Individual Attitudes and Market Dynamics Towards Imprecision

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An Example

February 2021:

- European Centre for Disease Prevention and Control (ECDC) assesses the risk associated with further spread of the SARS-CoV-2 VOC (variant of concern) as “high” to “very high” for the overall population and as “very high” for vulnerable individuals

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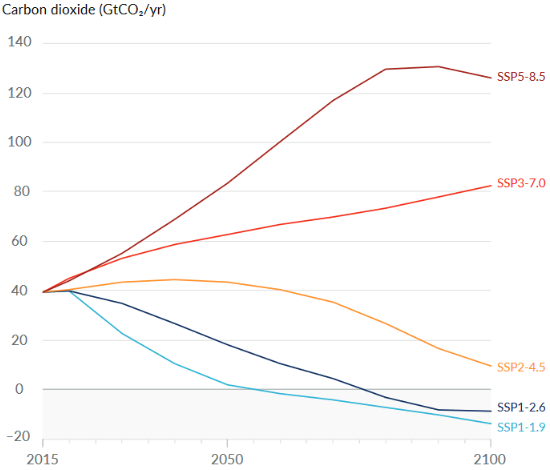
  - pneumonia
  - acute respiratory distress syndrome, and other complications
  - death

Another example

CO_2 scenarios for the climate



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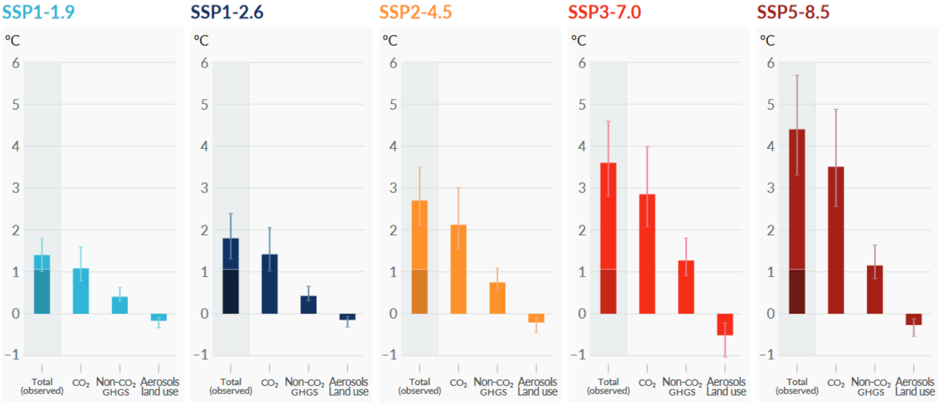

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- we can observe and measure the frequency of hurricane occurrence ex-post
- but very little insights in how the likelihood of hurricanes in a specific region will be in a couple of years from now
- Even more concerning: the extent of damage they may cause is very much unclear!

Motivation

- many situations in which both a prospects probability of occurrence and its consequences are unknown
- Standard economic models and experiments in this context distinguish between
  - risk, where both a prospects respective probabilities and its consequences are known, and
  - uncertainty, where a prospects consequences are known, but the respective probabilities associated with the consequences are not.

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  - uncertainty, where a prospects consequences are known, but the respective probabilities associated with the consequences are not.
- But: in many real-life situations there is even higher degree of unknownness
  - we often have some idea about consequences in the form of a range of potential outcomes
  - but we rarely have a clear idea of all potential outcomes, let alone the likelihood of each of them materializing

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- At the same time, there are often situations that are guided by a two-dimensional uncertainty, e.g. in financial markets:
  - probabilities over realizations are uncertain
  - actual outcome realizations are also uncertain

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Related findings

- Mixed results for ambiguity/imprecision in probabilities in asset market studies (Camerer & Kunreuther, 1989; Weber, 1989; Sarin & Weber, 1993; Bossaerts et al., 2010; Kocher & Trautmann, 2013; Füllbrunn et al., 2014)

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2. Relate investors individual attitudes towards imprecision to market outcomes

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- 320 subjects, 1 hour, average payment €13.10

