

Rationality and Preference Aggregation of Group Decision under Risk

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Introduction

- In various contexts, many important decisions are made by groups.
- Heterogeneity in various dimensions:
 - Risk preference: risk assessment in environmental policy-making in committees
 - Time preference: household savings and consumption decisions.
 - Rationality
- It is important to understand how individual heterogeneity in a collective influences final outcomes.

Introduction: Research Questions

1. Rationality extension:

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

2 Risk preference aggregation:

- Are individual's risk preferences reflected into that of a group?

3. Efficiency:

- Are group's choices Pareto efficient?
- How is the efficiency related to group members' rationality and preferences?

Introduction: Why Experiments?

- The laboratory experiment can be stripped of many confounding factors, and decisions can be observed in a highly **controlled environment**.
- By applying the revealed preference theory, we can directly measure rationality and risk preference without noise.
- Beyond measuring rationality and risk preference, we can investigate how these are **aggregated** in collective decisions.
- We finally analyze an efficiency of group decisions as a function of members' rationality and preference.

Related Literature

1. Preference aggregation



2 Testable implication

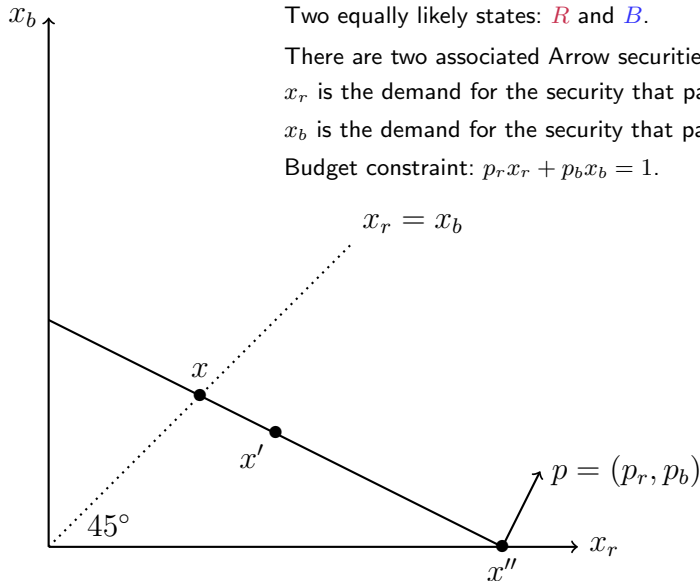


3. Intra-household bargaining

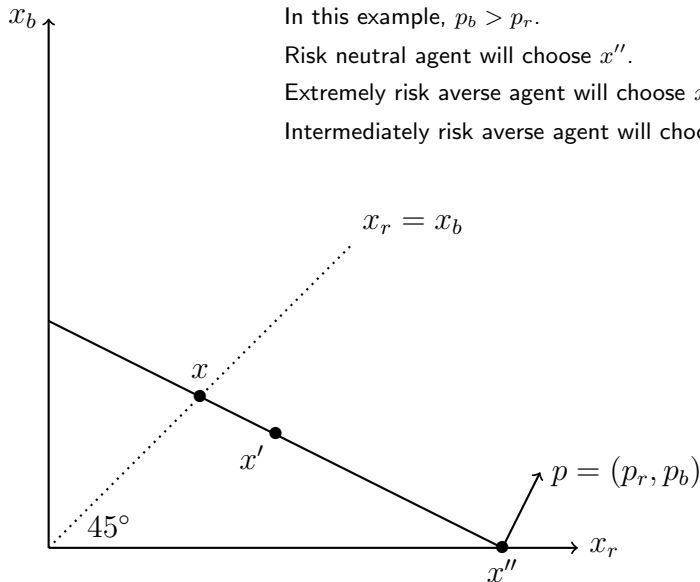


Experimental Design and Subjects

Experimental Design



Experimental Design



In this example, $p_b > p_r$.

Risk neutral agent will choose x'' .

Extremely risk averse agent will choose x .

Intermediately risk averse agent will choose x' .

Procedure and Subjects

- We conducted the experiment in 12 middle schools in Daegu.
- The number of students: 1572.
- The number of groups: 786.
- The instructions were read by an experiment in each classroom.
- Each subject participate in two sessions: individual and group decisions.
- Each session consisted of 18 independent decision rounds.
- Each round started by having the computer select a budget line randomly from the set of lines that intersect at least one axis at or above 300 KRW or below 1500 KRW.

