Convergence in Agricultural Productivity in the EU

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Grigorios Emvalomatis
Alfons Oude Lansink
Spiro E. Stefanou

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Treaty of Rome: two of the main objectives of the CAP are:

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Background & Motivation
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- The two objectives are related to the concept of productivity
  - agricultural productivity $\rightarrow$ Total Factor Productivity (TFP)
  - fair standard of living $\rightarrow$ farm income/labor productivity
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- Common market and convergence in productivity:
  - “the main reason for divergent trends in cost competitiveness across countries is differences in productivity growth rates”
  - Divergent productivity can lead to imbalances in farm income, trade and development
Guidance Section of the European Agricultural Guidance and Guarantee Fund aims at structural changes in agriculture.

European Regional Development Fund and Cohesion Fund aim at rural development in general.
Objectives

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Do productivity differentials tend to shrink or widen?

**Objective:**
Examine whether farm income (labor productivity) and Total Factor Productivity (TFP) converge across:

- countries
- FADN regions
\[ \beta - \text{convergence implies that all units (countries or regions) are expected to reach the same steady state} \]

\[ \beta - \text{convergence in the model: } y_{it} = \delta + \rho y_{i,t-1} + \gamma t + \varepsilon_{it}, \]

\[ \rho < 1 \text{ implies } \beta - \text{convergence in } y \]

\[ \Rightarrow E(y_t) = \left[ \frac{\delta}{1-\rho} - \frac{\gamma \rho}{(1-\rho)^2} \right] + \left[ \frac{\gamma}{1-\rho} \right] t \]
\( \sigma \)-Convergence

- \( \sigma \)-convergence implies that differences across units (countries or regions) shrink over time.
- If \( \sigma^2(t) \) is the variance of \( y_{it} \) across units at time \( t \), \( \frac{d\sigma^2(t)}{dt} < 0 \) implies \( \sigma \)-convergence in \( y \).
**β-Convergence Model**

- $y_i$ is the variable of interest (labor productivity or TFP)
- $i$ indexes units (countries or regions)
- $t$ indexes time

**β-convergence:**

$$y_{it} = \delta + \rho y_{i,t-1} + \gamma t + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma^2)$$

- $\rho < 1 \rightarrow$ β-convergence
- $\rho = 1 \rightarrow$ no tendency for change
- $\rho > 1 \rightarrow$ β-divergence
**σ-Convergence Model**

- \( y \) is the variable of interest (labor productivity or TFP)
- \( i \) indexes units (countries or regions)
- \( t \) indexes time

\[ y_{it} = \delta + \rho y_{i,t-1} + \gamma t + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma^2_t) \]

\[ \log \sigma^2_t = -\zeta - \eta \cdot t \]

- \( \eta > 0 \) → \( \sigma \)-convergence
- \( \eta = 0 \) → no tendency for change
- \( \eta < 0 \) → \( \sigma \)-divergence
Hypotheses can be (partly) tested using unit-root tests (strong assumptions & data requirements)
Estimation and Model Comparison

- Hypotheses can be (partly) tested using unit-root tests (strong assumptions & data requirements)

- Perform estimation in a Bayesian setting:
  - estimate three models per hypothesis
  - each model imposes restrictions on the parameters ($\rho$ and $\eta$)
  - models are compared based on the posterior odds ratio:

\[
\frac{\text{Prob}(M_1|D)}{\text{Prob}(M_2|D)} = \frac{\text{p}(D|M_1)}{\text{p}(D|M_2)} \cdot \frac{\text{Prob}(M_1)}{\text{Prob}(M_2)}
\]
Labor productivity: Farm Net Value Added (FNVA) per Annual Working Unit (AWU)

\[
\text{FNVA per AWU} = \frac{\text{Total Value of Production}}{\text{AWU}}
\]

- \text{Intermediate Consumption}
- \text{Depreciation}
- \text{Subsidies and Taxes}

