”Hunger Games II: Does Hunger Affects Risk Preferences?.”

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Hunger Games II: Does Hunger Affect Risk Preferences?

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Introduction

- Part of an INRA Project:

  Impact of physiological/metabolic states on psychological traits: Hunger and alcohol intoxication.

- Growing evidence that our cognitive, emotional and visceral states fluctuate and mediate behavioral biases and preferences (DellaVigna, 2009; Hunter, 2013) ⇒ **biosocial science.**

- Important decisions are made under stress, fatigue, hunger, pain, or alcohol.

⇒ What is the impact of hunger on underlying preferences of economic behavior: here risk attitudes.

Two original features of this research:

- Hunger manipulation mechanism using high-protein drink.
- Non-standard experimental method of elicitation of risk attitudes (under EUT and Prospect Theory, i.e. PT).

Outline

1. Literature.
2. Elicitation method.
3. Experimental design.
4. Results
5. Conclusion

Literature

States and traits: from Neuro to Eco

Neuroeconomics: understanding how and which brain sytems are associated with individual economic decisions (Camerer, Loewenstein, Prelec, 2005).

Empirically, there is some evidence of a link between physiological and biological factors and economic behavior.

For example, there are many empirical studies on the effect of emotions (anger, happiness, arousal, fear, surprise) on decision-making (Nguyen & Noussair, 2014 for a review with risk attitudes.)

Concerning risk attitudes:

- Stress induced by mild physical pain (Porcelli & Delgado, 2009) increases risk aversion in gain and risk seeking in losses and by cortisone pills (Kandasamy, & al, 2014) increases risk aversion and overweighting of small probabilities in gains.

- Effects of estrogen and testosterone on risk attitudes (Apicella & al., 2008)$\neq$ (Zethraeus & al., 2009) on postmenopausal women.

Hunger and neuroscience

In Neuroscience, Hunger or food deprivation and satiety have been studied in great depth:

- Hunger associated with food deprivation increases the incentive value of food, which is reflected in enhanced responses to appetitive stimuli in reward-related brain areas .
- Conversely, consumption of food is associated with reduced activity in reward circuitry
- Reduction of BOLD activity to rewarding stimuli between satiety and pre-meal hunger state are confirmed (in vmPFC, OFC, ventral striatum, hypothalamus, insula, amygdala, and hippocampus). (Thomas & al, 2015).

⇒ Robust results even with pre-meal hunger and post-meal satiety.

- OFC is also the area that evaluates rewards (Wallis, 2007) and assigns value in economic choices (Padoa-Shiopa & Assad, 2006)

⇒ Hunger/satiety may have impact on economic decisions and thus on the underlying individual preferences.

Hunger and economic decision

Studies on Hunger and economic decision

- *"Law is what the judge ate for breakfast" :* Danziger & al (2011) find that about 65% of favorable decision at the beginning of a session and drop nearly to zero at the end.
- High caloric intake leads to improvement in physical and cognitive tasks and increases productivity (Schofield, 2013) compared to low caloric intake (Ramadan cdt)
- Glucose increases individuals response times (Dickinson & al., 2014) and the likelihood of making a Bayesian choice over a heuristic-based choice.
- Meta-analysis of blood glucose effects on human decision-making (Orquin & Kursban, 2015): willingness to pay, to work, time discounting and decision style but no risk attitude.
- Hunger increases impatience (Ashton, 2016).

The Economy/Ecology analogy

Physiological state-dependence play no part in economic theory in contrast to ecology theory: dependence of foraging behavior on metabolic state (Stephens, 1981; McNamara, 1999)

- If energy intake or reserves is below a certain reference point (survival or reproductive threshold), induces greater risk seeking, = **scarcity/risk hypothesis**

- Conversely, period of abundanc can also induce greater risk seeking because animals can actually afford to forage or hunt: **abundance/risk hypothesis.**

⇒ Both hypothesis apply to wild chimpanzees and seem to depend of individuals risk attitudes (Gilby &Wranghram, 2007).

⇒Pre-meal hunger induces less transitivity violations in food choices in captive marmoset monkeys (Yamada, 2017).