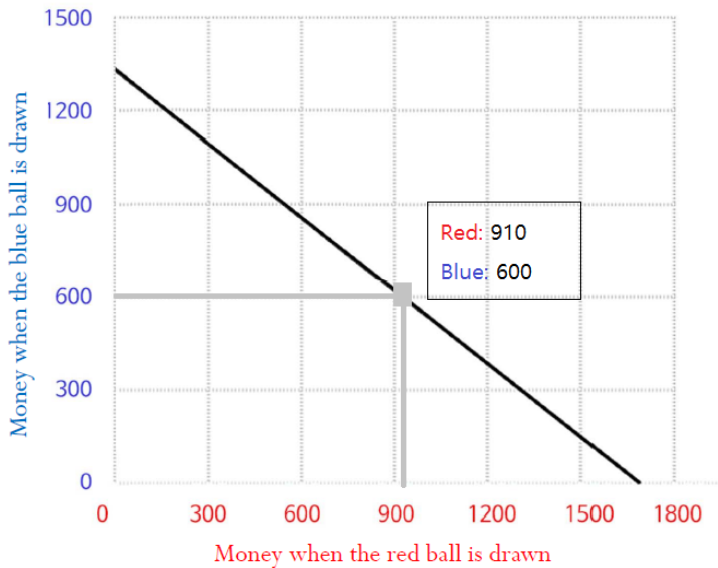
Procedure and Subjects

- At the end of each round, the computer randomly selected one of the two states (R and B).
- Subjects were not informed of the state that was actually selected at the end of each round.
- Each subject was paid for he/she earned in a randomly selected round.
- After every student finishes the first session, the second session begins.
- Two students in the same classroom were randomly matched.
- A student moved to the other partner's desk and make collective decisions by sharing the computer.
- We allowed students to discuss how to make decisions for 1 min before starting the second session.

Experimental Design



Experimental Design: Screenshot

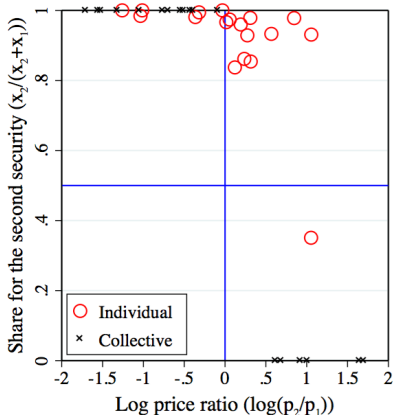


Experimental Design: Example

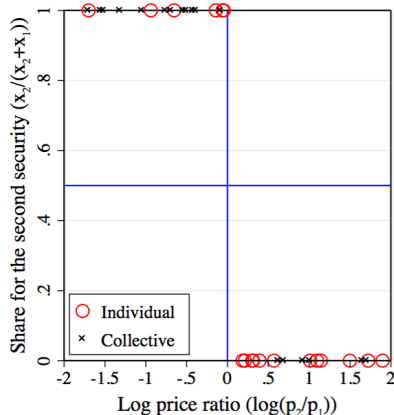
Group ID: 1

Collective CCEI: 1.00

Risk Preference: 0.00, DAU



Individual CCEI: 1.00
Risk Preference: 0.59, EU
Id: 1110105



Individual CCEI: 1.00
Risk Preference: 0.00, DAU
Id: 1110102

Result 1: Rationality Extension

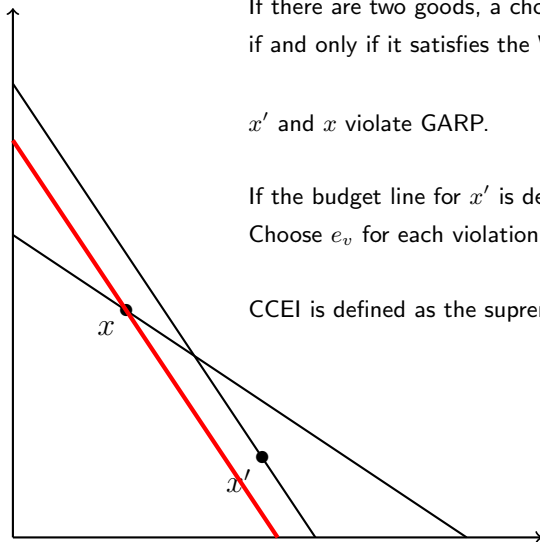
Measurement: Afriat's Efficiency Index (a.k.a. CCEI)

If there are two goods, a choice dataset satisfies the GARP if and only if it satisfies the WARP.

x' and x violate GARP.

