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# INTEGRATION BRINGS CONVERGENCE? THE ROLE OF PUBLIC AND HUMAN CAPITAL

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## Abstract

This work decompose labor-productivity growth and convergence in EU into components attributable to technological change (shifts in the European production frontier), technological catch-up (movements toward or away from the frontier) and factor accumulation (movement toward or away from the frontier). This work extends previous researches considering public capital and human capital as additional productive inputs and analysing its separate contribution to convergence as components of factor accumulation. In the case of human capital, we also test its rate effect as determinant factor of technical change. With this purpose we applied the Malmquist index of total factor productivity to an European data base to provide evidence for the 15 EU State Members. The results show that growth is primarily driven by factor accumulation which contribution is fundamental for lagging countries. We do not find evidence of any significant convergence over the whole period studied related to integration with factor accumulation and efficiency change as important factors of convergence while technical change (encouraged by greater human capital) has worked against it.

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Key words: Human Capital, Malmquist Index, Source of Convergence.

JEL Classification: O47 H54 D24

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## 1. Introduction

Empirical growth evidence over the past 10 years has supplied new estimates of productivity growth rates, not by traditional growth accounting, but by a combination of two methods: the Malmquist index and nonparametric productivity measurement. Färe *et al.* (1994) pioneered this approach for OECD countries. Following their research, several studies have been carried out covering different country samples (Krüger *et al.*, 2002), considering additional productive factors (Henderson *et al.*, 2001, Maudos *et al.*, 2003) and establishing links with convergence literature (Kumar and Russell, 2002).

In this context, this paper targets the growth and convergence performance for the 15 EU State Members over the period 1980–2001 and extends previous results, considering public capital and human capital as separate productive inputs. We exploit labour productivity decomposition to test the implication of the level and rate effects on the convergence of human capital accumulation. In this study, we have used a homogeneous European database that covers our sample of countries and allows us to make estimates of public and private capital. We complete this set of information by measuring human capital on a cost-based method that emphasizes the differences in educational resources<sup>1</sup>.

The analytic framework is briefly explained in Section 2. Section 3 presents the database used and reports the results of the empirical analysis. Section 4 presents our conclusions.

## 2. The analytic framework

In this study, we decompose the growth and convergence of labour productivity ( $y$ ) into components attributable to technological change (*TECH*), technological catch-up (*EFF*) and factor accumulation (*KACCUM*)<sup>2</sup>:

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<sup>1</sup> See Wößmann (2003) for excellent surveys and a discussion of the different strands of the human capital literature, and drawbacks of the different measures.

<sup>2</sup> See e.g. Kumar and Russell (2002) for details of this tripartite decomposition of factors affecting labour productivity.

$$(y^{t+1}/y^t) = EFF \times TECH \times KACCUM = TFP \times KACCUM \quad (1)$$

This exercise can be quantified by using a nonparametric frontier function, determined by Data Envelopment Analysis (DEA)<sup>3</sup> and then tracking its changes over time using the decomposition of the Malmquist index of total factor productivity (TFP) provided by Färe *et al.* (1994)<sup>4</sup>.

Once the components of labour productivity growth are obtained, we centre on their relative contributions to convergence. We extend this analysis by decomposing capital deepening:

$$KACCUM_{it} = \frac{k_{it+1}}{k_{it}} + \frac{p_{it+1}}{p_{it}} + \frac{e_{it+1}}{e_{it}} + a_{it}, \quad (2)$$

where  $k$ ,  $p$  and  $e$  represent, respectively, the rates of growth of  $K/L$ ,  $P/L$  and  $E/L$ .

Additionally, we consider in this analysis the role of human capital as a factor determining the rate of technological change (rate effect):

$$TECH_{it} = \mathbf{a} + \mathbf{g} \cdot \log(E_{it}) + u_{it} \quad (3)$$

Following Serrano (1999), we will use the information obtained in (1), (2) and (3) to break down the parameter of  $\beta$ -convergence into its potential sources by running separate panel data estimations<sup>5</sup> of the contribution to convergence of each source on the initial labour productivity level ( $\log y_{i0}$ ):

$$SC_j = c_j + \mathbf{b}_j \log y_{i0} + v_j \quad (4)$$

$$j = 1, \dots, 11$$

$$SC_j = \frac{y_{it+1}}{y_{it}}, EFF_{it}, TECH_{it}, TFP_{it}, KACCUM_{it}, \frac{k_{it+1}}{k_{it}}, \frac{p_{it+1}}{p_{it}}, \frac{e_{it+1}}{e_{it}}, KACCUM_{it}^r, TECH_{it}^h, TECH_{it}^r$$

where:  $TECH^h$  is technological change determined by human capital,  $TECH^r$  is the residual  $TECH$  not explained by human capital and  $KACCUM^r$  is the residual input accumulation.

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<sup>3</sup> For overviews of the various DEA models see e.g. Seiford and Thrall (1994).

