Evaluating the Expected Welfare Gain from Insurance

by

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October 2015

ABSTRACT.

Economic theory tells us how to evaluate the expected welfare gain from insurance products on offer to individuals. If we know the risk preferences of the individual, and subjective beliefs about loss contingencies and likelihood of payout, there is a certainty equivalent of the risky insurance policy that can be compared to the certain insurance premium. This simple logic extends to non-standard models of risk preferences, such as those in which individuals exhibit "optimism" or "pessimism" about loss contingencies in their evaluation of the risky insurance policy. We illustrate the application of these basic ideas about the welfare evaluation of insurance policies in a controlled laboratory experiment. We estimate the risk preferences of individuals from one task, and separately present the individual with a number of insurance policies in which loss contingencies are objective. We then estimate the expected consumer surplus gained or foregone from observed take-up decisions. There is striking evidence of foregone expected consumer surplus from incorrect take-up decisions. Indeed, the metric of take-up itself, widely used in welfare evaluations of insurance products, provides a qualitatively incorrect guide to the expected welfare effects of insurance.

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We are grateful for comments from seminar participants at the RMI Department of Georgia State University. Details of procedures and literature are available in CEAR Working Paper 2015-10 at http://cear.gsu.edu.

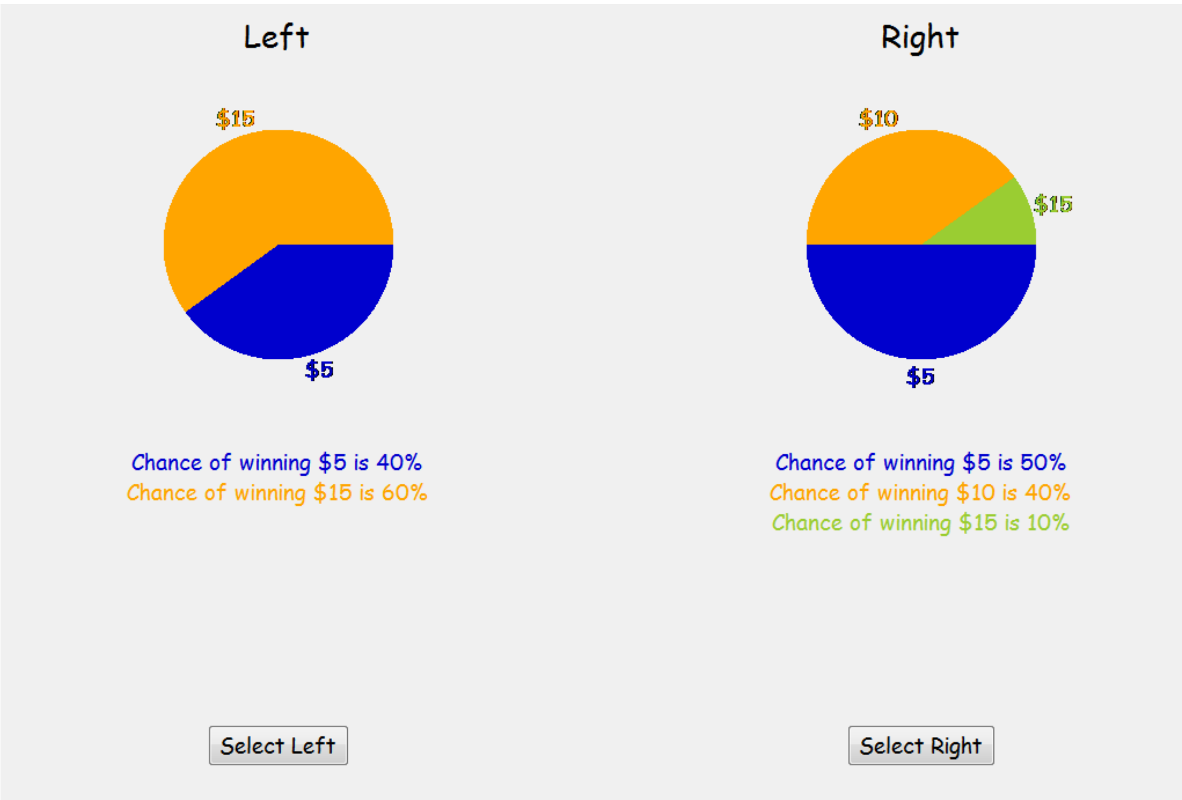
Appendix A: Instructions (Online Working Paper)

A.1. Risk Preferences

Choices Over Risky Prospects

This is a task where you will choose between prospects with varying prizes and chances of winning. You will be presented with a series of pairs of prospects where you will choose one of them. There are 50 pairs in the series. For each pair of prospects, you should choose the prospect you prefer to play. You will actually get the chance to play **one** of the prospects you choose, and you will be paid according to the outcome of that prospect, so you should think carefully about which prospect you prefer.

Here is an example of what the computer display of such a pair of prospects will look like.



The outcome of the prospects will be determined by the draw of a random number between 1 and 100. Each number between, and including, 1 and 100 is equally likely to occur. In fact, you will be able to draw the number yourself using two 10-sided dice.

In the above example the left prospect pays five dollars ($5) if the number drawn is between 1 and 40, and pays fifteen dollars ($15) if the number is between 41 and 100. The blue color in the pie chart corresponds to 40% of the area and illustrates the chances that the number drawn will be between 1 and 40 and your prize will be $5. The orange area in the pie chart corresponds to 60% of the area and illustrates the chances that the number drawn will be between 41 and 100 and your prize will be $15. When you select the lottery to be played out the computer will tell you what die throws translate into what prize.

Now look at the pie in the chart on the right. It pays five dollars ($5) if the number drawn is between 1 and 50, ten dollars ($10) if the number is between 51 and 90, and fifteen dollars ($15) if the number is between 91 and 100. As with the prospect on the left, the pie slices represent the fraction of the possible numbers which yield each payoff. For example, the size of the $15 pie slice is 10% of the total pie.

Each pair of prospects is shown on a separate screen on the computer. On each screen, you should indicate which prospect you prefer to play by clicking on one of the buttons beneath the prospects.

After you have worked through all of the pairs of prospects, raise your hand and an experimenter will come over. You will then roll two 10-sided die to determine which pair of prospects will be played out. Since there is a chance that any of your 50 choices could be played out for real, you should approach each pair of prospects as if it is the one that you will play out. Finally, you will roll the two 10-sided dice to determine the outcome of the prospect you chose.

For instance, suppose you picked the prospect on the left in the above example. If the random number was 37, you would win $5; if it was 93, you would get $15. If you picked the prospect on the right and drew the number 37, you would get $5; if it was 93, you would get $15.

Therefore, your payoff is determined by three things:

- by which prospect you selected, the left or the right, for each of these 50 pairs;
- by which prospect pair is chosen to be played out in the series of 50 such pairs using two 10-sided die; and
- by the outcome of that prospect when you roll the two 10-sided dice.

Which prospects you prefer is a matter of personal taste. The people next to you may be presented with different prospects, and may have different preferences, so their responses should not matter to you. Please work silently, and make your choices by thinking carefully about each prospect.

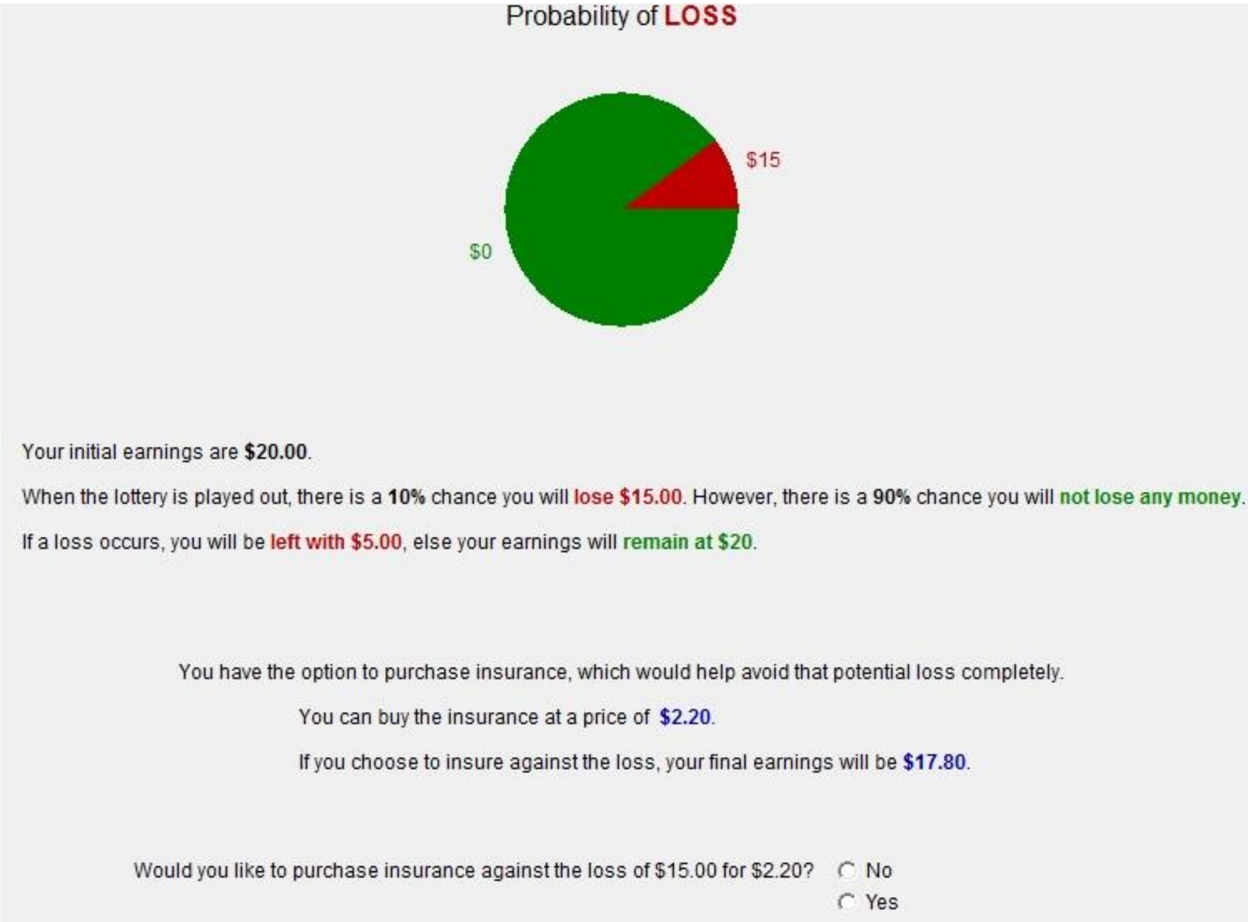
All payoffs are in cash, and are in addition to the $7.50 show-up fee that you receive just for being here, as well as any other earnings in other tasks.

