Glenn Harrison

Evaluating Index Insurance Contracts

ETH zürich

ETH Risk Center

ETH Risk Center Course in
Behavioral Economics and Insurance,
May 12 2017, Zürich

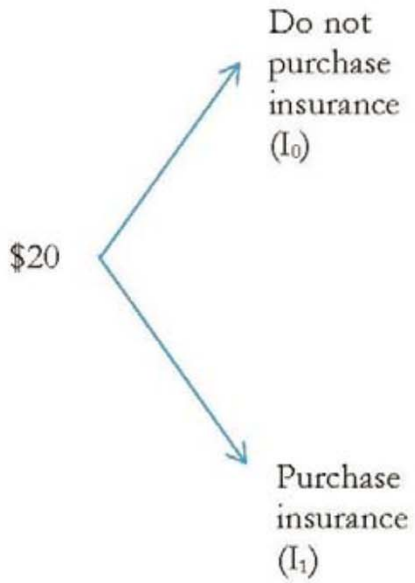
Center for the Economic Analysis of Risk

Georgia State University | CEAR CENTER FOR THE ECONOMIC ANALYSIS OF RISK

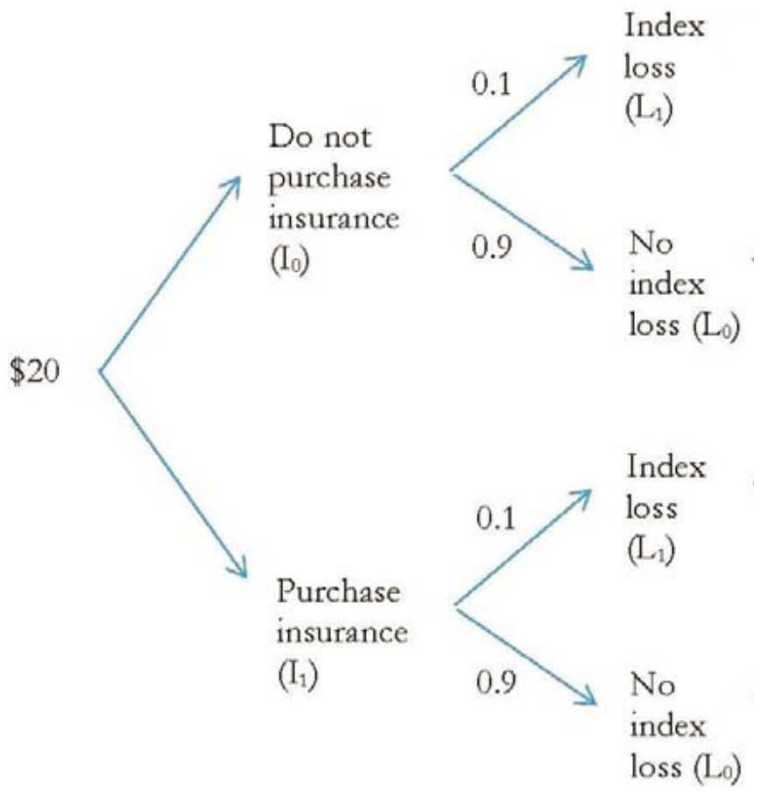
Motivation

- How are index insurance (II) products evaluated?
  - Take-up
  - Effects on levels of activity
  - Welfare
- Effects of attributes of II on choices and welfare
  - Loss probability, premium, correlation of index
  - Reduction of Compound Lotteries axiom of behavior
- Behavioral welfare economics
  - What is the metric of evaluation?
  - Measuring risk preferences without assuming ROCL, if one wants to test the effects of violating ROCL

