Turn the Tables!
Reframing Measurement of Capital in Japanese National Accounts

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Today’s Topics

Capital: Two Aspects of One Entity
- Concepts of Capital Stock
- Capital Value and Depreciation

Measurement in Japanese National Accounts
- Net, CFC, and Gross

Alternative Measurement
- Price and Quantity of Capital Service
- Aggregating Capital
- Land as a Capital
- Capitalization of Software
- IT Capital and Price Statistics
- Capital Costs for Non-Market Production

Conclusion: Proposals for Reframing
Traditional Concepts of Capital Stock

Gross Capital Stock

Net Capital Stock
Three Concepts of Capital Stock

- Gross Capital Stock
- Net Capital Stock
- Productive Capital Stock

Age-Efficiency Profile

Service

Age-Price Profile

Wealth
Gross Capital Stock

Nominal Investment

\[ I_{t-\tau} \]

\[ A_{t-\tau} \]

Constant-Quality Investment

\[ A_{t-3} \]
\[ A_{t-2} \]
\[ A_{t-1} \]
\[ A_t \]

Gross Capital Stock

\[ S_{t,0}^G = A_t \]
\[ S_{t,1}^G = A_{t-1} \]
\[ S_{t,2}^G = A_{t-2} \]
\[ S_{t,3}^G = A_{t-3} \]
\[ \vdots \]
\[ S_{t,\tau}^G = A_{t-\tau} \]
Productive Capital Stock

Constant Quality Investment

\[
\begin{align*}
A_t &= S^G_{t,0} \\
A_{t-1} &= S^G_{t,1} \\
A_{t-2} &= S^G_{t,2} \\
A_{t-3} &= S^G_{t,3} \\
&\quad \vdots \\
A_{t-\tau} &= S^G_{t, \tau}
\end{align*}
\]

Gross Capital Stock

\[
\begin{align*}
S^G_{t,0} &= At \\
S^G_{t,1} &= d_1 A_{t-1} \\
S^G_{t,2} &= d_2 A_{t-2} \\
S^G_{t,3} &= d_3 A_{t-3} \\
&\quad \vdots \\
S^G_{t, \tau} &= d_\tau A_{t-\tau}
\end{align*}
\]

Productive Capital Stock

\[
\begin{align*}
S^G_{t,0} &= At \\
S^G_{t,1} &= d_1 A_{t-1} \\
S^G_{t,2} &= d_2 A_{t-2} \\
S^G_{t,3} &= d_3 A_{t-3} \\
&\quad \vdots \\
S^G_{t, \tau} &= d_\tau A_{t-\tau}
\end{align*}
\]

\(d_\tau: \) age-efficiency profile
Net Capital Stock

Constant Quality Investment

<table>
<thead>
<tr>
<th>$A_t$</th>
<th>$S_t^G$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{t-1}$</td>
<td>$S_{t,1}^G$</td>
</tr>
<tr>
<td>$A_{t-2}$</td>
<td>$S_{t,2}^G$</td>
</tr>
<tr>
<td>$A_{t-3}$</td>
<td>$S_{t,3}^G$</td>
</tr>
<tr>
<td>\vdots</td>
<td>\vdots</td>
</tr>
<tr>
<td>$A_{t-\tau}$</td>
<td>$S_{t,\tau}^G$</td>
</tr>
</tbody>
</table>

Gross Capital Stock

| $S_{t,0}^G$ | $S_{t,1}^N$ | $S_{t,2}^N$ | $S_{t,3}^N$ | \vdots | $S_{t,\tau}^N$ |

Net Capital Stock

<table>
<thead>
<tr>
<th>$At$</th>
<th>$d_{\tau}^{p}$: age-price profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{t,0}^N$</td>
<td>$At$</td>
</tr>
<tr>
<td>$S_{t,1}^N$</td>
<td>$d_{1}^{p}At_{1}$</td>
</tr>
<tr>
<td>$S_{t,2}^N$</td>
<td>$d_{2}^{p}At_{2}$</td>
</tr>
<tr>
<td>$S_{t,3}^N$</td>
<td>$d_{3}^{p}At_{3}$</td>
</tr>
<tr>
<td>\vdots</td>
<td>\vdots</td>
</tr>
<tr>
<td>$S_{t,\tau}^N$</td>
<td>$d_{\tau}^{p}At_{\tau}$</td>
</tr>
</tbody>
</table>
Order of Magnitudes in Three Capital Stock

\[ S_t^N \leq S_t \leq S_t^G \] under Usual AEP

\[ S_t^N < S_t = S_t^G \] under one-hoss shay

\[ S_t^N = S_t < S_t^G \] under BGA
Age-Efficiency Profile and Age-Price Profile

Discount rate = 0.05,
Average Life $T_{\mu\varepsilon} = 20(\delta = 0.2057)$
Geometric vs Hyperbolic

