ITPU
International Transport Policy Research Unit
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One-day International Workshop on
Sustainable Transportation and Energy
– Leading-edge Technologies and Policies

Emission Trade in International Air Transportation

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Sanjo Conference Hall / University of Tokyo

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Outline

1. Recent Policy Situation of International Aviation and Climate Change
2. Emission Trading Simulation under NCG Theory Framework
3. Welfare Consideration for Bargaining among States

1. Recent Policy Situation of International Aviation and Climate Change

Major Countries' Positions

Kyoto Protocol

【Reduction obligation】

CAP & Trade (EU-ETS)

– 8 % **EU**

（？）

Sector specific / indexed unit base

– 6 % **JAPAN** [Balance with NDC]

【No Reduction】

0 % **Russia（FSU）**

【Common But Differentiated Responsibilities】
【CBDR】

0 % [Economic Growth]

CHINA, INDIA, BRAZIL, SOUTH AFRICA,… [NDC]

Outside of Kyoto Protocol

[Economic Growth]

[Balance with NDC]

<< Reduction obligation >>

– 7 %

US（Bush ad.）

↓

US（Obama ad.）

（？）

Economy-wide Cap & Trade

Details not certain yet

cf; Waxman=Markey Bill (Cap & Trade)

Int'l Aviation and Climate Change

- **ICAO is the forum designated by Kyoto P. for Int'l aviation. (Domestic is included in KP.)**
- **ICAO set up GIACC (high level group on the issue) and GIACC reached agreement.**
- **EU pursues their own EU-ETS approach.**
- **US is still under policy formation phase.**
- **China & others sticks to CBDR principle.**

EU Directive(09/01/13)

- ✈ Introduce aviation into EU-ETS in 2012
- ✈ Need each country's own enactment
- ✈ All airlines to/from EU must buy some allowance from EU-ETS
- ✈ Allowance are distributed more than 80% free and the rest by auction from 2012.

13.1.2009 EN Official Journal of the European Union L 8/3

DIRECTIVES

DIRECTIVE 2008/101/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 19 November 2008

amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Economic and Social Committee (1),

Having regard to the opinion of the Committee of the Regions (2),

Acting in accordance with the procedure laid down in Article 251 of the Treaty (3),

Whereas:

(1) Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community (4) established a scheme for greenhouse gas emission allowance trading within the Community in order to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner.

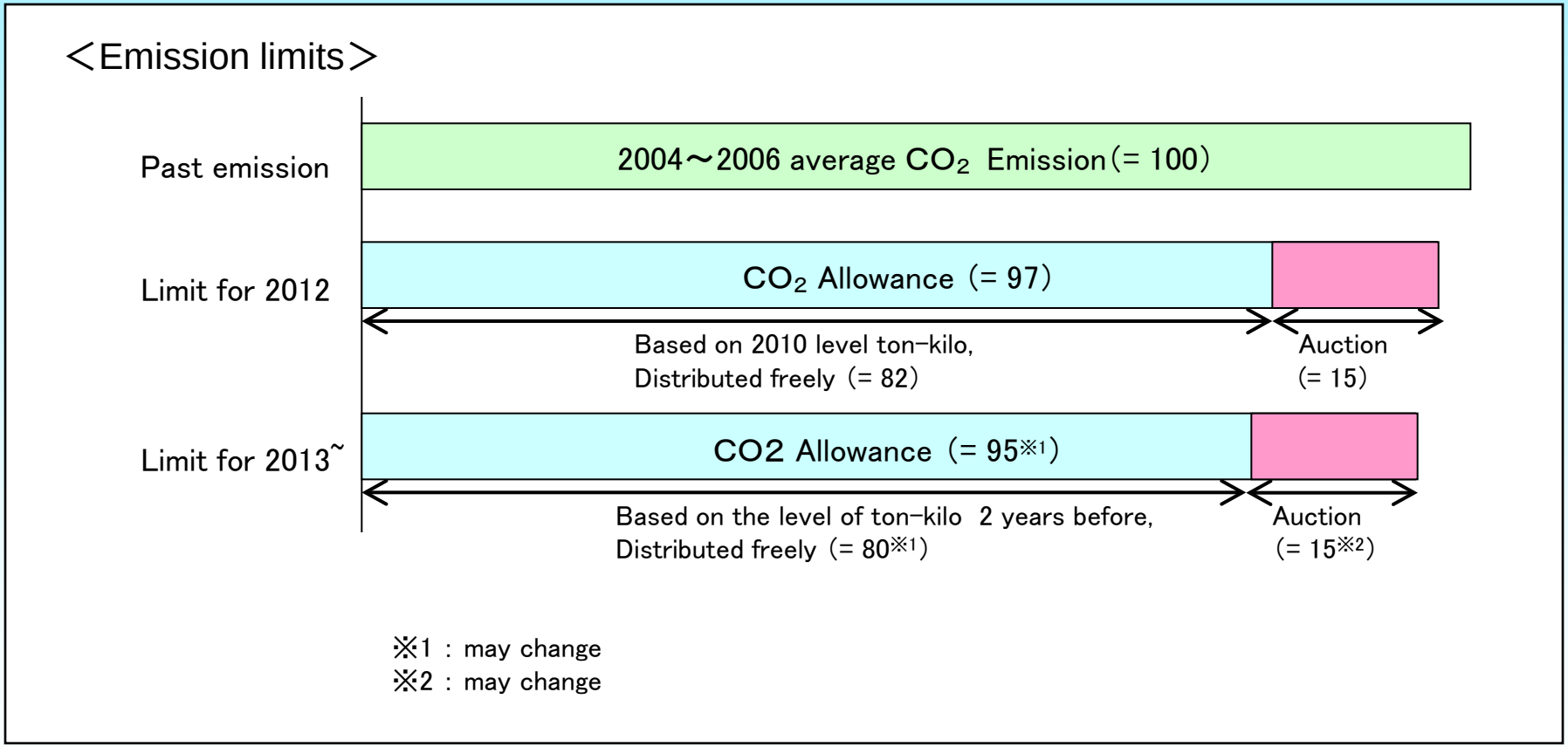
(2) The ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), which was approved on behalf of the European Community by Council Decision 94/69/EC (5), is to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

