ICA-RUS/CCRP-PJ2 International Workshop 2013
Session 5: Presentations relevant to S-10-4
 (Assessment of risk management options)

Model Development and Gaming Simulations Focusing on the Interactions of Multiple Decision Makers in the Global Policy Agreement

Preliminary results

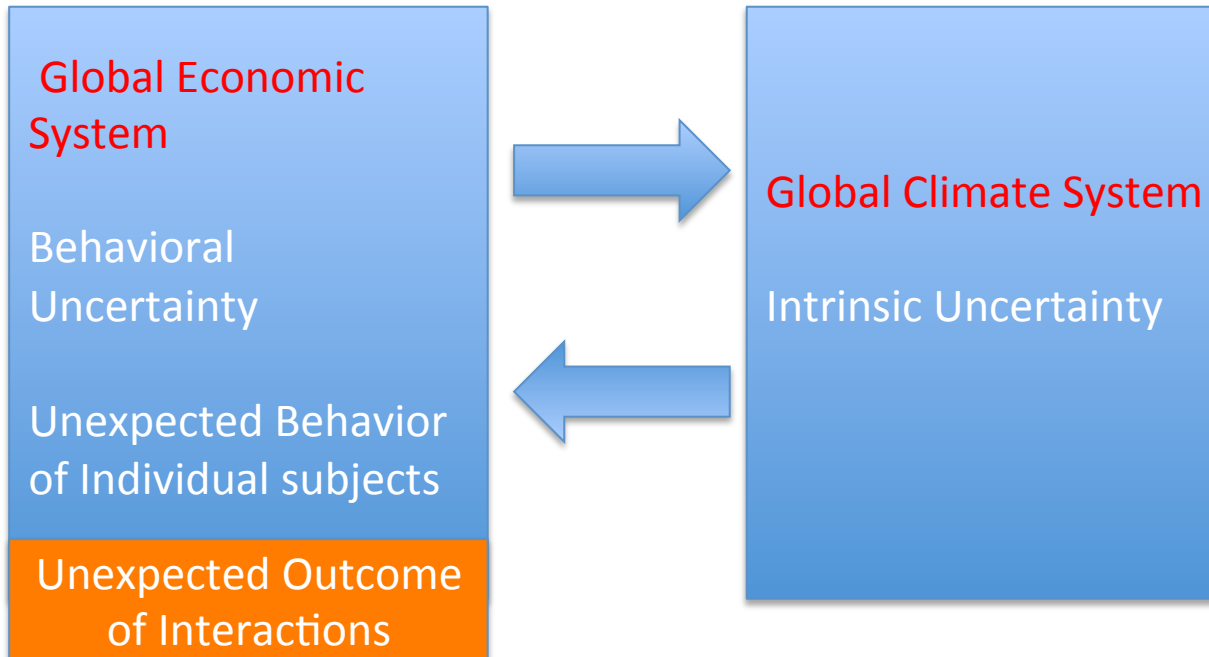## Regional and sectoral impacts of climate change under international climate agreements

Toyoaki WASHIDA, Prof.
Shin SAKAUE, Ph.D.
Koichi YAMAURA, Ph.D.
Sophia University

Two Box Model

Global Economic System

Behavioral Uncertainty

Unexpected Behavior of Individual subjects

Unexpected Outcome of Interactions

Global Climate System

Intrinsic Uncertainty

• Interaction and Decision in economics affect those two global systems.

• We can estimate those effects using a dynamic integrated model (EMEDA).

