# AIM/Material Model

## *Features, model and necessary data*

**Toshihiko MASUI and Ashish RANA**
**National Institute for Environmental Studies**

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**Introduction to Component Models (Cont.)**

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# Coverage in this workshop

- **Summary (This session)**

  **For understanding AIM/Material model**

  - ***What is AIM/Material model?***
  - ***Model formulation***
  - ***Necessary data for simulation***
  - ***Future scenario***

- **Training (Session 5)**
  - ***Operation of AIM/Material model***

- **Application (Session 7)**
  - ***Application of AIM/Material model to India and Japan***

# Features of AIM/Material Model

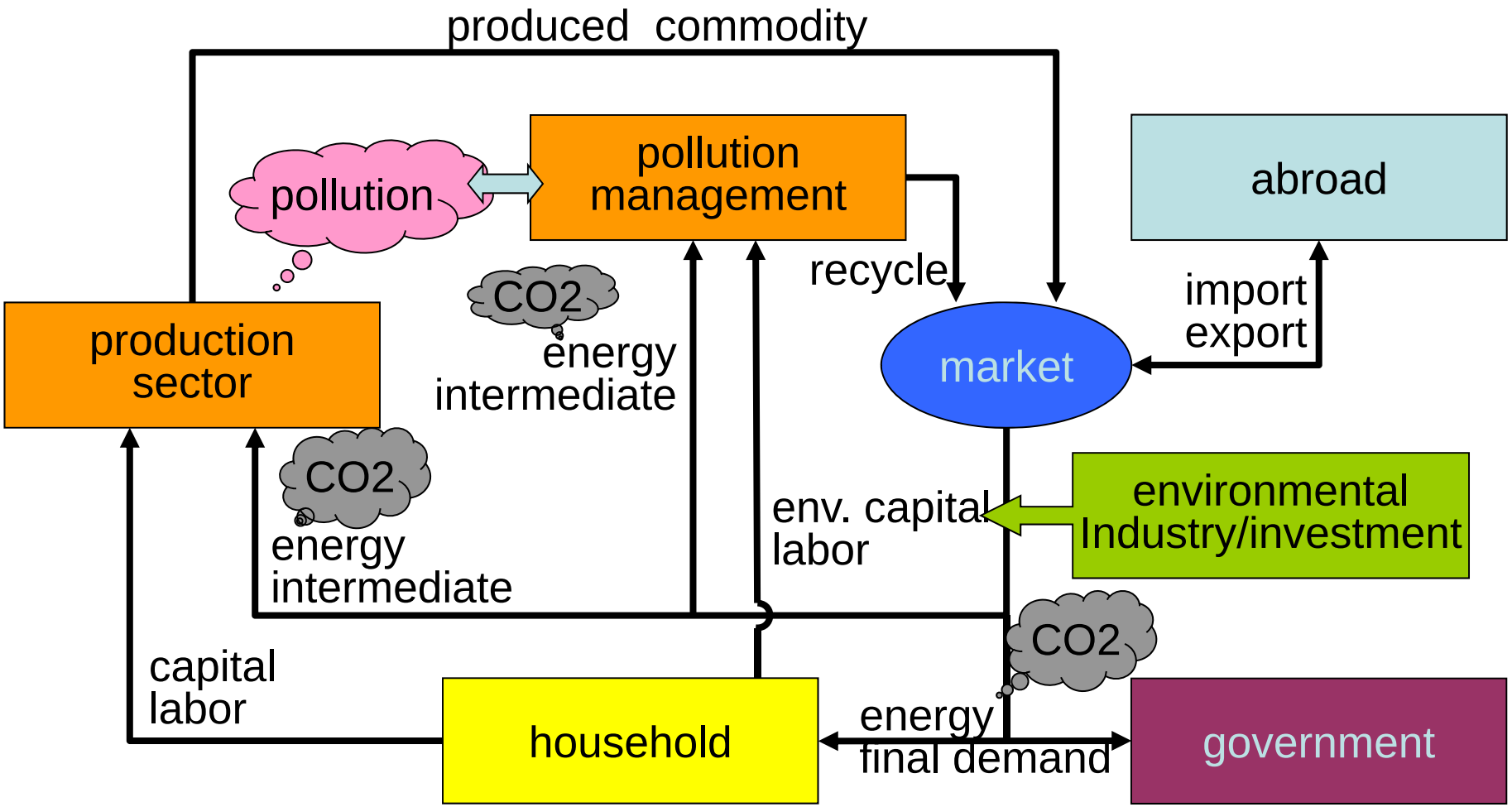
- **Top-down model**
- **Domestic model**
- **Computable General Equilibrium model**
- **Recursive dynamics**
- **Treatment of pollution generation, management and discharge**
- **Activity of environmental industry and environmental investment**
- **Consistent material balance**
- **Link with technology model such as AIM/Emission model for technology progress**