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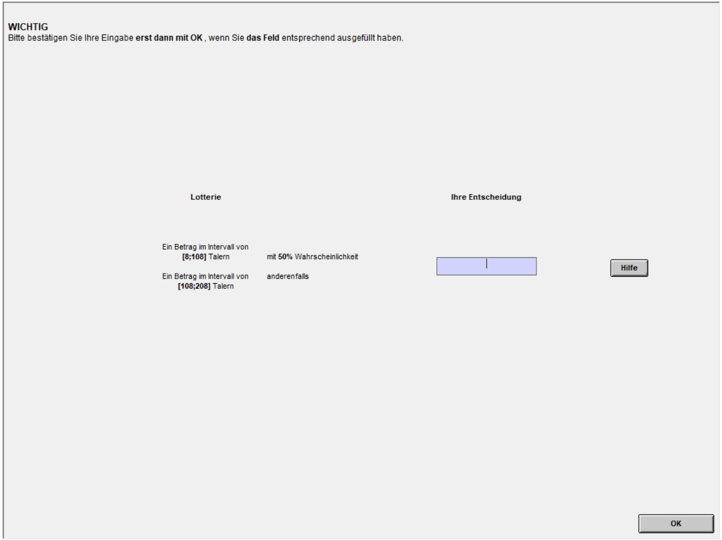
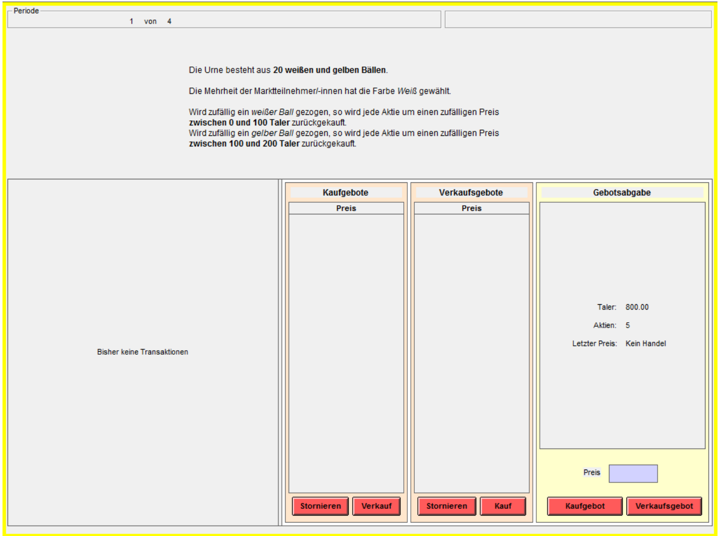
Screenshot - Individual Task

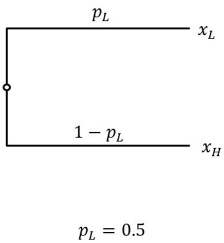


Screenshot - Market

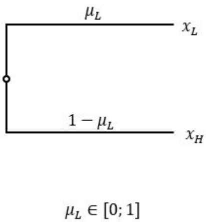


Model and Hypotheses

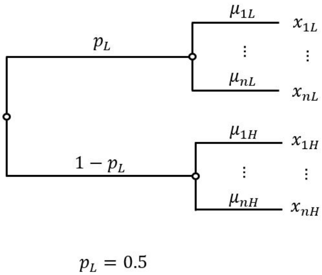
Illustration



(a) NI



(b) IP



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Theoretical Framework

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- Allows us to do data fitting

Theoretical Framework - NI

- two possible states, a low payoff $x_L = 58$ and a high payoff $x_H = 158$
- two objective probabilities associated with the possible outcomes, p_L and p_H, with $p_H = (1 - p_L)$, in our experiment $p_L = p_H = 0.5$

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- we assume Expected Utility (EU)
- then under EU, a decision maker evaluates the prospect by

$$\begin{aligned} \mathrm{EU}_{\mathrm{ni}} &= p_L u(x_L) + (1 - p_L) u(x_H) \\ &= \frac{u(x_L) + u(x_H)}{2} \end{aligned} \tag{1}$$

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  - preferences are represented by a generalization of the multiple prior model (Maxmin Expected Utility, MEU) of Gilboa & Schmeidler (1989)
    i.e., we assume $\alpha-$MEU
  - there is Bernoulli utility function u which is twice differentiable, strictly increasing, and concave

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- Then a decision maker with $\alpha-$MEU preferences evaluates the prospect by

$$\begin{aligned} \alpha - \text{MEU}_{IP} = \alpha\ \ & \min_{\pi_L \in P}[\pi_L u(x_L) + (1 - \pi_L)u(x_H)] + \\ & (1-\alpha)\ \ \max_{\pi_L \in P}[\pi_L u(x_L) + (1 - \pi_L)u(x_H)] \end{aligned} \tag{2}$$

