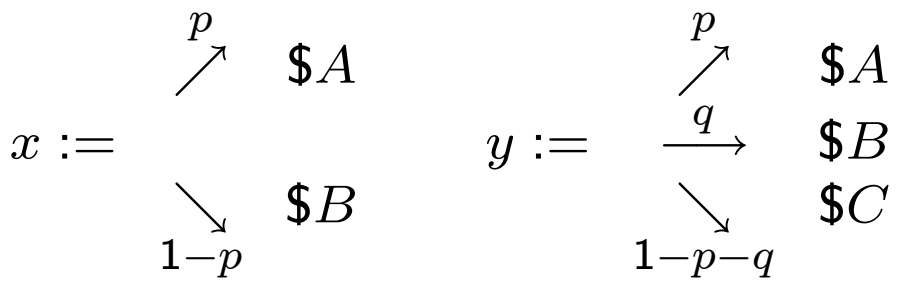
UC Berkeley
Haas School of Business
Game Theory
(EMBA 296 & EWMBA 211)
Summer 2015

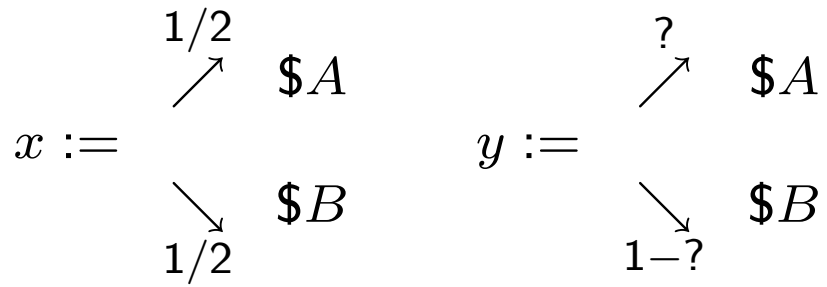
Risk preferences

Block 2
Jun 11-12, 2015

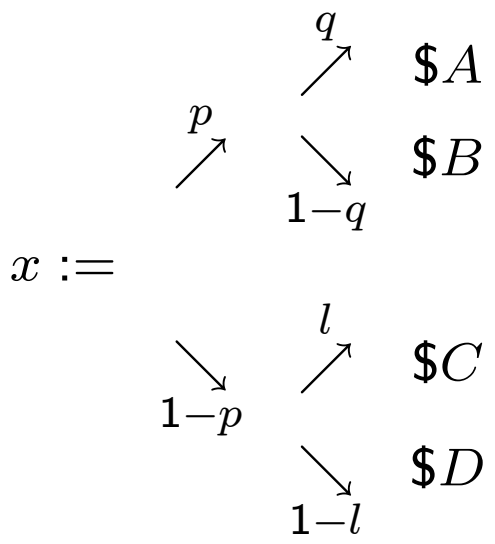
Life is full of lotteries :-(



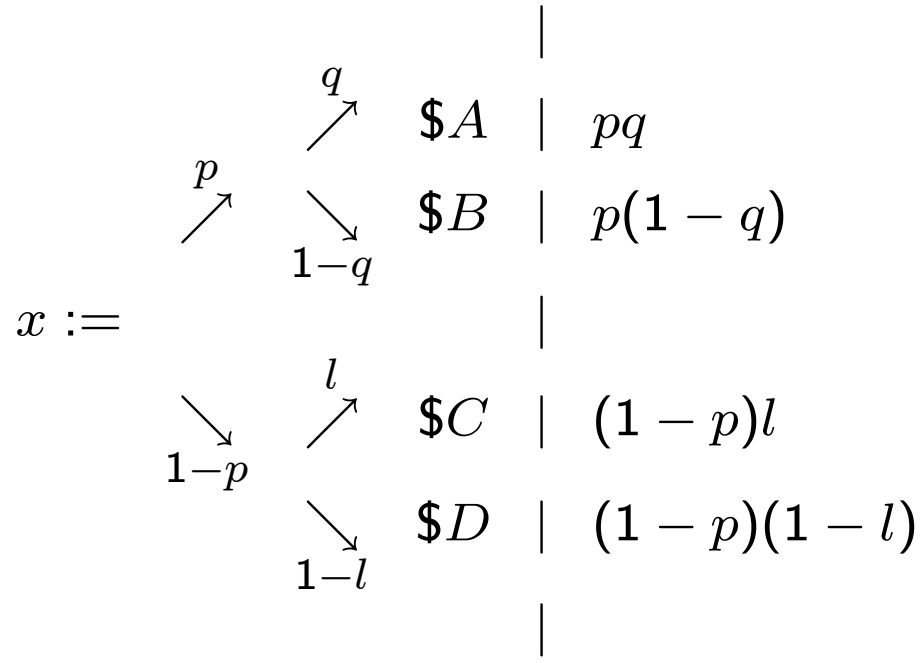
A risky lottery (left) and an ambiguous lottery (right)



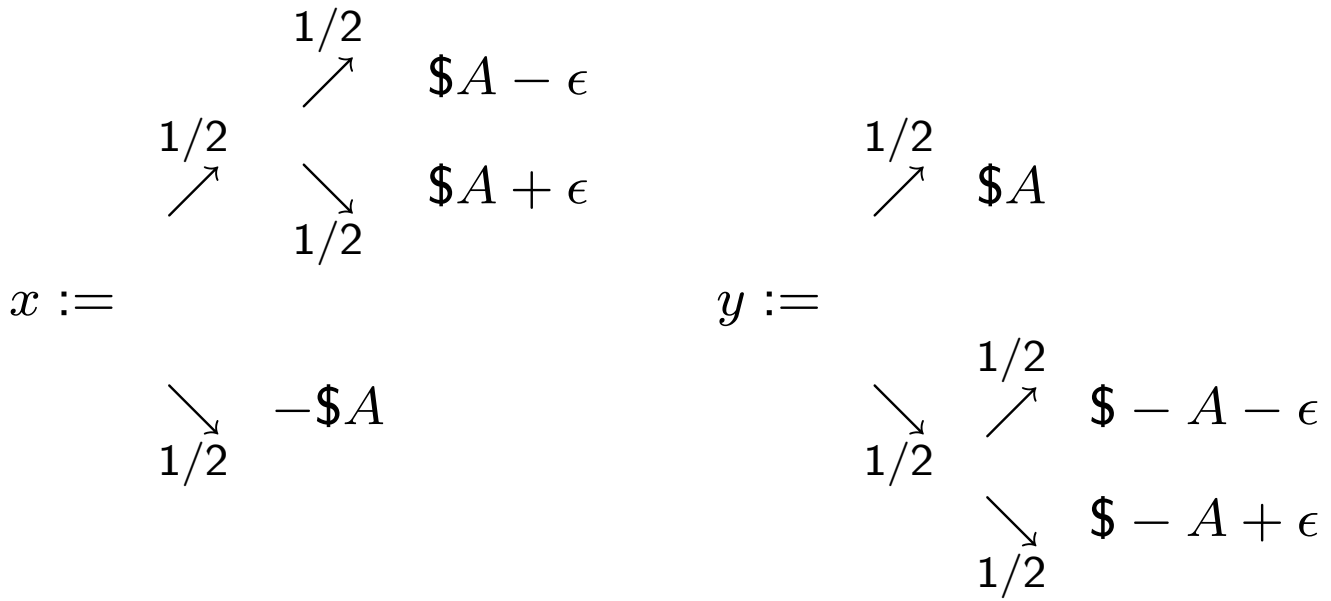
A compounded lottery



The reduction of a compounded lottery



Prudence

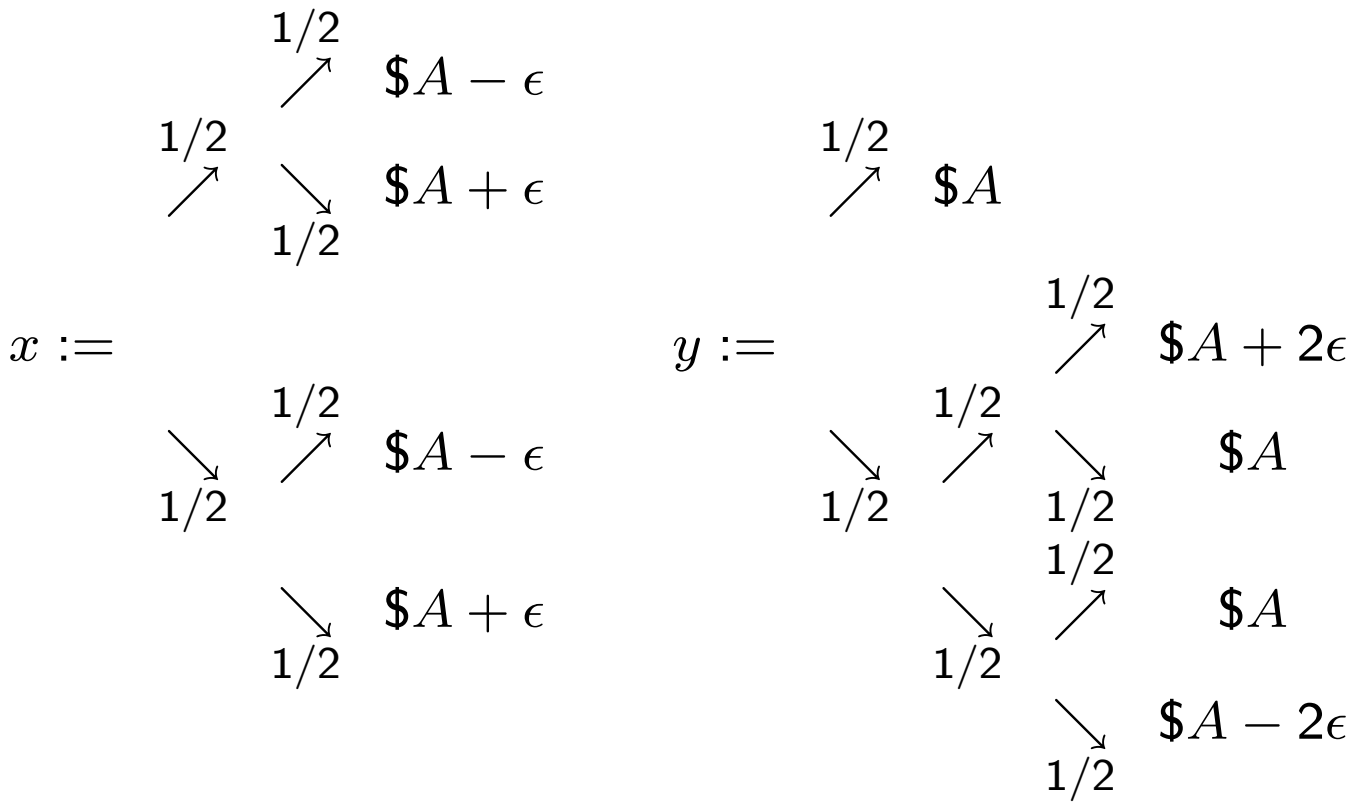

$x :=$
1/2
1/2
$\$A - \epsilon$
1/2
$\$A + \epsilon$
1/2
$-\$A$
$y :=$
1/2
$\$A$
1/2
1/2
$\$ - A - \epsilon$
1/2
$\$ - A + \epsilon$

What is prudence ?

