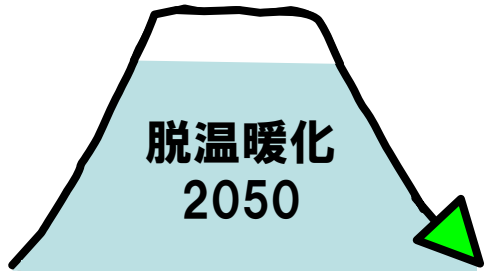


AIM/Material Stock and Flow Model

Reina Kawase
Kyoto University

19 October, 2006
AIM Training Workshop
National Institute for Environmental Studies, Tsukuba

Contents

1) Introduction

2) Importance of estimation of material stock

3) What is Material Stock and Flow Model ?

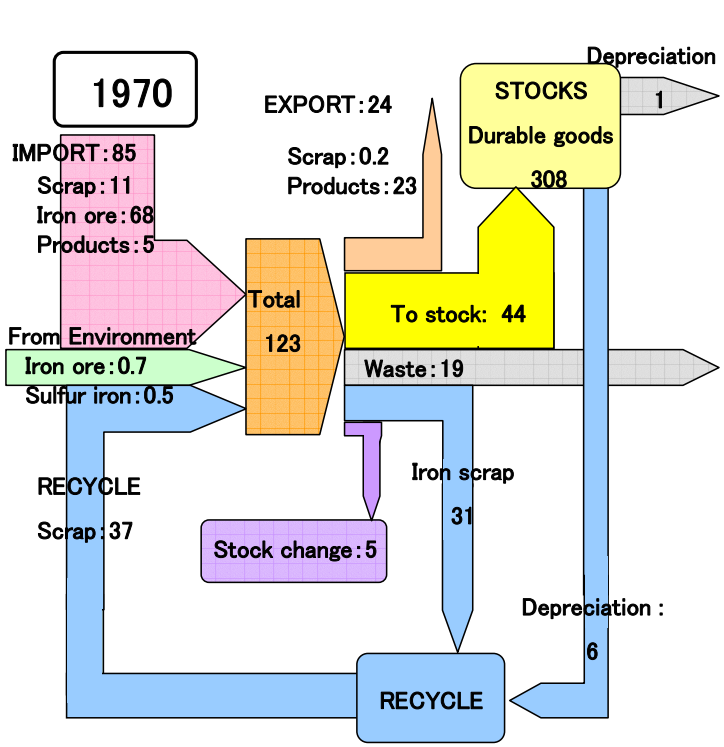
4) Description and Data

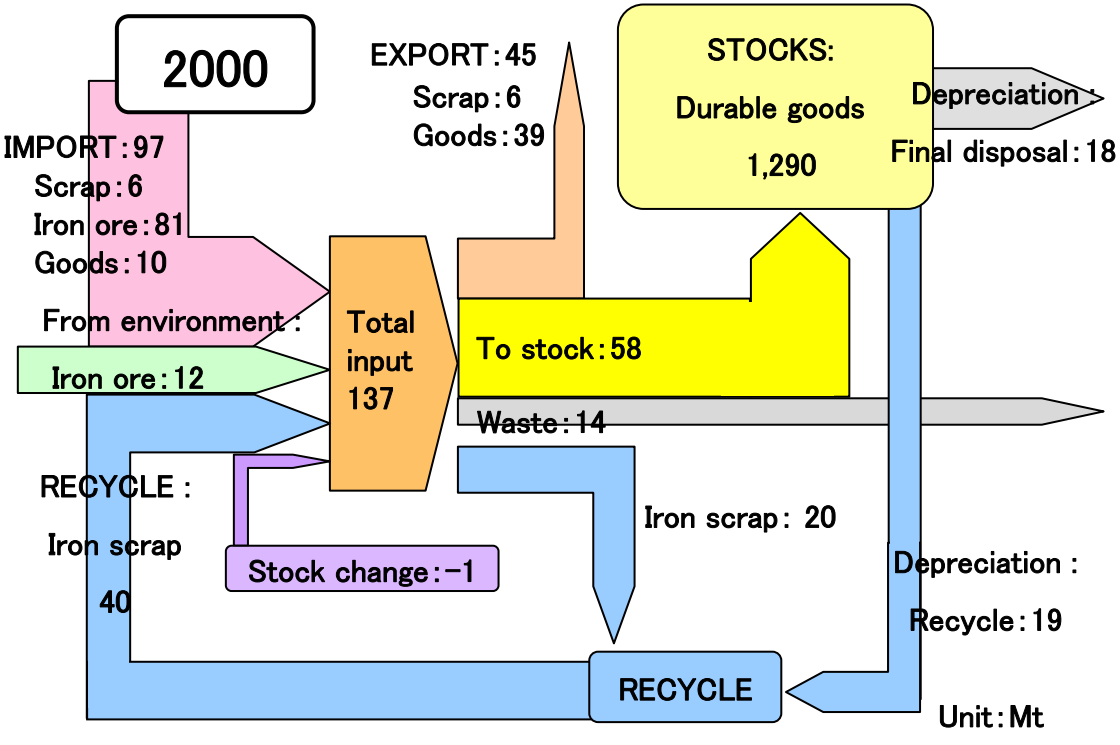
5) Methodology of developing the model

6) Basic concepts and equations

Current situation: Iron in Japan

With an increase of demands for goods, a lot of materials have been accumulated as durable goods in the society.





How will these stocks change in the future?

How will these stocks affect the society?

Importance f Estimation of Stock

1.Estimation of Demand

Stocks affect the demand for goods. In the future, demand is given as a function of stock.

ex. Saturation with infrastructure and housing

The number of the car per person

→ Material only for repair, maintenance, or rehabilitation is required.

$$Demand = f(Stock)$$

2.Waste Generation

A large amount of materials accumulated in a society as durable goods are expected to generate a large amount of wastes when goods reach the end of their lifetimes.

Importance f Estimation of Stock

3.Resource

The materials contained in stocks can be treated as resources.

Considering resource constraints, following points are important,

a) what quantities of what materials will be needed in both stocks and flows in order to fulfill final demand in the future?