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- coefficient α measures the degree of aversion to imprecision in probabilities ("ambiguity aversion")
  - $\alpha = 1 \rightarrow$ imprecision-in-probabilities aversion
  - $\alpha = 0 \rightarrow$ imprecision-in-probabilities seeking

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- this is in accordance with the design of our experiment, where we explicitly describe that the possible probabilities for the realization of outcomes are in the set {0%, 5%, 10%, 15%, ..., 85%, 90%, 95%, 100%}, and thus the respective minimum and maximum values are explicitly highlighted
- The "worst" case scenario corresponds to $\pi_L = 1$, and the "best" case scenario corresponds to $\pi_L = 0$. We can then rewrite

$$
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(1-\alpha) \ \max\nolimits_{\pi_L \in P}[\pi_L u(x_L) + (1-\pi_L)u(x_H)] \qquad (3) \\
= \alpha u(x_L) + (1-\alpha)u(x_H)
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$$\alpha - \mathrm{MEU}_{IP} = \alpha u(x_L) + (1-\alpha)u(x_H) = \frac{u(x_L) + u(x_H)}{2} = \mathrm{EU}_{NI} \tag{5}$$

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- modeled as a two-stage lottery (as in experimental design)
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$$\begin{aligned}\alpha - \mathrm{MEU}_{IO} = p_L[\alpha \min_{\mu_{iL} \in Q_L} \mathrm{EU}(\mu_{1L} : x_{1L}, ..., \mu_{nL} : x_{nL}) \\ + (1-\alpha) \max_{(\mu_{iL} \in Q_L)} \mathrm{EU}(\mu_{1L} : x_{1L}, ..., \mu_{nL} : x_{nL})] \\ + (1-p_L)[\alpha \min_{\mu_{iH} \in Q_H} \mathrm{EU}(\mu_{1H} : x_{1H}, ..., \mu_{nH} : x_{nH}) \\ + (1-\alpha) \max_{\mu_{iH} \in Q_H} \mathrm{EU}(\mu_{1H} : x_{1H}, ..., \mu_{nH} : x_{nH})]\end{aligned} \tag{6}$$

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- The "worst" case scenario corresponds to a probability distribution that assigns a probability of 1 to the lowest possible outcome in the respective outcome range ($\mu_{1L} = 1$, $\mu_{2L}, ..., \mu_{nL} = 0$ for low outcome range, $\mu_{1H} = 1$, $\mu_{2H}, ..., \mu_{nH} = 0$),
- and the "best" case scenario corresponds to a probability distribution that assigns a probability of 1 to the highest possible outcome in the respective outcome range ($\mu_{1L}, ..., \mu_{(n-1)L} = 0$, $\mu_{nL} = 1$ for low outcome range, $\mu_{1H}, ..., \mu_{(n-1)H}, \mu_{nH} = 0$)

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- assumption: the objective "worst" and "best" case scenarios are in set of subjective prior probabilities
- We can now rewrite to

$$\alpha - \mathrm{MEU}_{IO} = p_L[\alpha u(x_{L1}) + (1-\alpha)u(x_{Ln})] + (1-p_L)[\alpha u(x_{H1}) + (1-\alpha)u(x_{Hn})] \quad (7)$$

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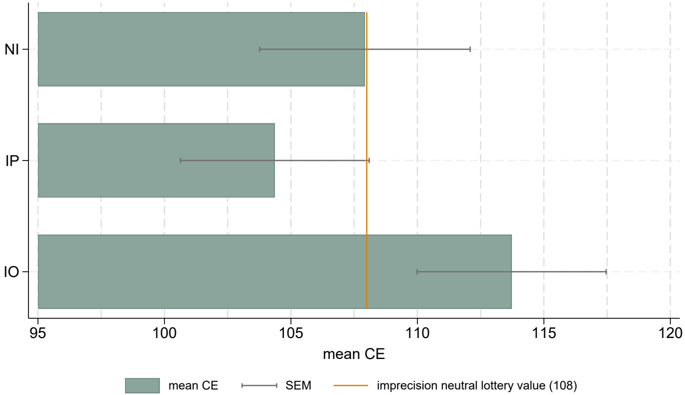
Results