A.2. Insurance Choices

Choices Over Insurance Prospects

In this task you will be asked to make a series of insurance decisions. For each decision, you will start off with an initial amount of money. You will then be presented with the probability and value of a potential loss, as well as the price of the insurance you could purchase to avoid that loss. You have to decide if you want to purchase the insurance that would protect you if that loss should occur. There are 24 such decisions to be made in this task. After all the decisions have been made, you will actually get the chance to play out one of the insurance decisions you make. You will be paid according to the outcome of that event, so you should think carefully about how much the insurance is worth to you.

Here is an example of what your decision would look like on the computer screen.



In this lottery, there is a 10% chance you will experience a loss of fifteen dollars ($15) that corresponds with the red portion of the pie, and a 90% chance you will experience no loss ($0) that corresponds with the green portion of the pie. Since you start out with $20, this means there is a 90% chance your earnings remain at $20, but there is a 10% chance you will lose $15, which would leave you with $5.

You are given the option to buy insurance to protect yourself against the potential loss in this lottery. You should decide if you want the insurance before you know if a loss will occur. In this example, the insurance will cost you $2.20. This is full insurance, meaning if you purchase the insurance and a loss should occur, the insurance will cover the full loss, and your net earnings will be your initial earnings of $20 less the price paid for the insurance ($2.20), which is $17.80. If you choose to purchase insurance and there was no loss you would still need to pay for the $2.20 insurance, and your net earnings will be $17.80.

Each decision you have to make is shown on a separate screen on the computer. For each decision, you should indicate your choice to purchase, or not purchase the insurance by clicking on your preferred option, then clicking the 'OK' button.

We will use die rolls to play out the probabilities. After everyone has worked through all of the insurance decisions, please wait in your seat, an experimenter will come to you. You will then roll a 30-sided die to determine which insurance decision will be played out. Since there are only 24 decisions, you will keep rolling the die until a number between 1 and 24 comes up. There is an equal chance that any of your 24 choices could be selected, so you should approach each decision as if it is the one that you will actually play out to determine your payoff. Once the decision to play out is selected, you will roll the 10-sided die to determine the outcome of the lottery. If a 0 is rolled on the die, a loss event has occurred. If a number 1 to 9 is rolled, then there is no loss.

Based on the example given in the display above, here is a summary of the outcomes of your insurance choices:

Die Roll	**Without Insurance**	**With Insurance**
-	Initial earnings are $20.	Initial earnings are $20.
-	Nothing paid for insurance.	Price of insurance, $2.20, paid
0	Loss occurs in the lottery. $15 loss incurred, net earnings will be $5.	Loss occurs in the lottery. Insurance will cover the loss, earnings less insurance price will be $17.80.
1 - 9	No loss occurs. Net earnings will be $20.	No loss occurs. Earnings less insurance price will be $17.80.

Therefore, your payoff is determined by three factors:

- whether or not you chose to buy insurance for each of the 24 decisions;
- the decision selected to actually be played out using a 30-sided die; and
- whether or not there is a loss based on the die roll from a 10-sided die.

Whether or not you prefer to buy the insurance is a matter of personal taste. You may choose to buy insurance on some or all of your 24 choices, or none of the choices. The people next to you may be presented with different insurance prices, and may have different preferences, so their responses should not matter to you. Please work silently, and make your choices by thinking carefully about each prospect.

All payoffs are in cash, and are in addition to the show-up fee that you receive just for being here, as well as any other earnings in other tasks.

Are there any questions?

Appendix B: Risk Lottery Parameters (Online Working Paper)

	Left Lottery						Right Lottery					
Lottery ID	Prize 1	Probability 1	Prize 2	Probability 2	Prize 3	Probability 3	Prize 1	Probability 1	Prize 2	Probability 2	Prize 3	Probability 3
ls1_rl	$10	0	$30	0.25	$50	0.75	$10	0.15	$30	0	$50	0.85
ls2_rl	$10	0.15	$30	0.25	$50	0.6	$10	0.3	$30	0	$50	0.7
ls3_rl	$10	0	$30	0.5	$50	0.5	$10	0.3	$30	0	$50	0.7
ls4_lr	$10	0.15	$30	0.25	$50	0.6	$10	0	$30	0.5	$50	0.5
ls5_lr	$10	0.15	$30	0.75	$50	0.1	$10	0	$30	1	$50	0
ls6_lr	$10	0.6	$30	0	$50	0.4	$10	0	$30	1	$50	0
ls7_lr	$10	0.6	$30	0	$50	0.4	$10	0.15	$30	0.75	$50	0.1
ls8_lr	$10	0.9	$30	0	$50	0.1	$10	0.75	$30	0.25	$50	0
ls9_rl	$10	0	$30	0.2	$50	0.8	$10	0.1	$30	0	$50	0.9
ls10_rl	$10	0.1	$30	0.8	$50	0.1	$10	0.5	$30	0	$50	0.5
ls11_lr	$10	0.5	$30	0	$50	0.5	$10	0	$30	1	$50	0
ls12_rl	$10	0	$30	1	$50	0	$10	0.1	$30	0.8	$50	0.1
ls13_rl	$10	0.5	$30	0.4	$50	0.1	$10	0.7	$30	0	$50	0.3
ls14_rl	$10	0.4	$30	0.6	$50	0	$10	0.7	$30	0	$50	0.3
ls15_rl	$10	0.4	$30	0.6	$50	0	$10	0.5	$30	0.4	$50	0.1
ls16_lr	$10	0.9	$30	0	$50	0.1	$10	0.8	$30	0.2	$50	0
ls17_rl	$10	0	$30	0.25	$50	0.75	$10	0.1	$30	0	$50	0.9
ls18_rl	$10	0.1	$30	0.75	$50	0.15	$10	0.4	$30	0	$50	0.6
ls19_rl	$10	0	$30	1	$50	0	$10	0.4	$30	0	$50	0.6
ls20_rl	$10	0	$30	1	$50	0	$10	0.1	$30	0.75	$50	0.15
ls21_lr	$10	0.7	$30	0	$50	0.3	$10	0.6	$30	0.25	$50	0.15
ls22_lr	$10	0.7	$30	0	$50	0.3	$10	0.5	$30	0.5	$50	0
ls23_lr	$10	0.6	$30	0.25	$50	0.15	$10	0.5	$30	0.5	$50	0
ls24_rl	$10	0.75	$30	0.25	$50	0	$10	0.85	$30	0	$50	0.15
ls25_lr	$10	0.1	$30	0	$50	0.9	$10	0	$30	0.3	$50	0.7
ls26_rl	$10	0.2	$30	0.6	$50	0.2	$10	0.4	$30	0	$50	0.6
ls27_lr	$10	0.4	$30	0	$50	0.6	$10	0.1	$30	0.9	$50	0
ls28_rl	$10	0.1	$30	0.9	$50	0	$10	0.2	$30	0.6	$50	0.2
ls29_rl	$10	0.5	$30	0.3	$50	0.2	$10	0.6	$30	0	$50	0.4
ls30_lr	$10	0.6	$30	0	$50	0.4	$10	0.4	$30	0.6	$50	0
ls31_rl	$10	0.4	$30	0.6	$50	0	$10	0.5	$30	0.3	$50	0.2
ls32_lr	$10	0.8	$30	0	$50	0.2	$10	0.7	$30	0.3	$50	0
ls33_rl	$10	0	$30	0.4	$50	0.6	$10	0.1	$30	0	$50	0.9
ls34_rl	$10	0.1	$30	0.6	$50	0.3	$10	0.25	$30	0	$50	0.75
ls35_rl	$10	0	$30	1	$50	0	$10	0.25	$30	0	$50	0.75
ls36_rl	$10	0	$30	1	$50	0	$10	0.1	$30	0.6	$50	0.3
ls37_lr	$10	0.5	$30	0.2	$50	0.3	$10	0.4	$30	0.6	$50	0
ls38_lr	$10	0.55	$30	0	$50	0.45	$10	0.4	$30	0.6	$50	0
ls39_rl	$10	0.5	$30	0.2	$50	0.3	$10	0.55	$30	0	$50	0.45
ls40_lr	$10	0.7	$30	0	$50	0.3	$10	0.6	$30	0.4	$50	0