Geometric
- \( d_\tau = (1-\delta) \tau \)
- AEP and APP are identical
- Simplify Perpetual Inventory Method
  (possible to neglect the age structure for aggregating assets with different ages)
  \( S_t = (1-\delta)S_{t-1} + A_t \)
- The U.S. BEA, the Statistics Canada

Hyperbolic
- \( d_\tau = (T-\tau)/(T-\beta\tau) \)
- More Flexible
  - one-hoss shay in case of \( \beta = 1 \)
  - concave function in case of \( 0 < \beta < 1 \)
  - straight line in case of \( \beta = 0 \)
  - convex function in case of \( \beta < 0 \)
- The U.S. BLS, Australian Bureau of Statistics
Capital Value and Rental Prices

Productive Capital Stock

<table>
<thead>
<tr>
<th>$d_t$</th>
<th>$d_{t+1}$</th>
<th>$d_{t+2}$</th>
<th>$d_{t+3}$</th>
<th>$d_{t+\tau}$</th>
<th>$0$</th>
</tr>
</thead>
</table>

Capital Service Price

- $pK_t$, $pK_{t+1}$, $pK_{t+2}$, $pK_{t+3}$, $pK_{t+\tau}$

$\begin{aligned}
\text{age-price profile: } & pA_t, \\
\text{value of asset with age: } & \tau
\end{aligned}$

$\begin{aligned}
\text{value of new asset: } & pA_t \\
\text{age-price profile: } & d^p_{t, \tau} = \frac{pA_{t, \tau}}{pA_t}
\end{aligned}$
Capital Value and Depreciation

The difference of Value

\[(P_{t-1, \tau} - P_{t, \tau + 1}) = (P_{t, \tau} - P_{t, \tau + 1}) - (P_{t, \tau} - P_{t-1, \tau})\]

\[(P_{t-1, \tau} - P_{t, \tau + 1})\]
: time-series depreciation (Hill, Diewert),
full depreciation (Oliner), economic depreciation and asset inflation (Hulten-Wyckoff)

\[(P_{t, \tau} - P_{t, \tau + 1})\]
: cross-section depreciation (Hill, Diewert), partial depreciation (Oliner), economic depreciation (Hulten-Wyckoff)

\[(P_{t, \tau} - P_{t-1, \tau})\]
: revaluation
BEA’s Revision in 1997

Wealth Account
- Net Capital Stock
  Survival Function + Straight-line for Decay
  → Geometric Distribution as a Default
- Gross Capital Stock
  → No Longer Produced!

Production Account
- Consumption of Fixed Capital
  → Consistent with Stock Measurement
  Time-series Depreciation
  → Cross-section Depreciation
Capital Stock in the Japanese National Accounts

- Gross Capital Stock
- Net Capital Stock
- Productive Capital Stock
- Wealth

Service

GCSPE

JSNA-NCS
Net Capital Stock in the Japanese National Accounts

JSNA-NCS

- Six Tangible Assets
  1) dwellings, 2) other building, 3) other structures, 4) transport equipment, 5) other machinery and equipment, 6) cultivated assets

- One Intangible Assets
  custom software, only

- Depreciation Distribution
  Straight-line for infrastructure
  Geometric for other assets

- Benchmark Year
  1970 National Wealth Survey

- Underestimate?
  30-40 percent lower than our estimates in 2000 due to too-high depreciation rates?
Consumption of Fixed Capital in the Japanese National Accounts

JSNA-CFC

- Prices
  : Based on Historical Prices (Book-Value)
- CFC in the 1993 SNA
  : “Its value may deviate considerably from depreciation as recorded in business accounts or as allowed for taxation purpose, especially when there is inflation” (paragraph 6.179)
Gross Capital Stock in the Japanese National Accounts

GCSPE (Gross Capital Stock of Private Enterprises)

- **Coverage**
  - All assets, except residential owned by company
  - Excluding Non-profit Institution
- **No Assets Classification**
- **No Investment in Current Prices**
- **Overestimate as Production Capacity?**
  - 20 percent higher than our estimates in 2000
Alternative Estimates

Periods

Classification
- 102 Asset Classification by 70 Sectors
  Assets: 90 Tangible Assets, 5 Intangible Assets
  (3 Software, others), 3 Inventories, 4 Types of Land
  Sectors: 45 industries, Government, Household, 23 Infrastructures

Geometric Approach
- \( AEP = APP \)
Price and Quantity of Capital Service

Basic Assumption
- \( K_t^{kj} = \phi^{kj} S_t^{kj} \), \( \phi \) = annualization factor (constant)

