How the FAO’s Capital Stock Database can be used for Productivity Analysis

OECD EXPERT WORKSHOP: MEASURING ENVIRONMENTALLY ADJUSTED AGRICULTURAL TOTAL FACTOR PRODUCTIVITY (EATFP) & ITS DETERMINANTS

Sangita Dubey, Statistics Division, FAO

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Outline of Presentation

I. Introduction
II. Methodology
III. Key findings
IV. Issues/Challenges
I INTRODUCTION – THE NEED FOR AN AGRICULTURE CAPITAL STOCK DATABASE

✓ Agricultural Investment a vital driver of productivity and growth, with investment data necessary to monitor trends and inform public policy.

• Investment ↑ ➔ Productivity ↑ ➔ Real Income ↑ ➔ Food Security ↑

• Address Market Failures; Smooth farmer’s incomes

Understanding physical investment in agriculture is essential to productivity analysis.
Strong correlation between the growth in ACS and hunger reduction

Annual rates of ACS growth (1990-2005): best and worst performing countries
Does investment explain regional trends? Agriculture share of GDP now highest in Africa and declining in Asia & Pacific countries ...

*Other Developed includes Australia, Japan and New Zealand*
... though Asia & the Pacific’s contribution to Global Agricultural value-added grew from 35% to 50% between 1970 and 2013.

...while Africa’s contribution remained around 10%
II. Methodology - General Approach to new FAO data

**UNDERLYING PHILOSOPHY:**

*Use frameworks that harmonize data across countries/time*

*Minimize respondent burden, duplication & resource requirements*

- Collaborate with other international organizations to use official country data and existing global databases based on official country data

  *The Agriculture Capital Stock (ACS) database is an ANALYTICAL database providing PROVISIONAL data and indicators.*

- Document data sources, assumptions and underlying methodology in metadata.

- Validate approach & results with country officials and other experts

- Improve data with validated assumptions and new official statistics

Official country data are the backbone of the databases and proposed indicators.
II. Methodology – the old FAOSTAT approach

• Previous methodology for Agricultural Capital Stock (net and gross, 2005 constant prices), covered 1975-2007, and aggregated FAOSTAT data on
  • Land Development
  • Livestock (Fixed Assets) and Livestock (Inventory)
  • Machinery & Equipment
  • Plantation Crops
  • Structures for Livestock

• Its limitations come from the components covered, incorrect methodologies used, and weaknesses in underlying data
II. Methodology – example of asset calculations in the Old FAOSTAT approach

LAND DEVELOPMENT

“Land development = ∑ {(arable land) x (unit price) + (irrigated land) x (unit price)}
Plantation crops = ∑ (land under permanent crop) x (unit price)”

AGRICULTURE MACHINERY

“Machinery and equipment = ∑ {(number of machinery for \textit{i}) x (unit price of machinery for \textit{i}) + (economically active population in agriculture) x US $35)}

Where \textit{i} stands for tractor, harvester & threshers and milking machine. US $ 35 has been taken from 1995 series after adjusting for price rises.”
II. Methodology - Old FAO approach results in much higher or lower GCS and NCS estimates compared to OECD-STAN

Old FAOSTAT/OECD estimates of 2005 GCS and NCS, 2005 Constant USD
II. Methodology – a New FAOSTAT Approach

Old FAO Methodology…

Estimate capital stock using the physical inventory approach, which adds up the sector’s components of produced assets.

Approach evaluated and abandoned:

- **Data quality issues**: low response rates, incomplete data reported by countries, particularly for machinery and equipment.
- **Methodological issues** in the calculation of the components such as land development or machinery equipment's;
- **Limited coverage**: only available for select countries, and only on narrow agriculture sector, excluding forestry and fisheries.

New FAO Methodology…

Estimate capital stock using a national accounts framework, and existing country data where available.

Where unavailable, estimate capital stock using the **PERPETUAL INVENTORY METHOD** with double declining balances:

\[ K_t = K_{t-1} + GFCF_t - D_t \]

Requires assumptions about **initial capital stock** and the **depreciation rate (DR)**.