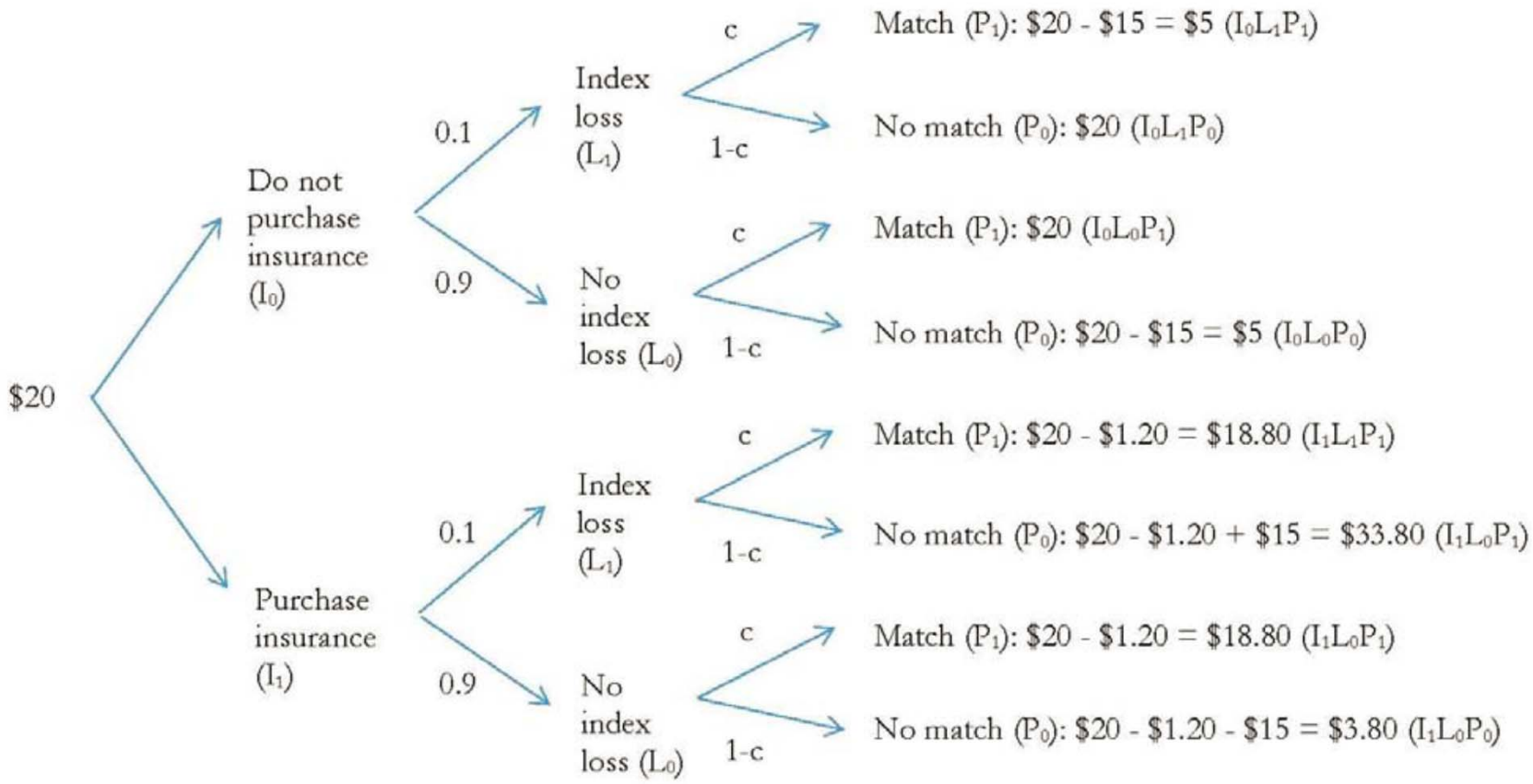
Index Insurance



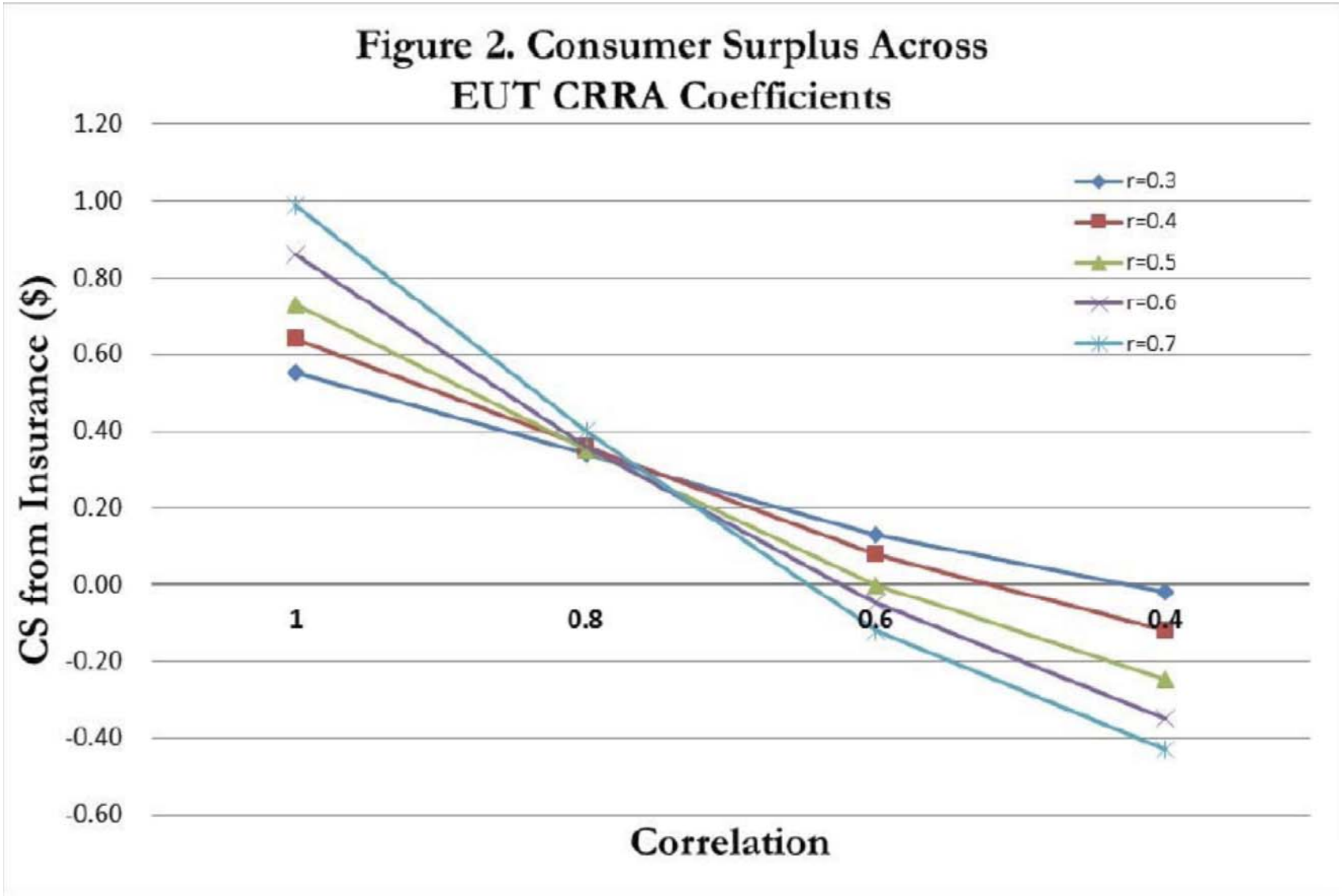
Index Insurance



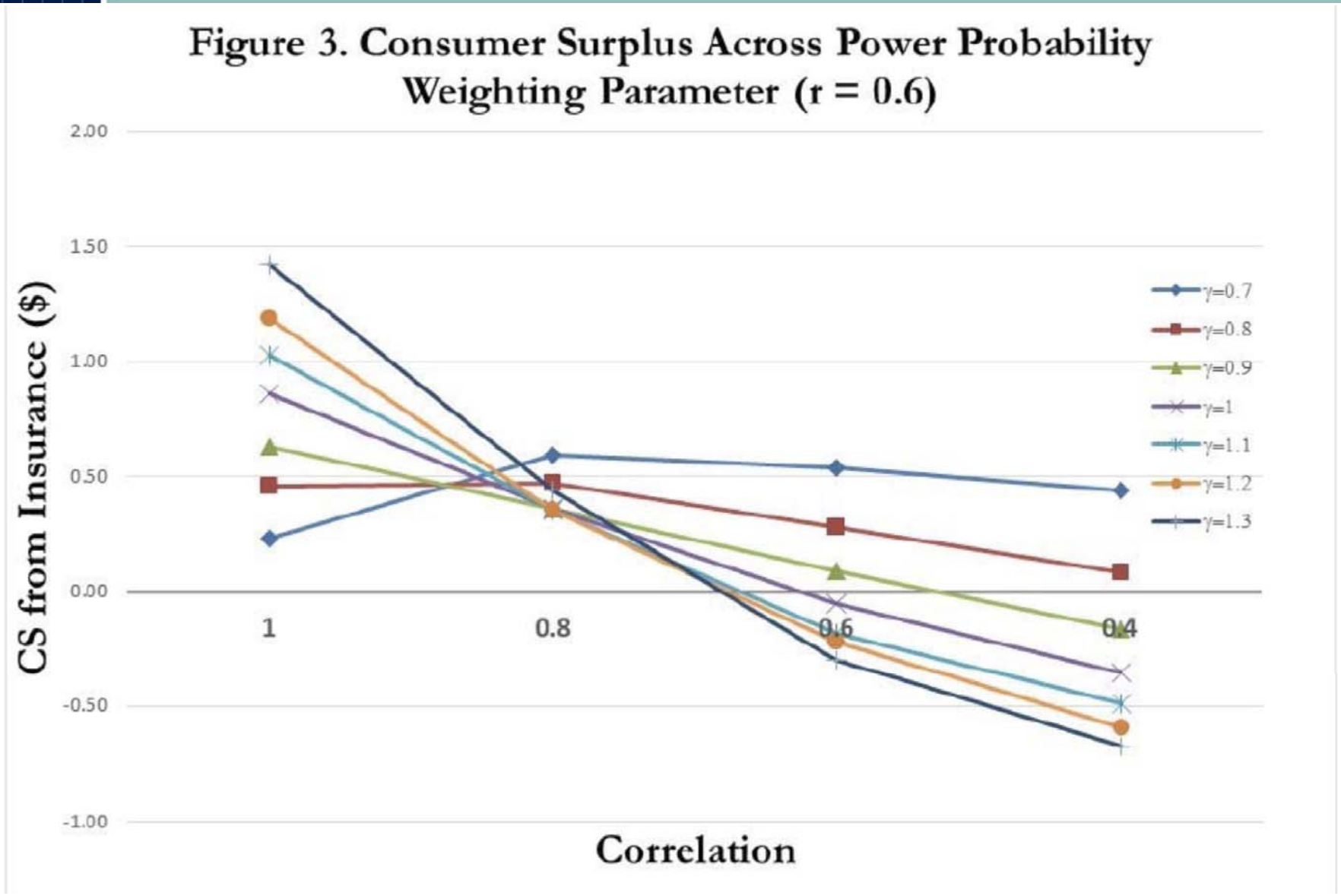
Index Insurance



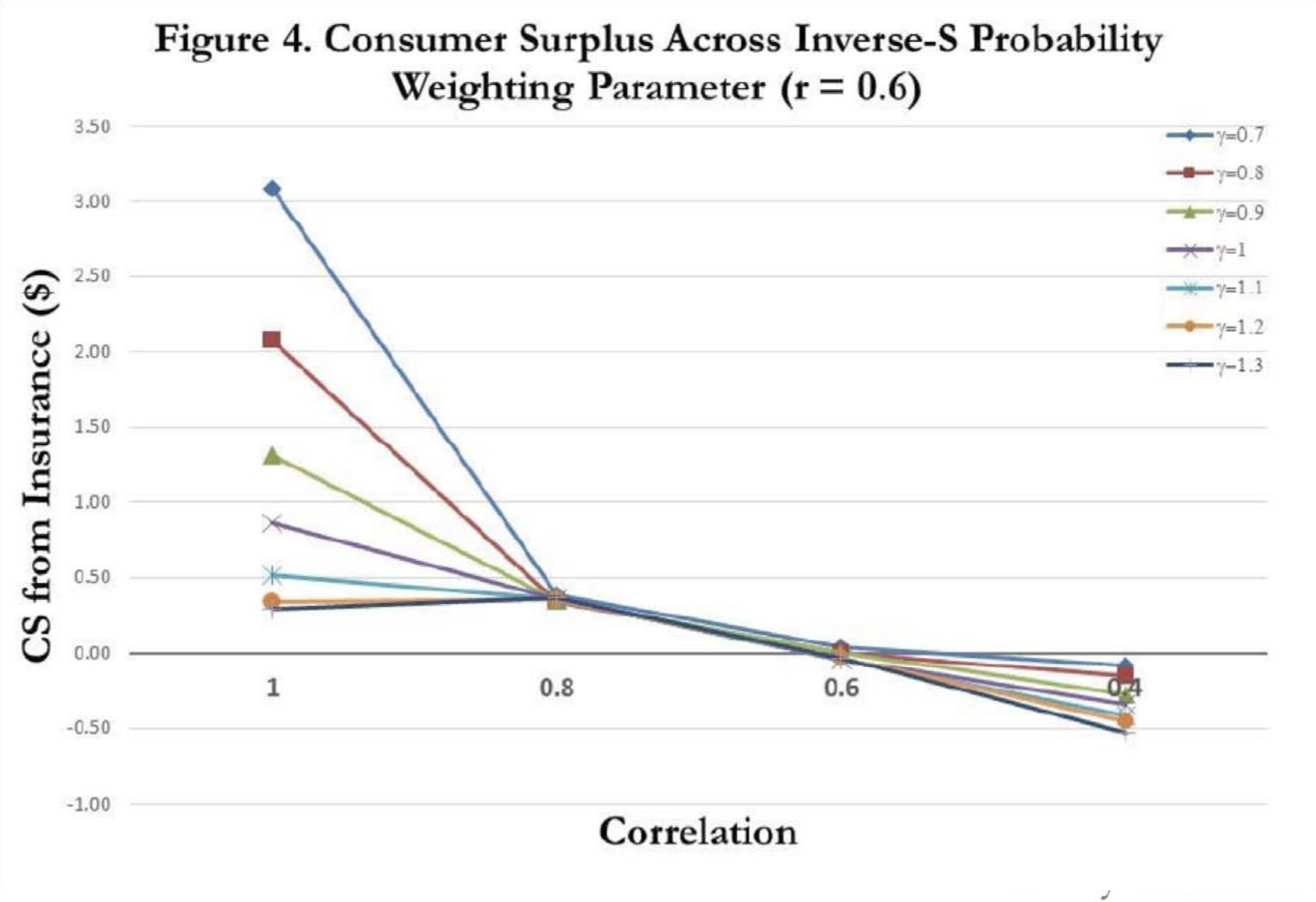
Consumer Surplus, I



Consumer Surplus, II



Consumer Surplus, III



Experiment

- Insurance task (32 choices)
  - Loss probability = 10% or 20%
  - Premium = $0.50, $1.20, $1.80, $3.50
  - Correlation = 100%, 80%, 60%, 40%

Choice	Correlation	Premium Amount ($)	Index Loss Probability	Initial Endowment ($)	Loss Amount ($)
1	1	0.5	0.1	20	15
2	0.8	0.5	0.1	20	15
3	0.6	0.5	0.1	20	15
4	0.4	0.5	0.1	20	15
5	1	1.2	0.1	20	15
6	0.8	1.2	0.1	20	15
7	0.6	1.2	0.1	20	15
8	0.4	1.2	0.1	20	15
9	1	1.8	0.1	20	15
10	0.8	1.8	0.1	20	15
11	0.6	1.8	0.1	20	15
12	0.4	1.8	0.1	20	15
13	1	3.5	0.1	20	15
14	0.8	3.5	0.1	20	15
15	0.6	3.5	0.1	20	15
16	0.4	3.5	0.1	20	15
17	1	0.5	0.2	20	15
18	0.8	0.5	0.2	20	15
19	0.6	0.5	0.2	20	15
20	0.4	0.5	0.2	20	15
21	1	1.2	0.2	20	15
22	0.8	1.2	0.2	20	15
23	0.6	1.2	0.2	20	15
24	0.4	1.2	0.2	20	15
25	1	1.8	0.2	20	15
26	0.8	1.8	0.2	20	15
27	0.6	1.8	0.2	20	15
28	0.4	1.8	0.2	20	15
29	1	3.5	0.2	20	15
30	0.8	3.5	0.2	20	15
31	0.6	3.5	0.2	20	15
32	0.4	3.5	0.2	20	15

Choice	Correlation	Premium Amount ($)	Index Loss Probability	Initial Endowment ($)	Loss Amount ($)
1	1	0.5	0.1	20	15
2	0.8	0.5	0.1	20	15
3	0.6	0.5	0.1	20	15
4	0.4	0.5	0.1	20	15
5	1	1.2	0.1	20	15
6	0.8	1.2	0.1	20	15
7	0.6	1.2	0.1	20	15
8	0.4	1.2	0.1	20	15
9	1	1.8	0.1	20	15
10	0.8	1.8	0.1	20	15
11	0.6	1.8	0.1	20	15
12	0.4	1.8	0.1	20	15
13	1	3.5	0.1	20	15
14	0.8	3.5	0.1	20	15
15	0.6	3.5	0.1	20	15
16	0.4	3.5	0.1	20	15
17	1	0.5	0.2	20	15
18	0.8	0.5	0.2	20	15
19	0.6	0.5	0.2	20	15
20	0.4	0.5	0.2	20	15
21	1	1.2	0.2	20	15
22	0.8	1.2	0.2	20	15
23	0.6	1.2	0.2	20	15
24	0.4	1.2	0.2	20	15
25	1	1.8	0.2	20	15
26	0.8	1.8	0.2	20	15
27	0.6	1.8	0.2	20	15
28	0.4	1.8	0.2	20	15
29	1	3.5	0.2	20	15
30	0.8	3.5	0.2	20	15
31	0.6	3.5	0.2	20	15
32	0.4	3.5	0.2	20	15

Choice	Correlation	Premium Amount ($)	Index Loss Probability	Initial Endowment ($)	Loss Amount ($)
1	1	0.5	0.1	20	15
2	0.8	0.5	0.1	20	15
3	0.6	0.5	0.1	20	15
4	0.4	0.5	0.1	20	15
5	1	1.2	0.1	20	15
6	0.8	1.2	0.1	20	15
7	0.6	1.2	0.1	20	15
8	0.4	1.2	0.1	20	15
9	1	1.8	0.1	20	15
10	0.8	1.8	0.1	20	15
11	0.6	1.8	0.1	20	15
12	0.4	1.8	0.1	20	15
13	1	3.5	0.1	20	15
14	0.8	3.5	0.1	20	15
15	0.6	3.5	0.1	20	15
16	0.4	3.5	0.1	20	15
17	1	0.5	0.2	20	15
18	0.8	0.5	0.2	20	15
19	0.6	0.5	0.2	20	15
20	0.4	0.5	0.2	20	15
21	1	1.2	0.2	20	15
22	0.8	1.2	0.2	20	15
23	0.6	1.2	0.2	20	15
24	0.4	1.2	0.2	20	15
25	1	1.8	0.2	20	15
26	0.8	1.8	0.2	20	15
27	0.6	1.8	0.2	20	15
28	0.4	1.8	0.2	20	15
29	1	3.5	0.2	20	15
30	0.8	3.5	0.2	20	15
31	0.6	3.5	0.2	20	15
32	0.4	3.5	0.2	20	15

Choice	Correlation	Premium Amount ($)	Index Loss Probability	Initial Endowment ($)	Loss Amount ($)
1	1	0.5	0.1	20	15
2	0.8	0.5	0.1	20	15
3	0.6	0.5	0.1	20	15
4	0.4	0.5	0.1	20	15
5	1	1.2	0.1	20	15
6	0.8	1.2	0.1	20	15
7	0.6	1.2	0.1	20	15
8	0.4	1.2	0.1	20	15
9	1	1.8	0.1	20	15
10	0.8	1.8	0.1	20	15
11	0.6	1.8	0.1	20	15
12	0.4	1.8	0.1	20	15
13	1	3.5	0.1	20	15
14	0.8	3.5	0.1	20	15
15	0.6	3.5	0.1	20	15
16	0.4	3.5	0.1	20	15
17	1	0.5	0.2	20	15
18	0.8	0.5	0.2	20	15
19	0.6	0.5	0.2	20	15
20	0.4	0.5	0.2	20	15
21	1	1.2	0.2	20	15
22	0.8	1.2	0.2	20	15
23	0.6	1.2	0.2	20	15
24	0.4	1.2	0.2	20	15
25	1	1.8	0.2	20	15
26	0.8	1.8	0.2	20	15
27	0.6	1.8	0.2	20	15
28	0.4	1.8	0.2	20	15
29	1	3.5	0.2	20	15
30	0.8	3.5	0.2	20	15
31	0.6	3.5	0.2	20	15
32	0.4	3.5	0.2	20	15