⇒ Prediction for humans is not straightforward: no evolutionary argument for risk seeking behavior in case of starvation threat.

Hunger and risk attitudes : benchmark studies

Two empirical economics studies have highlighted how stock market volatilities declines sharply in Muslim countries during Ramadan (Seyyed & al., 2005; Bialkowski & al., 2012).

⇒ This suggests that hungry people feel less able to afford speculative risk and are therefore more risk averse.

This is confirmed by the following two experimental studies:

- Symmonds & al. (2010) find a decrease in risk aversion just after meal (metabolic states measures (acyl-ghrelin), N=19, within).
- Levy & al. (2013) extend previous study but find mixed effects: for risk averse subjects, hunger decreases risk aversion but increases risk aversion for risk seeking ones. (N=55, within)

⇒ Two benchmarks eliciting risk attitudes under EUT using multiple binary lottery choices.

Risk attitudes elicitation methods

Heterogeneity of the scientific evidence on risk attitudes is also due to the numerous elicitation methods:

- Psychometric measure: Likert scale of willingness of taking risks (Dohmen & al), adapted for survey questionnaire but not for connecting with theoretical economics or decision theory.
- Binary lottery choices: Basis of thought experiment, most intuitive and easy task, require an high number of choices to account for individual heterogeneity of preferences (Hey & Orme, 1994) and parametric estimation of decision models.
- Equivalents' elicitation : Certainty equivalents or matching probability are points of indifference between two prospects: very informative continuous variable, choice list to help understanding the task, European School in DT.
- Budget allocation: Convex combination of two prospects: continuous variable, easy to understand, Californian school in DT and micro: Kariv, Andreoni, Gneezy etc.. $\Rightarrow$ few studies outside EUT.