**We have been developing AIM/Material for both CO2 and other environmental problems.**

# Structure of AIM/Material Model

- **Production sector**
  - **Input: capital, labor, energy, other intermediate input, pollution (inputs for pollution management)**
  - **Output: commodity**
- **Household**
  - **Endowment: capital, labor**
  - **Demand: household final consumption, investment**
- **Government**
  - **Revenue: tax including environmental tax**
  - **Demand: government final consumption, government investment**

# Structure of AIM/Material Model



# Procedure of model analysis

1. Formulation of model
2. Preparation of dataset in initial year, and calibration
3. Preparation of future scenarios
4. Simulation
    i. Reference case
    ii. Policy case

# Social account matrix for AIM/Material

| | | | Production sector | | | Final Consumption | Investment | | | Supply | Price | Endowment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sector 1 | Sector 2 | Sector 3 | | Sector 1 | Sector 2 | Sector 3 | | | |
| Input | Intermediate inputs | Commodity 1 | $X_{11}$ | $X_{12}$ | $X_{13}$ | $C_1$ | $I_{11}$ | $I_{12}$ | $I_{13}$ | $Y_{11}+Y_{21}+Y_{31}$ | $P_1$ | |
| | | Commodity 2 | $X_{21}$ | $X_{22}$ | $X_{23}$ | $C_2$ | $I_{21}$ | $I_{22}$ | $I_{23}$ | $Y_{12}+Y_{22}+Y_{32}$ | $P_2$ | |
| | | Commodity 3 | $X_{31}$ | $X_{32}$ | $X_{33}$ | $C_3$ | | | | $Y_{33}$ | $P_3$ | |
| | Capital | | $K_1$ | $K_2$ | $K_3$ | | | | | | $P_K$ | $K^*$ |
| | Labor | | $L_1$ | $L_2$ | $L_3$ | | | | | | $P_L$ | $L^*$ |
| | Final disposal | | | | $W_3$ | | | | | | $P_W$ | $W^*$ |
| Output | Commodity 1 | | $Y_{11}$ | $Y_{21}$ | $Y_{31}$ | | | | | | $P_1$ | |
| | Commodity 2 | | $Y_{12}$ | $Y_{22}$ | $Y_{32}$ | | | | | | $P_2$ | |
| | Commodity 3 | | | | $Y_{33}$ | | | | | | $P_3$ | |

# Formulation of AIM/Material

- **Market equilibrium**
  - **Produced commodity**

$$P_i \left\{ \sum_{j=1}^{3} Y_{ji} - \left( \sum_{j=1}^{3} X_{ij} + C_i + \sum_{j=1}^{3} I_{ij} \right) \right\} = 0$$

$$P_i \geq 0$$

$$\sum_{j=1}^{3} Y_{ji} - \left( \sum_{j=1}^{3} X_{ij} + C_i + \sum_{j=1}^{3} I_{ij} \right) \geq 0$$

