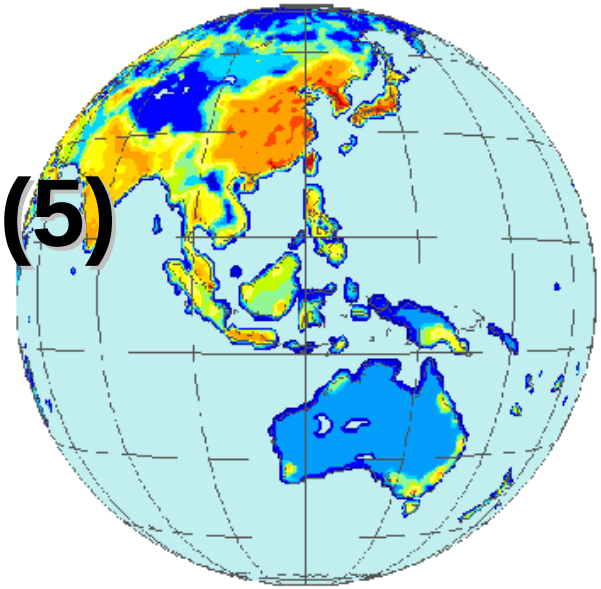
CGE model development (5)

Detailed CGE <3>

Modeling of Environmental



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Environmental investment

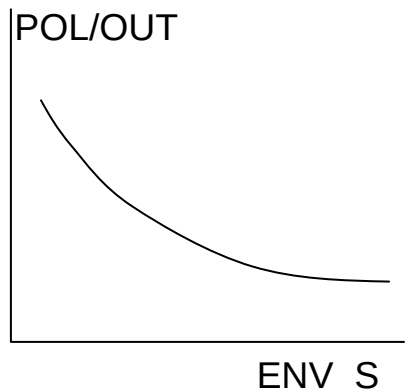
- Investment to protect environment does not contribute to promote production, but increase of stock to protect environment.
  - Energy input becomes more efficient.
  - Pollutants can be treated more.

INV: total investment
PRO_I: production investment
ENV_I: environmental investment
ENV_S: environmental capital stock
POL: pollution emission
OUT: output

$$INV_t = PRO\_I_t + ENV\_I_t$$

$$ENV\_S_{t+1} = ENV\_S_t * (1-\delta) + ENV\_I_t$$

$$\Rightarrow POL_{t+1}/OUT_{t+1} = f\left(ENV\_S_{t+1}\right)$$



Environmental investment

- Energy efficiency improvement

```
I:PE(E)     Q:(Q_EN(E,J)*GR_E(E,J)) P:RP_EN(E) E.TL:
I:PCO2#(E) Q:(CO2(E,J)*GR_E(E,J))  P:0          E.TL:
```

  - By implementing energy-saving investment, GR_E becomes smaller. (energy-saving investment ➜ decrease of energy input ➜ GR_E(E,J) ↓ ➜ decrease of CO2 emission)

- Solid waste and waste water

```
I:PW       Q:(WST(J)*GR_W(J))      P:0
```

  PW: waste disposal right

  WST(J): waste generation in benchmark year

  GR_W(J): efficiency of waste generation

  - By implementing environmental investment, waste generation per output is reduced (GR_W(J) ↓).

- During the iteration process, parameters on technology change are updated according to capacity of environmental protection (stock of capital for environmental protection).

Resource extraction

- As fossil fuel resources are extracted, fuel extraction cost becomes higher. This means output to inputs becomes worse.