b) how should these resources be most effectively used?

4.Relationship between Material Use and Energy Consumption

Economic activities use many kinds of materials. Some law material industries are energy-intensive. Under the LCS, how the material is used? What influence dose the promotion of material recycling give the energy consumption ?

What is Material Stock and Flow Model?

Material stock and flow model (MSFM)

* Estimates the change of material stocks and flow in the society.
* The factors considered in the model are
  - final consumption
  - investments which are affected by capital stocks
  - material densities of goods
  - physical input output coefficients of production sectors
  - recycling rate of wastes

  Etc
* Analyzes the mechanism of changes in material stocks and flow, and the effect of recycling materials in the future society, and looks for the measures towards the LCS in connection with material consumption.

Statistics

population, the number of household, GDP, income, lifetime, import/export, land use, production/stocks/inputs of durable goods, recycling, *etc*

Macroeconomic method

Relation between the factors
Demand＝f(stock, price, dep.)
Material share＝f(time,,,)

2000:
Stocks(cohort)
Material flow

Parameter
Material density (t/$)
Depreciation ratio
Recycling ratio

Scenario
Factors
Relation

Estimation of factors

Scenario
Tech. inv
Consump.

EXO：future demand

INITIAL

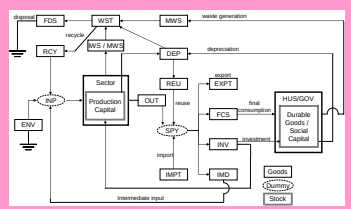
PARAMETER

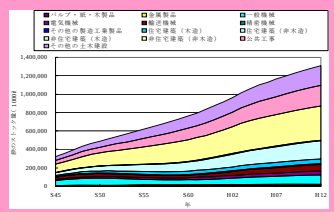
Goods / Material / Sector / Waste Balance,
Technology function, Resource constraints, *etc*