Careful good judgment (caution or circumspection) that allows someone to avoid danger or risks. One of the four cardinal virtues or core values (the others are justice, courage and temperance).

An individual who is prudent prefers lottery x over lottery y.

Temperance



What is temperance?

Moderation in action, thought, or feeling, studied by religious thinkers, philosophers, and psychologists. It is considered a virtue, a core value that can be seen consistently across time and cultures.

A temperate individual prefers lottery x over lottery y.

Rationality

For any pair of lotteries x and y,

if the decision maker says that x is at least as good as y, we write

$$x \succsim y$$

and say that x is weakly preferred to y.

Foundations of Economic Analysis (1947)

Paul A. Samuelson (1915-2009) – the first American Nobel laureate in economics and the foremost (academic) economist of the 20th century (and the uncle of Larry Summers…).

The basic assumptions about preferences

The theory begins with three assumptions. These assumptions are so fundamental that we can refer to them as the "axioms" of decision theory.

[1] Completeness

$$x \succsim y \text{ or } y \succsim x$$

for any pair of lotteries x and y.

The second axiom is called transitivity:

[2] Transitivity

$$\text{if } x \succsim y \text{ and } y \succsim z \text{ then } x \succsim z$$

for any three lotteries x, y and z.

Together, completeness and transitivity constitute the formal definition of *rationality* as the term is used in economics. Rational decision makers are ones who

- have the ability to make choices [1],
- and whose choices display a logical consistency [2].

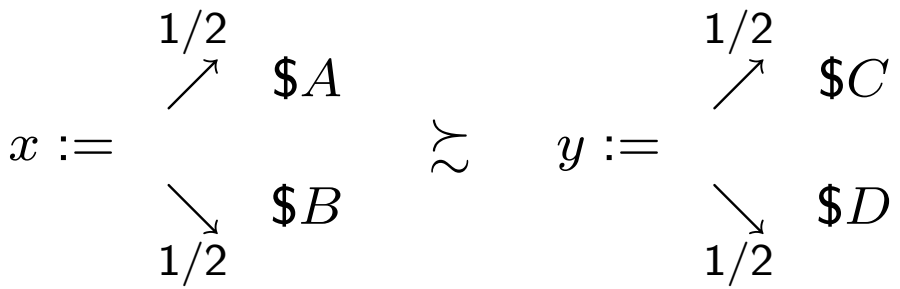
[3] The third axiom is called independence:

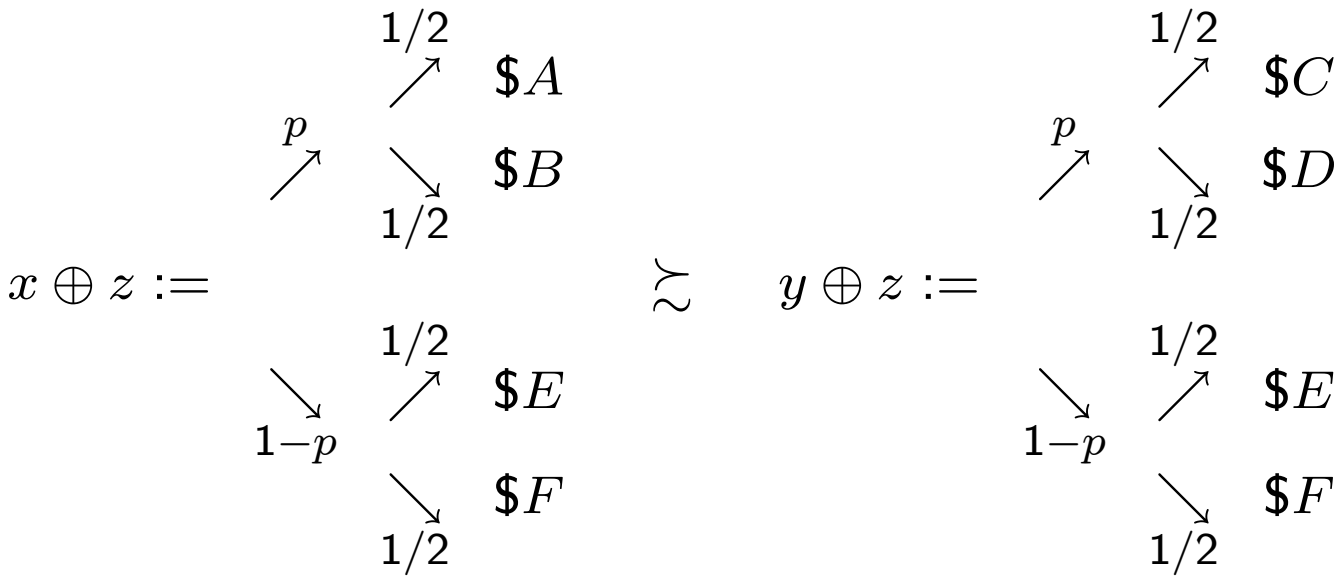
Independence

For any lotteries x, y, z and $0 < p < 1$

$$\text{if } x \succ y \quad \text{then } px + (1-p)z \succ py + (1-p)z.$$

Independence




$x \oplus z :=$
1/2
$A
p
$B
1/2
1/2
$E
1−p
$F
1/2
≿
$y \oplus z :=$
1/2
$C
p
$D
1/2
1/2
$E
1−p
$F
1/2

Allais (1953) I

Choose between the two lotteries:

$$x := \begin{array}{cc} \overset{.33}{\nearrow} & \$25,000 \\ \xrightarrow{.66} & \$24,000 \\ \underset{.01}{\searrow} & \$0 \end{array} \qquad y := \xrightarrow{1} \$24,000$$

Allais (1953) II

Choose between the two lotteries:

$$z := \begin{array}{ll} \overset{.33}{\nearrow} & \$25,000 \\ \searrow_{.67} & \$0 \end{array} \qquad w := \begin{array}{ll} \overset{.34}{\nearrow} & \$24,000 \\ \searrow_{.66} & \$0 \end{array}$$

A not-so-new experimental design

An experimental design that has a couple of innovations over previous work:

- A selection of a bundle of contingent commodities from a budget set (a portfolio choice problem).
- A graphical experimental interface that allows for the collection of a rich individual-level data set.

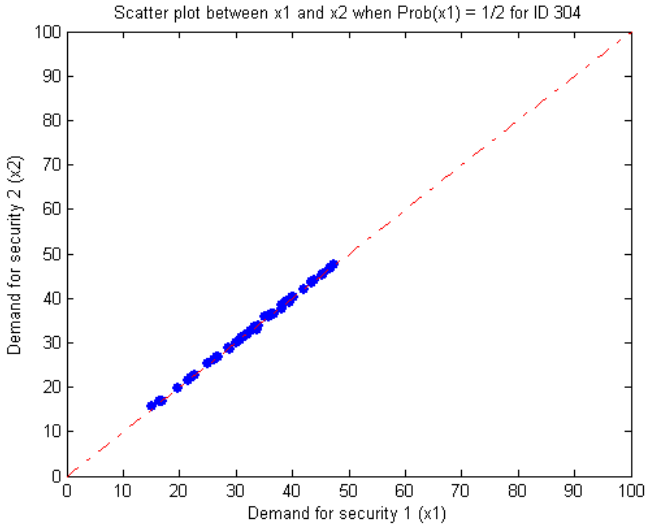
The CentERdata and American Life Panel

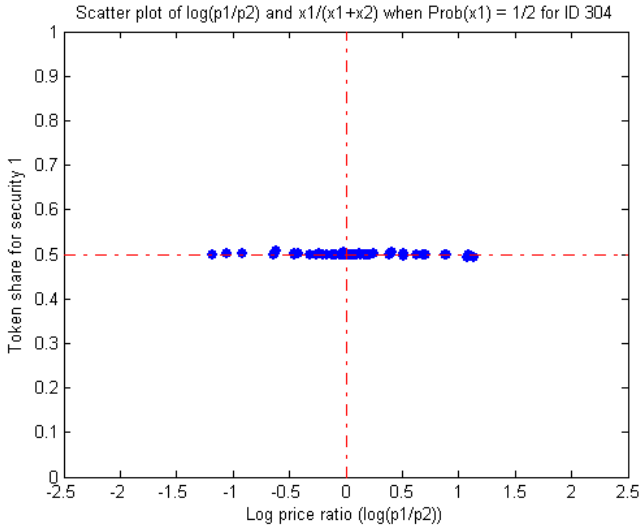
An uncommon opportunity to combine sophisticated experimental data with a wide range of individual economic and demographic information from survey data.

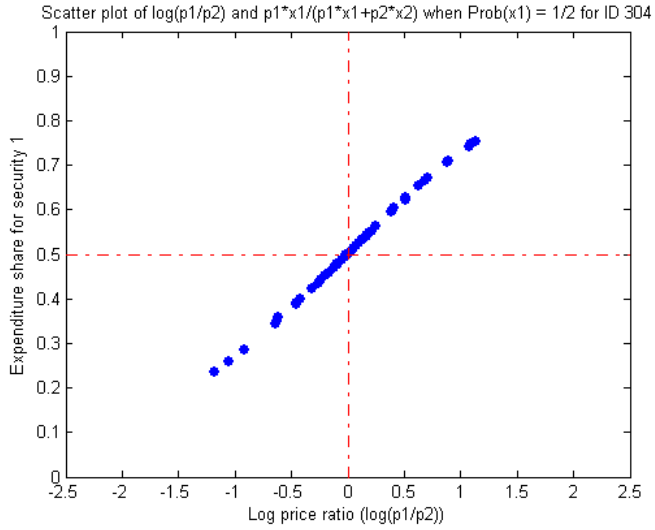
Our studies to date consist of a combination of structural and descriptive work and provides:

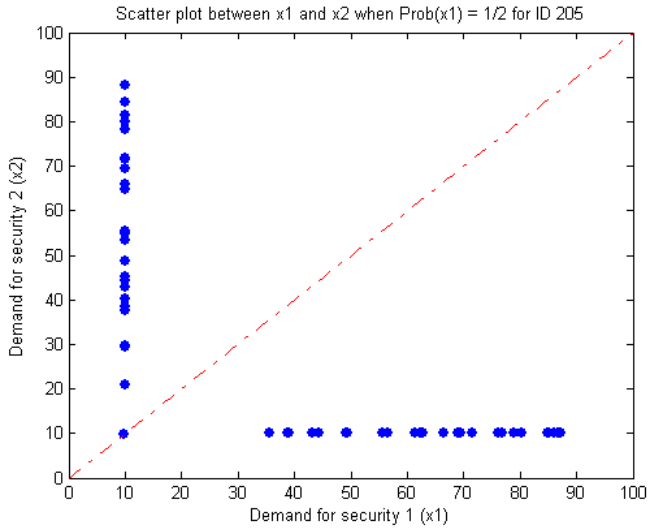
- analysis of the relationship between the degree of rationality, preferences, and socio-demographics
- investigation of the correspondence between experimental choice data to economic outcomes in "the wild."

