Consistency and Risk Preferences:

A Panel Experiment

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Introduction

- A major concern in economics and psychology is related to understanding choices under uncertainty.

- Empirical researchers have developed their own methods of measuring individual attitudes toward uncertainty.

- Choi, Fisman, Gale and Kariv (2007) proposed a novel experimental method of collecting a rich dataset to study individual behavior under uncertainty.

- We combine this method into an online panel survey to link between experimental and survey data.

Research Questions

- Consistency
  - How consistent are subjects' choices with utility-maximization in the general population? Are measures of consistency related to observable personal characteristics in the survey?

- Structure
  - Does the choice data in experiment exhibit some special structural properties?
  - If so, can we classify individuals with finite distinct types and relate them to observable characteristics?

- Risk preferences
  - What is a parsimonious modeling approach of measuring individual attitudes toward uncertainty?
  - How can we link revealed preferences with the panel data?
- From experiment to survey
  - Is the experimental data informative to understanding real-life financial decision making?

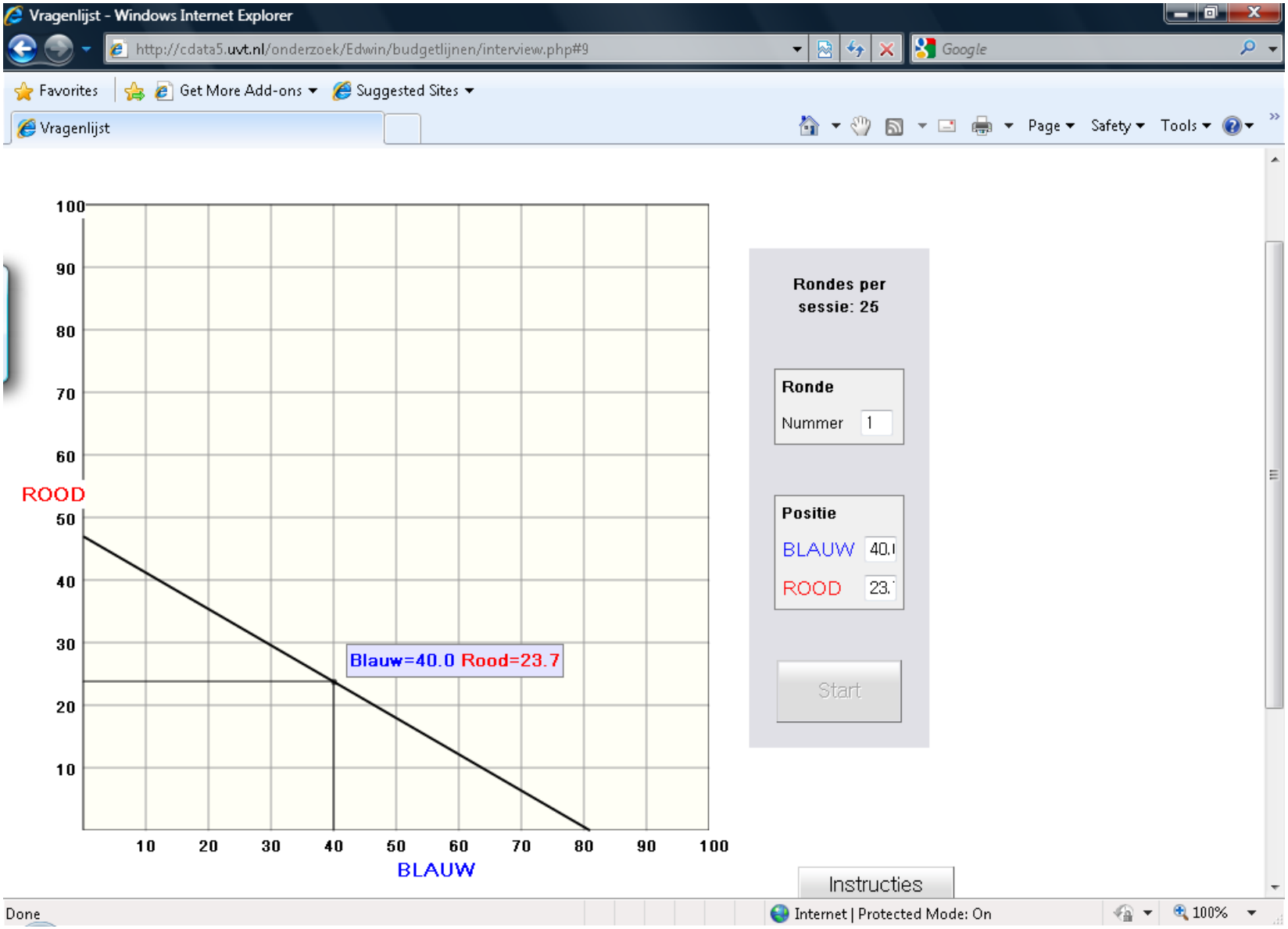
Decision in the Experiment

- Subjects are presented with a standard portfolio choice problem. There are two states of natures, $s = 1, 2$, that occur equally likely, and two Arrow securities corresponding to the two states.

- Subjects are allowed to choose any non-negative portfolio $x = (x_1, x_2)$ satisfying the budget constraint

$$p_1 x_1 + p_2 x_2 = 1.$$

- A graphical experimental interface displays randomly generated budget sets from which subjects make choices by "pointing and clicking".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Page
Safety
Tools
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ROOD
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10 20 30 40 50 60 70 80 90 100
BLAUW
Blauw=40.0 Rood=23.7
Rondes per sessie: 25
Ronde
Nummer 1
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BLAUW 40.
ROOD 23.
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Environment

- The field environment is the CentERpanel that consists of over 2000 households in the Netherlands.

- The panel members complete survey questionnaires on the internet from home every weekend.

- Incorporating the graphical interface into the CentERpanel survey allows large scale, web-based experiments.

- The surveys include data on individual socio-demographic variables and economic activities such as saving and investment.

Experimental procedures

- The experiment was conducted in late May 2009. Among 2340 panel members who were initially invited, 1372 members logged on to the experiment.

- 1182 members (86.2%) completed the experiment while 190 subjects (13.8%) did not.

