FAO’s new macroeconomic statistics: Agricultural Capital Stock and Agro-Industry Measurement

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Outline of Presentation

I. Introduction/Motivation
II. Methodology
III. Preliminary findings
IV. Next Steps
Agriculture’s share of GDP continues to decline in Asia & Pacific countries, already down from 25% to 8% in 45 years

Figure 1: Agriculture Share of GDP by region, 1970-2014

- Africa
- Asia & Pacific
- Europe
- Latin America & Caribbean
- Northern America
- Other Developed
... this co-exists with the region’s growing share of Global Agriculture value-added, which rose from 35% to 50% from 1970 to 2014

Is this explained by differences in investment in capital?
In the agriculture value-chain, food processing rises relative to agriculture as GDP per capita rises.

GDP PER CAPITA (2005 USD) AGAINST RELATIVE SIZE OF FOOD PROCESSING AND BEVERAGE VS. AGRICULTURE, CROSS-COUNTRY, 1990-2013

(*) OECD & BRIC countries, Bulgaria, Taiwan, Cyprus, Indonesia, Latvia, Lithuania, Malta, Romania. For each country, 5-years averages.
## 1. Introduction – some key policy questions

- Given increasingly complexity and inter-relationship of industrial sectors, what is the overall economic impact of the Agricultural sector (ISIC Rev 4. Sec. A)?
- What are the limitations in using value-added contribution to GDP to answer the above? Should we use a value-chain notion?
- If so, how do we define and measure the agricultural value-chain, and how does it evolve over the development cycle?
  - How does Agriculture link to other industries, such as fertilizer production, food processing, manufacturing, transportation, wholesale and retail distribution?
  - How does Agriculture generate jobs and value-addition in downstream industries?
- What level of investment in agriculture is necessary to alleviate rural poverty and hunger?
- What types of investment are the most effective in raising real incomes and productivity of rural inhabitants and agricultural producers? What is the role of agricultural capital?
- To measure capital’s contribution to productivity, how do we determine the levels of investment in agricultural capital across countries and time?
  - What is the level of agricultural capital stock and capital investment (GFCF)?
  - How does it impact agricultural productivity, value-added, food-security and real incomes?
I. Introduction

To help answer these questions and meet the growing need for consistent statistics to measure the agricultural value-chain and the role of capital in agricultural production and productivity, FAO’s Statistics Division (ESS) began construction of **GLOBAL MACROECONOMIC STATISTICS** databases on:

- **Agricultural Capital Stock (CS) and Related Structural Statistics**
- **Agro-Industry Measurement (AIM) (jointly with UNIDO)**
Agriculture, forestry and fishery GFCF in 2013 estimated at $363 billion globally (2005 USD), up 5% from 2012 and 50% from 2000.

Asia & Pacific showed highest recent levels of agricultural investment - $131 billion 2005 USD in 2013 - passing Europe, which led till 2008.

Note: Analysis begins in 2000 due to missing or unreliable data for many countries prior to 2000.
II. Methodology - General Approach

UNDERLYING PHILOSOPHY:

Use National Accounts (NA) framework to 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 AIM and Agriculture Capital Stock (ACS) databases are analytical databases providing provisional data and indicators.*

- Document data sources, assumptions and underlying methodology in metadata, to enable feedback and improvements

Minimize burden and duplication, maximize coherence and consistency
II. Methodology - Challenges

- **WHAT DATA SOURCES SHOULD WE USE?**
  - Existing International Databases
- **HOW DO WE ENSURE CONSISTENT MEASUREMENT ACROSS DATA BASES?**
  - Use a National Accounts Framework
- **HOW DO WE TAKE INTO ACCOUNT DIFFERENT DATA VINTAGES? THAT IS, HOW DO WE DEVELOP LONG TIME SERIES GIVEN CHANGES IN ISIC REVISIONS AND SNA VERSIONS?**
  - Bridge data across series for key variables (Value-Added, GFCF, Gross Output)
- **HOW DO WE ESTIMATE CAPITAL STOCK?**
  - Perpetual Inventory Method (PIMs),
    - with ‘best guess’ on depreciation rates
- **HOW DO WE DEFINE THE AGRICULTURE VALUE CHAIN, OR THE AGRO-INDUSTRY (A QUESTION ASKED MY COUNTRIES)?**
  - Start with the food processing sector of manufacturing
- **HOW DO WE IMPUTE MISSING DATA**
  - FOR MISSING YEARS?
  - FOR MISSING SERIES?
  - Evaluate alternative methods applied to shares not levels (cold deck imputation/projection; linear regression; ARIMAX)
II. Methodology - General Approach, National Accounts Framework

