Accounting for Growth in Global Agriculture

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20th Century: Growing agricultural abundance despite population growth due to productivity gains

21st Century: Is productivity growth slowing down?

Source: ERS
Rate of growth in cereal crop yield has slowed

The pace of improvement has slowed steadily...
Annual % change in crop yield

Annual average productivity growth (%)
1970-90 2.0%
1990-2007 1.1%
2007-14 forecast 0.8%

Toward a more complete assessment of productivity growth: **Total factor productivity**

- TFP growth
  - technical change
  - allocative efficiency

- Yield growth

- Area growth

- Input intensification

- Research
- Extension & education
- Institutions
- Markets
- Price & trade policies
- Infrastructure

Real output growth
Measuring national and global ag TFP growth

- Previous studies: Malmquist Distance function
  - Uses only input and output *quantity* data
  - Results sensitive to data quality & dimensionality issue
  - Inconclusive findings on rate of global ag TFP growth

- ERS approach: use Solow-type growth accounting method
  - TFP growth is difference between output growth and input growth

\[
\Delta TFP = \sum_{i}^{N} r_i \Delta Y_i - \sum_{j}^{M} s_j \Delta X_j
\]

  - Only compare TFP *growth*, not TFP *levels*, among countries and regions
  - Tornqvist-Thiel index adjusts revenue and cost shares to account for changing composition of outputs and inputs
Empirical implementation

• Output: FAO Gross Agricultural Output series to create Output Index
  – Aggregates 190 crop and livestock farm outputs using fixed global prices from 2004-2006

• Input: aggregate FAO input quantities to create Input Index using cost shares from published studies
  – Cost shares vary over time (if observed)
  – If not available, assign cost share from “similar” country
Observations on agricultural cost shares and their application to regions

The views expressed are those of the author(s) and should not be attributed to the Economic Research Service or USDA.
Congruence of input cost shares - use of modern inputs increases with development
Constructing an input index

Growth rate of aggregate input is the weighted average of growth in Land, Labor, Capital and Materials, where weights are their (fixed or varying) cost shares.
Constructing an input index from FAO input data

- **Inputs**
  - Land (rainfed cropland equivalents)
  - Labor (number of workers)
  - Farm-supplied Capital
  - Purchased Capital
  - Crop Materials
  - Livestock Materials

  - Rainfed cropland (weight: 1.00)
  - Irrigated cropland (weight: 1-3)
  - Permanent Pasture (weight: 0.05-0.09)
  - Livestock (animal units)
  - Machinery (horsepower) (& energy)
  - Fertilizers (& seed, chemicals)
  - Feed (DM, Mcal, CP)

- Tractors (4wh & 2wh)
- Harvester-threshers
Feed Use Rising Faster than Livestock Population

- rations include higher proportion of protein

Growth in Global Animal Feed

Source: ERS
Quality-adjusting agricultural land
-use different weights for irrigated, rainfed cropland and permanent pasture
How good is this method?

- Limitations
  - Cost shares extrapolated from countries to region
  - Global average, not local, prices used for output
  - Not all inputs directly measured (seed, pesticide, energy)

- Country studies constructing Tornqvist-Thiel productivity indexes use more detailed and complete input and output quantity and price data

- Country studies may also quality-adjust inputs (e.g., ERS quality-adjusts labor, land, chemical, machinery inputs in measuring US ag TFP)

- Comparing ERS TFP indexes against country- or region-specific studies serves as a check on this approach
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Real output growth
Agricultural growth accounting: declining input and rising TFP

Source: ERS
Patterns of agricultural growth vary widely across global economy

Industrialized market economies:
TFP enables output to grow even as resources leave sector

Developing countries:
TFP becoming an important source of growth

Source: ERS
Patterns of agricultural growth vary widely across global economy

Transition economies:
Little evidence of long-term TFP growth

Source: ERS
Long-run average agricultural TFP growth, 1961-2010

Average annual TFP growth

- > 2%
- 1-2%
- < 1%

Circled regions show persistently low TFP growth

Source: ERS
Agricultural TFP growth has spread more widely, but remains uneven across countries.
Agricultural TFP growth varies even within countries

Source: Fuglie, Wang, Ball (2012)
What about the **drivers** of TFP growth?

Yield growth

Area growth

Input intensification

- Technical change
- Allocative efficiency

**Area growth**

**TFP growth**

**Institutions**

- Research
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**Markets**

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**Infrastructure**

Real output growth
National indexes of “technology capital” strongly associated with agricultural TFP growth

Evidence from 90 developing countries over 1970-2010

Source: Evenson & Fuglie
Some conclusions

• Global agricultural TFP growth not slowing but accelerating
  – Led by large developing countries (China, Brazil)
  – Rise in global food prices due primarily to other factors (demand and input price shocks)

• ‘Technology capital’ is major driver of long-run TFP growth
  – Evidence strong except for sub-Saharan Africa
  – Enabling environment for innovation also important

• Resource degradation may offset TFP
  – Water constraints
  – Climate change