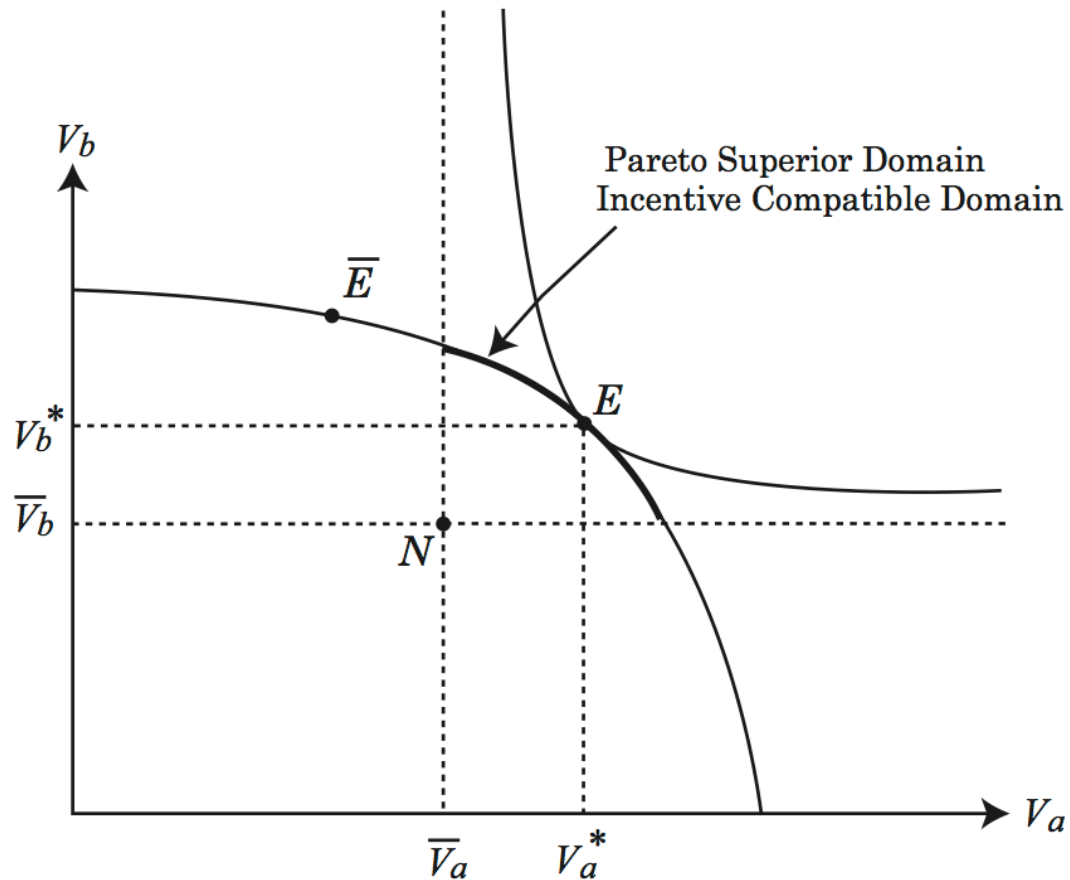# Two Solution Concepts in Game Theory

John F. Nash, 1928 -

(1) Nash Equilibrium: Every player tries to maximize his own benefit. Nobody has any incentive to change their strategy.

(2) Nash Bargaining Solution: It shows the outcome axiomatically. It attains Pareto Optimum.

# Equilibrium in Cooperative and Selfish Behavior

Methodology

About a EMEDA:

- EMEDA is a CGE model first developed by Washida (2010) to simulate economic damages resulting from global warming damage and adaptation costs

- Economy: 8 regions, 8 sectors

- Periods: From 2004 to 2100 by year

- Data: GTAP7 Data Base, UNdata, EIA, SSP (Shared Socioeconomic Pathways)

- Global warming and damage functions modified from DICE2010 and RICE2010 (Nordhaus, 2012)

Regions and sectors in a EMEDA

Regions	Sectors
1 Japan	1 Agriculture
2 China	2 Forestry
3 USA	3 Fishing
4 EU25_WEurope	4 Extraction
5 FSU_EEurope	5 LightMnfc
6 OAsiaOceania	6 HeavyMnfc
7 OAmerica	7 TransComm
8 Africa	8 OthServices