	Left Lottery						Right Lottery					
Lottery ID	Prize 1	Probability 1	Prize 2	Probability 2	Prize 3	Probability 3	Prize 1	Probability 1	Prize 2	Probability 2	Prize 3	Probability 3
ls1i_rl	$10	0.03	$30	0.2	$50	0.77	$10	0.12	$30	0.05	$50	0.83
ls2i_rl	$10	0.18	$30	0.2	$50	0.62	$10	0.27	$30	0.05	$50	0.68
ls3i_lr	$10	0.27	$30	0.05	$50	0.68	$10	0.03	$30	0.45	$50	0.52
ls4i_lr	$10	0.12	$30	0.3	$50	0.58	$10	0.03	$30	0.45	$50	0.52
ls5i_rl	$10	0.06	$30	0.9	$50	0.04	$10	0.12	$30	0.8	$50	0.08
ls6i_lr	$10	0.54	$30	0.1	$50	0.36	$10	0.06	$30	0.9	$50	0.04
ls7i_rl	$10	0.18	$30	0.7	$50	0.12	$10	0.54	$30	0.1	$50	0.36
ls8i_lr	$10	0.84	$30	0.1	$50	0.06	$10	0.78	$30	0.2	$50	0.02
ls9i_lr	$10	0.08	$30	0.04	$50	0.88	$10	0.05	$30	0.1	$50	0.85
ls10i_rl	$10	0.2	$30	0.6	$50	0.2	$10	0.45	$30	0.1	$50	0.45
ls11i_rl	$10	0.1	$30	0.8	$50	0.1	$10	0.45	$30	0.1	$50	0.45
ls12i_lr	$10	0.08	$30	0.84	$50	0.08	$10	0.05	$30	0.9	$50	0.05
ls13i_lr	$10	0.65	$30	0.1	$50	0.25	$10	0.55	$30	0.3	$50	0.15
ls14i_lr	$10	0.65	$30	0.1	$50	0.25	$10	0.45	$30	0.5	$50	0.05
ls15i_lr	$10	0.48	$30	0.44	$50	0.08	$10	0.44	$30	0.52	$50	0.04
ls16i_rl	$10	0.83	$30	0.14	$50	0.03	$10	0.88	$30	0.04	$50	0.08
ls17i_lr	$10	0.08	$30	0.05	$50	0.87	$10	0.04	$30	0.15	$50	0.81
ls18i_lr	$10	0.38	$30	0.05	$50	0.57	$10	0.14	$30	0.65	$50	0.21
ls19i_lr	$10	0.38	$30	0.05	$50	0.57	$10	0.04	$30	0.9	$50	0.06
ls20i_rl	$10	0.02	$30	0.95	$50	0.03	$10	0.08	$30	0.8	$50	0.12
ls21i_rl	$10	0.62	$30	0.2	$50	0.18	$10	0.68	$30	0.05	$50	0.27
ls22i_lr	$10	0.66	$30	0.1	$50	0.24	$10	0.54	$30	0.4	$50	0.06
ls23i_rl	$10	0.52	$30	0.45	$50	0.03	$10	0.58	$30	0.3	$50	0.12
ls24i_lr	$10	0.81	$30	0.1	$50	0.09	$10	0.77	$30	0.2	$50	0.03
ls25i_lr	$10	0.08	$30	0.06	$50	0.86	$10	0.02	$30	0.24	$50	0.74
ls26i_rl	$10	0.25	$30	0.45	$50	0.3	$10	0.35	$30	0.15	$50	0.5
ls27i_lr	$10	0.35	$30	0.15	$50	0.5	$10	0.15	$30	0.75	$50	0.1
ls28i_lr	$10	0.18	$30	0.66	$50	0.16	$10	0.12	$30	0.84	$50	0.04
ls29i_rl	$10	0.53	$30	0.21	$50	0.26	$10	0.58	$30	0.06	$50	0.36
ls30i_lr	$10	0.55	$30	0.15	$50	0.3	$10	0.45	$30	0.45	$50	0.1
ls31i_lr	$10	0.48	$30	0.36	$50	0.16	$10	0.42	$30	0.54	$50	0.04
ls32i_lr	$10	0.78	$30	0.06	$50	0.16	$10	0.72	$30	0.24	$50	0.04
ls33i_lr	$10	0.08	$30	0.08	$50	0.84	$10	0.02	$30	0.32	$50	0.66
ls34i_lr	$10	0.22	$30	0.12	$50	0.66	$10	0.13	$30	0.48	$50	0.39
ls35i_lr	$10	0.2	$30	0.2	$50	0.6	$10	0.1	$30	0.6	$50	0.3
ls36i_rl	$10	0.02	$30	0.92	$50	0.06	$10	0.08	$30	0.68	$50	0.24
ls37i_lr	$10	0.48	$30	0.28	$50	0.24	$10	0.44	$30	0.44	$50	0.12
ls38i_rl	$10	0.45	$30	0.4	$50	0.15	$10	0.5	$30	0.2	$50	0.3
ls39i_lr	$10	0.54	$30	0.04	$50	0.42	$10	0.52	$30	0.12	$50	0.36
ls40i_rl	$10	0.65	$30	0.2	$50	0.15	$10	0.68	$30	0.08	$50	0.24

Appendix C: Maximum Likelihood Point Estimates (Online Working Paper)

ID	Classification	EUT	RDU Inverse-S		RDU Power		RDU Prelec		
		r	r	γ	r	γ	r	η	ω
1	RDU Inverse-S	0.1968	-0.6212	2.8051	-0.8507	2.4608	-0.7238	2.3322	1.0617
2	RDU Power	0.8868	0.8379	1.3509	0.9541	0.1071	.	.	.
3	RDU Prelec	0.5306	.	.	.	.	-1.5427	4.4693	0.4611
4	EUT	0.0037	.	.	.	.	.	.	.
5	RDU Prelec	0.1770	-0.8191	3.6307	-0.6869	2.4926	-1.8834	3.6609	0.4876
6	EUT	0.0923	0.0901	1.0229	-0.2572	1.5114	-0.3780	1.5761	0.8304
7	RDU Inverse-S	.	0.9816	1.3554	.	.	.	.	.
8	EUT	0.3233	0.2893	0.7857	0.5118	0.6530	0.4642	0.6956	0.7426
9	EUT	0.1810	.	.	.	.	.	.	.
10	EUT	0.5704	0.5686	1.0492	0.5258	1.0971	0.5901	0.9924	1.1440
11	EUT	0.1723	-0.1909	1.9801	-0.4033	1.7887	0.2470	2.3717	6.6754
12	RDU Prelec	0.4096	0.4093	1.0236	0.6635	0.5504	0.7599	0.3979	1.3534
13	EUT	0.8852	0.8976	1.0668	0.9617	0.3007	.	.	.
14	RDU Prelec	0.6505	0.6423	1.3392	.	.	0.8569	0.7790	1.7646
15	EUT	0.6843	.	.	0.6804	1.0082	.	.	.
16	RDU Prelec	0.2117	0.1284	0.6264	0.0549	1.2607	-3.1195	4.6824	0.2669
17	EUT	0.6717	0.3164	3.7333	0.3217	2.6514	0.4527	3.8177	1.3549
18	RDU Power	.	.	.	0.8717	0.4338	.	.	.
19	RDU Prelec	0.5920	0.5393	1.3424	.	.	0.8348	0.4975	1.7807
20	EUT	0.2529	0.2154	1.2458	0.1341	1.1820	0.2559	1.0527	1.1921
21	RDU Prelec	0.7232	0.6545	1.3867	.	.	0.8685	0.8355	1.7452
22	RDU Prelec	-0.3745	-0.8009	1.5983	-0.8874	1.5546	-3.0351	3.1022	0.3471
23	EUT	0.7460	0.7751	0.9039	.	.	.	.	.
24	EUT	-0.0869	-0.0886	0.8989	-0.0478	0.9527	-0.1911	1.0677	0.8462
25	EUT	0.3446	0.3441	0.9632	0.4446	0.8271	0.4600	0.8064	1.0238
26	EUT	0.6921	0.6874	1.0276	0.6102	1.1686	0.6291	1.1584	1.0953
27	EUT	0.0285	-0.0697	1.5487	0.4042	0.5632	.	.	.
28	RDU Prelec	.	.	.	-2.0277	1.4217	-8.2198	6.6867	0.1463
29	EUT	0.6680	0.6114	0.8307	.	.	0.8654	0.3380	0.7513
30	RDU Prelec	-0.0821	-0.0807	1.0096	0.4976	0.4289	0.7930	0.1548	1.8337
31	EUT	0.6040	0.4965	1.7279	0.4046	1.4399	0.6458	1.1508	1.5153
32	RDU Prelec	.	0.7276	1.2759	.	.	0.9756	0.0979	3.1528
33	EUT	0.5635	0.3925	1.7439	0.3915	1.3350	0.6245	1.0629	1.7266
34	RDU Power	.	.	.	0.9130	0.6907	.	.	.
35	RDU Prelec	0.0912	-0.2039	1.8437	.	.	0.4926	0.7545	1.9317
36	EUT	0.5020	0.5020	0.9943	0.6525	0.6775	0.6844	0.6205	1.2293
37	RDU Prelec	-0.5325	-1.0770	1.8699	-1.1545	1.7698	-4.5321	4.3645	0.3017
38	EUT	0.5921	0.5743	1.2669	-0.8599	4.7639	-0.4745	17.1746	2.2849
39	EUT	0.6226	0.6684	2.0096	0.6054	1.0757	0.7837	2.4177	1.7065
40	EUT	0.2718	0.2336	1.2374	0.2703	1.0023	0.4351	0.8141	1.3425
41	EUT	0.6951	0.6733	0.8943	0.8121	0.5597	0.8320	0.5121	0.8746
42	RDU Prelec	0.8190	0.8626	1.2351	0.9322	0.2692	0.9057	0.3590	1.1156
43	EUT	0.7601	0.6239	1.4294	0.9293	0.1907	0.9774	1.0135	4.7932
44	EUT	0.5432	0.0956	2.2419	-0.0125	1.8895	.	.	.
45	EUT	-0.0235	-0.0874	1.3397	-2.8740	4.3179	-2.5502	4.8990	1.3546
46	RDU Prelec	0.1206	-0.1965	1.8223	-0.5795	1.7829	0.4441	0.7888	2.3210
47	RDU Inverse-S	.	-1.6555	3.3310	-1.6331	2.7143	-1.6916	4.4361	6.1368
48	RDU Prelec	-0.2039	-0.5541	1.5967	-0.6154	1.3751	0.4724	0.4451	2.0798
49	RDU Prelec	0.2103	0.1893	0.8626	0.4315	0.6387	0.3857	0.6846	0.8857
50	RDU Inverse-S	-1.0825	-3.7558	3.5504	.	.	0.3788	0.4666	3.0191
51	EUT	0.6161	0.6075	0.9562	0.7156	0.7278	0.7136	0.7294	0.9876
52	EUT	0.1891	0.1789	1.0798	0.1782	1.0158	0.2744	0.9088	1.1721
53	EUT	0.8663	0.9682	1.9548	0.8317	1.2998	.	.	.
54	EUT	0.4169	.	.	.	.	.	.	.
55	RDU Prelec	0.4142	0.4156	1.0331	0.6287	0.5830	0.6318	0.5800	1.0256
56	RDU Prelec	0.8839	0.8604	1.0594	.	.	0.9892	0.1478	3.1507
57	EUT	0.1942	.	.	.	.	.	.	.
58	EUT	-0.6461	-0.6854	1.2255	-0.9142	1.2212	-0.7815	1.1518	1.0635

