Demand for Insurance: Which Theory Fits Best?

Some VERY preliminary experimental results from Peru

Jean Paul Petraud
UC Davis

Steve Boucher
UC Davis

Michael Carter
UC Davis

I4 Technical Meeting
Hotel Capo D'Africa, Rome
June 14, 2012

Goals Today

- Theory
  - Consider a specific empirical context (Pisco, Peru);
  - Develop two alternative contracts: A) Linear, B) Lump Sum;
  - Compare predictions of insurance demand under:
    - Expected Utility Theory;
    - Cumulative Prospect Theory.
  - Highlight preference parameter spaces such that theories generate different demand predictions.
  - Preference parameters: Risk aversion, Probability weighting, Loss aversion.

- Empirical Approach
  - Experimental insurance games with Pisco cotton farmers
  - Part I: Elicit farmer-specific values of preference parameters
  - Part II: Elicit farmers' choice across contracts (Linear vs. Lump Sum vs. None)

- Descriptive evaluation of theories: Which theory seems to be most consistent with elicited parameters?

Linear vs. Lump Sum Contracts

- Income under ***No Insurance***:
  - $Y^N = Apq$
  - A: Area (ha); p: Output price ($/qq); q: yield (qq/ha)

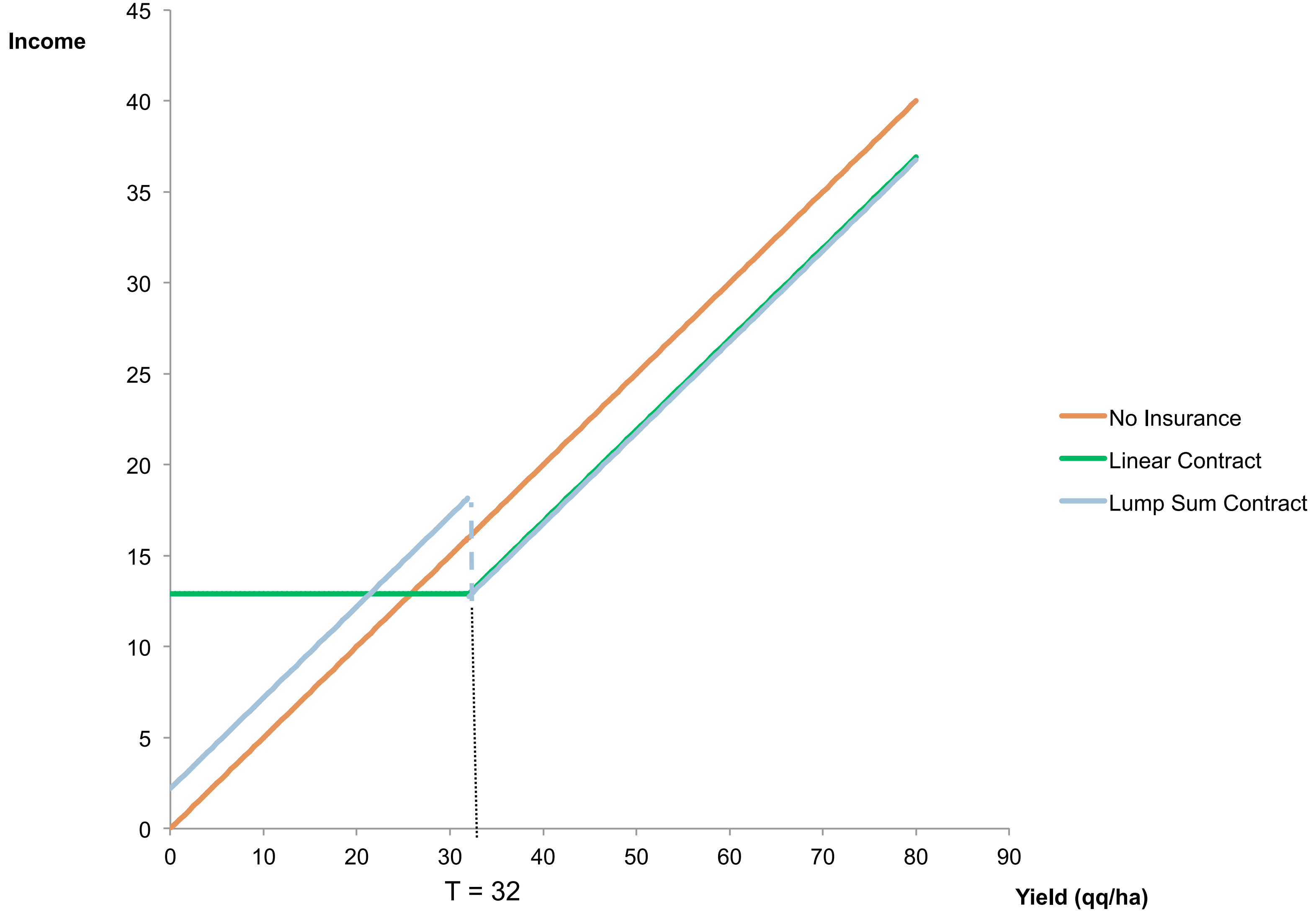
- Compare Linear vs Lump Sum contracts with identical: A) Strikepoint; B) Premium and C) Expected Indemnity payment (i.e., same Expected Income)

- Income under ***Linear Insurance***:
  - $Y^L = Ap[(T - q) - \pi]$ $\quad$ *if* $q \leq T$
  - $Y^L = Ap(q - \pi)$ $\quad$ *if* $q > T$
  - T: strikepoint (qq/ha); π: premium (qq/insured ha)

- Income under ***Lump Sum Insurance***:
  - $Y^S = Ap(q + s - \pi)$ $\quad$ *if* $q \leq T$
  - $Y^S = Ap(q - \pi)$ $\quad$ *if* $q > T$
  - s: Lump sum indemnity (qq/insured ha)

- Parameterize for Pisco
  - A = 5 ha; p = 100 S./qq;
  - T = 32 qq/ha; π = 620 S./ha; s = 1,060 S./ha

Linear vs. Lump Sum Contracts

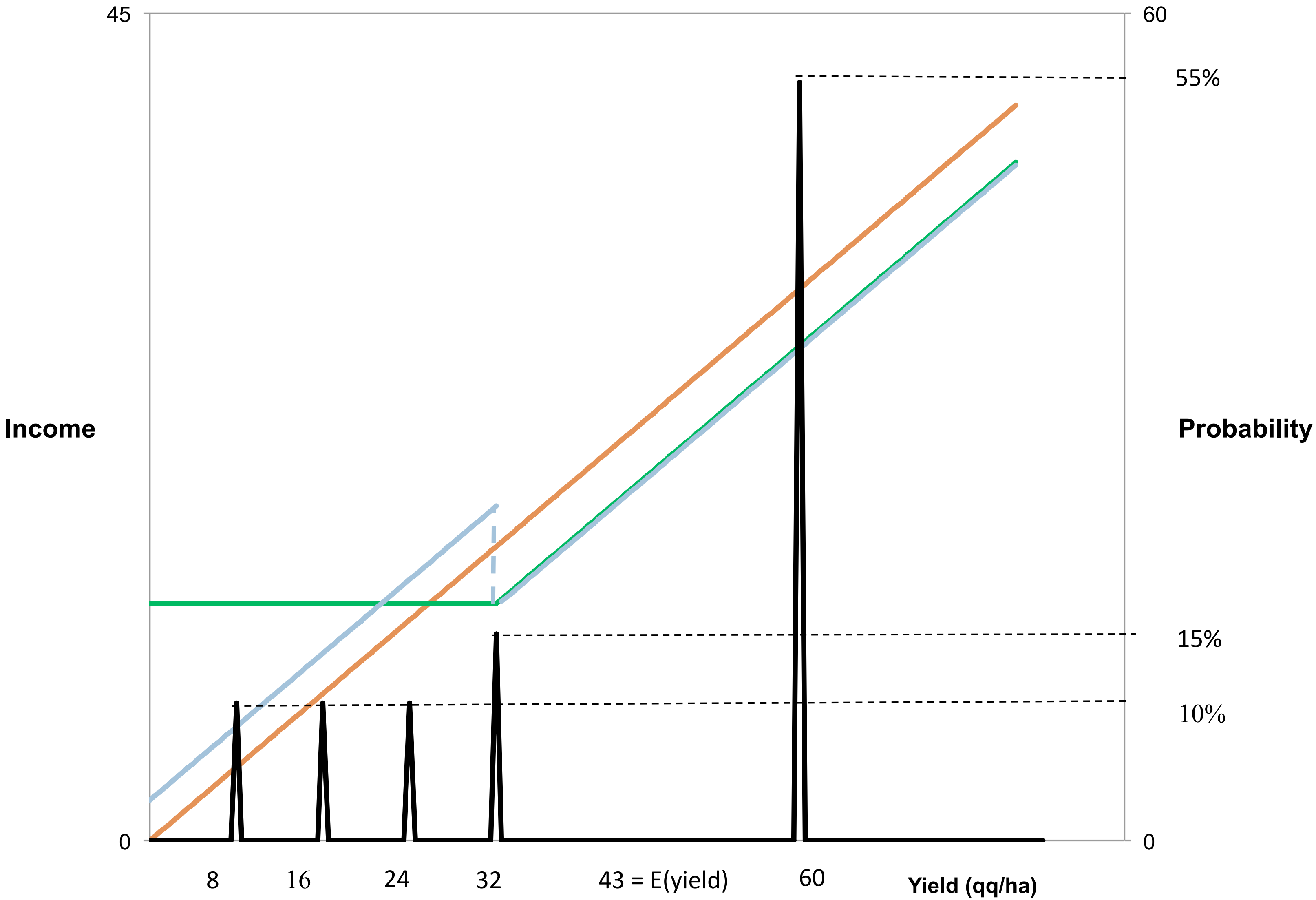


Discrete Version

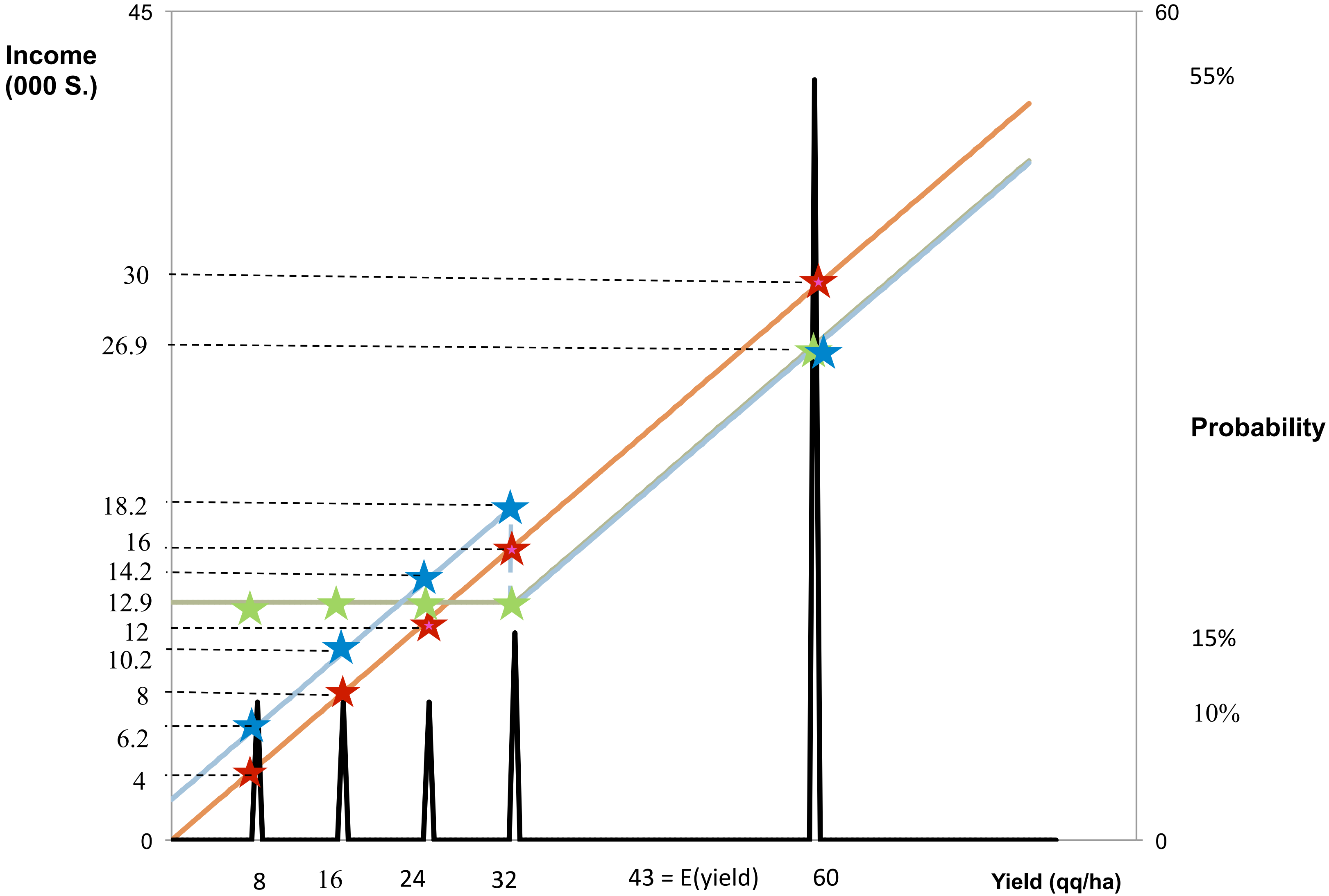
- Discrete yield distribution with 5 possible outcomes:
  - Start with empirical distribution of average yield in Pisco;
  - Collapse all density above mean into 1 outcome with 55% prob;
  - Collapse density below mean into 5 outcomes with smaller probabilities;

