TFP Interdependencies and European Integration

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Abstract

In this paper, we investigate factors of total factor productivity (TFP) interdependencies in a sample of 19 OECD countries for the period 1975-2009. Cointegration relationships are estimated between TFP’s level in order to measure TFP’s interdependencies. To identify factors of spillover effects, first we test for the relevance of specific variables as openness, R&D capital or specialization on TFP interdependencies. Results show a convergence effect between level of TFP and a positive effect of openness and the investment in R&D on the capacity of technology absorption. Then, distinguishing between European and non-European countries, openness appears to be less relevant for European country. This paper find that the European Union promotes technological convergence, whatever trade intensity.

Keywords: Trade, Growth, Integration, Specialization.
JEL: F4; F43; F02

1 Introduction

Coe and Helpman (1995) have emphasized the role of international trade in the process of technological diffusion among OECD countries. Their seminal results have been enriched by additional factors aiming at specifying the relative importance of various channels of technological diffusion. Hakura and Jaumotte (1999) have highlighted the importance of intra-industry trade, whereas Benhabib and Spiegel (1994) among others have focused on the process of human capital accumulation. These papers analyze determinants of the total factor productivity (TFP) panel regressions. For instance, a central question in those papers

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is the following: does the impact of the foreign R&D capital stock on country’s TFP remain unchanged when a catch-up variable or the accumulation of domestic human capital is introduced in the regression (Engelbrecht, 1997). As a consequence, effects of international spillovers are estimated in average for a sample of country without allowing differences between countries neither changes over time.

The paper provides a new assessment of spillover determinants that consist first in estimating country by country co-movements of the total factor productivity among OECD countries, and then, by investigating which channels of transmission might explain those co-movements. According to theories of endogenous growth, TFP interdependencies are expected to be related to domestic characteristics such as the degree of openness and the initial level of TFP as well as to the relative attribute of one country with respect to its commercial partners or neighbors. Therefore, we do not longer address the question of TFP (growth/level) determination but we try to explain why TFP interdependencies may vary across countries and over time. We pay a specific attention to European country in order to assess if geographical proximity, common policies and institutions may affect significantly TFP interdependencies.

In the section 2, we describe some features of the data. In the section 3, we measure TFP interdependencies by estimating cointegration relationships between TFP and testing for their stability. In the section 4, we report results from two steps of estimations: those with specific variables and those that distinguish between European and non-European countries. The section 5 summarizes our results and provides concluding remarks.

2 Data

The total factor productivity ($A$) represents the contribution of technology to the production ($Y$) when tacking into account the stock of physical capital ($K$) and the labour force ($L$) available in the economy. Using the standard Cobb-Douglass production function leads to following expression of TFP in log difference:

$$
\Delta \ln A_{i,t} = \ln \Delta Y_{i,t} - \theta \Delta \ln L_{i,t} - (1 - \theta) \Delta \ln K_{i,t}
$$

As in Coe et Helpman (1995), the labor share is $\theta = 2/3$.

European TFPs are computed for each country ($i$) as the average of remaining European countries’ TFPs (denoted $j$) weighted by bilateral import shares ($w_{ij,t}$).

$$
\ln A^\text{eur}_{i,t} = \sum_{j \neq i} w_{ij,t} \times \ln A_{j,t}
$$

Table 1 presents the evolutions of TFP and those of European counterparts. European countries, but Greece, have faced a decrease of their TFP growth rates which, in average, become twice smaller during the period 1995-2008 than between 1998 and 1995. Figures also report a catch-up effect of TFP. There is a negative relationship between initial levels
of TFPs and their growth rates. Moreover, standard deviations of TFP growth rates are declining during the period.

Table 1: TFP Evolutions 1981-2008

<table>
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<td><strong>2.70</strong></td>
<td><strong>9.63</strong></td>
<td><strong>5.47</strong></td>
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(1) Initial level of TFP in log. with respect to Germany (1)
(2) Annual average growth rates of log TFP
(3) Annual average growth rates of the European weighted average of log TFP

The comparison of TFP growth rates between each European country and its European partners provides some additional evidence in the convergence process of productivity across countries and over time. Initially lowest productive countries (Netherlands, Spain, Sweden
and the UK) experienced higher growth rates than other European countries, while more productive ones (Belgium, France, Italy, Portugal) faced TFP rates of growth smaller than their partners all over the period. In contrast, the convergence of productivity occurred only after 1995: higher productivity growth rate in Austria and Denmark and lower ones in Germany and Finland. The decrease in TFP rates of growth is also observed in other highly productive OECD countries. In average, European productivity has grown faster. The convergence process looks like a worldwide phenomenon.