\text{Total Value of Production} = \text{Total Value of Production} - \text{Intermediate Consumption} - \text{Depreciation} + \text{Subsidies and Taxes}
Definition of Variables

TFP: additional analysis to obtain TFP levels
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- Multiple methods to calculate TFP growth rates
- But we need TFP levels to test for convergence
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- Multiple methods to calculate TFP growth rates
- But we need TFP levels to test for convergence
- Use a transitive Törnqvist productivity index:
  - production process with $N$ inputs and $M$ outputs

$$\log \text{TFP}_{i,j} = \frac{1}{2} \left[ \sum_{m=1}^{M} (r_{m,i} + \bar{r}_m) (\log q_{m,i} - \log q_m) - \sum_{m=1}^{M} (r_{m,j} + \bar{r}_m) (\log q_{m,j} - \log q_m) \right]$$

$$- \frac{1}{2} \left[ \sum_{n=1}^{N} (s_{n,i} + \bar{s}_n) (\log x_{n,i} - \log x_n) - \sum_{n=1}^{N} (s_{n,i} + \bar{s}_n) (\log x_{n,i} - \log x_n) \right]$$
Data & Data Transformations

- Farm-level data from FADN
  - Period covered: 1995 to 2008
  - Analysis using data for EU15 and EU25
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- FNVA:
  - Deflate NFVA by the CPI to make data comparable over time
  - Use Purchasing Power Parities (PPP) to make the data comparable across countries
  - Calculate means across farms within a unit (country or region)
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- TFP:
  - Two outputs and four inputs (K L M and land)
  - Deflate monetary values by country-level price indexes
  - Construct transitive Fisher indexes for monetary values
  - Calculate opportunity costs for fixed inputs
FNVA per AWU – EU 15

![Graph showing FNVA per AWU for EU 15 countries from 1996 to 2008.](image)

The graph displays the FNVA per AWU (in 1,000 Euros) for 15 EU countries from 1996 to 2008. Each country is represented by a different line with specific markers and colors:

- **BEL** (Green)
- **DAN** (Blue)
- **DEU** (Red)
- **ELL** (Black)
- **ESP** (Brown)
- **FRA** (Red)
- **IRE** (Blue)
- **ITA** (Green)
- **LUX** (Black)
- **NED** (Brown)
- **OST** (Red)
- **POR** (Blue)
- **SUE** (Green)
- **SVE** (Black)
- **UKI** (Brown)

The x-axis represents the years from 1996 to 2008, while the y-axis shows the FNVA per AWU values ranging from 0 to 40 (in 1,000 Euros). The graph visually compares the FNVA trends across these countries over the specified period.
log TFP – EU 15

Year log TFP

BEL
DAN
DEU
ELL
ESP
FRA
IRE
ITA
LUX
NED
OST
POR
SUE
UKI

## Convergence at the Country Level

<table>
<thead>
<tr>
<th>FNVA per AWU</th>
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<tbody>
<tr>
<td><strong>EU15</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>$\beta$</td>
<td>0.822</td>
<td>0.177</td>
<td>0.002</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>0.119</td>
<td>0.650</td>
<td>0.231</td>
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<tr>
<td><strong>EU25</strong></td>
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<tr>
<td>$\beta$</td>
<td>0.934</td>
<td>0.065</td>
<td>0.001</td>
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<tr>
<td>$\sigma$</td>
<td>0.016</td>
<td>0.204</td>
<td>0.780</td>
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### FNVA per AWU

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### logTFP

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<td>( \beta )</td>
<td>0.092</td>
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<td>( \sigma )</td>
<td>–</td>
<td>–</td>
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<tr>
<td>EU25</td>
<td>( \beta )</td>
<td>0.088</td>
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Summary & Conclusions

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  - some evidence of $\sigma$-divergence in EU25
  - higher persistence in TFP than labor productivity
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- **Regional level:**
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  - $\beta$- and $\sigma$-convergence in TFP

- Economic integration and policy interventions do lead to convergence in productivity when targeting specific regions