Individual Task



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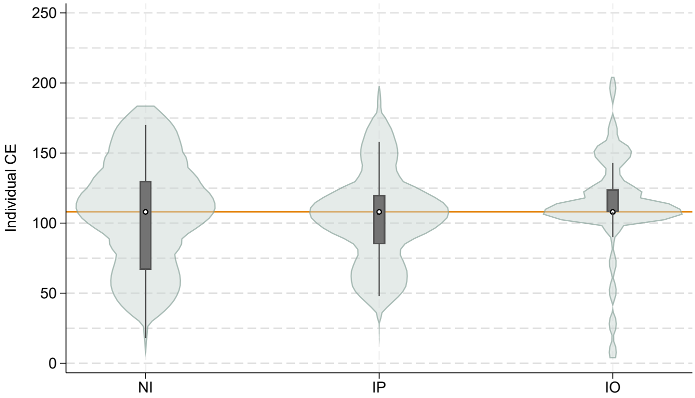

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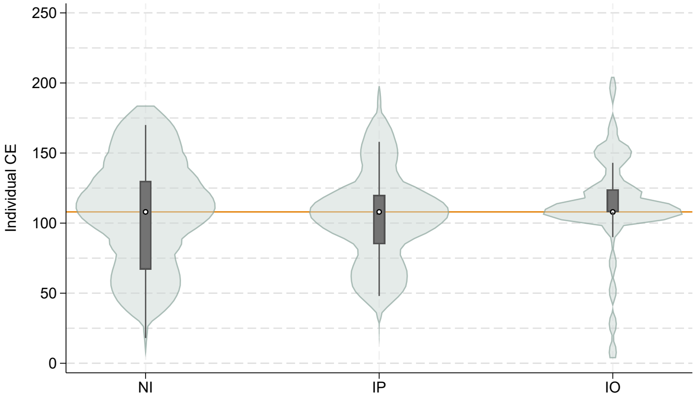

- Larger fraction above 108 in IO($p = 0.006$, Wilxocon signed-rank test)

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  - IP: $\alpha = 0.536$, we cannot reject imprecision neutrality ($p = 0.333$, Wald-test)
  - IO: $\alpha = 0.443$, we also cannot reject imprecision neutrality ($p = 0.130$, Wald-test)

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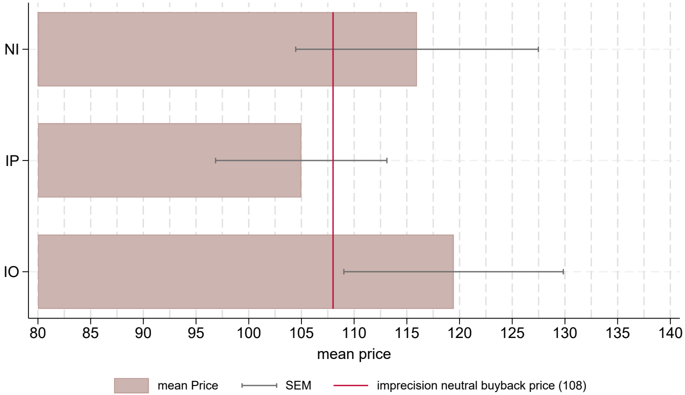
  - IO: $\alpha = 0.443$, we also cannot reject imprecision neutrality ($p = 0.130$, Wald-test)
  - But: we find that $\alpha_{IP} > \alpha_{IO}$ with $p = 0.038$