  - **production factor (capital, labor, ...)**

$$P_K \left\{ K^* - \sum_{j=1}^{3} K_j \right\} = 0,\ P_K \geq 0,\ \text{and}\ K^* - \sum_{j=1}^{3} K_j \geq 0$$

$$P_L \left\{ L^* - \sum_{j=1}^{3} L_j \right\} = 0,\ P_L \geq 0,\ \text{and}\ L^* - \sum_{j=1}^{3} L_j \geq 0$$

$$P_W \left\{ W^* - \sum_{j=1}^{3} W_j \right\} = 0,\ P_W \geq 0,\ \text{and}\ W^* - \sum_{j=1}^{3} W_j \geq 0$$

# Formulation of AIM/Material

- **Balance of production sector**

$$\sum_{i=1}^{3} P_i X_{ij} + P_K K_j + P_L L_j + P_W W_j = \sum_{i=1}^{3} P_i Y_{ij}$$

- **Balance of final demand sector**

$$H = P_K \sum_{j=1}^{3} K_j + P_L \sum_{j=1}^{3} L_j + P_W \sum_{j=1}^{3} W_j$$

$$H = \sum_{i=1}^{3} P_i (C_i + \sum_{j=1}^{3} I_{ij})$$

- **Capital stock and investment**
  - **for dynamics**

$$K_{j,t+1} = (1-\delta_j) K_{j,t} + \sum_{i=1}^{3} I_{ij}$$

# Formulation of AIM/Material

- **Relationship between input and output**
  - **Production function**
  - **Demand function**

    **CES, Leontief, Cobb-Douglas, Linear, ...**

- **Household: Maximize utility**
- **Production sector: Maximize profit**

**➔Find equilibrium solution**

# Dataset for AIM/Material Model

- **IO table (commodity x commodity)**
- **U matrix (commodity x sector)**
  - **Disaggregate pollution management**
- **V matrix (sector x commodity)**
- **Investment by sector**
  - **Disaggregate pollution management**
- **Pollution flow by sector**
  - **Generation, treatment, discharge, recycle, ...**
- **Supply and demand of reused material**

# Input-Output table

**household consumption, government consumption, investment, export**

| | commodity 1 | ... | commodity i | final demand | total output |
|---|---|---|---|---|---|
| commodity 1 | | | | | |
| : | | | | | |
| commodity i | | | | | |
| value added | | | | | |
| total output | | | | | |

Distribution of produced commodity to production of commodity and final demand is presented.

In order to produce commodity, what kind of inputs and how much of them are necessary.

