RATIONALITY, PREFERENCE AGGREGATION AND PARETO EFFICIENCY OF GROUP DECISION UNDER RISK

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- We make many types of collective decision in our daily life
  - Household's decision on consumption and saving, a firm's resource allocation among projects, decision on tax and transfer in legislature
- Previous studies have focused on preference aggregation (Baillon et al. (2016), Bateman and Munro (2005), Palma et al. (2010)) or inconsistency of group decision from preference conflict (Arrow (1951), Browning and Chiappori (1998), Chiappori and Ekeland (2011), Bourguignon et al. (2009))

Three fundamental questions on group decision

1. Rationality Extension:

If each individual's choices are consistent with the utility maximization model, do a group's choices also tend to be?

2. Risk Preference Aggregation:

Are individuals' risk preferences reflected into that of a group?

3. Pareto Efficiency:

Are a group's choices Pareto efficient? Is it maximizing social welfare?

Contribution

1. The first study answers for the three fundamental questions on group decision, using a unique experimental design and a large sample (N=1572)
2. We devise novel ways to test Pareto efficiency given individual and collective choice data on a budget line, and compute the severity of inefficiency from Pareto inefficient choices
3. Taking the revealed preference approach, we show the relationship between individual and group rationality

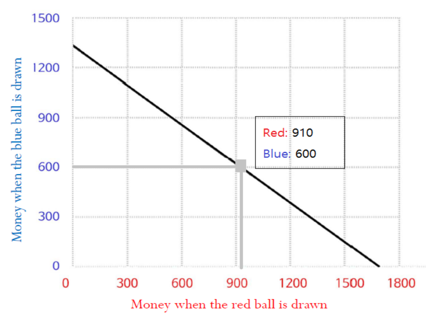
Preview for Results

Our main results are

1. Individual rationality extends to that of group
2. Individual risk preference (both probability weighting type (RDU or EUT) and risk aversion) is strongly reflected into that of group
3. Many joint decisions are close to be Pareto efficient. In addition, Pareto efficiency is positively correlated with collective rationality

Experimental Design[1] and Procedures

- A subject chooses the menu of the outcome (x_1, x_2) of a lottery $L = (x_1, x_2; 0.5, 0.5)$ on a given budget line $p_1 x_1 + p_2 x_2 = 1$



- 18 times of individual decisions $\Rightarrow$ 18 times of collective decisions (free conversation, random matching within a class)
- Each one of individual and collective choices is randomly selected to be reimbursed

[1] Basically it is based on Choi et al. (2007)

- Revealed preference approach : tests consistency within choices (Generalized Axiom of Revealed Preference (GARP))
- CCEI (Afriat (1972))[2] : 1-CCEI stands for how much of budget should be removed to rationalize inconsistent choices with the utility maximization model
- CCEI$\in [0, 1]$, and the bigger it is, the less severe the violation is

[2] We also use Varian (1991) for robustness check, and all results are preserved qualitatively

Extension: Individual Rationality Leads to Group Rationality

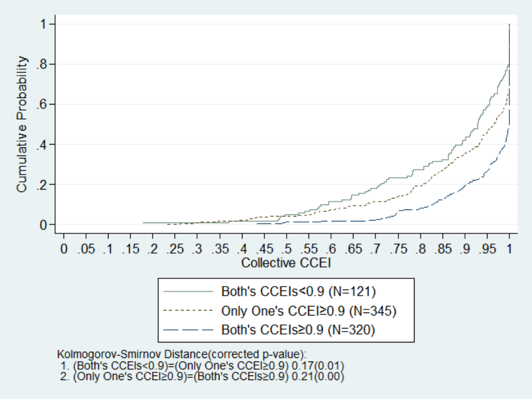


Figure: CDFs of Collective CCEI by Individual Rationality

- 57.8%, 64.9% and 80.9% of neither,either,both-rational pairs have CCEI≥ 0.9[3]

[3]This result is robust to the cutoff of CCEI - 0.95 and 0.99.

