京都議定書・国際排出権取引の
エージェントベースシミュレーション

Kyoto Protocol: International Emissions Trading with Agent-based Approach

- Agent-based Approach
- Kyoto Protocol and Emissions Trading
- Cost Landscapes
- Web-based Gaming System

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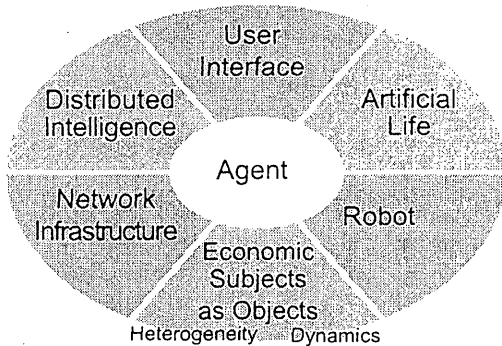*Climate Change Research Project*

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New Approach in Economics

➤ Agent-based Approach

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What's an Agent?

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Agent-based Approach

Artificial Market / Society with

- Individual agents and Software agents
- Heterogeneity and Dynamics
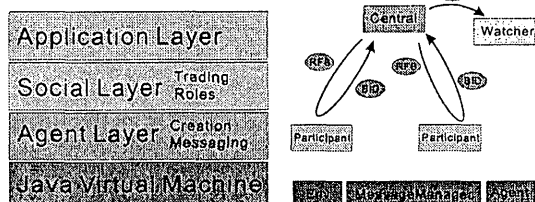- Well designed experiments

Model refinement through

Analysis

Simulation———————Gaming

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Agent-based Simulation Framework : ASIA

Artificial Society with Interacting Agents

- Java, Message, Multi Thread

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Kyoto Protocol

Sets targets of Greenhouse Gas (GHG) emissions in 2008-2012 below 1990 level
Japan shoud reduce 6%, and US 7%
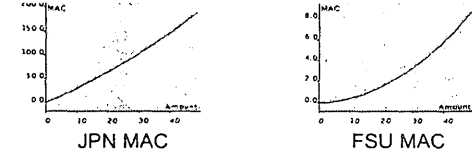BAU (Business as usual) Projections in 2010

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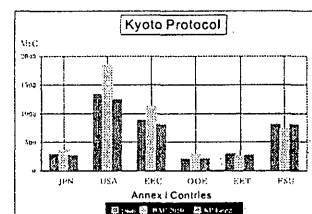
GHG Emissions Trading

Each Annex 1 country has different

- Assigned Reduction Target
- Domestic Marginal Abatement Cost (MAC)

International trading reduce the total cost.
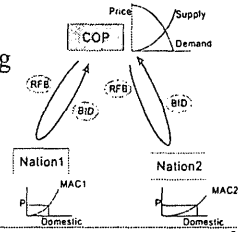
JPN MAC   FSU MAC

Simulation Model

At Each Trading Period

- Iterate RFB-BID transaction
- Find Equilibrium Price

Dynamic Strategies

- assignment partitioning
  - Early Action
  - Delayed Action
- Estimate
  - Price Changes
  - Total Cost

Trading and Market Price

Reduction R = Domestic D + Trade T

- Adjust D and T according to trading price
- Low MAC countries sell over achievements
- High MAC countries can buy the short

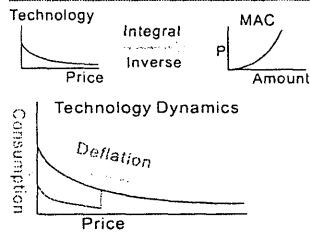Price Determination

- Price P equals MAC at D in each country
- At the Equilibrium Price, Supply = Demand

Domestic Cost = Integral(MAC)(R) + T * P

Dynamics
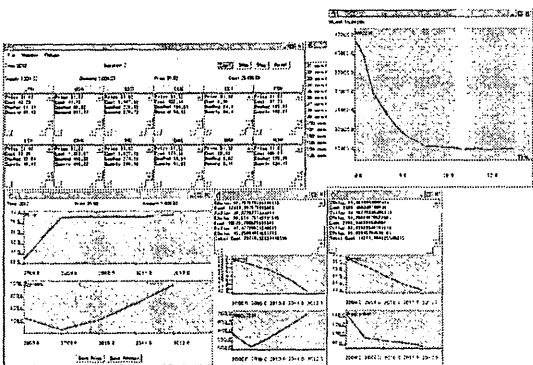
Strategy Learning

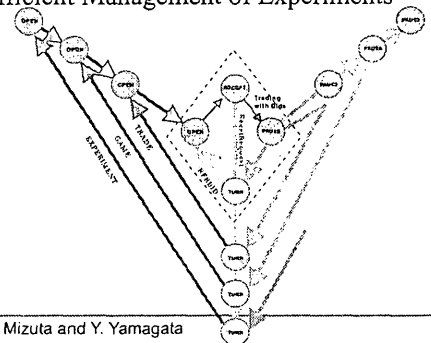- Each Nation re-partitions her assignment to reduce the cost after a series of the trade

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Agent-based Simulation

Process Transition Cycle

Cycle Status with Levels and Positions for Efficient Management of Experiments

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Cost Landscape

Agents' Strategies and Corresponding Costs

- For 2 Periods and 2 Players Case
  Each agent set only first year's reduction (R^j_1)
  R^1_1 and R^2_1 determine prices and costs for 2 years
- Learning Path on the Cost Landscapes
  Convergence or large cycle
- Mutual Impact Matrix
  variance of costs due to each agent's strategy

