Technological Change and Accumulated Capital
:A Dynamic Decomposition of Japan’s Growth

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Keio Data Base Keio Economic Observatory
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  – TFP under Static Structure
    : Static Unit TFP through Static Interdependency
  – TFP under the Dynamic Structural Change
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Official Statistics

• Input-Output Table
  – Basic Table: every five years from 1955
    • activity base - 519 × 403 (1995)
  – Extended Table: every year from 1973

• Capital Measurement
  – Capital Formation Matrix: every five years from 1970
  – Capital Stock Matrix: National Wealth Survey in 1955, 70
KDB

• Input-Output Table
  – every year during 1960-95

• Measurement of Capital
  – every year during 1955-92
    • Capital Formation Matrix : $I_{ij}$
    • Capital Stock Matrix : $S_{ij}$

• Measurement of Labor
  – every years during 1960-92
    • Man, Hour and Wage
      industry · age · sex · education · employment status
<table>
<thead>
<tr>
<th>Commodity Industry</th>
<th>Final Demand</th>
<th>Domestic</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>Com.</td>
<td>X</td>
<td>U</td>
<td>fd</td>
</tr>
<tr>
<td>Scrap Input</td>
<td></td>
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<tr>
<td>Ind.</td>
<td>V</td>
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<tr>
<td>Non-Competitive Import</td>
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<tr>
<td>Scrap Output</td>
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<td></td>
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<tr>
<td>Value Added</td>
<td>va</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Time-Series X-table

[Intermediate Inputs]
- 43 commodities
- 8 scraps

[Non-competitive Imports]
- raw oil, natural gas,
- iron ore, others

[Year]
- 1960-95

Management and Coordination Agency
in 1960, 65, 70, 75, 80, 85, 90
Private Investment

Private Fixed Capital Formation Matrix

Private Investment

Commodity; i

Industry; j

Fixed Capital Formation Matrix

Management and Coordination Agency

in 1970, 75, 80, 85, 90
Public Investment

Public Fixed Capital Formation Matrix

\[ I_{Gi} \]

industry \( j \)

\[ I_{Gij} \]

infrastructure \( k \)

\[ I_{Gik} \]

commodity \( i \)

Management and Coordination Agency
Estimation of Capital Formation Matrix
Estimation of Capital Stock Matrix
Capital Stock and Value Added

: Aggregated Level

(trillion yen - 1985 price)

**Capital Stock**
- 1960-70: 7.10%
- 1970-80: 9.17%
- 1980-90: 4.66%

**Real Value Added**
- 1960-70: 7.20%
- 1970-80: 4.13%
- 1980-90: 4.28%
Capital Coefficient - $B_{ij}$

Agriculture, Forestry and Fishery Industry

- Building & Construction (Land Improve., etc)
- Animal, Plants
- General Machinery for Agri.
- Transportation Equipment (Ships)
Capital Coefficient - $B_{ij}$

Road Transportation

Motor Vehicle

Building & Construction

Capital Coefficient $B_{ij}$
Service except Commerce, Trans., Medical, etc

- Electric Machinery
- Motor Vehicle
- Building & Construction
Capital Coefficient - $B_{ij}$

General Machinery Manufacturing
Capital Coefficient - $B_{ij}$
Motor Vehicle Manufacturing

Electric Machinery
General Machinery
Building & Construction

Structural Change

- Definition of Economic “Structure”
  - $A_{ij} = \frac{X_{ij}}{X_j}$: Input Coefficient
  - $B_{ij} = \frac{S_{ij}}{X_j}$: Capital Coefficient
Industry-base TFP

TPF ; $T_j$

- Industry-base
- Structural Change

$A_j, B_j, L_j$

- Production Function

$X_j = f(K_j, L_j, X_j, T_j)$
The Rate of Traditional TFP Growth in sector j

\( X_j \): real gross output
\( X_{ij} \): intermediate input \( l \)
\( L_{lj} \): labor input of type \( l \)
\( K_{kj} \): capital input of type \( k \)
\( p_{jt}, p_{lj}, p_{kj} \): prices of output, labor and capital inputs

\[
\begin{pmatrix}
\frac{T_j}{X_j} \\
\frac{T_j}{X_j}
\end{pmatrix}_t =
\begin{pmatrix}
\dot{X}_j \\
\dot{X}_j
\end{pmatrix}_t - \sum_i \frac{p_{ij}}{X_{ij}} X_{ij} \begin{pmatrix}
\dot{X}_{ij} \\
\dot{X}_{ij}
\end{pmatrix}_t - \sum_l \frac{p_{lj}}{L_{lj}} L_{lj} \begin{pmatrix}
\dot{L}_{lj} \\
\dot{L}_{lj}
\end{pmatrix}_t - \sum_k \frac{p_{kj}}{K_{kj}} K_{kj} \begin{pmatrix}
\dot{K}_{kj} \\
\dot{K}_{kj}
\end{pmatrix}_t
\]
Static Unit TFP