Markets


NI
IP
IO
80
85
90
95
100
105
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130
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mean price
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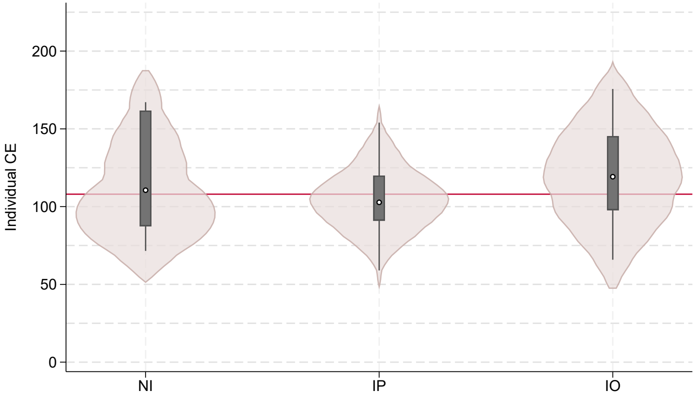
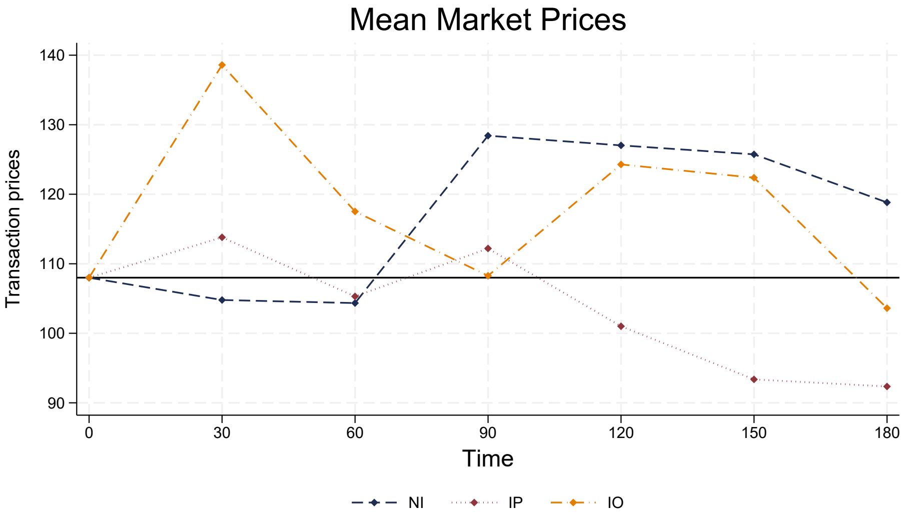
SEM
imprecision neutral buyback price (108)

Markets



Markets


Mean Market Prices
Transaction prices
140
130
120
110
100
90
0
30
60
90
120
150
180
Time
NI
IP
IO

Markets

We compute market deviations MD_m^i per market and interval, dependent on the price P_m^i and expected value EV:

$$\mathrm{MD}_m^i = \frac{P_m^i - EV}{EV} = \frac{P_m^i - 108}{108}$$

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	Interval 1			Interval 6		
Treatment	Mean	S.d.	p	Mean	S.d.	p
NI	0.078	(0.496)	0.846	0.100*	(0.182)	0.093
IP	0.054	(0.370)	0.553	−0.145*	(0.174)	0.051
IO	0.368*	(0.573)	0.075	−0.041	(0.353)	0.953

Markets

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  - we also cannot reject $\alpha_{IP} = \alpha_{IO}$ ($p = 0.26$)

Markets

Individual parameters (medians), individual task and markets

Treatment	NI		IP		IP	
	individual	market	individual	market	individual	market
r	1.00	1.23				
	(0.93)	(0.68)				
α			0.50	0.55	0.50	0.39
			(0.33)	(0.26)	(0.33)	(0.33)
p-value	0.569		0.952		0.487	

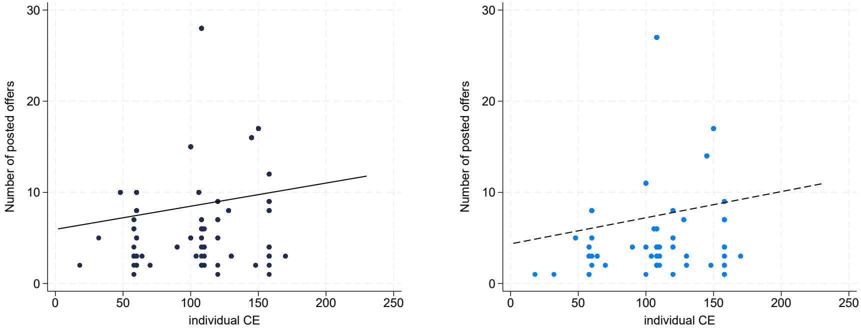
Markets

Trading Behavior: Market Volume, Volatility, and Dispersion of Final Asset Holdings

	VOLUME			VOLA			DISPERSION		
		p-value			p-value			p-value	
	mean	IP	IO	mean	IP	IO	mean	IP	IO
NI	25.8 (8.97)	0.342	0.896	0.59 (0.56)	0.248	0.280	3.68 (0.74)	0.211	0.072
IP	22.9 (11.77)		0.403	0.36 (0.19)		0.063	3.29 (0.85)		0.565
IO	26.1 (11.84)			0.81 (0.70)			3.48 (1.68)		