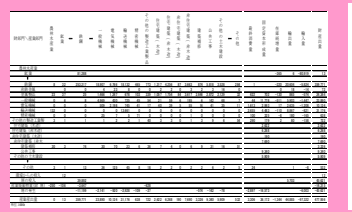
Material Stock and Flow Model

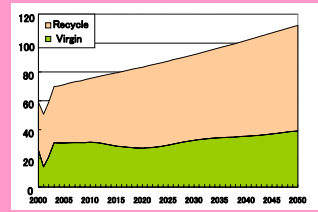
Results

Material Stocks/flows, waste, recycling, resource inputs









Model description and Data

Description

- **Target Material**

  iron, wood, cement, aluminum

- **Time Horizon**

  2000-2050

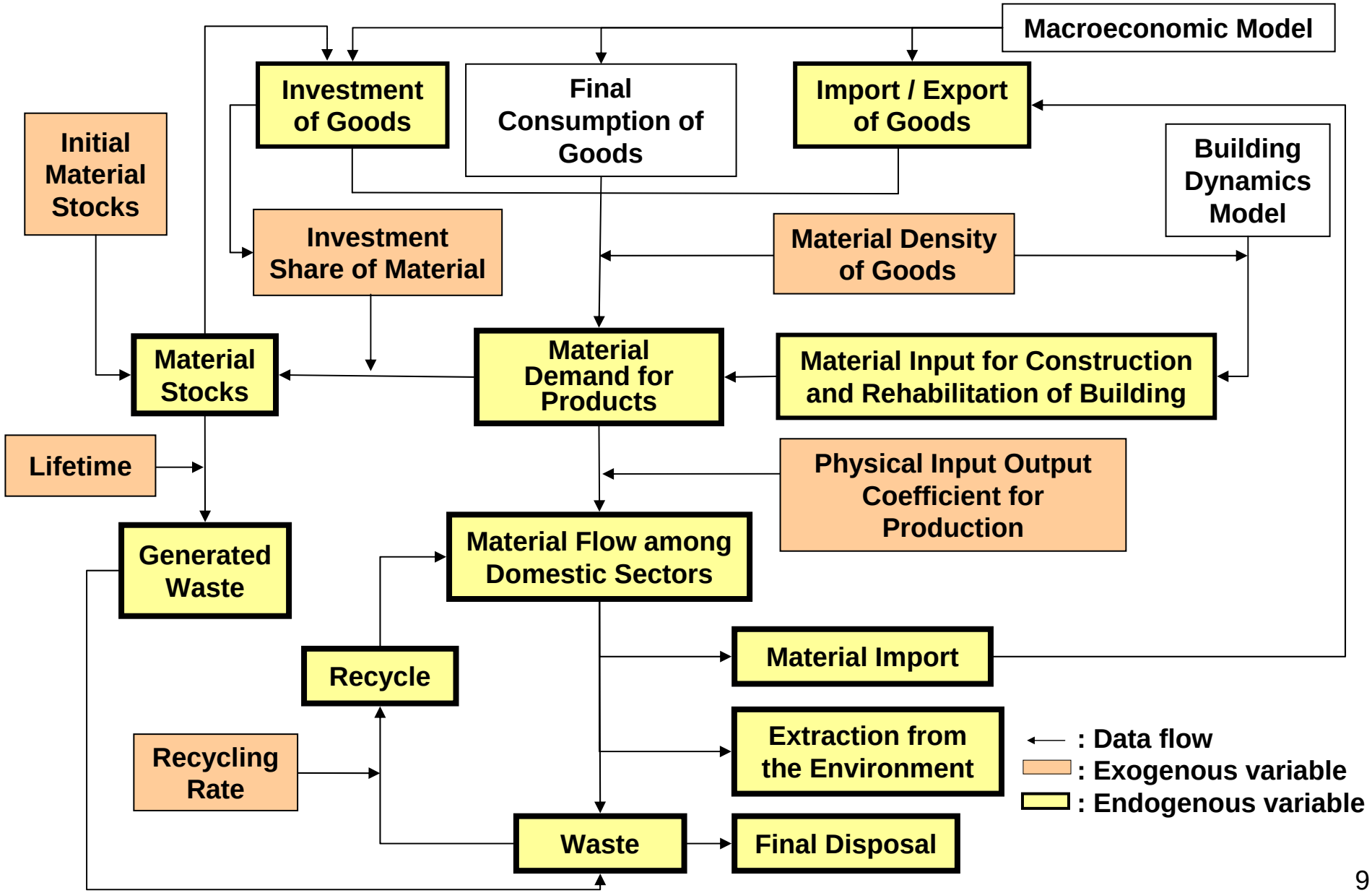
- **Goods**

  ex. Iron (Building, Civil engineering structure, Machinery, Others)