ID	Classification	EUT	RDU Inverse-S		RDU Power		RDU Prelec		
		r	r	γ	r	γ	r	η	ω
59	EUT	-0.3664	-0.5741	1.4918	-1.4995	1.7083	0.3527	0.5362	1.7709
60	EUT	0.4212	.	.	.	.	.	.	.
61	EUT	0.6019	0.5773	2.0325	0.5941	1.0316	0.9190	1.9498	3.6259
62	RDU Prelec	0.4636	0.4027	0.7555	0.6748	0.5071	0.6272	0.5903	0.7529
63	RDU Inverse-S	.	0.9351	1.0596	.	.	.	.	.
64	RDU Prelec	.	0.7247	1.3306	.	.	0.9429	0.0723	2.3838
65	EUT	0.8087	0.6755	1.5288	.	.	0.7647	1.1498	1.4579
66	RDU Prelec	0.4687	0.8349	0.3803	.	.	-2.3454	5.6302	0.4852
67	RDU Inverse-S	0.3209	0.2761	0.7121	0.4375	0.7772	0.2161	1.0738	0.5671
68	RDU Inverse-S	0.4450	0.0741	0.5372	0.5206	0.5938	0.2036	0.9635	0.4164
69	EUT	0.1042	0.0271	1.3157	-0.0616	1.2034	.	.	.
70	RDU Prelec	0.7977	0.6384	1.5623	0.5000	1.4779	0.7033	1.5260	1.5840
71	RDU Prelec	0.7584	0.5781	1.4704	.	.	0.7880	1.2251	1.9618
72	EUT	0.6857	.	.	0.8125	0.5521	.	.	.
73	EUT	0.3061	0.3056	1.0255	0.2354	1.1186	0.2194	1.1332	0.9740
74	RDU Prelec	-0.4461	-0.5055	1.2935	-0.6424	1.1446	0.1599	0.6336	1.4969
75	EUT	-0.0272	-0.3892	2.0114	-1.3166	2.3701	-0.1851	1.8981	2.2582
76	EUT	0.7799	0.6320	1.3723	.	.	0.8742	0.6073	2.2881
77	RDU Prelec	0.2483	0.0871	1.5995	-0.0297	1.3753	0.4478	0.9350	1.9402
78	RDU Prelec	0.3497	0.2577	1.4301	0.3238	1.0386	0.6844	0.5769	1.8181
79	RDU Prelec	0.6446	0.6076	1.3777	.	.	0.9574	0.4211	3.1279
80	EUT	0.7557	.	.	0.7394	1.0269	.	.	.
81	RDU Prelec	0.4568	0.3881	1.3630	.	.	0.7529	0.5701	2.1033
82	EUT	0.6110	0.6037	0.9685	0.7767	0.5558	0.7801	0.5448	0.9598
83	EUT	0.2083	-0.2427	2.4335	-0.2182	1.7159	-0.8234	2.3375	0.6118
84	EUT	0.6861	0.7453	0.6882	0.7644	0.7315	0.7941	0.6332	0.8432
85	EUT	-0.3014	-0.3682	1.2288	-0.3810	1.0833	-0.3370	1.0555	1.0583
86	EUT	-0.1910	-0.2286	0.8628	-2.5972	3.5067	.	.	.
87	RDU Prelec	-0.4293	-0.4658	0.4568	-0.4270	0.9871	-2.4999	3.2754	0.2464
88	RDU Prelec	0.0777	0.0778	0.9995	-0.1938	1.3783	-1.3937	2.6617	0.4566
89	RDU Prelec	-0.4294	-0.3952	0.6149	-0.2675	0.8418	-3.5191	3.3460	0.1590
90	RDU Prelec	0.6027	0.6095	1.2164	0.8828	0.3224	0.8276	0.4387	1.3169
91	RDU Prelec	-0.4153	-0.4725	1.2179	-0.4669	1.0383	0.3338	0.4790	1.8251
92	RDU Inverse-S	0.6252	0.4370	1.9734	0.4445	1.3659	0.5507	1.2100	1.2178
93	EUT	0.1155	0.1134	1.0174	0.2476	0.8243	0.4248	0.6258	1.4242
94	RDU Prelec	0.1656	0.1255	1.2601	0.2026	0.9502	0.4461	0.6883	1.3907
95	EUT	-0.2697	-0.3786	1.2107	-0.3544	1.0819	0.0980	0.6772	1.7410
96	RDU Prelec	0.1460	0.0133	0.7263	0.7116	0.2217	0.6359	0.2968	0.8284
97	RDU Prelec	0.4681	0.4653	0.8330	0.0829	1.9070	-0.2905	2.3660	0.7091
98	RDU Prelec	0.4748	0.1393	1.9745	-0.0289	1.7935	0.3473	1.3459	1.5838
99	RDU Inverse-S	.	0.9872	1.3814	.	.	.	.	.
100	EUT	0.1251	.	.	.	.	.	.	.
101	RDU Prelec	0.8111	0.7987	1.2578	0.9855	0.0600	0.9420	0.2127	1.3096
102	RDU Prelec	0.3747	.	.	.	.	-2.1075	5.9313	1.0571

Appendix D: Literature Review of Experimental Studies (Online Working Paper)

D.1. McClelland, Schulze and Coursey [1993]

McClelland et al. [1993] conducted laboratory experiments with real payments to see if insurance behavior is fundamentally different for low-probability events than for high-probability events. Their first study involved manipulating the probability of loss from very high (0.9) to very low (0.01), while keeping the size of the monetary loss fixed at $4. They used Vickrey auctions, where 8 subjects at a time bid for insurance against the loss scenarios, and the top 4 bidders receive the insurance at the cost of the 5th highest bid. The loss was determined by drawing a chip from a bag, and the result of that event applied to all subjects. The mean bids of the insurance converged at the expected value of the insurance for most probabilities of loss.

The results from the very low probabilities show bimodal behavior from the subjects: they either buy zero insurance or they bid much higher than the expected value. Their second study shows that this result continues to hold for a larger loss amount, or even as subjects gain experience. Risk preferences were not taken into account, and McClelland et al. [1993; p. 110] note that risk preferences could possibly help explain their results:

> Thus, at least for low probabilities, another theory such as [EUT] or [Prospect Theory] must be employed to explain the apparent oversensitivity to small probabilities observed in our experiments.

D.2. Irwin, McClelland and Schulze [1992]

Irwin et al. [1992] explore the effects of hypothetical versus real money and experience on insurance purchasing behavior. They make use of the same Vickrey auction as in McClellend et al. [1993], but set the number of draws at 50 or 150 for each subject with a fixed loss probability of 0.01 for all draws. Following McClelland et al. [1993], they claim the expected value of the lottery as the optimal cost of insurance and do not take into account the risk preference of the individual. Their results show that the bimodal result from McClelland et al. [1993] was less pronounced if hypothetical rewards were used, as there was an increased number of very low and very high bids, and that there is some effect of having more than one round in the experiment.

D.3. Ganderton, Brookshire, McKee, Stewart and Thurston [2000]

Ganderton et al. [2000] disagree with the conclusion McClelland et al. [1993], and do not observe the bimodal distribution of bids for very low probability losses. They attribute the difference in results to differences in their experimental set-up. They employ a more complex decision setting to reflect naturally-occurring disasters, and extract insurance choices from subjects in an extensive form game. Subjects face compound lotteries: each subject is first exposed to 3 possible outcomes (no event, a low probability event and a very low probability event), then if a loss event has occurred each subject could experience either a small loss or a large loss. A subject could randomly face any treatment from 18 parameter combinations across 5 insurance cost levels for a random number of rounds and periods.

Ganderton et al. [2000] examined how insurance purchasing behavior would vary for varying insurance costs, just as in our experiment. However, they used subject's choices from choices over lotteries with constant mean payoffs but increasing variance to infer risk preferences, and used the method of Cameron [1988] to predict willingness to pay from regression, rather than the implied CE.

As predicted by EUT, the results in their econometric models show that insurance purchase will be less likely when the cost of insurance is high, when the expected loss is low, and when the individual's wealth increases. But their results also show that repeated exposure to loss events results in a negative effect on insurance demand. They also show that subjects are relatively more sensitive to the low probability of a loss, rather than to the size of the potential loss. These results cannot be explained by EUT.

D.4. Laury, McInnes and Swarthout [2009]

The methodology for the insurance task in our experiment followed Laury, McInnes and Swarthout [2009]. They tested the belief that individuals tend to underinsure against catastrophic events with a low probability and high loss, relative to higher-probability, low-loss events (Kunreuther, Novemsky and Kahneman [2001]). Their purpose was to undertake a systematic study of the effect of the probability of a loss on insurance purchase decisions. This focused on whether subjects were more or less likely to purchase insurance as the probability of loss increased, while holding constant the expected value of the loss and the insurance load.

In the first part of their study they replicated the results from Slovic et al. [1977], a widely-cited laboratory study of insurance purchasing decisions even though all tasks were hypothetical. As much as possible, they replicated the survey that elicited willingness to purchase actuarially fair insurance for up to 8 different situations. The probability of loss was presented in terms of draws of orange and white balls from an urn, ranging from 0.0001 to 0.5. The loss amount and insurance price were expressed in points, and payments were hypothetical, even though the subjects were asked to treat the gambles as actual gambles. The loss amount was varied so that the expected loss and insurance price was kept at 1 point across all decisions. As Figure D1 shows, subjects in their replication were more inclined to purchase insurance than those in the original study. The main result from Slovic et al. [1977], however, was still replicated: the percentage of subjects purchasing insurance increases as the probability of a loss increases.

Laury et al. [2009] then conducted a new experiment to test if those results would hold if real money and incentive-compatible procedures were used to incentivize the subjects. This is the standard procedure that our experiment uses to elicit insurance preferences.

Laury et al. [2009] varied the choices the subjects would make by loss probability (0.01, 0.10), premium load (0.8, 1.0, 4.0), and expected value of loss ($0.15, $0.30, $0.60). The loss probabilities of 1% and 10% were chosen because they could be implemented in a laboratory setting, and so that there was a substantial expected change in proportion of subjects purchasing insurance between the two probabilities (based on results from the previous experiment). Varying the load on the actuarially-fair premiums allows testing of the robustness of results against the premium size.

Taking into account the within-subjects, full-factorial design of the three varying factors, each subject was asked to make a choice for each of the 18 insurance decisions, with an initial endowment of $60 for each decision. The experiment had 40 subjects receiving an actual payment, while 37 subjects did the experiment receiving a hypothetical payment.

Employing the exact conditional McNemar test, a nonparametric procedure, they find that the results in this experiment conflict with Slovic et al. [1977]. Specifically, they find that the earlier finding that more insurance is purchased as the probability of loss increases is *not* reflected when real rewards are used. In fact, the results of Laury et al [2009] show that significantly *less* insurance is purchased as the loss probability increases. They also showed that less insurance was purchased when the payments were hypothetical, but that the same pattern still holds. These results can be seen in Figure D2.