If the budget line for x' is deflated, then GARP is satisfied.
Choose e_v for each violation v .

CCEI is defined as the supremum over all the numbers e_v 's.



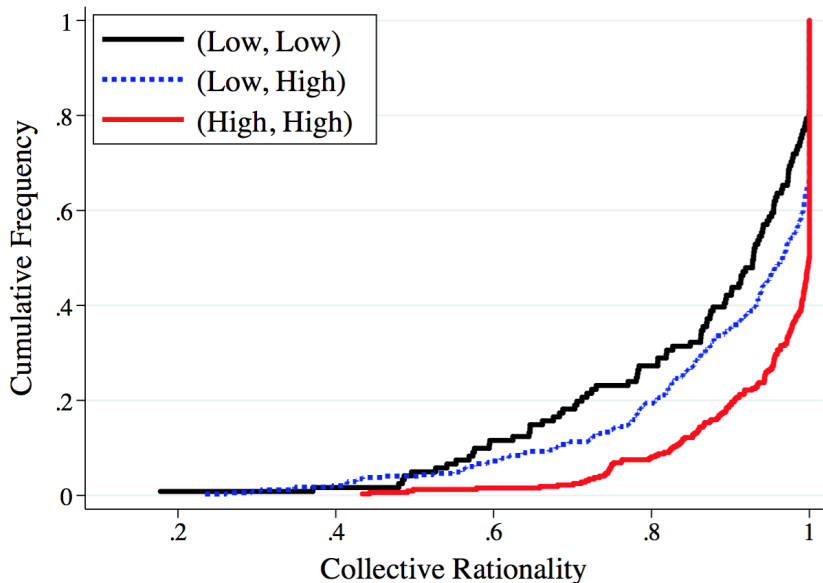
Measurement: Afriat's Efficiency Index (a.k.a. CCEI)

- By definition, $\text{CCEI} \in [0, 1]$.
- The **bigger** CCEI is, the **less** severe violation of GARP.
- Basic statistics of individual CCEI:
 - Average: 0.897 (0.136)
 - Quantiles: 0.838, 0.953, 1.
- Basic statistics of collective CCEI:
 - Average: 0.897 (0.136)
 - Quantiles: 0.868, 0.981, 1.

Rationality Extension: Research Question

Individual Rationality $\uparrow \Rightarrow$ Collective Rationality \uparrow ?

Rationality Extension: First-Order Stochastic Dominance



Rationality Extension: First-Order Stochastic Dominance

- We do a series of Kolmogorov-Smirnov tests:

$$H_0 : F_{\text{group } i}(X) = F_{\text{group } j}(X) \quad \text{for all values of } X.$$

- (Low, Low) v.s. (High, High): 0.17
 - The corresponding p-value is 0.01.
- (Low, High) v.s. (High, High): 0.21
 - The corresponding p-value is 0.00.

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- (Low, High) v.s. (High, High): 0.21
 - The corresponding p-value is 0.00.
- Our results are robust with respect to
 - another rationality measure (Varian's efficiency index)
 - cutoff values (0.99 or 0.95).

Rationality Extension: Econometric Analysis

| Collective CCEI | Coefficient | | |
|----------------------------|----------------------|----------------------|----------------------|
| | Model 1 | Model 2 | Model 3 |
| CCEI_Max | 0.368*** (0.083) | 0.327*** (0.074) | 0.302*** (0.089) |
| CCEI_Distance | -0.277*** (0.056) | -0.250*** (0.053) | -0.233*** (0.058) |
| Risk_Aversion_Max | | -0.189*** (0.056) | -0.172** (0.070) |
| Risk_Aversion_Distance | | 0.087* (0.048) | 0.093* (0.055) |
| Math_Score_Max | | | 0.012** (0.005) |
| Math_Distance | | | -0.010** (0.005) |
| Constant | 0.582*** (0.077) | 0.679*** (0.070) | 0.664*** (0.084) |
| Class Fixed Effect | Yes | Yes | Yes |
| Individual Characteristics | No | No | Yes |
| School Characteristics | No | No | Yes |
| Friendship | No | No | Yes |
| Observations | 786 | 786 | 786 |
| R-squared | 0.200 | 0.212 | 0.235 |