Data

- Bench mark year:
- * Physical Input-Output date of each sector
- (* Input-Output table [monetary term])
-
- Historical data: [for estimation of stock in a bench mark year]
- * Production statistic of each good
- (* Investment of each good)

Flow chart of MSFM



Development of the MSFM (1-1)

Step1: preparation of demand function

Methodology1: Input from other model
ex. Building dynamics model → Floor space of new dwellings

$$Iron\ for\ building = f(building\ type)$$
$$= a1*(wooden) + a2*(steel\ framed) + a3*(steel\text{-}reinforced\ concrete) + a4*(steel\ framed\ reinforced\ concrete\ structure) + a5*(others)$$

Tier1: Calculated by econometric method by using past data

Tier2: Assume constant value (ex. base year)

Development of the MSFM (1-2)

Step1: preparation of demand function

Methodology2: estimate/assume the function

① pick up the variables which explain the car demand
② find [assume] the relationship among the variables

TSP: language for the estimation and simulation of econometric models

$$Car\ demand = f(income, driver's\ license\ ownership,$$
$$output\ of\ material\ production\ sectors,\ \ ??\ )$$

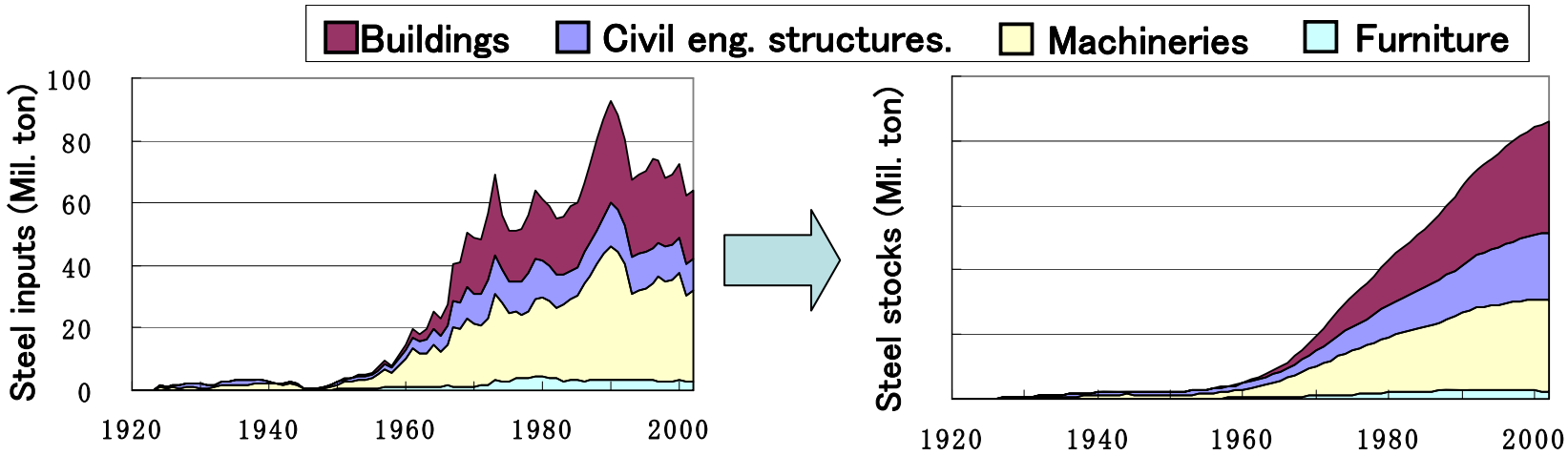
Year *t:*
Car production (t) = Car demand(t) – Stocks of car(t)

More information for TSP: http://www.tspintl.com/

Development of the MSFM (2)

Step2: Initial value of stocks

Tier1: you have physical data past several decades



Tier2: you have ONLY monetary data or few physical data

Base year : Physical stock [ton] = material density*(Capital stock [$])

material density (ton/$) : material per unit monetary amount

Assumption or rough estimation

Basic equation of MSFM (1)

