Real Convergence In The New Member States: Myth or Reality?

Andrea Ingianni*  Vaclav Zdarek+

6th EEFS Annual Meeting, 2007
Outline

1 Motivation
   - Research objectives
   - Background literature

2 Contribution
   - Main Results
   - Future Directions
Motivation

1. Research objectives
2. Background literature

Contribution

2. Main Results
3. Future Directions

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Real convergence in the EU8.
Research question.

"Will countries with different starting levels of GDP per capita converge in the long run?"

In the specific case: "Were new members converging during the enlargement process?"
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Countries under investigation (EU8): Estonia (EE), Lithuania (LT), Latvia (LV), Czech Republic (CZ), Slovakia (SK), Poland (PL), Hungary (HU), Slovenia (SL).

Data: Eurostat New Chronos and Statistical Annex to the EU economy, GDP per capita PPS and Euros at 1995, 2000 constant prices, annual or quarterly frequencies.
The EU enlargement.

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Real convergence in the EU8.
Theoretical Background.

- **Economic theory**: Neoclassical model [10, 11] with a standard Cobb-Douglas production function (CES function, neutral technological progress),

\[ Y_t = A_t \Delta(K_t^\alpha \Delta L_t^\beta), \quad \alpha, \beta \in (0, 1), \quad \alpha + \beta = 1 \]  

(1)

where the process towards the steady state can be described as:

\[ \frac{\dot{k}}{k} = sk^\alpha - (n + \omega + \delta) \]

with \( k \)- capital per unit of labour, \( n \)- growth rate of population, \( \omega \)- rate of exogenous technical progress, \( \delta \)- rate of capital depreciation and \( s \)- saving rate, dot means increase of given variable.

- **Empirical investigations**: Beta / sigma and time-series convergence.

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Empirical convergence.
I. Beta convergence

The standard [1] regression:

\[ T^{-1} \ln \left( \frac{Y_{T,i}}{Y_{0,i}} \right) = \alpha + \beta \ln(Y_{0,i}) + \varepsilon_{T,i} \] (2)

from which \( \beta_S = \frac{1-e^{-\beta T}}{T} \) (speed of convergence), is estimated in the alternative form\(^1\) (e.g. [9]):

\[ \frac{\dot{y}}{y} = \beta [\ln(y^*) - \ln(y)] \]

\(^1\) a Taylor expansion of (1) in \( \ln y \) about steady state \( y^* \), assuming balanced growth equilibrium: \( \dot{k}/k = \dot{y}/y \)
Empirical convergence.
1. Sigma convergence

Given a set of $N$ countries, we call $\sigma_t^2$ the variance of GDP per capita of the aggregate at time $t$:

$$\sigma_t^2 = N^{-1} \sum_{i=1}^{N} [\ln (y_{i,t}) - \bar{y}_t]^2$$

where $i \in [1, N]$, $t \in [1, T]$ and $\bar{y}_t = N^{-1} \sum_{i=1}^{N} \ln (y_{i,t})$.

Sigma-convergence occurs when: $\sigma_{t+n}^2 < \sigma_t^2$ with $n > 0$.
Empirical convergence.
II. Unit-roots and Cointegration - Fixed u.r.

According to [3] when the process:

\[ g_t = \rho g_{t-1} + \varepsilon_t \]

where \( g_t = \ln(y_{i,t}) - \ln(y_{j,t}) \), has a unit root (\( \rho = 1 \)), it is a non-stationary random walk and it should be interpreted as output divergence between countries \( i \) and \( j \).

More generally, for \( i = 1, 2, \ldots, N \), consider the (unrestricted) VAR of order \( p \):

\[
\Delta y_t = \Pi y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + Bx_t + \epsilon_t
\]

[2] conclude for convergence when \( r(\Pi) = \tau = N - 1 \).

[4] and [7, 6] are used for testing the two conditions.
Given the process ([5]):

\[ g_t = a_t g_{t-1} + \varepsilon_t \]

where \( a_t \) is a stationary series such as \( a_t \sim iid(1, w^2) \) and \( \varepsilon_t \sim iid(0, \sigma^2) \). The null is set to the pure unit-root (\( H_0 : w^2 = 0 \)), the alternative to the STUR (\( H_1 : w^2 > 0 \)) and the test statistic is calculated [8] as:

\[
\hat{Z}_T = \frac{\sum_{t=q+3}^{T} \left( \sum_{p=q+2}^{t-1} \hat{\varepsilon}_p \right)^2 \left( \hat{\varepsilon}_t - \hat{\sigma}^2 \right)}{\hat{k}\hat{\sigma}^2 \sqrt{T^3}}
\]

where: \( \hat{\varepsilon}_t = \Delta x_t - \hat{\alpha} - \hat{\gamma}t - \sum_{n=1}^{q} \hat{\beta}_n \Delta x_{t-n} \), \( \hat{\sigma}^2 = T^{-1} \sum_{t=1}^{T} \hat{\varepsilon}_t^2 \)

and \( k^2 = T^{-1} \sum_{t=1}^{T} \left( \hat{\varepsilon}_t - \hat{\sigma}^2 \right) \).
Empirical convergence
III. Hypothesis summary