<sup>4</sup> We estimated the model using the program DEAP 2.1 (Coelli, 1996).

<sup>5</sup> The estimations have been carried out with the D.P.D. package, programmed by Arellano and Bond (1998).

### 3. Data and empirical results

We present the results of estimation equations 1–4 using data for the 15 EU State Members and considering five different periods: 1980–2001, 1980–1985, 1986–1992, 1993–1996 and 1997–2000. Most of the data used in this paper were taken from the NewCronos Database (Eurostat), which offers on CD-ROM information concerning the series of Gross Value Added (1990 PPS) ( $Y$ ), labour ( $L$ ) and investments by sectors. There are no capital stock data directly available. Public ( $P$ ) and private ( $K$ ) capital stocks were estimated from investment data (1990 PPS) available since at least 1970, in many cases since 1960, by the standard perpetual inventory method (PIM). Expenditure on education series (1960–2000) was taken from OECD publications. Human capital ( $E$ ) was calculated from educational expenditure, expressed in 1990 PPS and again using PIM<sup>6</sup>.

The decomposition of labour productivity growth<sup>7</sup> (Table 1) leads to results coherent with recent studies that show that productivity improvement was attributable to the intense rate of capital deepening. Two features should be remarked from the EU-15 analysis: the significant fluctuations in the speed of growth, and the productivity developments by countries. We find that in the core countries (Austria, Germany, Benelux and France), growth spurts were driven by TFP growth and capital deepening, both accounting for part of the growth, while in Portugal, Greece and Spain (the countries with the least developed cohesion), growth resulted primarily from input contributions. The Malmquist index of total factor productivity allows us to characterize the observed development patterns: the core countries were able to maintain their leading position with respect to the pace of technological progress. Besides, technological catch-up has benefited relatively countries close to the best-practice frontier function as much as relatively lagging countries which indicates difficulties to narrow the technological gap amongst them.

The accumulation of inputs (level effect) accounts for most of the increases in productivity.

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<sup>6</sup> See Alvarez and Delgado (2002) for a detailed explanation of the procedures for estimating public, private and human capital.

<sup>7</sup> For an empirical test of the significance of human capital and public capital in the DEA model, the Banker test (Banker, 1996) was used. It indicated that both capitals are statistically significant.

To understand the role of private, public and human capital, we estimate their contributions to capital deepening (Table 2). We confirm the importance of human capital to this process over the whole period. We also test human capital's contribution to increasing the rate of technological progress (rate effect). Table 3 shows that human capital has driven the rate of technological change. However, human capital does not seem to have maintained the same level of influence over the entire period<sup>8</sup>.

Table 4 summarizes the results obtained in the conditional convergence analysis. Differences in the value of  $\beta$  show that convergence among the EU State Members does not show a stable path. We cannot identify periods of any significant or rapid convergence, so that the average (1980–2001) shows no significant convergence. This points to the possibly indefinite persistence of European disparities. When we analyse the parameters of total convergence, we see that it is motivated by capital accumulation (private, public and human capital) and efficiency changes, while technological change, encouraged by greater human capital (rate effect), has worked against it. We also decompose capital accumulation's contribution to convergence, allowing us to confirm that human capital (the level effect) favoured convergence. It is important to note that there are signs that the effects of human capital accumulation on convergence are not maintained over time. The possibility of over-education in human capital and the significant contribution to capital accumulation of public capital drive divergence. Finally, in the last period, technological change (favoured by human capital) becomes the main source of convergence, possibly showing a slowdown in technological progress that makes it possible.

#### **4. Conclusions**

In this paper, we have analysed the implications for convergence of the level effect and rate effect of human capital accumulation, by using a European database which includes its own

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<sup>8</sup> Similar results are obtained with different proxies to human capital. This is interpreted as a reduction in the rate of return to schooling and seems related to the increasing problem of over-education (see e.g. Maudos *et al.*, 2003).

estimation of private, public and human capital. Our results are in accordance with recent research on human capital. These conclusions rely heavily on the measurement used for human capital, which can be controversial, but the sensible results obtained suggest that differences in educational resources offer an alternative proxy estimate for this stock.

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Table 1. Labour productivity Growth and Malmquist Index decomposition.

