Semi-endogenous growth theory versus fully-endogenous growth theory: a sectoral approach

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WIOD Conference on Industry-Level Analyses of Globalization and its Consequences
First and second endogenous growth theories

Sectoral application
- Sample
- Previous unit root and cointegration tests
- Explanatory models of TFP growth

Conclusions
A sectoral approach

- Focus on the sectoral level.

- The best approach to assess the usefulness of innovation-based endogenous growth models (Aghion and Durlauf, 2009).
First-generation endogenous growth models

- Constant returns to scale in knowledge-creation function.

- TFP (and per capita output) growth depends on the population size.

- It will suffice to increase the population size to raise the TFP growth rate.
Economic reality

- Jones’s paradox

- U.S. productivity: acceleration at the start of the 2000s, in spite of the reduction in ICT investment.

  → Second-generation endogenous growth theories
  
  Semi-endogenous growth theory
  Fully-endogenous growth theory
Semi-endogenous growth theory

- Decreasing returns to scale in the knowledge-creation function.

- TFP (and per capita output) growth depends on **population growth rate**.

- It will be necessary to increase the population growth rate to raise the TFP growth rate.
**Fully-endogenous growth theory**

- Constant returns to scale in the knowledge-creation function.
- Product differentiation process associated with economic growth.

  The effectiveness of the R&D input is diluted

- TFP growth depends on *research intensity growth rate*, measuring the research intensity as R&D input/product proliferation.
  - It will be necessary to increase the research intensity growth rate to raise the TFP growth rate
  - TFP growth can remain constant (if the increase of the R&D input is smaller than the increase on the product differentiation).
Consequently

- Product differentiation prevents the population size from having a scale effect on long-run growth (a characteristic of the first-generation models).

- TFP growth depends on economic factors and economic policy measures (a crucial difference with respect to the semi-endogenous growth model).
Empirical application

- The Semi-endogenous growth theory and the fully-endogenous growth theory were tested at industrial-level in this paper.

- The sample:
  - Period 1979-2001
  - Ten industries
  - Finland, France, Italy, USA, Canada and Spain.
The TFP index used was the Tornqvist index.

$V, L$ and $K$ were taken from the STAN database.

Two variables representing the R&D input:
- Business R&D expenditures ($R$), taken from the OECD ANBERD.
- ($R/A$) (used in Schumpeterian models).

Product proliferation: $A/L$ or $V$.

Research intensity: $R/AL$ or $R/V$. 
Previous unit root and cointegration tests

- Madsen (2008) proposed:

\[ \ln X_t = \mu \ln Q_t + k \ln A_t + e_t. \]

where \( k = (1 - \Phi) / \sigma \) (\( \Phi \) is returns to scale in knowledge and \( \sigma \) is a duplication parameter).

- The semi-endogenous growth theory implies that
  - \( K > 0 \) (decreasing returns to scale)
  - \( \mu = 0 \) (without product proliferation)

- The Schumpeterian growth theory presupposes \( k=0 \) (constant returns to scale) and \( \mu = 1 \).
Results of tests

- All variables had a unit root
- The growth in all variables was stationary
- Cointegration tests:
  - Denied the validity of the Semi-endogenous hypothesis
  - Supported an extended semi-endogenous growth model (with product proliferation)
  - Suggested the validity of the Schumpeterian approach (although product differentiation had not the expected parameter)
First explanatory model

\[ \Delta \ln A_{ij} = \beta_{0,ij} + \beta_{1} \Delta \ln X_{ijt}^{d} + \beta_{2} \Delta \ln X_{ijt}^{f} + \]

\[ + \beta_{3} \ln \left( \frac{X_{ijt}^{d}}{Q^{d}} \right) + \beta_{4} \ln \left( \frac{X_{ijt}^{f}}{Q^{f}} \right) + i_{jt} \beta_{5} DF_{ij} + \varepsilon_{ij} \]
First explanatory model

- This expression nested the models and included:
  - International technological spillovers ($X^f$)
  - Distance to technological frontier ($DF$)
- The semi-endogenous growth hypothesis
  - $\beta_1 > 0$, $\beta_2 > 0$
  - $\beta_3 = \beta_4 = \beta_5 = 0$
- The Schumpeterian prediction
  - $\beta_1 = \beta_2 = 0$
  - $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 > 0$
First explanatory model

- $X^f$ was proxied as proposed by Coe and Helpman (1995).
- $DF$ was defined in two alternative forms:

$$DF1_{ijt} = \left( \frac{A_{\text{max}} - A_i}{A_{\text{max}}} \right)_{ijt-5}$$

$$DF2_{ijt} = \left( \frac{A_{\text{max}}}{A_i} \right)_{ijt-5}$$
Results of the estimation of the first explanatory model

- Estimates in five-year differences (240 observations).