- End up with:

Linear vs. Lump Sum Contracts

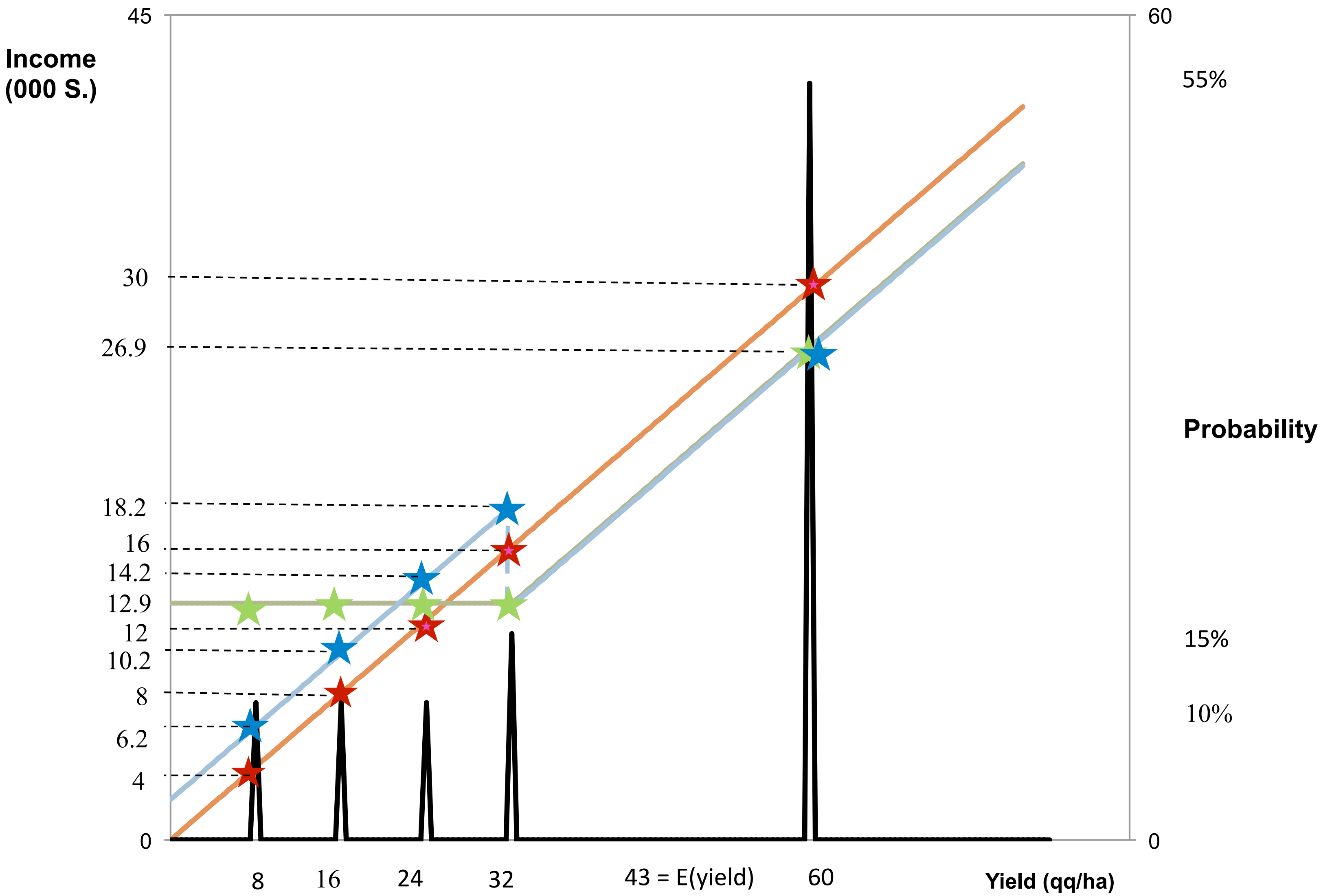


Linear vs. Lump Sum Contracts

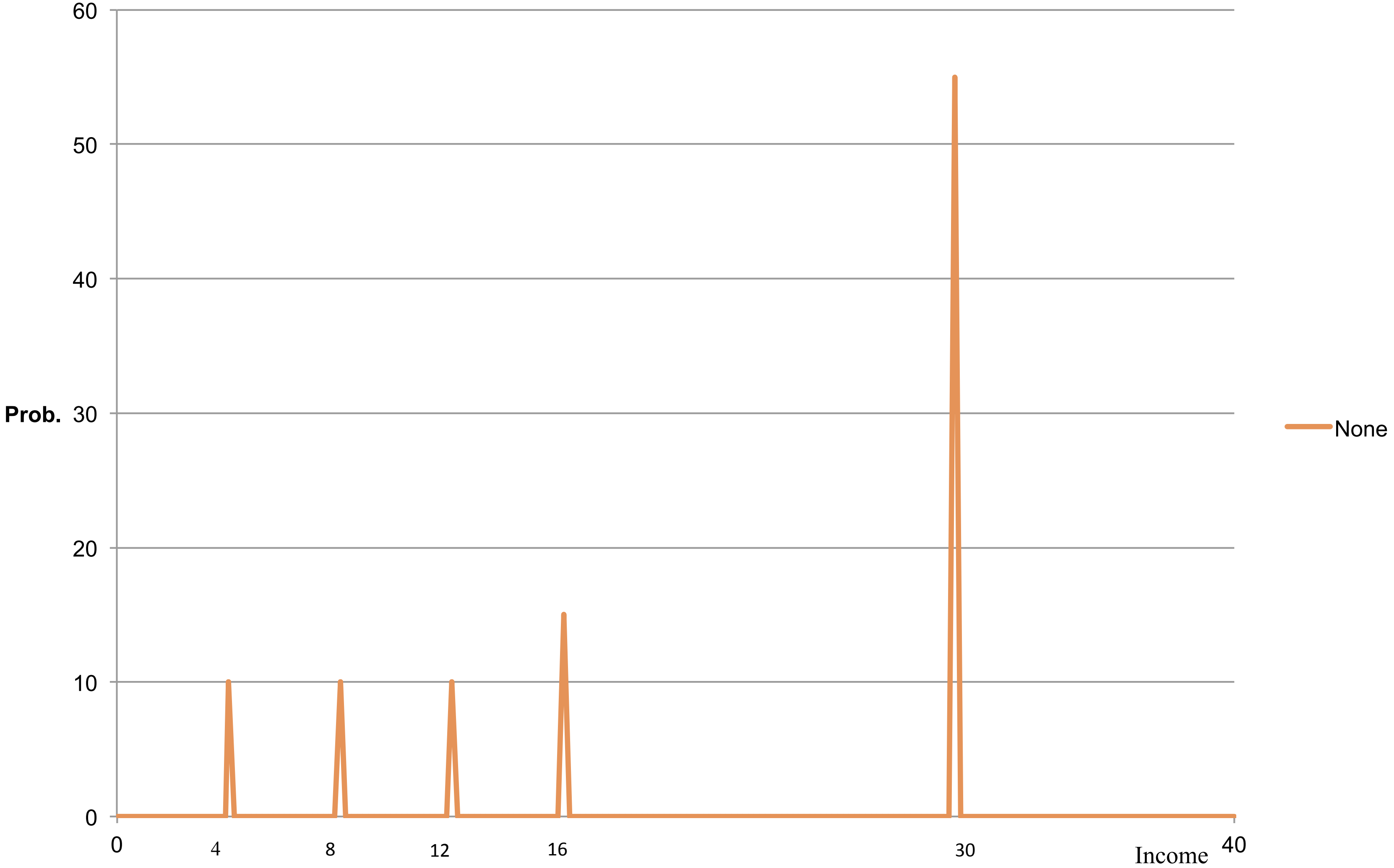


- How do we choose between Red vs. Green vs. Blue stars?

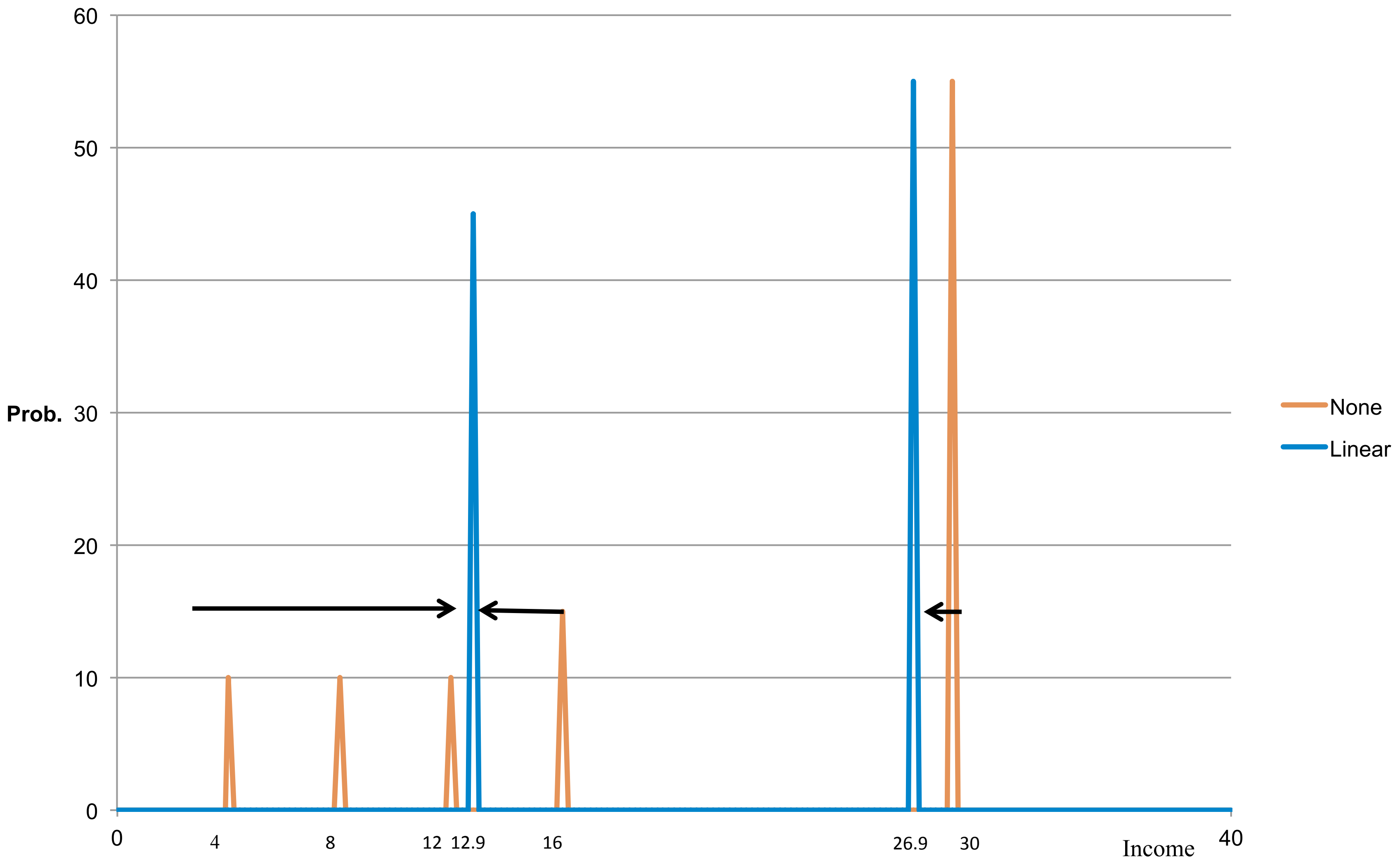
- Need to see how insurance effects PMF of income.