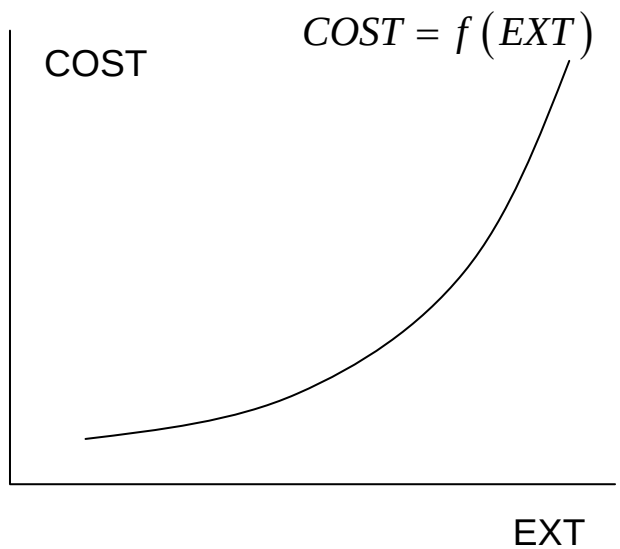
  OUT: fuel extraction

  EXT: total extracted fuel

  COST: fuel extraction cost

$$EXT_{t+1} = EXT_t + OUT_t$$

$$COST_{t+1} = f\left(EXT_{t+1}\right)$$

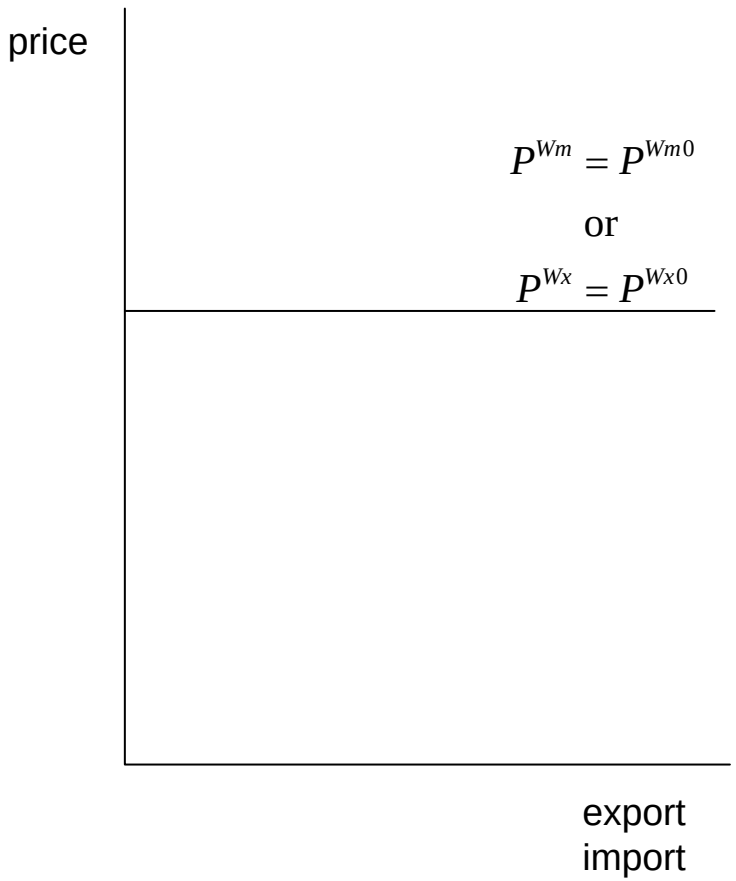


Resource extraction

`O:PY(I)` `Q:(V(J,I)*GR_O(J))`

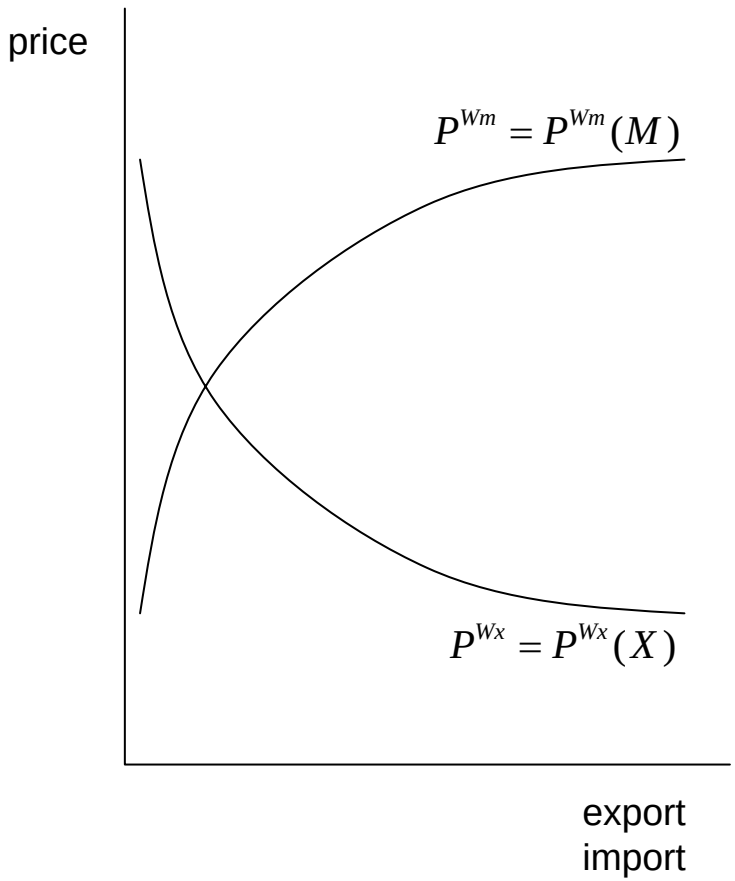
- According to cumulative resource extraction, extraction cost will increase. GR_O(J): ↓
- During the iteration process, values of GR_O(J) are updated.