<Basic concept of calculation of material flow>

Material balance (Goods / Sector / Waste)

Production function (Goods / Waste)

Stock / Depreciation

<Stock>

Physical data
material density*monetary data

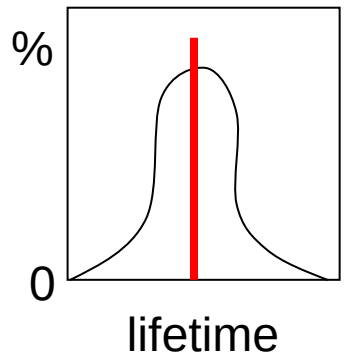
$$\sum STCK(i,m,t) =$$

$$\sum \left\{ STCK(i,m,t-1) - DEP(i,m,t) + INV(i,m,t) \right\}$$

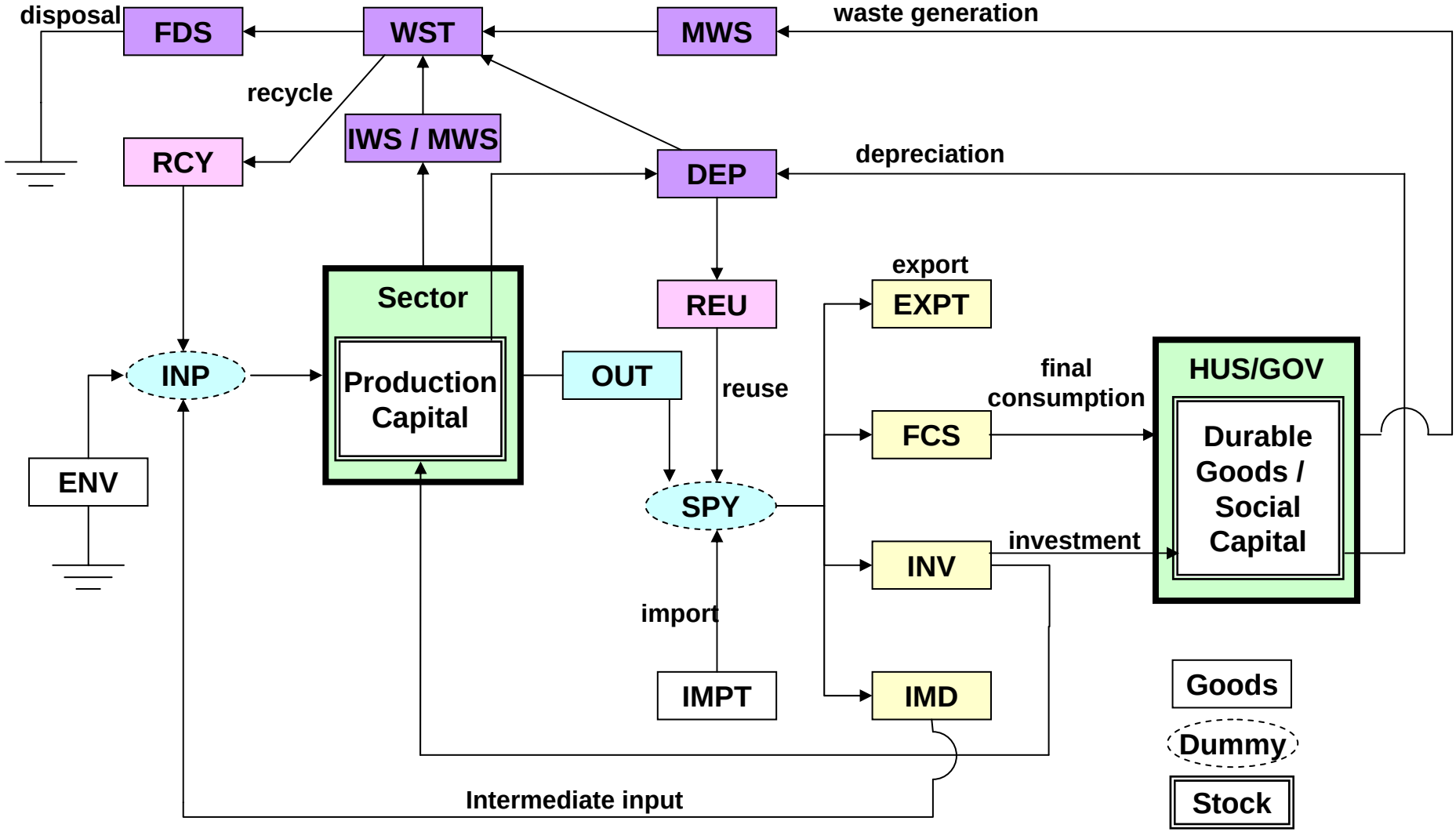
$$DEP(i,m,t) = \sum_{\tau \le t-1} INV(i,m,\tau) * pdf(i,t,\tau)$$