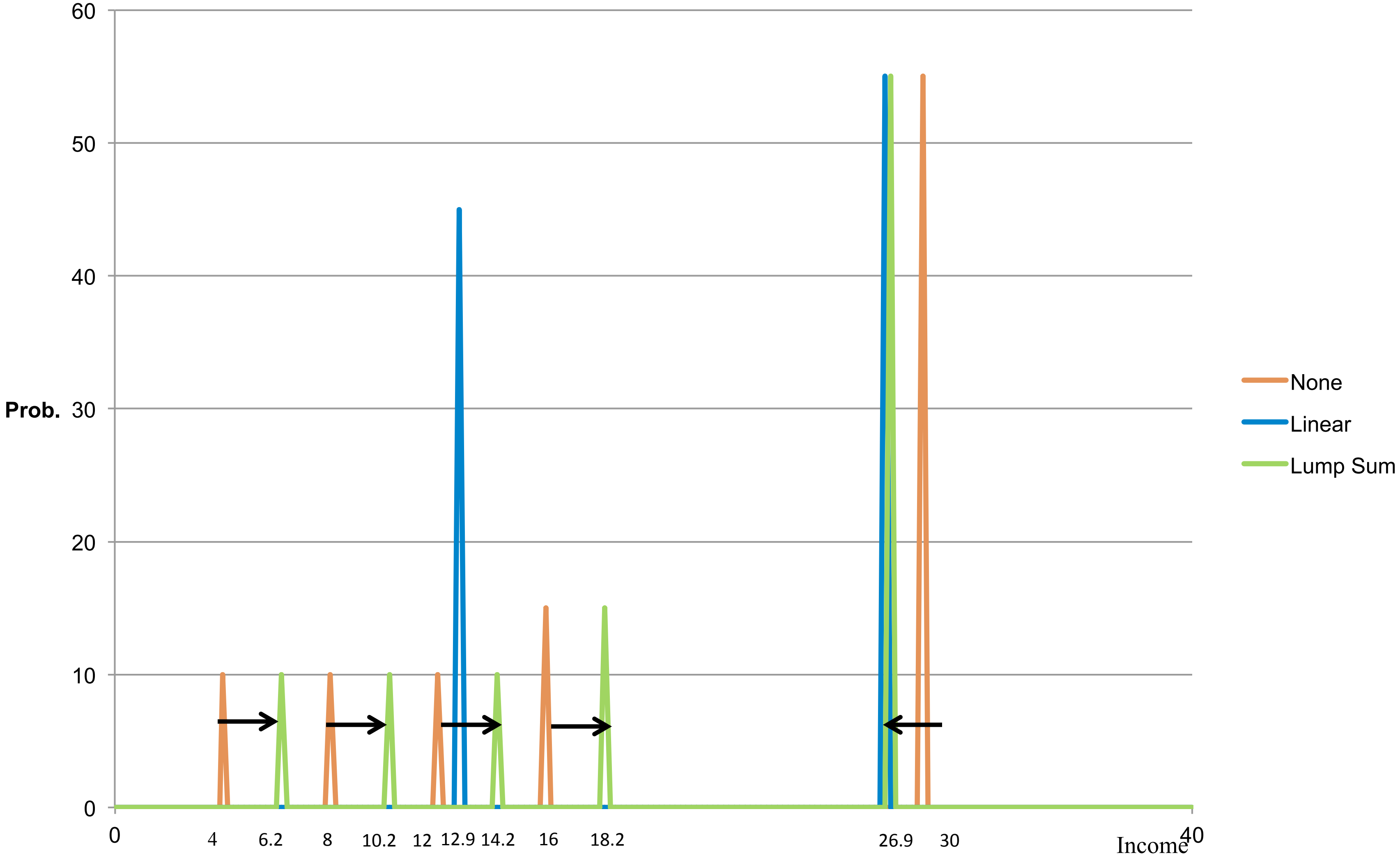
PMF's of income under different contracts



PMF's of income under different contracts



PMF's of income under different contracts



PMF's of income under different contracts

Contract choice under EUT versus CPT

- What matters under EUT?
  - Degree of risk aversion
    - γ: Coefficient of Relative Risk Aversion

- What matters under CPT?
  - Degree of risk aversion
  - Subjective probabilities
    - Decision weights assigned to each outcome may differ from objective probabilities
    - α: Coefficient from probability weighting function
  - Reference point and reflection
    - Do I treat "gains" systematically differently than "losses"
    - R: Reference point above which lie gains, below which lie losses.
  - Loss aversion
    - Degree of asymmetry of valuation of losses versus gains
    - λ: Coefficient of loss aversion

Contract Choice under EUT

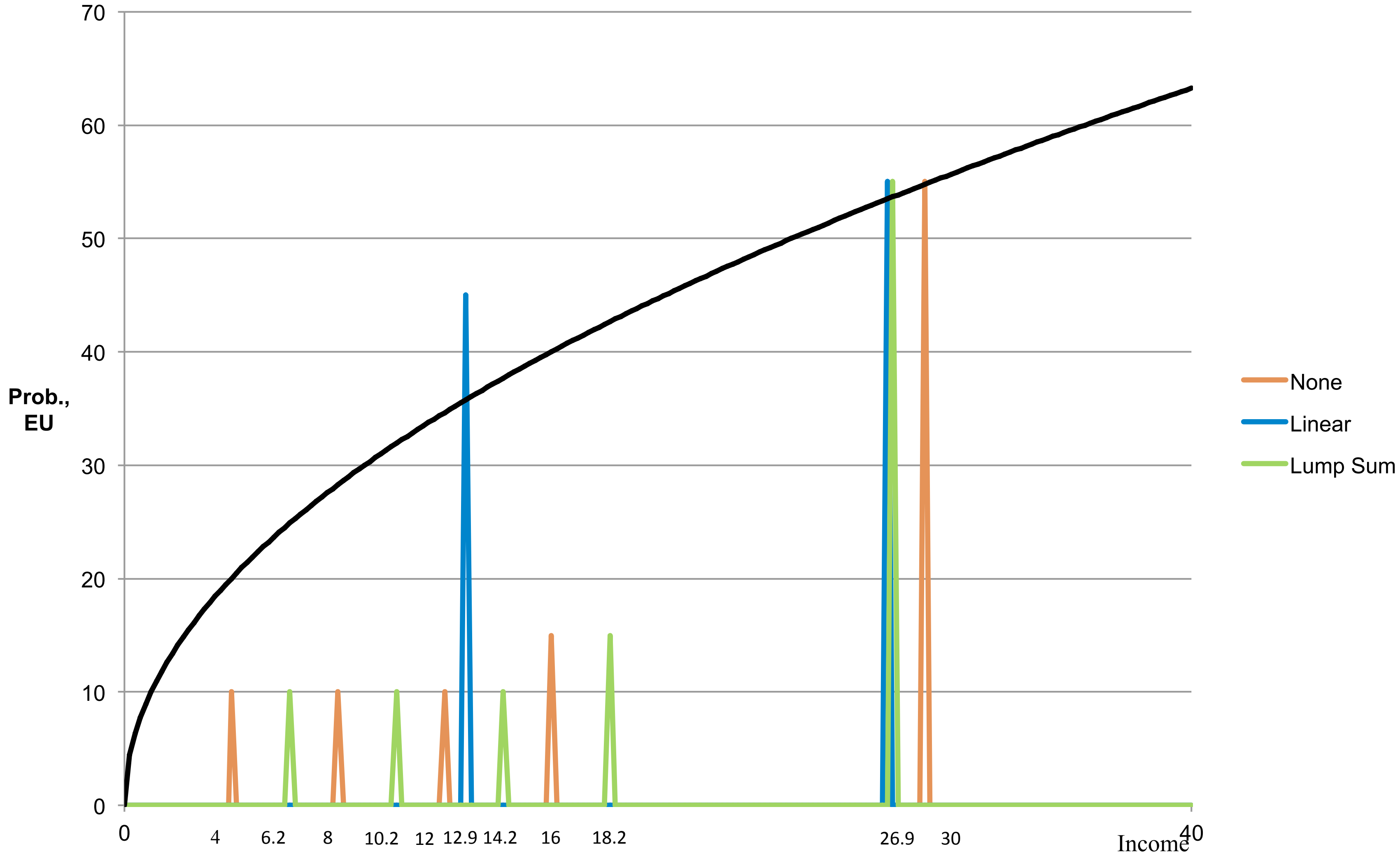
- $u(Y) = Y^{1-\gamma}$
  - Constant Relative Risk Aversion
  - γ is coefficient of relative risk aversion
  - $\gamma > 0$ → risk averse; $\gamma < 0$ → risk loving

- Linear contract gives greater risk reduction than lump sum contract.

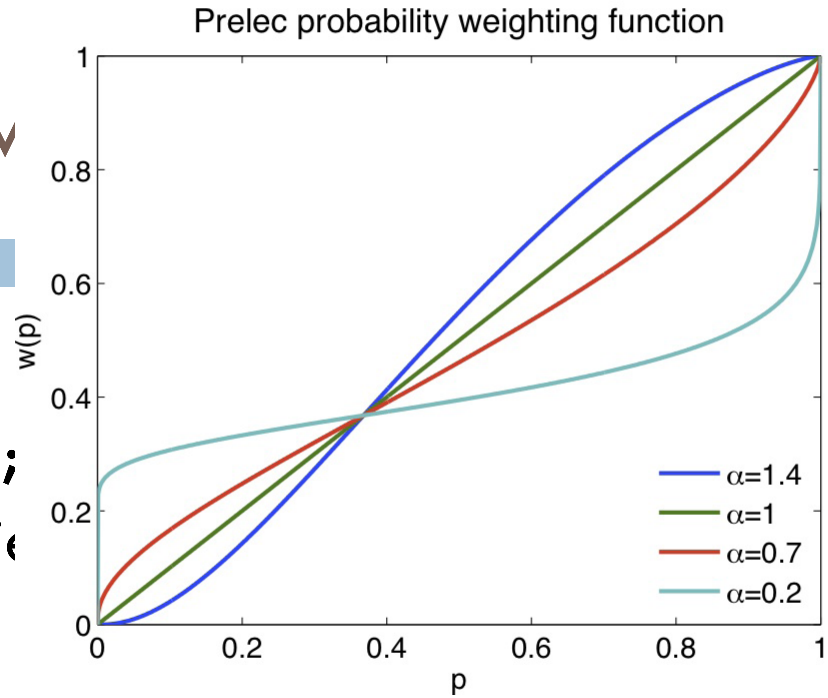
- Risk averse farmers will:
  - Never prefer lump sum to linear;
  - Buy linear if they are sufficiently risk averse ($\gamma > \gamma^*$), such that risk premium > insurance premium.

- Risk neutral & risk loving farmers will:
  - Always prefer no-insurance
    - Highest variance;
    - Loading → Highest E(Y)

Expected Utility Theory

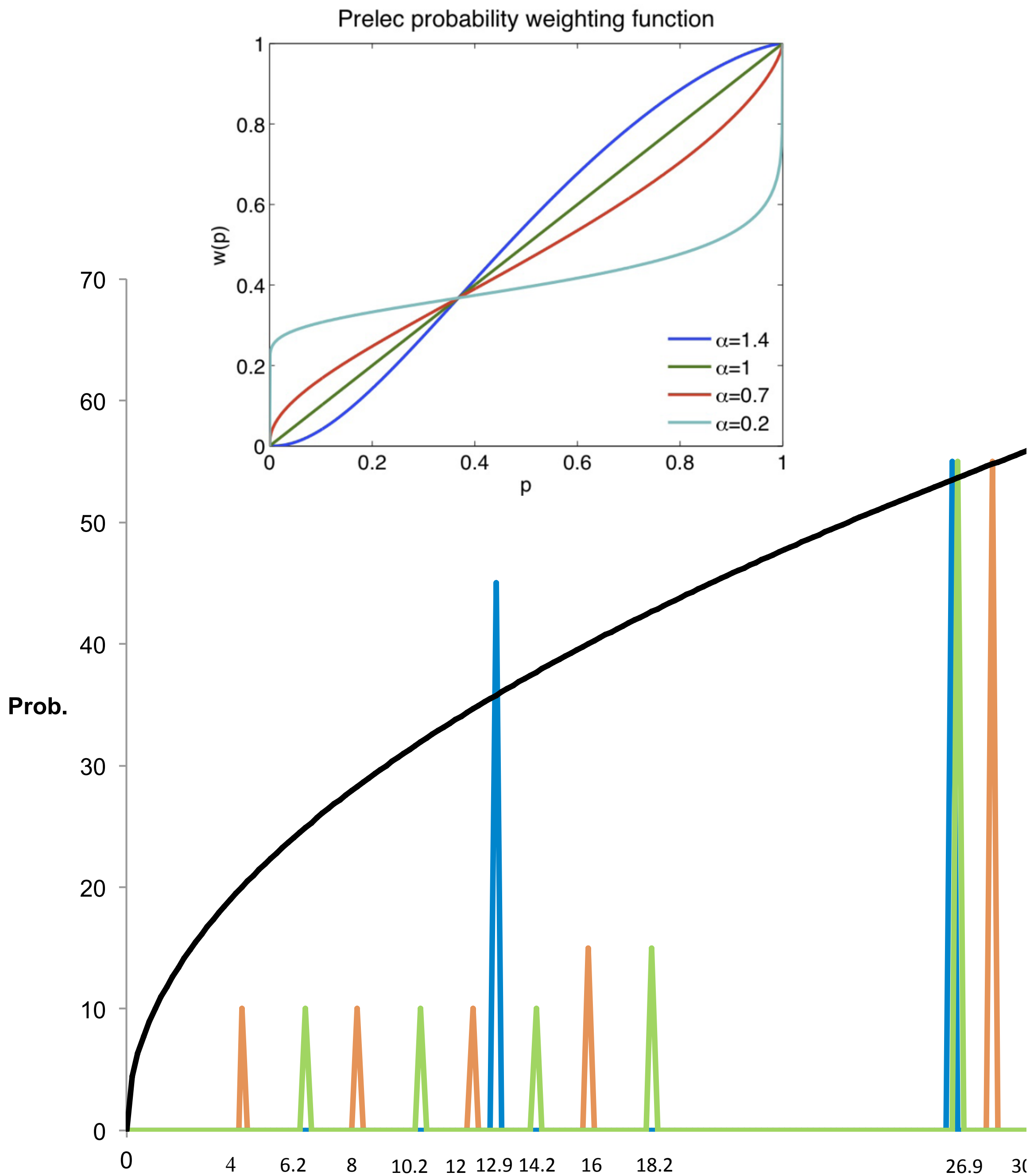


EUT Departure 1: Subjectiv



- People tend to:
  - Overweight small probabilities;
  - Underweight larger probabiliti
- Probability weighting function from Prelec (1998):
  - $w(p) = exp(-(-ln(p)^{\alpha})$
- Cumulative Prospect Theory (Kahneman & Tversky, 1992) transform *w(p)* into decision weights that:
  - Sum to 1;
  - Maintain monotonicity