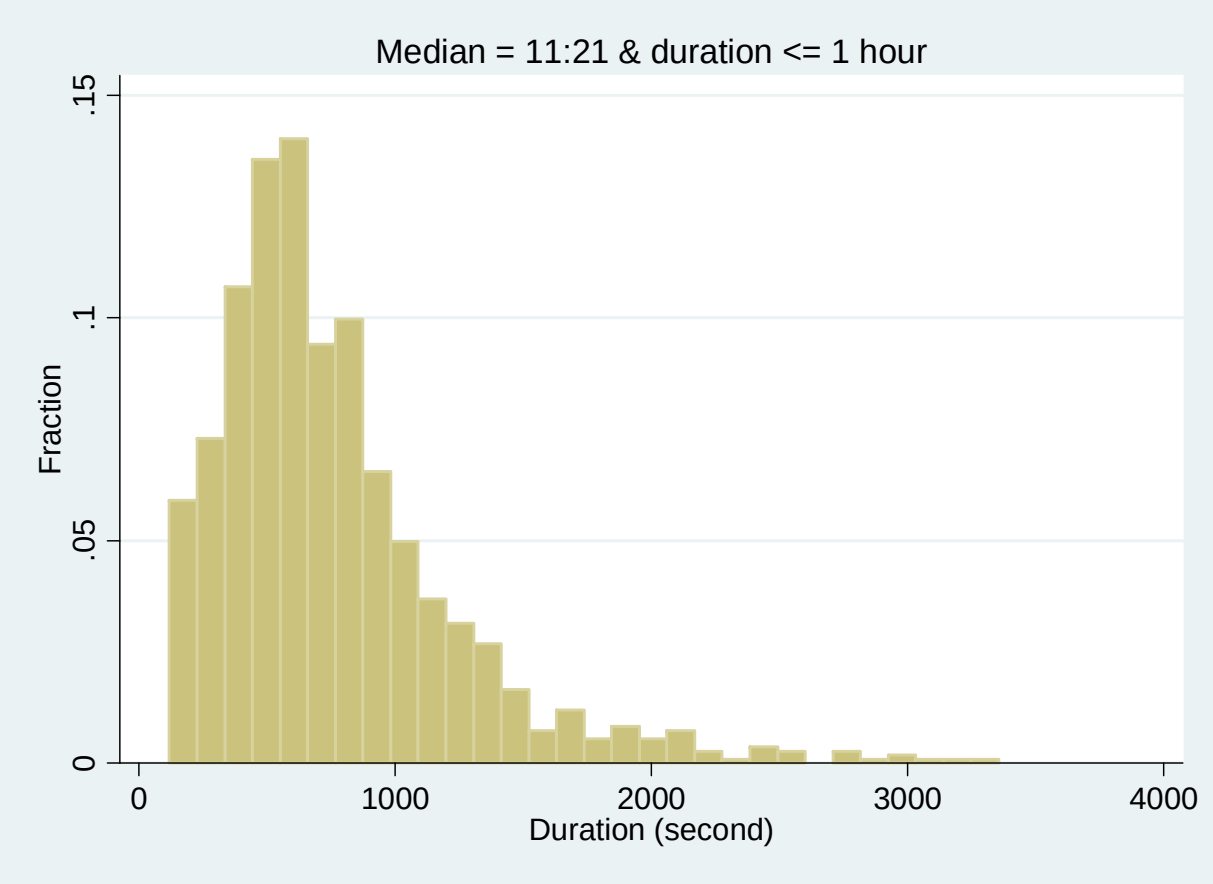
- Each subject repeated 25 independent decisions, one of which was randomly selected for payment at the end.

- The average earning in the experiment is € 6.58 with the maximum € 24.93 and the minimum € 0.

Descriptive statistics

	Final sample	Drop-outs	Non-participants
Female	45.43	37.89	50.00
Age			
Age 16 - 34	18.53	3.16	26.14
Age 35 - 49	26.14	12.11	32.13
Age 50 - 64	35.62	38.42	27.58
Age 65 +	19.71	46.32	14.15
Education			
Low	33.59	42.63	30.99
Medium	29.70	22.63	31.61
High	36.72	34.74	37.40
Income			
Less than EUR 2500	22.42	34.73	21.28
EUR 2500 - 3499	25.13	26.32	18.90
EUR 3500 - 4999	28.85	16.32	28.93
EUR 5000 +	23.60	22.63	30.89
Occupation			
Paid work	53.13	39.47	62.91
House work	11.59	7.89	8.78
Retired	20.90	42.63	13.95
Others	14.38	10.00	14.36
Household composition			
Partner	80.88	67.89	82.64
# of kids	0.84	0.32	1.09
# of observations	1182	190	968

The Distribution of Individual Duration in the Experiment



Rationality

Let $\{(p^t, x^t)\}_{t=1}^{25}$ be some observed individual data (p^t denotes the t-th observation of the price vector and x^t denotes the associated portfolio).

A utility function $U(x)$ *rationalizes* the observed behavior if it achieves the maximum on the budget set at the chosen portfolio

$$U(x^t) \geq U(x) \text{ for all } x \text{ s.t. } p^t \cdot x^t \geq p^t \cdot x.$$

Revealed Preference

A portfolio x^t is *directly revealed preferred* to a portfolio x if $p^t \cdot x^t \geq p^t \cdot x$.

A portfolio x^t is *(indirectly) revealed preferred* to x if there is a chain of directly revealed preferred portfolios linking x^t to x.

Generalized Axiom of Revealed Preference (GARP) *If x^t is revealed preferred to x^s, then x^s is not strictly directly revealed preferred (i.e. $p^s \cdot x^s \leq p^s \cdot x^t$) to x^t.*

GARP is tied to utility representation through the following theorem, which was first proved by Afriat (1967).

Afriat's Theorem *If the data satisfies GARP, then there exists a utility function that rationalizes the observed choices. Moreover, the utility function may be chosen to be increasing, continuous and concave.*

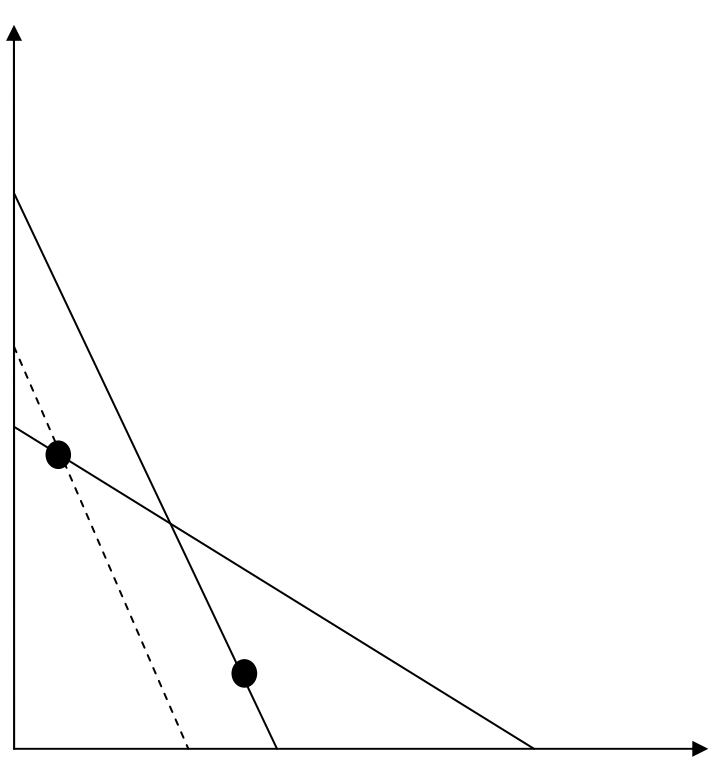
Goodness of Fit

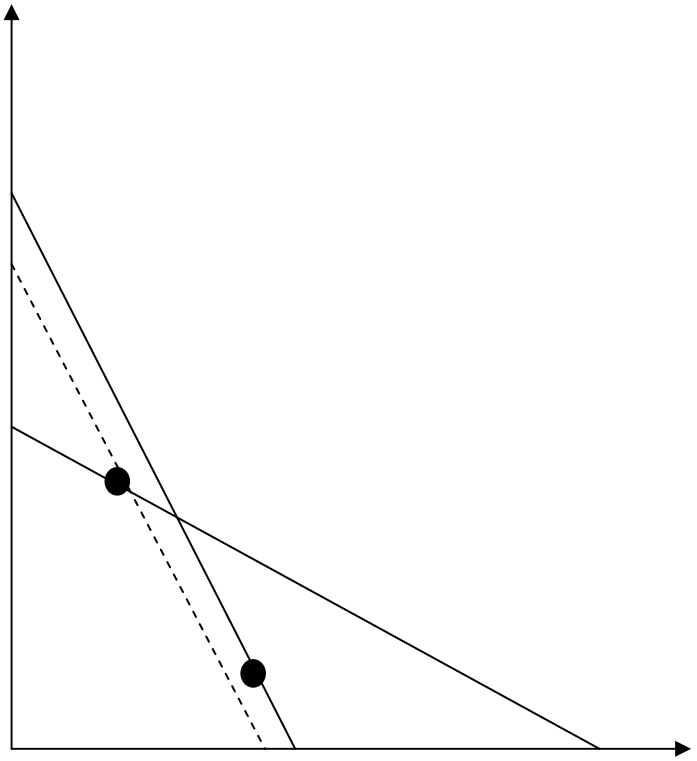
- GARP offers an exact test (either the data satisfy GARP or they do not).
- Since errors may be unavoidable, it is preferable to measure the extent (size of number) of GARP violations.
- We report a measure of GARP violation based on what Afriat (1972) calls the critical cost efficiency index (CCEI).