3 Long-run elasticities of TFP

The focus is on the following equation:

\[ \ln A_{i,t} = \alpha + \beta_1^1 \ln A_{i,t}^{Eur} + \beta_2^2 \ln A_{i,t}^{Row} + \epsilon_{i,t} \]  

We first test the significance of the cointegration relationship with the trace test of Johansen. For this test, the null hypothesis corresponds to no cointegration. Under the alternative, there is one (or more) cointegration relationship. Results show that all countries admit one cointegration relationship between their TFP and their European and non-European counterparts for the full sample (1975-2009). For three countries, Italy, Canada and Spain, there exist two cointegration relationships.

To estimate these cointegration relationships, Fully-Modified Ordinary Least Squares (FM-OLS) estimator is used. Indeed, the FM-OLS use kernel estimators of the nuisance parameters that affect the asymptotic distribution of the OLS estimator. Correlation can be hold between residuals of the relation of cointegration and innovations of regressors. In this case, OLS estimators are skewed. FM-OLS method accounts for a possible endogeneity of regressors and serial correlation of errors. Moreover, it does not depend on the cointegration dimensionality and no restriction of identification has to be imposed. Furthermore, t-ratios are asymptotically normally distributed and are not dependant on the correct choice of lag length.

In the table 2 estimated coefficients \( \beta^2 \) (relative to non-European TFP) go from -0.89 for Spain to 3.36 for Italy. Most of coefficients \( \beta^2 \) are positive except for Spain and Sweden. European coefficients go from -0.6 for Japan to 2.59 for Ireland. Again, most of coefficients are positive but exhibit a large volatility (see in appendix box plots for \( \beta^1 \)). Finally, the CUSUM FM-OLS test proposed by Hao and Inder (1996) show that the European coefficient admit a break for 7 countries.

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1 For more details, see Phillips (1995) and Hurlin and N’Diaye (1998).
Table 2: Cointegration test, estimation and stability test for the period 1975:2009

<table>
<thead>
<tr>
<th>Country</th>
<th>Rank</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>Stat.</th>
<th>Date</th>
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<td>0.89***</td>
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<tr>
<td>Denmark</td>
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<td>0.94***</td>
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<td>Finland</td>
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<td>1.40***</td>
<td>-0.02</td>
<td>-1,723***</td>
<td>1987:4</td>
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<td>France</td>
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<td>0.93***</td>
<td>0.64***</td>
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<td>Greece</td>
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<td>3,424***</td>
<td>1993:2</td>
</tr>
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<td>2.59***</td>
<td>0.90***</td>
<td>4.92***</td>
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</tr>
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<td>0.45***</td>
<td>3.36***</td>
<td>-1,174***</td>
<td>1987:1</td>
</tr>
<tr>
<td>Japan</td>
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<td>-0.60**</td>
<td>1.91***</td>
<td>-3,191***</td>
<td>1994:1</td>
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<td>1.54***</td>
<td>1,645***</td>
<td>1988:4</td>
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<td>Portugal</td>
<td>1</td>
<td>1.15***</td>
<td>1.97***</td>
<td>-1,132***</td>
<td>1995:2</td>
</tr>
<tr>
<td>Spain</td>
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<td>1.42***</td>
<td>-0.89***</td>
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<td>Sweden</td>
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<td>United-States</td>
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<td>1.73***</td>
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<td>1.175</td>
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* significant at 10%; ** significant at 5%; *** significant at 1%

4 Explanatory models of TFP interdependences

4.1 Trade, specialization and R&D Capital Stock

Besides the catch up effect of productivity in European countries, interdependences between domestic TFP and its European counterpart provide some cross countries differences. Trade is widely recognized to be a key channel for technological transfers and therefore could explain co-movements in production. Nevertheless, the degree of openness may dissimulate some disparities in the pattern of trade that can affect spillovers. Theoretically, Rivera-Batiz and Romer (1991) and Romer (1994) argue that when knowledge is incorporated into new varieties of goods, trade can lead to technological transfers without knowledge transfers.
In that case, openness do not explain productivity spillovers across country. Hakura and Jaumotte (1999) have shown, empirically that intra-industry trade promotes technology diffusion. In this paper we link TFP interdependences with the degree of openness and with the diversification/specialisation of production structure measured with the Krugman Index. Using data for 30 sectors, we compare the domestic sectorial shares with European sectorial shares. The Krugman index is bounded by 0 (the country is as diversified as others) and 1 (the country diversification is totally different from others). For non-European countries, bilateral Krugman indexes are not bounded, but do still increase with specialisation.