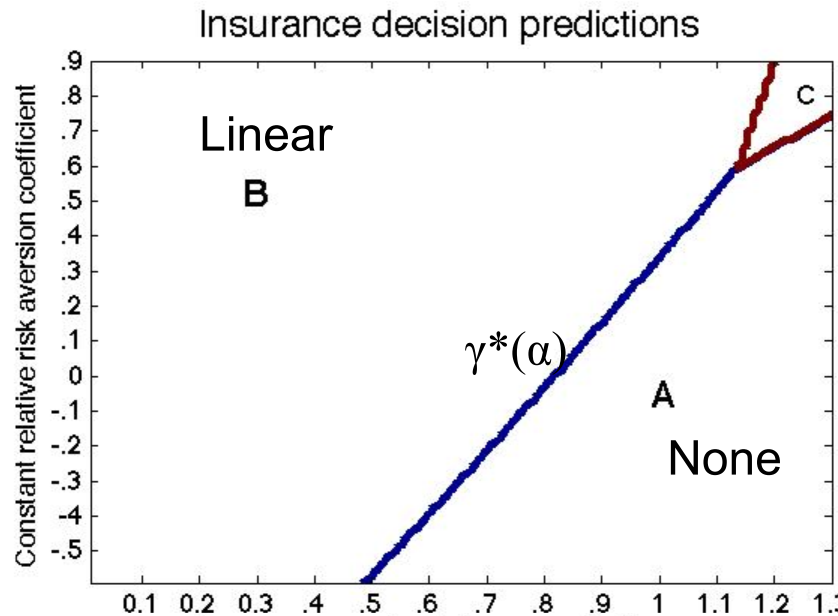
Impact of Prob. Weighting on Insurance Demand

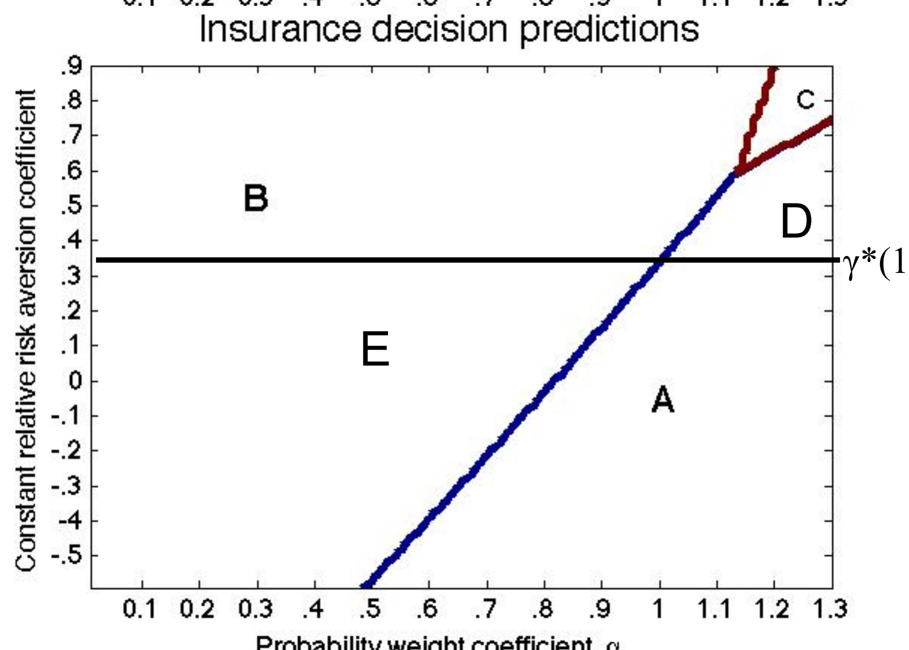


- In each option, relatively bad outcomes are lower prob.;
- Thus expected utility falls for ALL options as $\alpha \rightarrow 0$
- Linear becomes *relatively more* attractive because it truncates lowest outcomes

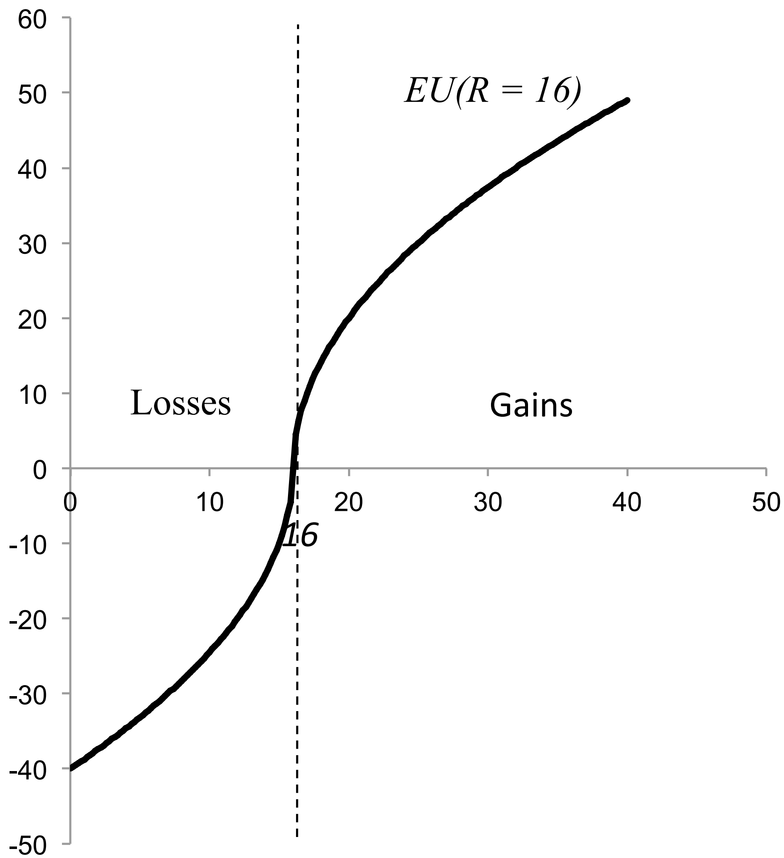
Impact of Probability Weighting: Summary

- γ^* is CRRA such that indifferent between Linear & No contracts;
- $\partial\gamma^*/\partial\alpha > 0$
  - As α falls from 1 to 0,
    - Linear becomes relatively more attractive
    - So marginally less risk averse people prefer Linear
  - As α increases above 1
    - Overweight high prob events;
    - Linear becomes less attractive;
    - Eventually prefer Lump Sum (area C).
- Demand Flip-floppers?
  - E: None (EUT) → Linear (CPT)
  - D: Linear (EUT) → None (CPT)
  - C: Linear (EUT) → Lump Sum (CPT)