Elicitation Method

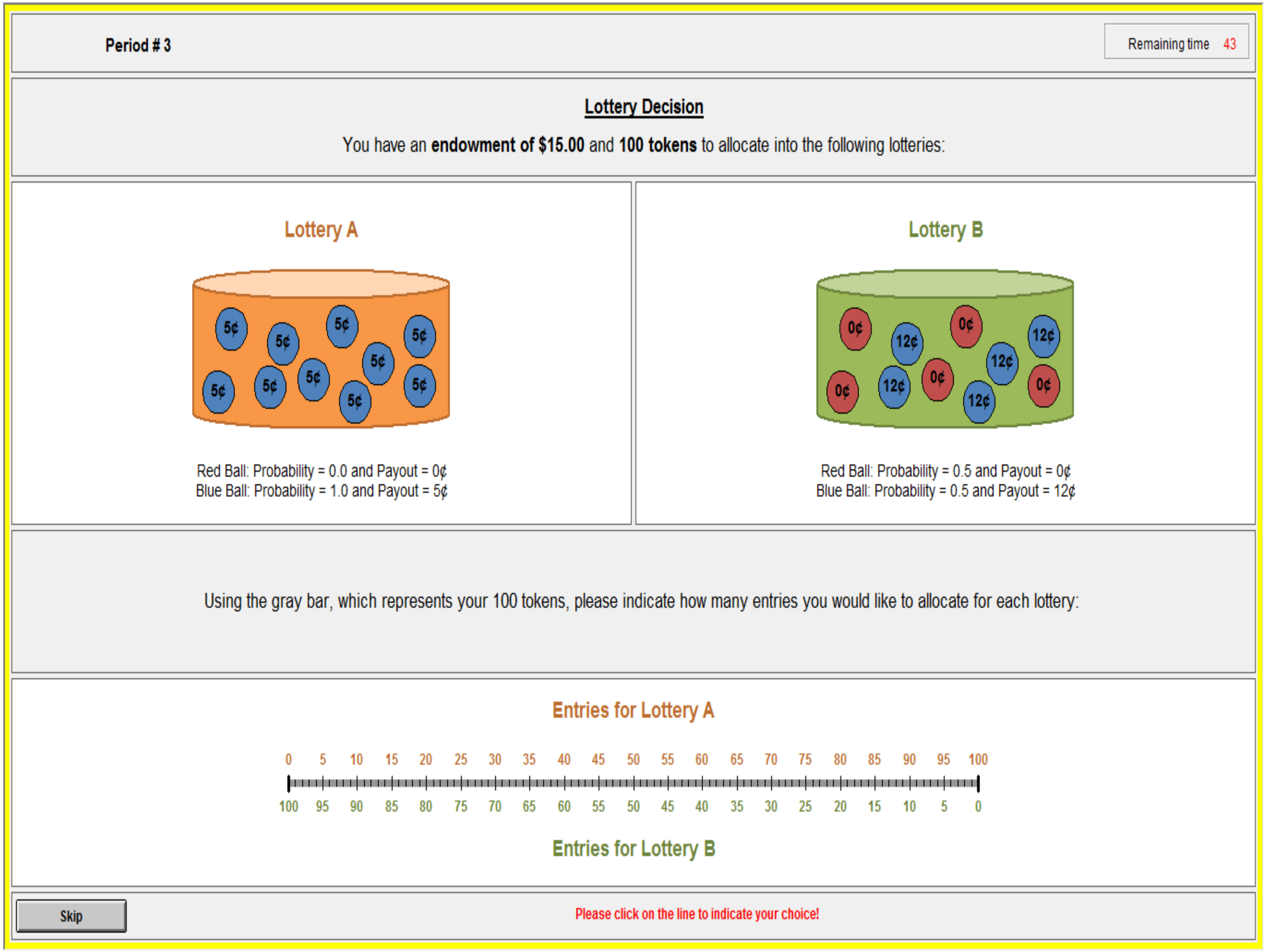
Convex Budget Allocation: set-up

- X the set of outcomes .
- State space $\mathcal{S}$ is partitioned by two events B , $R = B^c$ with $Pr(B) = p = 1 - Pr(R)$. (Risk=known probabilities).
- DM's preferences are defined over the set of comonotonic acts $\{(x, B; y) \mid x \geq y \geq 0\} \subset \Delta(X)$
- For simplicity, acts are lotteries denoted $(x, p; y)$ and constant acts $(x = y)$ are denoted z.
- DM has to choose a convex combination of a sure gain $A = z$ and a lottery $B = (x, p; y)$ with $x > z > y$.
- The choice variable is $\pi \in [0, 1]$ such that she obtains $\pi A + (1 - \pi)B$.

$\Rightarrow$Portfolio allocation between a safe and a risky asset.

$\Rightarrow$ Closely connected to well-studied economic situation (Arrow,1964).

Decision task



Convex Budget Allocation: Maximization program

Under EUT, with $A = z$ and a $B = (x, p; y)$

$$V_{EUT} = pu(\pi z + (1-\pi)x) + (1-p)u(\pi z + (1-\pi)y).$$

The first-order condition is $\frac{\partial V_{EUT}}{\partial \pi} = 0$.

$$\boxed{\Leftrightarrow \frac{u'(\pi z + (1-\pi)y)}{u'(\pi z + (1-\pi)x)} = \frac{p}{1-p}\frac{(x-z)}{(z-y)}}$$

Let assume $p = \frac{1}{2} \Rightarrow \frac{p}{1-p} = 1$ and $y = 0$

$$\boxed{\Leftrightarrow \frac{u'(\pi z)}{u'(\pi z + (1-\pi)x)} = \frac{(x-z)}{z}}$$

If $z = E(B) = \frac{x}{2}$, the interior solution is $\pi = [0, 1]$ and $u(x) = x$

$\Leftrightarrow$DM is risk neutral and indifferent to any allocation.

Predictions

Proposition: (Arrow, 1964; Rothschild-Stiglitz , 1971). For A and $B \in \Delta(X)$, where B is a mean-preserving spread of A, then the asset allocation problem is resolved as follows:

- if the DM is risk neutral and $\pi \in [0,1]$ and u is linear.
- if the DM is risk averse and $\pi = 1$ and u is concave.
- if the DM is risk seeking and $\pi = 0$ and u is convex.