Positive evidence of convergence is found when:

1. **Beta** convergence: $\beta < 0$.
2. **Sigma** convergence$^2$: $\sigma_t < \sigma_{t-1}$.
3. **Fixed unit roots** (ADF): reject a unit root ($\rho = 1$). [3]
4. **Cointegration**: $N - 1$ cointegrating relations among $N$ countries. [2]
5. **Stochastic unit-roots** (STUR): reject a pure unit-root ($w^2 = 0$) against a stochastic root. [12]

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Galton’s fallacy: $\sigma_t < \sigma_{t-1} \Rightarrow \beta < 0$ but $\beta < 0 \not\Rightarrow \sigma_t < \sigma_{t-1}$
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Beta and Sigma Convergence.

**Beta convergence**

![Fig. I - Euros](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>( \beta ) (pps)</th>
<th>( \beta ) (eur)</th>
<th>( \beta_S ) (pps)</th>
<th>( \beta_S ) (eur)</th>
<th>Conv.?</th>
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![Fig. II - PPS](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>( \beta ) (pps)</th>
<th>( \beta ) (eur)</th>
<th>( \beta_S ) (pps)</th>
<th>( \beta_S ) (eur)</th>
<th>Conv.?</th>
</tr>
</thead>
</table>
| Two Regions (EU8+EU15)
| 1995-06 | -0.0024           | -0.0967           | 2.27               | 6.04               | yes    |
|         | ( ... )           | ( ... )           |                    |                    |        |
| 1995-00 | -0.0142           | -0.057            | 1.37               | 4.9                | yes    |
|         | ( ... )           | ( ... )           |                    |                    |        |
| 2001-06 | -0.0421           | -0.2074           | 3.75               | 13.47              | yes    |


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Real convergence in the EU8.
Beta and Sigma Convergence.

Sigma convergence.

**Main Results**

<table>
<thead>
<tr>
<th>Year</th>
<th>$\beta_j$ (pps)</th>
<th>$\beta_j$ (eur)</th>
<th>$\sigma$-conv.?</th>
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**Two Regions (EU8+EU15)**

<table>
<thead>
<tr>
<th>Year</th>
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<th>$\beta_j$ (eur)</th>
<th>$\sigma$-conv.?</th>
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<td>2001-06</td>
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Source: New Chronos, 2007. Note: $\sigma_{j,t} = \alpha_j + \beta_j t + \varepsilon_{j,t}$, $j = (EU8), (EU8+EU15)$.
## Time-series Convergence

### Time-series Summary and Leybourne test

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<thead>
<tr>
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<th>hu</th>
<th>sl</th>
<th>ee</th>
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<th>lv</th>
<th>sk</th>
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<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y***</td>
</tr>
<tr>
<td>STUR</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
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<td>Cointegration</td>
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<td>Y</td>
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<tr>
<td>Overall</td>
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<td>Y-</td>
<td>Y-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
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</table>

<table>
<thead>
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<th>lt</th>
<th>lv</th>
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<td>STUR?</td>
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<td>yes</td>
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<table>
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<th>sk</th>
<th>pl</th>
<th>hu</th>
<th>sl</th>
</tr>
</thead>
<tbody>
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<td>0.25118*</td>
<td>0.287285*</td>
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<td>STUR?</td>
<td>no</td>
<td>no</td>
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<td>yes</td>
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</tbody>
</table>


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Future Directions

- Non linearities.
- Breaks.
- Sample size (time is limited, low frequencies).
- Seasonalities (seasonal unit roots).
Conclusions

- The EU enlargement is an attempt of promoting growth and convergence through integration. Our results show that, although positive signs are visible, it is difficult to have a clear answer about the achievement of this target.
- The evidence from aggregated beta and sigma analysis is pro-convergence but mixed from disaggregated time-series.
- A series of technical difficulties overshadow “reality” adding to the “myth”.

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Real convergence in the EU8.
R. J. Barro.
Economic growth in a cross section of nations.

Convergence in international output.

Are U.S. regional incomes converging? A time series analysis.
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Distribution of the estimators for autoregressive time series with a unit root.  

C. W. J. Granger and N. R. Swanson.  
An introduction to stochastic unit-root processes.  

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S. J. Leybourne, B. P. M. McCabe, and A. R. Tremayne.  
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