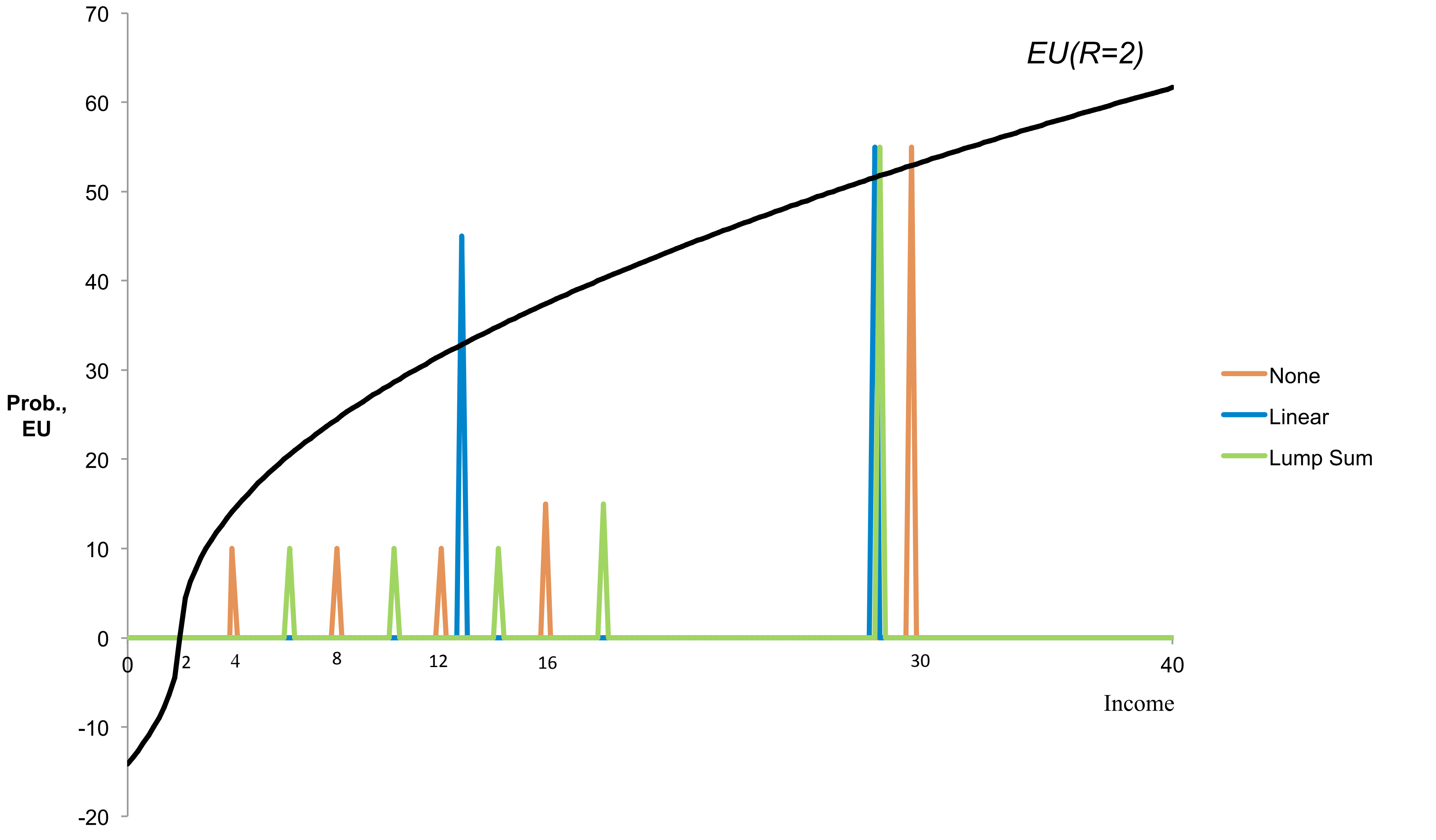


Departure #2: Reflection & Reference Point

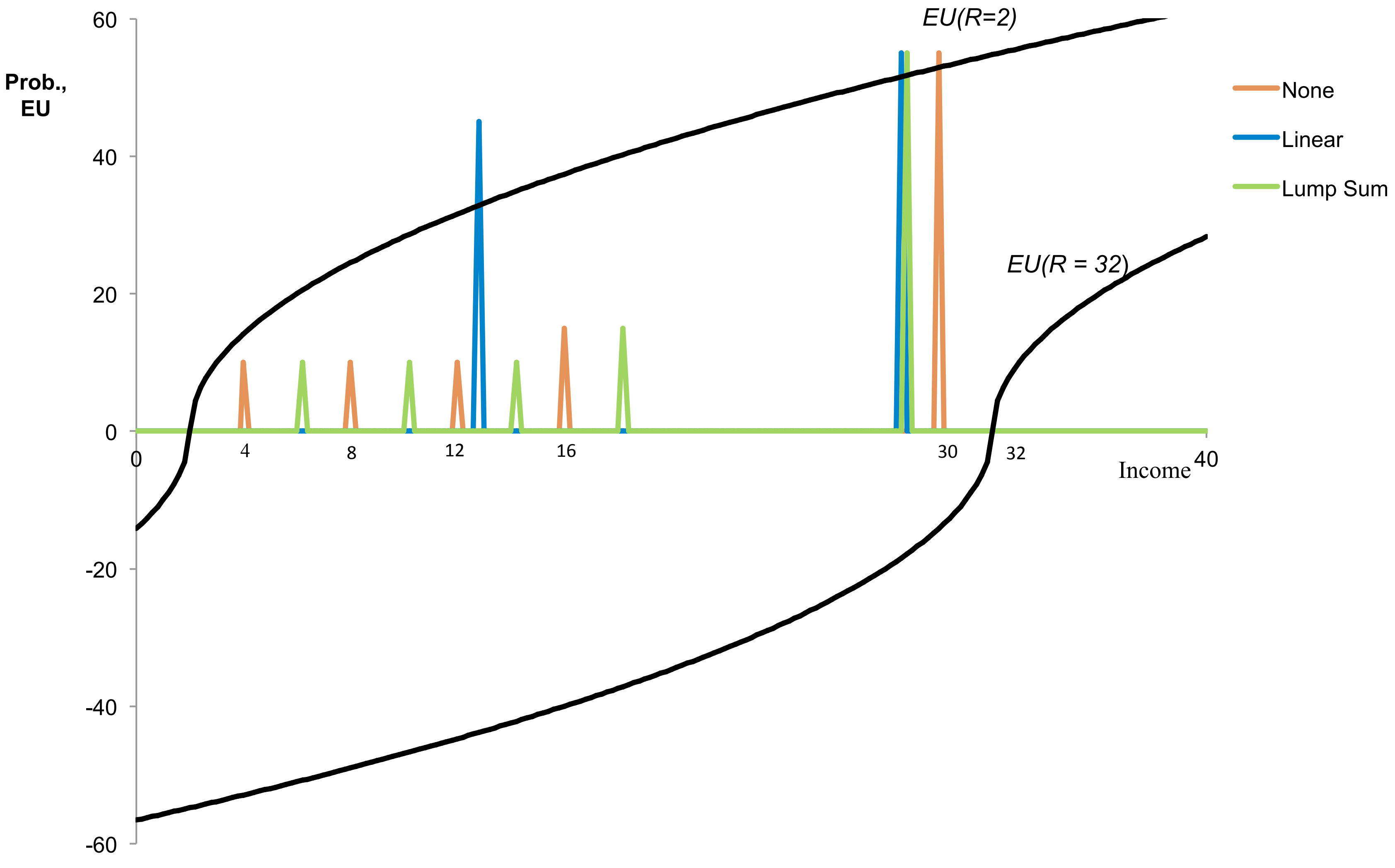


- $u(Y) = (Y\text{-}R)^{1-\gamma}$ *if* $Y > R$
- $u(Y) = -((R\text{-}Y)^{1-\gamma})$ *if* $Y > R$
- Utility function "reflected" around reference point, *R*.
- Risk averse behavior over "gains"
- Risk loving behavior over "losses"
- How does Reflection affect insurance demand?
  - Depends where *R* is…
  - (Wouter's *Proposition 5*)

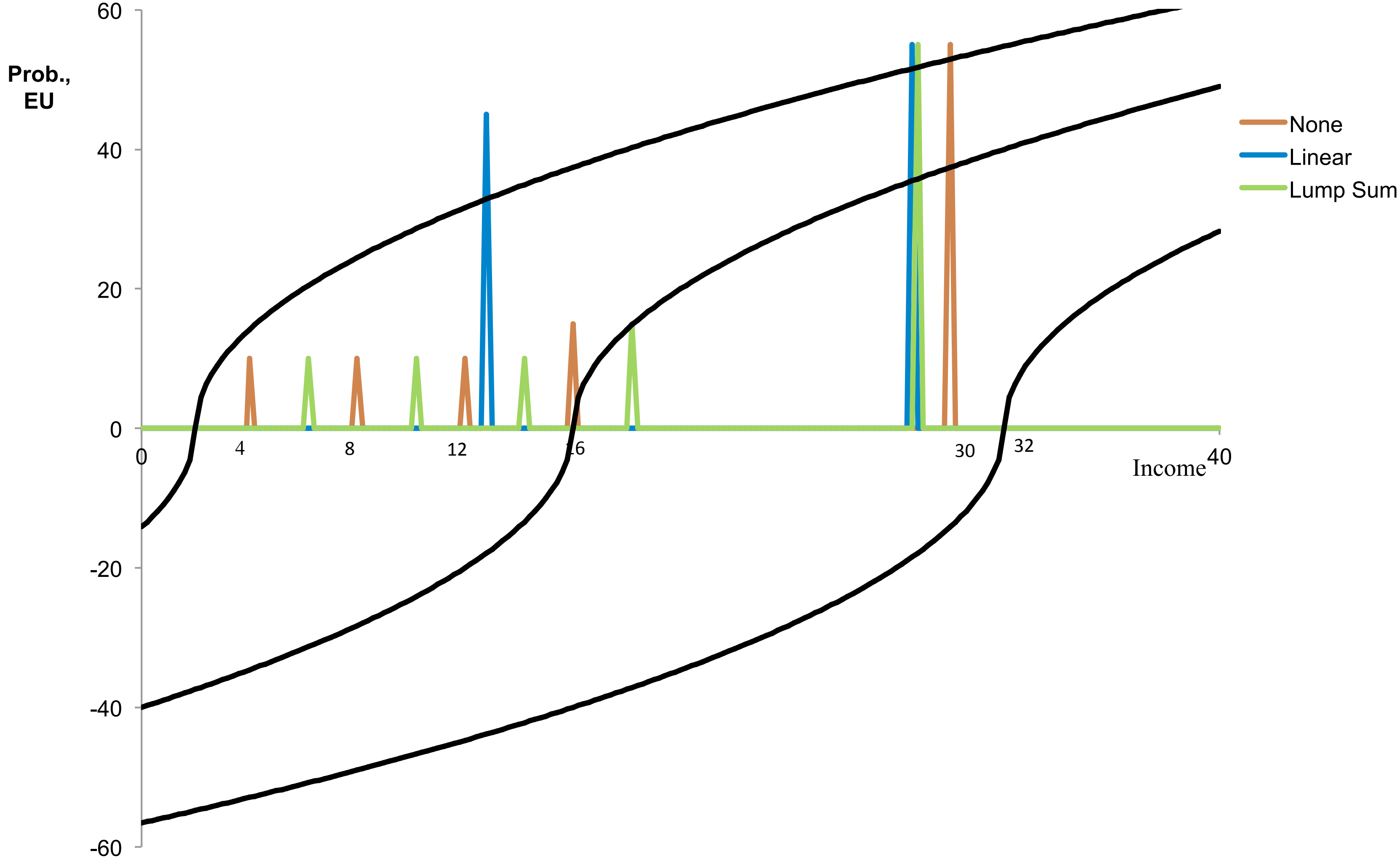
Low R → Insurance evaluated over "gains"



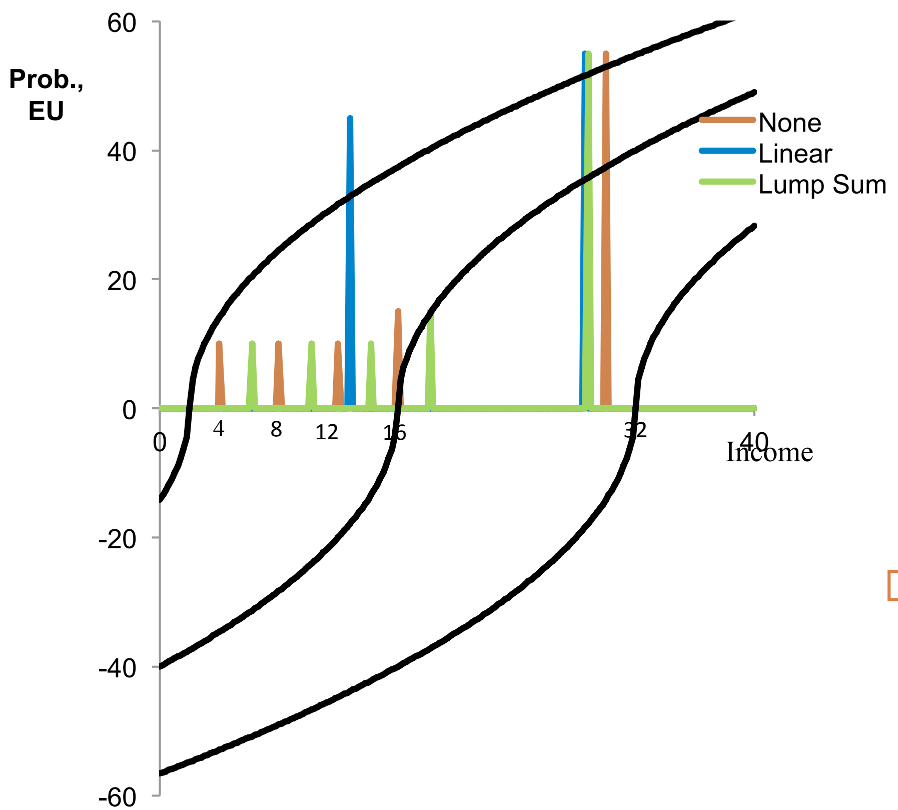
High R → Insurance evaluated over "losses"



Intermediate R → Insurance evaluated over "gains" & "losses"

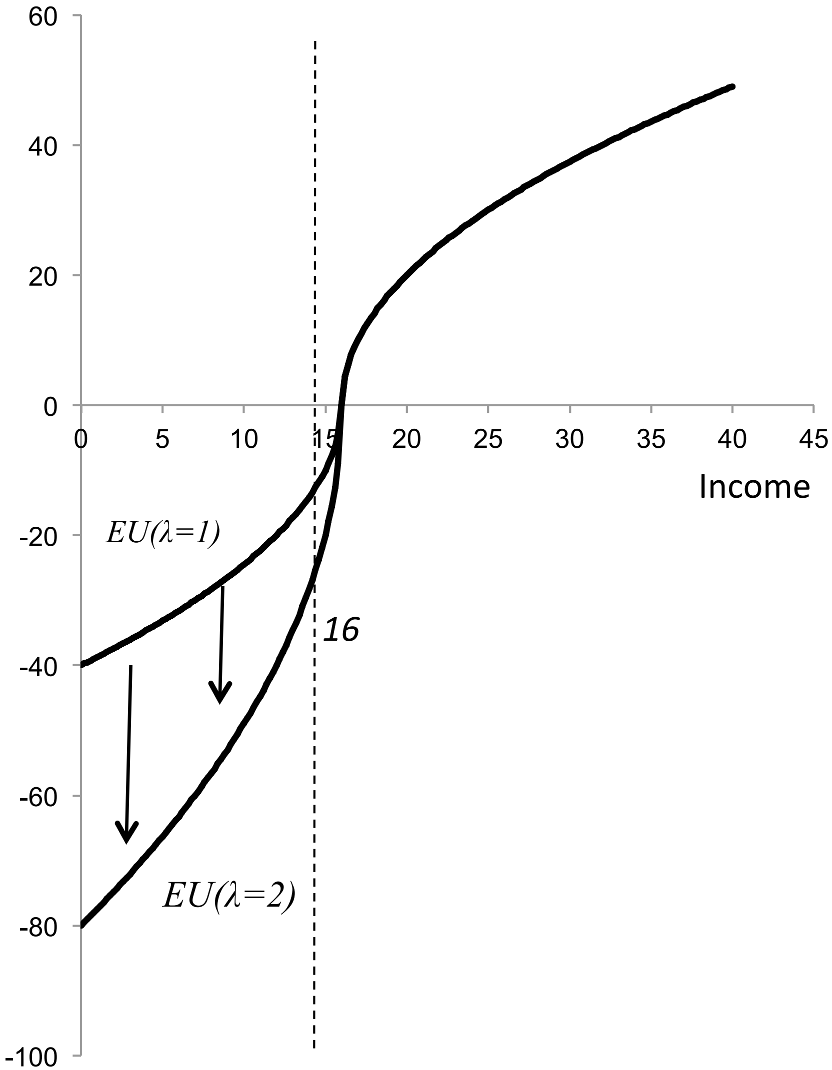


Impact of Reference Point: Summary



- As *R* increases:
  - Relatively more insured outcomes evaluated over losses;
  - Lump sum becomes relatively more attractive than linear;
  - Eventually no-insurance dominates
- In intermediate range (insured outcomes over both losses & gains), any ranking can obtain;

Departure #3: Loss Aversion (λ)



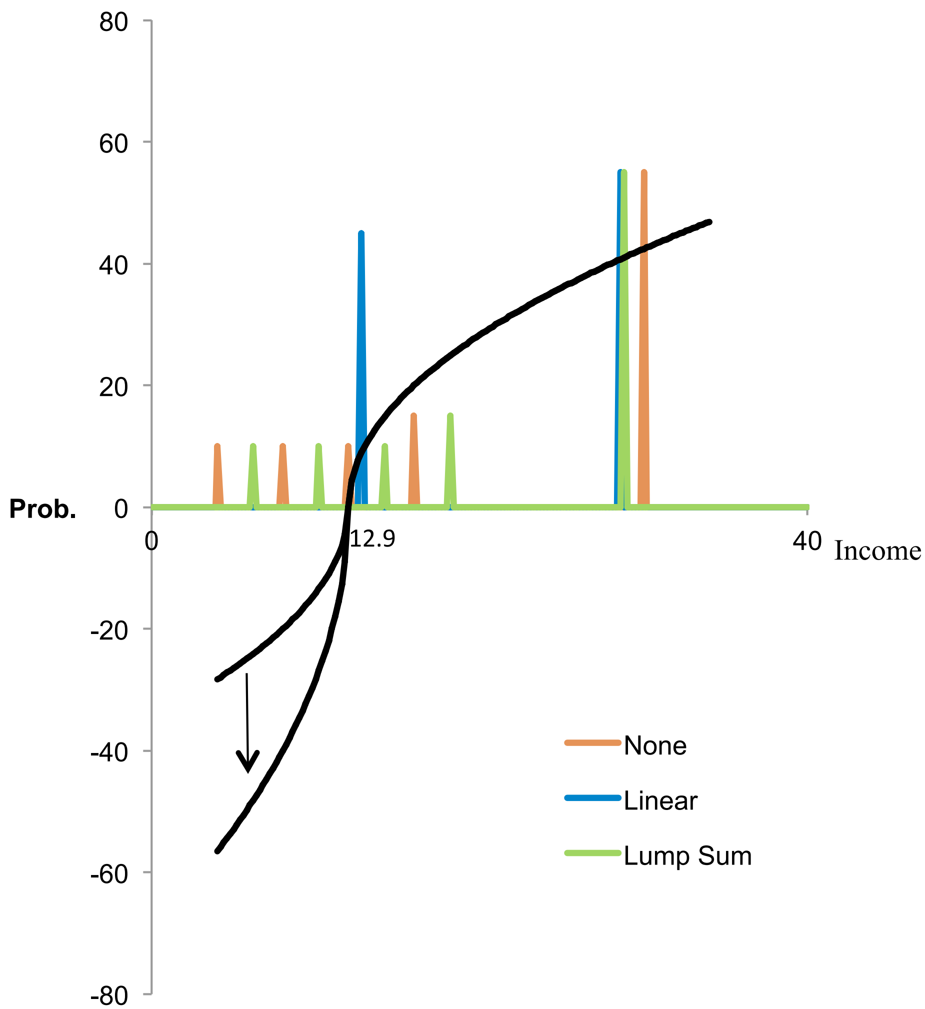
- $u(Y) = (Y\text{-}R)^{1-\gamma}$ *if* $Y > R$
- $u(Y) = -(\lambda(R\text{-}Y)^{1-\gamma})$ *if* $Y > R$

- λ introduces asymmetry in magnitude of loss and gain of given size;

- λ > 1 → Loss hurts more than a gain of equal size gain.