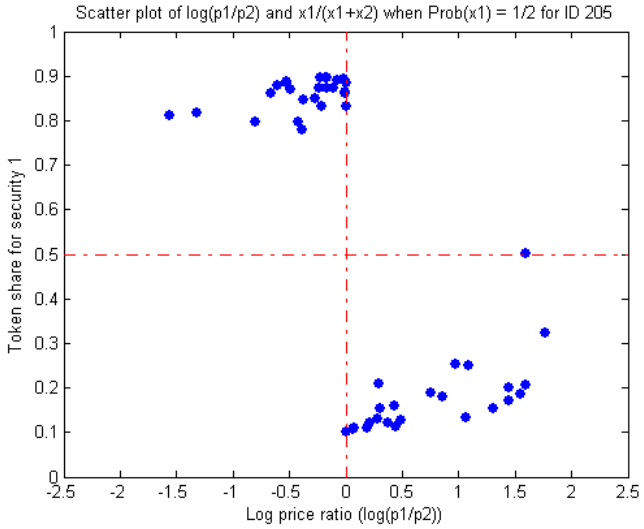
Individual-level data

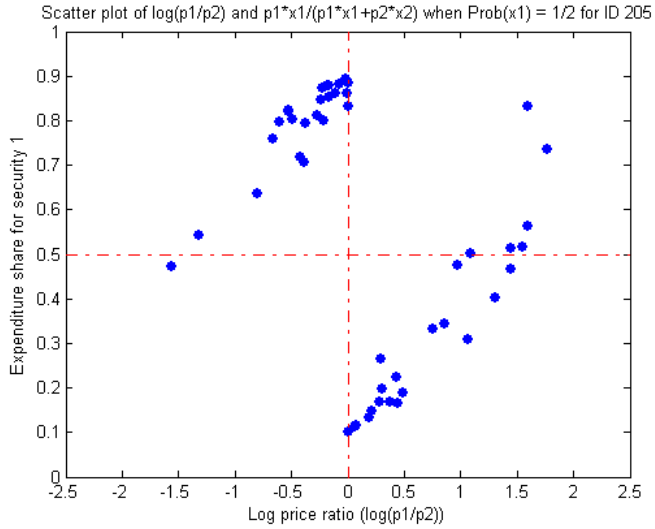


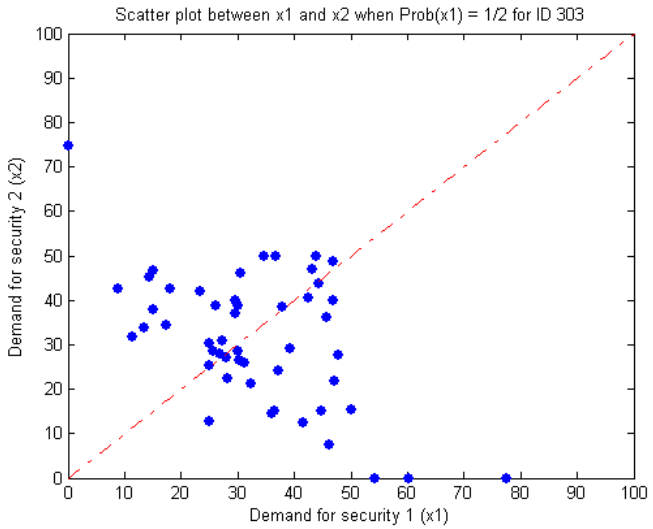


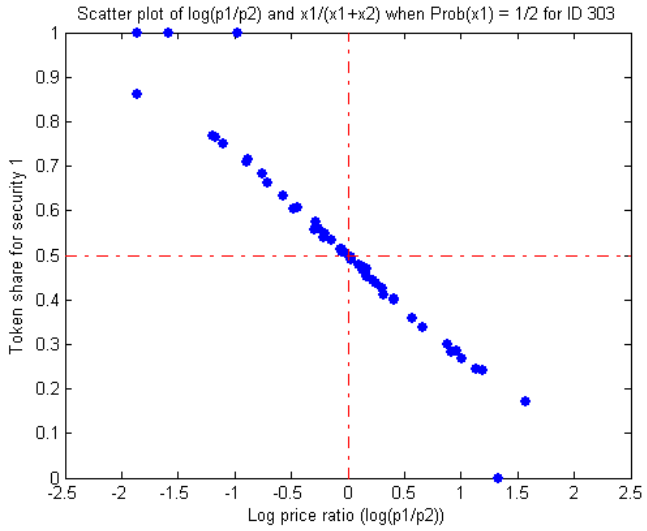


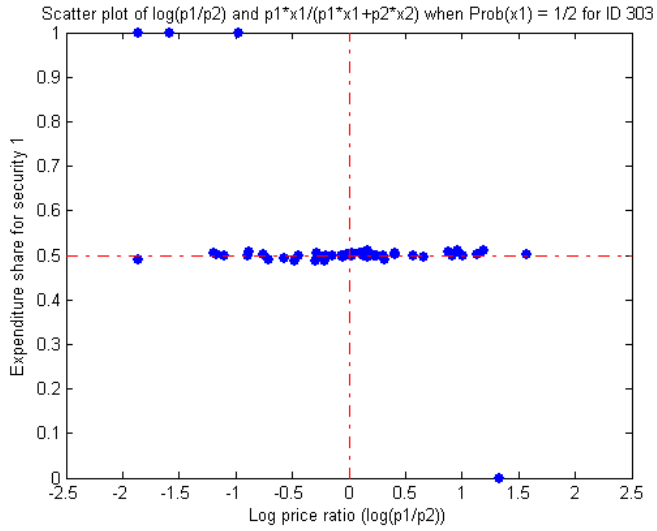

Scatter plot between x1 and x2 when Prob(x1) = 1/2 for ID 205
Demand for security 2 (x2)
Demand for security 1 (x1)
0
10
20
30
40
50
60
70
80
90
100

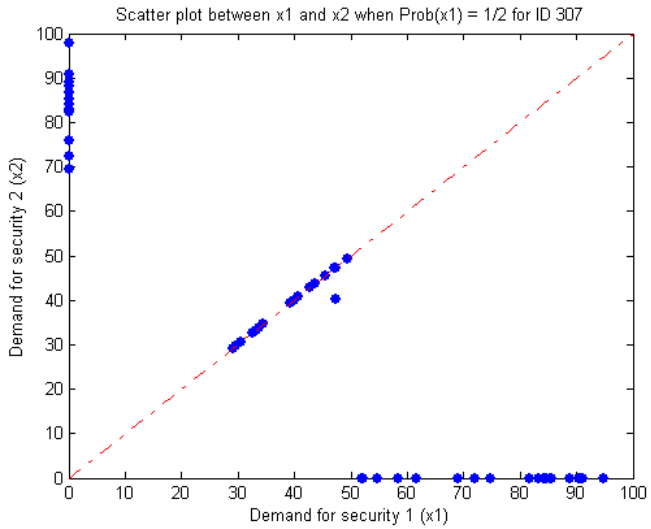

Scatter plot of log(p1/p2) and x1/(x1+x2) when Prob(x1) = 1/2 for ID 205
Token share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

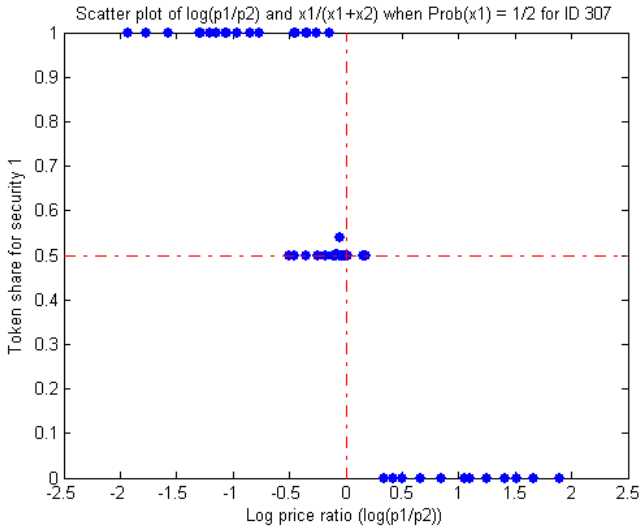

Scatter plot of log(p1/p2) and p1*x1/(p1*x1+p2*x2) when Prob(x1) = 1/2 for ID 205
Expenditure share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

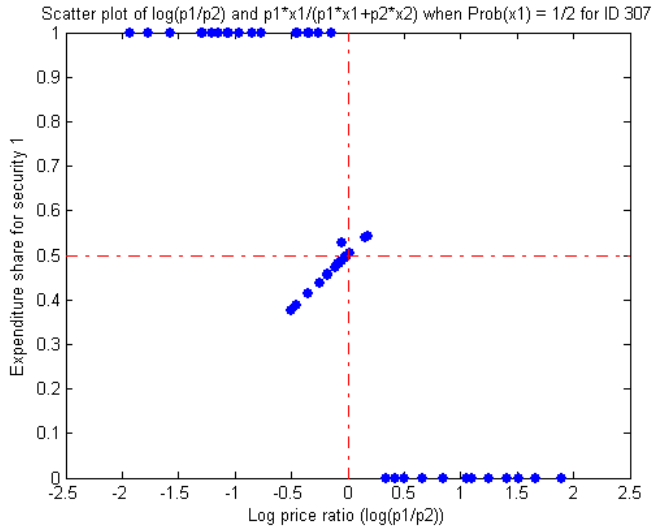

Scatter plot between x1 and x2 when Prob(x1) = 1/2 for ID 303
Demand for security 2 (x2)
Demand for security 1 (x1)
0
10
20
30
40
50
60
70
80
90
100

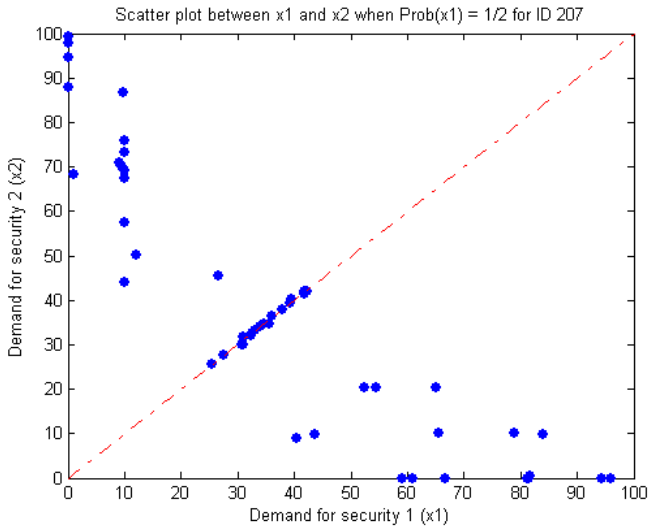

Scatter plot of log(p1/p2) and x1/(x1+x2) when Prob(x1) = 1/2 for ID 303
Token share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