(3) The European Council meeting in Brussels on 8 and 9 March 2007 underlined the vital importance of achieving the strategic objective of limiting the global average temperature increase to not more than 2 °C above pre-industrial levels. The latest scientific findings reported by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report demonstrate even more clearly that the negative impacts of climate change are increasingly posing a serious risk to ecosystems, food production and the attainment of sustainable development and of the Millennium Development Goals, as well as to human health and security. Keeping the 2 °C objective within reach requires stabilisation of the concentration of greenhouse gases in the atmosphere in line with about 450 ppmv CO_2 equivalent, which requires global greenhouse gas emissions to peak within the next 10 to 15 years and substantial global emission reductions to at least 50 % below 1990 levels by 2050.

(4) The European Council emphasised that the European Union is committed to transforming Europe into a highly energy-efficient and low greenhouse gas-emitting economy and, until a global and comprehensive post-2012 agreement is concluded, made a firm independent commitment for the EU to reduce its greenhouse gas emissions to at least 20 % below 1990 levels by 2020. The limitation of greenhouse gas emissions from aviation is an essential contribution in line with this commitment.

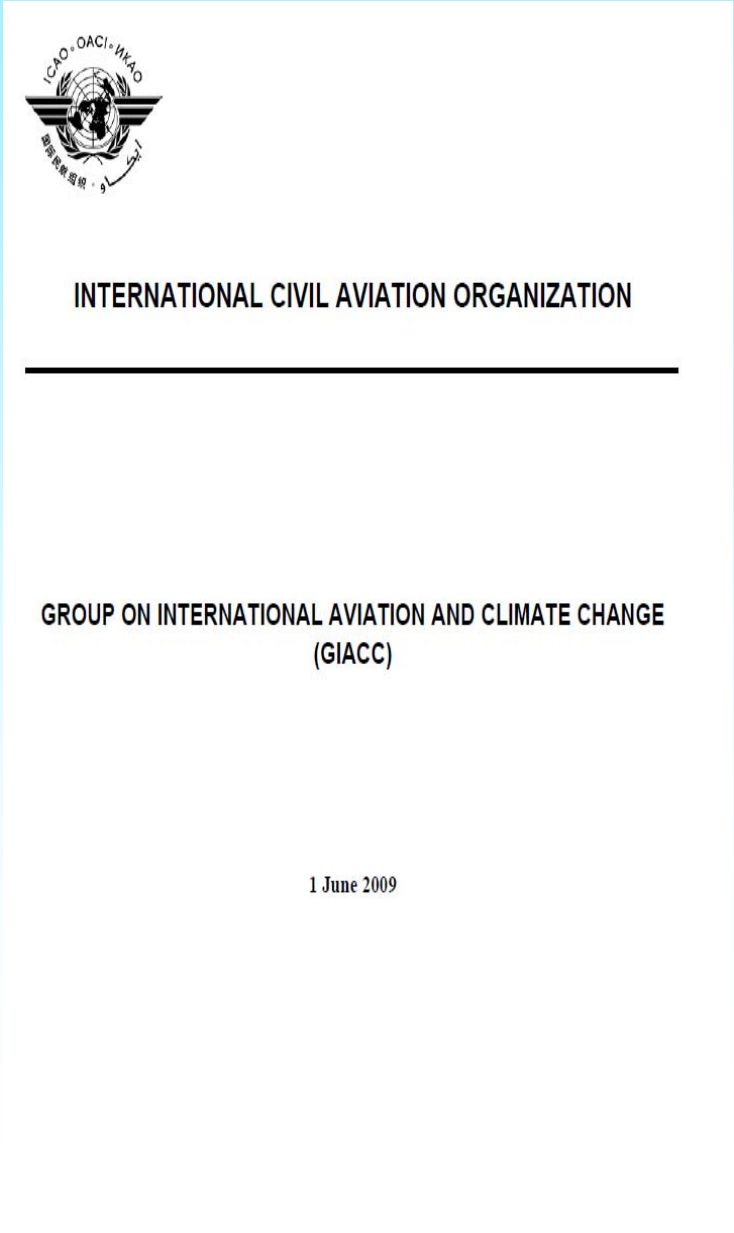
(1) OJ C 175, 27.7.2007, p. 47.
(2) OJ C 305, 15.12.2007, p. 13.
(3) Opinion of the European Parliament of 13 November 2007 (not yet published in the Official Journal), Council Common Position of 18 April 2008 (OJ C 122 E, 20.5.2008, p. 19) and Position of the European Parliament of 8 July 2008 (not yet published in the Official Journal). Council Decision of 24 October 2008.