Global Warming Model
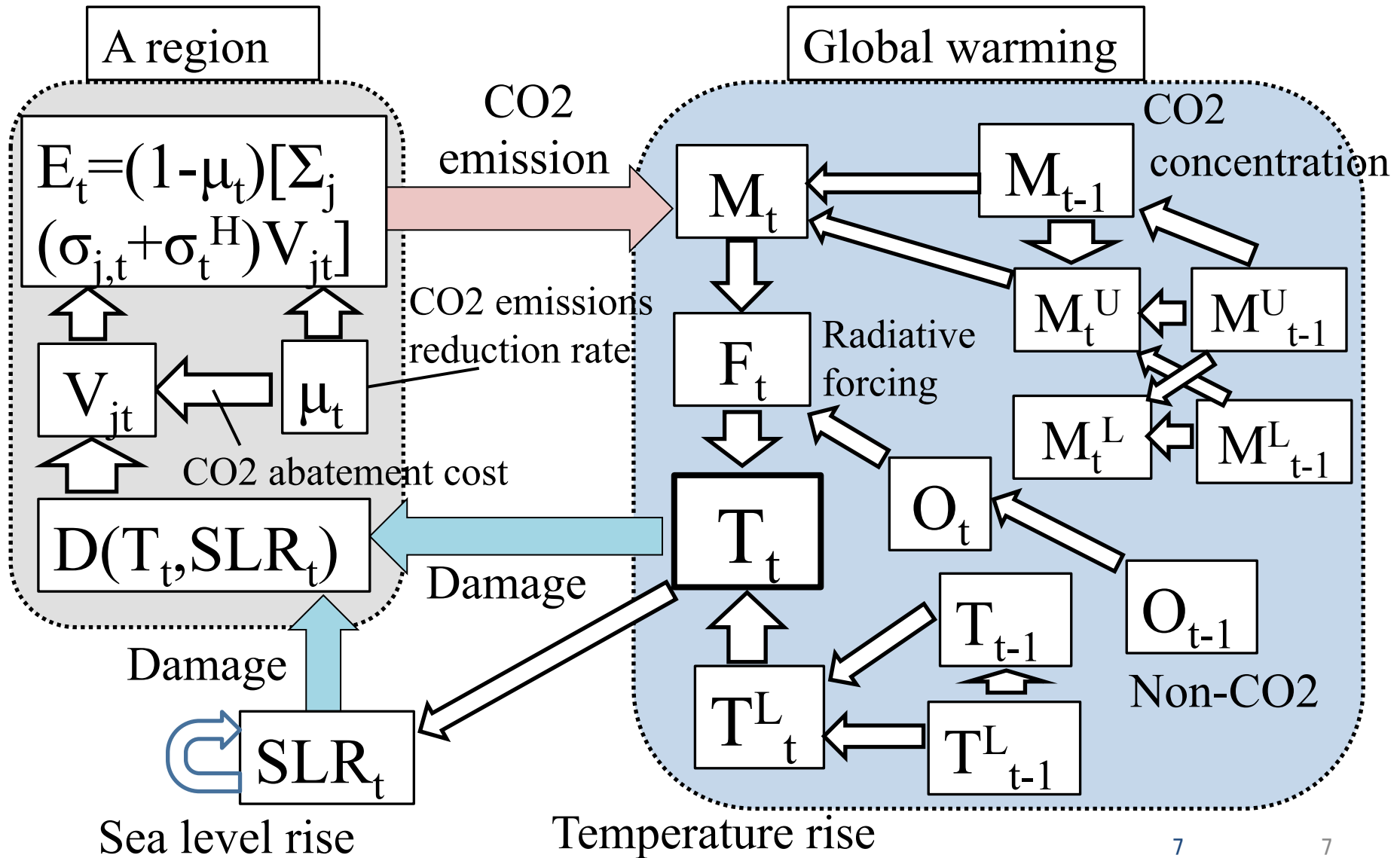
CO2 Emissions Reduction Rate