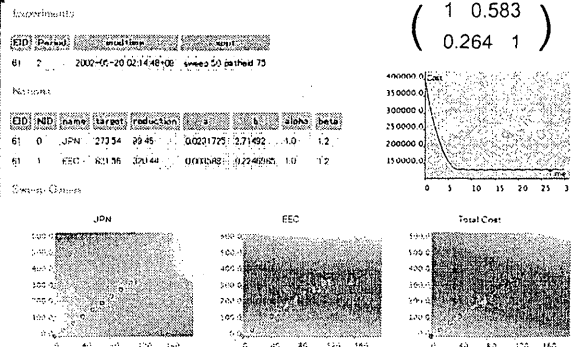$$V^i_0 \equiv \frac{1}{m}\sum_l \sum_k (c^i_{kl} - \frac{1}{m}\sum_k c^i_{kl})^2,$$
$$V^i_1 \equiv \frac{1}{m}\sum_k \sum_l (c^i_{kl} - \frac{1}{m}\sum_l c^i_{kl})^2.$$

$$p^i_j \equiv \begin{pmatrix} 1 & \bar{v}^0_1/\bar{v}^0_0 \\ \bar{v}^0_0/\bar{v}^0_1 & 1 \end{pmatrix}, \qquad \bar{v}^i_j \equiv \sqrt{\frac{V^i_j}{|r^j_{m-1} - r^j_0|}}.$$

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JPN - EEC

$$\begin{pmatrix} 1 & 0.583 \\ 0.264 & 1 \end{pmatrix}$$

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JPN - FSU

$$\begin{pmatrix} 1 & 0.779 \\ 1.432 & 1 \end{pmatrix}$$
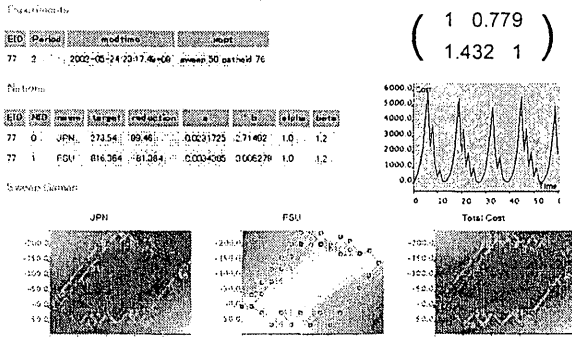
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Gaming System

Gaming Simulation for

- Behavior Model
- Training System
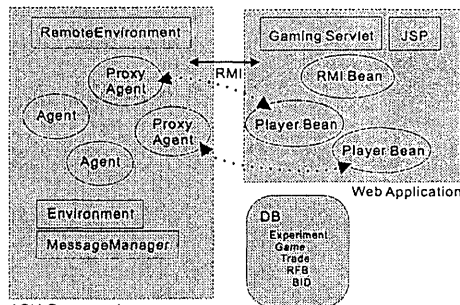- Realtime Decision Support Tool

Agent-based System and Gaming

- Same environment and model
- software agents and human players
- Reusable implementation

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Agent Framework and Web

Remote Access via RMI and Proxy Agents
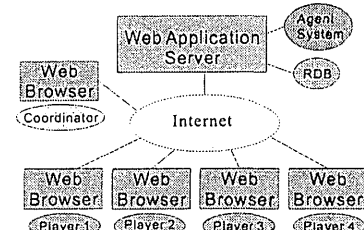

ASIA Framework

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Web-based Gaming System

Web Application and Gaming

- Standard protocol (http, https)
- Standard client (Web Browser)

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Trading Model

Walras Equilibrium Price

- One Price and Trade for One Year
- Trial Price in RFB
- Bid : Buy or Sell Amount

Double Auction

- Multiple Bids / Asks
- Trade when highest buy > lowest sell
- Bid : Price and Amount
- Player can change or remove previous bid
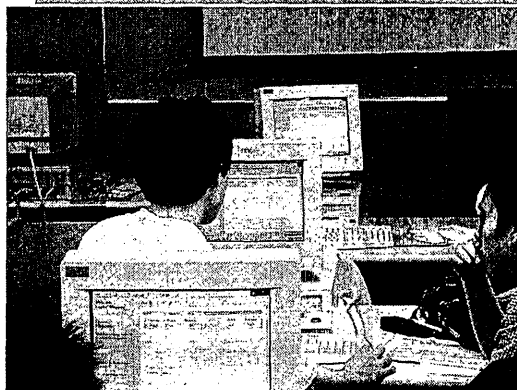
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Web-client View (Walras)

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Web-client View (DA)

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Gaming Experiment

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Results (DA 5 Year)

Nation	Target	Reduction	Cost
EEC	1600	1600	69780
JPN	495	495	22191
COE	435	435	7088
FSU	-410	-35	-25652
EET	-45	-45	-16549
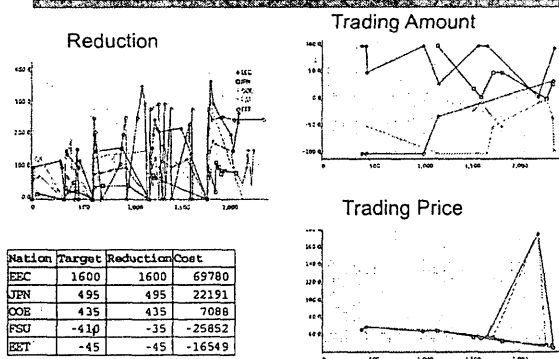
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Summary

Agent-based Approach

- Heterogeneity and Dynamics
- Simulation, Analysis, Gaming

International Emissions Trading for KP

- Agent-based Simulation
- Dynamic MAC and Strategies for Nations
- Cost Landscapes and Impact Matrix
  for 2 Periods and 2 Players
- Web-based Gaming Simulation

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