Development of Iron Stock & Flow Model in Japan and China

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It is important issue to grasp the relationship between socioeconomic activities and material use.

But we don’t know the whole material flow due to a lack of data: physical and monetary data.

Especially, STEEL is energy intensive raw materials, so its use in the future is the focus of attention as not only Material Use but also Energy Consumption.

1. Background

2. Outline of Material Stock and Flow Model
   Data, Structure, Formulation, Evaluation

3. Results in Japan and China
   Scrap generation and Stock by goods

4. Estimation Steel Investment under the saturation of Steel Stock per Capita

5. Future Task
China’s steel sector in the world

China: 34% of world steel production
1996-2006 => 4 times

Table. Crude Steel Production

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Mil ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>422.7</td>
</tr>
<tr>
<td>2</td>
<td>Japan</td>
<td>116.2</td>
</tr>
<tr>
<td>3</td>
<td>U.S.A</td>
<td>98.6</td>
</tr>
<tr>
<td>4</td>
<td>Russia</td>
<td>70.8</td>
</tr>
</tbody>
</table>
Outline of Developing MSFM

Objective

1) Iron and Steel Stock and Flow in the society
2) Flow & Stock which cannot be obtained from statistics
   → Stock, Scrap

Country

Japan, China

Econometric Method

Input-Output function of production sectors
Demand function of final demand goods
Goods balance, Material balance, Stock

Data

Physical data
Steel Statistic Yearbook, International Historical Statistics, etc.

Socioeconomic data
Summary of Japanese long-term statistics, ECONOMATE, I-O table, etc.

1. Preparing data over the past several decades
2. Constructing theoretical models (Formulation)
3. Estimating parameters by regression analysis
4. Evaluating the performance of the models
2. Iron and Steel Flow and Stock

Stock

Iron Ore

Pig Iron

Crude Steel

Scrap

Pig Iron

Other MTL

Mine

PRS Scrap

DPR Scrap

Car

Ship

Trs. MCN

Ind. MCN

Ele. MCN

Hsh. MCN

Building

Cvl. ENG

Landfill

Other

Goods

Production Sector

Car

Ship

Other TRS equip.

Ind. Machine

Ele. Machine

Hsh. Machine

Building

Civil Eng. Structures

Other
2. Formulation

**Production sector**

\[ X_{j}^{prd} = \sum a_i^j \cdot X_{i,j}^{csm} - SCR^*_j \]

**Goods balance**

\[ X_i^{prd} + X_i^{imp} = X_i^{exp} + X_i^{csm} + X_i^{inv} \]

\[ \sum_j SCR_j^{prd} + \sum_i SCR_i^{dpr} + SCR^{imp} = SCR^{csm} + SCR^{exp} + SCR^{ldf} \]

**Stock**

\[ STK_{if,t} = (1 - dpr_{if})STK_{if,t-1} + X_{if}^{inv} \]

**Home scrap**

\[ SCR_{CRD}^{prd} = a_1 \cdot CR^2 + a_2 \cdot CR + C \]

**Steel input to goods**

\[ X_i^{prd} = \sum_k d_k \cdot XDF_{i,k} \]

**Table: Driving force of steel consumption**

<table>
<thead>
<tr>
<th>Goods</th>
<th>Driving Force</th>
<th>units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>Car production</td>
<td>units</td>
</tr>
<tr>
<td>Ship</td>
<td>Ship production</td>
<td>G.T.</td>
</tr>
<tr>
<td>Train</td>
<td>Train production</td>
<td>units</td>
</tr>
<tr>
<td>Machine</td>
<td>Output of Machines</td>
<td>Mil. yuan</td>
</tr>
<tr>
<td>Cvl Eng Structures</td>
<td>Railway rail length</td>
<td>km</td>
</tr>
<tr>
<td>Building</td>
<td>Floor area</td>
<td>m²</td>
</tr>
<tr>
<td>Other</td>
<td>Output of Metal products</td>
<td>Mil. Yuan</td>
</tr>
</tbody>
</table>
3. Estimation of parameters: regression analysis

Steel input to Building

\[= 1185 + 0.094 \times \text{Floor} + 0.95 \times (\text{Floor}(-1) - 1185 - 0.094 \times \text{Floor})\]

Steel input to Ind. Machine

\[= 600 + 0.16 \times \text{Mcn}\]

Steel input per Floor area

\[\rightarrow \text{Report} : 0.089 \text{ [ton/m}^2\text{]}\]

Pig iron production

\[= -633 + 0.58 \times \text{Ironore} + 0.85 \times \text{Pellet}\]

Crude steel production

\[= -1644 + 0.90 \times \text{Pigiron} + 0.81 \times \text{Scrap}\]

Balance or Iron ore

\[\text{Ironore}_{\text{imp}} + 0.9648 \times \text{Ironore}_{\text{prd}} = 6.4 + 0 \times \text{Ironore}_{\text{exp}} + 0.9997 \times \text{Ironore}_{\text{csn}}\]
4. Evaluation of Model Performance

Evaluation

Each equation by regression analysis: t value, R² value, Darbin–Watson ratio

Model performance by Partial test (PT) & Final test (FT): Mean Absolute Percentage Error

\[ \text{MAPE} = \left( \frac{\sum_{i} (X_{i} - \hat{X}_{i})}{\sum_{i} X_{i}} \right) * 100 \% \]