Choice	Correlation	Premium Amount ($)	Index Loss Probability	Initial Endowment ($)	Loss Amount ($)
1	1	0.5	0.1	20	15
2	0.8	0.5	0.1	20	15
3	0.6	0.5	0.1	20	15
4	0.4	0.5	0.1	20	15
5	1	1.2	0.1	20	15
6	0.8	1.2	0.1	20	15
7	0.6	1.2	0.1	20	15
8	0.4	1.2	0.1	20	15
9	1	1.8	0.1	20	15
10	0.8	1.8	0.1	20	15
11	0.6	1.8	0.1	20	15
12	0.4	1.8	0.1	20	15
13	1	3.5	0.1	20	15
14	0.8	3.5	0.1	20	15
15	0.6	3.5	0.1	20	15
16	0.4	3.5	0.1	20	15
17	1	0.5	0.2	20	15
18	0.8	0.5	0.2	20	15
19	0.6	0.5	0.2	20	15
20	0.4	0.5	0.2	20	15
21	1	1.2	0.2	20	15
22	0.8	1.2	0.2	20	15
23	0.6	1.2	0.2	20	15
24	0.4	1.2	0.2	20	15
25	1	1.8	0.2	20	15
26	0.8	1.8	0.2	20	15
27	0.6	1.8	0.2	20	15
28	0.4	1.8	0.2	20	15
29	1	3.5	0.2	20	15
30	0.8	3.5	0.2	20	15
31	0.6	3.5	0.2	20	15
32	0.4	3.5	0.2	20	15

Experiment

- Insurance task (32 choices)
  - Loss probability = 10% or 20%
  - Premium = $0.50, $1.20, $1.80, $3.50
  - Correlation = 100%, 80%, 60%, 40%
- Insurance contracts
  - Index Insurance contract (II)
  - Actuarially Equivalent simple contract (AE)
  - Index Insurance contract with a Contextual Clue (II-CC)

II treatment (55 subjects)

Your initial stakes are **$20.00**.

You may **lose $15** or **not lose any money**, depending on the outcome of your **PERSONAL** event.

You have the option to purchase insurance, which will only compensate for the $15 loss if the outcome of the **INDEX** is **BAD**.

This insurance will cost you **$1.80**

INDEX Probability

10% BAD

90% GOOD

PERSONAL Probability

80% SAME

20% DIFFERS

Possible Outcomes **WITHOUT Insurance**

Index is **BAD** and Personal **MATCHES**: **$5**

Index is **BAD** and Personal **DIFFERS**: **$20**

Index is **GOOD** and Personal **MATCHES**: **$20**

Index is **GOOD** and Personal **DIFFERS**: **$5**

DO NOT BUY INSURANCE

Possible Outcomes **WITH Insurance**

Index is **BAD** and Personal **MATCHES**: **$18.20**

Index is **BAD** and Personal **DIFFERS**: **$33.20**

Index is **GOOD** and Personal **MATCHES**: **$18.20**

Index is **GOOD** and Personal **DIFFERS**: **$3.20**

BUY INSURANCE

Georgia State University | CEAR CENTER FOR THE ECONOMIC ANALYSIS OF RISK

AE treatment (57 subjects)

Your initial stakes are **$20.00**.

You may **lose $15** or **not lose any money**, depending on the outcome of your **PERSONAL** event.

INDEX: 10% BAD, 90% GOOD

PERSONAL: 80% SAME, 20% DIFFERS

You have the option to purchase insurance, which will only compensate for the $15 loss if the outcome of the **INDEX** is BAD.

This insurance will cost you **$1.80**.

Without Insurance

26% chance you keep **$5.00**

74% chance you keep **$20.00**

DO NOT BUY INSURANCE

With Insurance

18% chance you keep **$3.20**

80% chance you keep **$18.20**

2% chance you keep **$33.20**

BUY INSURANCE

Georgia State University | CEAR CENTER FOR THE ECONOMIC ANALYSIS OF RISK

Contextual Clue treatment (33 subjects)

Information on Real-World Counterpart

This task is based on a real-world insurance product known as index insurance, widely used for farmers who grow crops in poor countries.

Index insurance is insurance that is linked to an index such as rainfall, temperature, humidity or crop yields, rather than an actual loss. An example of index insurance is the use of an index of rainfall totals to insure against drought-related crop loss. Payouts occur when rainfall totals over some time period fall below some pre-agreed threshold that can be expected to result in crop loss in a geographic area.

One advantage of using the index is that, unlike traditional crop insurance, the insurance company does not need to visit farmers' fields to assess losses and determine payouts. That is expensive to do, and means that traditional premiums would have to be too high for most farmers to afford. Instead, index insurance uses data from rain gauges near the farmer's field. If these data show the rainfall amount is below the threshold, the insurance pays out; if the data show the rainfall amount exceeds the threshold, the insurance does not pay out. All the insurance company has to do, to figure out if it should pay out, is check the rain gauge. This reduces the cost of providing insurance to these farmers.

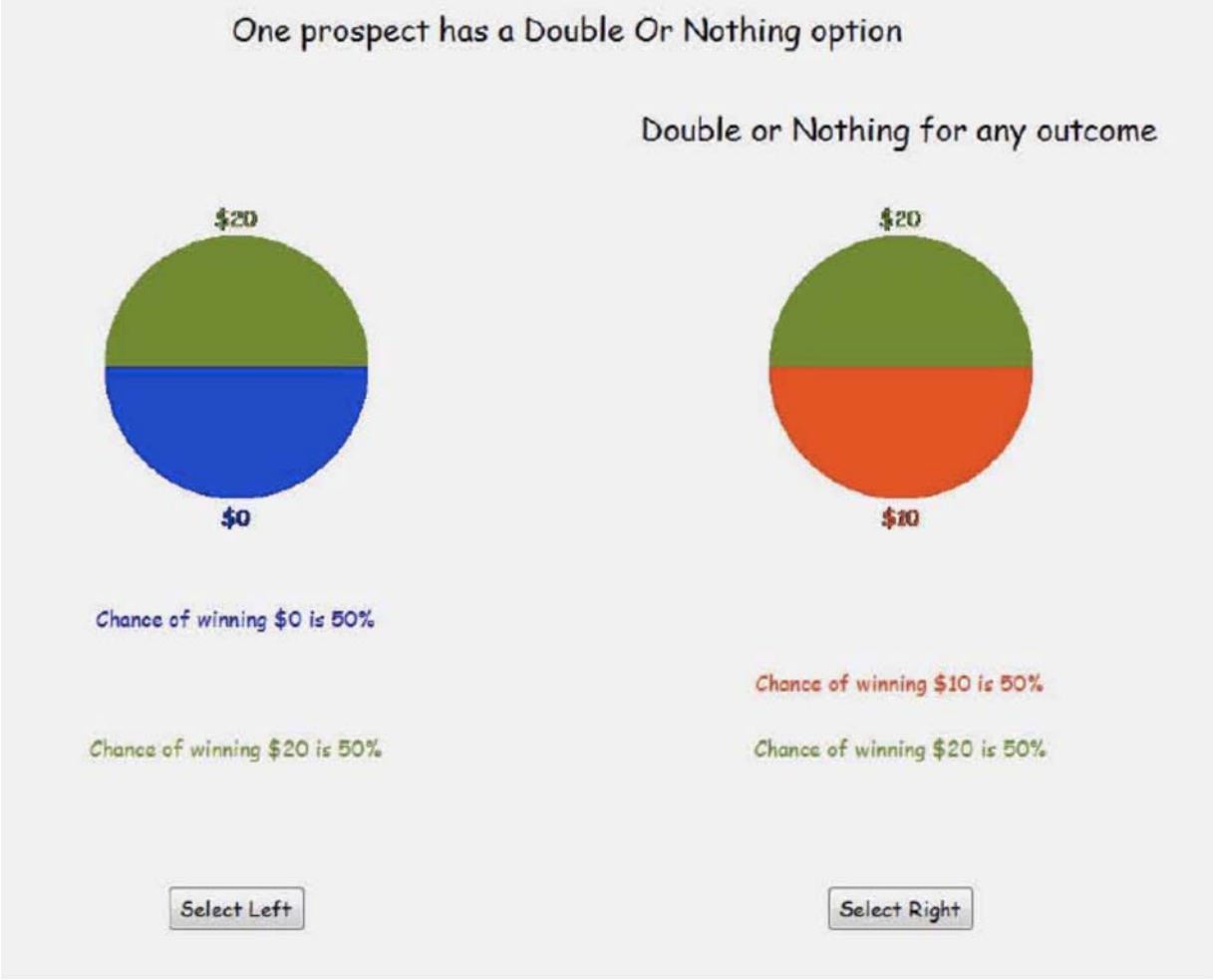
Experiment

- Insurance task (32 choices)
  - Loss probability = 10% or 20%
  - Premium = $0.50, $1.20, $1.80, $3.50
  - Correlation = 100%, 80%, 60%, 40%
- Insurance contracts
  - Index Insurance contract
  - Actuarially Equivalent simple contract
  - Index Insurance contract with a Contextual Clue
- Risk preferences (76 choices)
  - Test for IA of EUT (30 choices)
  - Test for ROCL (30 choices)
  - “Naked AE” (16 choices)

Generic interface for risk choice

Georgia State University | CEAR CENTER FOR THE ECONOMIC ANALYSIS OF RISK

Interface for test of ROCL



Georgia State University | CEAR CENTER FOR THE ECONOMIC ANALYSIS OF RISK

Tests for ROCL

- 30 lottery pairs
  - 15 were Simple – Compound Choices
  - 15 were paired Simple – AE Simple

Journal of Economic Behavior & Organization 119 (2015) 32–55

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

Reduction of compound lotteries with objective probabilities: Theory and evidence☆

Glenn W. Harrison[a,d], Jimmy Martínez-Correa[b,*], J. Todd Swarthout[c]

Estimating risk preferences, I

- Estimate for each subject, and then "type" the subject
- Assuming ROCL
  - EUT
  - Rank Dependent Utility – relaxes the CIA
- Relaxing ROCL
  - Source-dependent EUT
    - Allows for different r in compound lotteries and simple lotteries
  - Recursive RDU
    - Replace second stage with RDU CE, then evaluate RDU of the first stage using these CE
    - Using the CE for the second stage "throws away" the probabilities need to apply ROCL overall

Estimating risk preferences, II

- Or one could assume uncertainty aversion with respect to the compound risks
  - An aversion to the variability of known states of the world
  - The KMM model relaxes ROCL *across* these states

Journal of Economic Behavior & Organization 118 (2015) 150–166

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

Compound-risk aversion, ambiguity and the willingness to pay for microinsurance☆

Ghada Elabed[a,*], Michael R. Carter[b,c]

Estimating risk preferences, II

$$qv[pu(y_g - \tau)] + (1-p)u(y_b - \tau + \pi)] + (1-q)v[pu(y_g - \tau) + (1-p)u(y_b - \tau)],$$