Result 2: Preference Aggregation

Measurement: A Parametric Measure

- We consider a constant absolute risk aversion (CARA) utility function over outcomes:

$$u(x) = -\frac{e^{-\rho x}}{\rho}.$$

- We consider two different types of utility function over lotteries:
 - Expected utility (EU) by von Neumann and Morgenstern (1953):

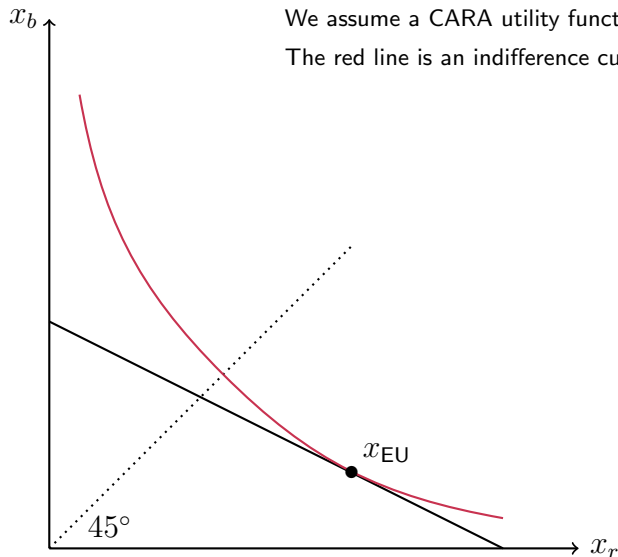
$$U(Z) = \frac{1}{2}u(x_{\max}) + \frac{1}{2}u(x_{\min}).$$

- Disappointment aversion utility (DAU) by Gul (1991):

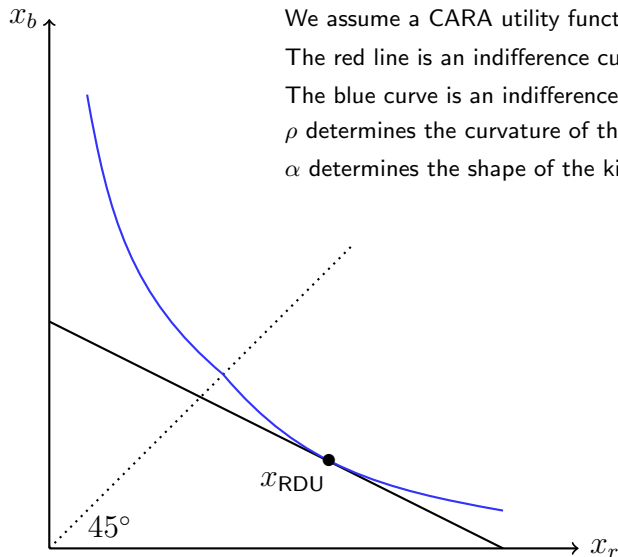
$$U(Z) = \alpha u(x_{\max}) + (1 - \alpha)u(x_{\min}) \quad \text{where } \alpha = \frac{1}{2 + \beta}$$

- $\beta > 0$: disappointment aversion
 - $-1 < \beta < 0$: elation seeking.
- We estimate ρ and β simultaneously by using NLLS.

Measurement: Indifference Curves



Measurement: Indifference Curves



We assume a CARA utility function: $u(x) = -e^{-\rho x} / \rho$.

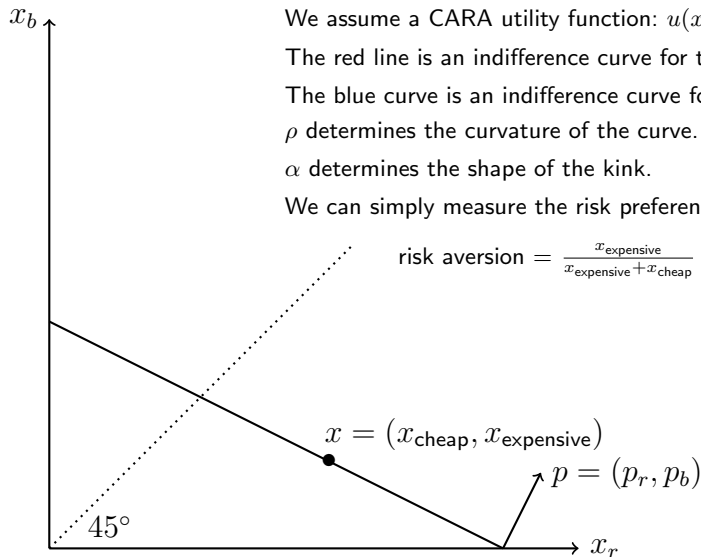
The red line is an indifference curve for the EU.