* Ex. Normal distribution function
* Estimate the function by historical data

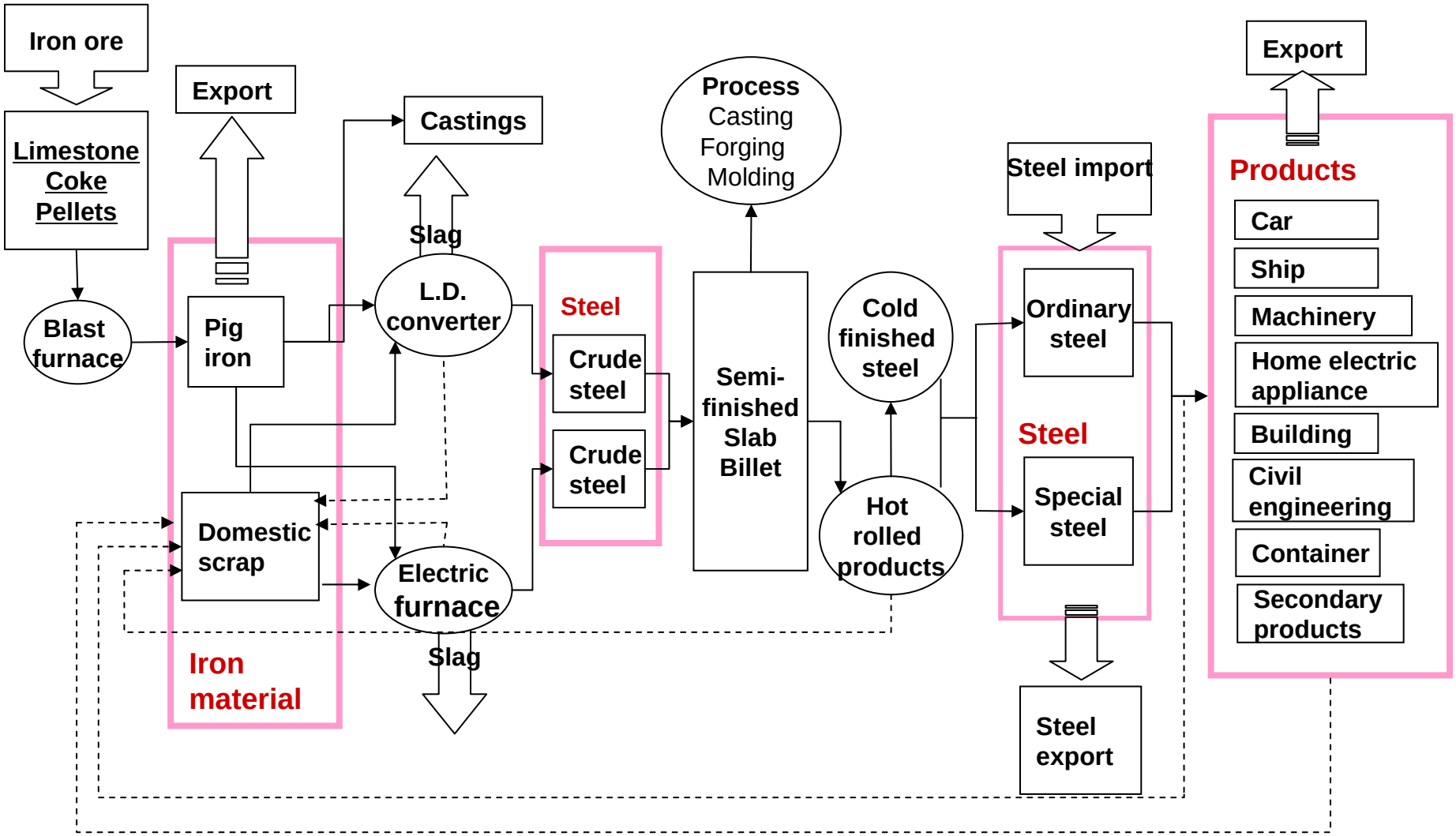
Example of *pdf*(t)