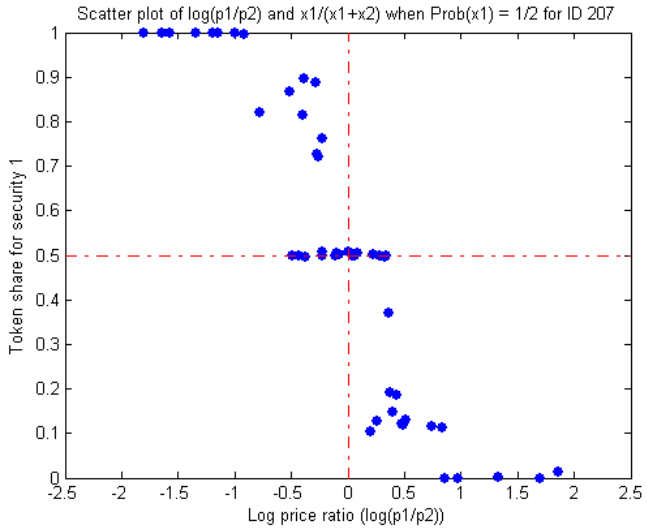

Scatter plot of log(p1/p2) and p1*x1/(p1*x1+p2*x2) when Prob(x1) = 1/2 for ID 303
Expenditure share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

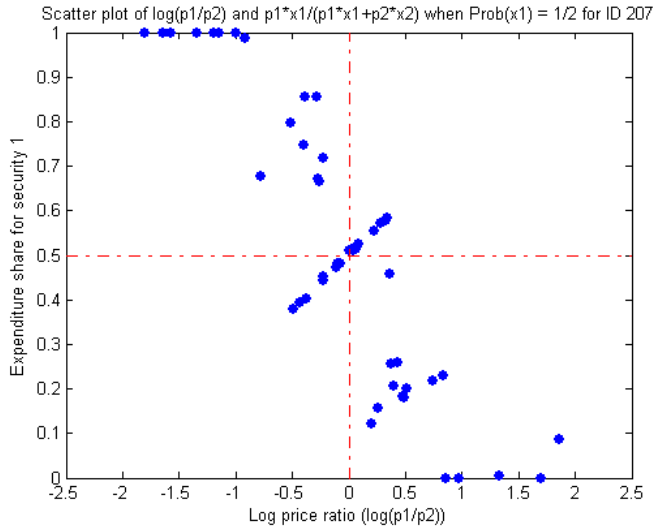

Scatter plot between x1 and x2 when Prob(x1) = 1/2 for ID 307
Demand for security 2 (x2)
Demand for security 1 (x1)
0
10
20
30
40
50
60
70
80
90
100

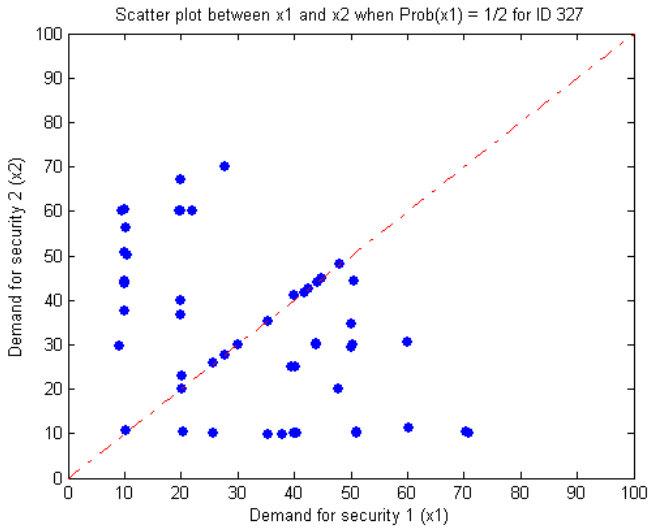

Scatter plot of log(p1/p2) and x1/(x1+x2) when Prob(x1) = 1/2 for ID 307
Token share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

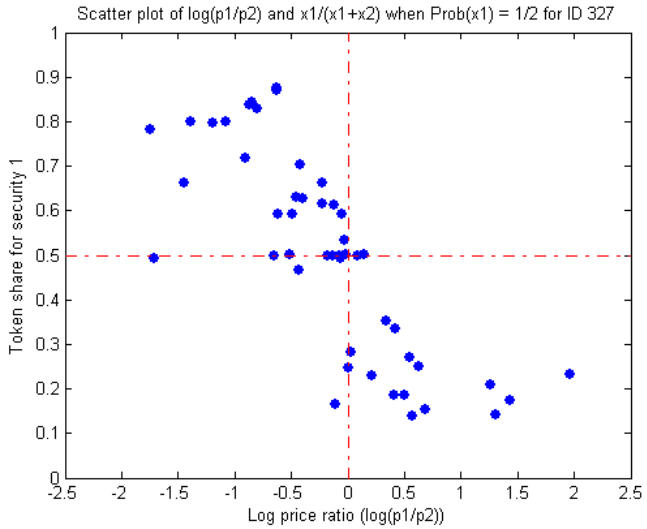

Scatter plot of log(p1/p2) and p1*x1/(p1*x1+p2*x2) when Prob(x1) = 1/2 for ID 307
Expenditure share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

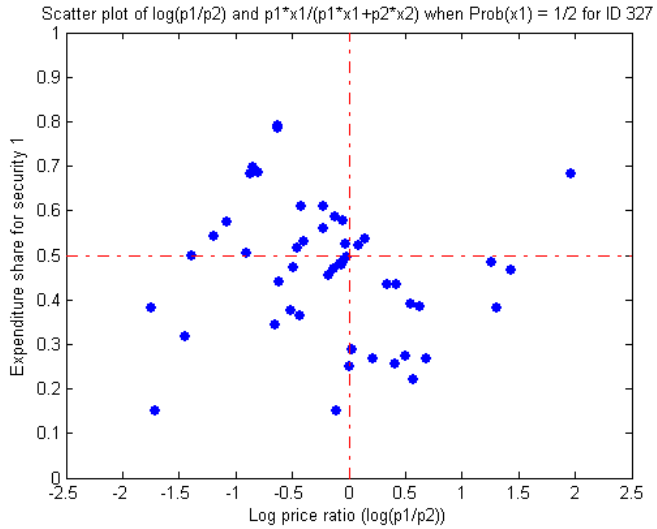

Scatter plot between x1 and x2 when Prob(x1) = 1/2 for ID 207
Demand for security 2 (x2)
Demand for security 1 (x1)
0
10
20
30
40
50
60
70
80
90
100

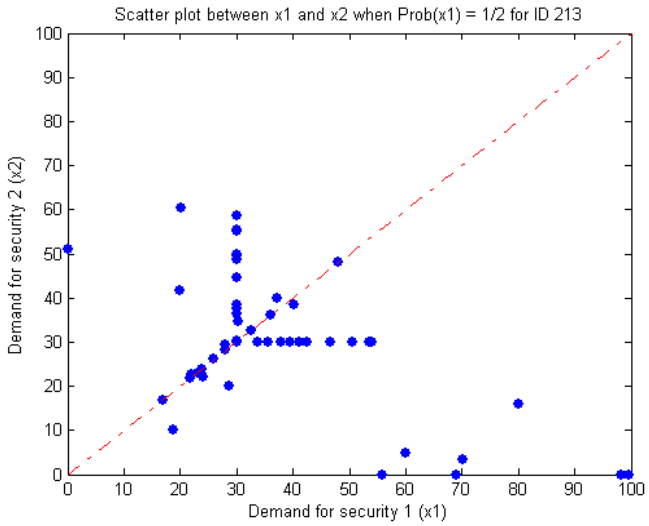

Scatter plot of log(p1/p2) and x1/(x1+x2) when Prob(x1) = 1/2 for ID 207
Token share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

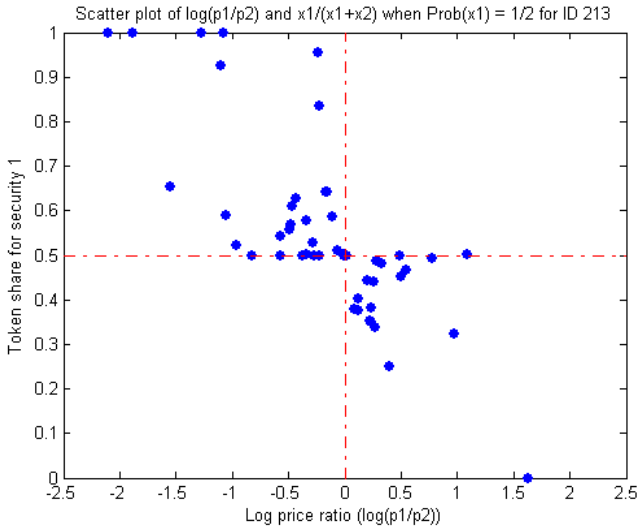

Scatter plot of log(p1/p2) and p1*x1/(p1*x1+p2*x2) when Prob(x1) = 1/2 for ID 207
Expenditure share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

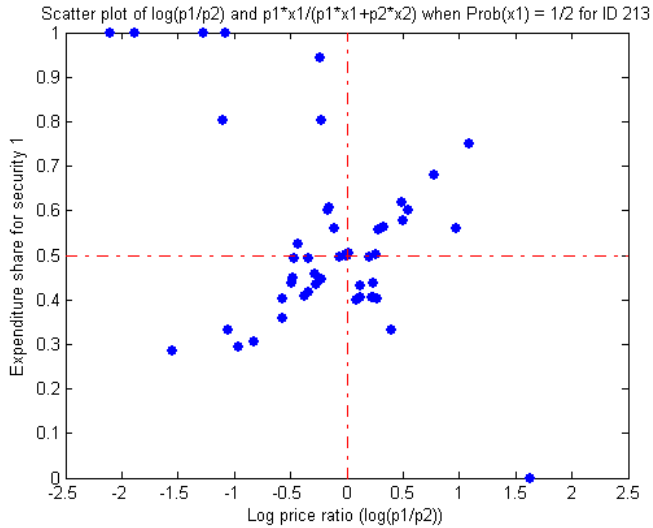

Scatter plot between x1 and x2 when Prob(x1) = 1/2 for ID 327
Demand for security 2 (x2)
Demand for security 1 (x1)
0
10
20
30
40
50
60
70
80
90
100


Scatter plot of log(p1/p2) and x1/(x1+x2) when Prob(x1) = 1/2 for ID 327
Token share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


Scatter plot of log(p1/p2) and p1*x1/(p1*x1+p2*x2) when Prob(x1) = 1/2 for ID 327
Expenditure share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


Scatter plot between x1 and x2 when Prob(x1) = 1/2 for ID 213
Demand for security 2 (x2)
Demand for security 1 (x1)
0
10
20
30
40
50
60
70
80
90
100


Scatter plot of log(p1/p2) and x1/(x1+x2) when Prob(x1) = 1/2 for ID 213
Token share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5


Scatter plot of log(p1/p2) and p1*x1/(p1*x1+p2*x2) when Prob(x1) = 1/2 for ID 213
Expenditure share for security 1
Log price ratio (log(p1/p2))
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5

Consistency

Afriat's (1967) Theorem *The following conditions are equivalent:*

- *The data satisfy the Generalized Axiom of Revealed Preference (GARP).*
- *There exists a non-satiated utility function that rationalizes the data.*
- *There exists a well-behaved (concave, monotonic, continuous, non-satiated) utility function that rationalizes the data.*

