiggin (2017)

- Applied CPT and a state-contingent model of production under uncertainty to model decisions of farmers in Malawi on whether to adopt a new Drought Tolerant (DT) maize. Key findings were
  - **More risk averse households were more likely to adopt DT maize**, less likely to adopt other improved maize varieties and less likely to dis-adopt traditional local maize
  - **Exposure to past drought shocks stimulated adoption of DT maize** and dis-adoption of local maize.
  - More loss averse households were more likely to adopt DT maize
  - **Probability weighting had no significant effect**

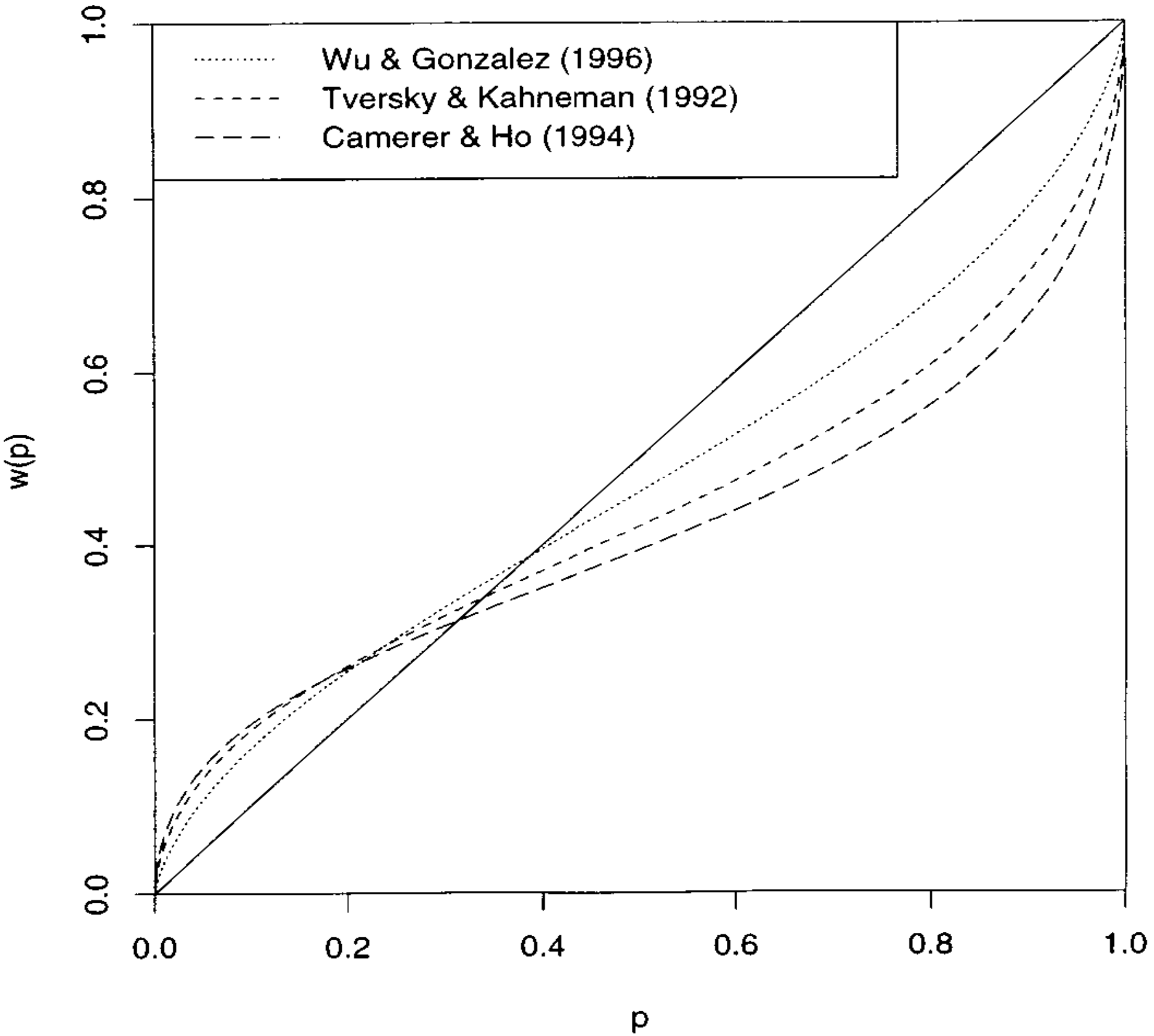
Value function and parameters

- 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:
    - Subjective probability weighting (**alpha**)