Material flow in the society



Material Flow: Iron



Basic equation of MSFM (2)

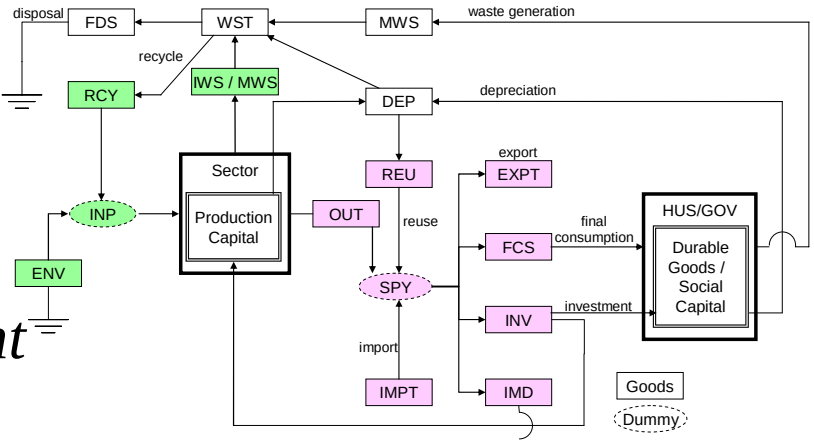
〈Goods Balance〉

$$Production + Import + Reuse$$

$$= Total\ Spply =$$

$$Intermediate + Final\ Consumption + Investment + Export$$

〈Sector Balance〉



$$Intermediate + \mathrm{Re}\,cycle + Environment$$

$$= Total\ Input =$$

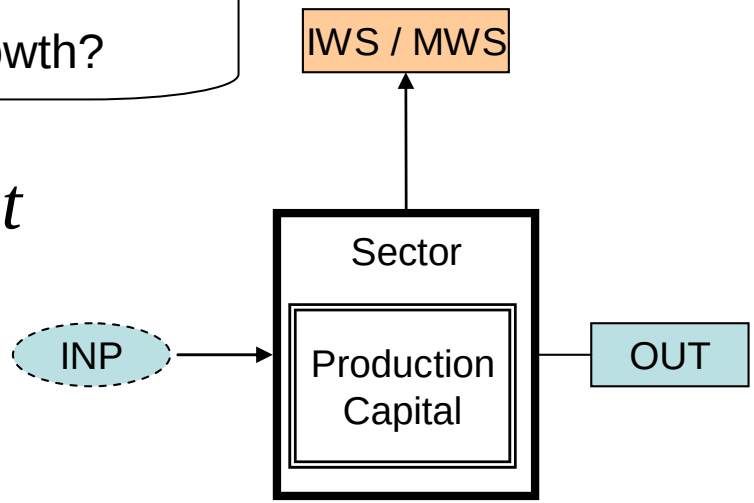
$$Production * aji + Industrial\ Waste + Municipal\ Waste + Strage$$

Basic equation of MSFM (3)

〈Production〉

Fix?
Function of time by tech. growth?

$$Output = (1 + tech) \cdot Total\ input$$



〈Waste generation〉

Production process: $Waste = (1 + tech) \cdot Output$

Final demand sector: $Waste = a(t) \cdot Consumption$

If you assume that “Technology parameter” changes depending on time,,,,,,

1) estimate by using historical data ← TSP

2) assume the figure

Expected results

- Where, What kinds of, and how much of materials are accumulated in the society?
- Material flow among the sectors
- What kinds of and how much of wastes are generated?
- How much of material is recycled?

After linking the material consumption and energy consumption, analyze

- The relationship between the material use and energy consumption[CO2 emission]
- Possibility or limitation of contribution of material flow change to develop LCS.