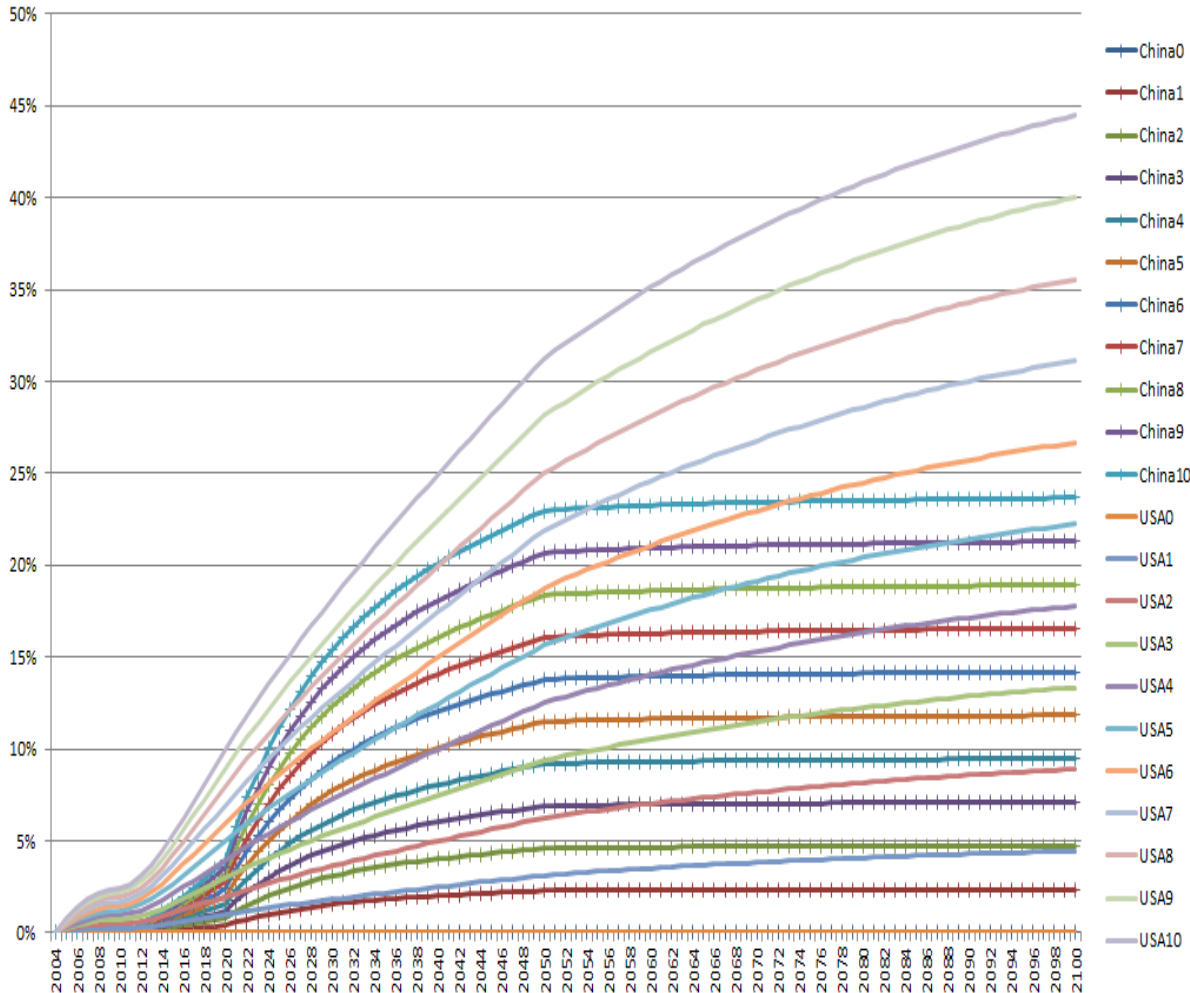# in the Base Scenario $\mu_r{'}$