Small country assumption



- Even if quantities of import or export are changed, international price is not changed.

Large country assumption



quantity of import: ↑

demand in international market: ↑

international price: ↑

quantity of export: ↑

supply in international market: ↑

international price: ↓

Large country assumption

Small country assumption:

```
$CONSTRAINT:IM_QN(N)$(-IMP(N))
-IMP(N)*IM_QN(N) =E= SUP(N)*(-U(N,"A_IMP")) ;
```

Large country assumption

```
$CONSTRAINT:IM_QN(N)$(-IMP(N))
    (-IMP(N)*IM_QN(N)/IMP0(N))
=E= (PM(N)/PM0(N))**(el_m(N)) ;

$CONSTRAINT:EX_QN(I)$(EXP(I))
    (EXP(I)*EX_QN(I)/EXP0(I))
=E= (PX(I)/PX0(I))**(-el_x(I)) ;

***0: reference values
el_*: elasticity (el_* > 0)
```

Linkage with end-use model

sectors	energy type	BaU	policy case	additional cost
		MTOE	MTOE	M¥
Steel	coal	100	80	50
	electricity	20	18	8
Transport	gasoline	200	150	100
	electricity	150	180	-

Energy demand changes sector by sector & energy by energy are represented in GR_E or GR_E_N.

Additional costs are treated as energy saving investment. Related investment goods should be identified.

Example of carbon tax in Japan (2003 version)

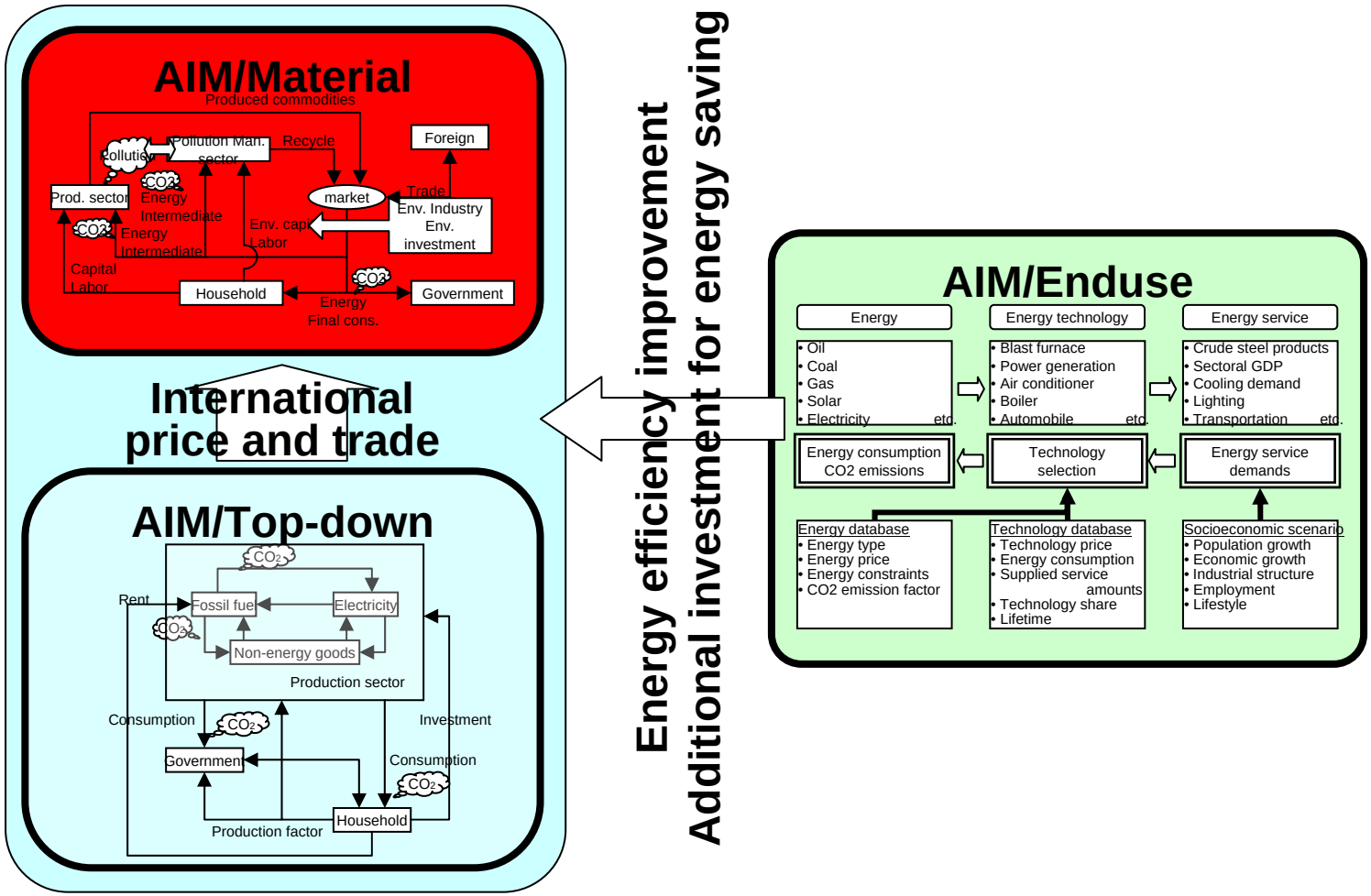
- **Kyoto Protocol**
  - **In Japan, GHG emissions in the 1st commitment period (2008-2012) should be reduced by 6% of those in 1990.**
- **New Climate Change Policy Programme (2002, Gov. of Japan)**