$\Rightarrow$ When $B \neq MPS(A)$, under power utility assumption ($u(x) = x^{\alpha}$), convenient way to estimate risk aversion parameter of a DM exhibiting an interior allocation:

$$\boxed{\Leftrightarrow \frac{\pi z+(1-\pi)y}{\pi z+(1-\pi)x} = \left[\frac{p}{1-p}\frac{(x-z)}{(z-y)}\right]^{\frac{1}{\alpha-1}} = K}$$

$$\boxed{\pi_{th} = \frac{1}{1+\frac{z(1-K)}{xK-y}}}$$

RDU elicitation

Under PT, with $A = z$ and $B = (x, p; y)$ with $x > z > y > 0$

$$V_{PT} = w(p)u(\pi z + (1-\pi)x) + [1 - w(p)]u(\pi z + (1-\pi)y).$$

The first-order condition (for an interior solution) is $\frac{\partial V_{PT}}{\partial \pi} = 0$.

$$\boxed{\Leftrightarrow \frac{u'(\pi z+(1-\pi)y)}{u'(\pi z+(1-\pi)x)} = \frac{w(p)}{1-w(p)} \frac{(x-z)}{(z-y)}}$$

$$\boxed{\Leftrightarrow \frac{\pi z+(1-\pi)y}{\pi z+(1-\pi)x} = \left[\frac{w_\gamma(p)}{1-w_\gamma(p)} \frac{(x-z)}{(z-y)}\right]^{\frac{1}{\alpha-1}} = K(\alpha,\gamma)}$$

$$\boxed{\pi_{th}(\alpha,\gamma) = \frac{1}{1+\frac{z(1-K(\alpha,\gamma))}{xK(\alpha,\gamma)-y}}}$$

Experimental design

Main features

- 106 participants in Xlab at University of Berkeley.
- Sign-up process 24h before the experiment (requirement of minimal 3h fasting before the session).
- 55 computer-based experimental tasks of budget allocations.
- Maximal time of 45 sec per allocation. Total duration $\sim$ 45min.
- One allocation is played randomly selected and played for real at the end of the experiment (RIS). $E(G)$ =\$38+ flat fee of \$10.
- One tasting activity before the tasks (Hunger = 0 or 1)
- 35,5 cl nutritional drink with high protein (35g), low calorie (160 cal), low sugar (1g). Protein: most satiating macro-nutrient.
- Psychometric scales of hunger measured before and after tasting
- One mental calculus activity before or after the tasks (Fatigue condition).

Practical set up

Drink:

Xlab

The allocation tasks' module

The 55 allocation tasks are divided as follows:

- 40 allocations between a safe and a risky asset, 15 between two risky assets.
- 25 allocations between an asset and a mean preserving spread (MPS): 10 between a safe and MPS, 15 between a lottery and a MPS.
- 19 allocations with a positive endowment: 11 involving losses, 8 gains ⇒ 36 without endowment.
- 8 allocations with varying gains ⇒ Estimation of the utility.
- 9 allocations with varying probabilities ⇒ Estimation of the pwf.
- 4 allocations as variation of Allais paradox

⇒ I will focuss on 21 allocation tasks in this talk: for estimating RDU and 8 MPS

Mean preserving spread tasks (gain and loss)

Table 1: Simple allocation with MPS lotteries (gain and loss)

	π between z and $(x, 1/2; y)$							
Task	1	2	3	4	1'	2'	3'	4'
z	15	30	30	35	-15	-30	-30	-35
x	20	40	50	45	-20	-40	-20	-45
y	10	20	10	25	-10	-20	-10	-25

- 1,..,4 (1',..,4') allows testing EUT prediction in the gain (loss) domain and comparison with the benchmark (Symmonds & al.).

Probability weighting and utility tasks

Table 2: Utility allocation (outcomes changes)

	z and $(x, 1/2, y)$			
Task	5	6	7	8
z	5	10	15	20
x	12	25	35	50
y	0	0	0	0

⇒ Allow estimating utility in gain under EUT or PT.