Employing a panel probit model to the data also gave similar results. Demographics were not found to have significant impact on purchase rates. Both hypothetical payments and premium loading were found to decrease purchase rates at the 5% significance level.

Laury et al. [2009] have shown that incentives matter for correctly inferring behavior in experiements. When real, high-consequence losses were implemented, there was no evidence of underinsurance of low probability losses. This experiment shows that subjects overestimating the low-probabilities are not the reason why individuals tend to under-insure against low-probability high-loss events, relative to high-probability loss-loss events, if indeed they do.

Laury et al. [2009] focus on how insurance decisions were affected by low-probability high-loss events relative to high-probability low-loss events, while holding expected loss and premium loading constant. Our experiment varies only the premium while holding the loss probability and loss amount constant, but it applies the subjects' estimated risk models to evaluate the expected welfare gains from insurance decisions.

Figure D1. Comparison of Replication to Slovic et al. [1977] Results

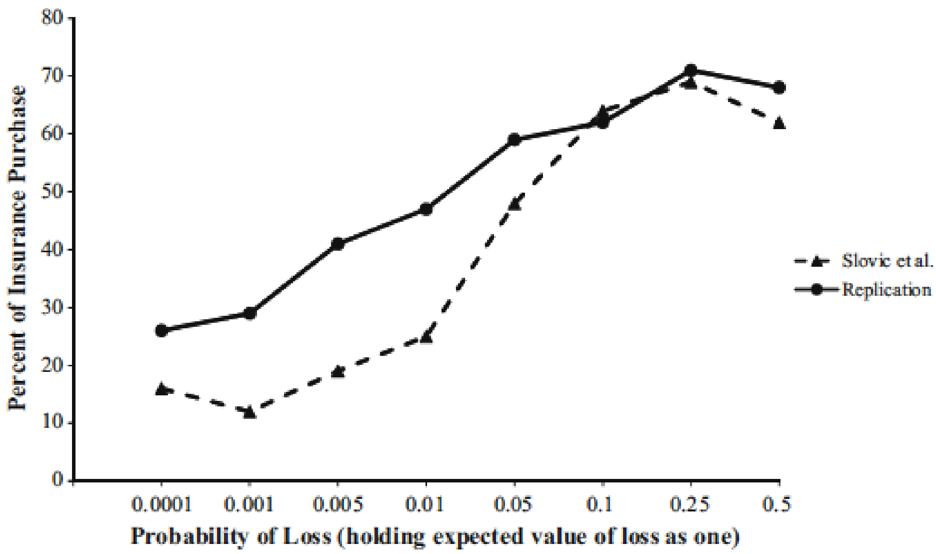
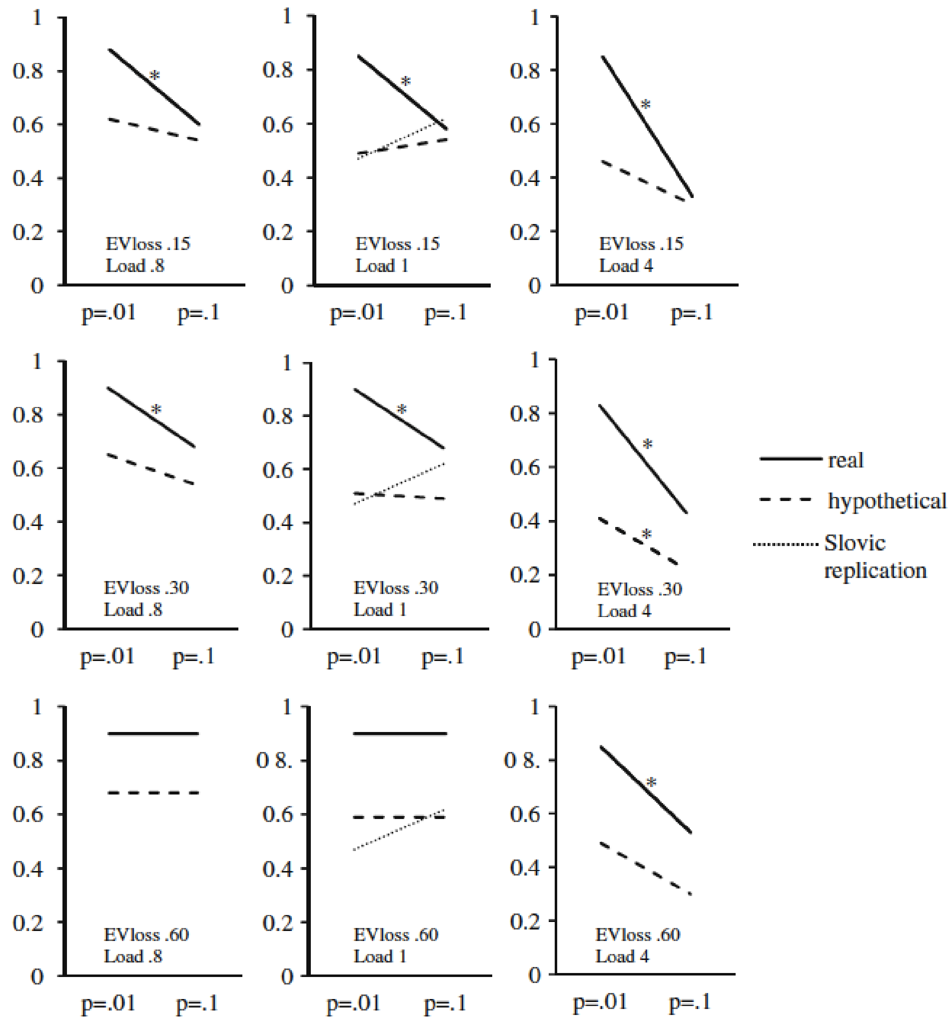


Figure D2. McNemar Test Results



D.5. Additional Literature

Laury and McInnes [2003] considered insurance purchases in which subjects actually received real rewards, but they did not elicit risk attitudes. They comment (p.228) that the fact that a majority of subjects decided to purchase the actuarially fair insurance is consistent with them being risk averse, and that this is in turn consistent with the evidence from virtually every comparable experiment.[14]

Schade, Kunreuther and Koellinger [2012] consider the purchase of insurance

[14] In their experiments 74% of choices were to purchase insurance. Three of 60 subjects never purchased insurance, and 17 of 60 always purchased insurance.

against the loss of a valuable object. They are motivated by deviations from EV in elicited WTP for insurance products noted by previous studies. Their review (p. 534) correctly notes that risk aversion can explain these extreme choices:

> There is empirical evidence that many individuals exhibit behavior that implies that they are either unconcerned or extremely risk averse when deciding whether to purchase insurance against events that have a small probability of occurring [...] The unconcerned individuals are not willing to pay a penny even if premiums are subsidized, whereas those who appear to be highly risk averse opt for premiums that are more than 10 times the expected loss.

Their experiments have some unfortunate procedural features. First, only 2 of 263 subjects were to be paid in a salient manner, and for the others the only motivation was a small fixed, non-salient participation payment. Second, subjects were not told that probability at the outset (p. 535), and had no way of knowing how many subjects would be in the experiment. Third, they used the Becker-DeGroot- Marschak (BDM) procedure to elicit WTP for insurance.[15] The BDM has been shown to have extremely poor behavioral properties (Harrison [1992] and Rutström [1998]). They replicated prior findings in a qualitative sense, finding highly skewed distributions of WTP. They do not report if they observe the bimodality of WTP noted in prior research when one uses real rewards compared to hypothetical survey questions.

Di Mauro and Maffioletti [1996] consider, among other things, a "self-insurance" experiment which is for our purposes the same as an insurance purchase.[16] They frame it as self-insurance to contrast with self-protection experiments in which subjects could pay to have the probability of a loss reduced. In any event, each of 38 subjects has a stake of £10 and makes 8 choices, 4 of which are over risky outcomes of interest here. The loss

[15] The BDM version employed in this study used a nice, credible method for generating the random purchase prices (p. 536), but is the same as the BDM applied for many decades by experimental economists.

[16] Di Mauro and Maffioletti [2001] appear to report exactly the same experimental design and data.

probabilities for the 4 risky choices are 3%, 20%, 50% and 80%. The subject reports a WTP in each case using a real-time English clock auction: as the price ticks along from £0 to £10, in increments that are not reported, the subject indicates when to "drop out" of the auction. There is considerable evidence from Rutström [1998] and Harstad [2001] that this English auction reliably elicits homegrown values from subjects, certainly by comparison with the theoretically isomorphic Vickrey sealed-bid auction or BDM procedure. Average and median bids are reported (p. 62), along with the standard deviation of bids. There is evidence of slight skewness in WTP, but not as severe as prior studies. There is no evidence presented in either direction about the existence of bimodality of WTP. Median WTP tracks EV closely for all but the highest loss probability, when it is 89% of EV. Average WTP exceeds EV for the 3% and 20% loss probabilities, and is 220% and 128% of EV, respectively; it is less than EV for the 50% and 80% probabilities, and is 87% and 81% of EV, respectively.

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Appendix E: Literature Review of Welfare Metrics (Online Working Paper)

In this section we elaborate on how the existing literature has defined welfare gain from insurance, and how it has been measured. Although our experiment only considers simple indemnity insurance with no deductibles, we consider here literature studying a wider range of products, particularly index insurance. We have broadly categorized the various methods of calculating welfare gain from insurance into 4 groups: take-up of insurance, WTP for insurance, risk reduction proxies, and "some other metric."

Table E1 lists each study, and several salient characteristics of each. We only cover the more important studies here in greater detail.

E.1. Take-up of Insurance

Hill and Robles [2011] developed a market of weather securities in southern Ethiopia to replace the more traditional index insurance contract. Their motivation is to develop a risk management product that better meets the heterogeneous needs of rainfall protection for farmers, which can be dependent on crop choice, land quality or production practices. These factors can vary even among farmers within close proximity of each other. This study has proxied for this protection from uncertain rainfall as take-up of weather securities. They have indicated that a high take-up rate of 20% reflects a welfare gain, but do not specify if a lower take-up reflects a smaller welfare gain or if it would reflect a negative welfare gain.