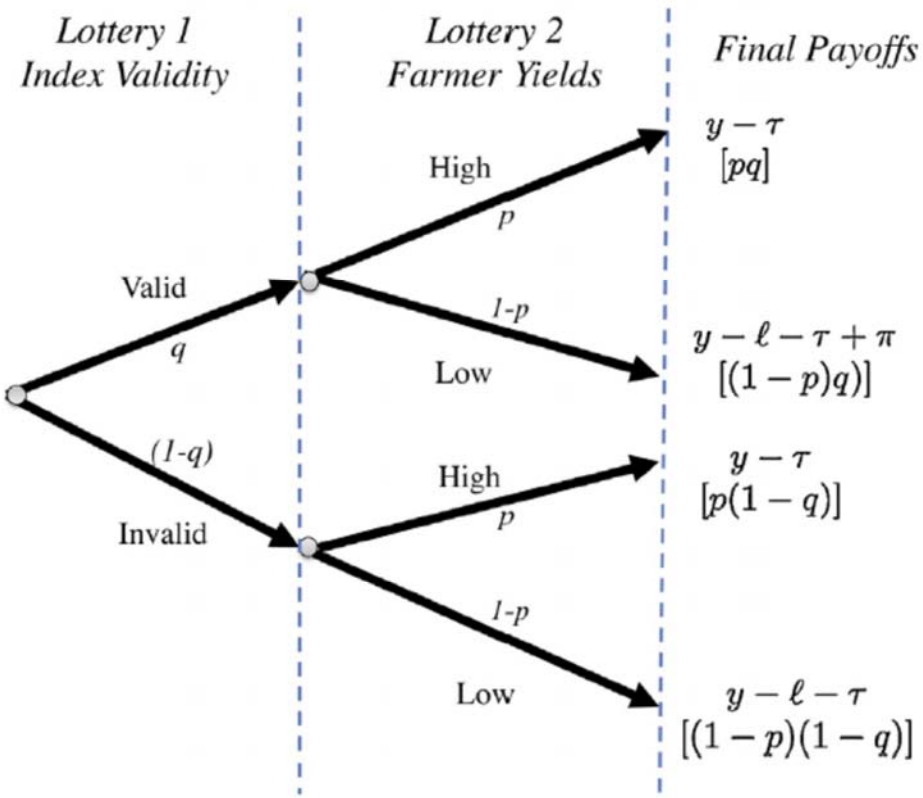


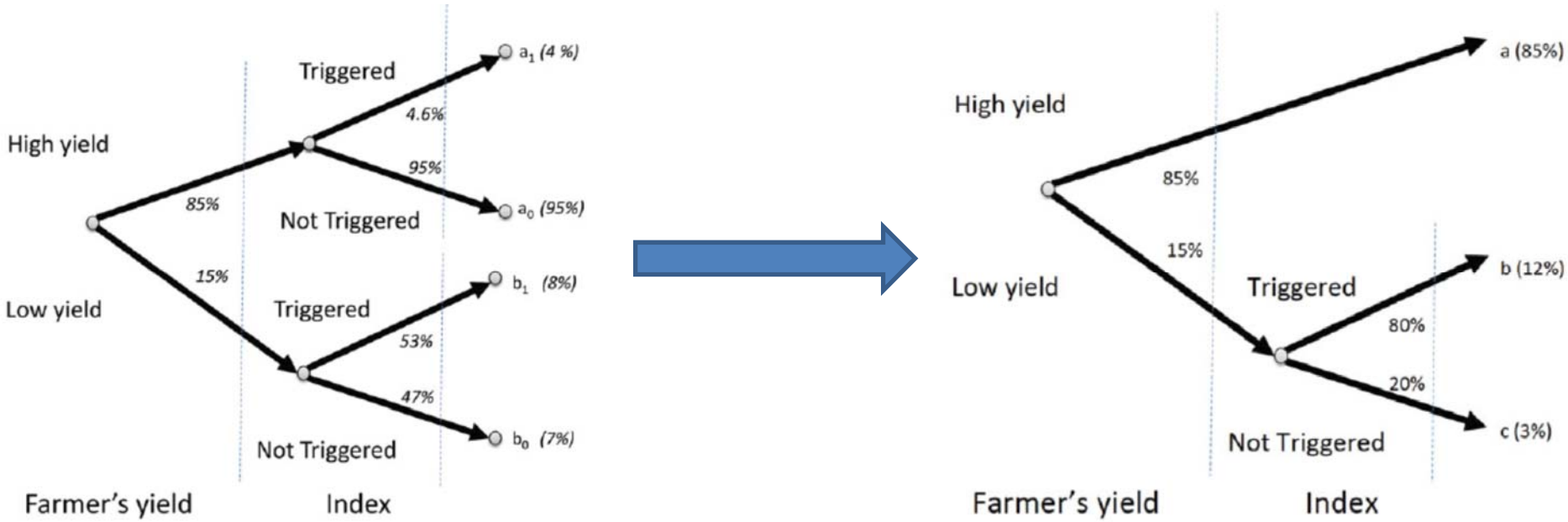
Fig. 1. Index insurance as a compound lottery.

- u″ < 0 measures simple risk aversion
- v″ < 0 measures compound risk aversion
- v″ = 0 is ROCL

Georgia State University | CEAR CENTER FOR THE ECONOMIC ANALYSIS OF RISK

Estimating risk preferences, II

- Evidence of compound risk aversion for downside basis risk, akin to non-performance risk
- Evidence from calibrations of choices
  - One implies a CRRA interval for simple risks
  - Another implies a CRUA interval for compound risks



Risk preferences assuming ROCL

Figure 8: Classifying Subjects as EUT or RDU

N=145, one *p*-value per individual

Estimates for each individual of EUT and RDU specifications

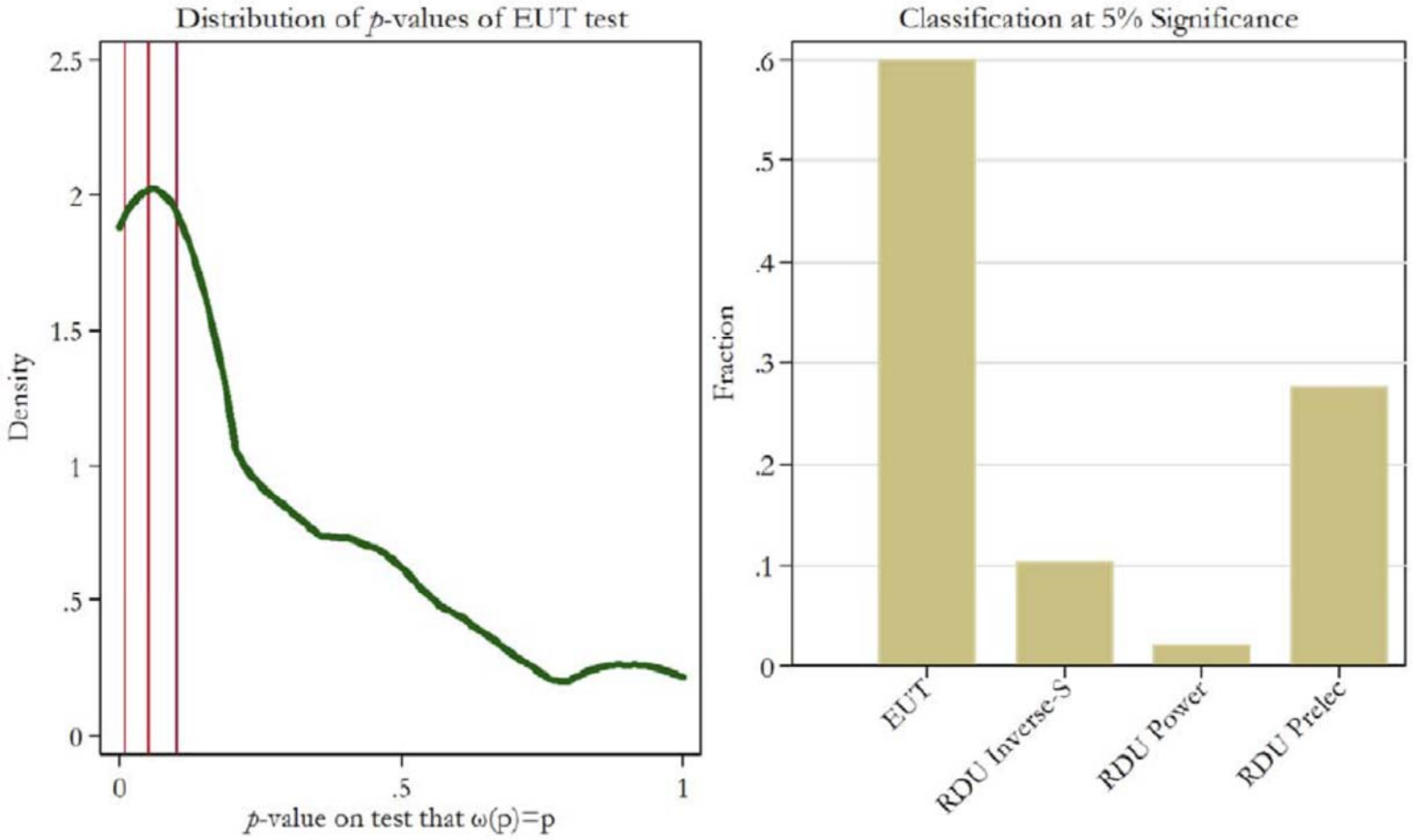


Figure 9: Estimated Risk Parameters for Subject #2

Subject #2 is classifed RDU with EUT p-value = 0.000 (< 0.05)

