

## **Integrated policy impact assessment CGE model for trade, environment and regional cooperation**

---

**Satoshi Kojima**

Manager, Economic Analysis Team (EA)  
Institute for Global Environmental Strategies (IGES)

**ISAP EA session, 26 June 2009**  
**Shinan Village Centre, Hayama, Japan**

### **Outline of the presentation**

---

- 1. Overview of Integrated Policy Assessment model**
- 2. REPA model as a prototype**
- 3. Application of REPA model to Japan LCS study**
- 4. Simulation results**
- 5. Conclusions**

## Importance of integrated policy assessment for SD

---

- Sustainable Development (**SD**) aims to alleviate the present poverty without losing key ecosystem functions underpinning human well-being, e.g. hydrological cycle, nutrient cycle, atmospheric composition stabilisation, provision of natural resources (Kojima 2007).
- Ex-ante policy impact assessment greatly facilitates formulating and implementing **SD** policies by:
  - Simulating the overall results of complicated direct and indirect impacts of policies.
  - Demonstrating win-win solutions for convincing stakeholders.

3

## Integrated Policy Assessment Model (IPAM)

---

- We are developing **IPAM** to conduct integrated policy assessment for **SD**, particularly focusing on trade, environment and regional cooperation.
- Multi-regional dynamic computable general equilibrium (CGE) model seems suitable for **IPAM** for trade, environment and regional cooperation issues. It can model:
  - International and inter-sectoral economic linkages
  - Linkages between environmental/poverty status and economic activities
  - Impacts of investment decision, particularly public investment decision
  - Transitional dynamics (i.e. free from "steady-state equilibrium" assumption that is too restrictive)

4

## REPA model as a prototype of IPAM

---

- So far, we have done (i) development of a prototype model (REPA model, see Kojima 2008), and (ii) conceptual design of full model.
- **REPA (Regional Environmental Policy Assessment)** model has been developed to conduct integrated policy impact assessment, but following challenges are unsolved:
  - Reflecting resource constraints e.g. water, land, fossil fuels
  - Explicit treatment of investment, particularly public investment and foreign direct investment
  - Elaboration of poverty assessment (currently poverty headcount only), e.g. unemployment, income distribution
  - Introduction of full dynamics (forward-looking dynamics).

5

## REPA model: Basic specifications

---

- **REPA model** incorporates environment and poverty side modules into GTAP-E model (Global Trade Analysis Project model with energy substitution side modules). REPA is multi-regional computable general equilibrium (CGE) model.
- **REPA model** assesses impacts of policies on environmental indicators (CO<sub>2</sub>, SO<sub>x</sub>, etc.), sectoral and macro economic performance, and poverty headcount (determined by unskilled labour wage, see Anderson et al. 2006).
- **REPA model** consists of 12 regions (10 regions for ASEAN + 3, Rest of OECD, and Rest of the World) and 32 sectors.
- **REPA model** employs recursive dynamic approach to simulate policy impacts in future period. Base database corresponds to 2001 (GTAP Database v.6) and can be updated until 2020 by running the model against macro economic exogenous shocks.

6

## Application of REPA model: Japan LCS scenarios study

7

### What are Japan LCS scenarios?

---

- **Japan Low Carbon Society (LCS) scenarios:**
  - Proposed in 2007, by a research project funded by the Ministry of the Environment Japan, led by National Institute for Environmental Studies (the LCS2050 project).
  - Demonstrating the technological potential to reduce Japanese CO<sub>2</sub> emissions by 60-80 % from the 1990 level by the year 2050 with satisfying necessary service demands.
  - For realising the scenarios, "a dozen actions towards LCS" are also proposed in 2008.
  - Japan LCS scenarios underpin Japanese long-term climate policy. For example, **the Fukuda Vision** (June 2008) set the Japanese CO<sub>2</sub> emissions reduction target by 2050 as 60-80 % from the current level.

\* For details of Japan LCS scenarios, see "2050 Japan Low-Carbon Society" scenario team 2008.

8

## Outline of Japan LCS scenarios study

---

### □ Motivation

- Before this study, the LCS project did not quantitatively assess international impacts of Japan LCS scenarios.
- Japan LCS scenarios underpin Japanese climate policy, which is a subject of international negotiation.
- International competitiveness is always a hot issue for low carbon policy debate.