Hill and Robles [2011] conducted an experiment offering six different weather securities, two securities: one against severe drought and one against moderate drought, in each of the three main month of the rainy season. Farmers are given an endowment and can choose which securities they would like to purchase if at all. Securities were priced at expected value. Payouts were given in real time, depending on actual rainfall levels, to closer model real life. The same securities were subsequently offered in a pilot program a year later. Weather securities designed in this way can better meet the heterogeneous rainfall risks of the farmers, relative to a standard index insurance contract. The regression results from the experiment and the pilot program are similar. Farmers who grew barley were much more likely to purchase securities later in the season when barley grows and less for the beginning of the season. Use of fertilizer did not affect whether a farmer purchased securities, but it did affect which securities he was likely to buy. Those who use soil conservation were more inclined to purchase securities for the beginning of the season. Welfare gain in this study was measured as take-up of the weather securities, and Hill and Robles [2011] were interested in the determinants of securities choices. The do however clarify that though their results have some merit in understanding the benefits from weather securities, purchasing securities does not equate to purchasing securities that correctly hedge risk.

Hill et al [2013] used survey questions on take-up to measure WTP for weather-index insurance among Ethiopian households. The survey asks questions to see how characteristics such as risk and time preferences, initial wealth, ability to borrow money, and price of insurance affect whether or not the household would purchase a hypothetical insurance product. The survey uses methodology from Binswanger [1980] to elicit risk preferences. However, rather than assuming a parametric form for utility to calculate the risk coefficient that corresponds with the subject's lottery choice, they use the direct relationship between the subject's preferred choice and take-up to draw their conclusions of how risk aversion affects take-up. The impact from basis risk is measured by using distance from the closest weather station as a proxy for basis risk.

They claim that using a probit model allows them to calculate the change in WTP brought about by each determinant of demand. Not only so, the probit model will allow them to generate an estimated WTP *for each individual*. All that means however is that the average coefficients estimated across the population can be applied to the individual's specific characteristics to estimate the impact these characteristics have on WTP. For instance, their data shows increasing the distance from the nearest weather station from 5 to 15 km reduces the demand for insurance by 8.6 percentage points which corresponds to a reduction in willingness to pay of 10.75 Birr. Using a probit model, the relationship between level of risk aversion and insurance demand is limited to a linear or quadratic relationship.

Hill et al [2013] set out to examine how individual household characteristics impact weather index insurance demand, and their study shows that educated, rich and proactive individuals are more willing to purchase insurance. However, through their result, they are implying that an increase in insurance take-up reflects welfare gain for the household. In their introduction they explain that the welfare gain from insurance is from the reduction in adverse consequences from shocks, which include the loss of livelihood through loss of assets, slower income growth, reduced investment in human capital, and discouragement against risky actions which could potentially lead to higher yields. They cannot measure exactly how households benefit from insurance in these ways, if at all. Since they use a probit model, they can only tell if a certain characteristic, risk aversion for example, impacts insurance demand on average for the entire sample. They cannot determine if the insurance product would benefit a specific individual based on his specific risk preferences, and how much that benefit is. In other words, they cannot account for insurance benefitting some individuals and not others.

Cole, Stein and Tobacman [2014] study the long-term impact of payouts of insurance claims on future take-up of index insurance. Their data is based on a rainfall insurance product sold by an NGO called SEWA in Gujarat India. They used randomized marketing packages as an exogenous variation in insurance coverage to households. These packages included discounts, targeted marketing messages, and special offers on multiple policy purchases. Using instrumental variable (IV) specifications, they instrument for the lag of number of insurance policies purchased and the amount of payouts received using variables characterizing the lagged marketing packages with lagged insurance payouts. Their results show that an increase in payout by Rs 1,000 in the *village* as a whole results in a 29% average increase in the probability of purchasing insurance the following year, which is significantly positive. The coefficient of the *individual* payout received in the previous year, though positive, is not statistically significant. As the lag time increases, for two and three year lags, the estimated effect of the village payout decreases, while the effect of the individual payout increases.

E.2. WTP for Insurance

In their field experiment, **Elabed and Carter [2014]** use WTP for a weather index insurance product to measure welfare benefit of the insurance for cotton farmers in Mali. As in our experiment, they take into account risk preferences when measuring welfare. However, they assume that all the farmers evaluate risk using EUT. Their study looks into the impact of compound risk preferences from basis risk on WTP for weather index insurance. They make use of the Smooth Model of Ambiguity Aversion formalized by Kilbanoff, Marinacci and Mukerji [2005] (KMM) to separate preferences on simple risk and on compound risk. The premium for the compound lottery is approximated by the formula derived by Maccheroni et al. [2013], which breaks the premium down into a compound-risk premium and the classical Pratt risk premium, allowing the CE to be derived as the expected value of the lottery less the risk premium. WTP for the index insurance contract is then calculated as the difference between the CE of the index insurance contract and the CE of the simply lottery faced in the autarkic situation.

Their experiment is divided into two tasks, where one of the tasks is randomly selected to actually be played out for real money. The first task presents insurance contracts with no basis risk using a methodology similar to Binswanger [1991], where the menu of insurance options are presented to the subject, and they select their preferred choice. The options are presented to the subjects as blocks of insurance: six discrete yield levels are specified with a probability assigned to each level, and subjects were asked to select how much insurance coverage they wanted such that they would be guaranteed a minimum of that yield level. The probability, revenue and premium for each yield level were determined beforehand and shown to the subjects. Premia were set at 20% above the actuarially fair price. The actual yield outcome was then randomly selected based on the probabilities shown to the subjects. Assuming CRRA preferences, the subject's CRRA risk parameter was then inferred from the range consistent with the selected insurance contract. This experiment frames the risk parameter elicitation question in the context of insurance, unlike our experiment which used simple lotteries. Although the parameters of this experiment were set up to reflect real-life scenarios, with a 50% chance of a highest yield, this does not allow one to reliably identify non-EUT models. Furthermore, the range of CRRA risk parameter that can be captured only spans 0.08 to 0.55. Lastly, with this methodology only one data point, the mid-point of the interval that corresponds to the subject's preference, is used to estimate the risk preferences for each individual subject, hence there is no standard deviation.

The second task presents the subjects with the index insurance contract, where there is a 20% chance the insurance will not pay out even though the subject has a low yield. Only downward basis risk is considered here. Given the price of the index insurance contract, a Switching Multiple Price List, following Andersen, Harrison, Lau and Rutström [2006], was used to elicit the minimum price of the "fail-safe" insurance where the index insurance would start being preferred over the "fail-safe" insurance contract. Such a set-up might frame the questions such that it leads subjects to select a switch-over price in the middle of the prices offered. Only compound risk aversion, and not risk loving, is considered. WTP to avoid basis risk is defined as the difference between the price the subject is willing to pay to avoid switching to index insurance and the market price of the "fail-safe" insurance, which was determined in the previous task as 120% of the actuarially fair premium.

Using the CRRA risk parameter elicited from the first task and assuming constant compound risk aversion, the compound risk parameter was also estimated, and 57% of subjects were found to be compound risk averse to varying degrees. They use the estimated risk parameter and compound risk parameter to calculate the WTP of index insurance and, and demand for the insurance product is defined as whether WTP lies above or below the market price which is defined as 120% of actuarially fair premium. Taking into consideration compound risk aversion when calculating WTP would reflect a demand that is only slightly over half of the demand estimated when only simple risk aversion parameters are used to calculate WTP.

Elabed and Carter [2014] states that the welfare benefits from insurance are from the expected impact on the improved well-being of households exposed to risk. They implicitly estimate this expected improved well-being by measuring WTP of the individual subjects, and determine there is a positive welfare gain from purchasing insurance if WTP is greater than 120% of the actuarially fair premium, and a negative welfare gain from purchasing insurance if WTP is below that market price.

E.3. Risk Reduction Proxies

Mobarak and Rosenzweig [2013] used a Randomized Control Trial (RCT) to examine the relationships between informal risk sharing, index insurance and risk-taking behaviors in India. They made use of preexisting census data, offers of rainfall insurance contracts that provided a cash payment if rainfall was delayed beyond a predetermined date at randomized discounted prices, and knowledge of the extent of informal risk sharing within readily identifiable, exogenously formed networks: the subcaste, or *jati*. *Jatis* were their natural risk-sharing network: the data indicated that the majority of loans and transfers to the households were from family and fellow caste members, but also they were from fellow caste members originating from outside the village. This meant that this informal framework could also indemnify rainfall risk which was on a village-level, as well as household-specific idiosyncratic risk. Another feature of their design is that they randomly placed weather stations in some of the project villages, and proxied basis risk of the household as their distance from these weather stations. This allows them to explore how basis risk affects take-up of index insurance, and how informal risk sharing affects the impact of basis risk on the index insurance take-up.

Using their results Mobarak and Rosenzweig [2013] measure welfare gain in three ways. First, they examined whether and how caste-based risk sharing affects the demand for formal insurance. Second, they compared the effects of index insurance provision and informal risk sharing on farmers' willingness to invest in risky production methods and technologies which could lead to higher yield and profits, which was measured by adaption of these methods and technologies. Third, they assessed the general equilibrium effects of offering insurance to both cultivators of the land as well as to agricultural laborers on wage levels and volatility of the wage levels. This was done by estimating labor supply and labor demand effects.

To answer the first question regarding index insurance demand, Mobarak and Rosenzweig [2012] embeds a model of index insurance with basis risk in the cooperative risk-sharing model developed by Arnott and Stiglitz [1991]. This model predicts that (a) when there is no basis risk, index insurance demand is independent of whether or not there is informal risk sharing, and (b) as basis risk increases, it can decrease index insurance take-up, but having an informal risk sharing network can increase that demand as it can still cover the idiosyncratic loss when the index contract fails. The results from the RCT corroborate those predictions. For the second question regarding welfare gain from willingness to invest in riskier production techniques and new technologies, the modified Arnott-Stiglitz model predicts that higher informal coverage may be associated with less risk taking. The level of risk taken by farmers was proxied for by using sensitivity of their crop yield and profits to rainfall. This was measured by how much their crop yields and profits vary according to rainfall levels, and is based on the assumption that the larger the risk the farmers take, the more their yields and profits are exposed and dependent on rainfall. Once again the results are consistent with the theory. Farmers who depended more on index insurance had profits and yields that were more sensitive to rainfall, relative to farmers to depended more in informal risk sharing. The impact of this welfare gain although clear, could not be quantified.