Total 2% of CO2 reduction is assumed to be target.

- **CO2 emissions from energy use: ±0%**
- **Reduction by innovative technologies and change of lifestyle: -2%**
- **Others**
  - **CO2 emissions from non-energy use, methane emissions, and nitrous oxide emissions: -0.5%**
  - **Emissions of HFCs, PFCs and SF6: +2.0%**
  - **The use of Sinks: -3.9%**

Model analysis on CO2 reduction policy

-Country top-down model approach-



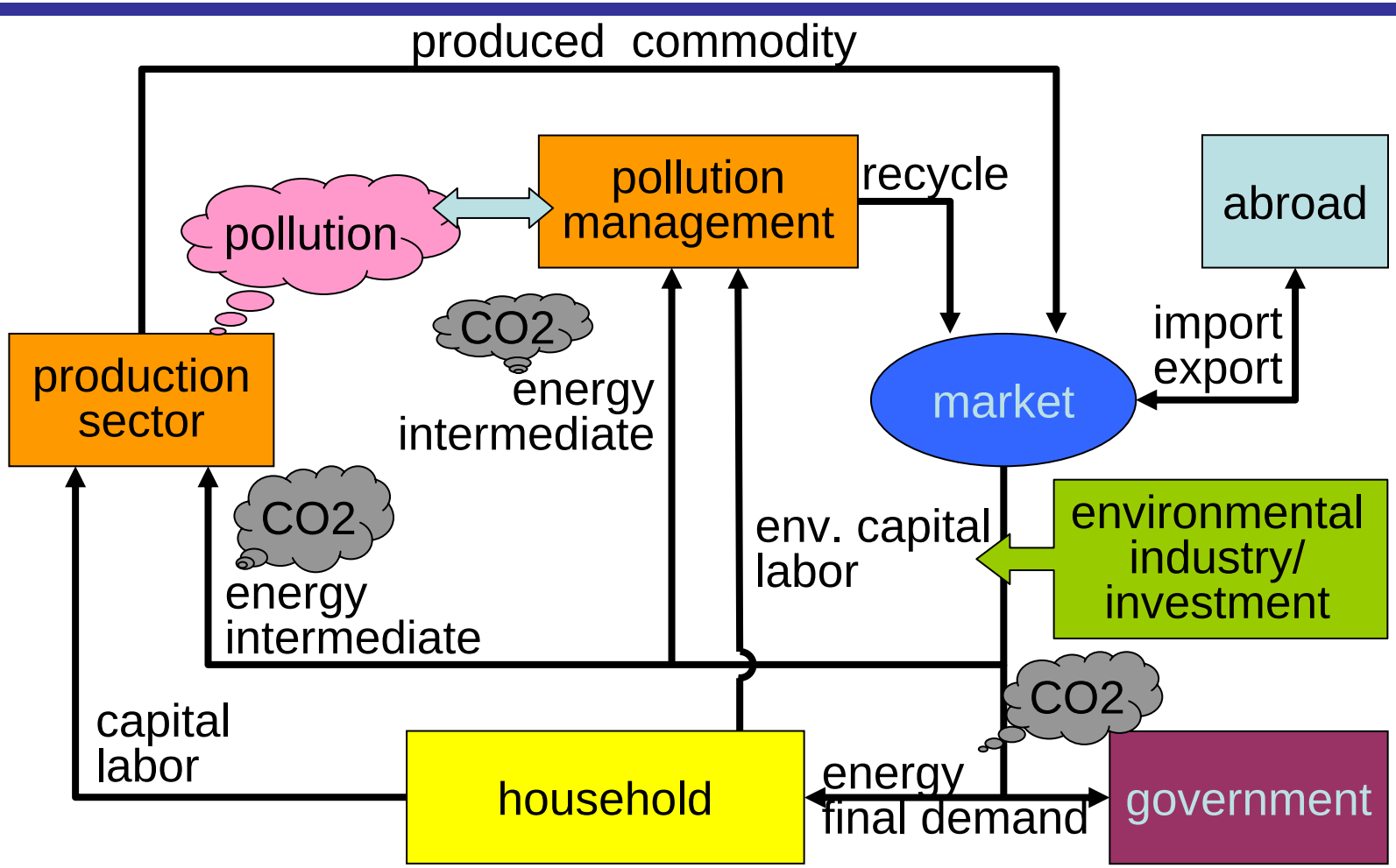
Model analysis on CO2 reduction policy

-Country top-down model approach-

- **Features of AIM/Material model**
  - **Model: Computable general equilibrium model**
  - **Country: Japan**
  - **Time period: 1995 to 2012 (recursive dynamic)**
  - **Activity: 41 sectors and 49 commodities**
  - **Solid waste: 18 waste types of industrial waste and 8 types of municipal waste.**
    - **In this analysis, the constraint on solid waste is not taken into account.**
  - **Other features**
    - **Both economic balance and material balance are kept.**
    - **Energy efficiency improvement is given from solution of AIM/End-use model**
  - **Scenarios:**
    - **Reference Case: Without CO2 constraints.**
    - **Tax case: CO2 reduction by only introducing carbon tax.**
    - **Tax + subsidy case: CO2 reduction by introducing carbon tax with subsidy for energy saving equipment.**