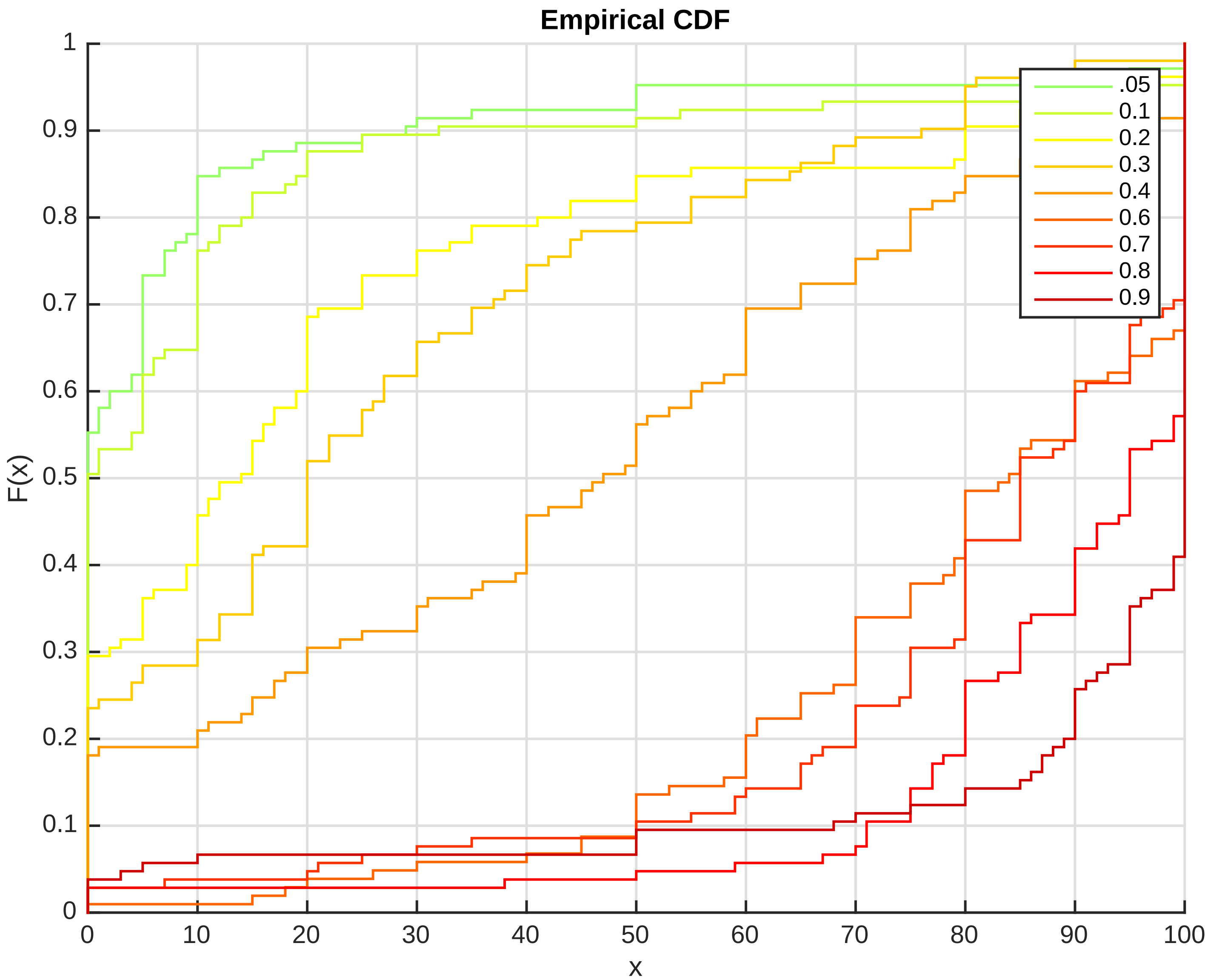
Table 3: Pwf allocation (probability changes)

	π between z and (x, p, y)								
Task	9	10	11	12	13	14	15	16	17
z	2.5	5	10	15	20	25	30	35	40
x	50	50	50	50	50	50	50	50	50
y	0	0	0	0	0	0	0	0	0
p	0.05	0.1	0.2	0.3	0.4	0.6	0.7	0.8	0.9