→ **This study aims to fill this important research gap.**

### □ Objectives of the study

- Assess international impacts of Japan LCS scenarios.
- Demonstrate how regional cooperation could contribute to regional CO<sub>2</sub> emission reduction without negative economic and poverty impacts, through regional cooperation.

9

## How to reflect costs of low carbon policies?

---

- Payments for abatement activities (e.g. energy efficiency improvement) are received by somebody (by machine manufacturer, labourers, etc.).
  - **Not necessarily the costs for the economy!**
- Assume some portion of value-added (labour + capital input) is diverted from production to abatement activities.
  - **Lower productivity is the costs for the economy!**
- An attempt to estimate such productivity loss based on the marginal abatement cost curves (Klepper and Peterson 2004) resulted in very small loss (almost "free lunch").
- For this study, costs in terms of productivity loss of value added input are "guessed". To improve this point, we plan to conduct survey to collect data for this estimation.

10

## LCS scenarios for this study: Base scenario (LCS-1)

---

### Based on "a dozen actions", LCS-1 scenario assumed:

- ❑ 40% reduction in households' electricity demand, which requires 20% increase in households' demand of electronics and other manufacturing goods as the cost.
- ❑ 40% increase in productivity of energy input for agricultural, manufacturing and service sectors except for the electricity sector, which is achieved by diversion of capital and labour inputs represented by 20% reduction in productivity of value added inputs.
- ❑ 40% increase in total factor productivity for electricity sector, which is achieved by diversion of capital and labour inputs represented by 40% reduction in productivity of value-added inputs.

11

## LCS scenarios with carbon pricing: LCS-2 and LCS-3

---

### LCS-2 and LCS-3 introduce carbon pricing into LCS-1:

- ❑ LCS-2 introduces carbon tax into LCS-1. LCS-3 introduces regional emission trading among ASEAN+3 countries into LCS-1.
- ❑ Carbon prices (carbon tax rate or carbon credit price) are **endogenously determined such that the pre-specified CO<sub>2</sub> emission target can be achieved.**
- ❑ This study set this target as 30% reduction from the 1990 level by the year 2020 (roughly corresponds to 70% reductions from the 1990 level by the year 2050, employed by the LCS 2050 project).

12

## Regional cooperation reflected in LCS-3

---

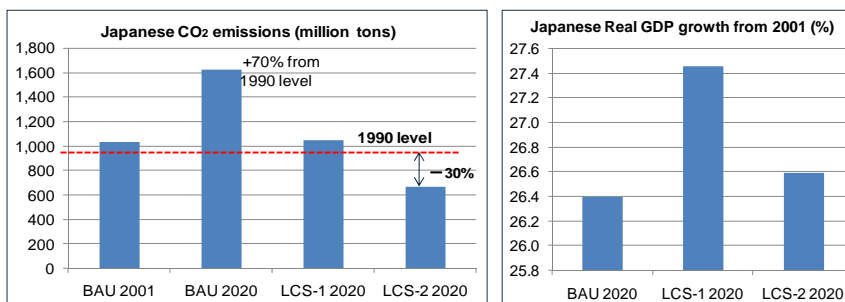
- **LCS-3** aims to demonstrate potential of Japan LCS Scenarios to regional CO<sub>2</sub> emission reduction without severe negative impacts on other countries, through regional cooperation.
- Allocation of emission quota to each member reflects its development level as follows:
  - Japan: -30% from the 1990 level
  - Korea: -10% from the 2001 level
  - Less developed ASEAN (Viet Nam, etc.): +20% from the 2020 BAU emissions.
  - The rest of the members: -20% from the 2020 BAU emissions.
- In addition, financial cooperation from Japan to other members (excl. Korea and Singapore, in total 4000 million USD) is assumed.

