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

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- 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

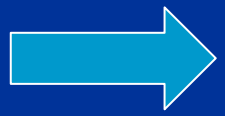
Fully-endogenous growth theory

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.

Variables

- The TFP index used (*A*) 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 :

$$ln\, X_t = \mu\, lnQ_t + k\, lnA_t + e_t.$$

where $k = (1- \Phi)/\sigma$ (Φ is returns to scale in knowledge and σ 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

$$\Delta \ln A_{ijt} = \beta_{0,ij} + \beta_1 \Delta \ln X^d{}_{ijt} + \beta_2 \Delta \ln X^f{}_{ijt} +$$

$$\beta_3 \ln\left(\frac{X^d}{Q^d}\right)_{ijt} + \beta_4 \ln\left(\frac{X^f}{Q^f}\right)_{ijt} + \beta_5 DF_{ij} + \varepsilon i_{jt}$$

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:

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

$$DF2_{ijt} = \left(\frac{A_{\max}}{Ai} \right)_{ijt-5}$$

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

$$\Delta \ln A_{ijt} = \beta_{0,ij} + \beta_1 \Delta \ln X^{d}_{ijt} + \beta_2 \Delta \ln X^{f}_{ijt} +$$

$$\beta_3 \Delta \ln \left(\frac{X^{d}_{efect}}{Q^{d}} \right)_{ijt} + \beta_4 \Delta \ln \left(\frac{X^{f}_{efect}}{Q^{f}} \right)_{ijt} + \beta_5 DF_{ijt} + \varepsilon_{ijt}$$

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)

$$\Delta \ln A_{ijt} = \beta_{0,ij} + \beta_1 \Delta \ln X^{d}_{ijt} + \beta_2 \Delta \ln X^{f}_{ijt} + \beta_3 \Delta \ln \left(\frac{X^{d}_{efect}}{Q^{d}} \right)_{ijt}$$

$$+ \beta_4 \Delta \ln \left(\frac{X^{f}_{efect}}{Q^{f}} \right)_{ijt} + \beta_5 DF_{ij} + \beta_6 \ln \left(\frac{X^{d}_{efect}}{Q^{d}} \right)_{ijt} DF_{ij} + \varepsilon_{ijt}$$

- 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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