Changes in Regional CO2 Emissions Reduction Rate $\mu_r{'}$ in the Base Scenario
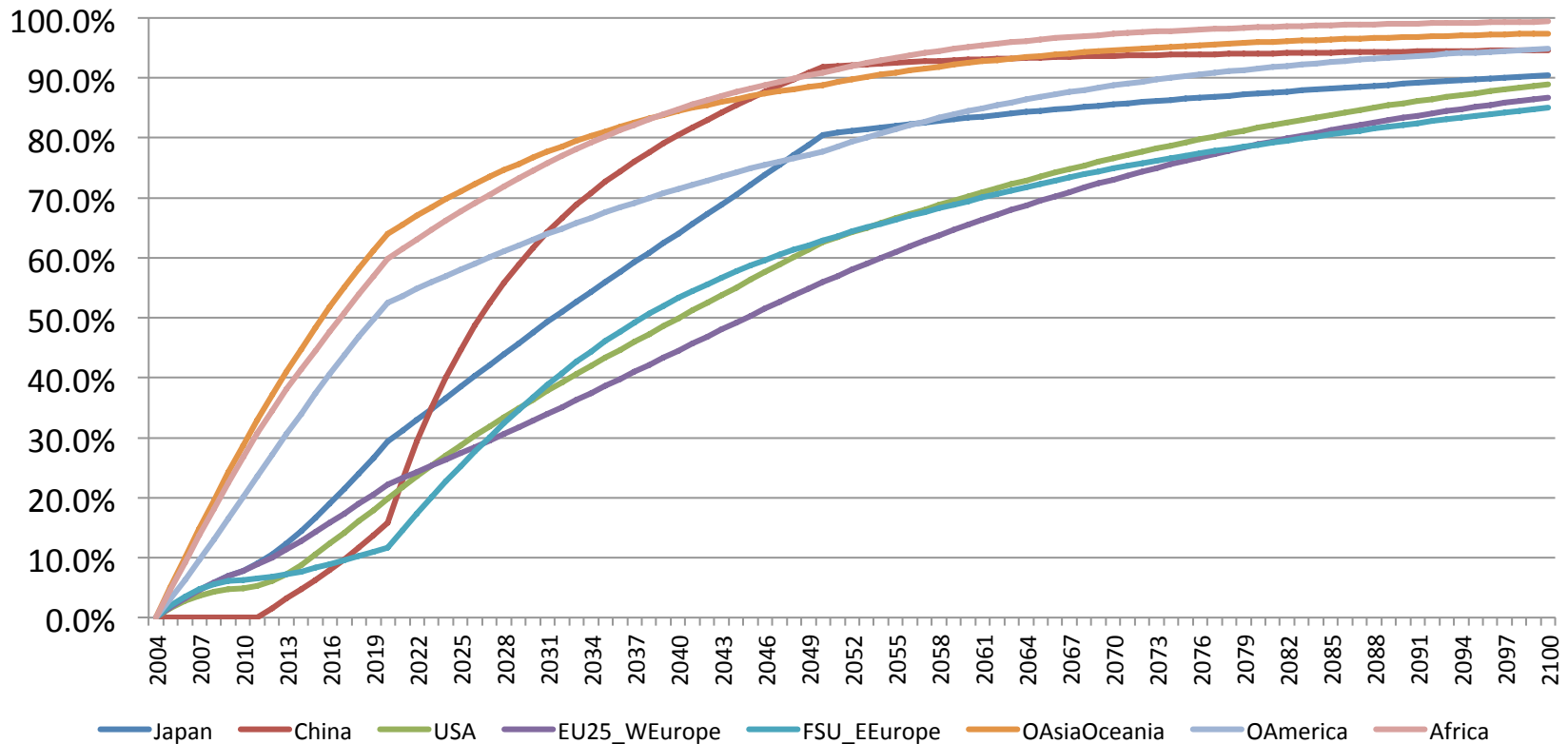
Strategies in two-player game
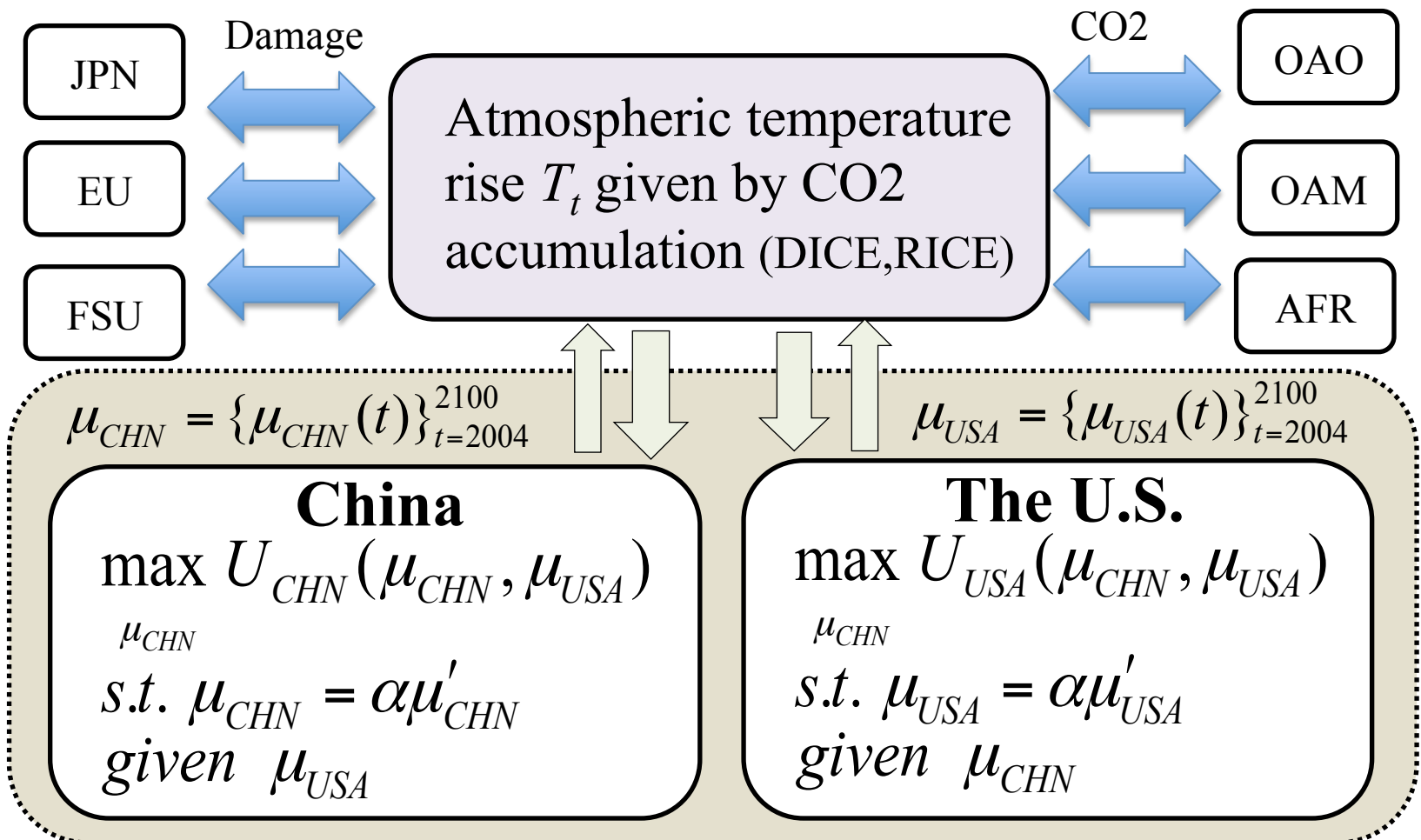
CO2 emissions reduction rates