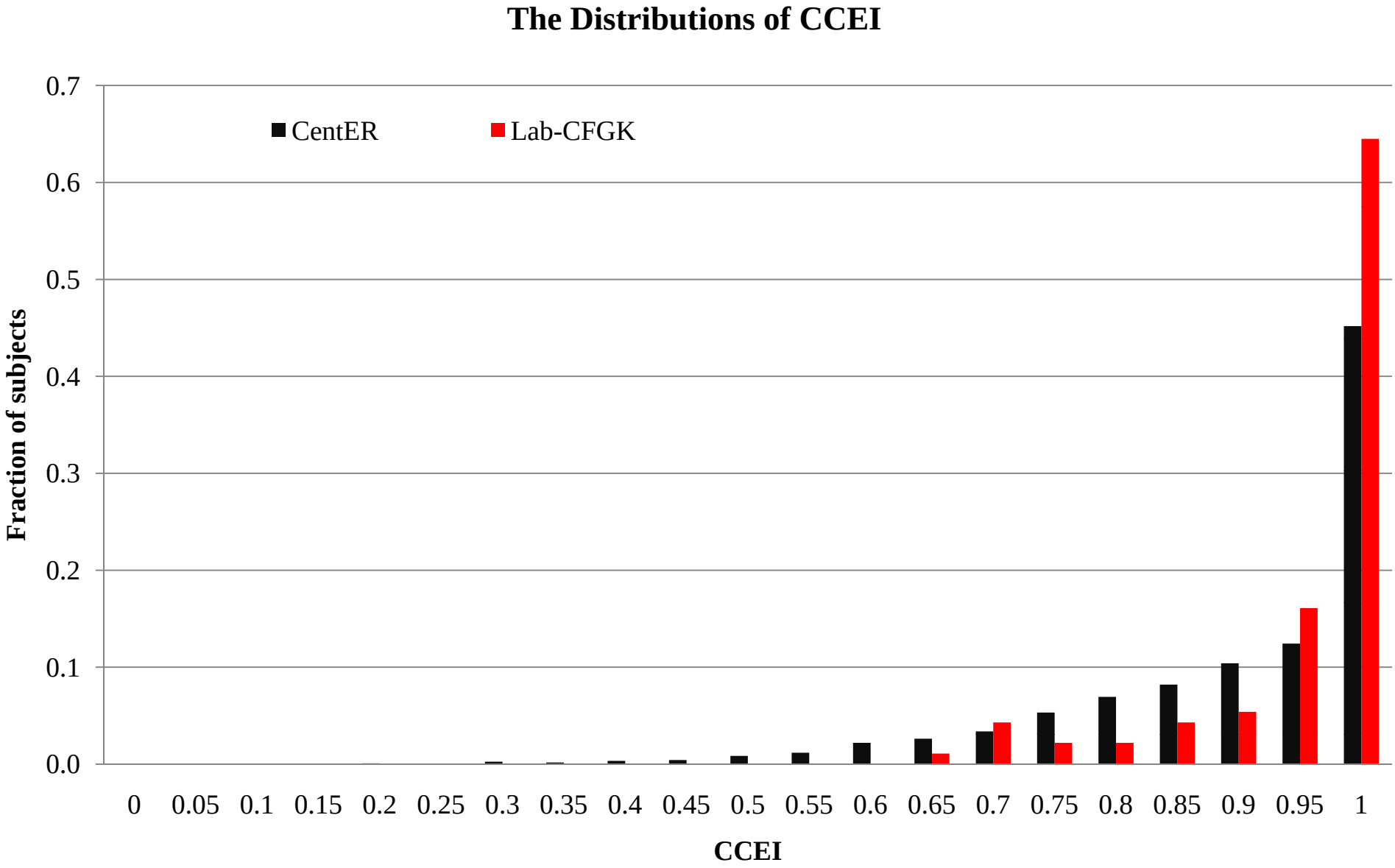
Afriat's critical cost efficiency index (CCEI) *How much we have to relax every budget constraint in order for the data to be consistent with maximization.*

The CCEI is bounded between zero and one. The closer it is to one, the smaller the perturbation required to remove all violations and thus the closer the data are to satisfying GARP.

Comparisons of CCEIs for a simple violation of GARP






The Distributions of CCEI
CentER
Lab-CFGK
Fraction of subjects
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
CCEI

CCEI and Economic Cognition

- Instead of adopting a dichotomous view on rationality / irrationality in economic behavior, we may want to develop a continuous measure of "economic cognition".

- CCEI is a natural candidate of measuring the degree of rationality or economic cognition.

- There is notable evidence that some observable variables in the panel data are linked to the variations in CCEI.

Relation between CCEI and background information

	OLS	QR - 25 %	QR - 75 %	Fractional logit
Constant	.887***	.863***	.967***	2.228***
	(.022)	(.039)	(.002)	(.208)
Female	-.024***	-.048***	-.001*	-.238***
	(.009)	(.015)	(.001)	(.085)
Age				
Age 35 - 49	-.016	-.037	-.001	-.194
	(.011)	(.022)	(.001)	(.142)
Age 50 - 64	-.052***	-.101***	-.011***	-.566***
	(.011)	(.021)	(.001)	(.126)
Age 65 +	-.051**	-.136***	.001	-.565***
	(.020)	(.033)	(.001)	(.183)
Education				
Medium	.009	.022	.003***	.068
	(.011)	(.018)	(.001)	(.096)
High	.026**	.062***	.004***	.242**
	(.011)	(.019)	(.001)	(.104)
Income				
EUR 2500 - 3499	.026**	.052**	.005***	.230**
	(.012)	(.020)	(.001)	(.110)
EUR 3500 - 4999	.020	.028	.005***	.171
	(.013)	(.021)	(.001)	(.118)
EUR 5000 +	.033**	.051**	.006***	.312**
	(.014)	(.023)	(.001)	(.133)
Occupation				
Paid work	.028	-.009	.026***	.234
	(.018)	(.028)	(.001)	(.144)
House work	.047**	.054*	.026***	.406**
	(.021)	(.032)	(.001)	(.171)
Others	.037*	.010	.026***	.306*
	(.019)	(.032)	(.001)	(.160)
Partner	-.026**	-.023	-.003***	-.258**
	(.011)	(.019)	(.001)	(.110)
# of kids	.001	.003	.001*	-.002
	(.004)	(.008)	(.000)	(.045)
(pseudo) R2 / log pseudo likelih	.068	0.055	0.018	-325.71
# of observations	1182	1182	1182	1182

Demand Behavior

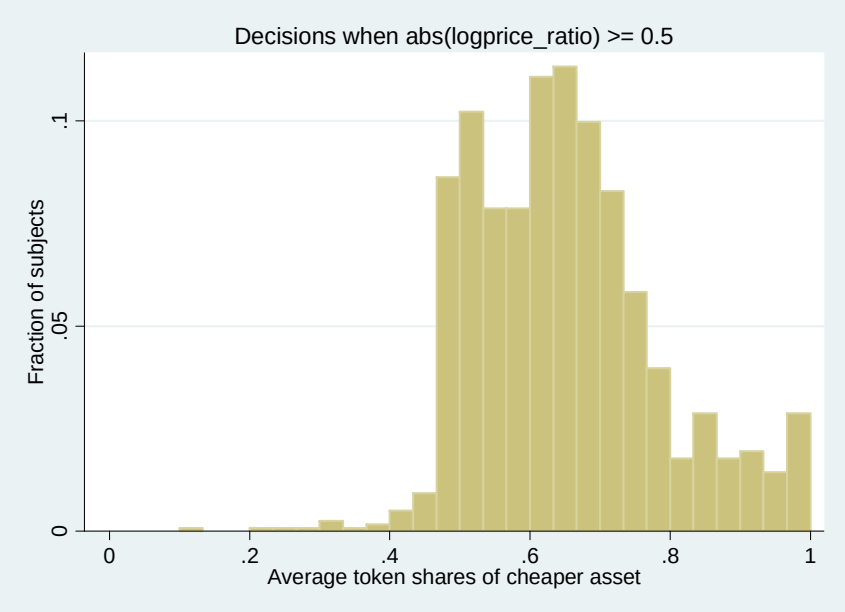
- We overview the demand behavior both at the aggregate level and at the individual level.