<table>
<thead>
<tr>
<th>Variables</th>
<th>PT</th>
<th>FT</th>
<th>R² Value</th>
<th>DW Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car production</td>
<td>3.31</td>
<td>3.31</td>
<td>0.96</td>
<td>1.23</td>
</tr>
<tr>
<td>Ship production</td>
<td>9.09</td>
<td>9.09</td>
<td>0.88</td>
<td>1.03</td>
</tr>
<tr>
<td>Floor area</td>
<td>2.96</td>
<td>8.22</td>
<td>0.95</td>
<td>1.20</td>
</tr>
<tr>
<td>Cvl Eng Structures</td>
<td>4.80</td>
<td>7.13</td>
<td>0.69</td>
<td>1.34</td>
</tr>
<tr>
<td>Ind. Machines</td>
<td>7.91</td>
<td>7.91</td>
<td>0.89</td>
<td>0.71</td>
</tr>
<tr>
<td>Ele. Machines</td>
<td>8.39</td>
<td>8.39</td>
<td>0.53</td>
<td>0.64</td>
</tr>
<tr>
<td>Hsh. Machines</td>
<td>19.28</td>
<td>19.28</td>
<td>0.56</td>
<td>0.47</td>
</tr>
<tr>
<td>Steel balance</td>
<td>0.00</td>
<td>3.48</td>
<td>1.00</td>
<td>2.84</td>
</tr>
<tr>
<td>Crude steel consumption</td>
<td>3.62</td>
<td>5.67</td>
<td>0.83</td>
<td>1.41</td>
</tr>
<tr>
<td>Crude steel balance</td>
<td>0.00</td>
<td>4.23</td>
<td>1.00</td>
<td>2.26</td>
</tr>
<tr>
<td>Pig iron consumption</td>
<td>0.79</td>
<td>4.49</td>
<td>0.99</td>
<td>0.35</td>
</tr>
<tr>
<td>Iron ore consumption</td>
<td>0.62</td>
<td>5.63</td>
<td>0.99</td>
<td>1.40</td>
</tr>
<tr>
<td>Iron ore import</td>
<td>0.02</td>
<td>5.64</td>
<td>1.00</td>
<td>1.13</td>
</tr>
<tr>
<td>Pellet balance</td>
<td>0.00</td>
<td>28.90</td>
<td>1.00</td>
<td>1.49</td>
</tr>
<tr>
<td>Home scrap generation</td>
<td>0.94</td>
<td>4.46</td>
<td>0.97</td>
<td>1.14</td>
</tr>
</tbody>
</table>
4. Comparison with other researches

2000
Steel Assoc. : 1.22 bil. ton
Steel yearbook : 1.24 bil. ton
MSFM estimation: 1.10 bil. ton

2004
Home scr. : 26.5 Mil. ton
Dpr. scr. : 32.0 Mil. ton
MSFM Home scr. : 13.6 Mil. ton
MSFM estimation : 36.9 Mil. ton
Up to 2004, the supply and demand of iron scrap was balances.

→ Recycling rate was not 100% = > Shortfall were met with Imports.

Recycled depreciation scrap = Consumption – Net Import – Home scrap

→ The recycling rate of depreciation scrap is increasing, reaching 57% in 2005

(Including Home scrap; 65 %)
Steel Stock and Investment in Japan

The share of the Stock, Investment and Scrap are different → Lifetime

Cvl.Eng. Str. : 28.2%
Building: 49.7%
Transport: 10.9% (Car: 4.9, Oth: 5.8)
Machine: 8.6% (Ind; 5.4, E.le2.6)
Steel Stock and Investment in China

CvI. Eng. Structures: 11.4%

Building: 57.4%

Transport: 8.5% (Car: 6.2, Ship: 1.4)

Machine: 22.7%
Question for future steel use

Domestic investment is done to meet “STOCK DEMAND”

→ How will the stock demand change?
→ How much steel is required?

Japan

China
Steel stocks of main steel production countries

The steel stock per capita will be saturated at a certain level.

The level is different depending on countries.
Future steel stock and steel investment in Japan

- Steel Stock (100 Million tons)
  - Case 1
  - Case 2
  - Case 3
  - Output from MSFM

- Required Investment (100 Million tons)
  - Case 1
  - Case 2
  - Case 3
  - Output from MSFM
Future steel stock and steel production in China

![Graphs showing steel stock and steel production in China, with data for different cases and output from MSFM.]
Future task

Why is the steel stock per capita different?

→ The shares of the stock of goods are different.

\[ \text{Steel} \_ \text{STK}_t = \sum_i a_i \cdot \text{DF} \_ \text{STK}_{i,t} \]

Why is the component of the stock different?

→ The social situation is different ???

① \[ \text{DF} \_ \text{STK}_i = f(Z_{i,j}) \]

② \[ \text{DF} \_ \text{STK}_i = \text{POP} \cdot \text{DF} \_ \text{STK} \_ \text{CAP}_i \]
\[ = \text{POP} \cdot f(Z_{i,j}) \]

Population density

The level of compact city

Size of household

Preference,,,

<table>
<thead>
<tr>
<th>JPN</th>
<th>USA</th>
<th>GEM</th>
<th>UK</th>
<th>FRN</th>
<th>ITL</th>
<th>CHN</th>
</tr>
</thead>
</table>

Passengers car in use per capita

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90

Thank you
Supplement
1. Preparing Data: steel input to sectors

Fig. Ordinary steel input to sectors

Fig. Special steel input to sectors

Fig. Steel Input to sectors

Fig. Other steel input to sectors