China

0	$0\% \mu'_{China}$	6	$15\% \mu'_{China}$
1	$2.5\% \mu'_{China}$	7	$17.5\% \mu'_{China}$
2	$5\% \mu'_{China}$	8	$20\% \mu'_{China}$
3	$7.5\% \mu'_{China}$	9	$22.5\% \mu'_{China}$
4	$10\% \mu'_{China}$	10	$25\% \mu'_{China}$
5	$12.5\% \mu'_{China}$		

USA

0	$0\% \mu'_{USA}$	6	$30\% \mu'_{USA}$
1	$5\% \mu'_{USA}$	7	$35\% \mu'_{USA}$
2	$10\% \mu'_{USA}$	8	$40\% \mu'_{USA}$
3	$15\% \mu'_{USA}$	9	$45\% \mu'_{USA}$
4	$20\% \mu'_{USA}$	10	$50\% \mu'_{USA}$
5	$25\% \mu'_{USA}$		

A two-player CO2 abatement game

JPN	Damage ⟷	Atmospheric temperature rise T_t given by CO2 accumulation (DICE,RICE)	CO2 ⟷	OAO
EU	⟷		⟷	OAM
FSU	⟷		⟷	AFR

$\mu_{CHN} = \{\mu_{CHN}(t)\}_{t=2004}^{2100}$ 　　　　　 $\mu_{USA} = \{\mu_{USA}(t)\}_{t=2004}^{2100}$

China
$$\max_{\mu_{CHN}} U_{CHN}(\mu_{CHN}, \mu_{USA})$$
$$s.t.\ \mu_{CHN} = \alpha\mu'_{CHN}$$
$$given\ \mu_{USA}$$

The U.S.
$$\max_{\mu_{CHN}} U_{USA}(\mu_{CHN}, \mu_{USA})$$
$$s.t.\ \mu_{USA} = \alpha\mu'_{USA}$$
$$given\ \mu_{CHN}$$

μ_r: CO2 reduction rates
μ'_r : μ_r in the base scenario

$$U_r = \sum_{t=2004}^{2100} \frac{u_{r,t}(C_{r,t}, S_{r,t}, G_{r,t})}{(1+\rho)^{t-2004}}$$

10

Results in the two-player game

CO2 emissions reduction rates of solutions ($\rho=3\%$)

Regions	Nash equilibrium	Nash bargaining solution
China	$7.5\%\mu'_{China}$	$15\%\mu'_{China}$
USA	$15\%\mu'_{USA}$	$35\%\mu'_{USA}$

Results in the two-player game (China, USA)

Rate of time preference	Nash equilibrium	Nash bargaining solution
1%	(7.5%,20%)	(20%,45%)
3%	(7.5%,15%)	(15%,35%)
5%	(7.5%,15%)	(12.5%,25%)
10%	(5%,10%)	(7.5%,15%)

Distribution of payoffs by strategy in two-player game
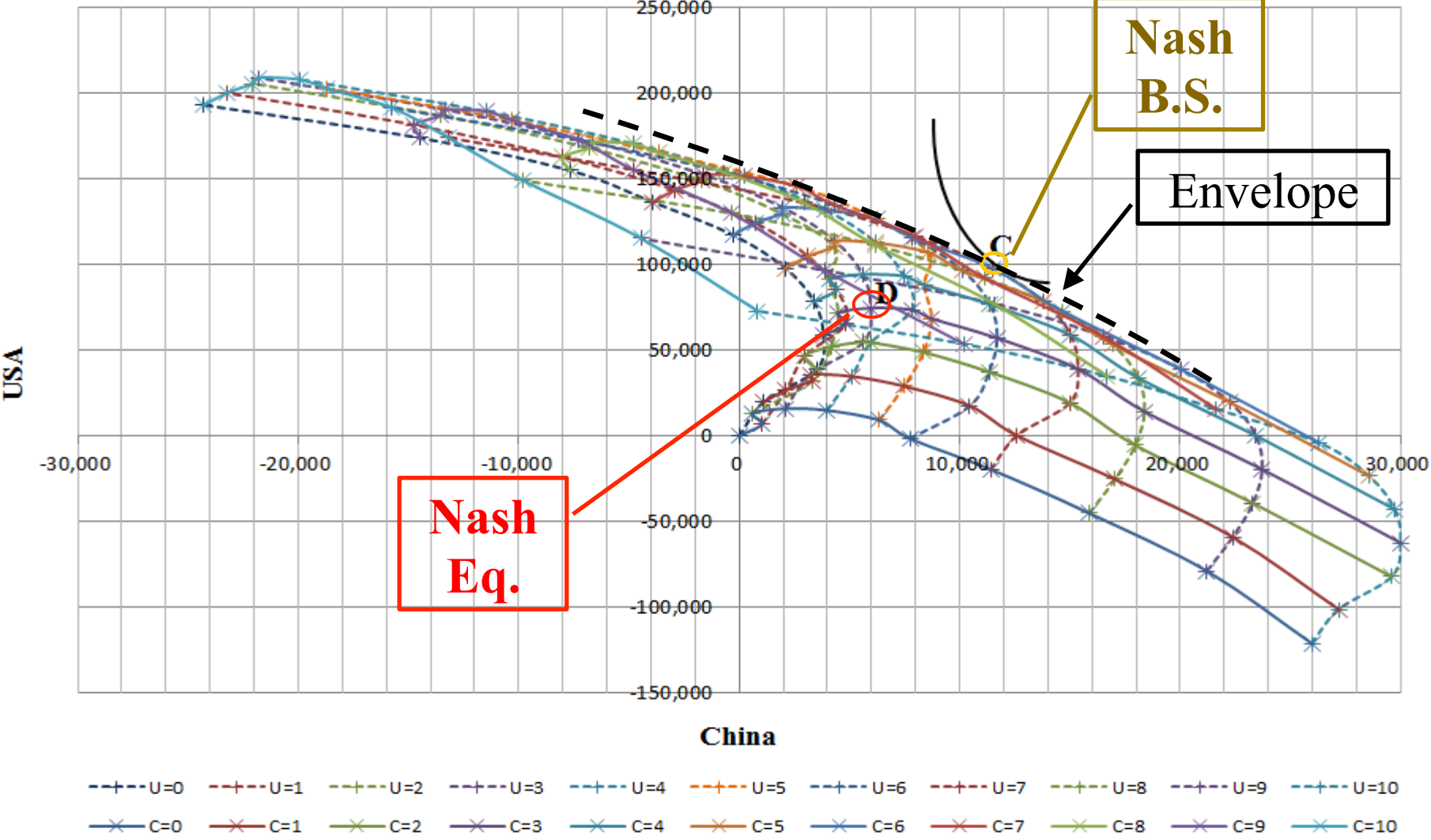
Comparison of Changes in Temperature