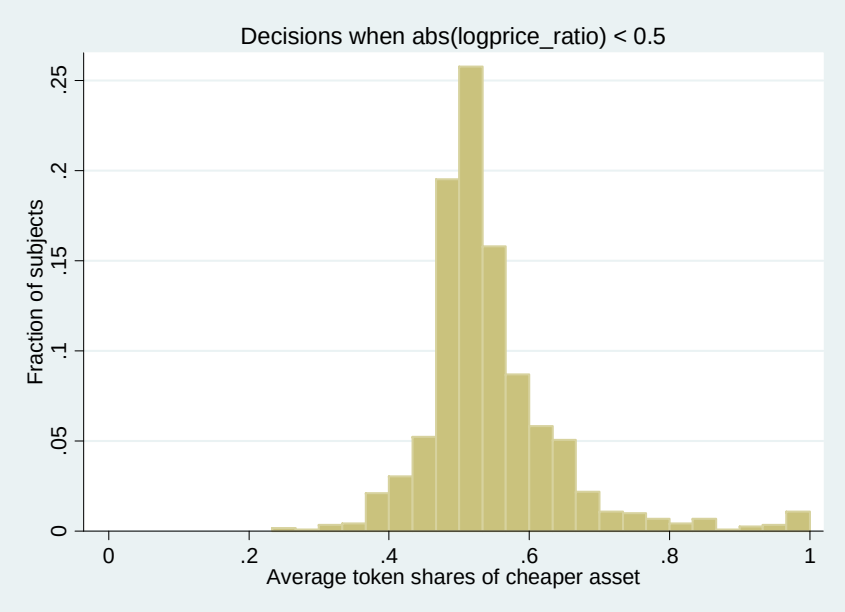
- For the aggregate behavior, we consider the distribution of average token shares for cheaper asset: $x_{cheaper}/\left(x_1 + x_2\right)$.

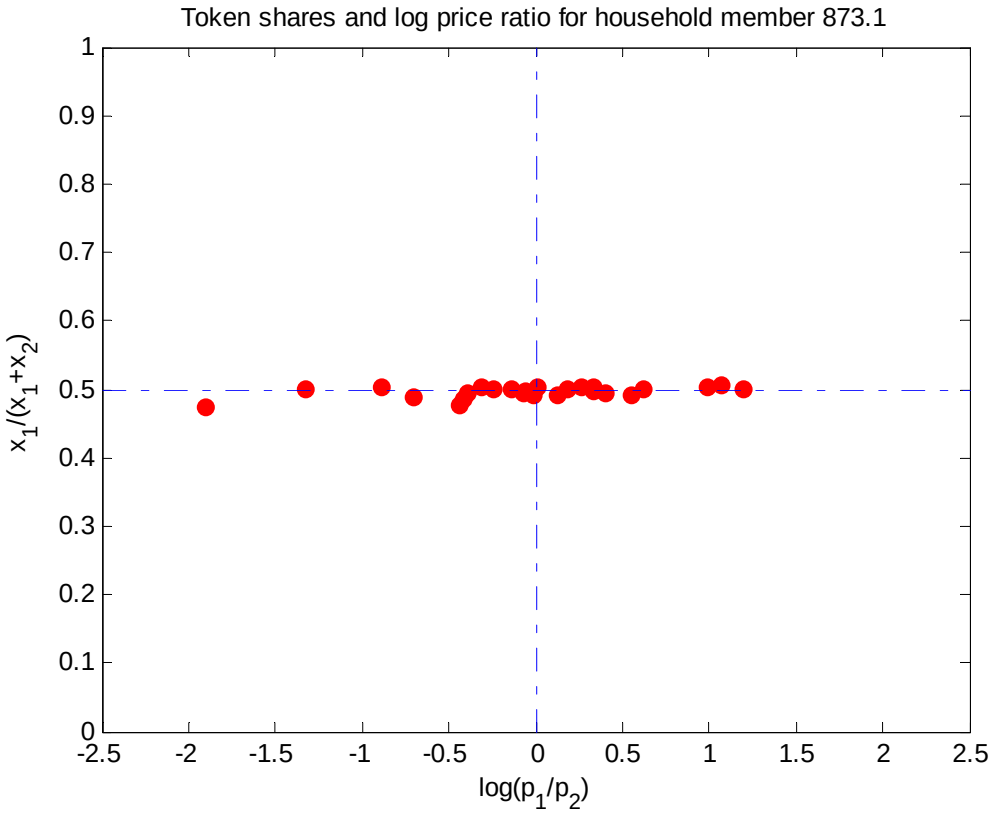
- For the individual behavior, we select some individuals to draw the scatter plots between $\ln\left(p_1/p_2\right)$ and $x_1/\left(x_1 + x_2\right)$.

  - Despite the heterogeneity, there are regular patterns within and across individual subjects.