Unit Structure of $i$ - commodity

Intermediate Input

Capital Input

Labor Input

Output

Static Unit TFP ; $T_i$

- Unit Structure
- Structural Change

$A_{ij}, B_{ij}, L_{kj}$

- Aggregation of Industry-base TFP

$$\frac{T_i}{T_i} = \sum_j \frac{P_j X_j}{P^* V} \frac{T_j}{T_j}$$

- Pecuniary Spillover Effects through Static Technological Relationship
Static Unit TFP of Commodity $i$

\[
L_t^* = B^L_t \left\langle (I - A_t)^{-1} e_{(i)} \right\rangle \\
K_t^* = B^K_t \left\langle (I - A_t)^{-1} e_{(i)} \right\rangle
\]

\[
\left( \frac{\dot{T}_i}{T_i} \right)_t = -\sum_j \sum_l p_{i,t}^L \frac{L_{lj}^*}{L_{lj}} \left( \frac{\dot{L}_{lj}}{L_{lj}} \right)_t - \sum_j \sum_k p_{i,t}^K \frac{K_{kj}^*}{K_{kj}} \left( \frac{\dot{K}_{kj}}{K_{kj}} \right)_t
\]
Dynamic Inverse

Static IO Balance: \( A_{ij} X_j + I_{ij} + C_i = X_i \)

Capital Accumulation: \( K_{ij}^{t+1} = (1 - \varpi i) K_{ij}^t + I_{ij} \)

Dynamic IO Balance: \( A_{ij} X_j^t + B_{ij} X_j^{t+1} + C_i = X_i^t \)

- Intermediate Input
- Capital Input
- Labor Input
- Output
Dynamic Unit TFP

Dynamic Unit Structure of \( i \) - commodity

- Decomposition by Dynamic Inverse
- Structural Change

\[ A_{ij}, \ B_{ij}, \ L_{kj}, t=0, \ldots, -\infty \]

- Aggregation of Time-series Static Unit TFP

\[ \frac{T_{i}^{*}}{T_{i}^{0}} = \frac{T_{i}^{0}}{T_{i}^{0}} + \frac{K_{r}^{0}}{P_{V}^{0}} t=-1 \]

- Pecuniary Spillover Effects through Capital Accumulation and Structural Change
Dynamic Unit TFP

\[
\begin{pmatrix} \dot{T} \\ T \end{pmatrix}_t \ D(f_t^*) = \begin{pmatrix} \dot{T} \\ T \end{pmatrix}_t \ U(f_t^*) + \sigma^*_{K,t} \sum_{\tau=1}^{\infty} \Phi^*_{t-\tau} \begin{pmatrix} \dot{T} \\ T \end{pmatrix}_{t-\tau}
\]

and

\[
\begin{pmatrix} \dot{T} \\ T \end{pmatrix}_t \ D(f_t^*) = \begin{pmatrix} \dot{f}_t^* \\ f_t^* \end{pmatrix}_t - \sigma^*_L \begin{pmatrix} \dot{L}_t^* \\ L_t^* \end{pmatrix}_t - \sigma^*_K \sum_{\tau=1}^{\infty} \Phi^*_{t-\tau} \sigma^*_{L,t-\tau} \begin{pmatrix} \dot{L}_t^* \\ L_t^* \end{pmatrix}_{t-\tau}
\]

\[
\Phi^*_{t-\tau} = S_{t-\tau}^* S_{t-\tau+1}^* \left( \frac{(1-\delta)S_{t-\tau+1}^*}{I_{t-\tau+1}^*} + \sigma^*_{K,t-\tau+1} \right)
\]
Dynamic Inverse

Required Output Induced by Motor Vehicle Demand in 1992
Dynamic Inverse
Required Output Induced by Motor Vehicle Demand in 1980

- Motor Vehicle
  - $t=0$
  - Demand as Capital Goods, mainly
    - $t=-1$
    - $t=-2$
    - $t=-3$

- General Machinery
  - $t=0$
  - $t=-1$

- Building & Construction
  - $t=-1$
  - $t=-2$
  - $t=-3$

- Iron & Steel
  - $t=0$

- Electric Machinery
  - $t=0$

- Wholesale & Retail
  - $t=0$

- Other Service
  - $t=0$
  - $t=-1$

- Demand as Intermediate Goods, mainly
Comparison of TFP

Electric Machinery

Composition of $B_{ij}$
Comparison of TFP
Agriculture, Forestry and Fishery

Composition of $B_{ij}$

Industry-base TFP
Static Unit TFP
Dynamic Unit TFP

(1970=1.0)
Comparison of TFP

Motor Vehicle

Composition of $B_{ij}$

Industry-base TFP
Static Unit TFP
Dynamic Unit TFP

(1970=1.0)
Comparison of TFP

: General Machinery

(1970=1.0)

Industry-base TFP
Static Unit TFP
Dynamic Unit TFP

Composition of $B_{ij}$
Comparison of TFP

Aggregated Level


TFP (Industry-base TFP = Static Unit TFP)

Dynamic Unit TFP

Composition of Bij
Contribution to Growth

: Aggregated Level

(Real GDP Growth = 1.0 during 1975-90)
## Contribution to Growth: Aggregated Level

<table>
<thead>
<tr>
<th>Period</th>
<th>L(0)</th>
<th>L(-1)</th>
<th>TFP(0)</th>
<th>TFP(-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-75</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1975-80</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1980-85</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1985-90</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1975-90</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Diagram shows the contribution of different factors to growth at various periods.
Thank you for your attention. If you need more information, please take a contact to the following address.

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