Capital Service Prices
- \( P_{K,kj}^t = (r_t - \pi_t^k) P_{A,k}^{t-1} + \delta^k P_{A,k}^t \)
- \( V_{K,j}^t = \sum_k P_{K,kj}^{t-1} K_{t}^{kj} \)
- Endogenous Rate of Return (after tax rate of return on equity) by Industry
- Japanese Tax Structure
  Corporate income tax, business income tax, property tax, acquisition tax, capital consumption allowance, income allowance and reserves, special depreciation, capital gain tax, dividend tax
## Capital Stock and Services in Japan: In Case of Fixed Assets

<table>
<thead>
<tr>
<th>Period</th>
<th>Z</th>
<th>Z*</th>
<th>K</th>
<th>GCSPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-65</td>
<td>9.11</td>
<td>7.80</td>
<td>13.88</td>
<td>&lt; 11.55</td>
</tr>
<tr>
<td>1965-70</td>
<td>10.44</td>
<td>9.53</td>
<td>12.27</td>
<td>&lt; 12.45</td>
</tr>
<tr>
<td>1970-75</td>
<td>9.56</td>
<td>9.25</td>
<td>9.96</td>
<td>&lt; 10.10</td>
</tr>
<tr>
<td>1975-80</td>
<td>6.15</td>
<td>6.18</td>
<td>5.81</td>
<td>&lt; 6.38</td>
</tr>
<tr>
<td>1980-85</td>
<td>4.80</td>
<td>4.69</td>
<td>5.24</td>
<td>&lt; 6.72</td>
</tr>
<tr>
<td>1985-90</td>
<td>5.04</td>
<td>4.87</td>
<td>6.02</td>
<td>&lt; 6.79</td>
</tr>
<tr>
<td>1990-95</td>
<td>4.42</td>
<td>4.40</td>
<td>5.08</td>
<td>&lt; 5.15</td>
</tr>
<tr>
<td>95-2000</td>
<td>2.56</td>
<td>2.60</td>
<td>2.49</td>
<td>&lt; 3.48</td>
</tr>
<tr>
<td>60-2000</td>
<td>6.51</td>
<td>6.16</td>
<td>7.59</td>
<td>&lt; 7.83</td>
</tr>
</tbody>
</table>

Source: Nomura[2004a]
### Capital Stock and Services in Japan: In Case of Total Assets

<table>
<thead>
<tr>
<th>Period</th>
<th>Z</th>
<th>Z*</th>
<th>K</th>
<th>ref: GCSPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-65</td>
<td>4.97</td>
<td>3.64</td>
<td>9.85</td>
<td>&lt;&lt; 11.55</td>
</tr>
<tr>
<td>1965-70</td>
<td>5.94</td>
<td>4.93</td>
<td>9.76</td>
<td>&lt;&lt; 12.45</td>
</tr>
<tr>
<td>1970-75</td>
<td>5.43</td>
<td>5.05</td>
<td>8.17</td>
<td>&lt;&lt; 10.10</td>
</tr>
<tr>
<td>1975-80</td>
<td>3.79</td>
<td>3.57</td>
<td>4.67</td>
<td>&lt;&lt; 6.38</td>
</tr>
<tr>
<td>1980-85</td>
<td>2.73</td>
<td>2.57</td>
<td>3.87</td>
<td>&lt;&lt; 6.72</td>
</tr>
<tr>
<td>1985-90</td>
<td>2.69</td>
<td>2.68</td>
<td>4.94</td>
<td>&lt;&lt; 6.79</td>
</tr>
<tr>
<td>1990-95</td>
<td>2.42</td>
<td>2.52</td>
<td>3.82</td>
<td>&lt;&lt; 5.15</td>
</tr>
<tr>
<td>95-2000</td>
<td>1.74</td>
<td>1.73</td>
<td>2.05</td>
<td>&lt;&lt; 3.48</td>
</tr>
<tr>
<td>60-2000</td>
<td>3.72</td>
<td>3.34</td>
<td>5.89</td>
<td>&lt;&lt; 7.83</td>
</tr>
</tbody>
</table>

Source: Nomura [2004a], GCSPE is defined by fixed assets only.
Land as a Capital

Share of Land to Total Capital Stock in 2000
- 23.6 percent in the U.S. (Jorgenson-Landefeld, 2005)
- 43.5 percent in Japan (Nomura, 2004)

Impacts to TFP
- Canada: Neglecting of land and inventories leads to a decline in average TFP growth rates of 0.1 percent per year during 1963-96 (TFP Growth=0.5-0.6), Diewert-Lawrence (2000)
- Japan: Neglecting of land and inventories leads to a decline in average TFP growth rates of 0.7 percent per year during 1960-2000 (TFP Growth=1.5), Nomura (2004)

Impacts to Relative Prices in 1990 (Nomura, 2004)
- Relative Price of Capital Stock between the U.S. and Japan
  1.31 for fixed assets \(\rightarrow\) 3.05 for total assets
- Relative Price of Capital Services between the U.S. and Japan
  1.36 for fixed assets \(\rightarrow\) 1.70 for total assets
Endogenous Ex-Post RoR