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

    - Curvature of value function (sigma)(not used)
    - Loss aversion (lambda):
      - Gains: $v(x) = x^{\sigma}$ Losses: $v(x) = -\lambda(-x)^{\sigma}$

Probability weighting functions



Probability weighting

- The probability weighting parameter determines how much one overweights small probabilities and underweights large probabilities. The smaller the alpha is, the more one overweights small probabilities and the further away subjective probability departs from the objective linear probability.
- One might overweight the small probability event, such as severe pesticide infestation or event of drought
- This may result in over-use of risk-substituting inputs (e.g. pesticide) and under-use of risk-complementary inputs (e.g. fertilizer) relative to an EU-maximizer

How to measure technology adoption?

- Assess fertilizer adoption for 3 types of maize:
  - **LM** (Local maize)
  - **DT** (Drought Tolerant) maize varieties
  - **OI** (Other improved) maize varieties
- Assess **Intensity of Fertilizer Use** per farm and on each type of maize (measured as kg Fertilizer by maize type)

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)

Hypotheses

- H1) Fertilizer use intensity is lower for more risk averse producers.
- H2) Fertilizer use intensity is higher for low-risk DT maize than for high risk OI and local maize
- H3) Subjective overweighting of low probability extreme events is associated with less intensive fertilizer use on maize.
- H4) Subjective overweighting of low probability extreme events is more strongly associated with less fertilizer use on the more risky OI and local maize than the less risky DT maize.
- H5) Access to subsidized inputs enhances intensity of fertilizer use for all types of maize

Data and methods

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

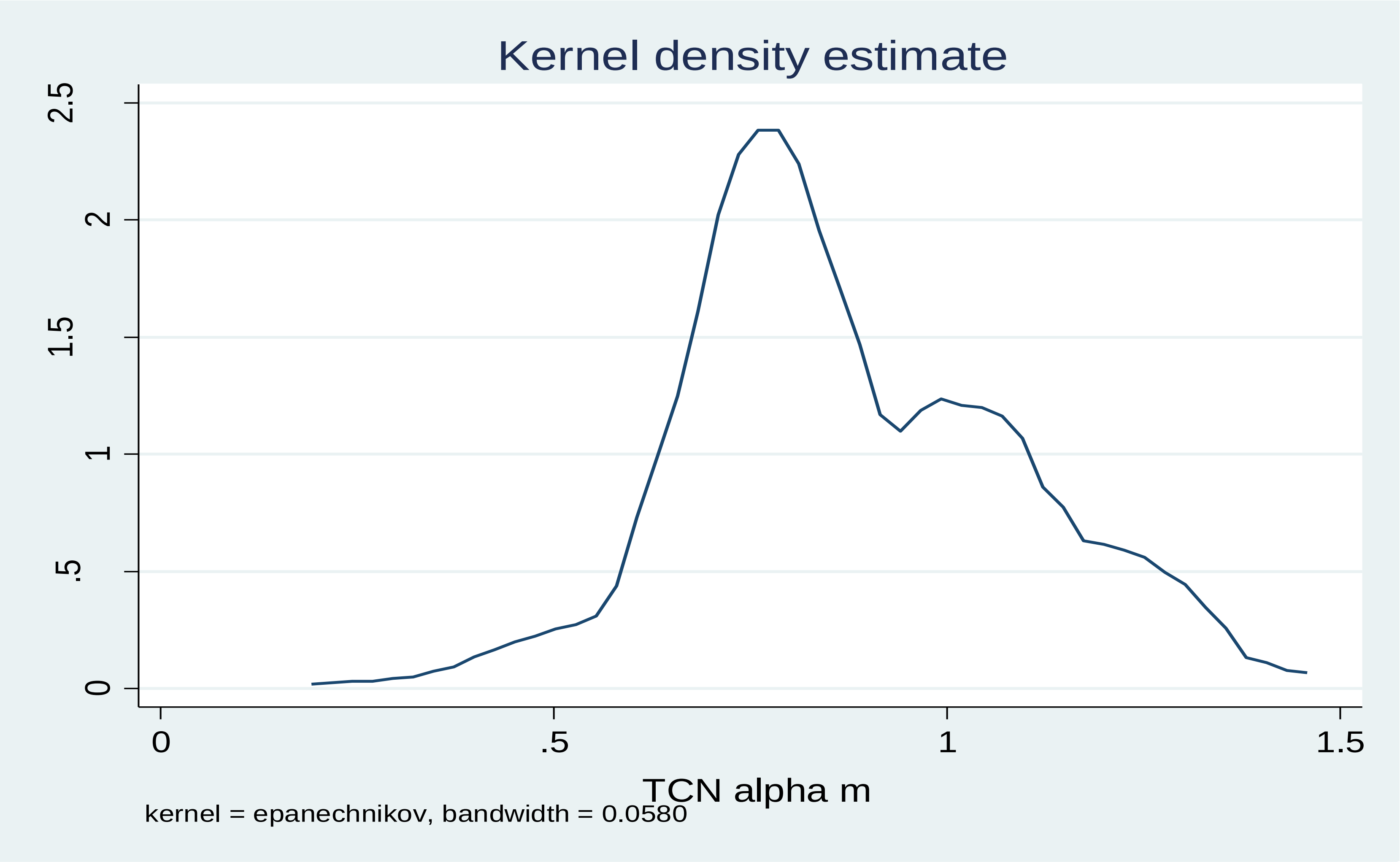
- Econometric analysis
  - Censored Tobit (Demand for fertilizer by MZ-technology)
    - Pooled and separate models for each maize type

