AIM/Material Model

Features, model and necessary data

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Session 4: Asia Pacific Integrated Model (AIM):
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

-What is 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

## Model formulation

<table>
<thead>
<tr>
<th>Input</th>
<th>Production sector</th>
<th>Investment</th>
<th>Supply</th>
<th>Price</th>
<th>Endowment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sector 1</td>
<td>Sector 2</td>
<td>Sector 3</td>
<td>Sector 1</td>
<td>Sector 2</td>
</tr>
<tr>
<td>Commodity 1</td>
<td>$X_{11}$</td>
<td>$X_{12}$</td>
<td>$X_{13}$</td>
<td>$C_1$</td>
<td>$I_{11}$</td>
</tr>
<tr>
<td>Commodity 2</td>
<td>$X_{21}$</td>
<td>$X_{22}$</td>
<td>$X_{23}$</td>
<td>$C_2$</td>
<td>$I_{21}$</td>
</tr>
<tr>
<td>Commodity 3</td>
<td>$X_{31}$</td>
<td>$X_{32}$</td>
<td>$X_{33}$</td>
<td>$C_3$</td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>$K_1$</td>
<td>$K_2$</td>
<td>$K_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>$L_1$</td>
<td>$L_2$</td>
<td>$L_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final disposal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>Commodity 1</td>
<td>$Y_{11}$</td>
<td>$Y_{21}$</td>
<td>$Y_{31}$</td>
<td></td>
</tr>
<tr>
<td>Commodity 2</td>
<td>$Y_{12}$</td>
<td>$Y_{22}$</td>
<td>$Y_{32}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commodity 3</td>
<td></td>
<td></td>
<td>$Y_{33}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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, ...)
    \[ P_K \left\{ K^* - \sum_{j=1}^{3} K_j \right\} = 0, \quad P_K \geq 0, \quad \text{and} \quad K^* - \sum_{j=1}^{3} K_j \geq 0 \]
    \[ P_L \left\{ L^* - \sum_{j=1}^{3} L_j \right\} = 0, \quad P_L \geq 0, \quad \text{and} \quad L^* - \sum_{j=1}^{3} L_j \geq 0 \]
    \[ P_W \left\{ W^* - \sum_{j=1}^{3} W_j \right\} = 0, \quad P_W \geq 0, \quad \text{and} \quad W^* - \sum_{j=1}^{3} W_j \geq 0 \]
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

<table>
<thead>
<tr>
<th></th>
<th>commodity 1</th>
<th>...</th>
<th>commodity i</th>
<th>final demand</th>
<th>total output</th>
</tr>
</thead>
<tbody>
<tr>
<td>commodity 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>commodity i</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>value added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

- Necessary data for simulation-

- household consumption, government consumption, investment, export
U matrix (Use matrix)

<table>
<thead>
<tr>
<th></th>
<th>sector 1</th>
<th>...</th>
<th>sector j</th>
<th>final demand</th>
<th>total output</th>
</tr>
</thead>
<tbody>
<tr>
<td>commodity 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>commodity i</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>value added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>commodity 1</th>
<th>production</th>
<th>management of pollution a</th>
<th>...</th>
<th>management of pollution p</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>value added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data of original U matrix are disaggregate into production and pollution management.

- Necessary data for simulation-
### V matrix (Make matrix)

<table>
<thead>
<tr>
<th></th>
<th>commodity 1</th>
<th>...</th>
<th>commodity i</th>
<th>total output</th>
</tr>
</thead>
<tbody>
<tr>
<td>sector 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sector j</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total output</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>commodity 1</th>
<th></th>
<th>commodity i</th>
<th>total investment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sector 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>sector j</strong></td>
<td></td>
<td></td>
<td></td>
<td>How much of commodity invested to sector j is represented.</td>
</tr>
<tr>
<td><strong>total output</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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, ...
### Pollution flow by sector

<table>
<thead>
<tr>
<th></th>
<th>pollution generation</th>
<th>discharge into environment</th>
<th>self treatment</th>
<th>discharge into environment</th>
<th>reduction</th>
<th>recycle</th>
<th>other treatment</th>
<th>direct other treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>sector j</td>
<td>pollution a</td>
<td>...</td>
<td>pollution p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Supply and demand of reused material

<table>
<thead>
<tr>
<th></th>
<th>commodity 1</th>
<th>...</th>
<th>commodity i</th>
<th>total generation of reused pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>pollution a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pollution p</td>
<td></td>
<td></td>
<td></td>
<td>[Blue highlighted cell]</td>
</tr>
<tr>
<td>total supply of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>reused commodity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How much of pollution can be supplied as commodity i.
Supply and demand of reused material

<table>
<thead>
<tr>
<th></th>
<th>sector 1</th>
<th>...</th>
<th>sector j</th>
<th>total supply of reused pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>commodity 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>commodity i</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total demand of reused commodity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.