Capitalization of Software

Japanese National Accounts
- Custom Software, only

Benchmark Input-Output Table
- 1995: Custom Software
- 2000: Custom Software, Prepackaged Software

Methodology to Estimate Own-Account Software
- Recommendations by the OECD Task Force on Software Measurement in the National Accounts:
### International Comparison of Software Professionals

<table>
<thead>
<tr>
<th>Year</th>
<th>Share to total employees</th>
<th>ISCO-213</th>
<th>ISCO-312</th>
<th>ISCO-213 / (213+312)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greece</td>
<td>1998</td>
<td>0.2</td>
<td>7444</td>
<td>7196</td>
</tr>
<tr>
<td>Spain</td>
<td>1998</td>
<td>0.3</td>
<td>44026</td>
<td>34107</td>
</tr>
<tr>
<td>France</td>
<td>1998</td>
<td>0.4</td>
<td>196705</td>
<td>99011</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1998</td>
<td>0.9</td>
<td>100765</td>
<td>82144</td>
</tr>
<tr>
<td>U.S.</td>
<td>2000</td>
<td>1.3</td>
<td>1633280</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>1999</td>
<td>1.3</td>
<td>75881</td>
<td>24474</td>
</tr>
<tr>
<td>Japan</td>
<td>2000</td>
<td>1.4</td>
<td>753493</td>
<td>363753</td>
</tr>
</tbody>
</table>

Data: Employee Base, U.S.(Occupational Employment and Wages, BLS), Japan(Population Census, MIC), Others(OECD, Ahmad [2003])
Classification: U.S. SOC-15-1020,30, 50 and J SSCO-06 correspond to ISCO-213
International Comparison of Own-Account Software Investment Share to GDP

Source: Japan (Nomura, 2004), U.S. (BEA), Belgium (Hemans, 2002), others (Ahmad, 2003)
International Comparison of Total Software Investment Share to GDP

- Sweden (1999)
- United States (2000)
- Japan (2000)
- Denmark (1997)
- Australia (1998/99)
- Netherlands (1998)
- Canada (1998)
- Belgium (2000)
- France (1998)
- Italy (1998)
- Spain (1996)
- United Kingdom (1999)
- Finland (1995)

Source: Japan (Nomura, 2004), U.S. (BEA), Belgium (Hemans, 2002), others (Ahmad, 2003)
Composition of Software between the U.S. and Japan

Source: Japan (Nomura, 2004), U.S. (BEA)
IT Capital Contribution Share to Total Capital Service

Source: U.S. (Jorgenson, Ho, Stiroh, 2005), Japan (Author’s Estimate)
Industry Capital Input Contributions in Japan, 1960-1977

Note: Industries sorted by IT Capital contribution
Industry Capital Input Contributions in Japan, 1977-1995

Note: Industries sorted by IT Capital contribution

Note: Industries sorted by productivity growth. Jorgenson-Ho-Stiroh (2005)

Note: Industries sorted by productivity growth.
Comparison of Computer Price at 5-digit SIC between the U.S. and Japan

Price Aggregation at the Most Detailed Item

Price Aggregation in the Most Detailed Item

- BOJ’s CGPI Laspeyres:
  Defined by Carli Price Index
  (Simple Arithmetic Average)
  ESRI uses CGPI Laspeyres at the Most Detailed Level

- BOJ’s CGPI Chained-Las:
  Defined by Jevons Price Index
  (Simple Geometric Average)

- Carli Price Index has an Upward Bias
  (Fisher, Diewert)
Who Extrapolate Prices Backward?

Price Statistics
- BLS-PPI
- BEA-Price
- ESRI

Prices for National Accounts
- BEA-Price
- BOJ-CGPI
- ESRI

U.S.

Japan
Prices for Investment as a Composite Goods

Why the Investment Price for Computer Declines Faster than Producer’s Price in BEA
- Investment Prices Should Be Defined by Purchaser’s Prices

Prices Can be Estimated and Revised Separately
- Investment Goods is Defined by Final Goods
- Embodiment: Software → Computer → Office Building
Capital Service Cost for Non-Market Production

Source: Author’s Estimate
Conclusion: Proposals for Reframing Measurement of Capital in the Japanese National Accounts

(i) Capitalization of Software
(ii) Reframing Net Capital Stock and Consumption of Fixed Capital
(iii) Gross Capital Stock to Productive Capital Stock
(iv) Constant-Quality Prices in Japan
(v) Empirical Studies for AEP and APP in Japan
(vi) Measurement of Price and Quantity of Capital Services
(vii) Land as a Capital
(viii) Capital Service cost for Non-Market Production