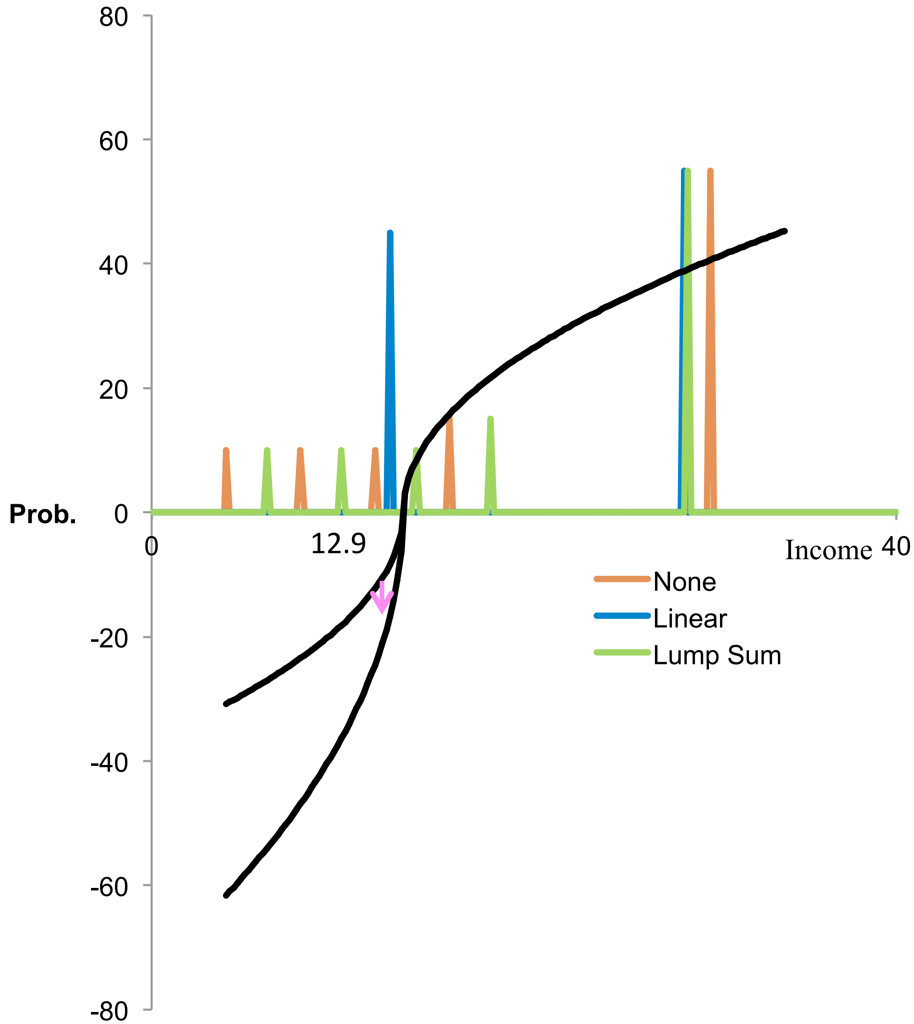
- How does λ affect insurance demand?
  - It depends on *R* (*Wouter's Proposition 6* ☺)

$R < 12.9 = Apq(T- \pi)$



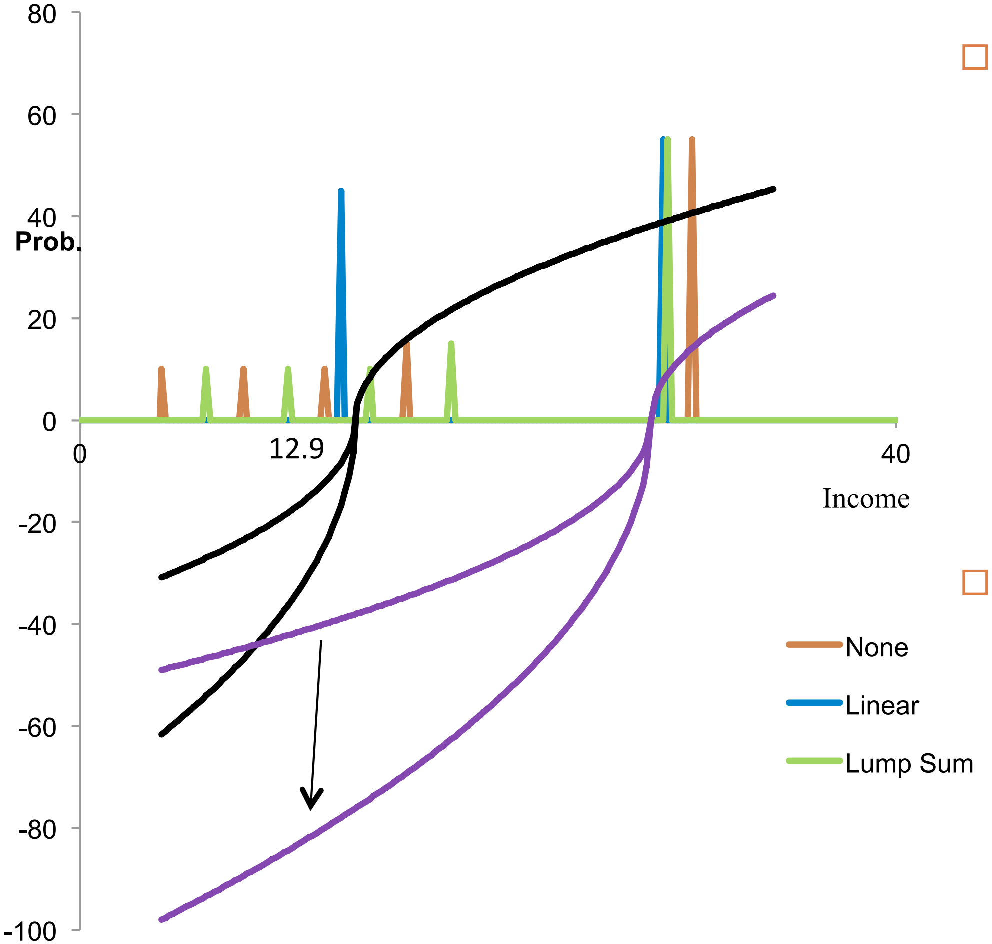
- Impact of ↑λ on EU:
  - No effect under LC;
  - Falls under LS;
  - Falls more under NC.
- Impact of ↑λ on demand:
  - Can flip from LS → LC or NC → LC if LS initially preferred.
  - No impact if LC initially preferred.

$R = 12.9 + \varepsilon = Apq(T - \pi) + \varepsilon$



- Impact of ↑λ on EU:
  - Falls under LSC;
  - Falls more under NC;
  - Falls less under LC (b.c. losses under LC are very small)
- Impact of ↑λ on demand (same):
  - Makes LC relatively more attractive than LSC.
  - Can flip from LS → LC or NC → LC if LS initially preferred.

$R = 12.9 + \varepsilon = Apq(T - \pi) + \varepsilon$



- Impact of ↑λ on EU:
  - Falls under LS;
  - Falls more under NC;
  - Also falls more under LC (b.c. as R shifts right, payout at 12.9 becoming larger and larger loss)
- Impact of ↑λ on demand (same):
  - Makes LSC relatively more attractive than both LC and NC.
  - Can flip from LC → LS or NC → LS if LS initially preferred.

CPT Summary

- Probability weighting (α)
  - Over-weighting low probability events makes both insurance contracts more attractive;
  - As over-weighting increases (i.e., α falls from 1 towards 0), linear contract becomes relatively more attractive than lump sum.

- Reflection and Reference point (R)
  - Reflection turns risk averse farmers into risk seekers over losses
  - $\uparrow$R $\rightarrow$ Lump sum becomes relatively more attractive than linear

- Loss Aversion;
  - $\uparrow\lambda$ $\rightarrow$ Makes lump sum more attractive than linear if $R < R^*$
  - $\uparrow\lambda$ $\rightarrow$ Makes linear more attractive than lump sum if $R > R^*$

- So…anything can happen! If only we knew the value of farmers' preference parameters??!!

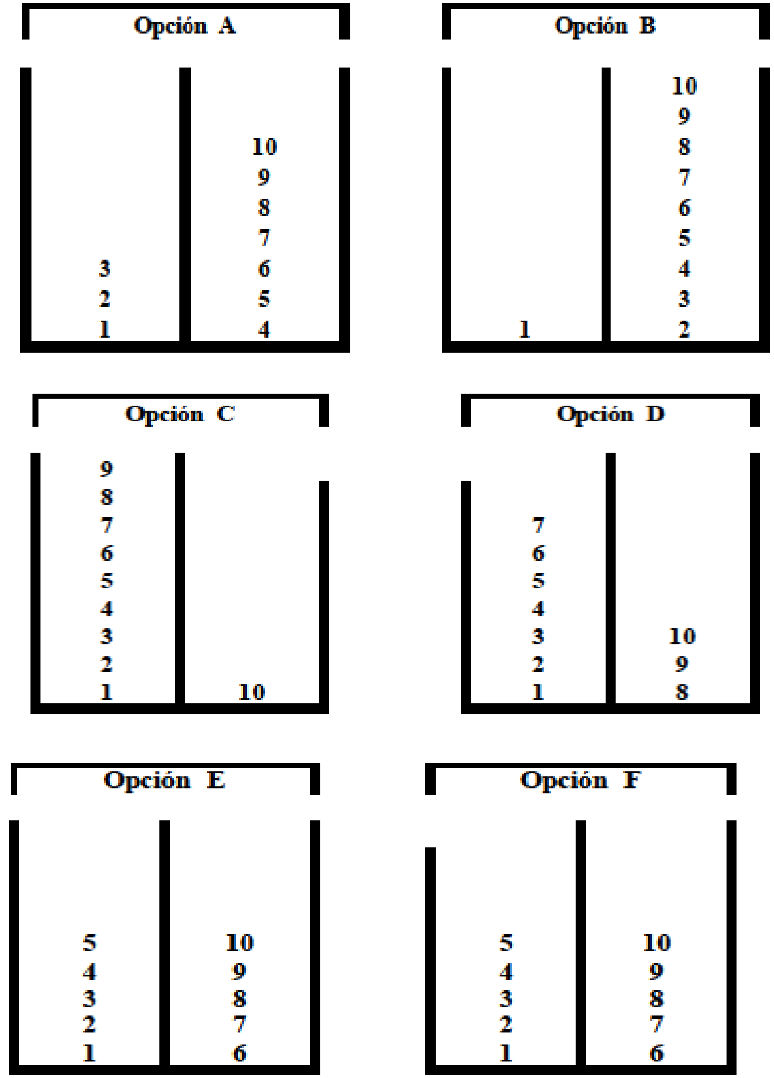
Framed field experiments in Pisco

First Activity: Preference Parameter Elicitation

- Method from Tanaka, Camerer & Nguyen (2010).
- Farmers play 3 unframed lottery games;
- In each lottery, observe "switch point" between two options;
- The three switch points determine farmer-specific values of: γ,α,λ

Preference Paramet

- Method from Tanaka et. al. (AER 2010).
- Farmers play 3 unframed lottery games;
- In each lottery, observe "switch point" between two options;
- Three switch points determine farmer-specific values of: γ,α,λ



Línea 27	25 Pesos	*- 4 Pesos*	30 Pesos	*- 21 Pesos*
Línea 28	4 Pesos	*- 4 Pesos*	30 Pesos	*- 21 Pesos*
Línea 29	1 Pesos	*- 4 Pesos*	30 Pesos	*- 21 Pesos*
Línea 30	1 Pesos	*- 4 Pesos*	30 Pesos	*- 16 Pesos*
Línea 31	1 Pesos	*- 8 Pesos*	30 Pesos	*- 16 Pesos*
Línea 32	1 Pesos	*- 8 Pesos*	30 Pesos	*- 14 Pesos*
Línea 33	1 Pesos	*- 8 Pesos*	30 Pesos	*- 11 Pesos*

Second Activity: Two Insurance Demand Games

- Game over gains:
  - 5 yield outcomes (values and probabilities as described above).
  - Game payouts framed as revenues, thus always positive.