Identify and bridge data across sources.
- OECD: STAN and NA databases
- WIOD: Socioeconomic accounts; World KLEMS
- UNIDO: INDSTAT databases

Create complete time series scaled to National Accounts
- Use official country data where possible
- **Focus on key variables**
- Impute missing values in existing series
- Impute missing series where possible
- Disaggregate by industry sub-sector, where possible

Calculate relevant indicators
- Share indicators: VA share of GDP; sector share of industry (FBT share of Manufacturing; Agriculture share of Agriculture-Forestry-Fishing)
- Other: Investment ratios (GFCF share of VA), Agriculture-orientation index (AOI)
II. Methodology - Database Content & Coverage

Variables, LCU & USD
- Value-added
- Gross Output
- Employment, Compensation of Employees (wages & salaries)
- Capital Stock and Capital Formation, etc. (for CS database)
- Include trade variables (exports, imports) and GFCF in AIM database?

Sector Coverage
- Agriculture, Forestry and Fisheries (ISIC Rev 3 A+B)
- Agriculture
- Manufacturing, and Food, Beverage & Tobacco (FBT) Processing
- Extend to forestry and fisheries; other agro-based manufacturing; disaggregate FBT by commodity?

Geographic & Time coverage
- 220+ countries for capital stock database
- 46 initial countries (OECD, BRICS+) in AIM database
- 1970-2014 for CS data
- 1990-2014 for AIM data
- Extend to developing countries reporting data to UNIDO?
II. Methodology - Agricultural Capital Stock (ACS)

Old FAOSTAT Methodology...

Estimate capital stock using the physical inventory approach, which adds up the sector’s components of produced assets: machinery & equipment, livestock, orchards, land improvements.

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 components such as land development or machinery and equipment;
- **Limited country coverage**: only for select countries, and only on narrow agriculture sector, excluding forestry and fisheries.

New FAOSTAT Methodology...

Use existing country data where available.

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

\[
K_t = K_{t-1} + I_t - \text{Depreciation}_t
\]

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

- OECD: DR = 0.08 (reported data)
- Developing countries: 0.04 < DR < 0.08 (estimate)
## II. Methodology - Agricultural Capital Stock (ACS) – data availability in UN-AMA and UN-OCD databases

<table>
<thead>
<tr>
<th>INDUSTRIES COVERED</th>
<th>ISIC Rev 3</th>
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<tbody>
<tr>
<td>AGRICULTURE, FORESTRY, FISHERY</td>
<td>A+B</td>
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<tr>
<td>AGRICULTURE HUNTING AND RELATED SERVICES</td>
<td>A01</td>
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<thead>
<tr>
<th></th>
<th>No. of countries with data</th>
<th>Total economy</th>
<th>A+B</th>
<th>A01</th>
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<tbody>
<tr>
<td>I. NA MAIN AGGREGATES (UNSD AMA)</td>
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<td>&gt;200</td>
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<tr>
<td>GDP (current and fixed prices, LCU and $)</td>
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<td>GFCF (current and fixed prices, LCU and $)</td>
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<td>GFCF deflator</td>
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<td>GDP/capita (current prices, LCU and $)</td>
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<td>Value added ISIC Rev3: A+B (current and fixed prices, LCU and $)</td>
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<tr>
<td>Value added deflator</td>
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<td>II. OFFICIAL COUNTRY DATA (UNSD-OCD)</td>
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<td>OUTPUT</td>
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<tr>
<td>VALUE ADDED, GROSS</td>
<td></td>
<td>Less Intermediate consumption</td>
<td>157</td>
<td>105</td>
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<tr>
<td>COMPENSATION OF EMPLOYEES</td>
<td></td>
<td>126</td>
<td>81</td>
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<tr>
<td>OPERATING SURPLUS, GROSS</td>
<td></td>
<td>134</td>
<td>78</td>
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<tr>
<td>MIXED INCOME, GROSS</td>
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<tr>
<td>Less CONSUMPTION OF FIXED CAPITAL</td>
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<tr>
<td>OPERATING SURPLUS, NET</td>
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<td>MIXED INCOME, NET</td>
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<tr>
<td>GROSS FIXED CAPITAL FORMATION</td>
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<td>CLOSING STOCK OF FIXED ASSETS</td>
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<td>23</td>
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<tr>
<td>EMPLOYMENT</td>
<td></td>
<td>70</td>
<td>50</td>
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Data for additional countries from STAN, OECD-NA and WIOD
II. Methodology- Calculation of capital stock