Model analysis on CO2 reduction policy

-Country top-down model approach-



Structure of AIM/Material

Model analysis on CO2 reduction policy

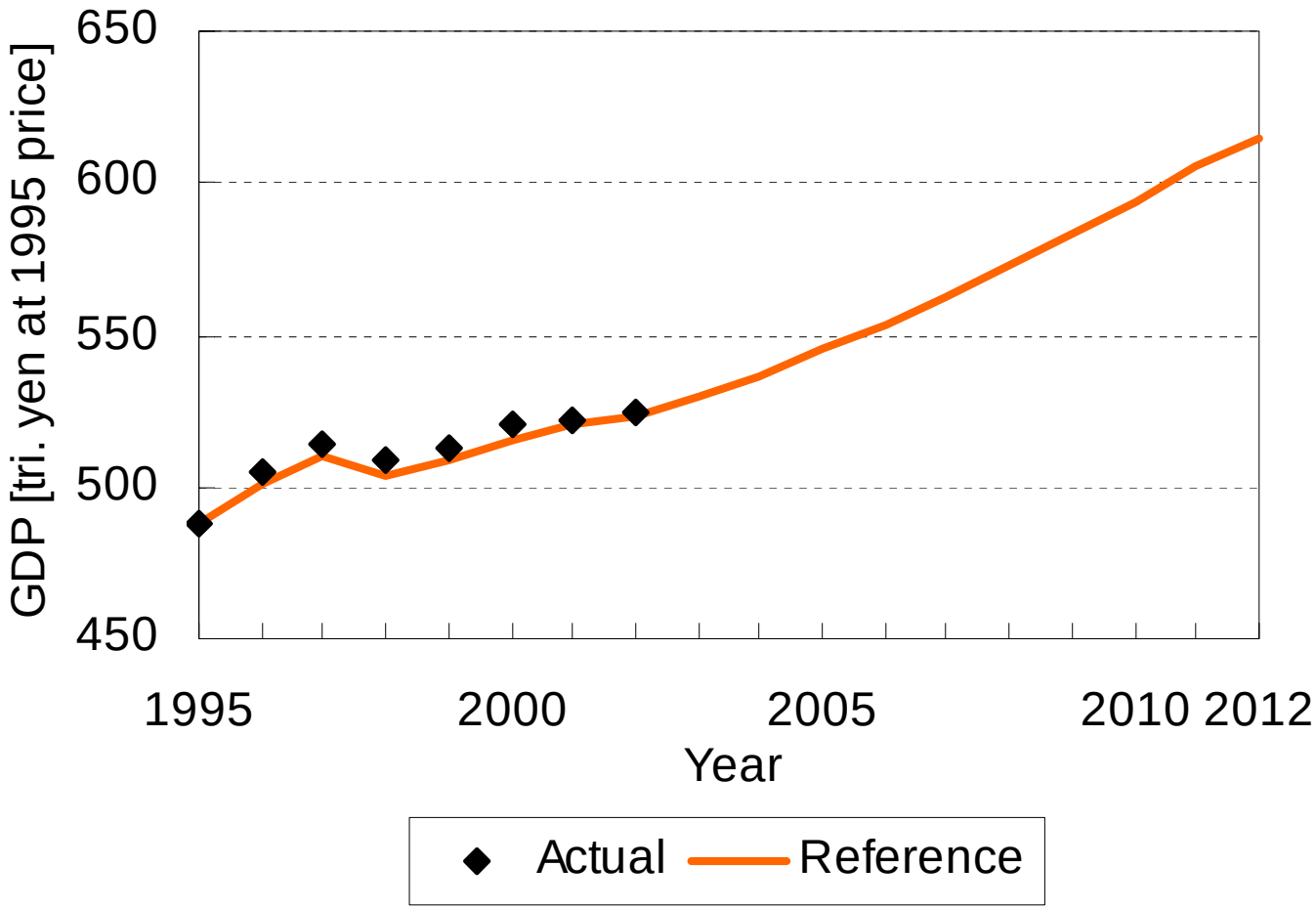
-Country top-down model approach-

Sectors and commodities

sector	commodity	sector	commodity
Agriculture, forestry & fisheries		Education, research, medical service, health & hygiene, & social welfare	
Mining except energy			
Coal mining	Coking coal	Goods renting & leasing	
	Coal for general use, lignite, anthracite	Car & machine repairing	
Crude oil mining		Other service	
Natural gas mining		Government service	
Food		Pollution management devices	
Textile mill products		Sewage service	
Lumber, wood products, pulp, paper & paper products		Municipal solid waste treatment service	
Chemical & allied products		Industrial solid waste treatment service	
Plastic		Manufacture of coal products	Coke
Ceramic, stone, & clay products			Other coal products
Iron, steel, non-ferrous metals & products			Paving materials
Non-ferrous metals & products		Manufacture of petroleum	Gasoline
Fabricated metal products			Jet fuel oil
General machinery			Kerosene
Electrical machinery, equipment & supplies			Light oil
Transportation equipment			Heavy oil
Precision instruments & machinery			Naphtha
Miscellaneous manufacturing industries			LPG
Construction			Other petroleum products
Steam & hot water supply		Manufacture of gas	Town gas
Water supply		Coal power generation	Electricity
Wholesale & retail trade		Oil power generation	
Finance & insurance		Gas power generation	
Real estate		Hydro power generation	
Transportation & communications		Nuclear power generation	