- $U(x_{min}, x_{max}) = \alpha u(x_{min}) + (1-\alpha)u(x_{max})$ [4] (Gul (1991))
- If $\alpha = \frac{1}{2}$, **Expected Utility Form (EUT)**. If $\alpha > \frac{1}{2}$, then one said to show disappointment aversion; $\alpha < \frac{1}{2}$, elation loving. Altogether, **Rank Dependent Utility Form (RDU)** [5]

Individual		Both EUT	EUT and RDU	Both RDU	Total
Collective	EUT	74.5(117)	59.1(52)	50.0(7)	68.0(176)
	RDU	25.5(40)	40.1(36)	50.0(7)	32.1(83)
	Total	100(157)	100(88)	100(14)	100(259)

EUT is defined as 0.5$\in$ 95% CI of α, N for each case in parenthesis

Only includes pairs with both individuals' and collective CCEI>=0.9

Table: Percentage of RDU Type of Pairs by Individual Type

▸ RDU ▸ ex ◂ est

[4] In addition, we assume CARA utility function which takes the specific form $u(x) = -\frac{exp(-\rho x)}{\rho}$

[5] In our data, 20.2%, 29.3% of individuals and pairs follow RDU, respectively. We define a utility function follows EUT if $0.5 \in 95\%$ of α using bootstrapped standard error

- We use $\Sigma_{j=1}^{18} \frac{x_{cheaper}}{x_1+x_2} \in [0.5, 1]$ which is between $(0.5, 1)$, and the bigger it is, the less risk averse the preference is [6]

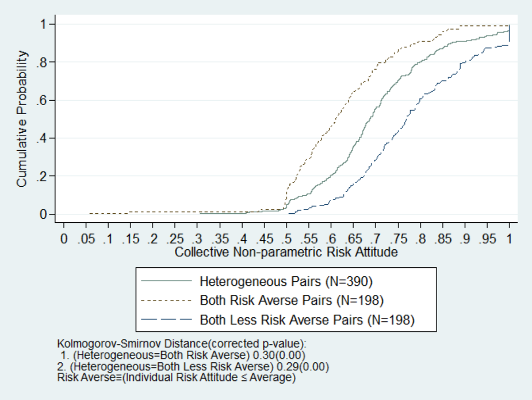
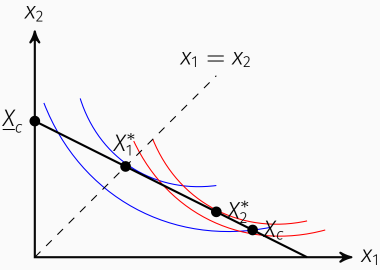


Figure: CDFs of Collective Risk Preference by Individual Risk Attitude

Pareto Efficiency:

A pair's choice X_c is **Pareto efficient** if and only if it is between $X_1^* = argmax_{(x_1,x_2)} \hat{U}_1(x_1, x_2)$ and $X_2^* = argmax_{(x_1,x_2)} \hat{U}_2(x_1, x_2)$[8]



[8]The condition holds as long as utility function is monotone and symmetric. We say a utility function is symmetric if $U(x_1, x_2) = U(x_2, x_1)$

Utility Loss from Pareto Inefficient Choice:=

$$\frac{1}{18}\Sigma_{j=1}^{18}\frac{1}{2}\Sigma_{i=1}^{2}\frac{u_i(\bar{X}_{cj}) - u_i(X_{cj})}{u_i(\bar{X}_{cj}) - u_i(\underline{X}_{ij})} \in [0,1] \tag{1}$$

where X_c: collective choice, $\underline{X}$: worst choice on the budget line. j denote the sequence of budget lines and i individuals. Finally, $\bar{X} = argmin(d(X_c, X)), X \in \{X|u_i(X) >= u_i(X_c)\}$ with strict inequality for one i. If such X does not exist, $\bar{X} = X_c$

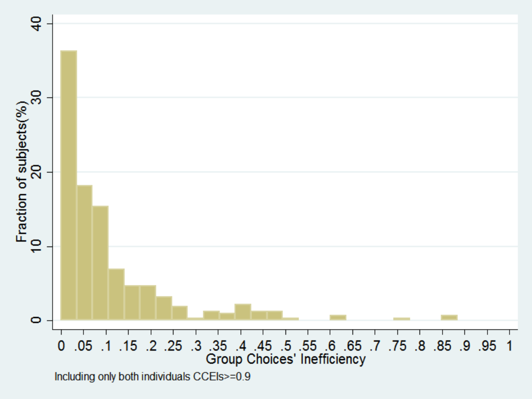


Figure: Distribution of the Utility Loss from Pareto Inefficiency By Pairs

- The mean(sd) of utility loss is 0.09(0.12) when only including pairs with both individuals' CCEI>0.9