The blue curve is an indifference curve for the RDU.

ρ determines the curvature of the curve.

α determines the shape of the kink.

Measurement: Indifference Curves



We assume a CARA utility function: $u(x) = -e^{-\rho x}/\rho$.

The red line is an indifference curve for the EU.

The blue curve is an indifference curve for the RDU.

ρ determines the curvature of the curve.

α determines the shape of the kink.

We can simply measure the risk preference by a ratio:

$$\text{risk aversion} = \frac{x_{\text{expensive}}}{x_{\text{expensive}} + x_{\text{cheap}}}$$

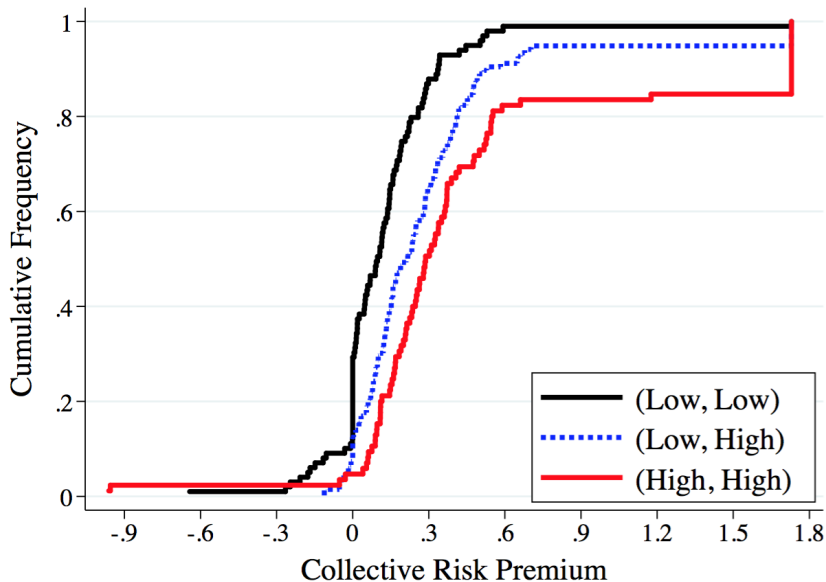
Measurement: Risk Preferences

- The degree of risk aversion is measured by both parametric and non-parametric methods.
- The **bigger** premium/ratio is, the **higher** risk aversion.
- Basic statistics of individual risk preference:
 - Risk premium: 0.220 (0.310)
 - Ratio: 0.324 (0.132).
- Basic statistics of collective risk preference:
 - Risk premium: 0.258 (0.371)
 - Ratio: 0.298 (0.139).

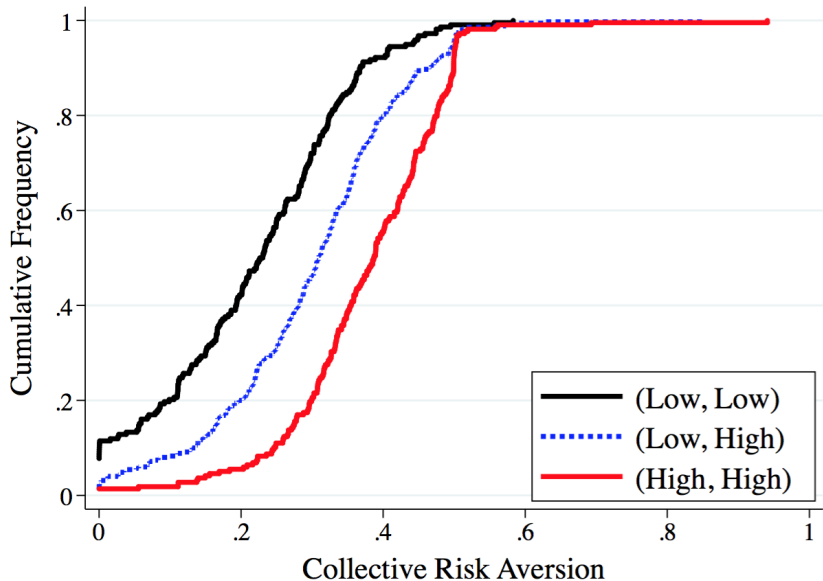
Risk Preference Aggregation: Research Question

Individual risk aversion $\uparrow \Rightarrow$ Collective risk aversion \uparrow ?