(4) OJ L 275, 25.10.2003, p. 32.
(5) OJ L 33, 7.2.1994, p. 11.

Emission Allowance under EU Directive



Source: MLIT

GIACC Final Report 0906



INTERNATIONAL CIVIL AVIATION ORGANIZATION

GROUP ON INTERNATIONAL AVIATION AND CLIMATE CHANGE
(GIACC)

1 June 2009

- *Global Aspirational Goal*;

  2% annual fuel efficiency* **improvement** from 2012 through 2050

  * : *Liter/RTK for in-service fleet average of Int'l operation*

- No agreement on economic measures, like ETS
- Future measures include;

  Drop-in bio-fuel,

  CO2 standard for new A/C type

2. Emission Trading Simulations under NCG Theory Framework

Basic Numbers in 90

Countries with obligation

	Carbon Emission in 90 in Mil. ton	GDP 90 B US$	Carbon Intensity
EU 15	915	6,961	0.13
FSU 22	989	1,535	0.64
Japan	292	2,970	0.10
US	1,315	5,794	0.23
China Area(incld HK, Macao)	662	484	1.37
Korea (x DPRK)	66	264	0.25
India	186	327	0.57

If Countries with obligation in Kyoto P. were in the Emission Trade System (ETS) in 1990, what seemed to happen under NCG approach to ETS (including aviation emission)?

← Just a simple calculation for the sake of discussion

Literature on the Model

- Nordhaus, W.D.,(1991), *The Cost of Slowing Climate Change: a Survey*, the Energy Journal 12, 37-65
- Bohm, P. and Larsen, B., (1994), *Fairness in a Tradable-Permit Treaty for Carbon Emissions Reduction in Europe and the former Soviet Union*, Environmental and Resource Economics 4, 219-239
- Okada, A.,(2004) "*International Negotiations on Climate Change: A Non-cooperative Game Analysis*" (Discussion paper #2004-2)