- Game over losses:
  - Same yield outcomes and probabilities.
  - Payouts framed as profits.
  - If yields fall below 32 qq/ha, revenues don't cover costs → losses.
  - Operationalized by giving farmer a 16 S/. "coupon"
    - It's their "reward" for playing this new game.
    - If they suffer a loss, they ***must pay us*** out of their coupon.
    - Makes farmer suffer/experience a true loss;
    - Makes real payoffs identical across the two games;
    - Avoids real out-of-pocket losses;

- Thus we force the Reference Point to = 0 in both games.

6

Número del participante: _________

1. Rondas de práctica. 1. Opción ___ 2. Opción ___3. Opción ___4. Opción ___5. Opción ___6. Opción ___7. Opción ___

Game over GAINS:

Probabilidades (pelotas) de cada evento	19 20	17 18	15 16	12 13 14	1 2 3 4 5 6 7 8 9 10 11
Rendimiento	8 qq/ha	16 qq/ha	24 qq/ha	32 qq/ha	60 qq/ha
Opción A	S/. 4 000				
Opción B	S/. 12 900				
Opción C	S/. 6 200				

2. Su decisión final: Opción _

7

Número del participante: _________

3. Rondas de práctica. 1. Opción ___ 2. Opción ___3. Opción ___4. Opción ___5. Opción ___6. Opción ___7. Opción ___

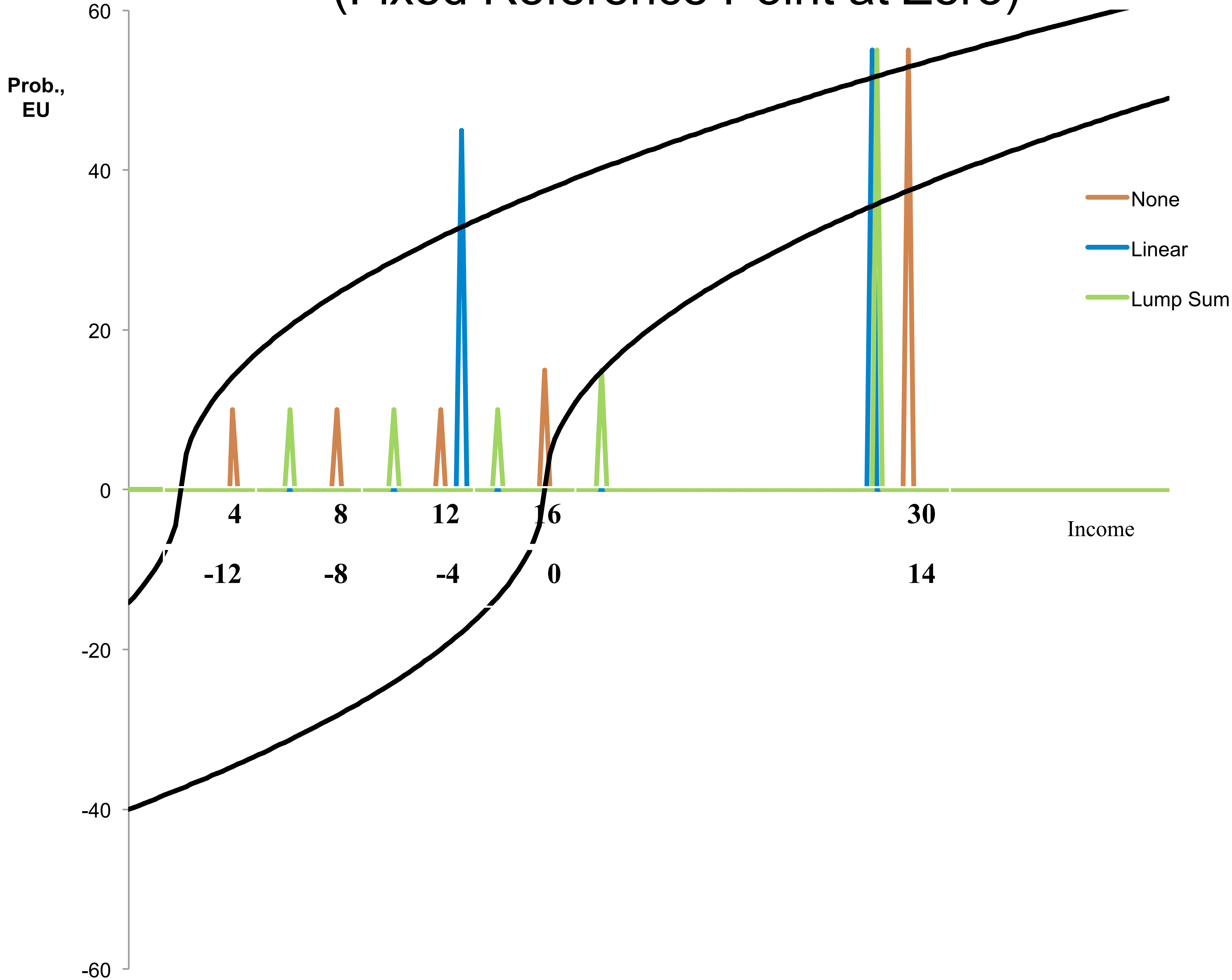
Game over LOSSES

Probabilidades (pelotas) de cada evento	19 20	17 18	15 16	12 13 14	1 2 3 4 5 6 7 8 9 10 11
Rendimiento	8 qq/ha	16 qq/ha	24 qq/ha	32 qq/ha	60 qq/ha
Opción A	*S/. – 12 000*	*S/. – 8 000*	*S/. – 4 000*	S/. cero	S/. 14 000
Opción B	*S/. – 3 100*	*S/. – 3 100*	*S/. – 3 100*	*S/. – 3 100*	S/. 10 900
Opción C	*S/. – 9 800*	*S/. – 5 800*	*S/. – 1 800*	S/. 2 200	S/. 10 900

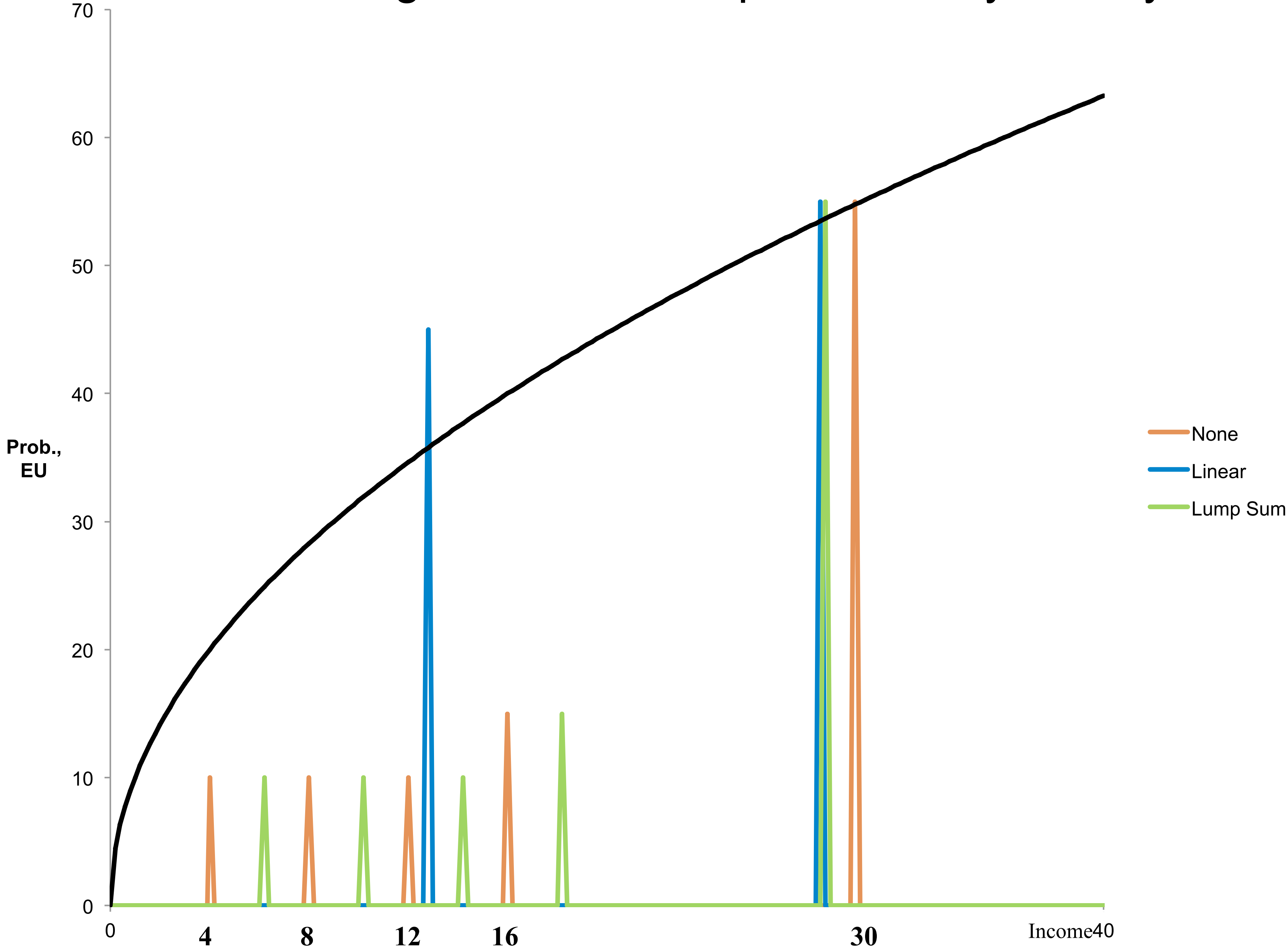
4. Su decisión final: Opción

Nubia is describing payoffs from Lump Sum contract ("Option C") under gains.

View of games under Prospect Theory (Fixed Reference Point at Zero)



View of games under Expected Utility Theory



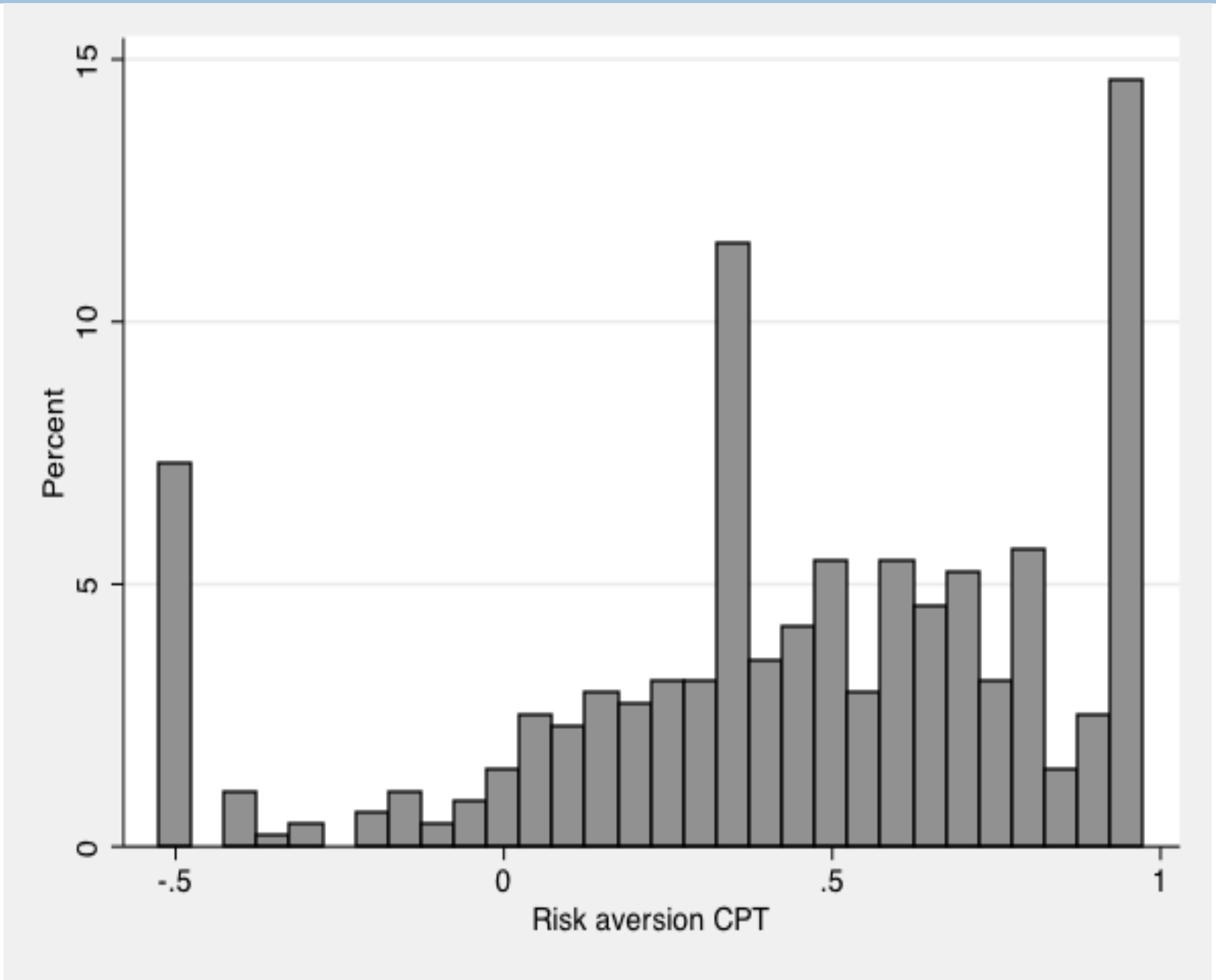
Sample/Fieldwork

- Randomly selected 30 irrigation sub-sectors in Pisco;
- Invitations delivered to 50 cotton farmers in each sub-sector (hoping that 20 would show up);
- Sample size = 480 farmers (16/sub-sector);
- One session per day;
- Fieldwork: November - December, 2011.