Model analysis on CO2 reduction policy

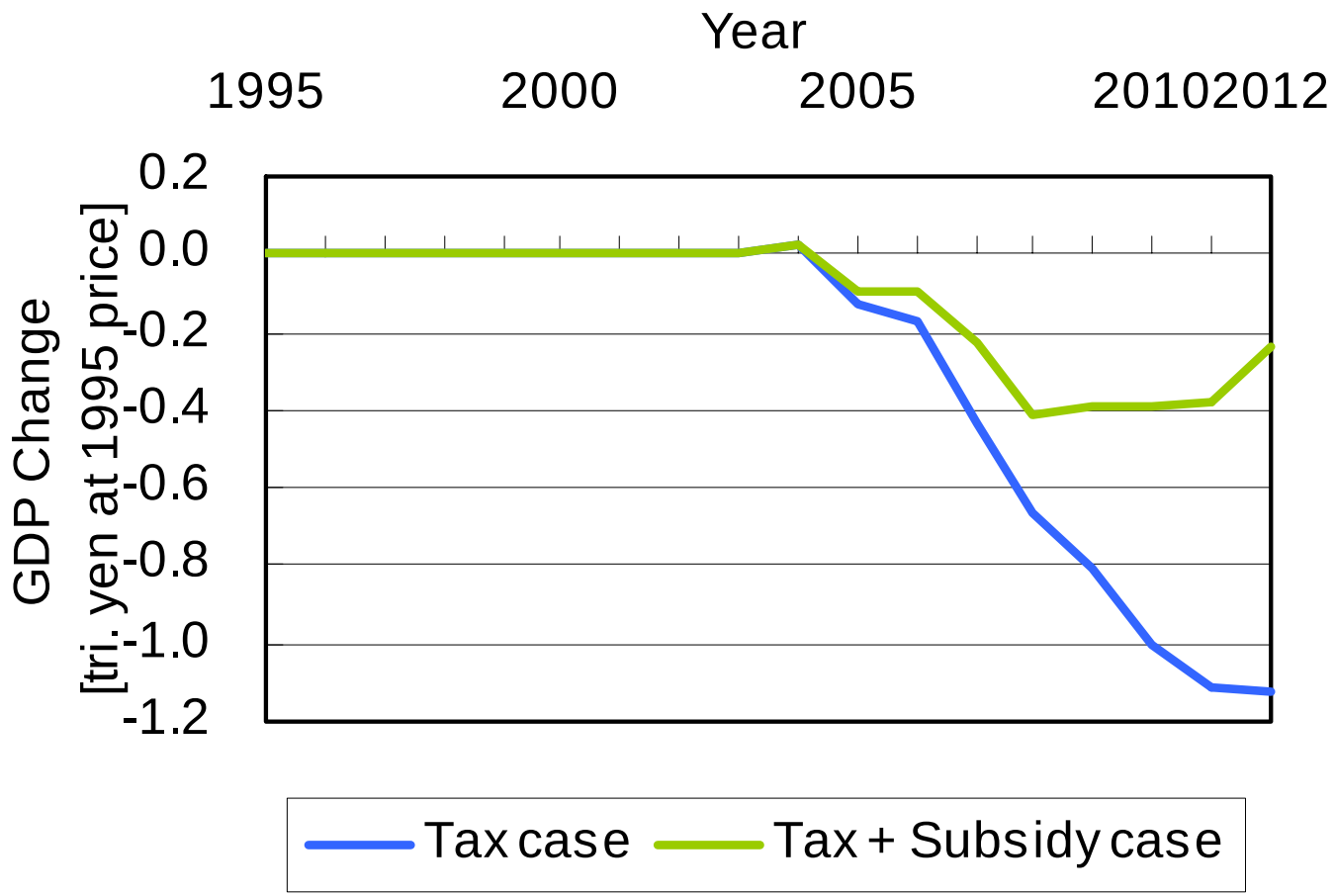
-Country top-down model approach-



Future GDP estimated from AIM/Material model

Model analysis on CO2 reduction policy