# U matrix (Use matrix)

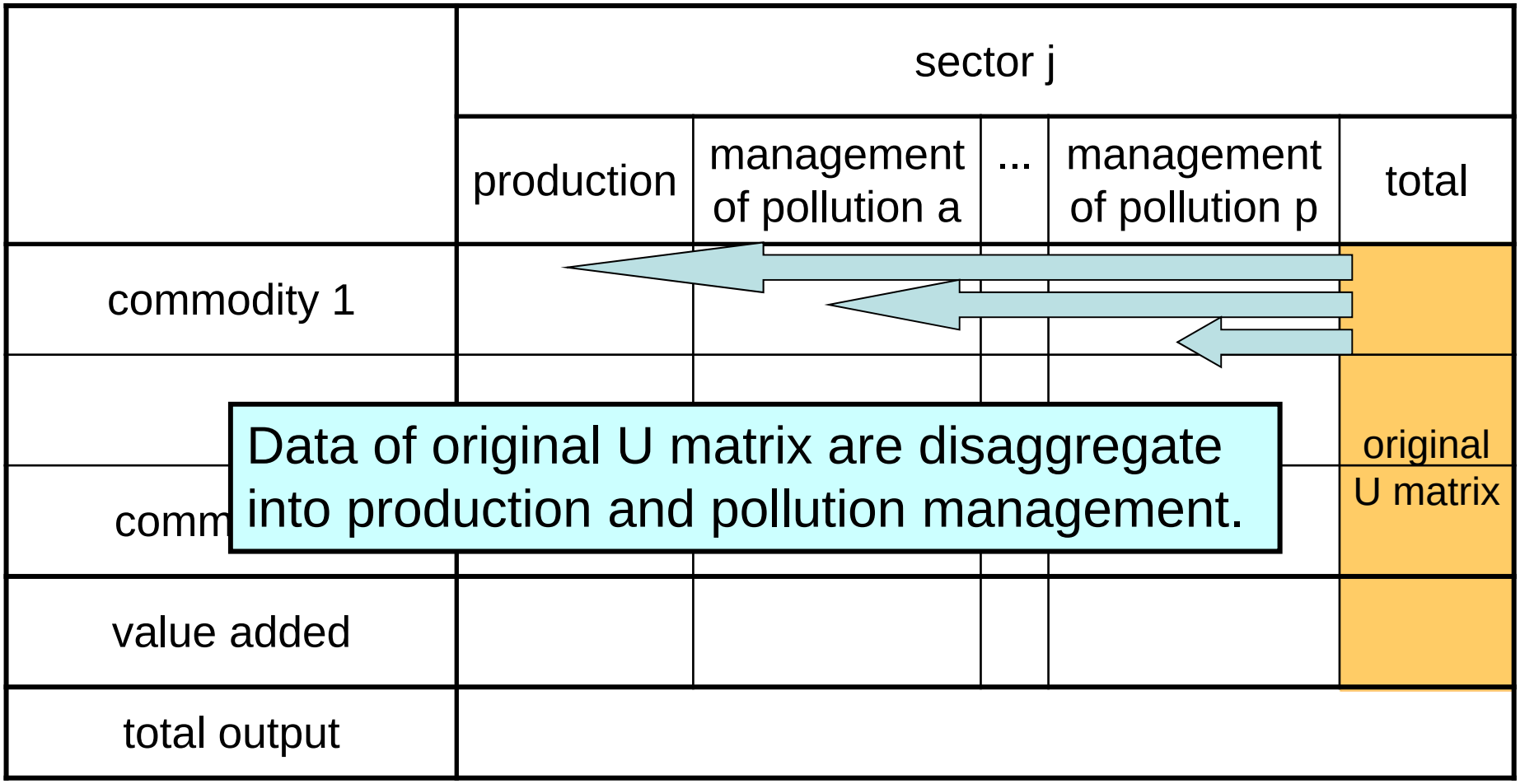
| | sector 1 | ... | sector j | final demand | total output |
|---|---|---|---|---|---|
| commodity 1 | | | | | |
| : | | | | | |
| commodity i | | | | | |
| value added | | | | | |
| total output | | | | | |

Distribution of produced commodity to sectors and final demand is presented.

What kind and how much of input for production activity are necessary in sector.

# Revised U matrix

## (disaggregate production and pollution management)



# V matrix (Make matrix)

| | commodity 1 | ... | commodity i | total output |
|---|---|---|---|---|
| sector 1 | | | | |
| : | | | | |
| sector j | | | | |
| total output | | | | |

How much of commodity i
produced by sector j
is represented.

# Investment by sector

| | commodity 1 | ... | commodity i | total investment |
|---|---|---|---|---|
| sector 1 | | | | |
| : | | | | |
| sector j | | | | |
| total output | | | | |

How much of commodity invested to sector j is represented.