Lastly, welfare gain was measured as a reduction in wage risk for landless agricultural laborers. Mobarak and Rosenzweig [2013] were able to measure this because they offered the index insurance to landless laborers as well as to cultivators, whereas most index insurance products are only marketed to landowners. The take-up rate of index insurance among the agricultural laborers was similar to that of the cultivators. A general equilibrium model was used to assess the impact of index insurance on the agricultural labor demand and supply. They assume workers work have to work more when rainfall levels are low in order to smooth income, and are able to take more leisure time when rain is plentiful, which would result in higher equilibrium wage rates in the good times and lower equilibrium wage rates when rainfall levels are lower . Regarding supply, number of days of agricultural work completed, for those with index insurance, was much less sensitive to rainfall than those without index insurance. Similarly probability of temporary migration as an *ex post* means to income smoothing was significantly less sensitive to rainfall for those who purchased insurance. On the demand side more male harvest labor was hired as rainfall levels increased, however the increase in demand for laborers was much steeper for farmers who were offered insurance. This indicates that when farmers purchase index insurance, their increased risk taking will increase wage levels, but labor demand volatility will also increase, which will increase wage risk. The welfare gain for laborers from purchasing index insurance should therefore increase if they know that the farmers are also purchasing index insurance, and this is reflected in laborer insurance take-up being higher when cultivators are also offered insurance.

DeBrauw and Eozenou [2014] conduct a hypothetical field experiment to measure risk preferences of Mozambican farmers regarding sweet potato production. Although their study does not consider insurance, they consider heterogeneity in risk preferences for farming inputs given uncertain weather conditions, and do not just assume that subjects are all EUT or CRRA. The results and methodology of this study could be applied to designing a weather insurance product that would match their objectives, which is to encourage people in rural Mozambique to grow and consume a more nutritional variety of sweet potato. The experiment was modelled after Holt and Laury [2002]. Respondents were given a series of 10 scenarios where they had to choose between two varieties of sweet potatoes which, depending on rainfall conditions, would produce different yields. The first variety would produce only average yields that vary less with rainfall, and the second variety would produce much higher yields under good weather conditions, but much lower yields under bad weather conditions. The probability of good rainfall increased across the scenarios from 10% to 100%.

Unlike our experiment, where we estimated risk preferences on an individual level, DeBrauw and Eozenou [2014] used the multiple price list (MPL) methodology. Using maximum likelihood, they could only estimate the average risk preferences of the sample. They were not clear on how exactly the risk preferences were estimated. They found that they can strongly reject CRRA preferences in favor of a more flexible utility function they call "Power Risk Aversion[17]" that nests the CRRA utility function. Regardless of utility function, they reject the hypothesis of EUT preferences for the pooled sample, in favor of RDU with S-shaped probability weighting functions where respondents on average underweight small probabilities and overweight larger probabilities. Their study focuses only on estimating the average risk preferences of the sample, and do not use the risk preferences to go one step further to estimate the WTP of insurance that would reduce the exposure of the subjects to risk.

Karlan et al [2014] clearly state that the welfare gains from improving financial markets through weather index insurance are threefold. Firstly, uninsured risk and limited access to credit could discourage risky investments that could produce higher yields. Secondly, weather risk is worth managing, as agriculture in northern Ghana where the study is conducted is almost exclusively rain-fed. Thirdly, index insurance can help smooth consumption. Karlan et al [2014] test the impact of insurance and credit on investment decisions by using a 2x2 treatment of either offering a cash grant or not, and offering insurance at varying prices or not. Using OLS they find that uninsured risk is a binding constraint on farmer *ex ante* investment (land investment costs and acres cultivated), but the liquidity constraints are not as binding as typically thought, meaning that credit markets alone are not sufficient to generate higher farm investments. They also find that there is sufficient demand for rainfall insurance. At actuarially fair prices, 40%-50% of farmers demanded insurance, purchasing coverage for more than 60% of their cultivated acreage. Factors such as basis risk, trust in the insurance company, and farmer's recent experience affected their demand for insurance. Since OLS was used, the methodology can only give the sign and size of the welfare gain for the average of the

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[17] $U(y) = 1/\gamma * \{ 1 - \exp (-\gamma [(y^{1-\sigma} -1)/(1-\sigma)]) \}$, where y is wealth, σ is the risk parameter. When $\gamma=0$, the utility function breaks down to a CRRA utility function.

sample population. They are unable to quantify, or tell if there is an expected welfare gain or loss for the individual, given the individual's characteristics.

Cai et al. [2015] considered welfare gain as an increase in the number of sows produced by pig farmers in Southwest China. Pig farmers have to decide if they raise their female piglets as sows for breeding purposes or if they spay them and raise them for their meat. A high mortality rate of sows (2%) deters farmers from choosing to not spay their female piglets, which leaves pork production numbers lower, and pork prices more sensitive to pork shortages. Cai et al. [2015] examine the effect sow insurance would have on the number of sows bred. The insurance is offered by the government, and pays out a lump sum of 1000 yuan should the sow die through disease, natural disaster or accident. To further encourage take-up of the sow insurance, the government subsidized 80% of the annual premium of 60 yuan, so the farmers only pay 20% or 12 yuan.

One cannot directly use ordinary least squares (OLS) to directly measure the causal impact of having sow insurance on number of sows in the village, as there is a problem of unobserved heterogeneity. There could be confounders that exist that would affect both insurance decisions and production decisions, and the regression study does not account for that. For instance, risk preferences, which are not considered in this study, might affect both the farmers' preference for insurance as well as preference in other activities that might prolong the life of the sows. Cai et al. [2015] therefore use the incentives for Animal Husbandry Workers (AHWs), as an IV to counter this unobserved heterogeneity. AHWs serve as the bridge between the formal institutions and the rural villages for matters involving animal husbandry, and are responsible for checking and marking the sow for insurance, as well as initiating the claim process in the event of a sow death. The AHWs are randomly assigned one of three incentive packages: the control group is given a higher base pay of 50 yuan, but is not given any additional incentive dependent on number of sows insured by the villages they go to. The low-incentive group was given a lower base pay of 20 yuan, but an additional small financial incentive of 2 yuan for every sow insured. The high-incentive group was given the same lower base pay of 20 yuan, but was given an additional higher financial incentive of 4 yuan for every sow insured. AHW incentives should be significantly and positively correlated with the number of insured sows, while only affecting number of total sows produced through the number of insured sows. This would make it suitable as an IV for this regression.

The results show that having insured sows significantly increases the number of sows. On average one additional insured sow increases the number of sows in the village by about 7.5 after 3 months, and 9.4 after 6 months. As the study estimates the results using OLS, it is able to show if the insurance actually provided a negative welfare gain on average. Welfare gain in this experiment can only be measured as an average on the village level, and not on a household level.

E.4. Other Metrics

Chou et al [2014] state that the welfare gain from health insurance is the resultant improvement in infant and child health. Having health insurance should lower the price of medical care services such as prenatal and neonatal care, delivery, vaccinations and immunizations, and this price reduction should increase demand for these services. Supply is also encouraged as insurance would guarantee payment for these services. They were interested in the effect of the National Health Insurance (NHI) coverage in Taiwan, which was introduced to all employees in 1995 when it was previously only offered to government employees. NHI was the only employee-based health coverage that provided benefits for infants of employees, and premium was subsidized by the government. The non-government employed households were assigned as the treatment group and the control group was the government-employed households that were already receiving NHI coverage. They tested the impact of introducing NHI on post neonatal deaths, and found that there was a significant reduction in post neonatal deaths among farm households, but not so among households who work in the private sector.

Chou el al [2014] used difference-in-difference to remove effects from unobserved trends while measuring the impact of insurance on post neonatal deaths. Using this methodology they are only able to estimate the average impact, and whether or not it was a positive or negative welfare gain on the sample population level, and not for the individual.

Table E1. Literature Review of Alternative Welfare Metrics

A. Welfare Measured by Take-up

Study	**Metric of Welfare**	**Measure**	**Data**	**Elicitation method for experiments (Hypothetical or Real)**	**Result**
Gumber (2001)	Take-up of health insurance and financial protection	Average	Household survey		Usage of private or public health facilities is price-sensitive.
Schneider and Diop (2001)	Take-up of health insurance	Average	Household survey		Low take-up, despite insurance improving financial access to care across all income levels. Social capital is an important determinant for participation.
Giné et al. (2008)	Take-up of rainfall index insurance	Average	Household survey		Lack of understanding, but also credit constraints, limited familiarity, and risk aversion discourage insurance purchase. Being previously insured, connected to village networks and self-indentifying as 'progressive' encourage insurance purchase.
Giesbert (2008)	Take-up of health insurance	Average	Actual insurance sold and survey		Understanding of concept of insurance beyond health insurance is mixed, though potential demand for insurance in survey area seems to be high.
Thornton et al. (2010)	Take-up of social security health insurance	Average	Actual insurance sold and survey		Low take-up and retention rates for insurance. Health services utilization did not increase with insurance. MFIs were not a more effective delivery agent than the government.
Hill and Robles (2011)	Take-up of varying weather securities	Average	Field experiment, actual insurance sold and survey	Choices on components of weather securities package (Real)	High take-up in Average and variance experimental game and pilot as weather securities are easily understood and fit heterogeneous farmers' needs. Crop and production choices, and soil characteristics have some explanatory power for security choices

Clarke and Kalani (2012)	Take up of index insurance, reduction of risk aversion	Average, variance, and MEU	Field experiment	Binswanger (Real)	Take-up is hump-shaped against wealth, where subjects with immediate levels of wealth have the highest take-up. There is no strong evidence of schooling, understanding of the decision problems or financial literacy significantly increasing take-up. Background risk however significantly affects take-up. Parametric assumptions matter when estimating determinants of risk aversion.
Hill et al (2013)	Reduced adverse consequence of shocks on income and consumption	Average	Survey	Double-bounded dichotomous choice elicitation (DBDC) (Real and Hypothetical)	Those who faced higher rainfall risk, were less averse, more educated, more proactive, and richer were more likely to puchase insurance. Offering insurance through a risk sharing group increases demand for less educated females, but is constrained by lack of trust amongst neighbors
Dercon et al. (2014)	Take-up of rainfall insurance	Average	Actual insurance sold and survey		Insurance demand increased when groups were exposed to training that encouraged sharing of insurance within groups. A suggested reason is that risk-sharing and index insurance can be shown to be complementary.
Banerjee et al. (2014)	Take-up of health insurance, through bundling with renewed loans	Average	Field survey and admin data		Adverse selection was not detected in take-up of bundled product because there was no demand for the product. Low demand could have been due to consumers' pessimism on how insurance would be implemented.
Vasilaky et al. (2014)	Take-up of index insurance	Average	Field experiment		Participation in educational game increases likelihood of purchasing insurance as well as amount purchased. The study focused on the context of scaling a large unsubsidized index insurance program.
Cole et al. (2014)	Take-up of rainfall index insurance	Average	Actual insurance sold and survey		Households in villages that have experienced insurance payouts are more likely to purchase in the following season, but this effect decreases over time. Households that have experienced payouts themselves are more likely to purchase two and three seasons later, than the first.