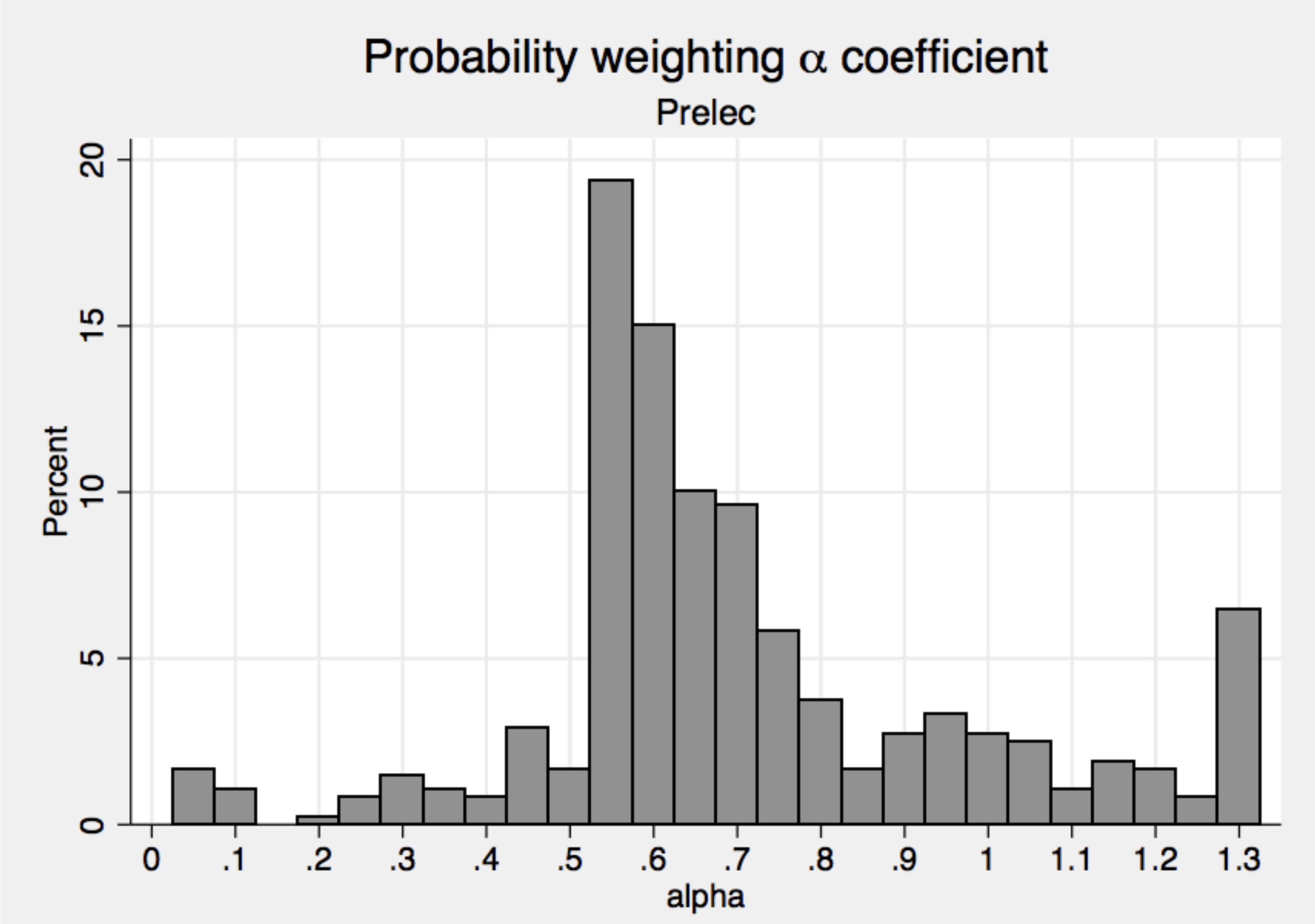
Farmer Mean Characteristics

- Socio-economic
  - Age: 53 years
  - Male: 78%
  - Area operated: 5.3 ha.
  - Cotton experience: 8.5 years
- Preference Parameters
  - γ: 0.56 (Risk Aversion)
  - α: 0.72 (Probability Weighting)
  - λ: 2.90 (Loss Aversion)
- One session per day;
- Fieldwork: November - December, 2011.

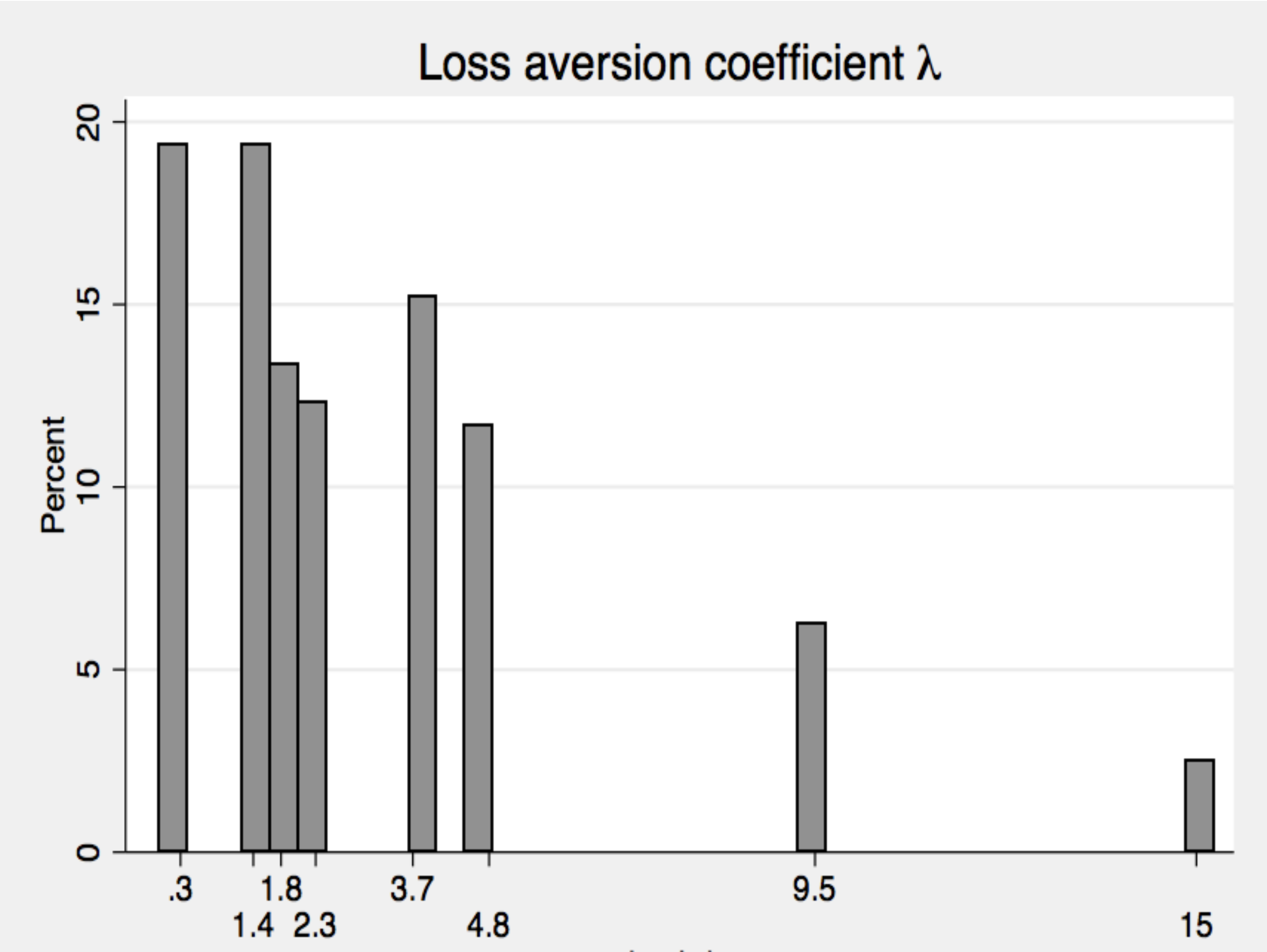
Marginal Distribution: Risk Aversion (γ)



Marginal Distribution: Probability Weighting



Marginal Distribution: Loss Aversion



Predictions Under Expected Utility Theory
(mean parameter values reported in each cell)

		Choice in GAINS game		
		No Insurance	Linear	Lump Sum
Choice in LOSSES game	No Insurance	N=118 $\gamma = 0.00$	N=0	N=0
	Linear	N=0	N=362 $\gamma = 0.58$	N=0
	Lump Sum	N=0	N=0	N=0

Predictions Under Prospect Theory

(mean parameter values reported in each cell)

		Choice in GAINS game		
		None	Linear	Lump Sum
Choice in LOSS Game	None	N=25 γ=-.006 α=1.01 λ=.58	N=10 γ=.245 α=.61 λ=.3	N=0
	Linear	N=44 γ=-.36 α=.69 λ=2.15	N=131 γ=.30 α=.54 λ=3.9	N=0
	Lump Sum	N=118 γ=.33 α=1.22 λ=3.56	N=221 γ=.77 α=.67 λ=2.8	N=0

Observed Choices
(mean parameter values reported in each cell)

		Choice in GAINS game			
		None	Linear	Lump Sum	TOTAL
Choice in LOSSES game	None	**N=82** $\gamma=.55$ $\alpha=.71$ $\lambda=2.3$	**N=19** $\gamma=.50$ $\alpha=.73$ $\lambda=2.1$	**N=18** $\gamma=.21$ $\alpha=.66$ $\lambda=2.4$	N=119
	Linear	**N=35** $\gamma=.54$ $\alpha=.63$ $\lambda=2.7$	**N=124** $\gamma=.43$ $\alpha=.70$ $\lambda=3.3$	**N=64** $\gamma=.41$ $\alpha=.70$ $\lambda=3.1$	N=223
	Lump Sum	**N=30** $\gamma=.48$ $\alpha=.70$ $\lambda=3.4$	**N=30** $\gamma=.38$ $\alpha=.79$ $\lambda=3.9$	**N=78** $\gamma=.37$ $\alpha=.74$ $\lambda=2.8$	N=138
	TOTAL	N=147	N=173	N=160	N=480

Linear probability model for choice over gains
Dependent Variable = Buy any insurance?

	(4)
VARIABLES	ins1
crrac (γ)	0.184***
	(3.512)
alpha	-0.0454
	(-0.578)
Bad shock in ultimate trial round	-0.107
	(-1.540)
Bad shock in penultimate trial rour	-0.0129
	(-0.206)
male	-0.0210
	(-0.393)
Q9: age	-0.00239
	(-1.148)
Q10: Education	-0.0273***
	(-4.392)
Q17: Plots	-0.0778**
	(-2.176)
Q18: Area	0.00213
	(0.622)
Q20: Years cotton	-0.00120
	(-0.141)
Q22: Cotton av yield	-0.000465
	(-0.257)
Constant	0.730***
	(4.006)
Observations	471
R-squared	0.088

What to make of this? Where to go next?

- First descriptive look not very satisfying
  - No clear "stories" to tell that would be consistent with EUT vs. CPT;
  - Risk Aversion result wrong direction

- Relative predictive power?
  - EUT:
    - In Gains Game: 32% predicted correctly
    - In Losses Game: 40% predicted correctly
    - 12% of joint outcomes predicted correctly
  - CPT:
    - In Gains Game: 31% predicted correctly
    - In Losses Game: 35% predicted correctly
    - 14% of joint outcome predicted correctly

What to make of this? Where to go next?

- Caveats
  - Are farmers bringing in alternative framings or “Reference Points”?
    - Example: I consider any yield < 60 qq/ha a “loss”
  - Risk Aversion result wrong direction:
    - Is insurance more like “technology adoption”?

- Next steps
  - Explore alternative functional forms;
  - Basic multi-nomial regressions;

- Other suggestions?