Markets

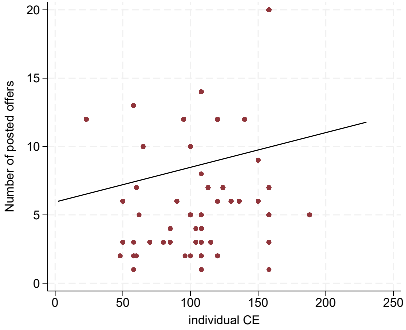
no imprecision



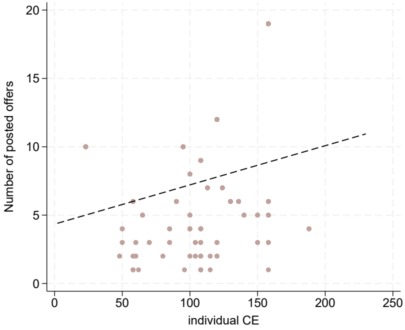
$r = 0.119,\ p = 0.056$ $\qquad$ $r = 0.145\ ,\ p = 0.020$

Markets

imprecision in probabilities



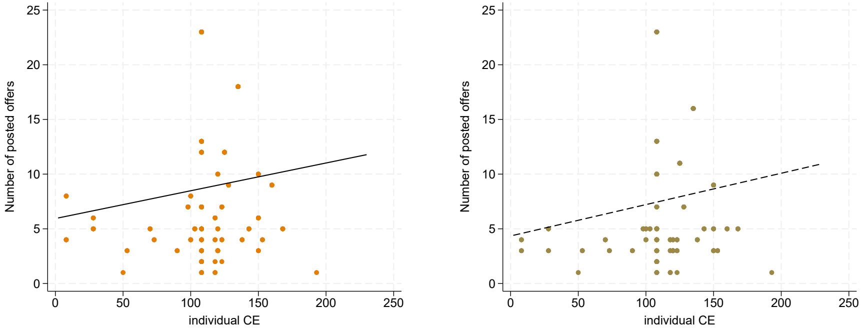
$r = 0.200,\ p = 0.002$



$r = 0.298\ ,\ p < 0.001$

Markets

imprecision in outcomes



$r = 0.148,\ p = 0.017$ $\qquad$ $r = 0.139\ ,\ p = 0.025$

Summary

- we analyzed different dimensions of imprecision and their impact on individual choice and market dynamics
- findings support the importance of distinguishing between imprecision in probabilities and imprecision in outcomes

  → preference for imprecision in outcomes in individual task

  → higher prices with imprecision in outcomes vs. imprecision in probabilities
- parameter estimates align with observed market dynamics, indicating a translation of individual attitudes into market behavior

References

Bossaerts, P., Ghirardato, P., Guarnaschelli, S., & Zame, W. R. (2010). Ambiguity in asset markets: Theory and experiment. The Review of Financial Studies, 23(4), 1325–1359.

Camerer, C., & Kunreuther, H. (1989). Experimental markets for insurance. Journal of Risk and Uncertainty, 2(3), 265–299.

Du, N., & Budescu, D. V. (2005). The effects of imprecise probabilities and outcomes in evaluating investment options. Management Science, 51(12), 1791–1803.

Füllbrunn, S., Rau, H. A., & Weitzel, U. (2014). Does ambiguity aversion survive in experimental asset markets? Journal of Economic Behavior & Organization, 107, 810–826.

Gilboa, I., & Schmeidler, D. (1989). Maxmin expected utility with non-unique prior. Journal of Mathematical Economics, 18(2), 141–153.

Knight, F. (1921). Risk, Uncertainty and Profit. Hougthon Mifflin (Boston).

Kocher, M. G., & Trautmann, S. T. (2013). Selection into auctions for risky and ambiguous prospects. Economic Inquiry, 51(1), 882–895.

Sarin, R., & Weber, M. (1993). Effects of ambiguity in market experiments. Management Science, 39, 602–615.

Weber, M. (1989). Ambiguität in Finanz- und Kapitalmärkten. Zeitschrift für betriebswirtschaftliche Forschung, 41, 447–471.