No reduction	Base scenario	The two-player game		The three-player game	
		Nash eq.	Nash bar. sol.	Nash eq.	Nash bar. sol.
4.426	*2.309*	*3.214*	*3.128*	*3.210*	*3.153*
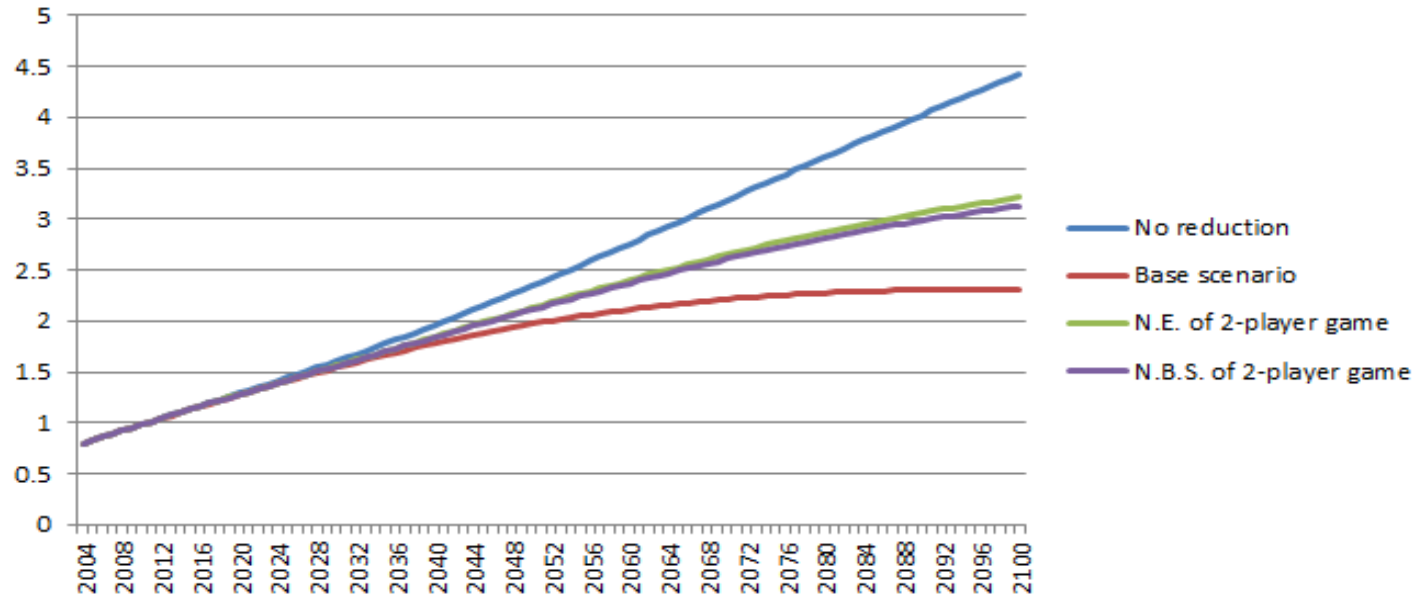
Temperature rise in 2100 (℃ above 1900)

How do we have to evaluate and understand those results (1) ?

1. "Non-cooperative" does not necessarily mean "no-reduction".

They have to reduce their emissions for reduction of their own damages and
the damages of the trade partners.

2. "Cooperative" does not necessarily mean "bold reduction".