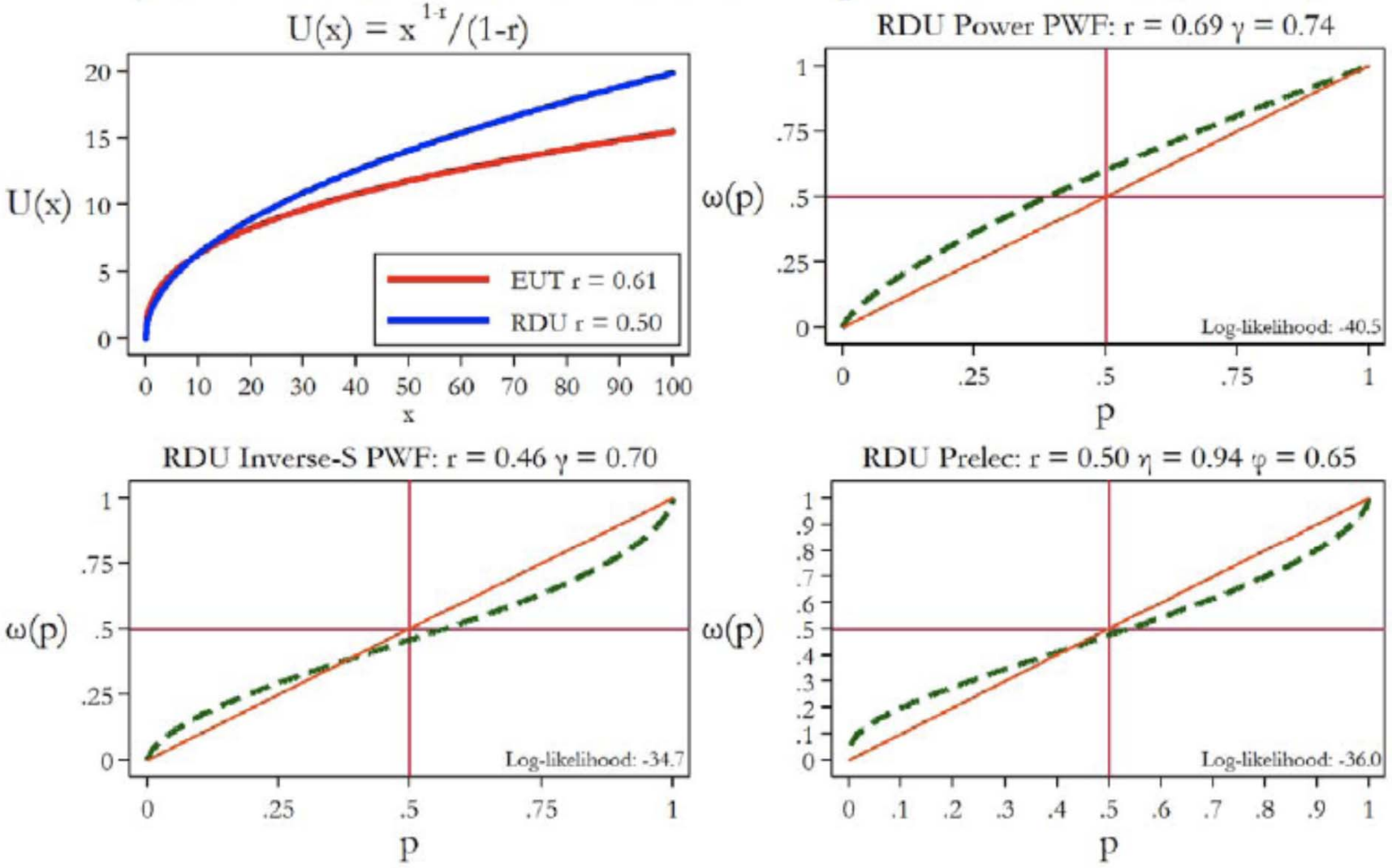


Figure 10: Consumer Surplus of Choices of Subject #2

Expected Utility Theory Risk Preferences

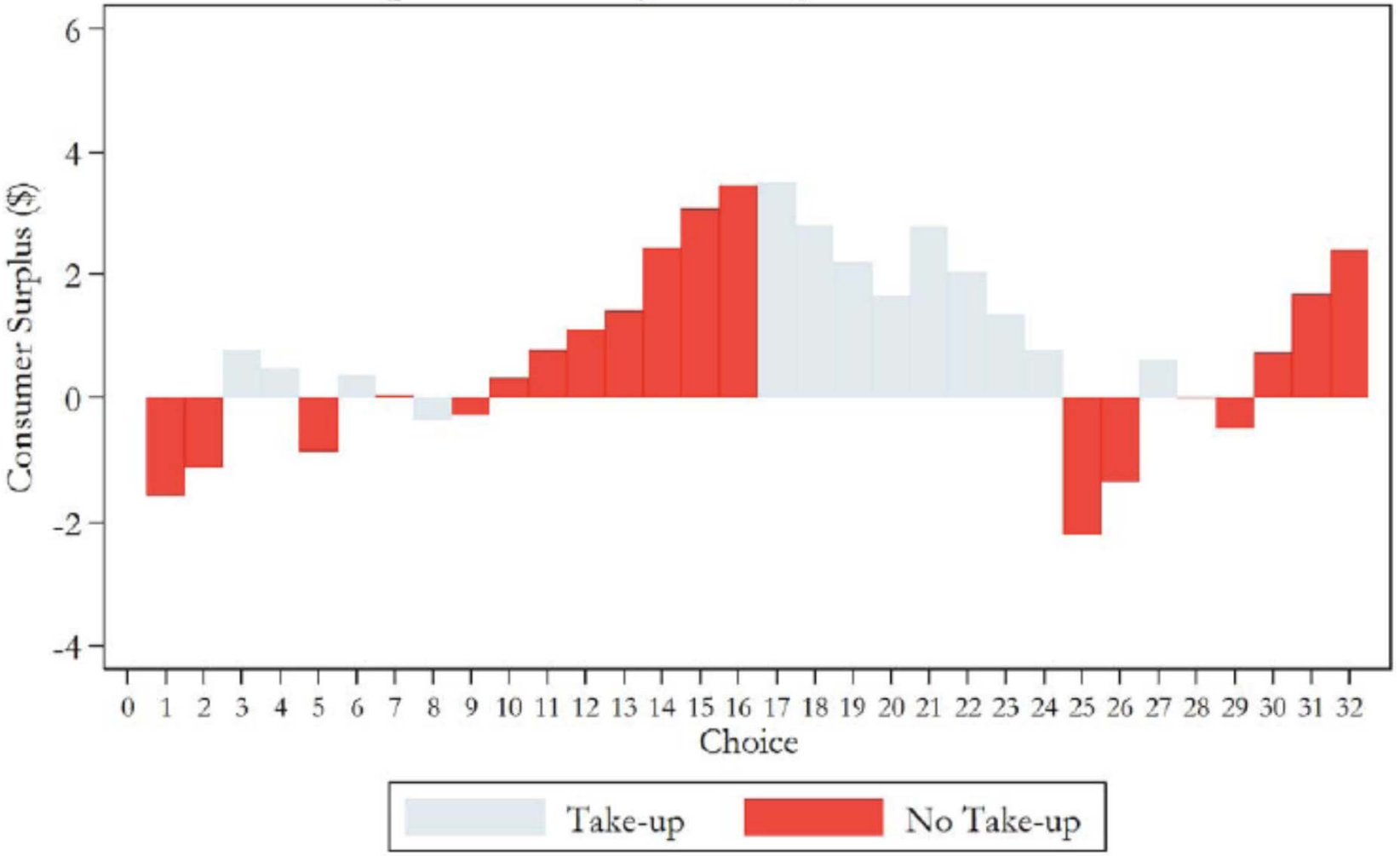


Figure 11: Consumer Surplus of Choices of Subject #2

Rank Dependent Utility (Inverse-S) Risk Preferences

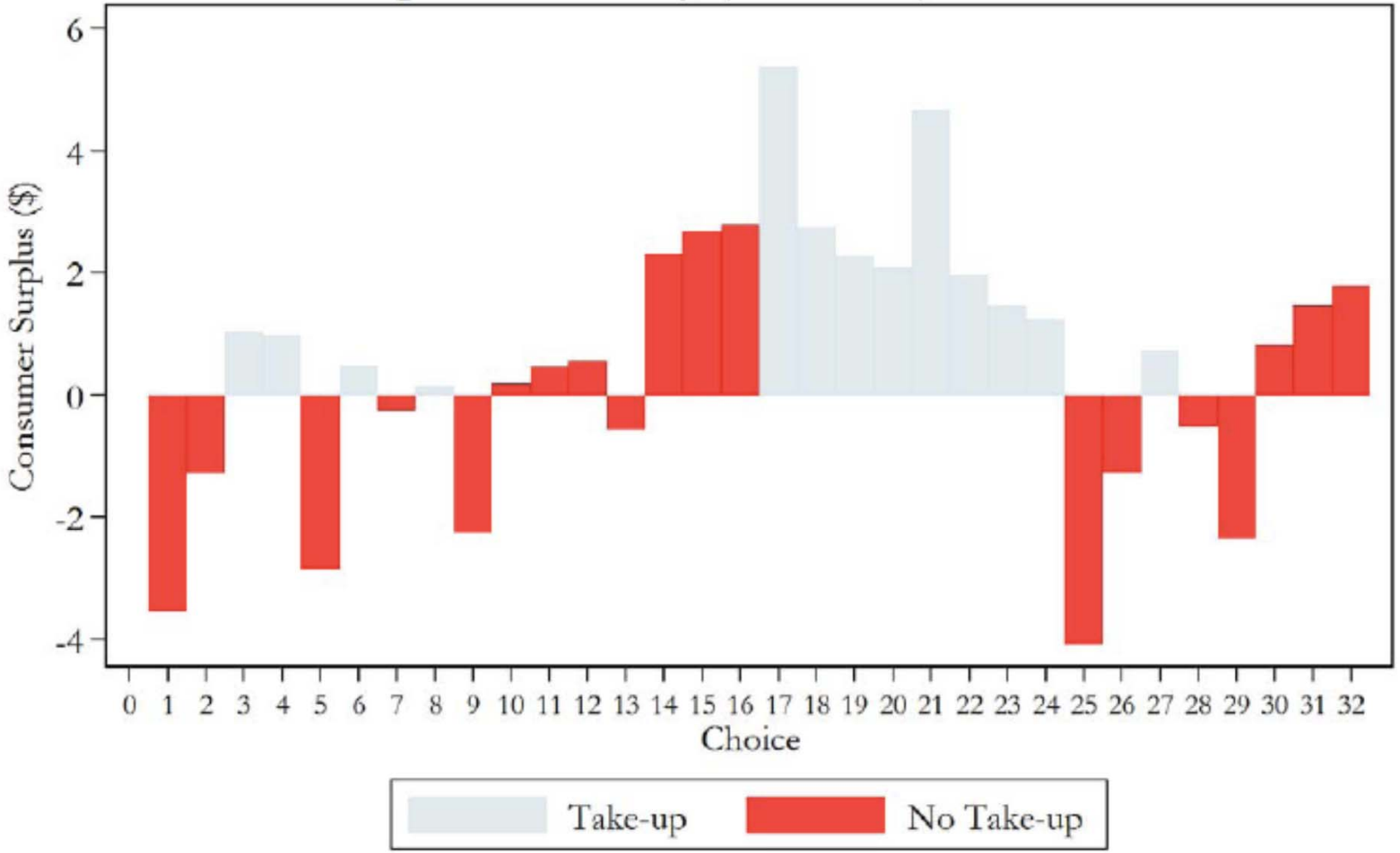


Figure 10: Consumer Surplus of Choices of Subject #2

Expected Utility Theory Risk Preferences

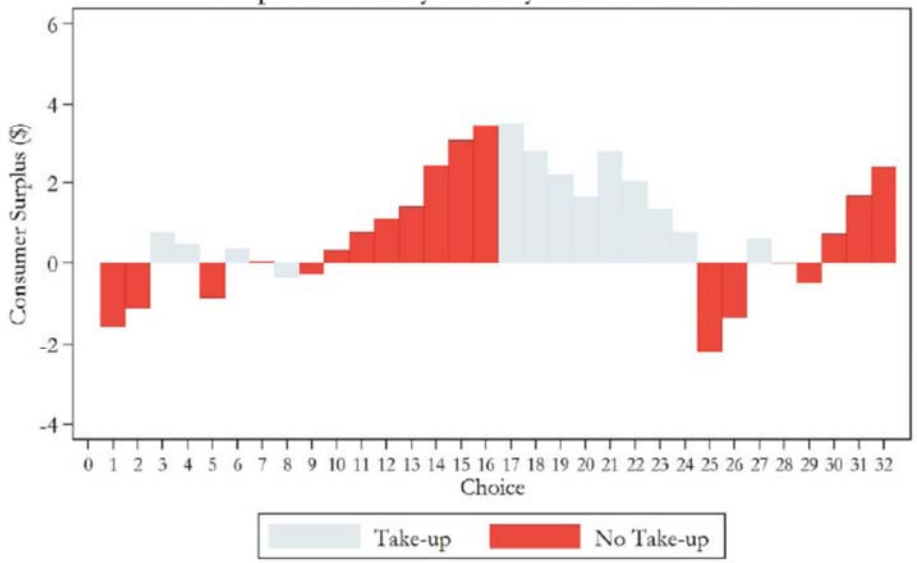


Figure 11: Consumer Surplus of Choices of Subject #2

Rank Dependent Utility (Inverse-S) Risk Preferences

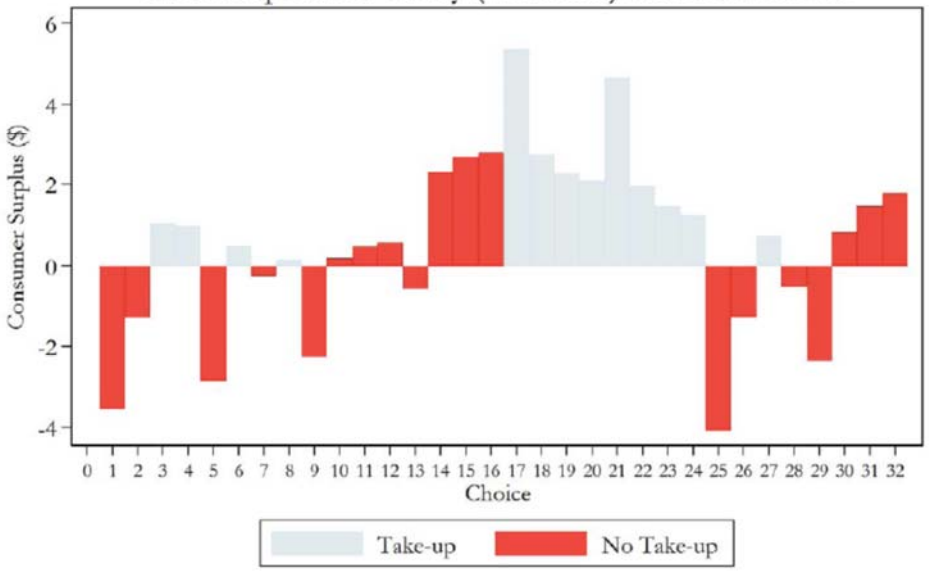