- OECD: DR = 0.8 (reported data)
- Developing countries: 0.4 < DR < 0.8

Document assumptions.
II. Methodology – a National Accounts based database

• Global database on Agricultural Capital Stock and related structural statistics,
  • Covering 223 countries and territories for 1970-2013, with supporting metadata/documentation

• Industrial Coverage: Total Economy; Agriculture, Forestry & Fishing (AFF), ISIC Rev.3:A+B; Agriculture (Ag) subsector, ISIC Rev.3:01

• Variables
  • Capital Stock related variables: GFCF, Net Capital Stock (NCS), Gross Capital Stock (GCS), Consumption of Fixed Capital (CFC)
  • Other SNA variables: Value-Added¹, Gross Output², Gross Operating Surplus, Net Operating Surplus, Compensation of Employees², Employment²

• Other indicators: Investment Ratio (IR), Agriculture Orientation Index (AOI)

¹ necessary for calculating the investment ratio and capital stock
² supporting variables in the calculation capital stock
II. Methodology - Variables in the new database

<table>
<thead>
<tr>
<th>a) Capital Stock related variables</th>
<th>Total economy</th>
<th>Agriculture, Forestry &amp; Fishery (AFF)</th>
<th>Agriculture (Ag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross fixed capital formation</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Net capital stock</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Gross capital stock</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Consumption of fixed capital</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b) Macro-economic variables not in a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value added¹</td>
</tr>
<tr>
<td>Gross Output²</td>
</tr>
<tr>
<td>Operating surplus, gross</td>
</tr>
<tr>
<td>Operating surplus, net</td>
</tr>
<tr>
<td>Compensation of employees²</td>
</tr>
<tr>
<td>Employment²</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c) Other labour variables (for OECD countries only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages and salaries, N. of employees, Self-employed, Full-time equivalents - total engaged &amp; employees, Hours worked - total engaged &amp; employees</td>
</tr>
</tbody>
</table>

¹ necessary for calculating the investment ratio and capital stock
² supporting variables in the calculation capital stock
³ refers to the Gross Domestic Product (GDP)
II. Methodology – General Approach

1. Data Source: selection varies by country and variable
   - OECD: Structural Analysis database (OECD-STAN), National Accounts Database (OECD-NA)
   - World Input Output Database (WIOD)

2. Data Bridging
   - Bridge across data series within a single data sources
   - Bridge across ISIC revisions 3. and 4.
   - Bridge across data sources
     Note: Bridging was essential to create a long time series for capital stock variables

3. FAO Estimation/imputation
   - Imputation/estimation missing observations in an existing series
   - Estimations of capital stock related variables, and variables required for these estimations (Value-Added, Gross Output)
     Note: No estimation or imputation was conducted for other variables
II Methodology - How data sources were used

• For OECD countries, by order of preference:
  1. OECD: Structural Analysis database (OECD-STAN)
  2. OECD - National Accounts Database (OECD-NA)
  3. UNSD: Official Country Data
  4. World Input Output Database (WIOD)

• For all other countries, by order of preference:
  1. UNSD: Official Country Data
  2. non-OECD countries covered in OECD-STAN and OECD-NA
  3. World Input Output Database (WIOD)
### II Methodology - Use multiple sources as no database offers complete coverage

<table>
<thead>
<tr>
<th>INDUSTRIES COVERED</th>
<th>ISIC Rev 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRICULTURE, FORESTRY, FISHERY</td>
<td>A+B</td>
</tr>
<tr>
<td>AGRICULTURE HUNTING AND RELATED SERVICES</td>
<td>A01</td>
</tr>
</tbody>
</table>