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

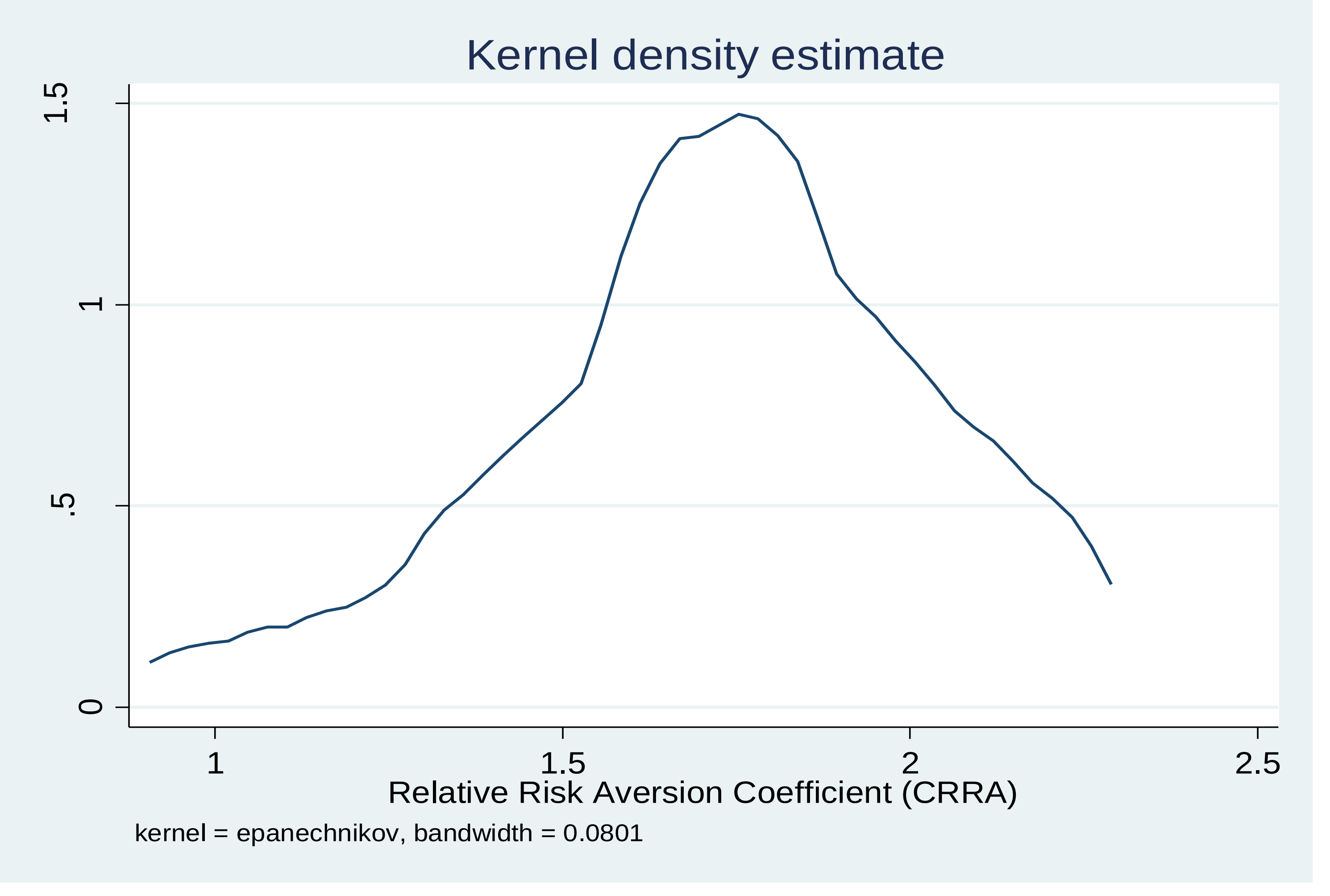
Holden, S. T. and Fischer, M. (2015). Can Adoption of Improved Maize Varieties Help Smallholder Farmers Adapt to Drought? Evidence from Malawi.