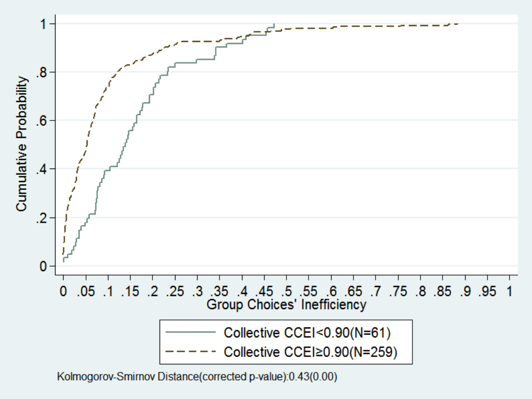


Figure: CDFs of the Utility Loss from Pareto Inefficient Choices by Collective Rationality

- Mean of utility loss for pairs with collective CCEI>0.08 is 0.15. For CCEI<0.9, it is 0.15. This difference is statistically significant at 1% significance level

We study fundamental questions on group decision. And the results show

Rationality Extension

Individual rationality extends to that of a group

Preference Aggregation

Individuals' risk attitude is strongly reflected into that of group

Pareto Efficiency

There exists remarkable heterogeneity across groups' loss from Pareto inefficient choices. Much of such variation is resulted from collective rationality

Groups	Main Focus	Literature
Experimental studies on the comparison between individual and group decision	Which one is closer to the theoretical prediction	Bone et al. (1999), Cason and Mui(1997), Charness et al. (2007), Charness and Sutter (2012), Cooper and Kagel (2005), Carbone et al. (2016), Kerr at el. (1996), Kugler et al. (2012), Masclet et al.(2009), Shupp and Williams (2008), Sutter (2009)
Experimental studies on preference aggregation	How risk attitude/ time preference is aggregated	Abdellaoui et al. (2010), Baillon et al. (2016), Bateman and Munro (2005), Palma et al. (2010), Lee at el. (2012)
Empirical studies on household resource allocation	Test representative agent model Factors for bargaining power	Browning and Chiappori (1998), Chiappori and Ekeland (2011), Friedberg and Webb (2006), Bourguignon et al. (2009)
Theoretical studies on preference aggregation	Representative agent models Impossibility theorem	Arrow, Jackson and Yariv (2014)

Experimental Design and Procedures

Stage 1 (Individual) $\xrightarrow{\text{Random matching}}$ Stage 2 (Pair)

Stage 1 (Individual)

- 18 times of choices
- Payoff for 1 randomly selected choice
- N=1572

Stage 2 (Pair)

- Matched individuals sit side by side
- 1 min 30 sec of discussion time
- 18 times of choices
- Payoff for 1 randomly selected choice is doubled and divided equally
- N=786

- No feedback is given during the experiment and subjects are informed only the sum of payoff from stage 1 and 2 after all the process
- The experiment is computerized using O-tree ex

Generalized Axiom of Revealed Preference (GARP)

If x^t is revealed preferred to x^s, then x^s is not strictly revealed preferred to x^t $(p^s x^s \leq p^s x^t)$

Afriat's theorem (Afriat (1967))

Observed choice data satisfy the GARP if and only if there exist a increasing, continuous and concave utility function that rationalize the observed choice.

Critical Cost Efficiency Index (CCEI(Afriat (1972)))

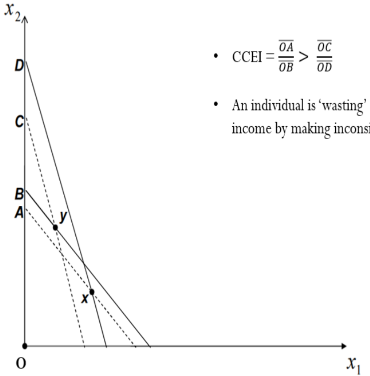
CCEI is the largest number $e \in [0,1]$ such that if $e(p^1x^1) \geq p^1x^2, e(p^2x^2) \geq p^2x^3, ..., e(p^{n-1}x^{n-1}) \geq p^{n-1}x^n$, then $e(p^nx^n) \leq p^nx^1$

▸ fig

In our data, 62.6%(50.7%) of individuals' CCEI are equal to or greater than 0.90(0.95). On pairs, the percentage is 70.4%(60%)