#### UNSD Data Sources

<table>
<thead>
<tr>
<th>I. NATIONAL ACCOUNTS ESTIMATES</th>
<th>No. of countries with data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total economy</td>
</tr>
<tr>
<td>GDP (current and fixed prices, LCU and $)</td>
<td>&gt;200</td>
</tr>
<tr>
<td>GFCF (current and fixed prices, LCU and $)</td>
<td>&gt;200</td>
</tr>
<tr>
<td>GFCF deflator</td>
<td>&gt;200</td>
</tr>
<tr>
<td>GDP/capita (current prices, LCU and $)</td>
<td>&gt;200</td>
</tr>
<tr>
<td>Value added ISIC Rev3: A+B (current and fixed prices, LCU and $)</td>
<td>&gt;200</td>
</tr>
<tr>
<td>Value added deflator</td>
<td>&gt;200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II. OFFICIAL COUNTRY DATA OUTPUT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>148</td>
</tr>
<tr>
<td>Less Intermediate consumption</td>
<td>157</td>
</tr>
<tr>
<td>COMPENSATION OF EMPLOYEES</td>
<td>126</td>
</tr>
<tr>
<td>OPERATING SURPLUS, GROSS</td>
<td>134</td>
</tr>
<tr>
<td>MIXED INCOME, GROSS</td>
<td>25</td>
</tr>
<tr>
<td>Less CONSUMPTION OF FIXED CAPITAL</td>
<td>98</td>
</tr>
<tr>
<td>OPERATING SURPLUS, NET</td>
<td>104</td>
</tr>
<tr>
<td>MIXED INCOME, NET</td>
<td>15</td>
</tr>
<tr>
<td>GROSS FIXED CAPITAL FORMATION</td>
<td>87</td>
</tr>
<tr>
<td>CLOSING STOCK OF FIXED ASSETS</td>
<td>23</td>
</tr>
<tr>
<td>EMPLOYMENT</td>
<td>70</td>
</tr>
</tbody>
</table>

Data for additional countries from STAN, OECD-NA and WIOD
II Methodology - GFCF Estimation/imputation

a. If reported data are available only for a limited number of years:
   the missing years' data are imputed based on data on the most recent, or an average of
   the most recent, available investment ratio (GFCF/VA).

b. If there are no data at all:
   • imputation for GFCF in Ag based on (1) value-added ratio for Ag over AFF to GFCF in AFF;
   • imputation for GFCF in Ag & GFCF in AFF are based on (2) regression equations (linear and
     logarithmic) in which the endogenous variable is the investment ratio and the
     exogenous variable GDP/capita.

VA/EMPL not used as regressor as many employment series missing or of dubious quality.

Parameters of the equation estimated based on countries from which data are available.
The $R^2$ value of the regressions vary between 0.9 (logarithmic regression for middle and
high income countries) and 0.74 (linear regression for low income countries).

When reported country data on CFC are available these are used for estimating GFCF, when
the latter are missing, as the averages of CFC and GFCF over a medium term period are
normally of the same magnitude.
## II Methodology - FAO Estimation/imputation

### b) Macro-economic variables not in a)

<table>
<thead>
<tr>
<th></th>
<th>Agriculture, Forestry &amp; Fishery (AFF)</th>
<th>Agriculture (Ag)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value added</strong></td>
<td>Missing data are replaced by bridged data of Value Added, UNSD-NAE. If there are no Official Country Data at all then the UNSD-NAE have been used.</td>
<td>Missing data are replaced by bridged data of Value Added, UNSD-NAE from those years when data are available. If there are no Official Country Data at all, then the whole data series are imputed, using UNSD-NAE for Agriculture, forestry, fishery (ISIC Rev.3:A+B) as the basis and then multiply by the value-added ratio of Agriculture (ISIC Rev.3:01) over Agriculture, forestry, fishery (ISIC Rev.3:A+B) for neighbouring countries with the same level of economic development and structure. What is meant by this? What variable(s) are used with what thresholds?</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>Missing data in country series of Gross Output, Official Country Data, are imputed using the ratio of Gross Output/Value Added of adjacent years. In case the data series are empty then Gross Output is estimated using the ratio of Gross Output/Value Added for neighbouring countries with the same level of economic development. What is meant by this? What variable(s) are used with what thresholds?</td>
<td>Missing data points in country series of Gross Output, Official Country Data, are imputed using the ratio of Gross Output/Value Added of adjacent years. How is growth adjustment made? Is there a different approach for missing data between official data years, and start and end of series? In case the data series are empty then Gross Output is estimated using the ratio of Gross Output/Value Added for neighbouring countries, with the same level of economic development and structure, applied to available data on Value added, National Accounts Estimates for Agriculture, forestry, fishery (ISIC Rev.3: A+B)</td>
</tr>
</tbody>
</table>
II Methodology – Capital Stock Estimation

Data on Net Capital Stock (NCS), Gross Capital Stock (GCS) and Consumption of Fixed Capital (CFC) is available only for a limited number of countries (mainly OECD countries).