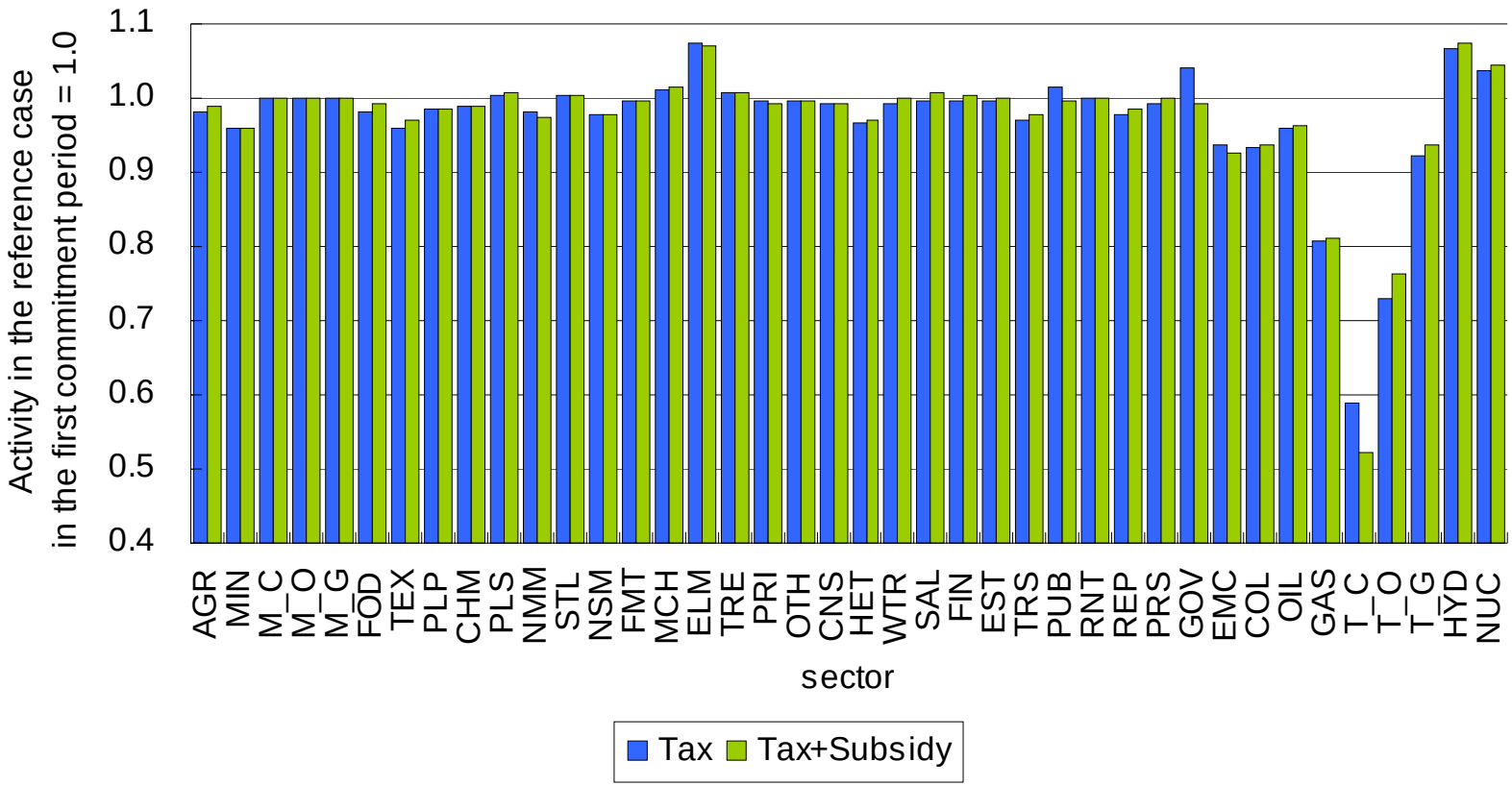
-Country top-down model approach-



GDP change compared to the reference case

Model analysis on CO2 reduction policy

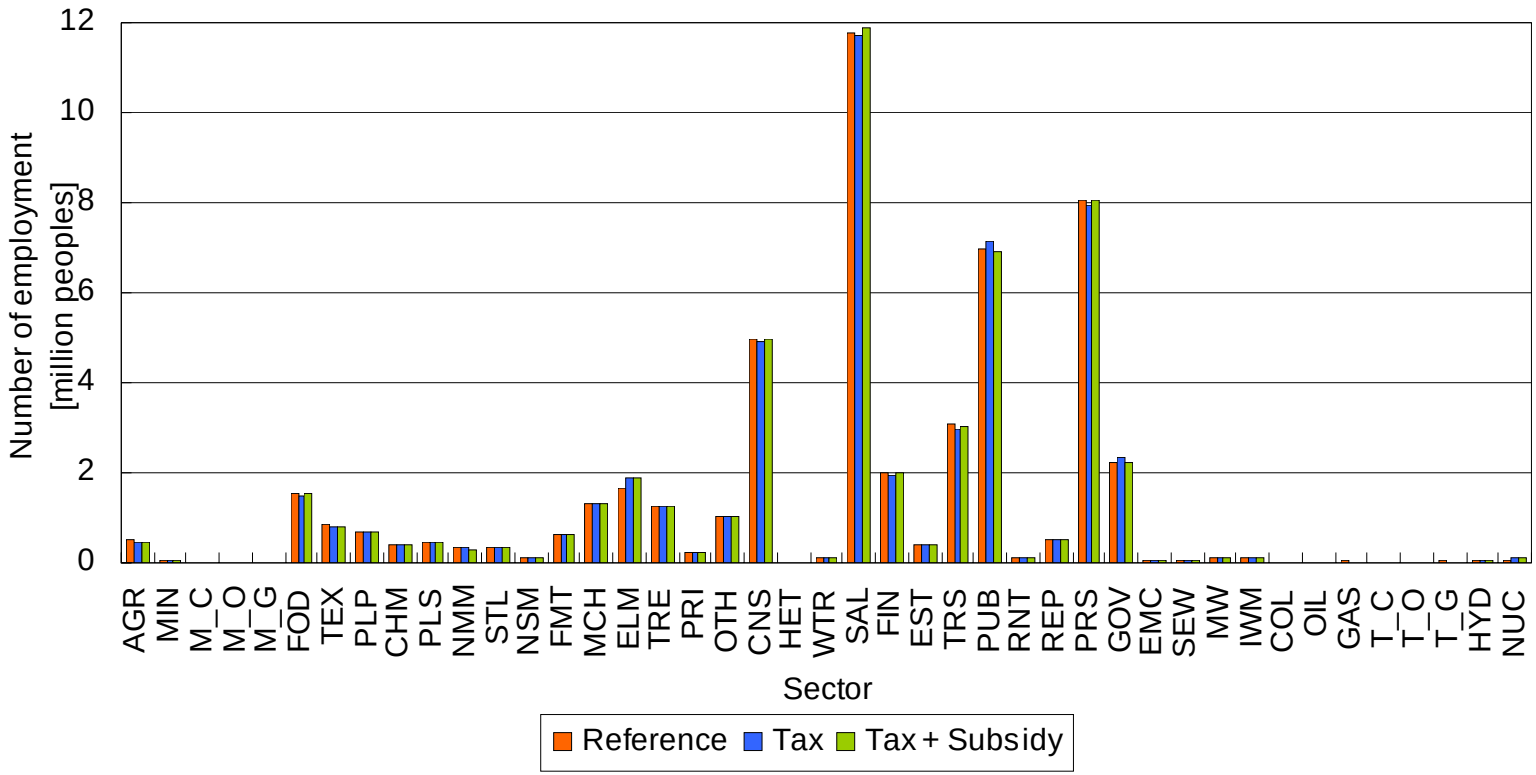
-Country top-down model approach-



Activity Change of each sector in the first commitment period (compared to reference case)

Model analysis on CO2 reduction policy

-Country top-down model approach-



Number of employment in the first commitment period