▸ ex

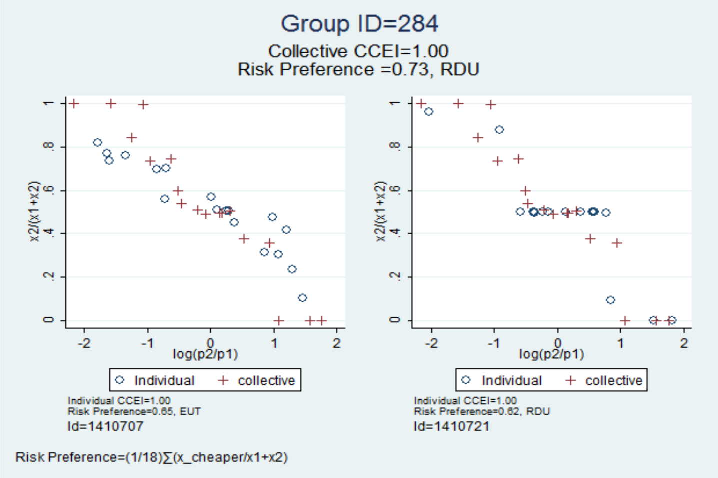
Extension: Measure of Rationality



- CCEI = $\frac{\overline{OA}}{\overline{OB}} > \frac{\overline{OC}}{\overline{OD}}$
- An individual is 'wasting' the (1-CCEI) fraction of income by making inconsistent choices

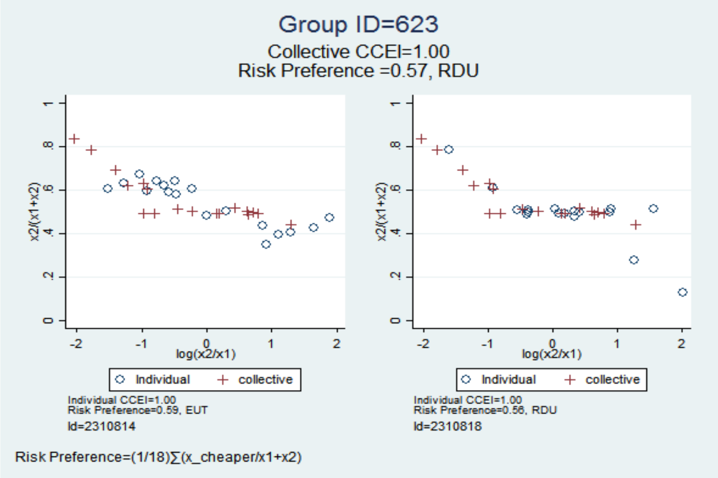
▸ CCEI

Example of Individual-pair Relative Demand Curve



◂ Design ◂ CCEI ◂ alpha ◂ Risk

Example of Individual-pair Relative Demand Curve



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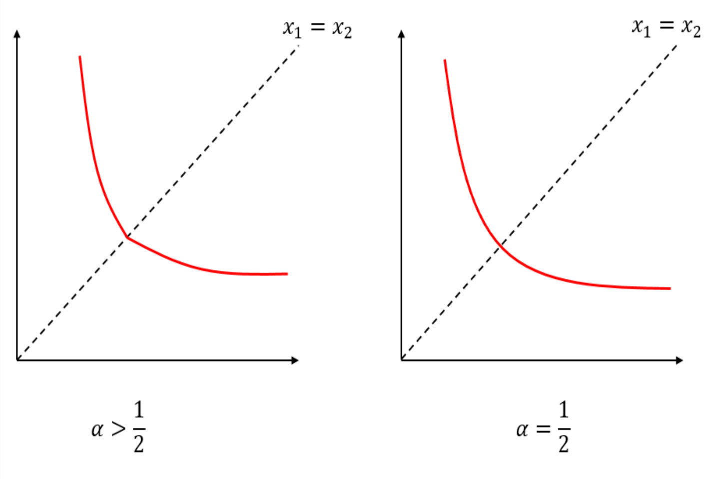

Figure: Indifference Curve Depending on Probability Weighting

Estimation of Utility Function

$$(\hat{\alpha}, \hat{\rho}) = argmin_{(\alpha,\rho)} \Sigma_{j=1}^{18} \left| \frac{x_{1j}^*(\alpha,\rho)}{x_{1j}^*(\alpha,\rho) + x_{2j}^*(\alpha,\rho)} - \frac{x_{1j}}{x_{1j} + x_{2j}} \right| \quad (2)$$

where

$$(x_{1j}^*(\alpha,\rho), x_{2j}^*(\alpha,\rho)) = argmax_{(x_{1j},x_{2j})} \alpha\left(-\frac{exp(-\rho x_{min})}{\rho}\right) + (1-\alpha)\left(-\frac{exp(-\rho x_{max})}{\rho}\right) \quad (3)$$

given $p_{1j}x_{1j} + p_{2j}x_{2j} = 1$ and $x_{min(max)} = min(max)(x_{1j}, x_{2j})$