By Emission Trade…

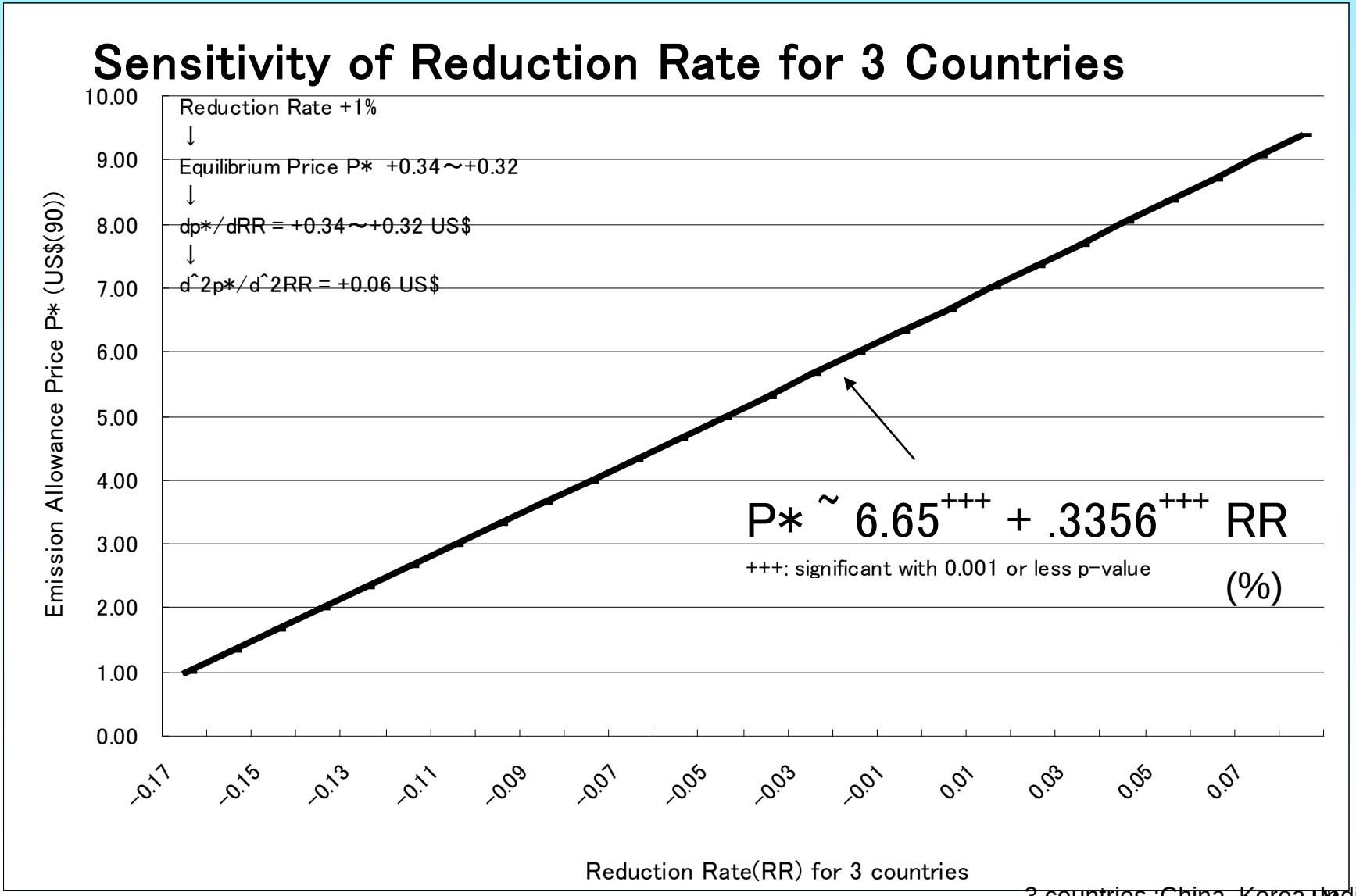
Country	Reduction rate	Reduction (Mil.ton)	Initial permits (Mi. ton)	P* (US$)	Equil. Cost (Mil. US$)
EU 15	0.08	73	841	9.65	575
FSU 22	0	0	989	9.65	-402
Japan	0.06	18	275	9.65	138
US	0.07	92	1223	9.65	563

If China, Korea, and India were in Kyoto P. with ETS, what seemed to happen?

Simulation with 3 countries

Countries	reduction rate	Reduction (mil. tons)	Initial permits (million tons)	P* US$	Equi. Cost (mil.US$)
EU 15	0.08	73	841	6.65	424
FSU 22	0	0	989	6.65	−192
Japan	0.06	18	275	6.65	102
US	0.07	92	1223	6.65	457
China Area(incld HK, Macao)	0	0	662	6.65	−143
Korea (x DPRK)	0	0	66	6.65	−8
India	0	0	186	6.65	−35

Sensitivity Analysis for EA Price



3 countries :China, Korea, India

3. Welfare Consideration for Bargaining among States

Basic Model (numerical example)

- There are only 2 states in the world.
- There is a common linearly separable uncertainty, ε.
- Each has utility function as follows;

$$V_1(c_1, X) = -\exp\{-0.2(c_1^{0.8}(10 - X)^{0.2} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))$$

$$V_2(c_2, X) = -\exp\{-0.2(c_2^{0.2}(10 - X)^{0.8} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))$$