Figure 12: Proportion of Actual Take-Up to Predicted Choices

Fisher Exact Test 2-sided p-value < 0.001

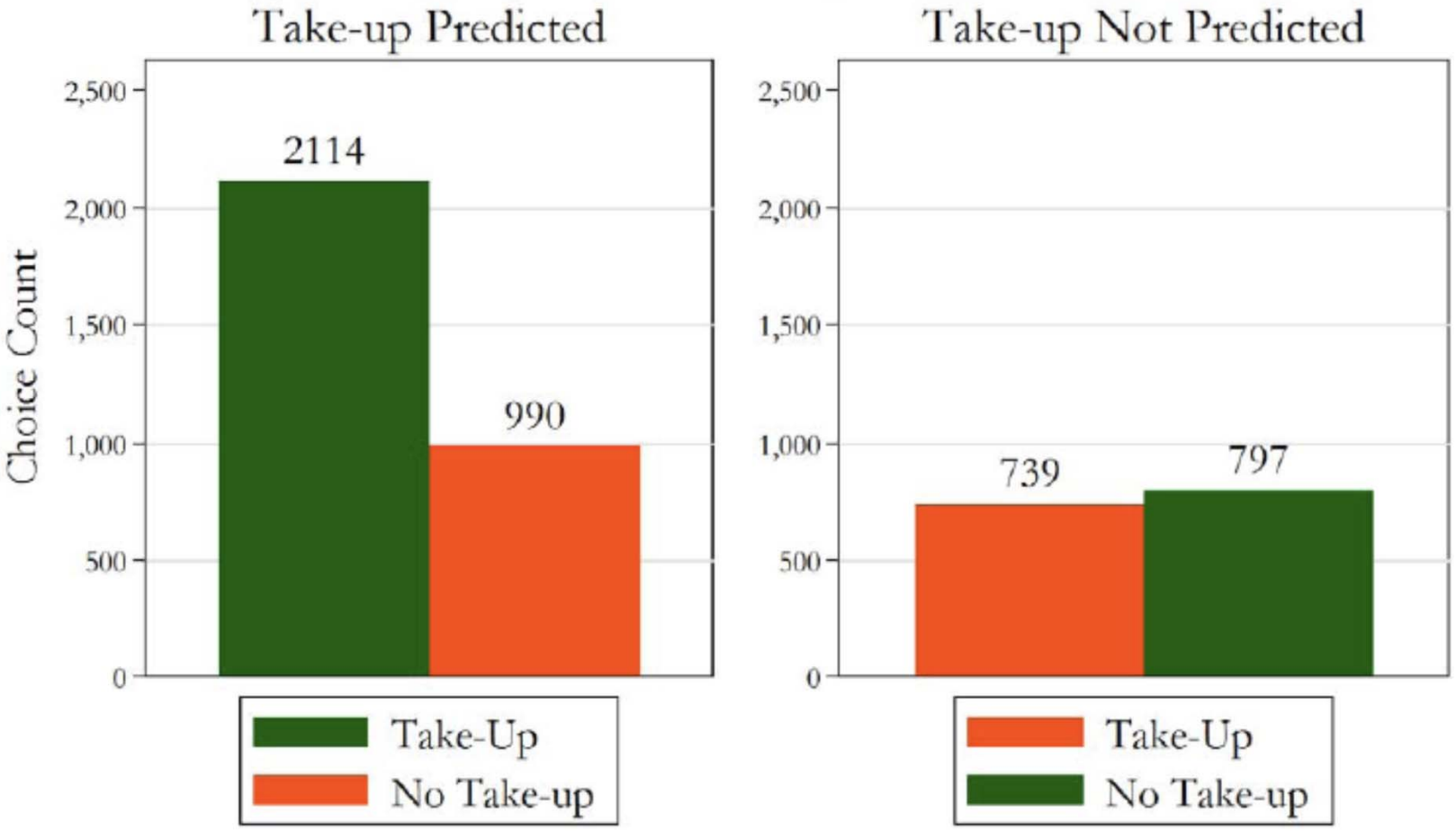


Figure 13: Comparison of Consumer Surplus Distribution for II and AE Treatments

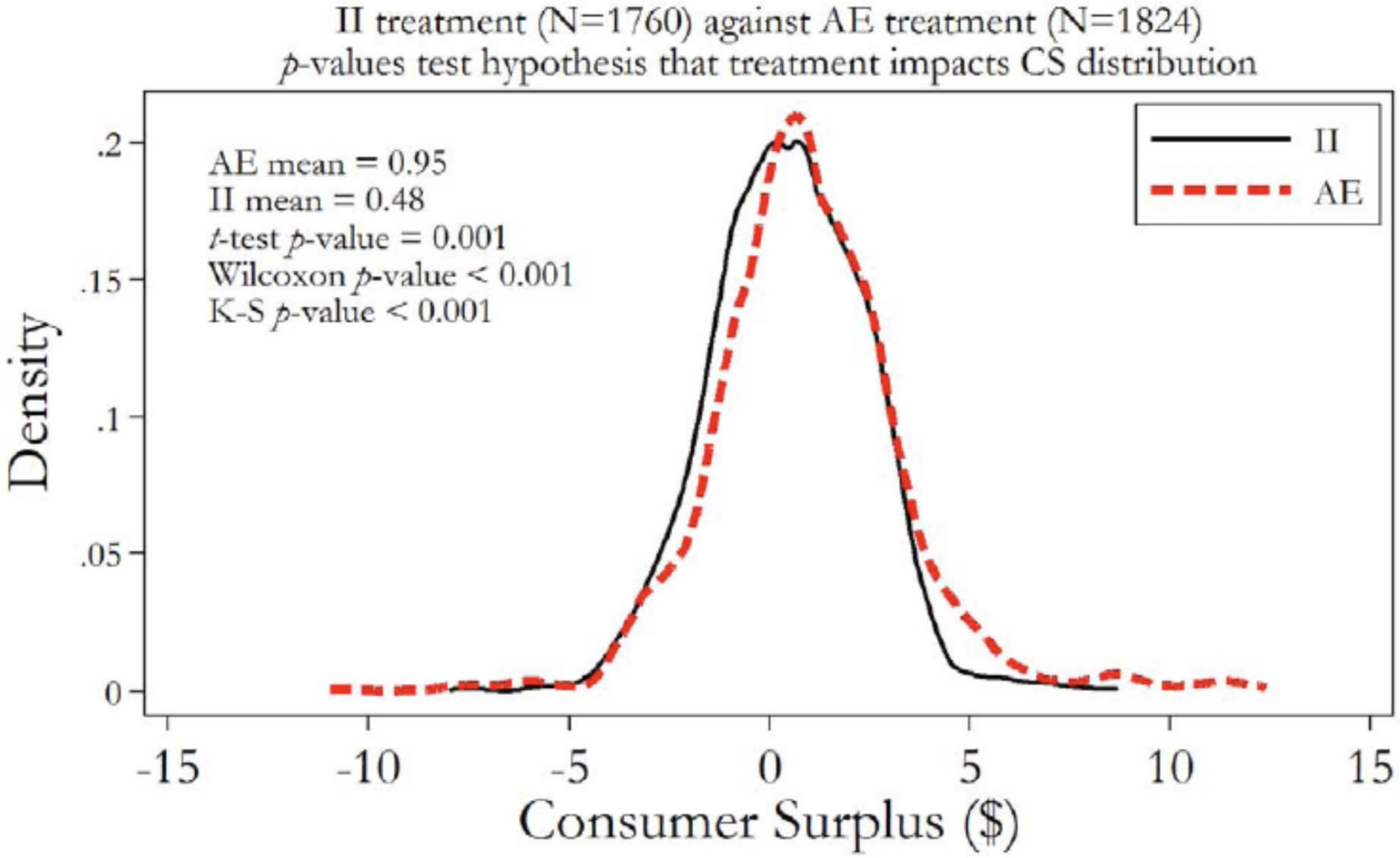


Figure 14: Comparison of Efficiency Distribution for II and AE Treatments

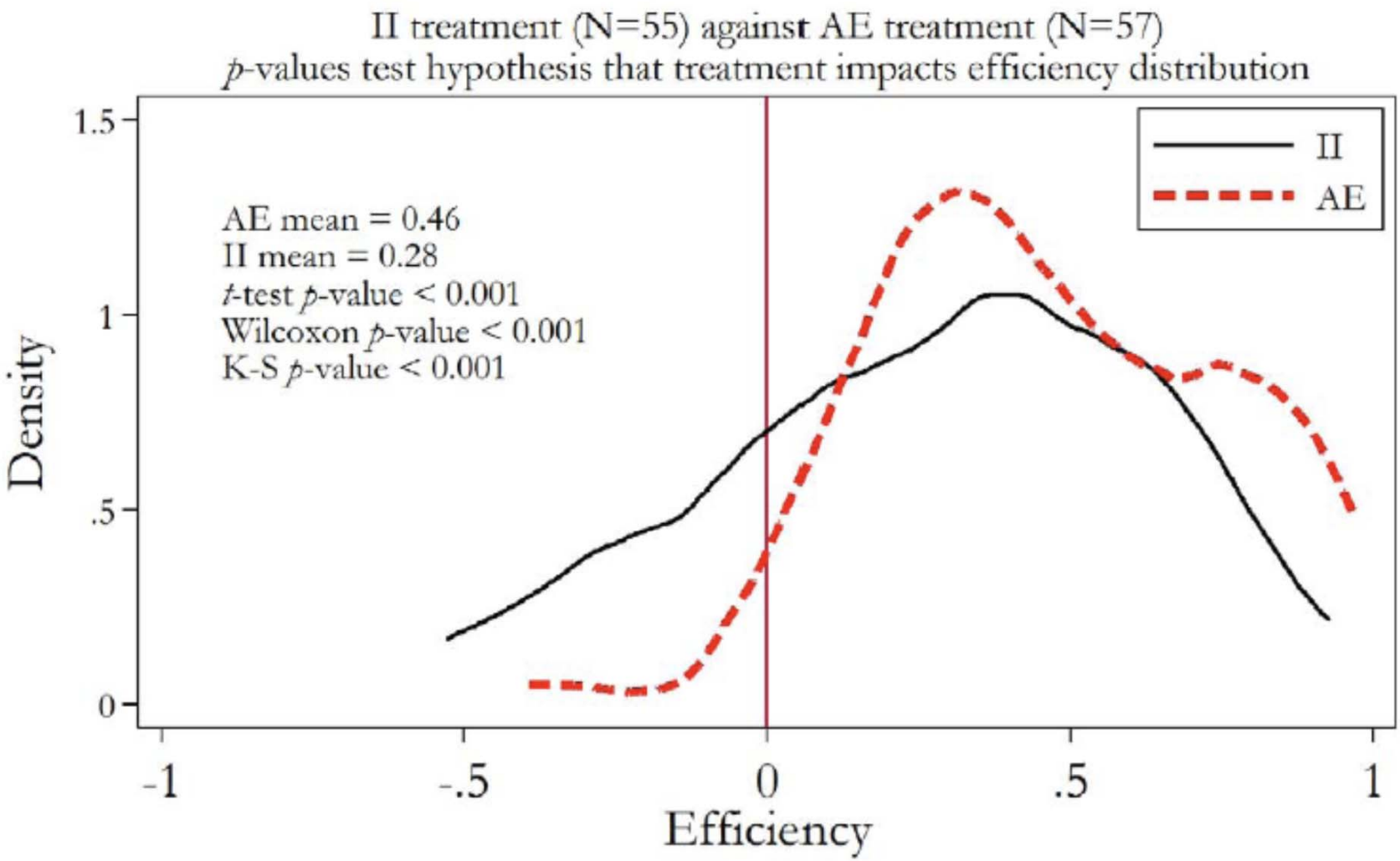


Figure 16: Comparison of Efficiency Distribution for II and II-CC Treatments

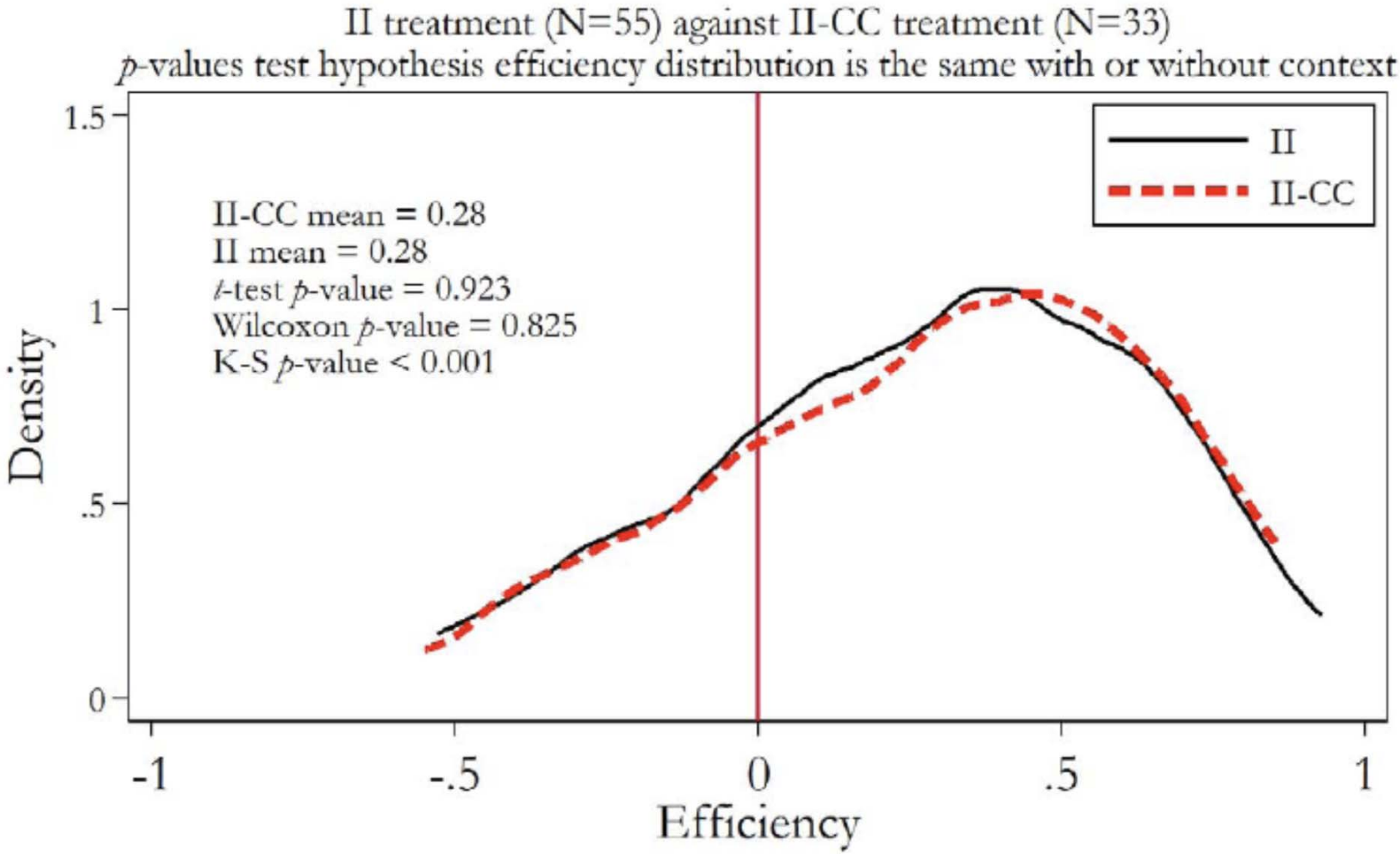


Figure 17: Classifying Subjects as Source-Dependent EUT or Recursive RDU Without Assuming ROCL

N=145, one *p*-value per individual