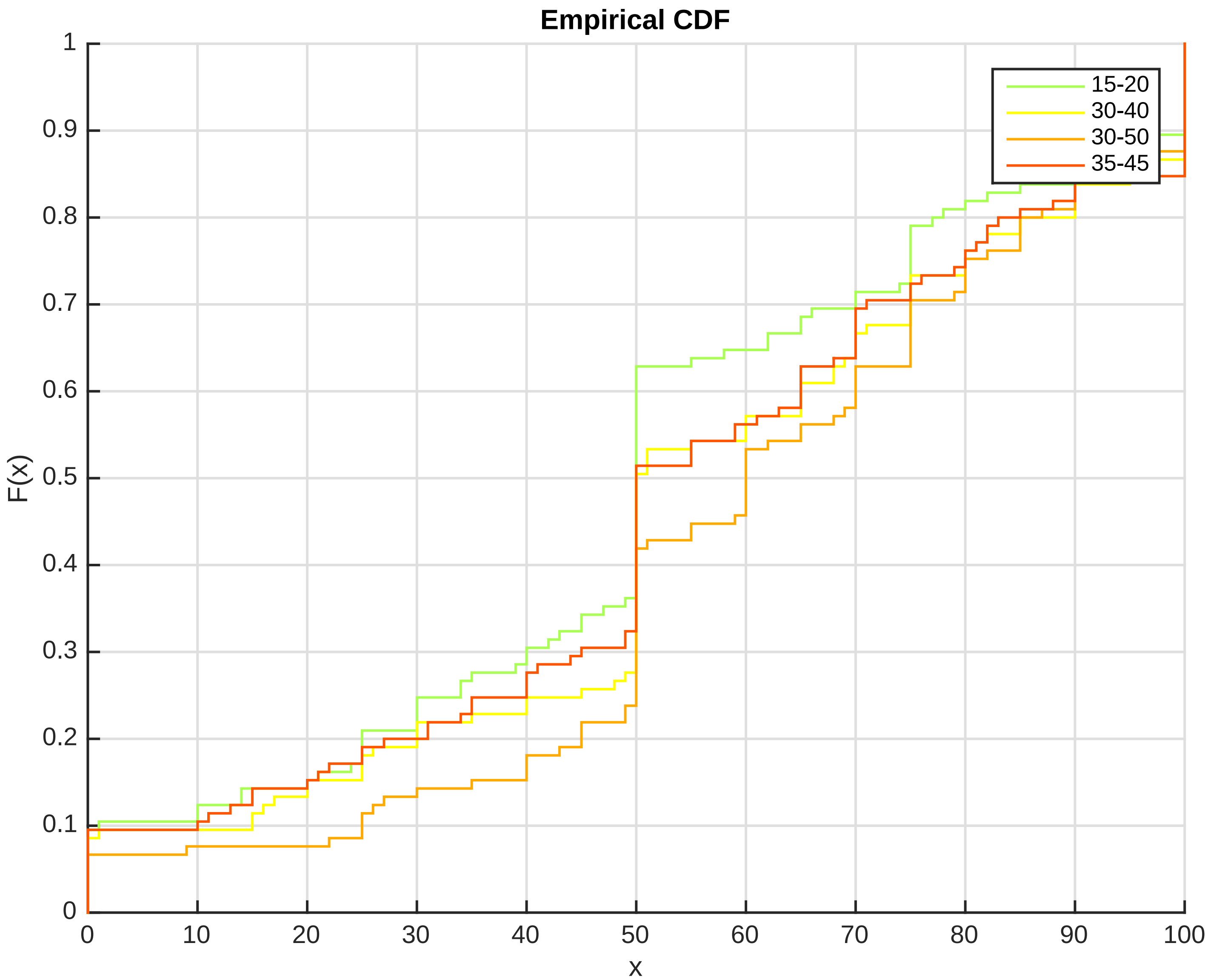
⇒ Allow estimating pwf in gains (π should increase with p)

General descriptive results

Probability changes: descriptive results.



MPS in gains: critical for EUT



Econometrical analysis

Model features

- One **Hunger** condition but two variables to control for it:

□ The tasting condition: protein drink (H0) or water (H1).
□ A self assessed hunger level before the allocation tasks module

⇒ Both variable are correlated: efficiency of our hunger manipulation device.

