Measuring industry productivity and cross-country convergence

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SEM Conference, July 22–24, Paris
Motivation

• Analysis of productivity convergence is of interest (Barro, 2012; Rodrik, 2013; Aghion et al., 2014), ...

• ... yet suffers from inadequate methods & data
  – Simultaneous cross-country/over-time setting
  – Accounting for outputs & all inputs
This paper

- New method for cross-country/over-time industry productivity measurement
  - Combination of Caves, Christensen & Diewert (1982) and Diewert & Morrison (1986)
This paper

- Illustration to convergence across 38 economies, 17 years and 2 sectors
  - Faster convergence in traded than non-traded sector
  - Extends literature on Harrod-Balassa-Samuelson to convergence setting
Value added function

\[
g^i(p, x) \equiv \max_y \left\{ \sum_{m=1}^{M} p_m y_m : (y, x) \in S^i \right\}; \; i = 1, \ldots, I
\]

- A set of \( M \) net outputs \( y \), primary inputs \( x \), output prices \( p \), and \( S^i \) the feasible production set for industry \( i \)
- Assumptions: competitive price takers, CRS, and homogeneity within each industry and assume translog functional form
- Follows Diewert & Morrison (1986)
Information requirement

- Value of net output $v_{ktm}$ ($K$ countries, $T$ years)
- Price of net output $p_{ktm}$
- Value of primary input $V_{ktn}$ ($N$ primary inputs)
- Prices of primary inputs $w_{ktn}$
- Values in current national prices, prices that are comparable across countries and years
Output prices

- Given the translog value added function and given the required data:
  \[ P_{kt/Js} \equiv P_T(p_{js}, p_{kt}, y_{js}, y_{kt}) = \exp \left[ \sum_{m=1}^{M} \frac{1}{2} (s_{jsm} + s_{kmt}) \ln(p_{kmt}/p_{jsm}) \right] \]

- Output quantity index as ratio of the value index \( v_{kt}/v_{js} \) and price index
Numeraire independence

• With multiple countries and years, the price index $P_{kt/hs}$ is not independent of the base country & year

• Solution (following Caves et al. 1982): average over all possible choices of $j$ and $s$:

$$P_{kt*} = \left[ \prod_{j=1}^{K} \prod_{s=1}^{T} P_{kt/hs} \right]^{1/KT} = \sum_{m=1}^{M} \frac{1}{2} (s_{..m} + s_{ktn}) \ln \left( \frac{p_{ktn}}{p_{..m}} \right)$$

Where $s_{..m}$ is the average net output share and $p_{..m}$ the average price, across all countries and years
Factor inputs

• Analogous logic, but aggregation of quantities, not prices:

\[
X_{kt/Js} \equiv Q_T(w_{js}, w_{kt}, x_{js}, x_{kt})
\]

\[
= \exp \left[ \sum_{n=1}^{N} \frac{1}{2} (S_{jsn} + S_{ktn}) \ln \left( \frac{x_{ktn}}{x_{jsn}} \right) \right]
\]

\[
X_{kt*} \equiv \left[ \prod_{j=1}^{K} \prod_{t=1}^{T} X_{kt/Js} \right]^{1/KT} = \sum_{n=1}^{N} \frac{1}{2} (S_{..n} + S_{ktn}) \ln \left( \frac{x_{ktn}}{x_{..n}} \right)
\]
Productivity

- Relative output divided by relative inputs:
  \[ \Gamma_{kt/js} \equiv \frac{Y_{kt/js}}{X_{kt/js}} \]

- Multilateral productivity index:
  \[ \Gamma_{kt} \equiv \frac{[Y_{kt*}/X_{kt*}]}{[Y_{11*}/X_{11*}]} = \frac{Y_{kt}}{X_{kt}} \]
Convergence

1. ‘World’ efficiency

\[ E_t = \frac{\Gamma_t}{\Gamma_{t,\text{max}}} , \]

where \( \Gamma_t \equiv \frac{\sum_{k=1}^{K} Y_{kt}}{\sum_{k=1}^{K} X_{kt}} \)

- Efficiency measure in the tradition of Debreu (1951) and Farell (1957)
- Fits with the ‘distance to the frontier’/Schumpeterian literature (Aghion et al., 2014).
2. Cross-country dispersion

\[ \sigma_t \equiv \left[ \sum_{k=1}^{K} \omega_{kt} \ln \left( \frac{\Gamma_{kt}}{\Gamma_t} \right)^2 \right]^{1/2} \]

where \( \omega_{kt} = \frac{X_{kt}}{\sum_{k=1}^{K} X_{kt}} \)

- Measure of \( \sigma \)-convergence, see Lichtenberg (1994) and Barro (2012)
- Productivity counterpart of cross-country income inequality (e.g. Milanovic, 2012).
Data

- Value of net outputs and primary inputs from WIOD Supply/Use Tables and Socio-Economic Accounts (in current prices, national currencies)

- Net output prices: ICP PPPs matched to commodities; interpolated (Diewert, 2014) and extrapolated.

- Primary input prices: wages by skill type, gross rental price (à la Dennison)

- Traded (agriculture, mining, manufacturing) vs. non-traded (utilities, construction, market services) sector
World efficiency

Non-traded sector

Market sector

Traded sector

1995 2000 2005 2010
Cross-country dispersion

- Traded sector
- Market sector
- Non-traded sector

Concluding remarks

- Has productivity converged?
  - This paper provides the method to answer this question
  - Aggregate productivity convergence is driven by China & India through increasing weight (world efficiency) and productivity growth (dispersion)
  - Faster convergence in traded than in non-traded sector