B. Welfare Measured by Willingness to Pay

Chantarat et al. (2009)	CE of herd growth rate	CE	Simulation		Household initial herd size is the key determinant of the product's performance, more so than household risk preferences or basis risk exposure. The product works least well for the poorest. The product is most valuable for the vulnerable non-poor, for whom insurance can stem collapses in herd size following predictable shocks. Demand appears to be highly price elastic, and willingness to pay is, on average, much lower than commercially viable rates.
Donfouet et al. (2011)	WTP for health insurance	Average	Surveys and field experiment	DBDC (Hypothetical)	Age, religion, usual means of seeking treatment when getting sick, profession, knowledge of insurance, income, and involvement in associations or health policies are key determinants of WTP. There is a demand for this insurance in the studied region.
Carriquiry and Osgood (2012)	Maximising expected utility (MEU)	Average, Variance	Theory		If contracts are appropriately designed there are important synergies between forecasts and insurance and effective input use.
Koufopoulos and Kozhan (2014)	MEU	Average	Theory		Full-insurance pooling equilibrium can exist when accounting for Average and variance asymmetric information and ambiguity. An increase in ambiguity may also lead to a strict pareto improvement.
Gerking et al. (2014)	WTP for reduction of mortality and morbidity risk	Average	Survey		This paper develops and applies an integrated model of human mortality and morbidity in an expected utility framework, extended to incorporate a sick state of illness, allows parents to make choices about risk exposure Average and variance for herself and for a child, and a multi-period framework.
De Janvry et al. (2014)	WTP for insurance against common shocks	Average	Theory		Insurance exacerbates free-riding when covering common shocks. Insurance against a common shock may be unprofitable to an individual if he anticipates others in the group not participating in it.
Elabed and Carter (2015)	WTP for agricultural index insurance	CE	Field experiment	Binswanger, sMPL (Real)	Accounting for compound risk aversion would significantly decrease the expected demand for insurance.
Jaramillo et al. (2015)	Risk reduction through informal insurance schemes	CE, Variance	Theory		Heterogeneity within groups reduces risk sharing, redistribution schemes could counter social exclusion, norms of reciprocity and social capital are key determinants of insurance arrangements.

Clarke (2015)	MEU	MEU	Theory		A model for rational demand for index insurance products is presented which explains two puzzles regarding index insurance demand: why demand for index insurance is lower than expected and why demand is low for more risk averse individuals.

C. Welfare Measured by Risk Reduction Proxies

Townsend (1994)	Smoothness of consumption as a result of risk sharing	MEU	Household survey		By using a general equilibrum framework, the results on consumption and income are mixed for the complete market hypothesis.
Skees et al. (2001)	Reduced revenue volatility of rainfall insurance	Coefficient of variation (CV) of expected revenue	Simulation on past data		A drought insurance program based on rainfall contracts would have reduced relative risk in Morocco.
Hess (2003)	Allowing risky farmers to maintain access to credit during drought and smooth income	Value-at-risk (VaR)	Simulation on past data		Integrated scheme can help banks reduce their lending volume while bringing down default rates and transaction costs. It can also help farmers stabilize their incomes and possible access to greater credit line from enhanced collateral
Jowett (2003)	Risk sharing (through informal networks or voluntary health insurance)	Average	Household survey		Individuals in highly cohesive communities are far less likely to purchase public voluntary health insurance.
Chou et al. (2003)	Reduced precautionary savings or risk reduction against unexpected health expenditures	Average	Government survey		Households significantly reduced their saving and increased their consumption when the comprehensive health insurance became available, with the largest effects on savings for households with the smallest savings.

Vedenov and Barnett (2004)	Efficiency: Reducing exposure to yield risk	Mean root square (MSR) of loss, VaR and CER (certainty equivalent of revenue)	Simulation on past data		Weather derivatives may reduce risk, but complicated combinations of derivatives are needed to achieve reasonable fits (basis risk is not transparent). Results from in-sample do not translate to out-sample data.
Giné et al. (2007)	Reduced exposure to rainfall risk	Variance	Household survey		There are large diversification benefits from holding a portfolio of insurance contracts, even though all insurance payouts are driven by rainfall in the same Indian state.
Breustedt et al. (2008)	Risk reduction on farm level yields (vs regional level)	MV (mean variance) and SSD (second-degree stochastic dominance)	Simulation on past data		Out of weather index, area yield index and farm yield insurance, none provide statistically significant risk reduction for every farm.
Giné and Yang (2009)	Take-up of loan to adopt new technology	Average	Actual insurance sold		Packaging rainfall insurance with loan to purchase high-yielding seed decreases take-up of loan for Maize and groundnut farmers in Malawi. This could be due to implicit insurance from limited liability in loan contract.
Clarke and Dercon (2009)	Vulnerability to poverty	Variance	Review		Insurance (Average and variance formal and informal), credit and safety nets can work together to reduce poverty
Hill and Viceisza (2012)	Take-up of fertilizer (input)	Average	Actual insurance sold		Presence of (mandated) insurance increases take-up of fertilizer. Take-up also depends on initial wealth and previous weather realizations that affect subjective beliefs of weather outcomes.
Cole et al. (2013)	Improved risk sharing of weather shocks - which should affect income variability	Average	Actual insurance sold and survey	Binswanger (Real)	Insurance demand is significantly price sensitive, with an elasticity of around unity. There is evidence that limited trust and understanding of the product, product salience and liquidity constraints also limit insurance take-up and demand.

Chantarat et al. (2013)	Reduction of livestock mortality risk	Average	Survey and household data		By addressing serious problems of covariate risk, asymmetric information, and high transactions costs that have precluded the emergence of commercial insurance in these areas to date, IBLI offers a novel opportunity to use financial risk transfer mechanisms to address a key driver of persistent poverty
Mobarak and Rosenzweig (2013)	Take-up of risky technologies and wage risk reduction for landless population	Average	Actual insurance sold and survey		As basis risk increases, index insurance take-up increases if there is also informal risk sharing. Although informal risk sharing in caste groups reduces the sensitivity of profit and output to rainfall, relative to index insurance, it also reduces average returns. Landless households are more likely to purchase index insurance if cultivators are also offered weather insurance.
Lin et al. (2014)	Overall increase in risk coverage (crowding out effect)	Average	Lab experiment		Formal partial insurance significantly crowds out public transfers, but without significant decline in risk coverage. Average altruistic preferences and fixed income inequalities contribute to the crowding-out effect
De Brauw et al. (2014)	EU from sweet potatoes yield	Average	Field experiment	MPL (Hypothetical)	Farmers' preferences better follow the more flexible power risk aversion preferences over CRRA, and RDU over EUT. Assuming CRRA would poorly predict risk preferences among those who are less risk averse for their sample.
Karlan et al (2014)	Increase in investments in risky input	Average	Actual insurance sold and survey		Uninsured risk is a binding constraint on farmer ex ante investment, but the liquidity constraints are not as binding as typically thought, meaning that credit markets alone are not sufficient to generate higher farm investments. They also find that there is sufficient demand for rainfall insurance, but factors such as basis risk, trust in the insurance company, and farmer's recent experience affected their demand for insurance.
Cai et al. (2015)	Number of sows raised (input)	Average	Actual insurance sold and government data		Providing access to formal insurance significantly increases farmers' tendency to raise sows. These short-run effects seem to have some persistence in the longer run. This increase is not in response to a substitution of other livestock. Lack of trust for government-sponsored insurance products acts a significant barrier for farmers' willingness to participate in the insurance program.

D. Welfare Measured by Some Other Metric

Bone et al. (2004)	*Ex ante* efficient risk sharing	Average	Lab experiment	Binswanger (Real)	When sharing a risky financial prospect, the results indicate that fairness is not a significant consideration, but rather that having to choose between prospects diverts partners from allocating the chosen prospect efficiently.
Wagstaff and Pradhan (2005)	Improvement of health outcomes and expansion of household consumption	Average	Survey		The program led to increased use of healthcare, reduction in out-of-pocket health expenditures and increase in nonmedical household consumption.
Franco et al. (2008)	Impact of community-based mutual health organizations (MHO) intervention on health utilization and financial protection.	Average and variance	Survey		Members were more likely to seek treatment, make pre-natal visits and use insecticide-treated nets. Distance significantly affects utilization, but enrollment not significantly associated with socioeconomic status, except for highest quintile. Members also have lower percentage of expenditures on health, lower out-of-pocket payments, and lower mean-to-median expenditures.
Rao et al. (2009)	Performance of Community Health Fund (CHF)	Average	Actual insurance sold and survey		Members had significantly higher utilization of healthcare services, but no evidence of reduced out-of-pocket spending. The main reasons for not enrolling were being unaware of the program, high premiums, and perceived low quality of services.
Charness and Genicot (2009)	Optimal equilibrum from risk sharing	Average	Lab experiment	Binswanger (Real)	Risk sharing exists, even without commitment, and depends on continuation probability of experiment, level of risk aversion of subject, reciprocity, prior expectations of subject, and relative initial income.
Aggarwal (2010)	Increase in health utilization and financial protection through health insurance programme	Average	Survey		Utilization of outpatient care and surgeries was greater in the insured group. Borrowings, and payments made from savings, incomes and other sources reduced.
Hamid et al. (2011)	Impact of addition of health insurance to microcredit on poverty indicators	Average	Actual insurance sold and survey		Adding MHI to microcredit has a significant beneficial effect only on food sufficiency, which could possibly be due to the short time frame of the study.

Chou et al. (2014)	Improved infant health and postneonatal mortality rate	Average	Government data		National Health Insurance (NHI) in Taiwan in 1995 led to reductions in the postneonatal mortality rate of infants born in farm households (previously uninsured, less education, low-weight births) but not to infants born in private sector households.

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