- One **Fatigue** condition: no task (F0) or mental calculus (F1).

- One individual characteristic: **Gender**

- Power specification for utility: $u(x) = x^{\alpha}$

- Prelec one parameter probability weighting function:

$$w(p) = exp(-(-lnp)^{\gamma})$$

⇒ The smaller α, the more risk averse

⇒ The smaller γ, the more probability distortion ($\gamma < 1$ corresponds to inverse S-Shape).

Estimation

- π_{th} is the theoretical allocation and π_{obs} the observed one.
- $\pi_{obs} = \pi_{th} + \epsilon$ with $\epsilon \sim N(0, \sigma)$ with σ log normally distributed across subjects.

Due to the measurement scale we only measure $\lfloor \pi_{obs} \rfloor$ which is the integer value of π_{obs}.
The probability of a given allocation is, without tremble:

$$P(\lfloor \pi_{obs} \rfloor) = P((\lfloor \pi_{obs} \rfloor - 0.5) < \pi_{obs} < (\lfloor \pi_{obs} \rfloor + 0.5))$$

If we assume a tremble, i.e. that a share μ of choices are given at random with μ varying across subjects according to a logistic distribution, then:

$$P(\lfloor \pi_{obs} \rfloor) = \frac{\mu}{100} + \frac{1-\mu}{100}(\phi\left(\frac{\lfloor \pi_{obs} \rfloor - \pi_{th} + 0.5}{\sigma}\right) - \phi\left(\frac{\lfloor \pi_{obs} \rfloor - \pi_{th} - 0.5}{\sigma}\right))$$

- Log-likelihood is calculated over the 13 allocations and maximized over α and γ as $\pi_{th}(\alpha, \gamma)$.

Structural equation model

The structural equation model is then the following:

$$\pi_{obs} = \pi_{th}(\alpha, \gamma) + \epsilon$$

$$log(\alpha_i) = \alpha_0 + \alpha_{hunger}\delta_{hunger,i} + \alpha_{gender}\delta_{male,i} + \alpha_{fatigue}\delta_{fatigue,i}$$

$$log(\gamma_i) = \gamma_0 + \gamma_{hunger}\delta_{hunger,i} + \gamma_{gender}\delta_{male,i} + \gamma_{fatigue}\delta_{fatigue,i}$$

where $\delta_{k,i}$ is a dummy variable that takes value 1 if condition k is true.

- The model is estimated by maximum likelihood.
- For the random coefficients (σ and μ), the likelihood is simulated from 500 Halton draws.
- 50 different starting values in order to avoid local optima.

Main results

	Estimate	SE	p values
α_0	-0.123	0.000	0.000
γ_0	-0.561	0.001	0.000
mean(μ)	-0.415	0.184	0.024
α_{hunger}	-0.003	0.000	0.000
α_{male}	0.121	0.001	0.000
$\alpha_{fatigue}$	-0.000	0.000	0.006
γ_{hunger}	-0.043	0.001	0.000
γ_{male}	-0.046	0.001	0.000
$\gamma_{fatigue}$	0.002	0.000	0.000

$\Rightarrow$ Gender effect is consistent with existing evidence.

$\Rightarrow$ Hunger induces more risk aversion and probability distorsion.

$\Rightarrow$ Fatigue has little impact on risk preferences.

Conclusion

Contributions and limitations of the study

We add to the existing corpus of evidence by including:

- ☐ A tractable hunger manipulation device (protein drink) that allows for between-subject design.
- ☐ An elicitation method that allows parametric estimation of many refined risk attitudes features (pwf, loss aversion, utility in losses)

But there are several limitations in our study:

- ☐ No physiological measure of hunger, BMI control.
- ☐ Our between-subject design may require a bigger sample size.
- ☐ Randomization between hunger condition was made between and not within session.

⇒ Hunger increases risk aversion and probability distortion: increases irrationality or heuristic based decisions?

⇒ Useful results to be extended in order to understand risk attitudes of at risk population (obese, poor population).

Thank you for your attention!