The Distributions of Individual Average Token Shares of Cheaper Asset





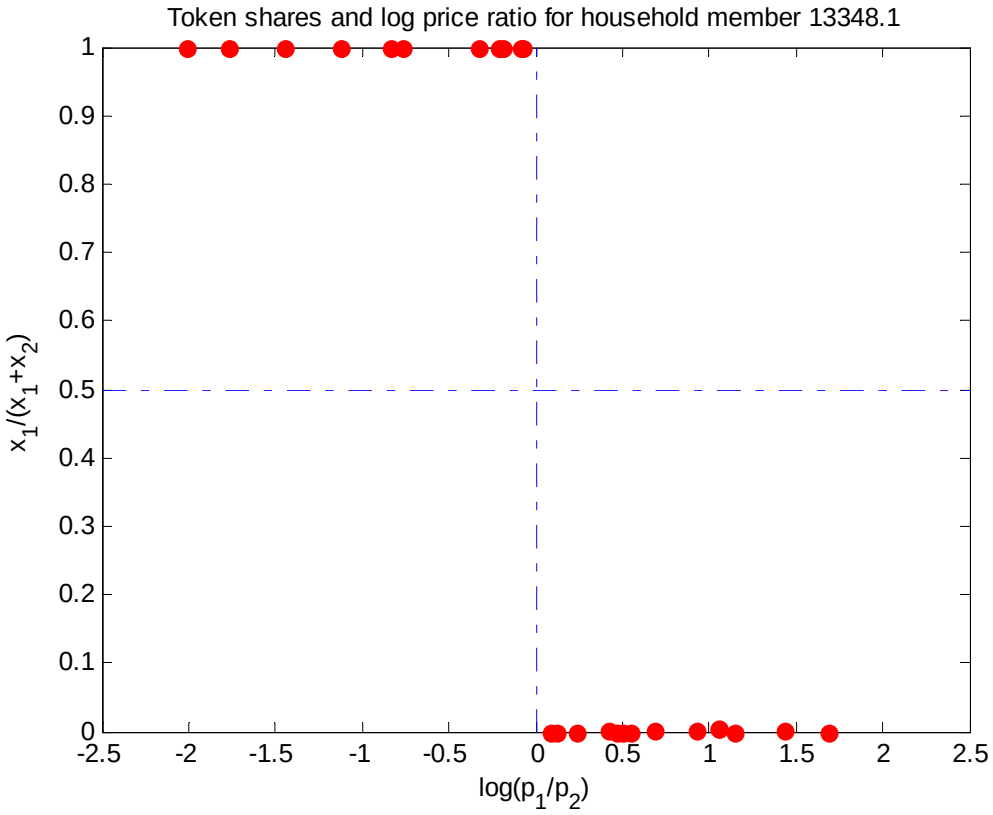


CCEI = 1; Male; 51 years old

Paid work; Mid education

HH income = €2600

# of HH members = 4

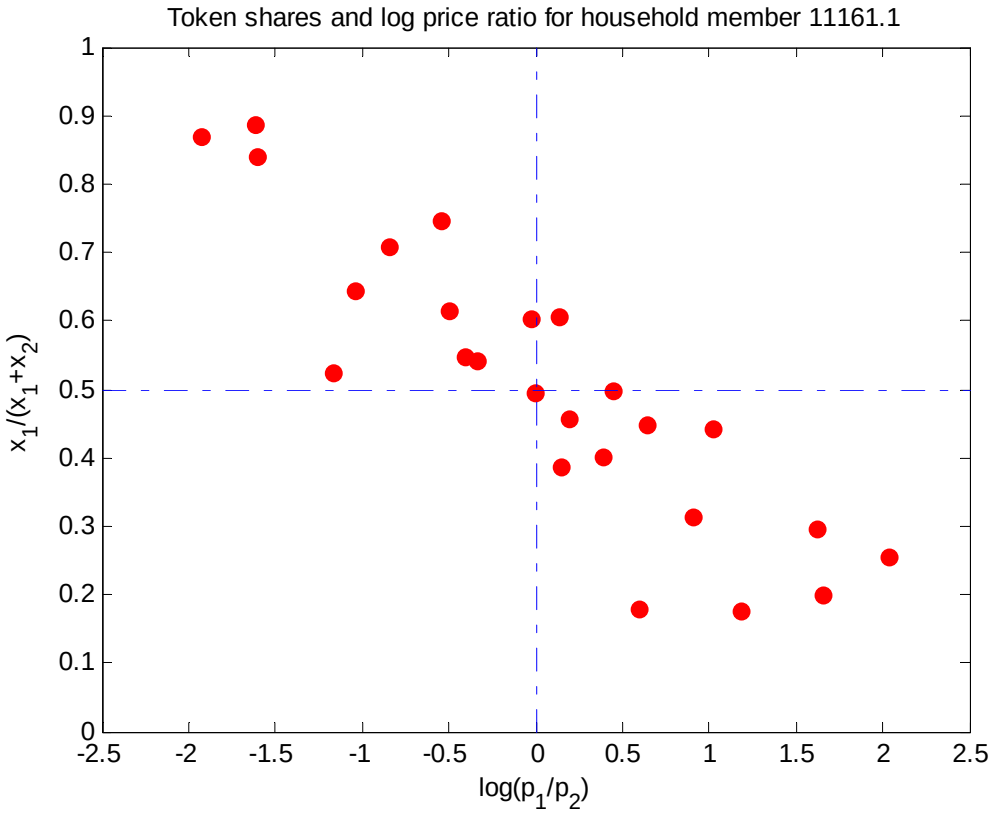


CCEI = 1; Male; 39 years old

Paid work; High education

HH income = €3500

# of HH members = 1

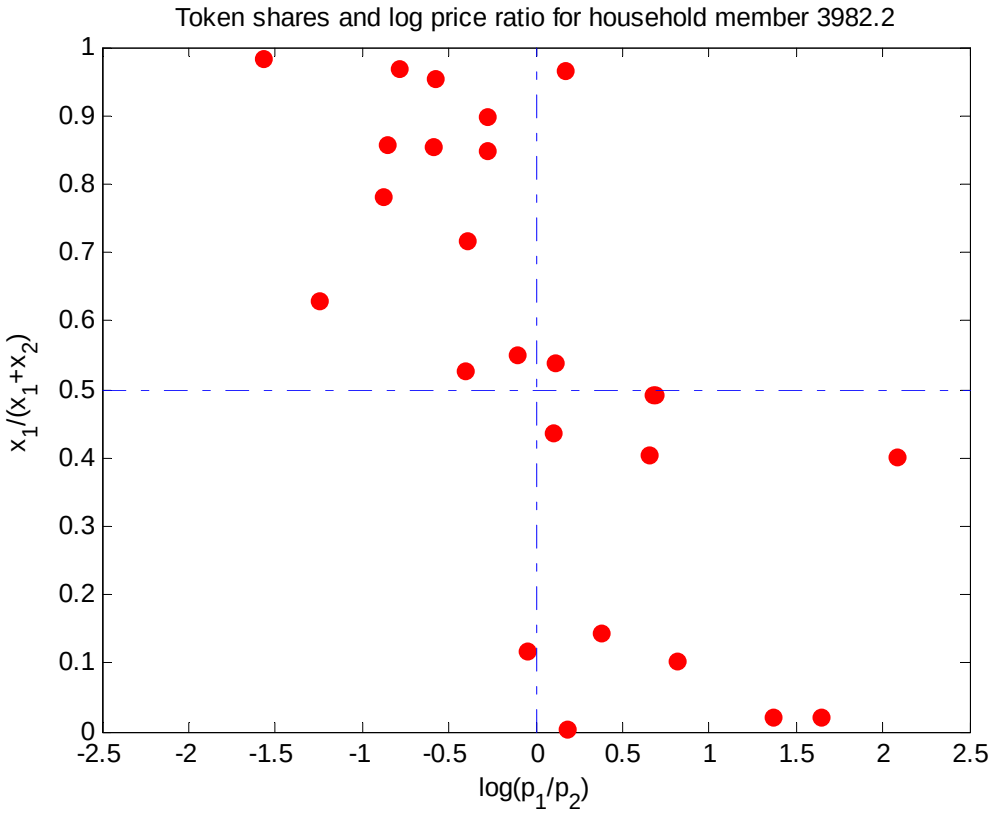


CCEI = 1; Female; 47 years old

Paid work; High education

HH income = €5164

# of HH members = 5

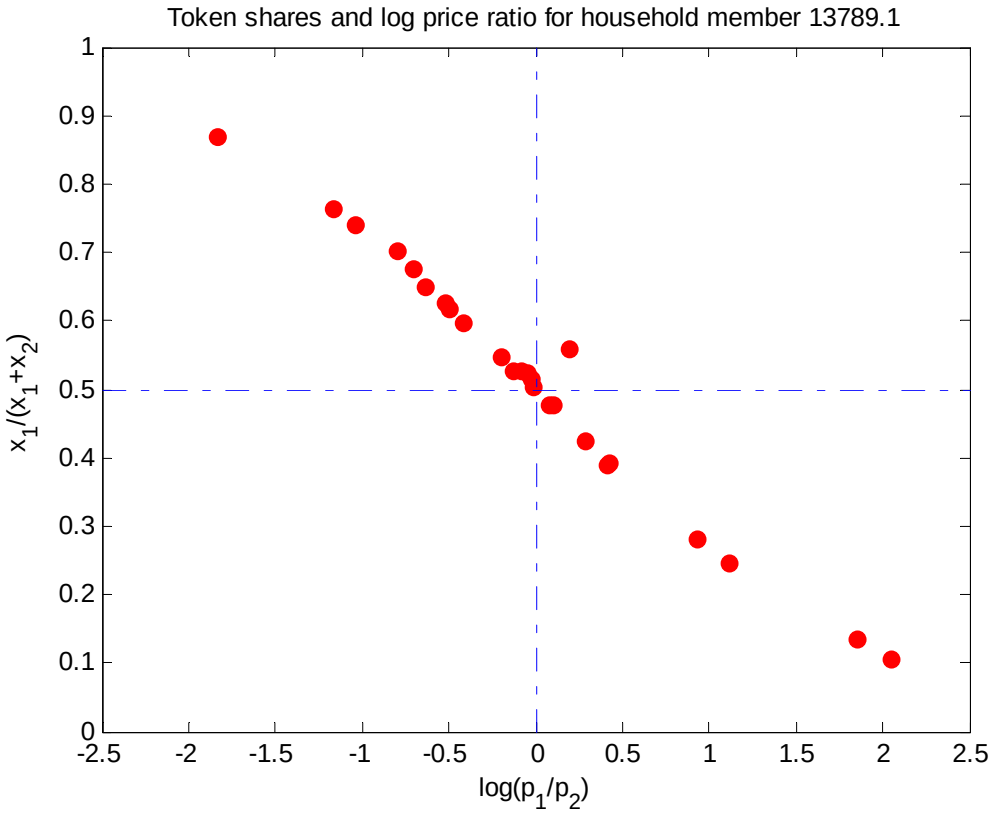


CCEI = 0.841; Male; 77 years old