- Positive and significant effect of domestic and foreign R&D expenditure growth (as postulated by the semi-endogenous theory).

- Negative and significant effect of domestic and foreign research intensity.

- Positive and significant effect of distance to the frontier.
A new research intensity variable

- Was research intensity properly measured?
- What may happen if a more adequate variable to measure effective technological research was used?
A new research intensity variable

- Why is the new variable more adequate?
- Because
  - R&D expenditure has to be sufficient to:
    - Compensate depreciation of capital
    - Increase in the stock of knowledge
    - Compensate product proliferation
Effective research intensity was measured using

- Technological stocks
- Hours worked by persons engaged and number of persons engaged (to proxy product differentiation).
Second explanatory model

\[ \Delta \ln A_{ijt} = \beta_{0,ij} + \beta_{1} \Delta \ln X_{ijt}^{d} + \beta_{2} \Delta \ln X_{ijt}^{f} + \]

\[ \beta_{3} \Delta \ln \left( \frac{X_{\text{efect}}^{d}}{Q^{d}} \right)_{ijt} + \beta_{4} \Delta \ln \left( \frac{X_{\text{efect}}^{f}}{Q^{f}} \right)_{ijt} + \beta_{5} DF_{ijt} + \varepsilon_{ijt} \]
Results of the estimation of the second explanatory model

- Domestic and foreign R&D expenditure growth lose their significance.

- Positive and significant effect of:
  - Effective technological research
  - Distance to the frontier
Third explanatory model
(effective research intensity & absorptive capacity)

\[ \Delta \ln A_{ijt} = \beta_{0,ij} + \beta_1 \Delta \ln \frac{X^d_{ijt}}{Q^f_{ijt}} + \beta_2 \Delta \ln \frac{X^f_{ijt}}{Q^f_{ijt}} + \beta_3 \Delta \ln \frac{X^d_{efect}}{Q^d_{ijt}} + \beta_{4} \Delta \ln \frac{X^f_{efect}}{Q^f_{ijt}} + \beta_{5} DF_{ij} + \beta_{6} \ln \frac{X^d_{efect}}{Q^d_{ijt}} + DF_{ij} + \epsilon_{ijt} \]
• The absorptive capacity was measured by the interaction between:

- Research intensity
- Distance to the frontier
Results of the estimation of the third explanatory model

- Domestic and foreign R&D expenditure growth could not be considered statistically significant.

- Domestic and foreign effective research intensity, distance to the frontier and absorptive capacity had positive and significant coefficients.
Conclusions

- Unit root and cointegration tests
- Estimation of the models
- Policy design
Conclusions of the tests

* The unit root and cointegration tests suggested the validity of a hybrid theoretical framework:
  
  Semi-endogenous approach + product proliferation
Conclusions of the estimations of the models

- In semi-endogenous models, when research intensity was proxied as a ratio between measures of R&D and product proliferation:
  - Domestic and foreign R&D expenditure growth had positive and significant coefficients
  - Research intensity showed a negative influence
Conclusions of the estimation of the models

- The empirical evidence supported the fully-endogenous growth models when TFP growth depends on:
  - The *effective* research intensity
  - Distance to the frontier
  - Absorptive capacity

- → Deeper analysis of the role of human capital and institutions is required.
Policy design

- Economic policy measures to ensure catching up and the possibility of imitating the leader are not adequate for countries which are not far from the technological frontier.

- A new pattern of intervention becomes necessary.

- The new innovation model requires to promote:
  - Effective research intensity.
  - Indirect sources of innovation and growth such as competition, investment in education, reduction of credit constraints and flexibility in labour markets.
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