Parametric risk attitude: Risk Premium

- $U(x_{min}, x_{max}) = \alpha u(x_{min}) + (1-\alpha)u(x_{max})$
- Risk premium $r(h=1)$: $U(w(1-r)) = \alpha U(w(1-h)) + (1-\alpha)U(w(1+h))$
- Mean(sd) of individual/collective game=0.15(0.96)/0.31(1.22)[9] ▸ ex

[9] CARA function assumed

Preference Attitude Aggregation: Result

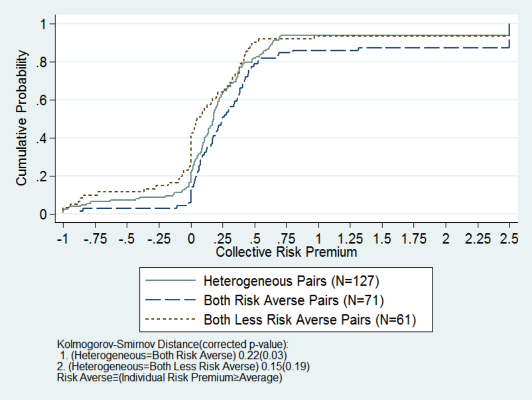

Figure: CDFs of Collective Risk Premium by Individual Risk Attitude

Dependent Var.	Collective Risk Preference		Collective Risk Premium	
	(1)	(2)	(3)	(4)
Ave.(Individual RP)	0.811***	0.796***		
	(0.060)	(0.062)		
Dist.(Individual RPs)	0.017	0.002		
	(0.052)	(0.054)		
Ave.(Individual Premium)			0.277**	0.242*
			(0.127)	(0.135)
Dist.(Individual Premium)			0.152*	0.170**
			(0.080)	(0.081)
Non coed		0.017		0.064
		(0.010)		(0.091)
Two boys		0.020		0.233
		(0.023)		(0.143)
Two girls		-0.021		0.296*
		(0.015)		(0.167)
Math Score	No	Yes	No	Yes
Network Characteristics	No	Yes	No	Yes
TIPI Scores	No	Yes	No	Yes
Constant	0.151***	0.065	0.157***	0.709
	(0.037)	(0.053)	(0.041)	(0.519)
Observations	786	771	320	314
R-squared	0.318	0.341	0.068	0.133

Notes: 1) *** p<0.01, **,p<0.05, * p<0.1, 2) Standard errors are clustered at class level 3) Network characteristics include mean, distance of indegree and outdegree. Dyadic relationship is also controlled., 4) TIPI scores consist of outgoing, openness to experience, conscientiousness, emotional stability and agreeableness.

Dependent Var.	Utility Loss from Collective Decision			
	(1)	(2)	(3)	(4)
Collective CCEI	-0.369***	-0.390***	-0.365***	-0.387***
	(0.067)	(0.058)	(0.066)	(0.056)
Ave.(Individual RP)	0.093	0.099		
	(0.114)	(0.101)		
Dist.(Individual RP)	-0.139*	-0.129**		
	(0.072)	(0.062)		
Ave.(Individual Premium)			-0.027	-0.027*
			(0.018)	(0.016)
Dist.(Individual Premium)			-0.002	-0.006
			(0.010)	(0.009)
Non Coed		-0.011		-0.009
		(0.023)		(0.023)
Two Boys		0.065*		0.072*
		(0.039)		(0.039)
Two Girls		-0.018		-0.014
		(0.027)		(0.026)
Constant	0.413***	0.352**	0.458***	0.400***
	(0.095)	(0.137)	(0.063)	(0.136)
Observations	320	314	320	314
R-squared	0.075	0.220	0.070	0.219

Notes: 1) *** p<0.01, **,p<0.05, * p<0.1, 2) Standard errors are clustered at class level 3) Network characteristics include mean, distance of indegree and outdegree. Dyadic relationship is also controlled., 4) TIPI scores consist of outgoing, openness to experience, conscientiousness, emotional stability and agreeableness.