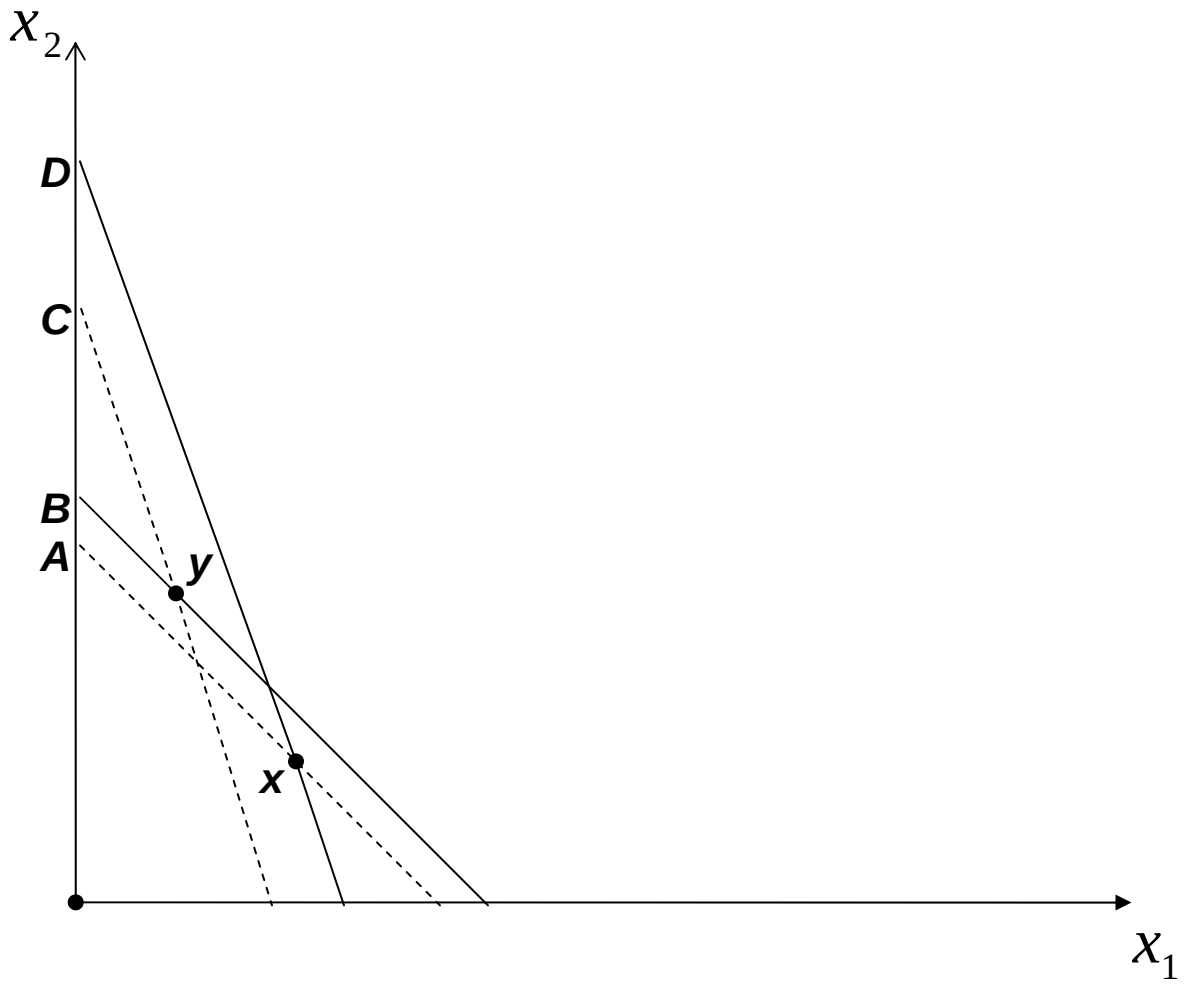
Afriat's (1972) critical cost efficiency index (CCEI)

The CCEI measures the fraction by which each budget constraint must be shifted in order to remove all violations of GARP.

- The CCEI is between 0 and 1 – indices closer to 1 mean the data are closer to perfect consistency with GARP and hence with utility maximization.

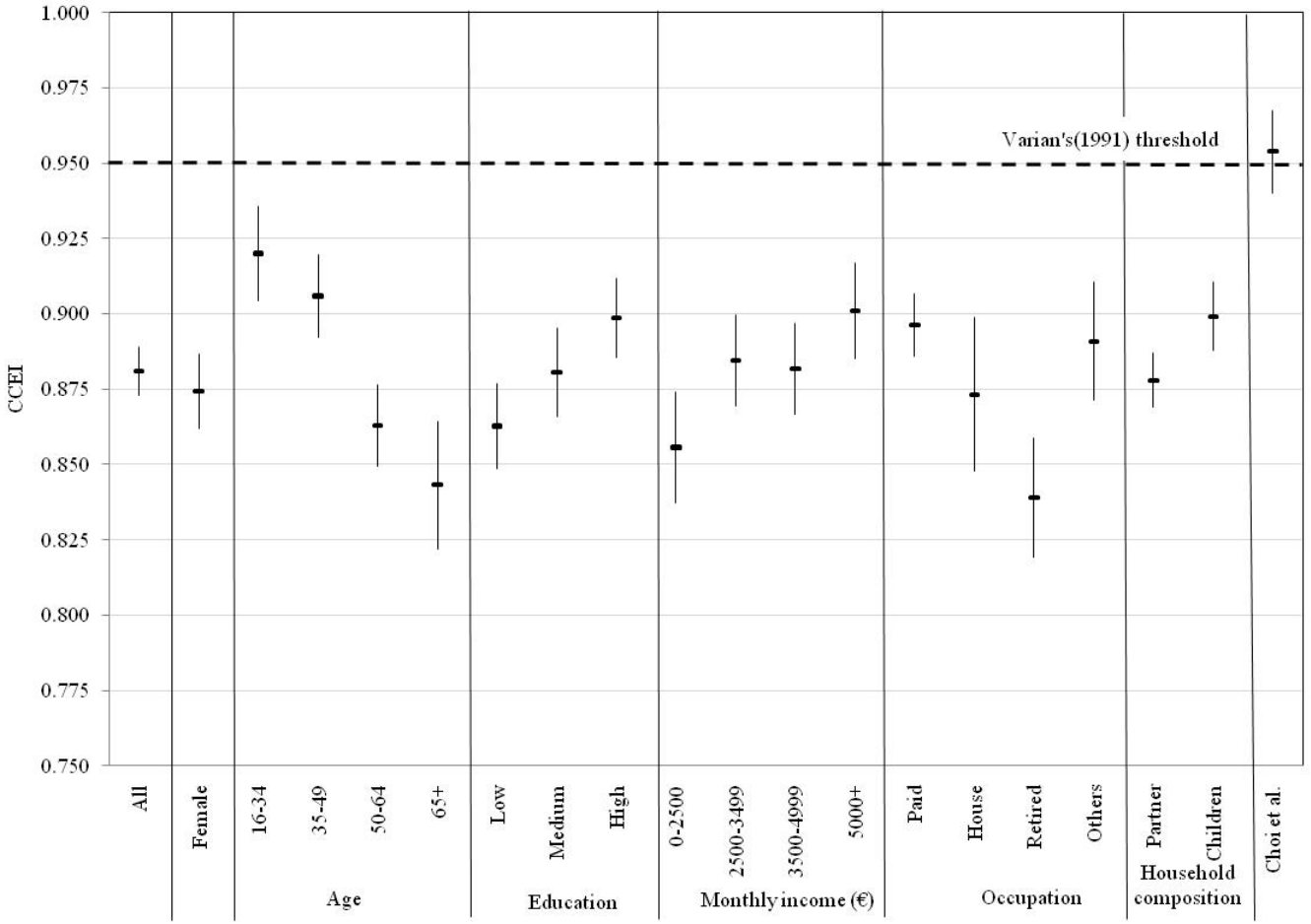
Because our subjects make choices in a wide range of budget sets, our data provides a stringent test of utility maximization.

The construction of the CCEI for a simple violation of GARP

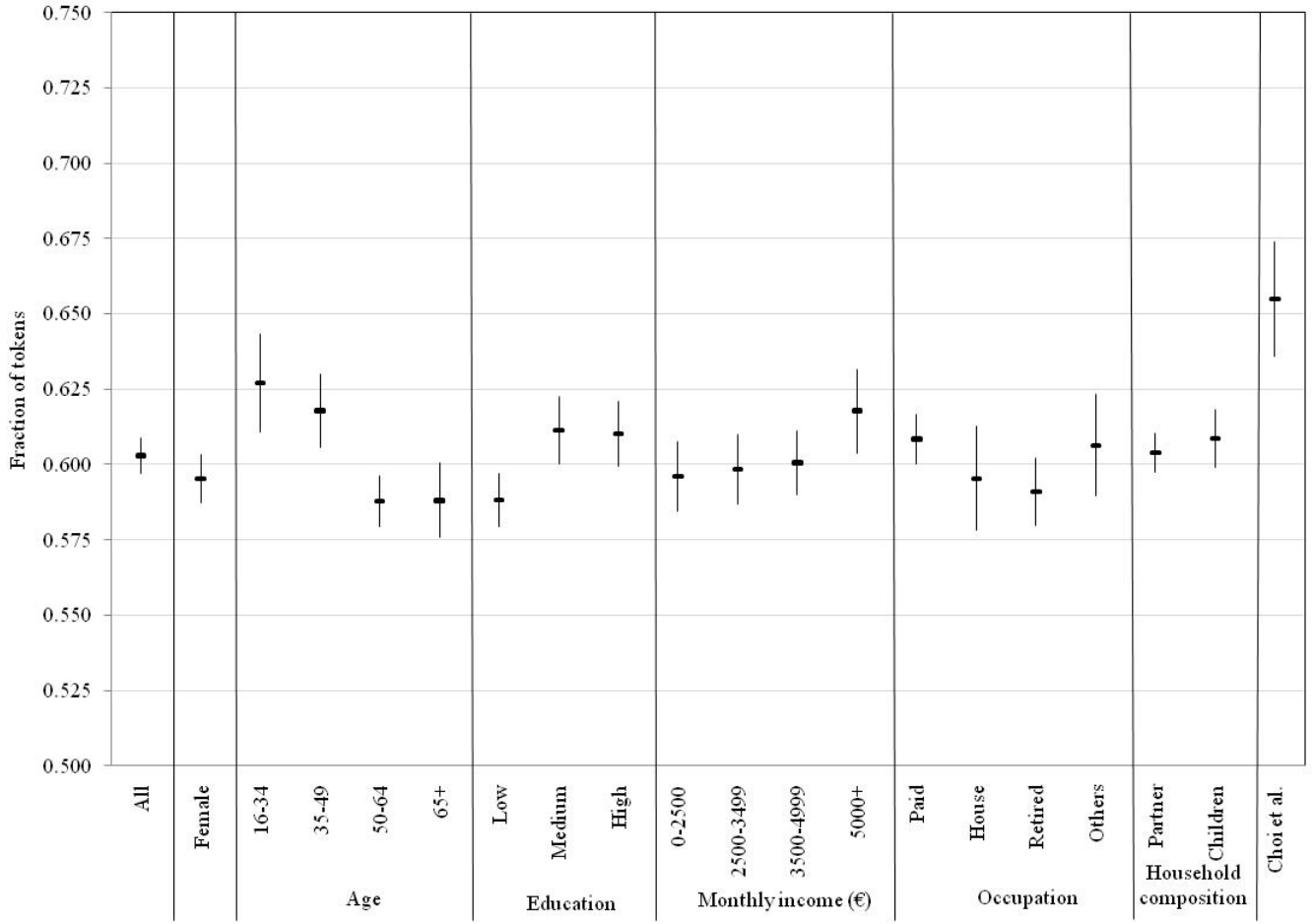


The agent is ‘wasting' as much as *A/B<C/D* of his income by making inefficient choices.