Retired; Low education

HH income = €2060

# of HH members = 2

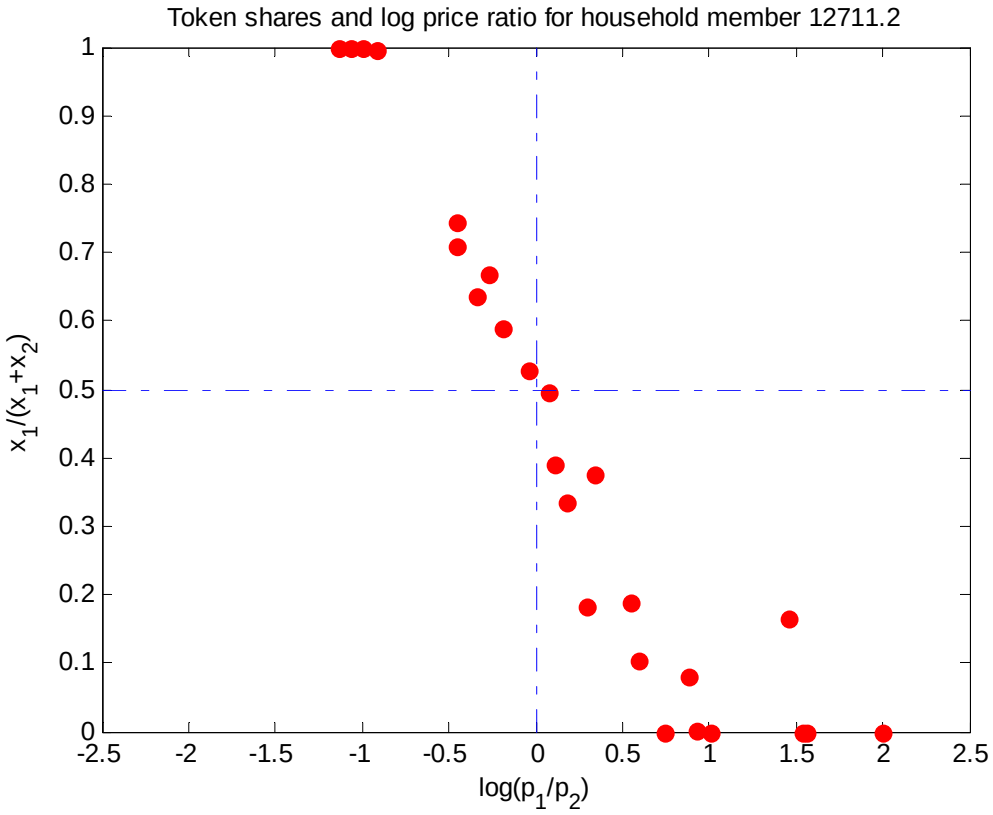


CCEI = 1; Male; 57 years old

Else; Mid education

HH income = €2500

# of HH members = 1

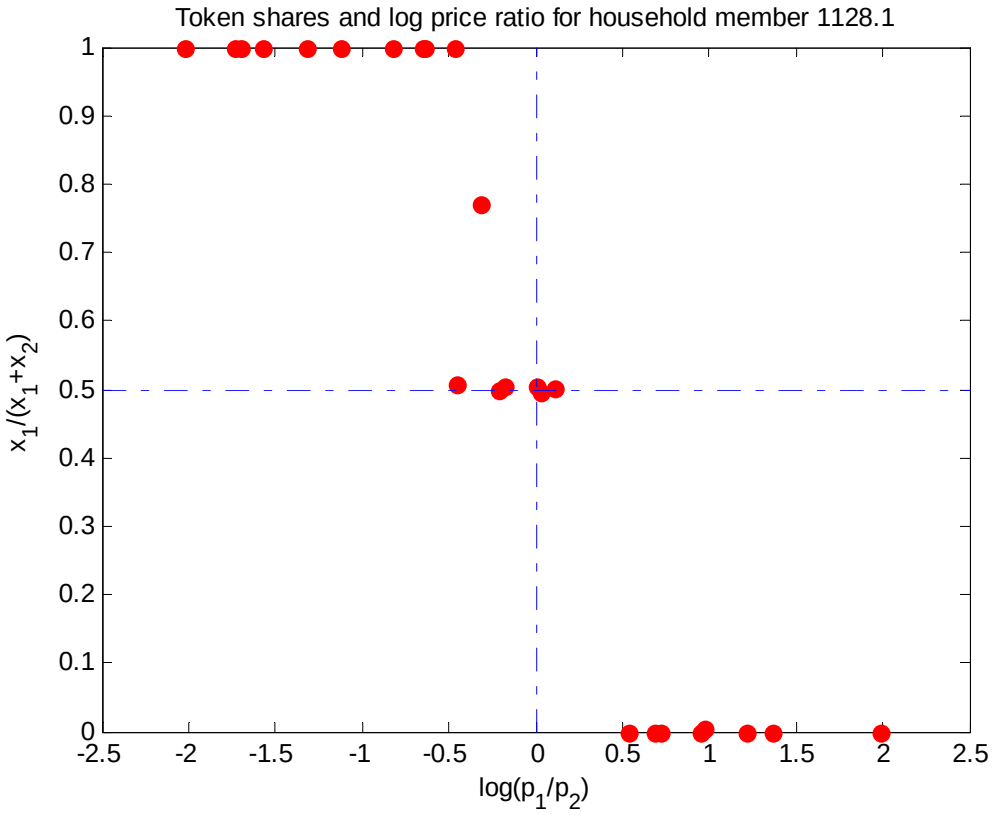


CCEI = 1; Female; 39 years old

Paid work; High education

HH income = €5432

# of HH members = 2

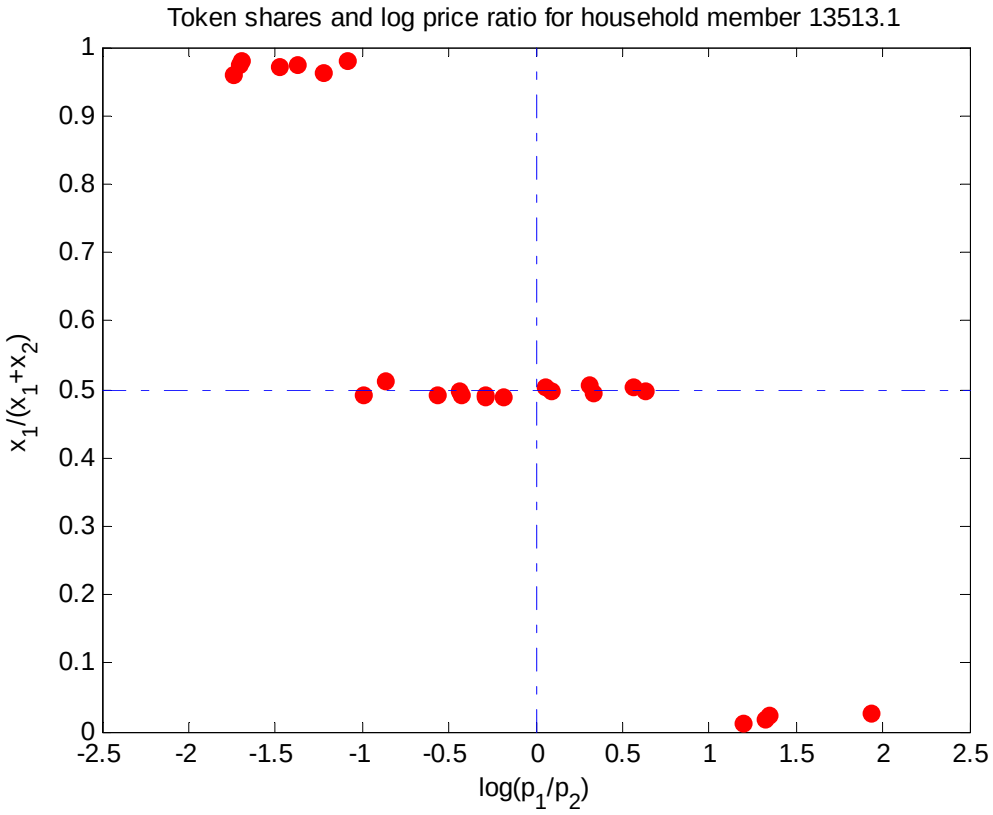


CCEI = 1; Male; 49 years old

Paid work; High education

HH income = €2860

# of HH members = 1

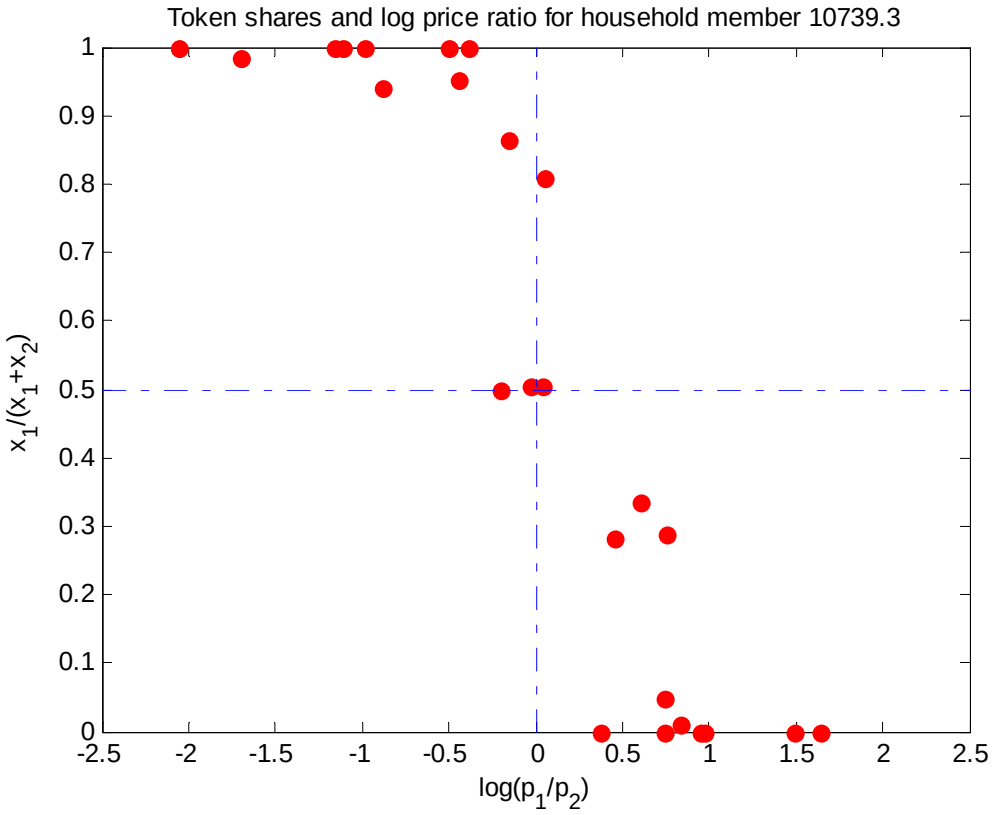


CCEI = 0.978; Male; 42 years old

Paid work; High education

HH income = €4700

# of HH members = 1



CCEI = 0.939; Male; 21 years old

Students; Mid education

HH income = €5937

# of HH members = 4

Specification for Preferences

- Choi et al. (2007) propose a two-parameter utility function based on the theory of loss / disappointment aversion by Gul (1991), where the safe portfolio is taken to be the reference point.

- Specifically, the utility function over portfolios (x_1, x_2) takes the form: for $\alpha \geq 1$,

$$\min \left\{ \alpha u\left(x_1\right) + u\left(x_2\right), u\left(x_1\right) + \alpha u\left(x_2\right) \right\},$$