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

\[
K_t = K_{t-1} + GFCF_t - \delta \left( \frac{I_t}{2} + K_{t-1} \right) = GFCF_t \left( 1 - \frac{\delta}{2} \right) + K_{t-1} \left( 1 - \delta \right)
\]

- \( K_t \) is net capital stock at end of period \( t \),
- \( GFCF_t \) is gross fixed capital formation in period \( t \),
- \( \delta \left( \frac{I_t}{2} + K_{t-1} \right) \) is consumption of fixed capital, or total depreciation,
- \( \delta \) is the depreciation rate
- \( \delta = \frac{R}{T^A} \) where \( T^A \) is average service life of asset, and \( R \) is a parameter around 2.

Note: Structures, and Machinery & Equipment, are two of the largest components of agricultural capital stock, with service lives that vary (likely also across countries), so getting better data on their service lives improved depreciation estimates.
II. Methodology- Imputing GFCF (partially missing series)

• Impute first the Agriculture Investment Ratio (AIR=GFCF/VA) using ARIMAX models (ARIMA with exogenous variables), and use this to estimate GFCF (for Agriculture).

• Use R or STATA script that automates the following, allowing for rapid update/testing:

  1. Load country-specific data and generate any useful transformation of the basic variable (e.g. log-transformation, first difference,...)
  2. Built loops to test the best prediction model based on the minimization of the BIC criteria: loop tests 144 model combinations defined along two broad dimensions: (i) parameter values of the ARIMA(p,d,q) and a set of predictors (diff_log_gdp_pc_USD2005, diff_gdp_per capita, inv_ratio_toteconomy and diff_inv_ratio_toteconomy, etc.)
  3. After selection of the country-specific preferred model, estimate and conduct one-step ahead prediction
  4. Graph predicted against observed value to allow for graphical visualization of prediction
  5. Store results and best model parameters values

countries for which no imputation was performed can be due to either existence of a full data series (e.g. Belgium, USA, Italy, etc.) or because the model cannot be applied because of too few observations and/or observation too erratic.
II. Methodology- Imputing GFCF (fully missing series)

- Impute first the Agriculture Investment Ratio (AIR=GFCF/VA), and use this to estimate GFCF (for Agriculture).

Model selection:
- Potential predictors: log of GDP per capita; log of real GDP (measured in 2005 USD); trade openness index in agriculture; the total economy investment ratio; annual GDP growth rate; total population; VA in agriculture as a share of GDP.
- Countries divided into two sets: low income countries and middle- and high-income countries (separation criterion set at 10,000 USD of GDP per capita, 2011 value)
- Best models for each set selected based on step-wise regression and the leaps-and-bounds algorithm (Furnival and Wilson, 1974).

Regression method:
- Once the benchmark model selected, different regression methods were assessed: pooled OLS, panel fixed-effects (FE); and panel random-effects (RE).
- The FE method was selected based sensitivity analysis and MSE based evaluation
Motivation:

• Assess agriculture’s contribution to the economy.

Definition Issue

• The agriculture value chain, at its most extensive, involves all economic activities in the production and distribution of products that originate from or are used in the production of agriculture output: from Farm-to-Fork

• But no clear statistical definition exists, resulting in confusion between agro-industry, agro-food, agro-business, concepts

AIM database methodology

✓ Start with food-processing sector for select countries; develop complete time series of key variables for select countries, based on UNIDO data and NA framework.