Year		Local maize	**DT maize**	OI 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

Subjective probability weight (**Alpha**) distribution



Relative risk aversion (**CRRA**) distributions



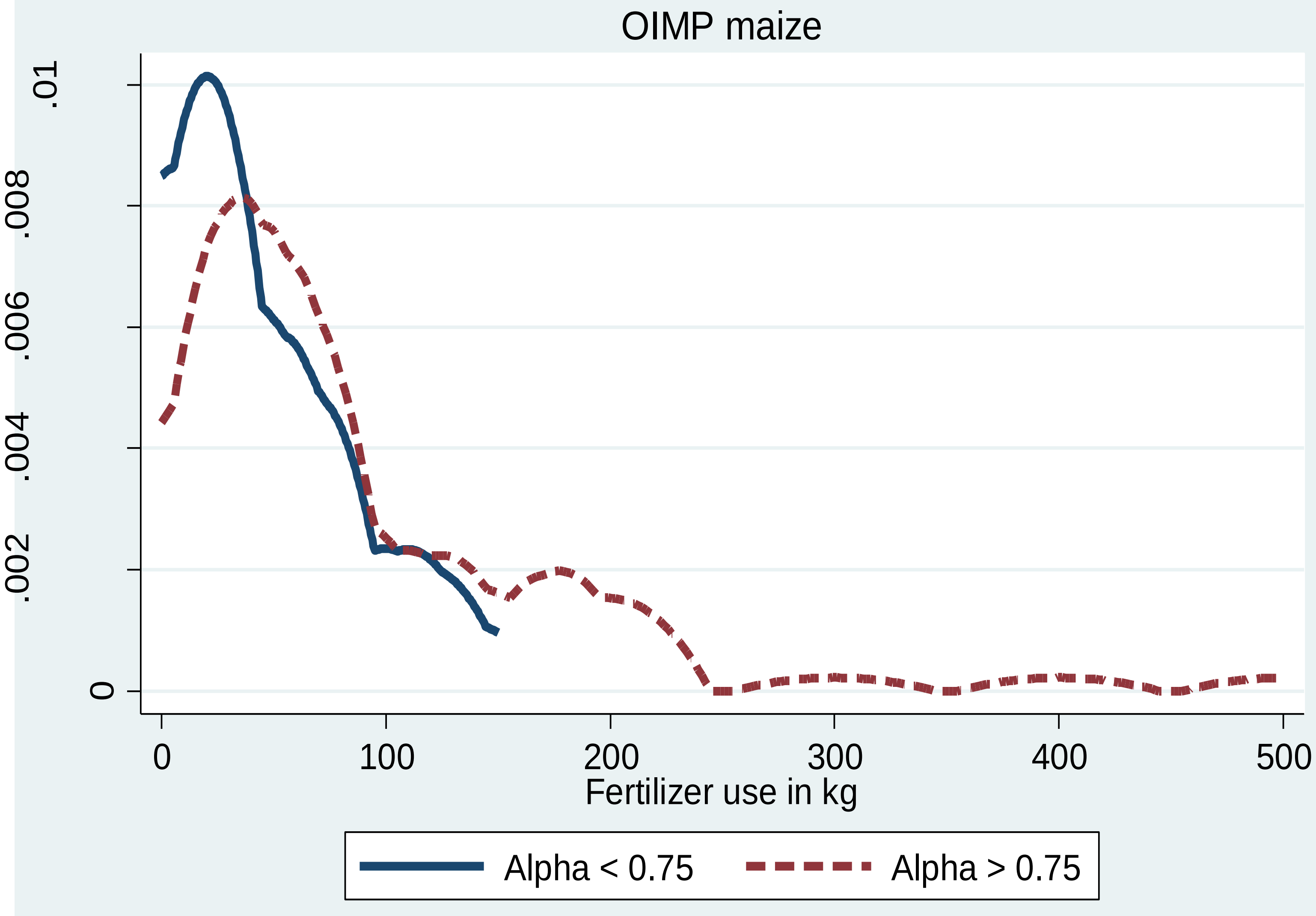
Censored tobit models for intensity of fertilizer use