13

## Assessment results

14

## Can LCS-1 achieve emission reduction target?

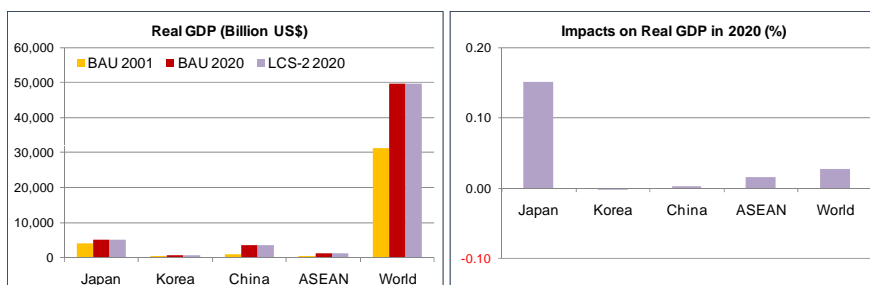


- ◆ **LCS-1** reduces CO2 reduction by 35% from BAU (Business-as-Usual, without low carbon measures).
- ◆ **However, LCS-1 cannot** achieve CO2 reduction from 1990 level. Carbon pricing seems necessary to achieve the target.
- ◆ **LCS-1** raises GDP by 0.8% from BAU, but whether it is the case or not depends on cost parameter (productivity loss due to abatement).

15

## LCS-2: Economic impacts on real GDP

- ◆ Under **LCS-2**, carbon tax rate becomes \$81/t-CO<sub>2</sub>, equivalent to ¥19/ℓ gasoline tax.
- ◆ **LCS-2** slightly raises Japanese GDP (0.15%) from BAU.
- ◆ International impacts on real GDP are almost negligible.

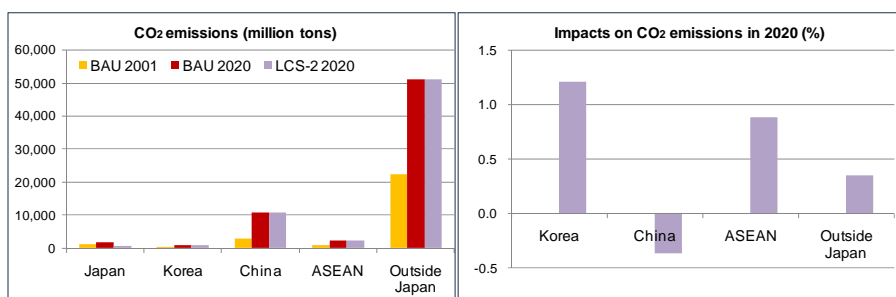


16



## LCS-2: International impacts on CO<sub>2</sub> emission

- ◆ International leakage effects of LCS-2 is mixed: emissions increase in Korea and ASEAN but reduce in China.
- ◆ Overall leakage is positive (increase emissions) by 0.3%.
- ◆ As Japan reduces by 30% from 1990 level, **global emissions reduce by 1.5% from BAU** .



17

## LCS-2: Impacts on international competitiveness

- ◆ Impacts on international competitiveness (figures are changes in sectoral production) are complex and some winners are not intuitive. The assessment results depend on cost parameters.

### Major winners

Japan	Korea	China	Thailand	World					
Gas	42.7%	Gas distribution	3.9%	Chemical, rubber, plastic prod	0.2%	Petroleum, coal products	1.0%	Electronic equipment	0.4%
Dwellings	2.0%	Fishing	0.8%	Electronic equipment	0.2%	Air transport	0.7%	Dwellings	0.3%
Ferrous metals	1.9%	Chemical, rubber, plastic prod	0.7%	Other agriculture	0.2%	Chemical, rubber, plastic prod	0.5%	Ferrous metals	0.1%