Mean CCEI scores



Risk aversion – the fraction of tokens allocated to the cheaper asset



Wealth differentials

$\Longrightarrow$ The heterogeneity in wealth is not well-explained either by standard observables (income, education, family structure) or by standard unobservables (intertemporal substitution, risk tolerance).

$\Longrightarrow$ If consistency with utility maximization in the experiment were a good proxy for (financial) decision-making quality then the degree to which consistency differ across subjects should help explain wealth differentials.

The relationship between CCEI scores and wealth

	(1)	(2)	(3)
CCEI	1.351**	1.109**	101888.0*
	(0.566)	(0.534)	(52691.9)
Log 2008 household income	0.584***	0.606***	
	(0.132)	(0.126)	
2008 household income			1.776***
			(0.4)
Female	-0.313*	-0.356**	-32484.3*
	(0.177)	(0.164)	(17523.9)
Partnered	0.652***	0.595***	46201.9***
	(0.181)	(0.171)	(17173.7)
# of children	0.090	0.109	14078.6*
	(0.093)	(0.086)	(8351.5)
Age	Y	Y	Y
Education	Y	Y	Y
Occupation	Y	Y	Y
Constant	6.292	0.469	76214.4
	(6.419)	(3.598)	(559677.5)
R^2	0.179	0.217	0.188
# of obs.	517	566	568

The robustness of the correlation -- controls for constraints

	(1)	(2)	(3)	(4)	(5)
CCEI	1.322**	1.318**	1.925***	1.888***	1.441**
	(0.570)	(0.574)	(0.672)	(0.652)	(0.578)
Log household income					
2008	19.770	1.000	0.544***	0.285*	0.616***
	(14.629)	.	(0.137)	(0.165)	(0.128)
2008^2	-2.194				
	(1.533)				
2008^3	0.082				
	(0.053)				
2006				0.232	
				(0.231)	
2004				0.215	
				(0.174)	
Female	-0.291	-0.201	-0.337*	-0.296	-0.321*
	(0.181)	(0.173)	(0.185)	(0.186)	(0.176)
Partnered	0.598***	0.561***	0.734***	0.707***	0.641***
	(0.181)	(0.178)	(0.192)	(0.193)	(0.179)
# of children	0.091	0.101	0.018	0.031	0.088
	(0.092)	(0.096)	(0.099)	(0.095)	(0.093)
Age	Y	Y	Y	Y	Y
Education	Y	Y	Y	Y	N
Occupation	Y	Y	Y	Y	Y
Constant	-47.059	0.864	5.354	3.016	6.398
	(46.275)	(6.545)	(6.93)	(7.109)	(6.484)
R^2	0.187		0.205	0.217	0.177
# of obs.	517	517	449	449	517

The robustness of the correlation -- controls for preferences and beliefs

	(1)	(2)	(3)	(4)	(5)
CCEI	1.379**	1.396**	1.404**	1.214*	1.237**
	(0.568)	(0.568)	(0.569)	(0.625)	(0.623)
Risk tolerance					
Quantitative (experiment)	-0.768	-0.808	-0.766		
	(0.714)	(0.711)	(0.718)		
Qualitative (survey)		0.017	0.023		
		(0.074)	(0.076)		
Qualitative (survey) missing		-0.190	-0.162		
		(0.335)	(0.482)		
Conscientiousness			0.089		
			(0.072)		
Conscientiousness missing			-0.040		
			(0.668)		
Longevity expectations					-0.034
					(0.040)
Log 2008 household income	0.589***	0.578***	0.572***	0.443***	0.434***
	(0.132)	(0.131)	(0.133)	(0.123)	(0.123)
Female	-0.316*	-0.310*	-0.323*	-0.415**	-0.417**
	(0.177)	(0.181)	(0.181)	(0.186)	(0.186)
Partnered	0.655***	0.658***	0.642***	0.686***	0.687***
	(0.181)	(0.181)	(0.182)	(0.204)	(0.205)
# of children	0.086	0.087	0.083	0.075	0.083
	(0.093)	(0.093)	(0.093)	(0.102)	(0.102)
Age	Y	Y	Y	Y	Y
Education	Y	Y	Y	Y	Y
Occupation	Y	Y	Y	Y	Y
Constant	6.840	6.883	6.496	3.777	4.411
	(6.361)	(6.357)	(6.395)	(15.258)	(15.256)
R^2	0.179	0.176	0.176	0.163	0.163
# of obs.	517	517	517	414	414

	(1)	(2)	(3)	(4)
CCEI	1.253*	1.401*	1.269*	1.177**
	(0.712)	(0.729)	(0.729)	(0.583)
CCEI (combined dataset)	0.099			
	-0.38			
von Gaudecker et al. (2011)			0.927*	
			(0.485)	
Cognitive Reflection Test (CRT)				0.120*
				(0.071)
CRT missing				-0.203
				(0.237)
Log 2008 household income	0.586***	0.388*	0.383*	0.577***
	(0.132)	(0.155)	(0.154)	(0.132)
Female	-0.314*	-0.218	-0.207	-0.292*
	(0.177)	(0.212)	(0.211)	(0.176)
Partnered	0.653***	0.907***	0.926***	0.690***
	(0.181)	(0.230)	(0.228)	(0.181)
# of children	0.089	0.105	0.096	0.091
	(0.093)	(0.114)	(0.113)	(0.092)
Age	Y	Y	Y	Y
Education	Y	Y	Y	Y
Occupation	Y	Y	Y	Y
Constant	6.237	10.056	8.355	6.855
	(6.424)	(6.976)	(6.990)	(6.464)
R^2	0.177	0.225	0.232	0.181
# of obs.	517	326	326	517

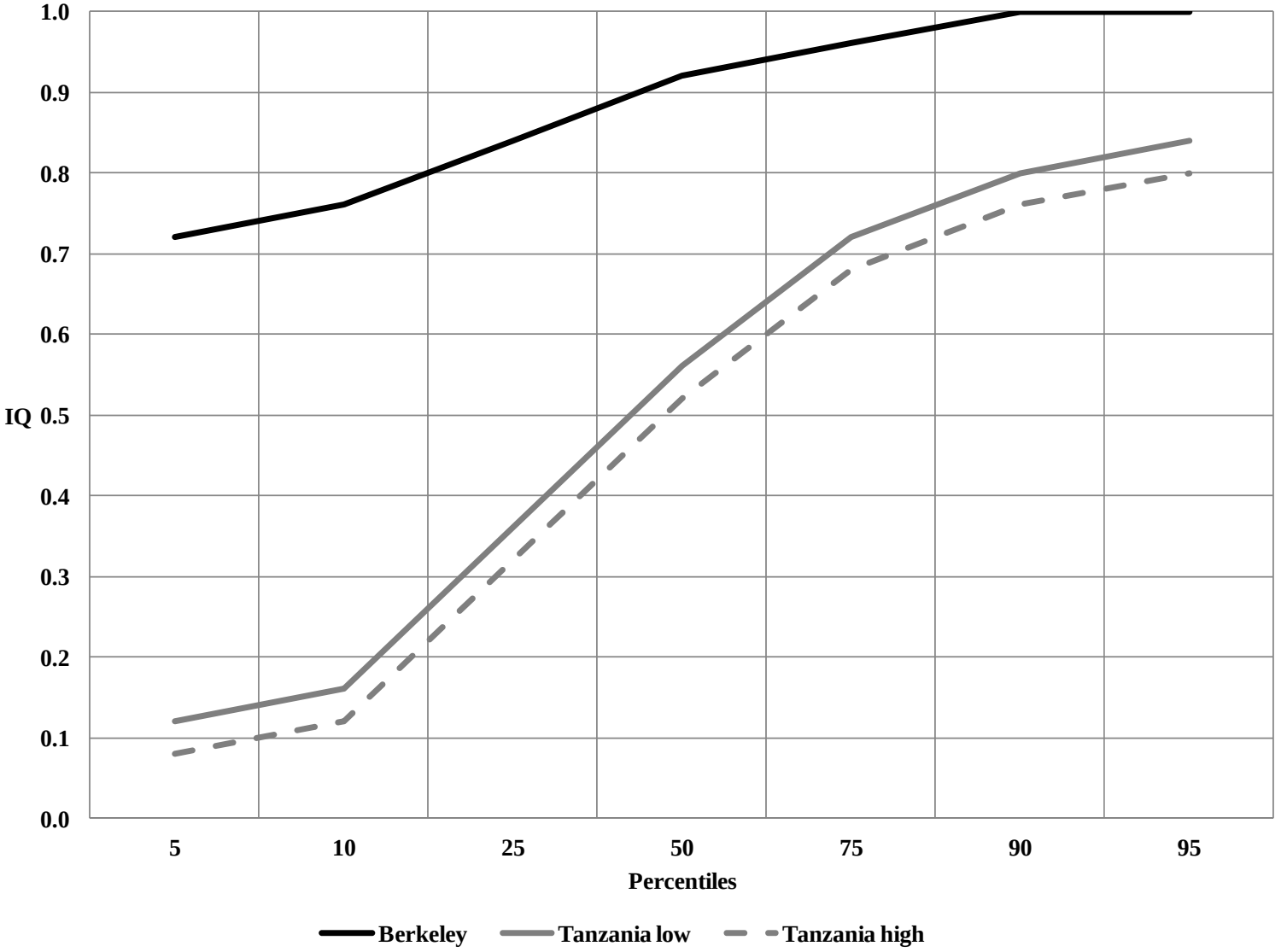
The sources of the relationship

	(1)	(2)	(3)	(4)
	Have checking	Fraction in checking	Have saving	Fraction in saving
CCEI	0.03	-0.098*	-0.047	-0.162*
	(0.032)	(0.057)	(0.053)	(0.097)
Log 2008 household income	0.001	-0.029**	0.003	-0.068***
	(0.002)	(0.013)	(0.010)	(0.021)
Female	0.007	0.023	0.014	0.038
	(0.005)	(0.020)	(0.019)	(0.033)
Partnered	-0.005	-0.031	0.017	-0.054
	(0.004)	(0.020)	(0.022)	(0.033)
# of children	0.000	-0.004	-0.025*	-0.043***
	(0.001)	(0.010)	(0.014)	(0.013)
Age	Y	Y	Y	Y
Education	Y	Y	Y	Y
Occupation	Y	Y	Y	Y
Constant	0.998***	0.106	1.126	1.448
	(0.172)	(0.822)	(0.848)	(1.288)
R^2	-0.007	0.021	-0.011	0.083
# of obs.	512	512	502	502

