Technology Diffusion, International Spillovers and Human Capital in the Mediterranean Agricultural Sector

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Goals

- *Investigation of the roles of **human capital** and **openness** in the process of technology diffusion and productivity growth in the Mediterranean agricultural sector:*
  - Evaluation of agricultural TFP using a random coefficient production function.
  - Estimation of a non-linear growth specification that nests the ***exponential*** and ***logistic*** technology diffusion patterns.

Context

- Countries in the Mediterranean region have been actively participating in the new wave of globalization.
- The adoption of advanced agricultural technologies can be a powerful force in boosting farming productivity growth and in fostering economic development.
- International trade is considered as the primary vehicle for foreign technology flows.
- To be of use to the recipient countries, advanced technology needs high endowment of skilled work force.

Context

- The interlinkages between trade, technology transfer, human capital and productivity growth is a topic of interest of many studies, few researches have however investigated the interaction between education, openness and technology diffusion in the agricultural sector.

Model Specification

- The analysis builds on the work of Benhabib and Spiegel (2002) and extends the the baseline specification to incorporate the interaction between openness and human capital in technology adoption.
- The most commonly used technology diffusion pattern is of the confined exponential type:

$$\frac{\dot{A}_i(t)}{A_i(t)} = g(H_i(t)) + f(H_i(t), Openness_i(t))\left[\frac{T(t)}{A_i(t)} - 1\right]$$

Model Specification

- A leading alternate is the logistic diffusion process:

$$\frac{\dot{A}_i(t)}{A_i(t)} = g(H_i(t)) + f(H_i(t), Openness_i(t))\left[1 - \frac{A_i(t)}{T(t)}\right]$$

The implications of these different technology diffusion specifications for the agricultural growth path may be quite divergent. We derive a specification that nests both functional forms:

Model Specification

$$\frac{\dot{B}_i(t)}{B_i(t)} = g(H_i(t)) - g(H_L) - \frac{f(H_i(t), Openness_i(t))}{s}\left[B_i(t)^s - 1\right]$$

$$B_i(t) = \frac{A_i(t)}{T_0 e^{g(H_L)t}} \qquad s \in [-1, 1]$$

$$B_i(t) = \left(\frac{1 + \frac{s(g_i - g_L)}{f_i}}{\left(1 + \left(B_0^{-s}\left(1 + \frac{s(g_i - g_L)}{f_i}\right) - 1\right)e^{-(s(g_i - g_L) + f_i)t}\right)} \right)^{1/s}$$

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Model Specification

- For $s<0$ countries would exhibit positive catch up in agricultural productivity with the technology leader, as there exists a stable steady state at :

$$B = \left(\frac{f_i + s(g_i - g_L)}{f_i} \right)^{1/s}$$

Model Specification

- If technology diffusion is of the logistic type, low-skilled economies may diverge relative to the frontier, since the level of education is not sufficiently high to allow for introducing foreign technology:

$$(g_i - g_L) + f_i < 0$$

$$\lim_{t \to \infty} B_i(t) = 0$$

Econometric Framework

$$GTFP_{it} = \gamma + \gamma_H h_{it} + \frac{\gamma_{op}}{s} op_{it} h_{it} - \frac{\gamma_{op}}{s} op_{it} h_{it} \left(\frac{A_{it}}{A_{Lt}} \right)^s + \eta_{it}$$

$GTFP_{it}$ is the growth rate of agricultural TFP, A_{it} the country i's agricultural TFP level, the economy with the highest level of TFP is the frontier (A_{Lt}.).

Econometric Framework

- To account for cross country heterogeneity, we estimate productivity using a dynamic random coefficients CD production function

$$y_{it} = \lambda_i y_{it-1} + (1-\lambda_i)\sum_j \beta_{ij} x_{ijt} + ln(A_{it}) + u_{it}$$

Econometric Framework

As an alternative to the nonlinear model we also investigated a linear specification:

$$GTFP_{it} = \delta_{it} + \beta \Delta ln(A_{Lt}) + \alpha_1 h_{it-1} + \alpha_2 op_{it-1} - \theta_1 ln\left(\frac{A_i}{A_L}\right)_{t-1} - \theta_2 h_{it-1} ln\left(\frac{A_i}{A_L}\right)_{t-1} -$$

$$\theta_3 op_{it-1} ln\left(\frac{A_i}{A_L}\right)_{t-1} + \kappa X_{it-1} + \upsilon_{it}$$

The speed of technology transfer is given by

$$\theta_1 + \theta_2 h_{it-1} + \theta_3 op_{it-1}$$

and the full effects of human capital and of openness on farming performance are measured by

$$\alpha_1 - \theta_2 ln\left(\frac{A_i}{A_L}\right)_{t-1} \qquad \alpha_2 - \theta_3 ln\left(\frac{A_i}{A_L}\right)_{t-1}$$

Data

- We consider panel data at the national level for agricultural productions in:
- nine SMC: Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Syria, Tunisia and Turkey;
- five EU Mediterranean countries: France, Greece, Italy, Portugal and Spain.
- Period: 1990-2005.