Estimates for each individual of EUT and RDU specifications
Classification at 5% Significance

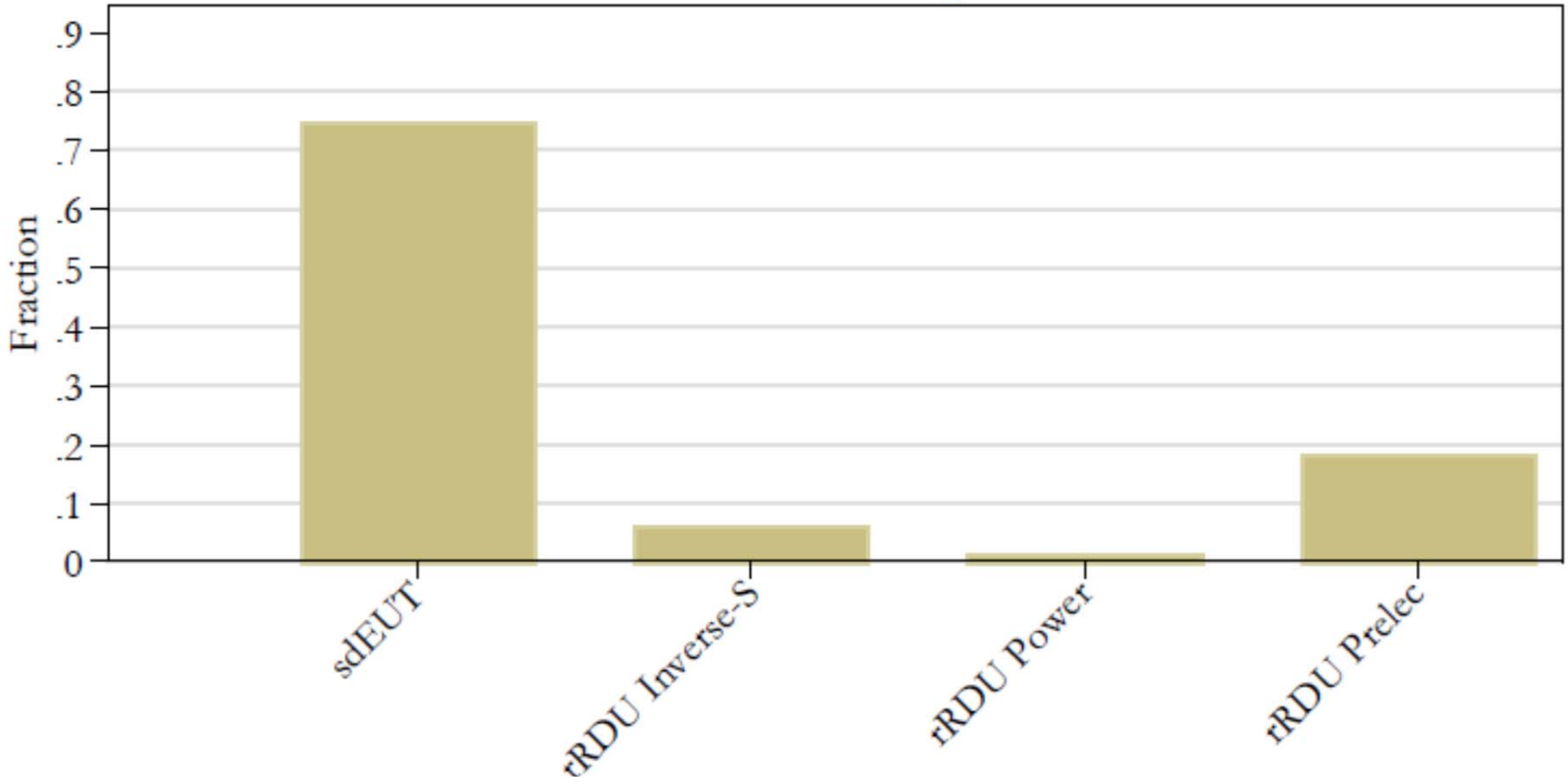


Figure 18: Tests of Source-Independence of EUT

Distribution of *p*-values of test of H_o: $r^{simple} = r^{compound}$
N=145, one *p*-value per individual
8.3%, 15.9% and 29.7% below *p*-values of 0.01, 0.05 and 0.1, respectively

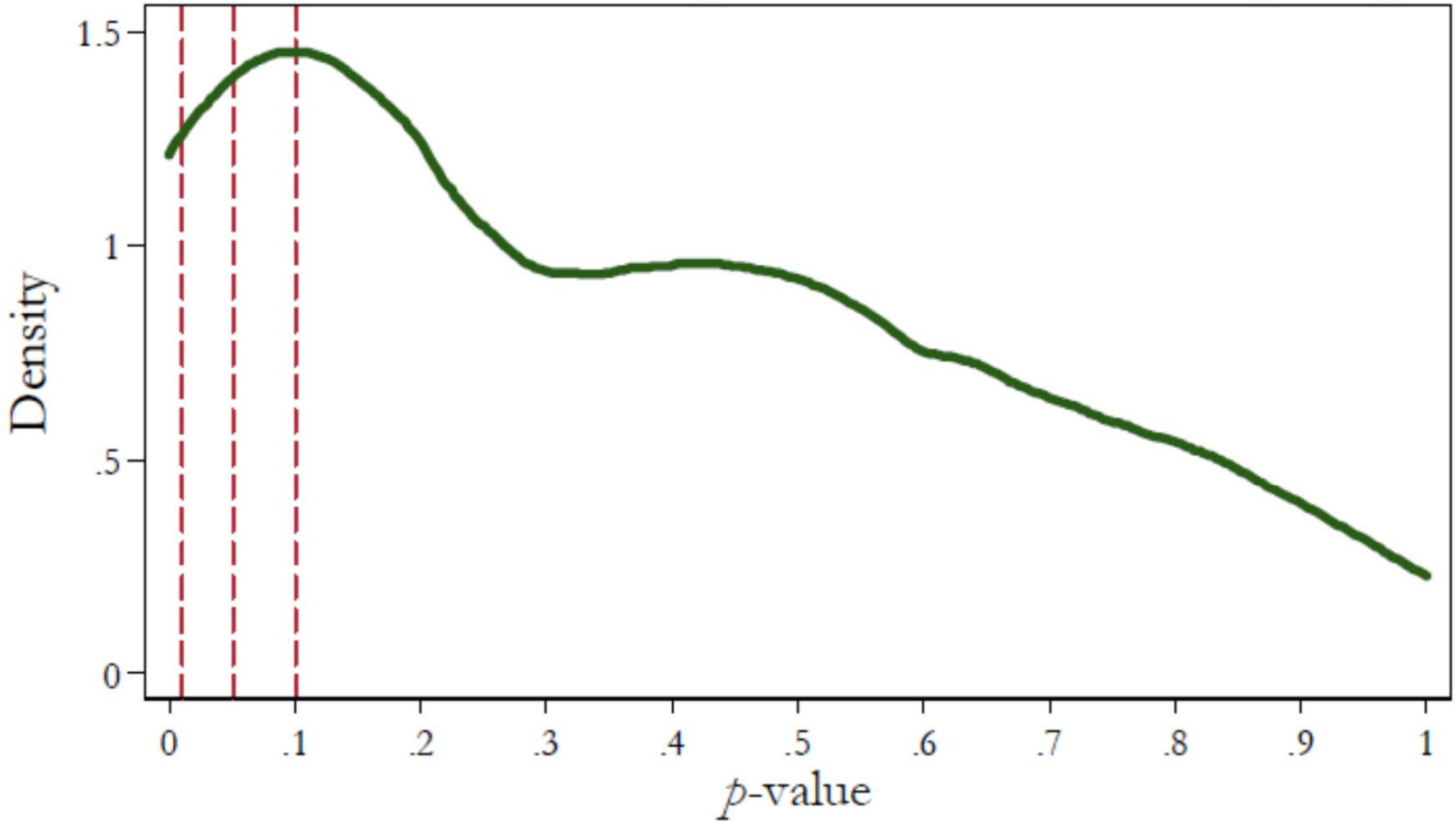


Figure 18: Tests of Source-Independence of EUT

Distribution of *p*-values of test of H_o: $r^{simple} = r^{compound}$
N=145, one *p*-value per individual
8.3%, 15.9% and 29.7% below *p*-values of 0.01, 0.05 and 0.1, respectively