Risk Preference Aggregation: FOSD by Premium



Risk Preference Aggregation: FOSD by Relative Ratio



Risk Preference Aggregation: Econometric Analysis

| Collective Risk Aversion | Coefficient | | |
|----------------------------|----------------------|----------------------|----------------------|
| | Model 1 | Model 2 | Model 3 |
| Risk_Aversion_Max | 0.792*** (0.066) | 0.808*** (0.063) | 0.759*** (0.073) |
| Risk_Aversion_Distance | -0.421*** (0.053) | -0.432*** (0.053) | -0.434*** (0.062) |
| CCEI_Max | | 0.165** (0.064) | 0.196*** (0.071) |
| CCEI_Distance | | 0.014 (0.033) | 0.040 (0.045) |
| Math_Score_Max | | | 0.000 (0.005) |
| Math_Distance | | | 0.005 (0.004) |
| Constant | 0.004 (0.027) | -0.156** (0.063) | -0.175** (0.077) |
| Class Fixed Effect | Yes | Yes | Yes |
| Individual Characteristics | No | No | Yes |
| School Characteristics | No | No | Yes |
| Friendship | No | No | Yes |
| Observations | 786 | 786 | 786 |
| R-squared | 0.372 | 0.378 | 0.382 |

Result 3: Efficiency

Efficiency: Measurement

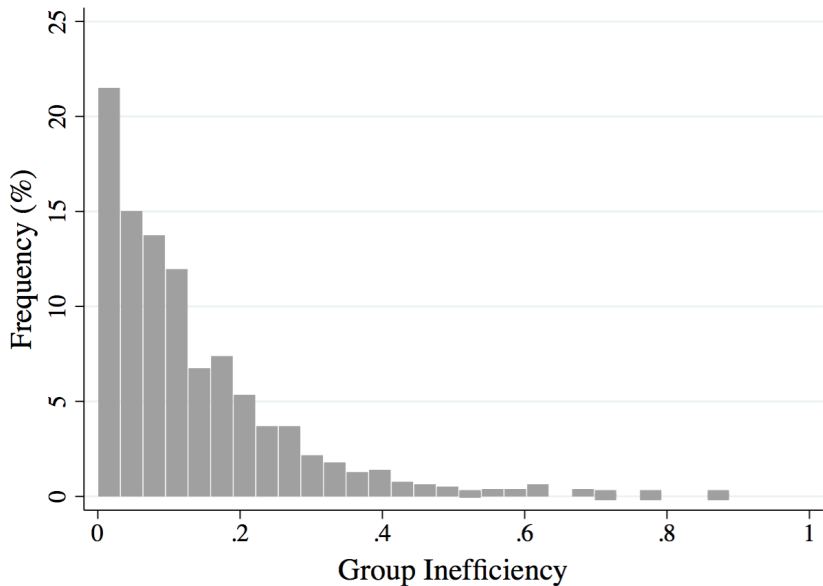
- **Claim:** A group's choice x_c is **Pareto efficient** if and only if it is between the members' optimal choices.
- We measure the group inefficiency as the average utility loss:

$$\text{Inefficiency}_g = \frac{1}{18} \sum_{k=1}^{18} \frac{1}{2} \sum_{i=1}^2 \frac{u_i(x_{ikb}) - u_i(x_{ck})}{u_i(x_{ikb}) - u_i(x_{ikw})}.$$

where

- x_{ck} : group choice in k -th round
 - x_{ikb} : member i 's best choice in k -th round
 - x_{ikw} : member i 's worst choice in k -th round.
- By definition, $\text{Loss}_g \in [0, 1]$.