where

$$u\left(x\right) = \frac{x^{1-\rho}}{1-\rho} \text{ or } -e^{-Ax}.$$

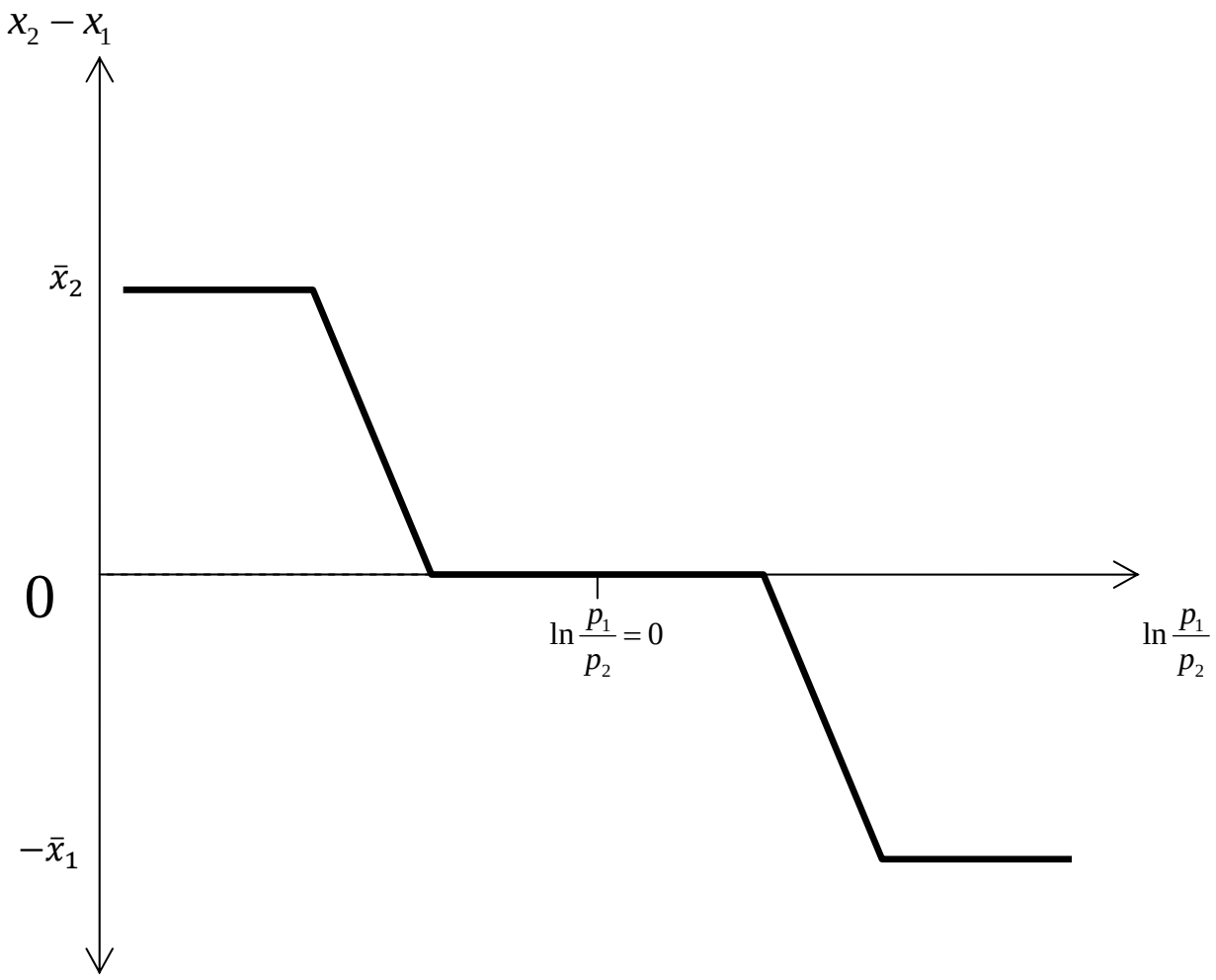
- If $\alpha = 1$, this amounts to the standard EUT representation. If $\alpha > 1$, there is a kink in an indifference curve along 45 degree line.

- Each utility specification represents a different relationship between portfolio choices $\left(\ln\left(\frac{x_1}{x_2}\right) \text{ or } (x_2 - x_2)\right)$ and log price ratios.

First-order Conditions from CARA

$$x_2^* - x_1^* = \begin{cases} \bar{x}_2 & \ln\left(\frac{\bar{x}_2}{\bar{x}_1}\right) \geq \ln\alpha + A\bar{x}_2, \\ \frac{1}{A}\left[\ln\left(\frac{\bar{x}_2}{\bar{x}_1}\right) - \ln\alpha\right] & \ln\alpha < \ln\left(\frac{\bar{x}_2}{\bar{x}_1}\right) < \ln\alpha + A\bar{x}_2, \\ 0 & -\ln\alpha \leq \ln\left(\frac{\bar{x}_2}{\bar{x}_1}\right) \leq \ln\alpha, \\ \frac{1}{A}\left[\ln\left(\frac{\bar{x}_2}{\bar{x}_1}\right) + \ln\alpha\right] & -\ln\alpha + A\bar{x}_1 < \ln\left(\frac{\bar{x}_2}{\bar{x}_1}\right) < -\ln\alpha, \\ -\bar{x}_1 & \ln\left(\frac{\bar{x}_2}{\bar{x}_1}\right) \leq -\ln\alpha + A\bar{x}_1. \end{cases}$$

An illustration of the relationship between $\ln(p_1 / p_2)$ and $x_2 - x_1$ from CARA function



Linking to the Panel Data

- We extend this to estimate the population distribution of individual parameters of loss and risk preferences.

- The model allows individual heterogeneity with respect to observable characteristics and unobservable factors.

- Thus, the model can be interpreted as a type of random coefficients model.

- A similar approach has been adopted in different contexts by Bellemare et al. (2008) and von Gaudecker et al. (2009).

- Specifically, we assume the following specification for (α_i, A_i) for individual subject i

$$\begin{aligned} \alpha_i - 1 &= \exp\left(Z_i\beta + \upsilon_i\right), \\ A_i &= \exp\left(Z_i\gamma + u_i\right), \end{aligned}$$

  where Z_i is a vector of observable characteristics and (υ_i, u_i) captures the unobserved heterogeneity component in the preference parameters. We further assume that (υ_i, u_i) follows a bivariate normal distribution with zero mean and covariance matrix Ω.

- This specification leads us to the method of maximum simulated likelihood estimation.

- We use the set of subjects whose CCEI is above 0.8.

Two Alternative Approaches

- There are two alternative (probably more naïve) approaches to estimate the relation between the behavior in experimental data and observable characteristics.

- The first method is regressing individual average token shares of cheaper asset on observable characteristics.

- The second one is (i) to estimate individual parameters (α, A) using only experimental data; (ii) then regress individual estimates on observable characteristics.

Relation between average token shares and background information: CCEI ≥ 0.8

	All 25 decisions	$\left\lvert \log\left(p_1 / p_2 \right) \right\rvert \geq 0.5$
Constant	.644***	.704***
	(.019)	(.025)
Female	-.021***	-.022**
	(.008)	(.010)
Age		
Age 35 - 49	-.011	-.015
	(.012)	(.016)
Age 50 - 64	-.048***	-.062***
	(.011)	(.015)
Age 65 +	-.054***	-.072***
	(.018)	(.023)
Education		
Medium	.018*	.025**
	(.009)	(.012)
High	.016*	.022*
	(.010)	(.013)
Income		
EUR 2500 - 3499	-.004	-.006
	(.011)	(.013)
EUR 3500 - 4999	-.007	-.008
	(.011)	(.014)
EUR 5000 +	.009	.007
	(.013)	(.016)
Occupation		
Paid work	-.009	-.018
	(.014)	(.018)
House work	.007	-.004
	(.017)	(.021)
Others	-.006	-.020
	(.016)	(.021)
Partner	.006	.012
	(.010)	(.013)
# of kids	-.005	-.007
	(.004)	(.005)
R2	0.045	0.044
# of observations	902	902

Relation between estimated loss/risk aversion parameters and background information: CCEI ≥ 0.8

	α	*A*
Constant	1.400***	.069***
	(.231)	(.022)
Female	.165*	-.026***
	(.097)	(.008)
Age		
Age 35 - 49	-.019	-.017
	(.133)	(.011)
Age 50 - 64	.174	-.005
	(.137)	(.011)
Age 65 +	.344*	.001
	(.196)	(.020)
Education		
Medium	.033	.007
	(.113)	(.010)
High	-.018	.009
	(.125)	(.010)
Income		
EUR 2500 - 3499	.021	-.021
	(.117)	(.013)
EUR 3500 - 4999	.261**	-.028**
	(.121)	(.013)
EUR 5000 +	.156	-.028*
	(.142)	(.015)
Occupation		
Paid work	.306*	.007
	(.156)	(.016)
House work	.130	.041**
	(.203)	(.020)
Others	-.015	.016
	(.175)	(.019)
Partner	-.081	.002
	(.134)	(.011)
# of kids	.057	.000
	(.050)	(.004)
R2	0.022	0.027
# of observations	814	901

What's next?

- With the current dataset we will, among others,
  - develop a type classification algorithm; link classified types with observable information.
  - investigate the relation between experimental measures (CCEI and attitudes toward risk) and real-life financial decision making.
- Over the next two years, we plan to conduct two more experiments in the CentERpanel survey:
  - a time preference experiment; risk/time experiments with repetition.