- Initial allocation rule for emission is skewed, namely 92.5% for state 1 and remaining 7.5% for state 2.

$$\theta_1 = 0.925$$

$$\theta_2 = 0.075$$

Literatures on the Model

- P. Samuelson (1954)

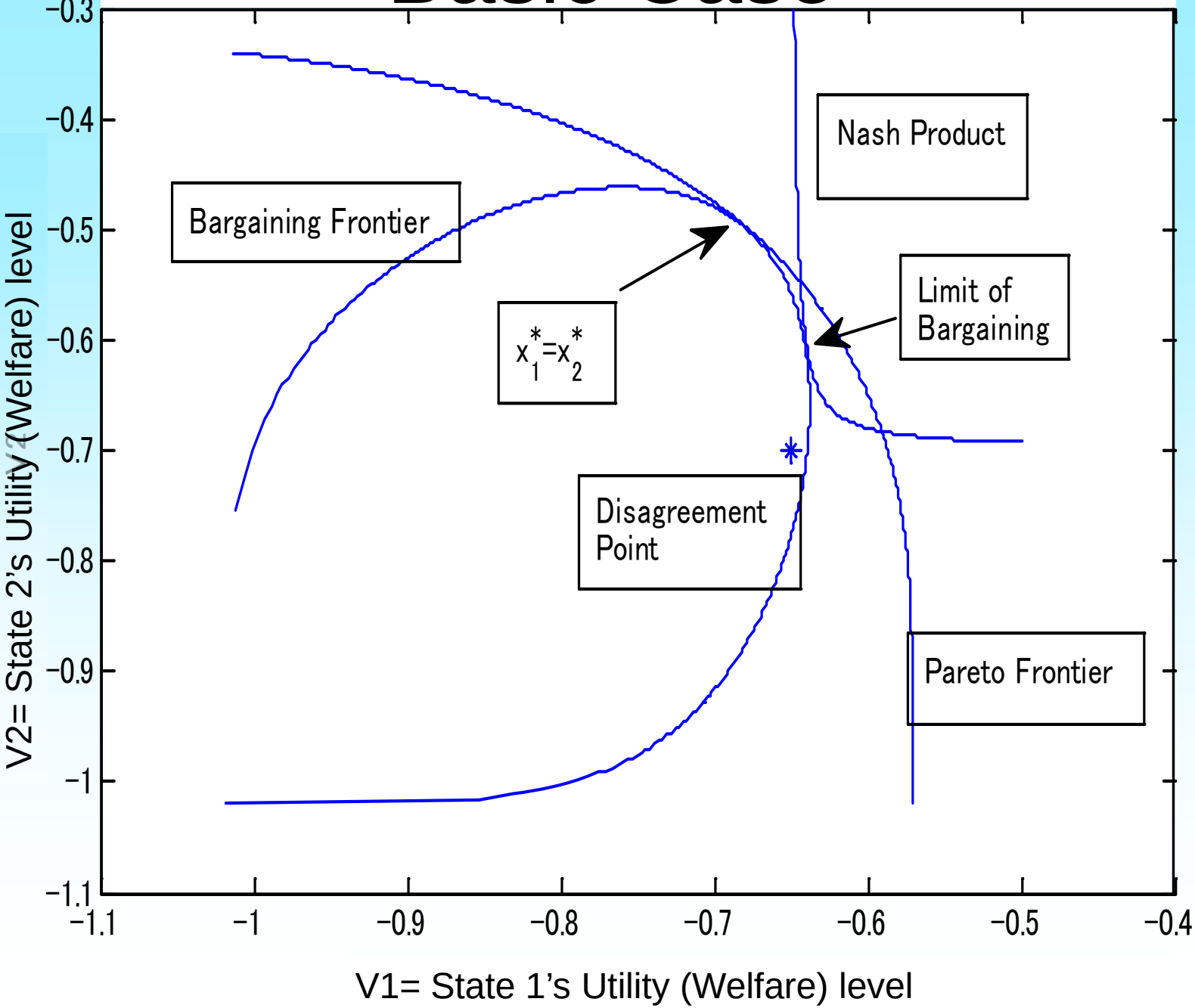
  “The Pure Theory of Public Expenditure” Review of Economic and Statistics, Vol. 36, pp.387-389