# Pollution flow by sector

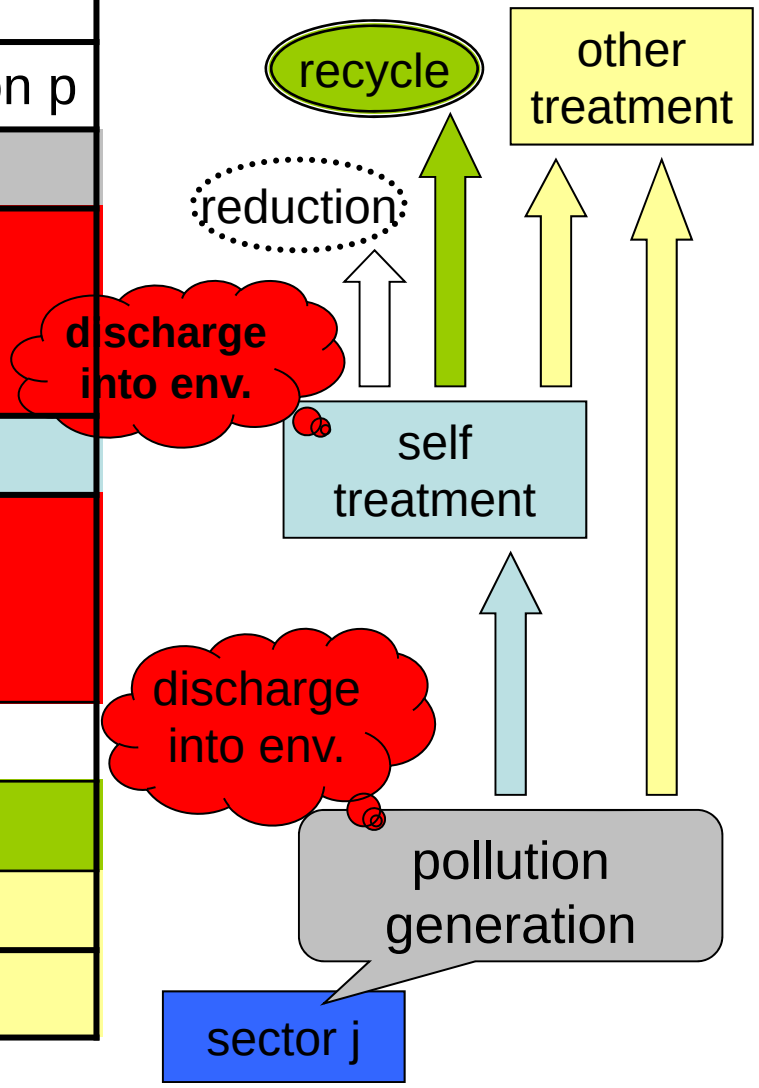
## Pollution type

- **Air pollution: SOx, NOx, CO2, ...**
- **Water pollution: BOD load, COD load, ...**
- **Solid waste: sludge, scrap metal, slag, ...**
  - **In the case of Japan, the number of the most detailed classification is almost 70.**
- **Other:**
  - **Toxic waste: Pb, dioxin, ...**

IO/U/V/investment/
pollution/reuse

# Pollution flow by sector

| | sector j | | |
|---|---|---|---|
| | pollution a | ... | pollution p |
| generation | | | |
| discharge into environment without treatment | | | |
| self treatment | | | |
| discharge into environment after treatment | | | |
| reduction | | | |
| recycle | | | |
| other treatment | | | |
| direct other treatment | | | |



*- Necessary data for simulation-*

# Supply and demand of reused material

| | commodity 1 | ... | commodity i | total generation of reused pollution |
|---|---|---|---|---|
| pollution a | | | | |
| : | | | | |
| pollution p | | | | |
| total supply of reused commodity | | | | |

How much of pollution
can be supplied as commodity i.

*- Necessary data for simulation-*

# Supply and demand of reused material

| | sector 1 | ... | sector j | total supply of reused pollution |
|---|---|---|---|---|
| commodity 1 | | | | |
| : | | | | |
| commodity i | | | | |
| total demand of reused commodity | | | | |

How much of recycled commodity i can be demanded in sector j.

# Optional Data for AIM/Material Model

- **Energy balance table**
  - **Link physical data from energy balance table and monetary data from U matrix**
- **Other physical material data**
  - **Raw materials such as wood, paper, steel, ...**
  - **Link these physical data and monetary data**

***Not yet completed***

# Scenarios for AIM/Material Model

- **Technology change**
  - **Energy efficiency, pollution generation, pollution management, recycled material input, and so on for new equipment (investment)**
- **Labor force**
- **Export and import**
- **Preference change**
  - **Final consumption, investment, ...**

# Application of AIM/Material Model

- **Economic impacts due to environmental preservation**
  - **CO2 reduction (Kyoto target), waste reduction, waste water treatment, ...**
- **Mitigation by countermeasures**
  - **Environmental investment, preference change, new technology, tax reform, CDM, ...**
- **Link with bottom up model such as AIM/Emission**

**➔Detailed results will be represented in session 7.**