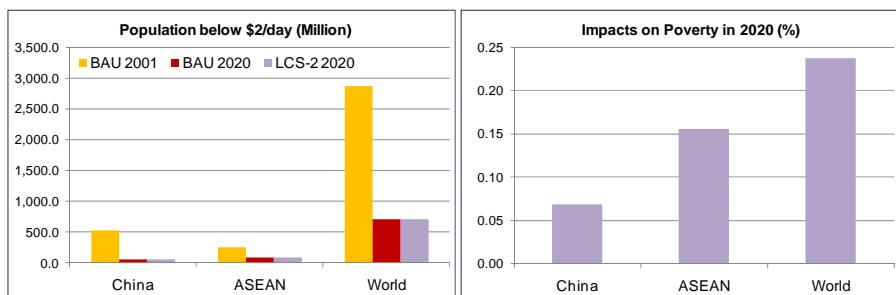
### Major losers

Japan	Korea	China	Thailand	World					
Gas distribution	-48.0%	Gas	-10.5%	Oil	-1.1%	Gas	-2.6%	Gas	-2.3%
Petroleum, coal products	-37.6%	Oil	-2.4%	Coal	-0.9%	Oil	-1.8%	Oil	-2.3%
Coal	-35.3%	Ferrous metals	-1.1%	Gas distribution	-0.5%	Gas distribution	-0.7%	Petroleum, coal products	-2.1%

18

## LCS-2: International impacts on poverty headcount

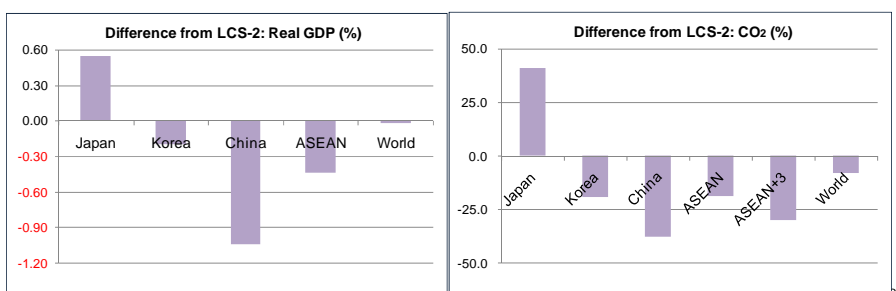
- ◆ **LCS-2** increases poverty headcount (Less than \$2/day population).
- ◆ But the magnitude is relatively small (less than 0.25%).



19

## LCS-3: Regional cooperation

- ◆ **LCS-3** reduces carbon price from \$81/t-CO<sub>2</sub> (under LCS-2) to \$13/t-CO<sub>2</sub> (equivalent to ¥3/ℓ gasoline tax).
- ◆ **LCS-3** achieves significant regional CO<sub>2</sub> emission reductions by 30%, but in terms of real GDP only Japan win.
- ◆ Theoretically, scaling up of financial cooperation from Japan may result in win-win for all members. But such attempt failed, probably due to too large shocks to attain steady-state equilibrium.



20

### LCS-3: Impacts on international competitiveness

- ◆ As LCS-3 introduces carbon price for all ASEAN+3 countries, all losers are fossil fuel sectors. Some winners are not intuitive, as they are determined by balance between energy efficiency gain and productivity loss (abatement costs)/carbon price.

#### Major winners

Japan		Korea		China		Thailand		World	
Gas	61.2%	Construction	1.8%	Electronic equipment	1.9%	Electronic equipment	2.0%	Electronic equipment	0.4%
Ferrous metals	5.5%	Non-ferrous metals	1.0%	Other agriculture	1.8%	Construction	1.1%	Dwellings	0.2%
Non-ferrous metals	3.5%	Oil seeds	0.4%	Textiles, apparel and leathers	1.6%	Wood products	0.9%	Sugar cane, sugar beet	0.1%

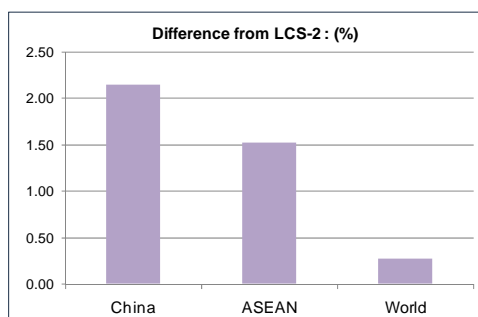
#### Major losers

Japan		Korea		China		Thailand		World	
Coal	-30.15%	Coal	-16.26%	Gas distribution	-41.28%	Coal	-28.52%	Coal	-10.67%
Petroleum, coal products	-24.19%	Gas	-15.79%	Coal	-33.91%	Gas distribution	-24.26%	Oil	-5.16%
Oil	-23.38%	Gas distribution	-14.50%	Gas	-33.86%	Petroleum, coal products	-9.73%	Petroleum, coal products	-5.10%