  Lindahl-Bowen-Samuelson (LBS) condition

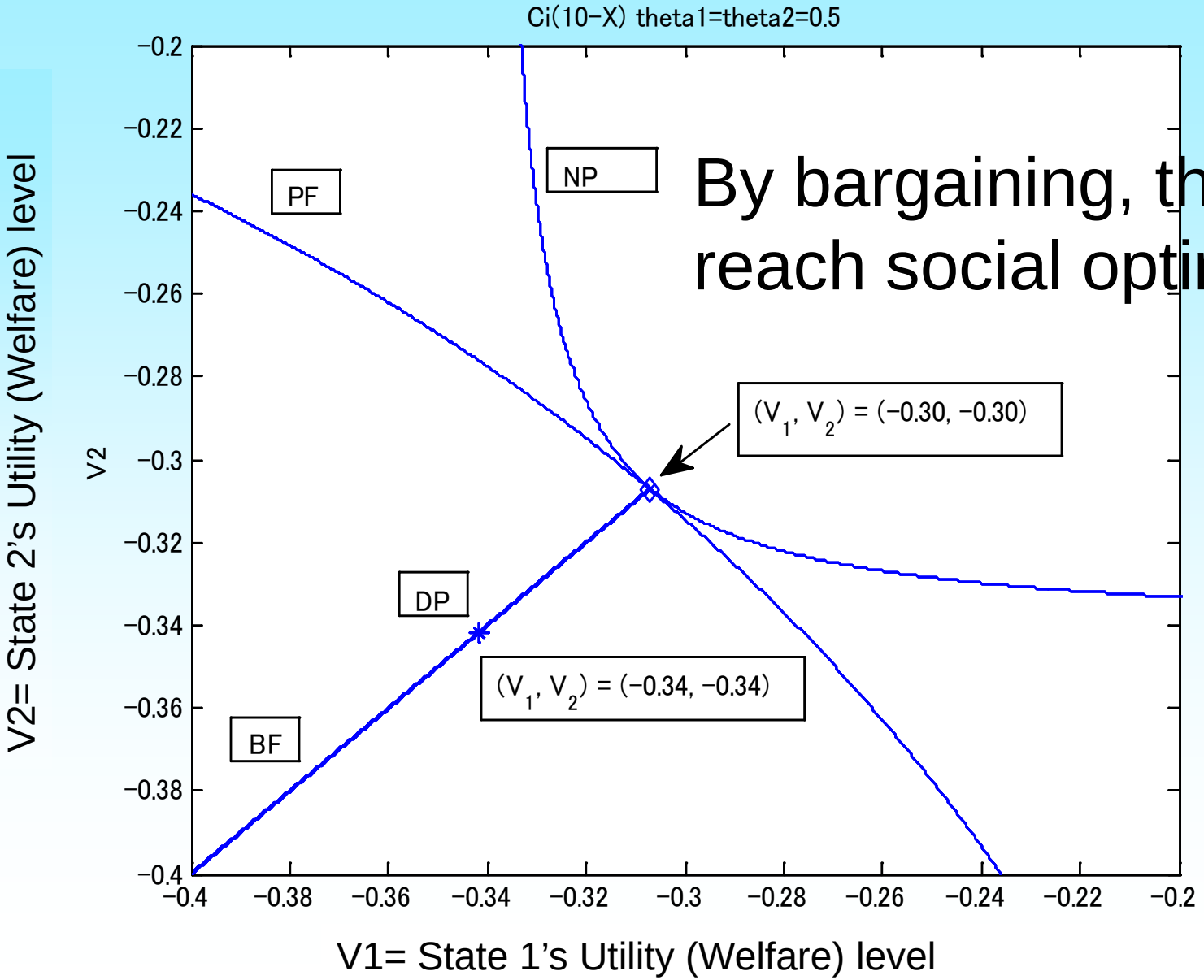
- K. Tadenuma(2003) "International Negotiations for Reduction of Green-house-Gases with Emission Permits Trading,“ "Project on International Equity (PIE) Discussion Paper Series, Hitotsubashi University“

- K. Hihara(2009) “Analysis on Bargaining about Global Climate Change Mitigation in Aviation Sector,” GraSPP Discussion Paper E-09-002, University of Tokyo <http://www.pp.u-tokyo.ac.jp/research/dp/documents/GraSPP-DP-E-09-002ITPU-DP-E-09-001.pdf>