	Parsimonious	With Endog. Var.
Relative risk aversion	-25.274	-13.681
Subj. probability weight	**96.137********	**97.579********
Number of shocks last 3 yrs	-3.751	1.983
Drought 2012, dummy	6.500	-1.074
Drought 2011, dummy	8.133	8.953
Drought 2010, dummy	-23.230	-17.946
Average rainfall	-0.121*	-0.114
Farm size, GPS meas., ha	15.662****	14.642****
Sex of respondent, male=1	-9.810	-2.693
Subsidized fertilizer, dummy		53.447****
Savings for fertilizer, MK		0.001****
Non-agric. business, dummy		2.548
Formal employment, dummy		16.586
DT maize, dummy	**36.498*****	**26.563****
Local maize, dummy	-15.783	-19.206
Village FE	Yes	Yes
Constant	152.559*	71.840
Sigma constant	75.320****	71.104****

Censored tobit models for intensity of fertilizer use

	Parsimonious models			With endogenous variables		
	DT	OI	LM	DT	OI	LM
Relative risk aversion	-48.584	-104.617**	-26.492	-41.447	-19.240	-25.260
Subj. probability weight	68.834**	178.206****	138.849***	156.619****	186.520***	116.428***
Number of shocks last 3 yrs	-10.146	6.572	-13.303	9.247	16.392	-7.996
Drought 2012, dummy	-13.184	-5.338	-59.271	-52.512**	-24.161	-26.762
Drought 2011, dummy	5.697	5.400	14.326	-6.965	6.834	13.484
Drought 2010, dummy	-8.758	-55.576**	-83.095****	-19.156	-43.740	-59.586***
Average rainfall	0.121	0.067	0.315***	-0.017	-0.040	0.132*
Farm size, GPS meas., ha	51.227****	-29.826****	12.587****	34.802****	-27.509****	12.709****
Sex of respondent, male=1	-19.578	23.998	-12.071	-0.174	34.536	-12.251
Subsid. fertilizer, dummy				60.771***	52.207*	33.125*
Savings for fertilizer, MK				0.002****	0.000	0.001****

Subjective Probability Weights (alpha) and Fertilizer Use



Summary of findings

- **Perceptions and preferences matter!**
- Subjective probability weighting (**over-weighting of low probabilities is associated with lower intensity of fertilizer use**)
- The reduction is higher for the more risky technology
- The implication is **under-use of the productivity and risk increasing input (Duflo et al. 2011)**
- Could this be an extra argument for fertilizer subsidies to stimulate fertilizer use? Debatable

Implications for policy

- Input subsidies have promoted more rapid adoption of Drought-Tolerant maize in Malawi compared to neighbouring countries with similar agroclimatic conditions
- This has also reduced the risk involved in using the risk complementary fertilizer input and thus stimulated its use