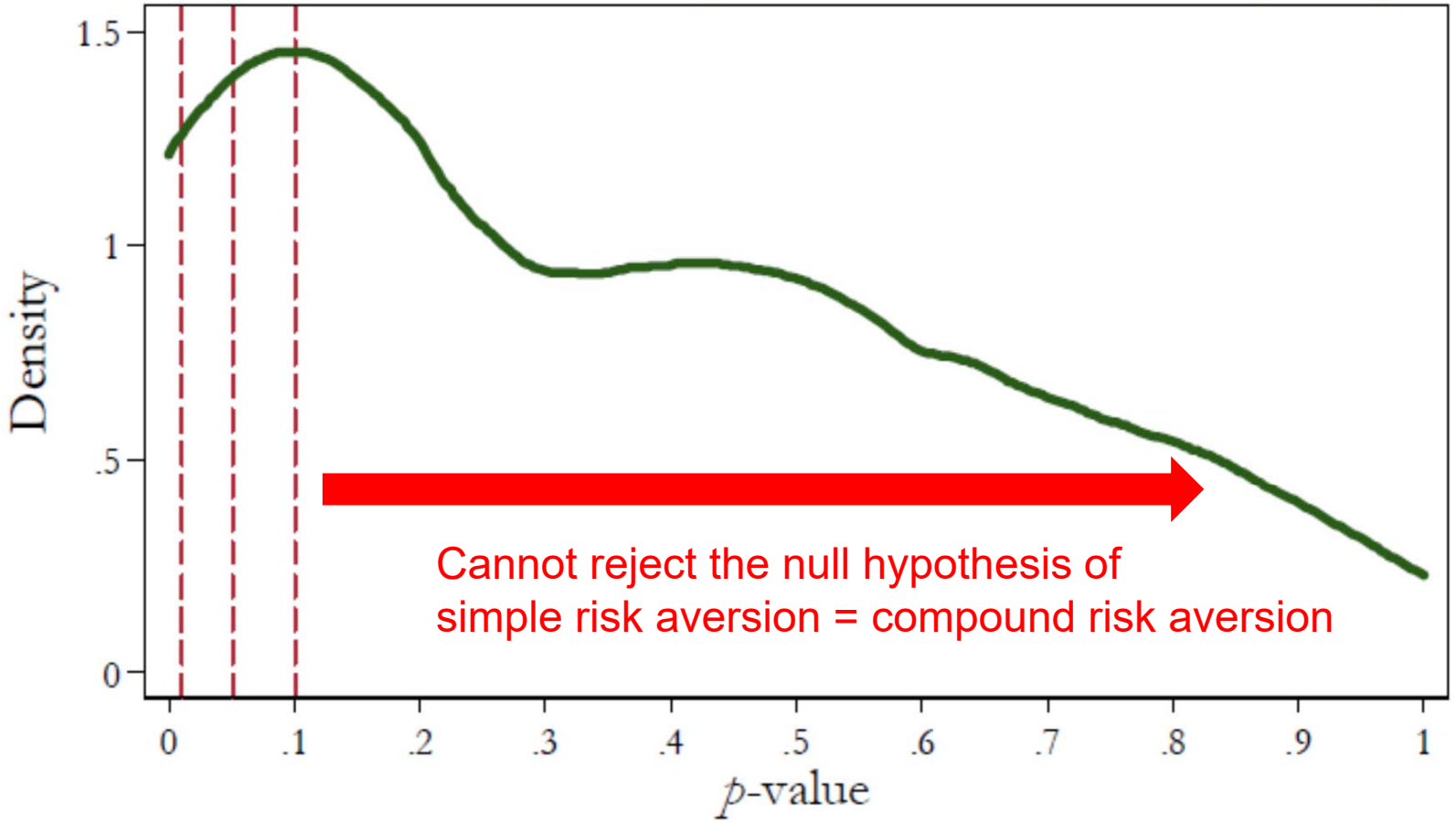


Figure 21: Comparison of Efficiency Distribution for II and AE Treatments, Without Assuming ROCL

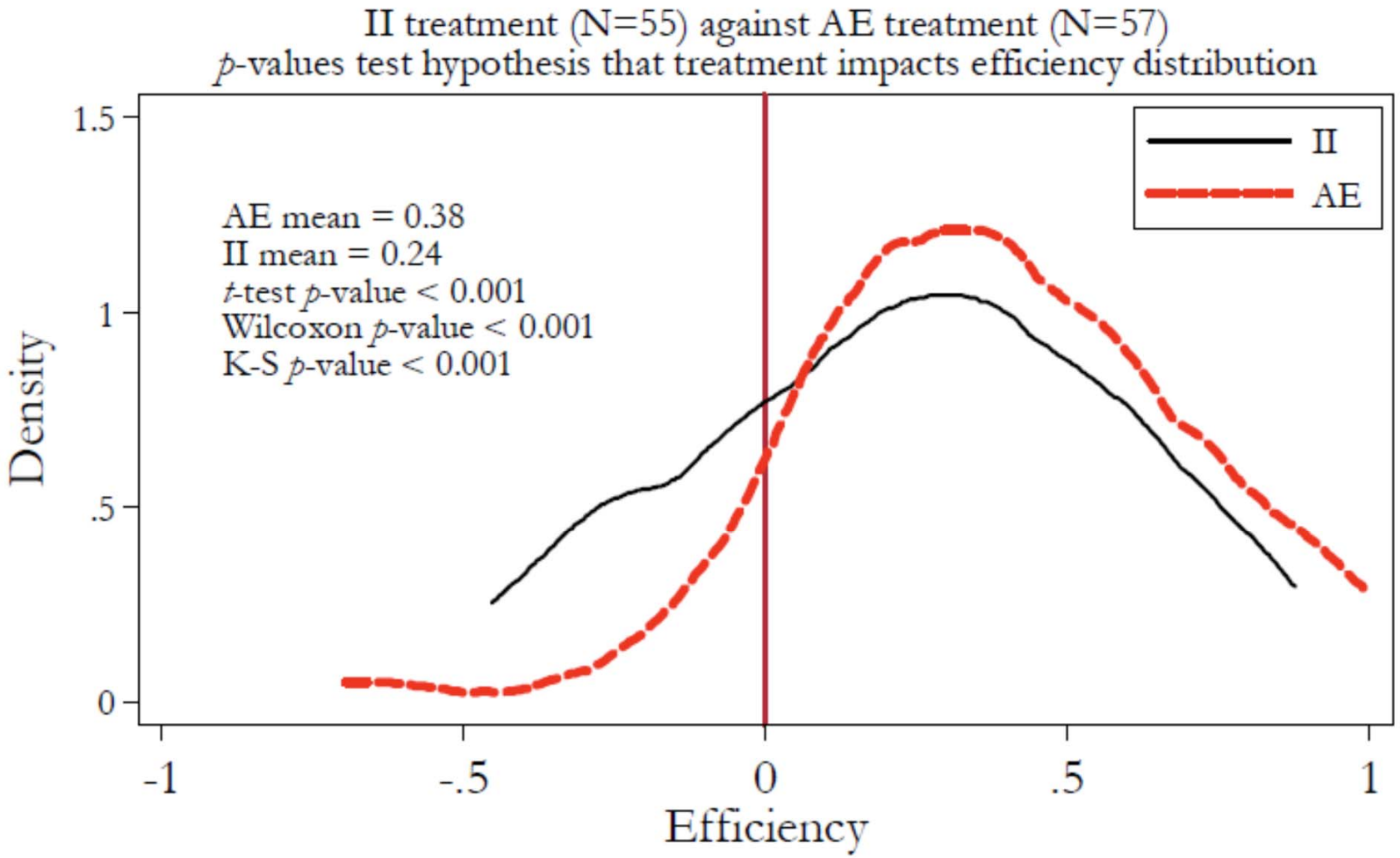
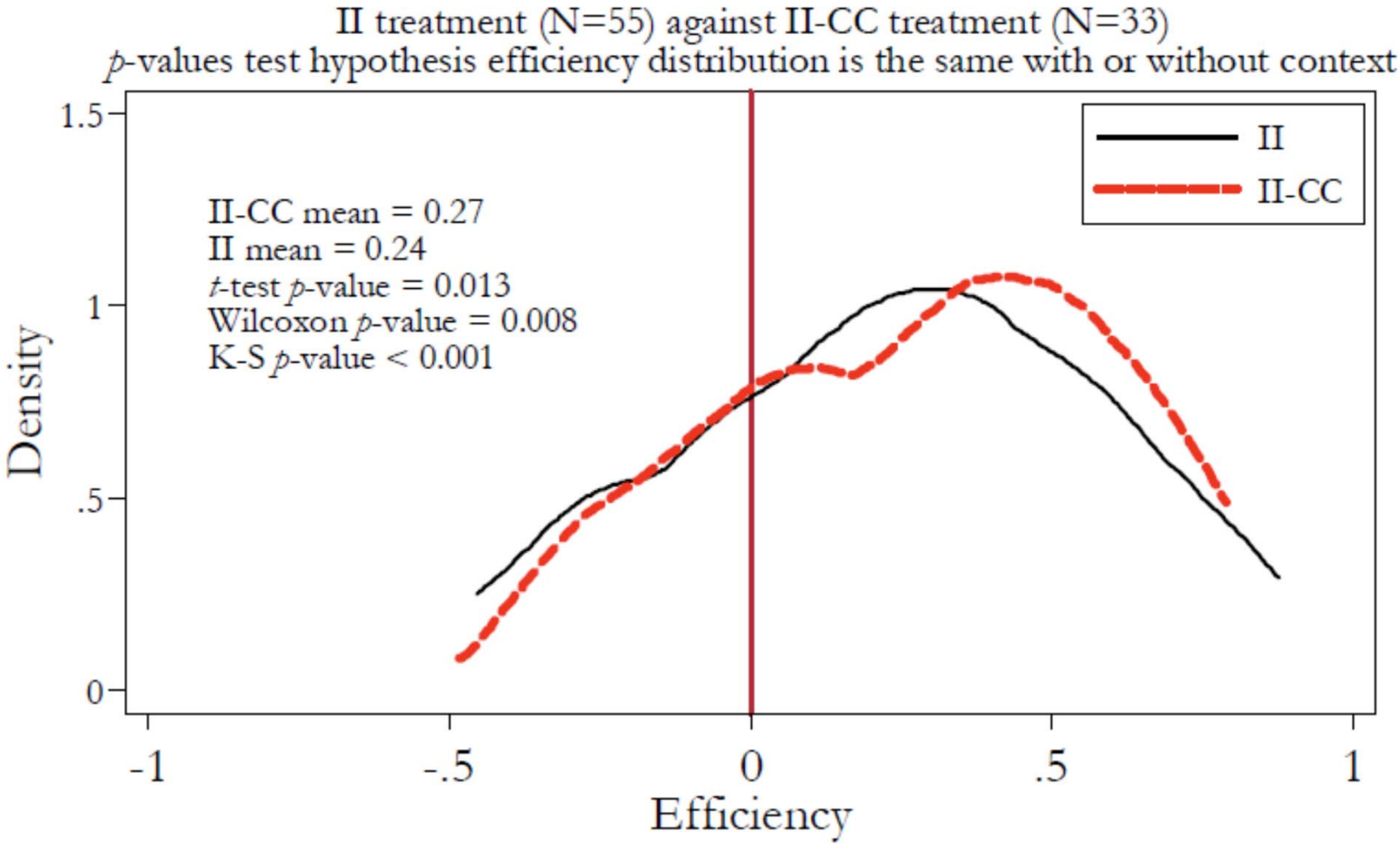


Figure 23: Comparison of Efficiency Distribution for II and II-CC Treatments, Without Assuming ROCL



Detailed analyses of choices and efficiency

- Using regression descriptively
  - Not OLS!! Binary or beta, as appropriate, and marginal effects
- Proponents of II advocate…
  - Lowering premia and/or increasing correlation
  - Neither has a statistically significant effect on welfare in II and II-CC
- But improving ROCL consistency does help
  - Each subject has a ROCL consistency count between 0 and 15
  - Average ROCL consistency count is 9.9 ≈ 10
  - Δ ROCL consistency count by 1 $\rightarrow$ Δ 5% impact on efficiency

Georgia State University | CEAR CENTER FOR THE ECONOMIC ANALYSIS OF RISK

Conclusions

- Welfare compared to take-up as metric
  - Take-up again is an unreliable metric, just for the sign
  - Take-up never says anything about size of the CS
- Expected welfare gain depends on risk preferences
  - Relaxing EUT, assuming ROCL
  - Relaxing ROCL
- Compound nature of basis risk matters in index insurance
  - Reduces take-up of insurance, and reduces CS from choices
- Policy recommendations for welfare
  - No significant effect of correlation or premia
  - Significant effect of ROCL literacy