Basic Case


Nash Product
Bargaining Frontier
Limit of Bargaining
$x_1^*=x_2^*$
Disagreement Point
Pareto Frontier
V2= State 2's Utility (Welfare) level
V1= State 1's Utility (Welfare) level
−0.3
−0.4
−0.5
−0.6
−0.7
−0.8
−0.9
−1
−1.1
−1.1
−1
−0.9
−0.8
−0.7
−0.6
−0.5
−0.4

Same Utility/ Even Initial Allocation

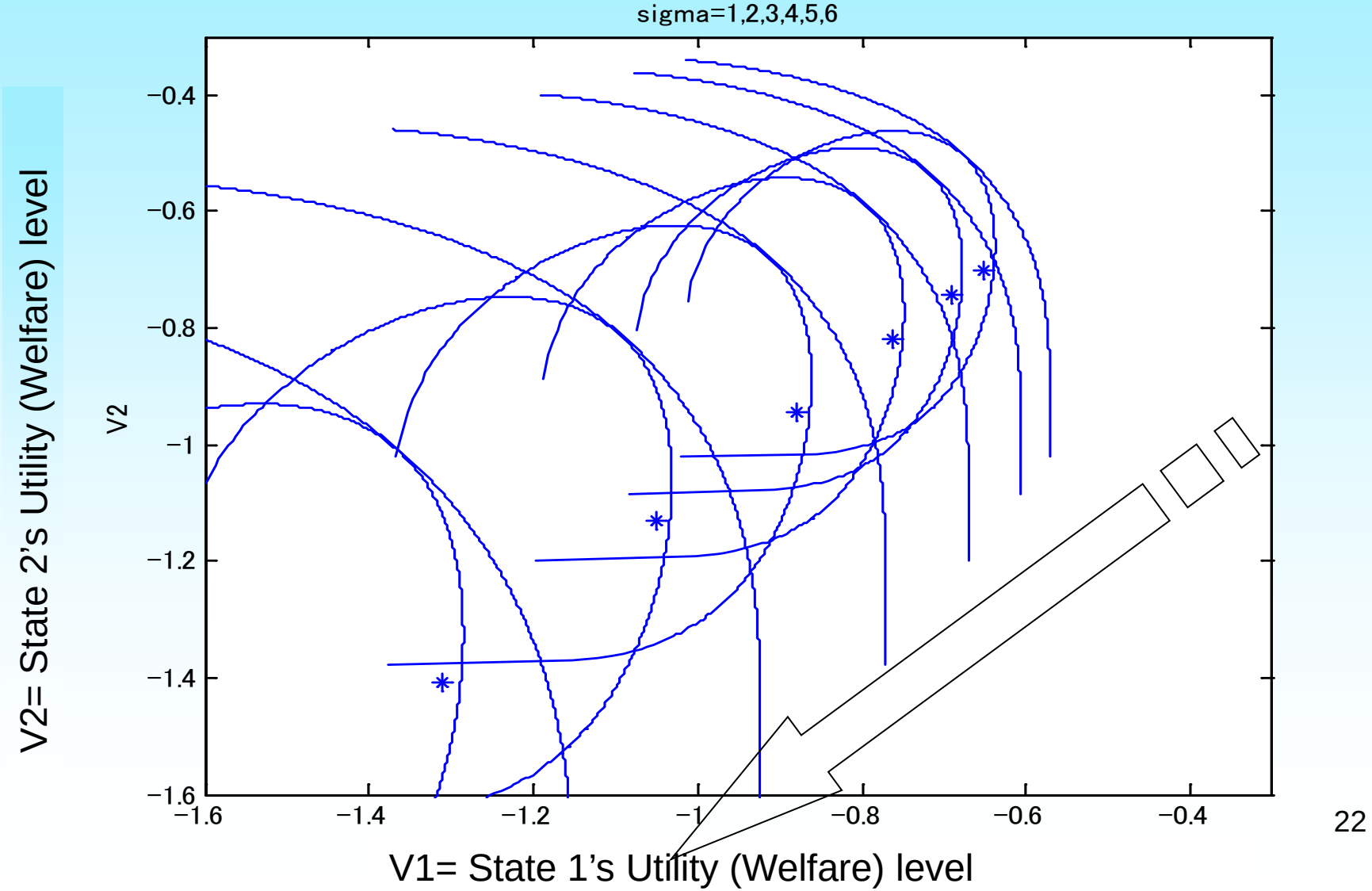


By bargaining, they can reach social optimum!!