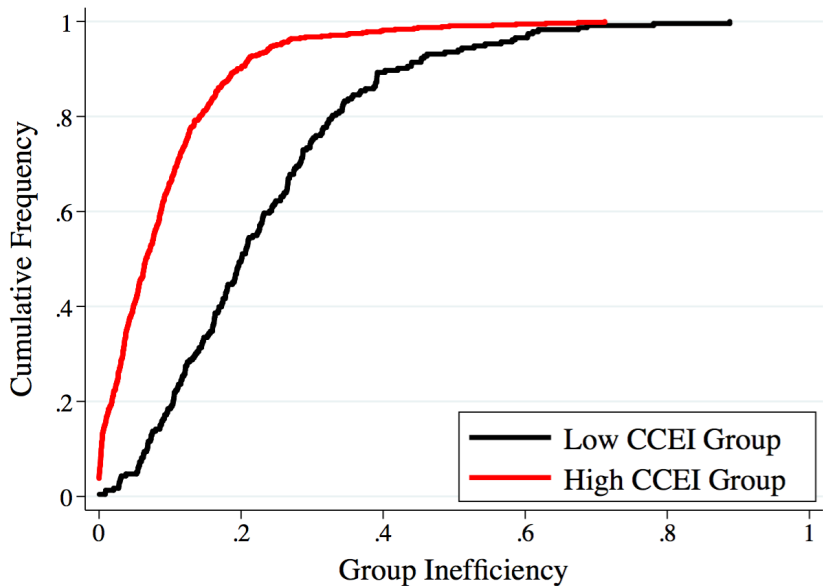
Efficiency: Distribution of Group Inefficiency



Efficiency: Research Question

How is the efficiency related to individual rationality and risk preference?

Efficiency: FOSD by Group Rationality



Efficiency: Econometric Analysis

| Group Inefficiency | Coefficient | | |
|----------------------------|----------------------|----------------------|----------------------|
| | Model 1 | Model 2 | Model 3 |
| CCEI_Group | -0.571*** (0.042) | -0.503*** (0.039) | -0.527*** (0.043) |
| CCEI_Max | | -0.296*** (0.045) | -0.242*** (0.051) |
| CCEI_Distance | | 0.165*** (0.042) | 0.178*** (0.052) |
| Risk_Aversion_Max | | -0.009 (0.056) | 0.023 (0.063) |
| Risk_Aversion_Distance | | -0.057* (0.031) | -0.073* (0.040) |
| Math_Score_Max | | | 0.002 (0.005) |
| Math_Distance | | | -0.004 (0.003) |
| Constant | 0.651*** (0.038) | 0.866*** (0.048) | 0.807*** (0.061) |
| Class Fixed Effect | Yes | Yes | Yes |
| Individual Characteristics | No | No | Yes |
| School Characteristics | No | No | Yes |
| Friendship | No | No | Yes |
| Observations | 786 | 786 | 786 |
| R-squared | 0.442 | 0.487 | 0.497 |

Conclusion

- In this paper, we measure rationality and risk preference in both individual and group levels.
- More rational individuals are more likely to make rational choices.
- More risk-averse individuals are more likely to make risk-averse choices.
- More rational groups choices are more likely to efficient decisions.
- More preference-aligned individuals need not make efficient decisions.

Robustness

Varian's Efficiency Index



Introduction: Risk Perception

1. Genetics: White males were more likely to perceive risks as being smaller (Bickerstaff, 2004; Flynn et al., 1994).
2. Psychology:
 - availability bias
 - experience
3. Knowledge and Information: public v.s. experts
4. Other factors
 - culture: Chinese individuals are significantly less risk-averse than individuals from Western countries when making financial decisions (Weber and Hsee, 1998).
 - power: high-power groups adopt a more positive attitude toward potential risks (Anderson and Galinsky, 2006; Magee et al., 2007; Geng et al, 2018).
 - social inequality: Sweden people with foreign backgrounds did perceive risks as higher than native people, but no difference between men and women.

Rank-Dependent Utility Function

- A functional form:
- Properties:
 - An indifference curve is only partially convex.
 - The slope of an indifference curve is calculated as

$$\frac{dy}{dx} =$$

- With a CARA (or CRRA) utility function, it can rationalize all the choices except the corner choices.
- When there are only two states, it is equivalent to the disappointment-aversion utility function by Gul (1991).
- Of course, this utility function is aligned with the first-order stochastic dominance relationships between lotteries.

Pareto Efficiency: Measurement

- For given budget set, let x_1^* and x_2^* be the optimal portfolio choice of agent 1 and agent 2, respectively.
- **Claim:** A group choice x_c is **Pareto efficient** if and only if $x_c \in [x_1^*, x_2^*]$.