For all other countries data have been calculated by FAO using the **Double Declining Balance Method**.

In applying this method, assumption were made of depreciation rates which range from 0.03 to 0.08 depending on the economic level of the countries.

There is **large degree of arbitrary judgements in applying these depreciation rates**. Hence, data should be interpreted with great care as they only might give an order of magnitude and not information about the exact level.
II Methodology - Components of the agriculture capital stock of fixed assets

Share of equipment and structures in NCS and GFCF in the USA

- Equipment-NCS
- Structures-NCS
- Equipment-Inv
- Structures-Inv
II – Calculation of capital stock measures

Double-declining balance method (proposed by the OECD Capital Stock Manual, the SNA 2008 and BEA)

\[ W^t_E = W^t_B + I^t - \delta \left( \frac{I^t}{2} + W^t_B \right) = I^t \left( 1 - \frac{\delta}{2} \right) + W^t_B \left( 1 - \delta \right) \]

Where

- \( W^t_E \) and \( W^t_B \) are the end-year and beginning-of-the-year net capital stocks,
- \( I^t \) is gross fixed capital formation,
- \( \delta \left( \frac{I^t}{2} + W^t_B \right) \) is consumption of fixed capital,
- \( \delta \) is the depreciation rate
- \( \delta = R / T^A \) where \( T^A \) is average service life of asset, and \( R \) is a parameter around 2.
II – Estimating Initial stocks

A starting stock for some period $t_0$ has to be computed

- Using capital survey information or
- Estimate for the long-run growth rate of volume investment when geometric age-efficiency or age-price profiles apply net stock at the beginning of the benchmark year $t_0$ can approximated by

$$W^{t_0} = \frac{I^{t_0}}{(\delta + \Theta)}$$

$\Theta$ = the long-run growth rate of volume GDP, or in our case, value added in agriculture
Agriculture, forestry and fishery GFCF in 2013 estimated at $363 billion globally (2005 USD), up 5% from 2012 and 50% from 2000.

Asia showed highest level of agricultural investment in 2013, with GFCF of $131 billion (2005 USD) in 2013, surpassing Europe which led until 2008.

Note: Analysis begins in 2000 due to missing or unreliable data for many countries prior to 2000.
GFCF share of Value Added in Agriculture, forestry and fishery by region, constant 2005 USD, 2000-2013

*Other Developed includes Australia, Japan and New Zealand
In developed countries, the GFCF Agriculture Orientation Index (AOI) usually exceeds 1, indicating a higher level of investment in AFF relative to its share of the economy.

Developing countries have a GFCF Agriculture Orientation Index (AOI) less than 1, indicating a lower share of agricultural investment relative to its economic share.
III. Key Findings (4) – Agricultural Capital Stock: Largest global shares of Agriculture capital are in Europe and in Asia & the Pacific.

Capital Stock by Region, USD billions, constant 2005 prices

- Europe
- Asia & Pacific
- Northern America
- Other Developed
- Africa
- Latin America & Caribbean
What is the implication of assumptions on:

- Depreciation rates for different groups of countries
- Assumed growth rates for the initial capital stock
- Deflators
- Imputations when there are missing data and when there are no data at all
- Stability of bridging data series (Rev 4 to Rev 3 and between different sources)
- How to get reliable data on GFCF in agriculture machinery (the instability of COMTRADE and PRODCOM data)
The fact that a large amount of data on GFCF is imputed or estimated is not the only weakness of the database.

Another weakness is that we have no information on how large share of GFCF is *machinery* and how large share is *structures*.

Assessing and addressing these weakness is a key next step, and where possible, obtaining official country data/estimates and improving our assumptions.

Developing and evaluating productivity indicators is also key next step in providing relevant statistics.
For more information, questions, or suggestions, please contact:

Sangita Dubey, Senior Statistician responsible for Economic Statistics ([Sangita.Dubey@fao.org](mailto:Sangita.Dubey@fao.org))

Ms. Marie Vander Donckt, National Accountant ([Marie.Vanderdonckt@fao.org](mailto:Marie.Vanderdonckt@fao.org))