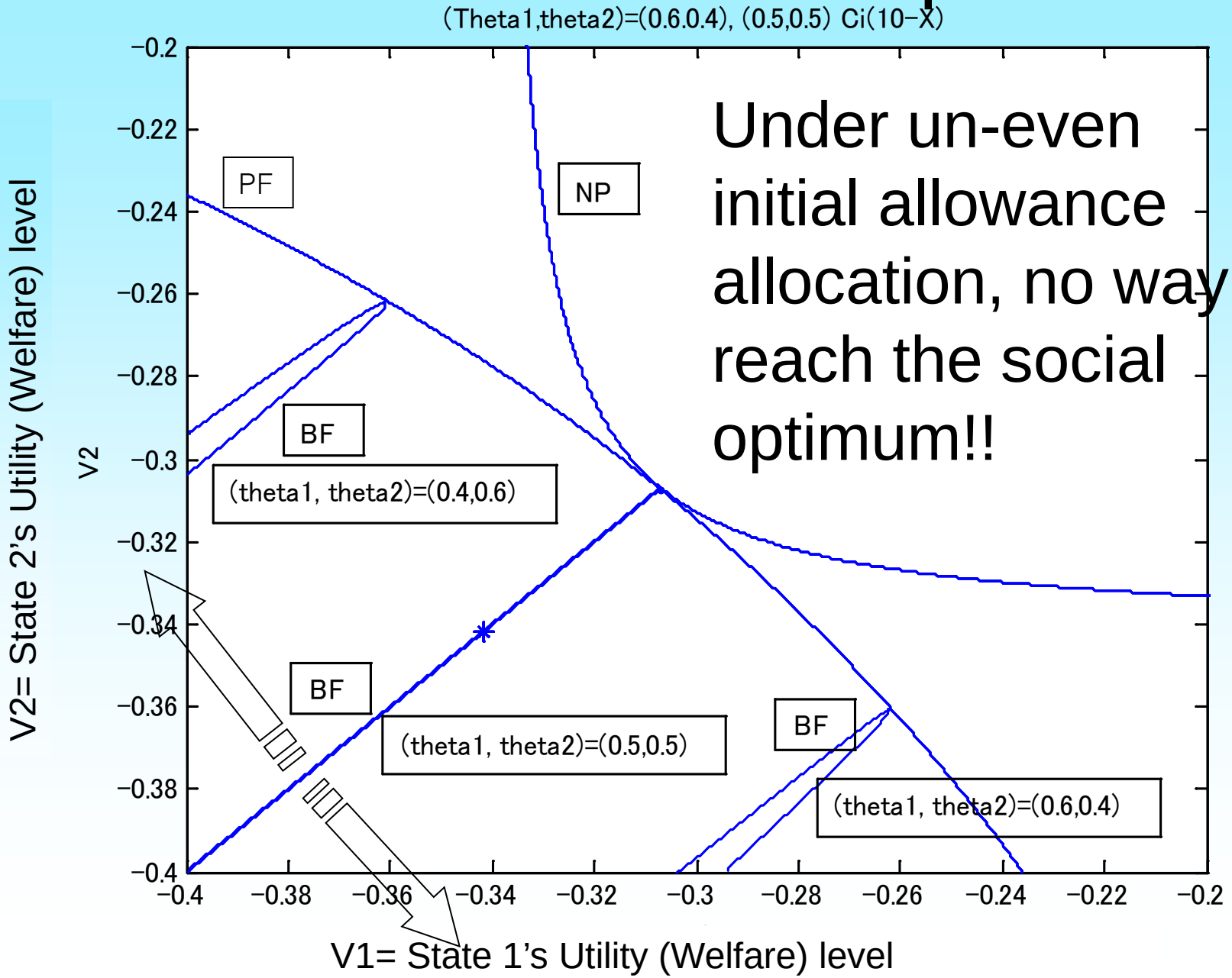
Uncertainty（σ）↑

$$V_1(c_1, X) = -\exp\{-0.2(c_1^{0.8}(10-X)^{0.2} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))$$
$$V_2(c_2, X) = -\exp\{-0.2(c_2^{0.2}(10-X)^{0.8} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))$$

→ World Shrinks!!



Initial Allocation's Impact



Under un-even initial allowance allocation, no way to reach the social optimum!!

Conclusion

- Simulation analysis about the effects on pricing of carbon emission allowances by including major players such as China and India.
- In a 2-country bargaining setting,

  ⇒ If uncertainty increases, then both Pareto Frontier and Bargaining Frontier shrink and make the negotiation harder.

  ⇒ Under different utility structure/a non-even initial allocation allowances, reaching the pareto frontier by bargaining could be extremely difficult.

Thank you for your attention!

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