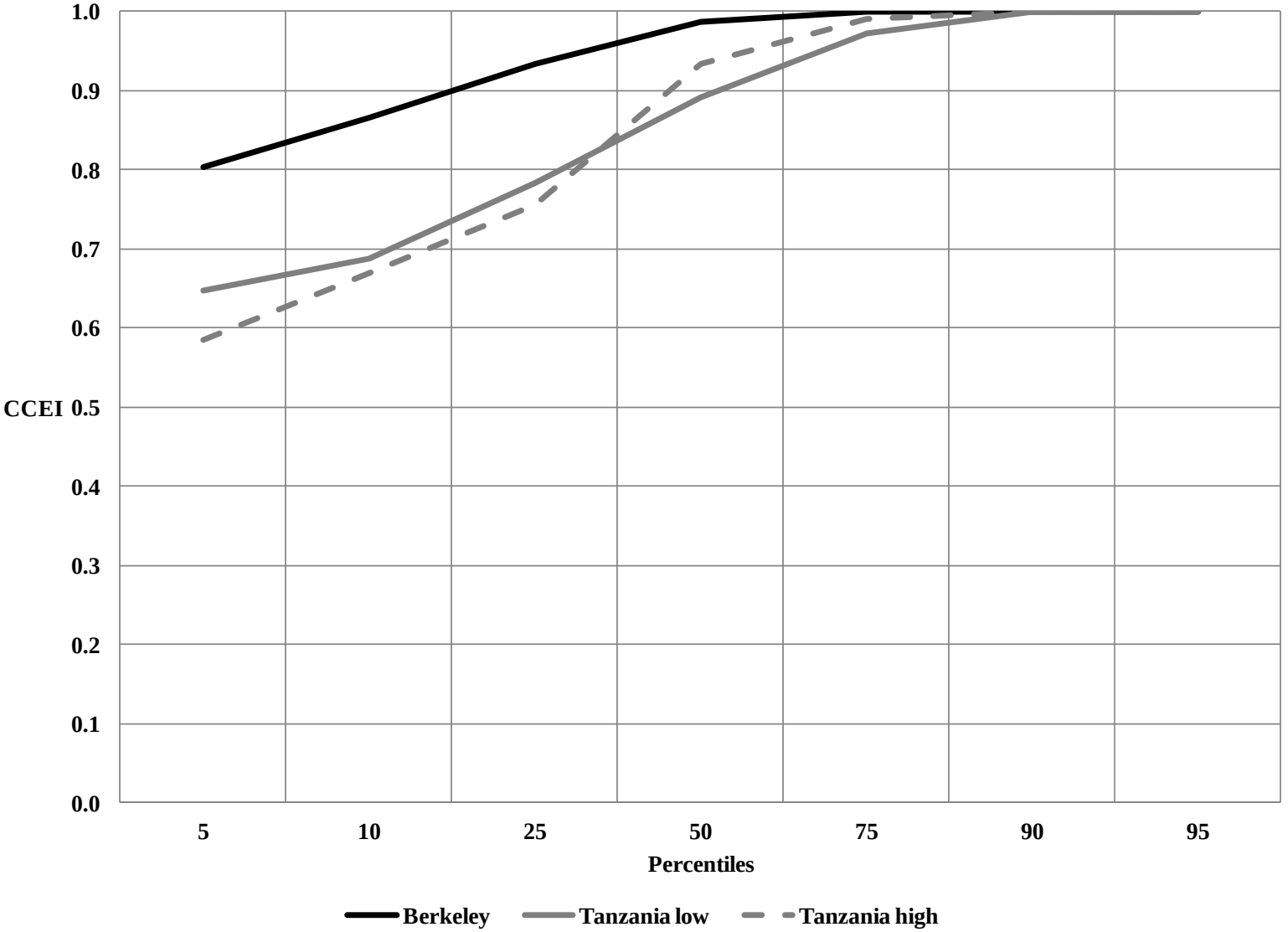
The sources of the relationship (cont.)

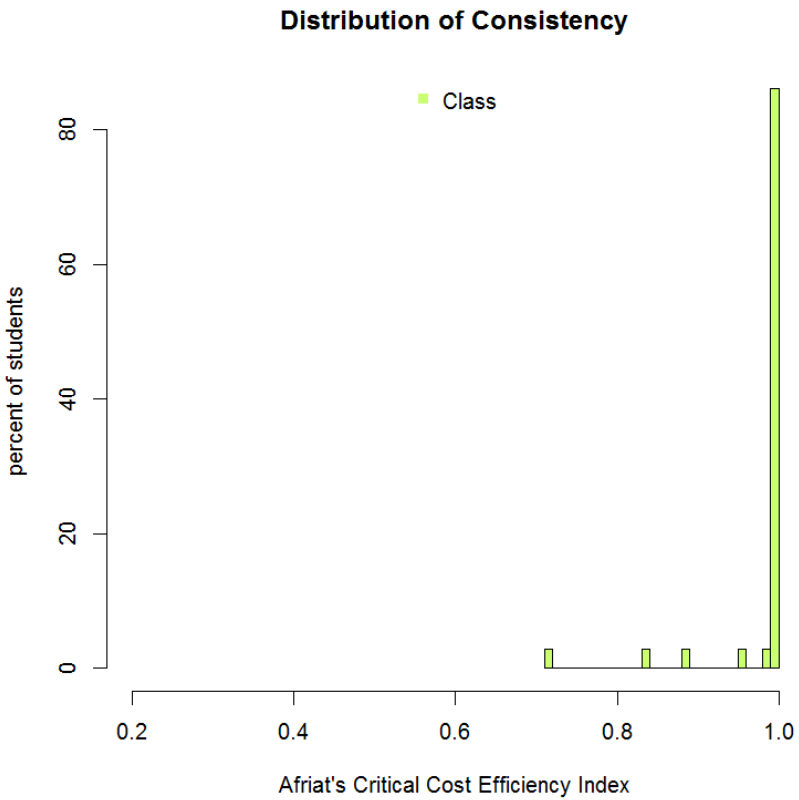
	(5)	(6)	(7)	(8)
	Have stocks	Fraction in stocks	Have a house	Fraction in house
CCEI	0.167	0.001	0.352**	0.324**
	(0.163)	(0.050)	(0.152)	(0.129)
Log 2008 household income	0.148***	0.013	0.134***	0.096***
	(0.031)	(0.009)	(0.029)	(0.024)
Female	0.007	0.009	-0.038	-0.066
	(0.050)	(0.013)	(0.050)	(0.043)
Partnered	0.005	-0.007	0.207***	0.127***
	(0.049)	(0.014)	(0.051)	(0.044)
# of children	0.003	0.000	0.048**	0.063***
	(0.026)	(0.007)	(0.020)	(0.019)
Age	Y	Y	Y	Y
Education	Y	Y	Y	Y
Occupation	Y	Y	Y	Y
Constant	-3.152*	-0.317	-1.047	-1.151
	(1.856)	(0.398)	(1.760)	(1.419)
R^2	0.079	0.002	0.148	0.123
# of obs.	514	514	479	479

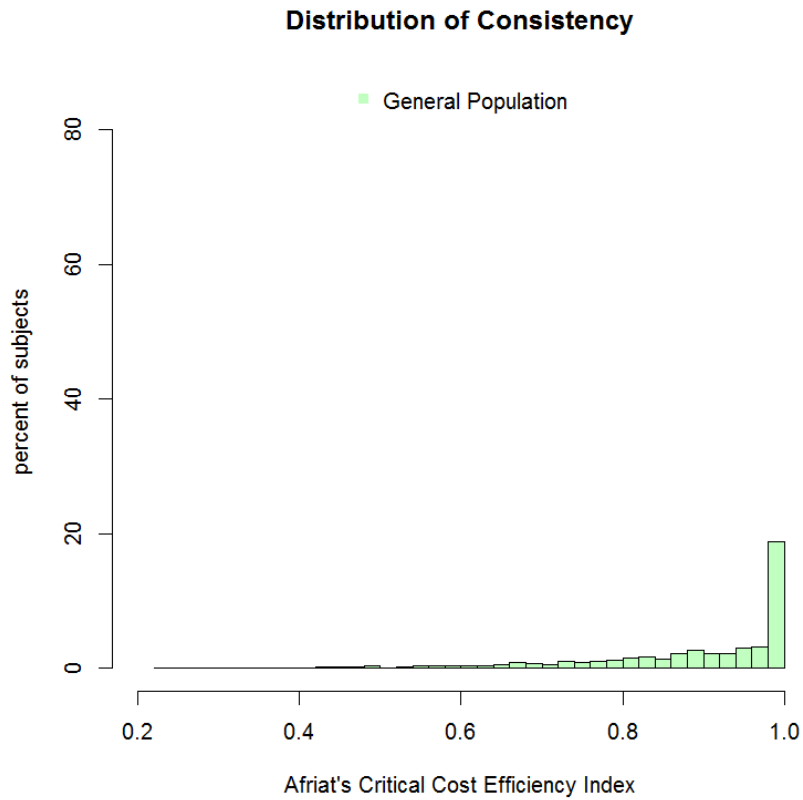
Is there a development gap in rationality (IQ)?

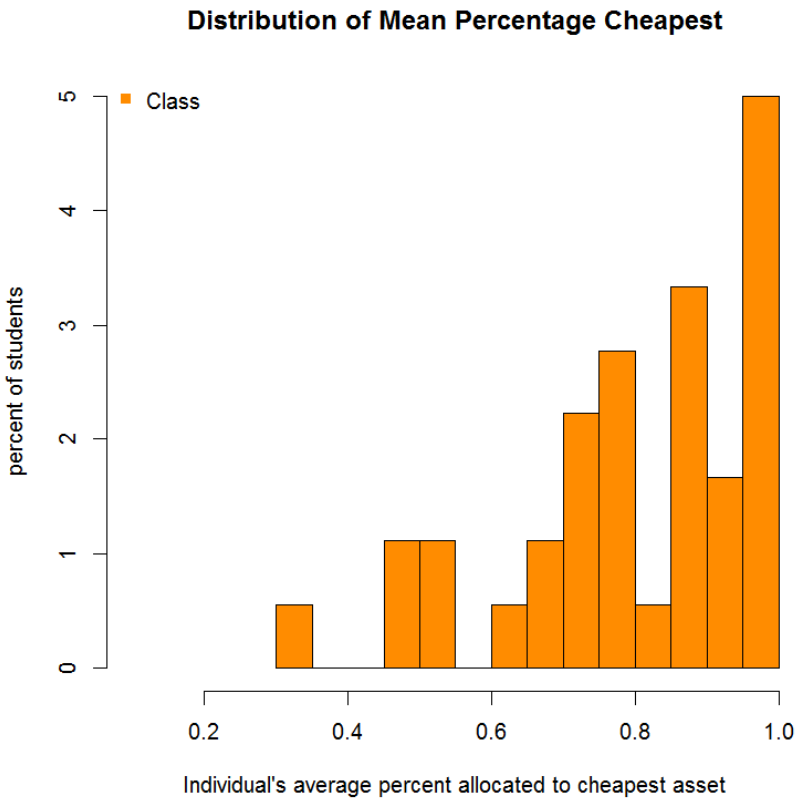


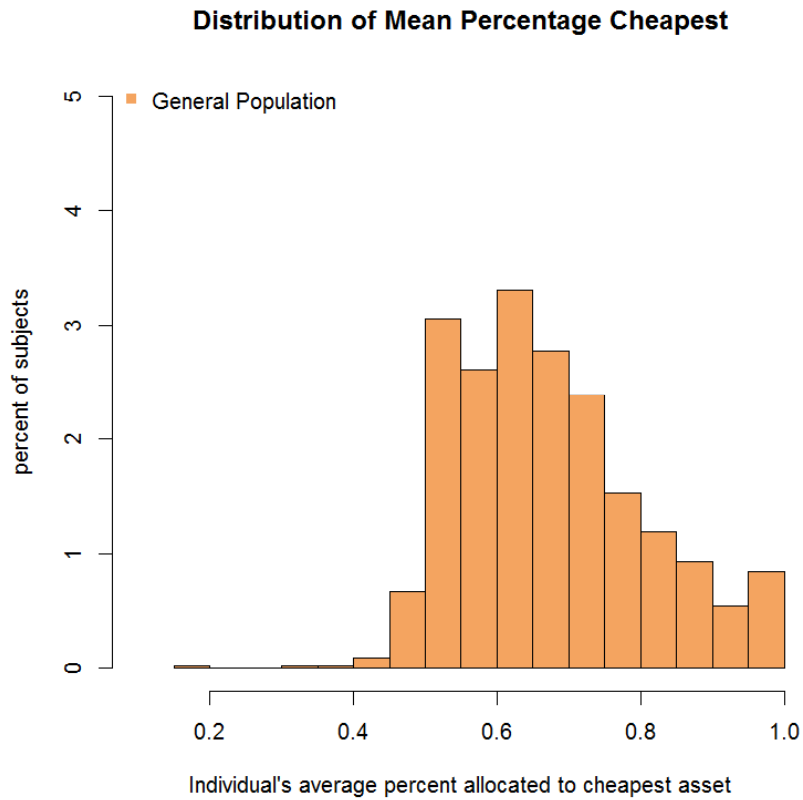
Is there a development gap in rationality (CCEI)?