A large part of the literature dealing with the explanation of spillovers across country mainly focus on the role played by the accumulation of knowledge. We compute the R&D capital stock from data on investments in R&D.

The collection of TFP elasticities with respect to European partners provide an indicator of TFP interdependencies, we aim to find the main determinants. These elasticities can be seen as a measure of "productivity spillovers" which are generated endogenously by the accumulation of knowledge in the economy, by the ability on an economy to absorb foreign technology (thanks to knowledge and specialisation), and by trade (which may also interact with knowledge and specialisation).

Estimated equations can be written as follows

$$\hat{\beta}_i^{11}[t,t+5] = \alpha_i + \Gamma X_{i,t} + \epsilon_{i,t} \quad t = [1981 ; 2005]$$

The fixed individual effect $\alpha_i$ captured in observable features that may explain TFP interdependencies such as legislation, cultural characteristics...

### 4.2 Absorption of technological spillovers

A first set of regressions aims at measuring the determinants of TFP interdependencies. We focus on the role played by the R&D capital stock (KRD) used as a proxy of technical knowledge accumulated by an economy and that may directly contribute to the productivity growth. Following Benhabib and Spiegel (1994) and Crespo et al. (2004) the stock of knowledge may also explain the capacity of an economy to absorb the technical progress from foreign countries. This effect is captured by an interaction term between KRD and the productivity gap $A_{eur}/A$. The degree of openness (OPEN) and the Krugman index of specialisation (KRUGMAN) are also introduced among explanatory variables in order to take into account the importance of international trade and the technological proximity between countries on the sources of international spillovers.

Results are reported in table and confirm the accumulation of knowledge can explain the importance of international spillovers. Nevertheless this effect is not estimated with precision when other factors are introduced. Nevertheless the interaction term of R&D capital stock

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2 Klenow and Rodriguez Clare (2005) provide a very complete survey of these models
and the productivity gap is significant with a negative sign. The role of knowledge is reduced when a country’s productivity is far above the one of its European partners. By contrast, for a given level of knowledge, low productive country tend to absorb more spillovers from the rest of Europe. This result clearly supports the conventional catch-up effect of levels of productivity. Indeed, The accumulation of technical knowledge promotes an endogenous and convergent growth.

We also find that the degree of openness enhances the TFP interdependencies while the specialisation of production may reduce the ability of an economy to take advantage from foreign productivity gains.

### 4.3 Effects of European integration

Results reported in table 4 draw some interesting features about channel of transmission of international spillovers. For European Countries, we still observe a positive impact of knowledge accumulation (measured par R&D capital stock) on the TFP interdependencies, this effect declines with the productivity gap between one country and its European partner. Then, we confirm the catch-up effect in productivity. Nevertheless, this result does not hold for extra-European countries. The effect of R&D capital stock on their sensibility to European productivity appears negative but insignificant. The interaction of R&D capital stock and the productivity gap is negative as expected, but its significance does not seem robust. Remaining results show that the effect of international trade and proximity of production
structure still have the expected sign on TFP interdependencies in both members and non members of the European Union. The size of effects is significantly different between the two groups of countries. On average, in the European Union, the degree of openness increases by 0.01 TFP interdependencies, while production specialisation reduces it by 1.17; these effects are about one tenth of those observed for non European countries.

Technological spillovers from the European Union tend to be absorbed by European countries thanks to their investment in R&D: productivity gaps tend to be reduced. Other OECD countries benefit from European productivity thanks to international trade. Absorption is easiest when countries face the same technology as EU countries. Surprisingly the EU enlargement of 1995 has a negative impact on productivity interdependencies. Actually, this result can be due to the fact that EU enlargements leads to an increase of the EU market size and heterogeneity: each country becomes less dependent of the remaining European partners.
Table 4: Effects of European integration

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<td>-0.24*</td>
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5 Conclusion

Among the huge amount of contributions dealing with determinants of international spillovers, the originality of the paper is twofold. First, we examine productivity co-movements country by country, rather than in an homogenous panel. Second, various channels of transmission of foreign productivity and their relative importance are investigated. We find strong evidence of cointegration between TFPs in each country and their European counterpart. Results also exhibit some differences in cointegrating coefficients across countries and over time. Explanatory models show that the stock of knowledge contribute to TFP interdependencies and lead to a convergence of productivity between country. This catch-up effect is
particularly important for EU Member-States. Extra-European countries also benefit from European productivity thanks to their participation to international trade, and their proximity to the European technology.
References


A Appendix

Figure 1: Box plot for $\beta^1$