Data

- **Openness:** four variables are used as measures of openness:
  - the ratio of agricultural exports plus imports to GDP,
  - trade barriers that include ad-valorem tariffs and indices of non-tariff barriers,
  - FDI net inflows measured in proportion to GDP,
  - the share of agricultural machinery and equipment imports in agricultural value added.
- **Human capital:**
  - Average years of schooling in the population over age 25,
  - the percentage of adult population with secondary education,
  - Literacy rate
  - Human development index.

Data

- **Country characteristics**:
  - agricultural research and development (R&D) expenditures,
  - infant mortality,
  - land fragmentation,
  - average holdings,
  - institutional variables such as political stability, government effectiveness, regulatory quality, rule of law and control of corruption.

Main Results

Impact of Human Capital and Openness on Agricultural TFP Growth

	Model 1	Model 2	Model 3	Model 4
Constant	-0.033	-0.04	-0.07	-0.098
lnH	0.013	0.015	0.021	0.033
lnH*trade	0.04**			
lnH*ltrade*GAPs	-0.04**			
lnH*tariff		-0.035*		
lnH*tariff*GAPs		0.035*		
lnH*imach			-0.184**	-0.12**
lnH*imach*GAPs			0.184**	0.12**
s	0.07	0.07	-0.823**	-1
Number of observations	1177	1177	1177	1777
R^2 adjusted	0.284	0.29	0.48	0.513

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Agricultural TFP linear growth regressions

	Model 1	Model 2	Model 3
$\Delta \ln A_L$	0.704**	0.606**	0.707**
lnH	0.037		0.063**
imach		0.18*	0.121*
lnGAP	-0.054**	-0.013*	-0.084*
lnH*lnGAP	-0.17*		-0.169**
imach*lnGAP		-0.269**	-0.267**
Average holding	0.017**	0.016**	0.017**
Land fragmentation	-0.001	-0.002**	-0.022*
R&D	0.026*	0.026**	0.028**
Mortality	-0.0032**	-0.006	-0.0023*
Political stability	0.0002*	0.0002*	0.0002*
Regularity quality	0.0004*	0.0003*	0.0003*
N. of observations	1177	1177	1177
R^2 adjusted	0.904	0.906	0.919

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Speed of technology diffusion and of the full productivity effects of Human Capital and Openness

	Speed of technology diffusion	Product. effect of human capital	Product. effect of equip. imports
Algeria	0.859	0.184	0.275
Egypt	0.59	0.286	0.467
Israel	0.946	0.104	0.184
Jordan	3.891	0.077	0.143
Lebanon	1.744	0.149	0.249
Morocco	1.119	0.162	0.264
Syria	1.345	0.111	0.196
Tunisia	1.237	0.144	0.245
Turkey	0.888	0.085	0.155
France	4.173	0.077	0.142
Greece	2.029	0.140	0.241
Italy	1.914	0.099	0.177
Portugal	2.934	0.142	0.243
Spain	2.063	0.112	0.197

Main Findings and Economic Implications

- The results favour the confined exponential specification, the steady state is a balanced growth path, with all backward economies growing at the pace determined by the leading edge.
- Foreign technology embodied in imported capital goods and HC play a significant positive role in speeding the catch up to the technology frontier and in boosting agricultural productivity in the Mediterranean region.

Main Findings and Economic Implications

- The IT externalities in the process of technology diffusion seem relatively more important in magnitude than the HC capital externalities.
- Countries with a larger technology gap against the frontier experience higher rates of productivity growth.
- There seems a strong positive long run association between a lagging economy's productivity and the leader nation TFP.

Main Findings and Economic Implications

- The interactions between HC and IT suggest strong complementary effects between openness and educational attainment in enhancing agricultural growth, and support the notion that a higher endowment of skilled labour force aids acquisition of advanced technology ferried via trade.
- The effects of both education and openness appear to be relatively important in Egypt, and to a lesser extent in Algeria, Morocco and Lebanon, as these countries have somewhat important technology gap with the leading economy.

Main Findings and Economic Implications

- These productivity effects are relatively low in countries lying in the frontier edge such as France, Italy, and Turkey.
- Regarding the speed of diffusion, globally the EU countries lie near the top with **France** exhibiting the higher speed rate.
- In the SMC panel, **Jordan** and to a lesser extent **Lebanon** and **Syria**, seem to experience significantly fast technology transfer. These countries have particularly important ratio of agricultural equipment imports.

Main Findings and Economic Implications

- The Mediterranean integration process may yield larger benefits with the implementation of a number of adjustment policies aiming at:
  - qualifying the farming labour force;
  - increasing the financial support for agricultural R&D;
  - Combating the fragmentation of land, enhancing the expansion of holdings and supporting equal redistribution of land;
  - Improving institutional factors and the quality of governance.