21

### LCS-3: Impacts on poverty headcount

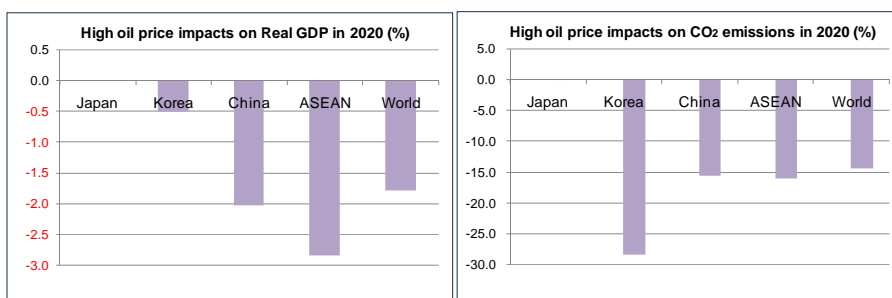
- ◆ **LCS-3** worsens the poverty impacts of Japan LCS scenario probably due to negative economic impacts of carbon pricing.
- ◆ Again, scaling up of financial cooperation from Japan might result in win-win for all member countries, but the current REPA model cannot simulate such scenario.



22

## Extra: LCS-2 scenario against crude oil price hike

- ◆ Assess **LCS-2** against doubled world crude oil price (and the output productivity of world crude oil sector is endogenously reduced).
- ◆ Doubled crude oil price reduces CO<sub>2</sub> emission reductions by 15% (worldwide). Note Japanese emissions are fixed with endogenous carbon tax rate (now **\$15/t-CO<sub>2</sub>**, against **\$81/t-CO<sub>2</sub>** in LCS-2).
- ◆ **LCS-2 makes Japanese economy robust** against oil price hike!



23

## Discussion of the results

- The assessment results illustrate complex nature of potential international impacts of Japan LCS Scenarios. Overall direction of impacts depend on the balance between:
  - Productivity gain from energy efficient technologies
  - Productivity loss (abatement costs)
  - Efficiency loss due to carbon pricing (market distortion).
- To have more reliable simulation results, further elaboration in both data and modelling technique is necessary.
- Demonstrating the win-win LCS scenarios for the region with increased financial cooperation is remaining challenge. Such regional cooperation would have been much better way to spend 2 trillion yen than allocating 12 thousand yen to all Japanese citizens...

24

## Conclusion

---

- This study demonstrates potential of multi-regional dynamic computable general equilibrium (CGE) model for integrated policy assessment for sustainable development, particularly focusing on trade, environment and regional cooperation.
- The REPA model was developed as a prototype of such tool for integrated policy assessment.
- The Japan LCS scenario study provides some useful insights from such assessment based on a prototype model (REPA model), but also reveals the remaining challenges to develop full Integrated Policy Impact Assessment model. We are now addressing these challenges to develop full model.

25

---

*Thank you for your attention.*

Contact address: [kojima@iges.or.jp](mailto:kojima@iges.or.jp)

26

## References

---

- Anderson, Kym, W. J. Martin, and D. van der Mensbrugghe. 2006. Global Impacts of the Doha Scenarios on Poverty. Washington DC: World Bank.
- Klepper, G. , and S. Peterson. 2004. Marginal Abatement Cost Curves in General Equilibrium: The Influence of World Energy Prices. Milan: Fondazione Eni Enrico Mattei.
- Kojima, Satoshi. 2007. Sustainable Development in Water-stressed Developing Countries: A Quantitative Policy Analysis. Cheltenham: Edward Elgar.
- Kojima, Satoshi. 2008. REPA Model for Impact Assessment of Environmental Policies under Regional Economic Integration in East Asia. IGES-EA Working Paper 2008-001. Hayama: IGES.
- "2050 Japan Low-Carbon Society" scenario team. 2008. Japan Scenarios and Actions towards Low-Carbon Societies (LCSs). Downloadable from: [http://2050.nies.go.jp/material/2050\\_LCS\\_Scenarios\\_Actions\\_English\\_080715.pdf](http://2050.nies.go.jp/material/2050_LCS_Scenarios_Actions_English_080715.pdf)