Simply it takes cost to reduce emission.

3. Decrease of discount rates causes the increase of the difference.

The difference in 3% discount rate is about 0.09 instead of 0.13 in 1% discount rate.

# How do we have to evaluate and understand those results (2) ?

4. Global economic system plays a kind of adaptation system.

   It absorbs extreme changes and extreme damages due to the efficiency of global markets.

5. Should bargaining reach some agreements?

   Our results show that voluntary and selfish actions not necessarily rush into a catastrophic situations.

Discount Rates and Temperature Increase
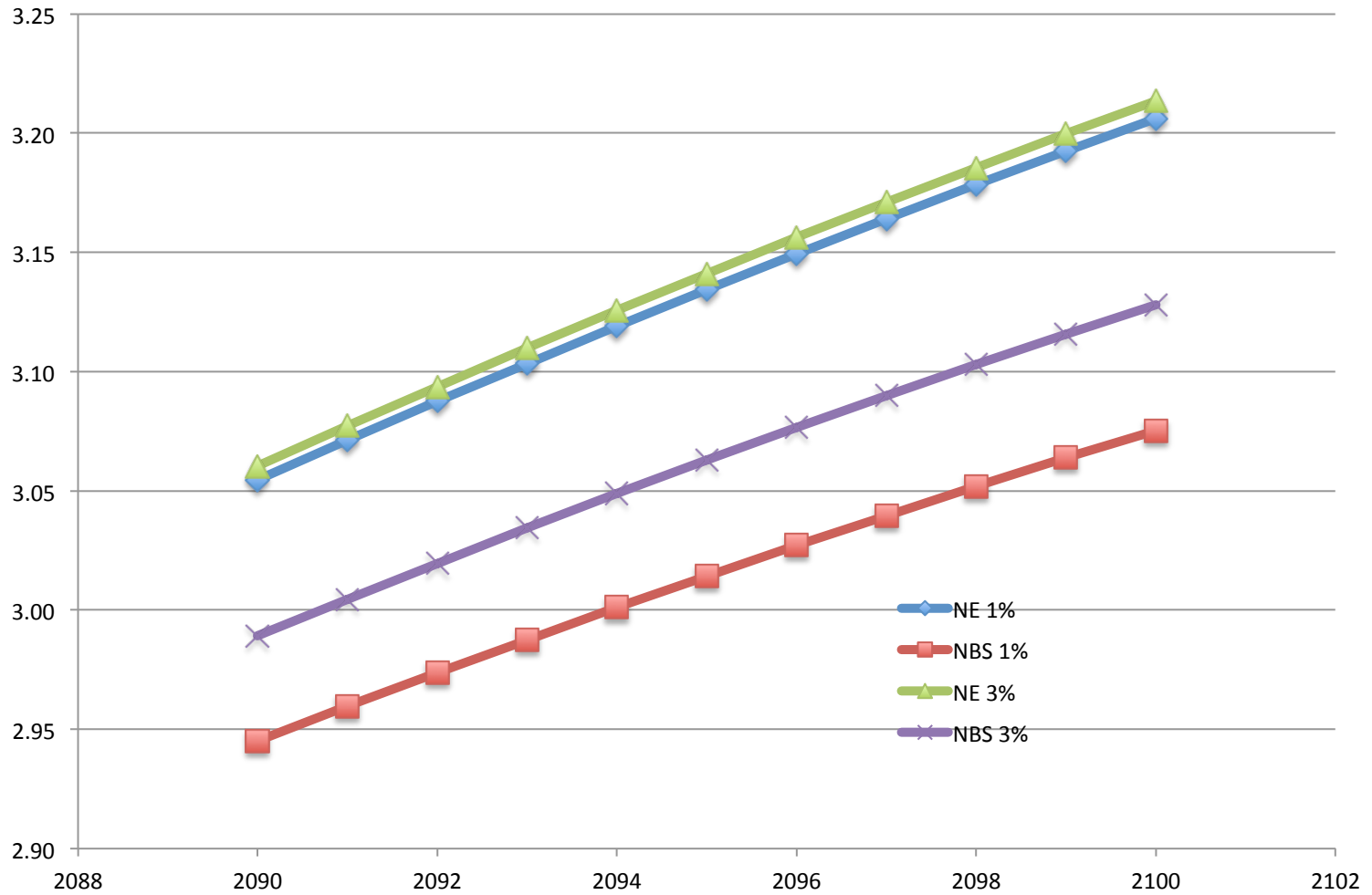
Conclusions

- We can execute specific simulations for bargaining among regions using an dynamic integrated model with multi-sectoral and multi-regional model.

- The difference for outcomes between global cooperation and global non-cooperation may not so large as people currently think. So, We should take voluntary actions into more serious considerations.

- Behavioral uncertainty in global economic system may be small.