✓ Validate approach, then expand coverage to other countries

• Prioritize other expansions:
  • Expand variables (GFCF, trade)
  • Disaggregate food-processing sector
  • Include other relevant manufacturing sectors (e.g. textiles, furniture manufacturing) that use agro inputs
  • Statistically define “Agro-industry”
II. Methodology – AIM Coverage

For the AIM project, we focused attention first on the *food-processing industry*

AIM project narrower in reach than

- *Agro-food supply chain* (as excludes activities further along the chain as transportation, storage, distribution...)
- *Agro-industry supply chain* as excludes agro-supply chain emanating from non-food agricultural products
II. Methodology – AIM Coverage

Activity coverage to start:

✓ Manufacturing (ISIC Rev. 4, C_10t33)
  ✓ Manufacture of food products, beverages & tobacco products (ISIC Rev. 4, C_10t12)
    ✓ Manufacture of food products (ISIC Rev. 4, C_10)
    ✓ Manufacture of beverages (ISIC Rev. 4, C_11)
    ✓ Manufacture of tobacco products (ISIC Rev. 4, C_12)

Selected indicators: Output, Value Added, Compensation of Employees, Employment (with gender dimension), and eventually GFCF

International comparability: LCU, constant LCU, USD and 2005 USD. As for now, only series in LCU have been treated.

Time coverage: 1990 up to Year-2 (e.g. 2013 in 2015).
II. AIM - Methodological Strategy

- Industrial Business Survey (BS) series available at higher disaggregation levels (up to 4 digits of ISIC)
- Yet, level difference between NA and IBS series
- Compile composition ratio in order to rescale INDSTAT2 series to NA series (e.g. FBT as share of Manufacturing)
III. Findings – Agricultural Capital Stock: Largest global shares of Agriculture capital are in Europe and in Asia & the Pacific
III. Findings: food processing share of GDP rises, relative to agriculture share, along the development cycle

Contribution of Agriculture (blue) and Food Processing (red) to GDP

France, 1990-2013

Spain, 1990-2013

Brazil, 1990-2013

China, 1995-2013
III. Findings – AIM: Agriculture and food processing share of GDP vary by level of economic development

Contribution of Agriculture (blue) and Food Processing (red) to GDP

Australia, 1990-2013

India, 1990-2012

Japan, 1990-2013

New Zealand, 1990-2012
III. Findings – AIM: food processing in developed countries is relatively income inelastic

EXAMPLE OF COMPOSITION EFFECT - THE 2008-2010 ECONOMIC CRISIS

Manufacturing as a share of Total Economy, Right-axis

FB as a share of Manufacturing, Left-axis

(*) Cross-country weighted shares along the time dimension
III. Findings – AIR & IRs across country sets

<table>
<thead>
<tr>
<th>(all years)</th>
<th>All countries</th>
<th>Low income countries</th>
<th>Middle- and high-income countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. AIR</td>
<td>0.214</td>
<td>0.109</td>
<td>0.255</td>
</tr>
<tr>
<td>Avg. Overall IR</td>
<td>0.231</td>
<td>0.222</td>
<td>0.235</td>
</tr>
</tbody>
</table>

- Underinvestment in Agriculture in low income countries both relative to total investment ratios, and agricultural investment in middle- and high-income countries
IV. Next Steps

• Publish AIM and CS databases in FAOSTAT, with detailed methodology notes, for feedback and review. Ensure users are aware these are analytical databases.

• Obtain, where possible, country estimates of agricultural capital stock (Rev 4 A/Rev 3. Div A+B, and Agriculture sub-sector)

• Obtain, where possible, more robust national depreciation rates, service lives, etc.

• Determine priority next steps for expansion of AIM

• Develop, with countries, proposed definition and classification of the “Agro-industry”
Expert Group on International Statistical Classifications

“central coordination body for the current and future work on classifications that are the responsibility of the UN Statistics Division, and for the coordination and review of other classifications that are the responsibility of other international organizations and that have been proposed for adoption by the Statistical Commission”

• led by UN Statistics Division
• Members: IOs, ROs, countries
• regularly reports to the UNSC
• meets every two years (next meeting in 2017)
• technical sub-groups may meet more often or be in contact by emails, conference calls etc.

Definition of agro-industry has been on the agenda of the EG in the past in the framework of ISIC revision - No common position for standard definition was reached
AGRICULTURE, FISHERY & FORESTRY (farm/holding)

agro-food ind.

MANUFACTURING (establishment)
Production and processing of products other than food
definition #3

AGRICULTURE, FISHERY & FORESTRY (farm/holding)

MANUFACTURING (establishment)

Wholesale & retail

agro-food ind.

Production and processing of products other than food
definition #4

AGRICULTURE, FISHERY & FORESTRY (farm/holding)

MANUFACTURING (establishment)

agro-food ind.

Whole sale & retail + other activities (construction, tourism, R&D, education, etc.)

Production and processing of products other than food
For more information, questions, or suggestions, please contact:

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