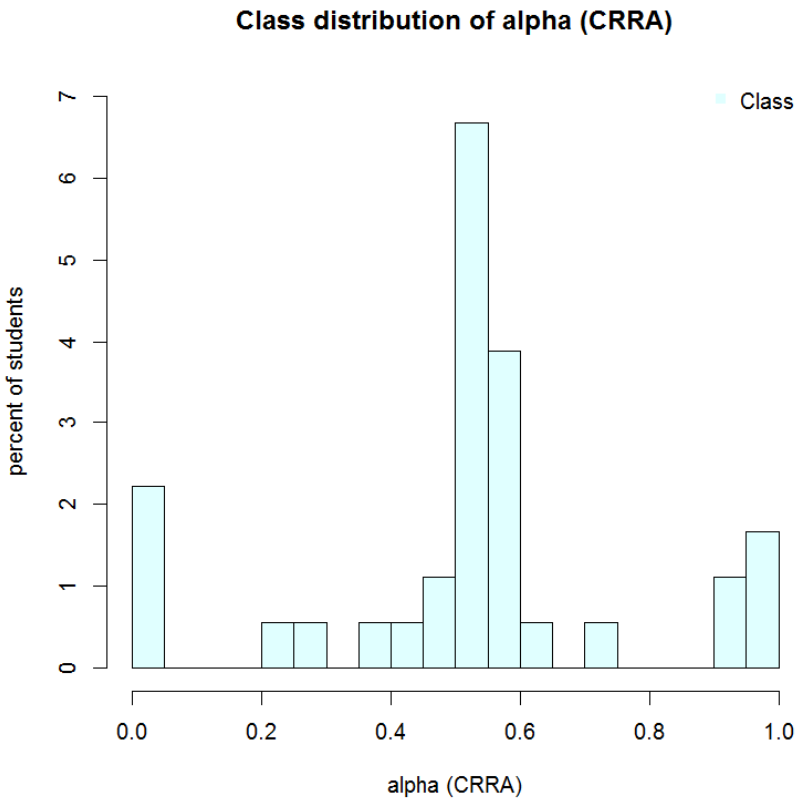


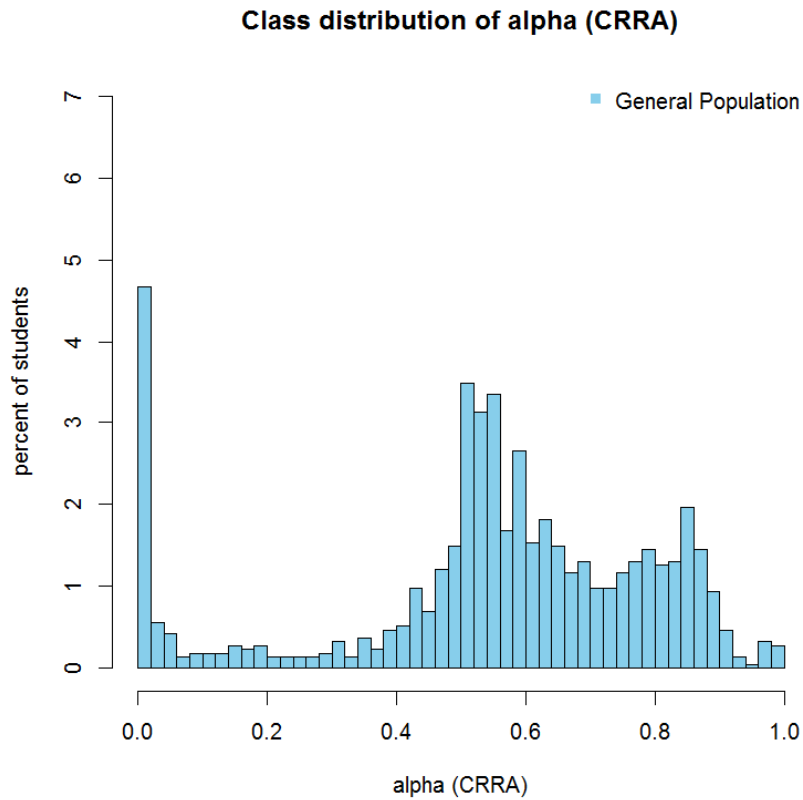

Distribution of Consistency
Class
percent of students
0
20
40
60
80
0.2
0.4
0.6
0.8
1.0
Afriat's Critical Cost Efficiency Index

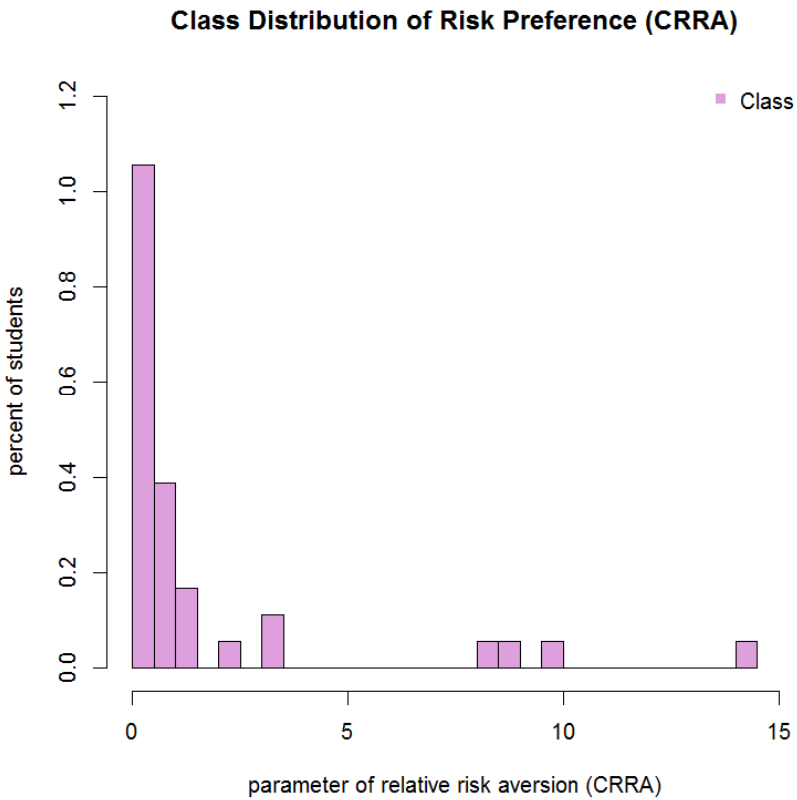

Distribution of Consistency
General Population
percent of subjects
0
20
40
60
80
0.2
0.4
0.6
0.8
1.0
Afriat's Critical Cost Efficiency Index

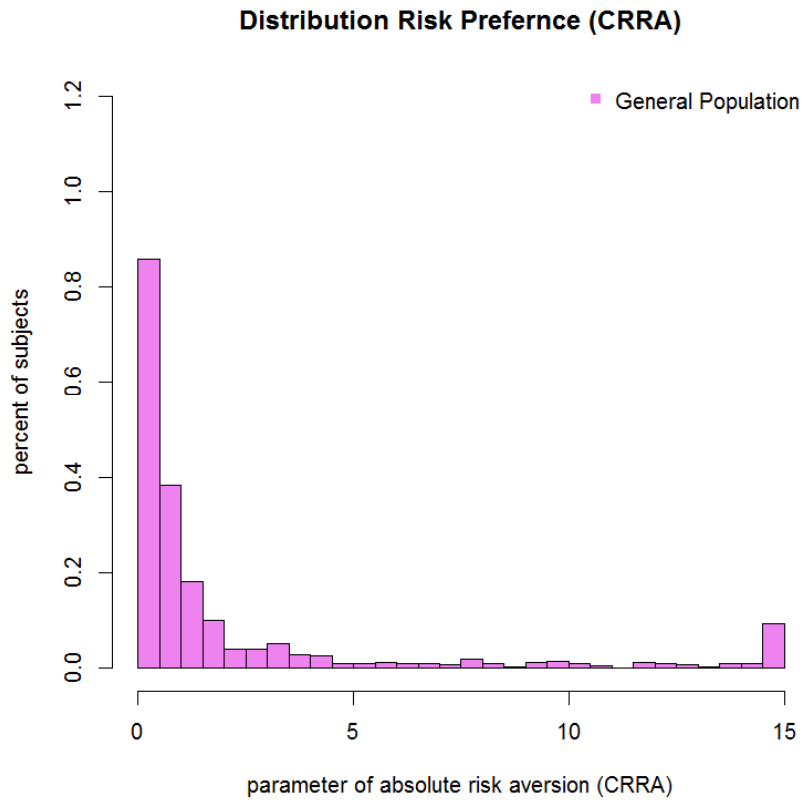

Distribution of Mean Percentage Cheapest
Class
percent of students
0
1
2
3
4
5
0.2
0.4
0.6
0.8
1.0
Individual's average percent allocated to cheapest asset


Distribution of Mean Percentage Cheapest
General Population
percent of subjects
0
1
2
3
4
5
0.2
0.4
0.6
0.8
1.0
Individual's average percent allocated to cheapest asset


Class distribution of alpha (CRRA)
Class
percent of students
0
1
2
3
4
5
6
7
0.0
0.2
0.4
0.6
0.8
1.0
alpha (CRRA)


Class distribution of alpha (CRRA)
General Population
percent of students
0
1
2
3
4
5
6
7
0.0
0.2
0.4
0.6
0.8
1.0
alpha (CRRA)


Class Distribution of Risk Preference (CRRA)
Class
percent of students
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
5
10
15
parameter of relative risk aversion (CRRA)


Distribution Risk Prefernce (CRRA)
General Population
percent of subjects
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
5
10
15
parameter of absolute risk aversion (CRRA)