	TFP					TECH					EFF					KACCUM					Y/L Growth				
	80-01	80-85	86-92	93-96	97-01	80-01	80-85	86-92	93-96	97-01	80-01	80-85	86-92	93-96	97-01	80-01	80-85	86-92	93-96	97-01	80-01	80-85	86-92	93-96	97-01
Austria	1.010	0.998	1.007	1.006	1.039	1.010	0.995	1.008	1.017	1.007	1.001	1.003	0.999	0.989	1.032	1.015	1.023	1.016	1.017	0.998	1.025	1.021	1.023	1.023	1.037
Germany	1.000	0.993	1.009	0.972	1.034	1.003	1.010	1.014	0.993	0.975	0.997	0.983	0.995	0.978	1.061	1.013	0.999	0.992	1.047	1.030	1.013	0.992	1.001	1.019	1.064
Belgium	1.013	1.002	1.021	1.020	1.012	1.018	1.002	1.020	1.039	1.006	0.995	1.000	1.001	0.981	1.006	1.003	1.015	1.000	0.998	0.996	1.016	1.017	1.021	1.018	1.008
Spain	0.941	0.954	0.948	0.905	0.917	0.959	0.954	0.948	0.924	0.977	0.982	1.000	1.000	0.979	0.939	1.071	1.073	1.063	1.107	1.071	1.012	1.027	1.011	1.012	0.988
Finland	1.005	1.013	0.977	1.018	1.028	1.001	1.002	0.978	1.017	1.004	1.005	1.011	0.999	1.000	1.024	1.026	1.009	1.055	1.018	1.003	1.031	1.022	1.032	1.036	1.031
France	1.002	1.000	1.008	0.983	1.012	1.012	1.000	1.014	1.017	1.006	0.991	1.000	0.995	0.967	1.006	1.013	1.017	1.009	1.032	1.001	1.015	1.017	1.017	1.015	1.013
Greece	0.873	0.840	0.833	0.903	0.979	0.894	0.840	0.833	0.947	1.014	0.976	1.000	1.000	0.953	0.966	1.139	1.176	1.186	1.115	1.017	1.012	1.016	1.019	1.018	0.996
Ireland	0.988	0.941	1.002	1.031	0.988	0.988	0.941	1.002	1.031	0.988	1.000	1.000	1.000	1.000	1.000	1.048	1.099	1.042	1.026	1.012	1.036	1.040	1.044	1.057	1.000
Italy	0.975	0.934	0.980	0.994	0.995	0.983	0.934	0.980	1.024	1.005	0.992	1.000	1.000	0.970	0.991	1.036	1.078	1.035	1.027	0.998	1.011	1.012	1.015	1.021	0.993
Luxembourg	1.005	1.004	1.008	0.999	0.985	1.005	1.004	1.008	0.999	0.985	1.000	1.000	1.000	1.000	1.000	1.018	1.012	1.012	1.038	1.019	1.023	1.016	1.020	1.037	1.004
Netherlands	1.008	0.992	1.006	1.014	1.031	1.020	1.007	1.015	1.048	1.004	0.988	0.985	0.991	0.967	1.027	0.996	0.994	0.994	0.998	1.001	1.004	0.986	1.000	1.012	1.032
Portugal	0.899	0.912	0.889	0.896	0.859	0.932	0.912	0.889	0.908	0.992	0.965	1.000	1.000	0.987	0.866	1.123	1.098	1.142	1.163	1.125	1.022	1.010	1.031	1.059	0.984
Denmark	1.010	1.004	0.998	1.020	1.021	1.016	1.008	1.009	1.028	1.009	0.994	0.996	0.988	0.992	1.012	1.012	1.016	1.018	1.000	1.007	1.022	1.020	1.016	1.020	1.028
U. Kingdom	0.990	1.009	0.963	1.004	0.988	1.001	1.009	0.963	1.021	1.017	0.990	1.000	1.000	0.983	0.971	1.034	1.048	1.044	1.013	1.015	1.024	1.057	1.007	1.017	1.003
Sweden	0.951	0.951	0.949	0.956	0.960	0.949	0.941	0.949	0.941	0.960	1.003	1.011	1.000	1.016	1.000	1.072	1.067	1.066	1.091	1.058	1.023	1.018	1.015	1.047	1.018
15 EU	0.977	0.969	0.972	0.980	0.989	0.985	0.969	0.974	0.996	0.996	0.992	0.999	0.998	0.984	0.992	1.042	1.048	1.039	1.040	1.030	1.019	1.017	1.011	1.020	1.019

NOTE: Subtracting unity from the table values gives annual growth rates.

Table 2. Inputs Contribution to Capital Accumulation. Fixed effects model.

	1980–2001	1980–1985	1986–1992	1993–1996	1997–2001
Growth K/L	0.36 (4.45)	0.15 (0.71)	0.302 (2.96)	0.95 (6.88)	-0.17 (-0.16)
Growth P/L	0.094 (1.55)	0.078 (0.61)	0.19 (1.94)	-0.0056 (-0.19)	-0.12 (-0.405)
Growth E/L	0.18 (7.58)	0.15 (2.78)	0.26 (7.56)	0.26 (14.41)	0.49 (0.84)
Wald Test Sig.	183.82 (D.F.=3)	50.89 (D.F.=3)	175.96 (D.F.=3)	386.27 (D.F.=3)	4.12 (D.F.=3)

D.F. = degree of freedom. T-statistics in brackets.

Note: The dependent variable (KACCUM) is the growth rate of input contribution.

Table 3. Effect of Human Capital on annual rate of Technological Change. Fixed effects model.

	1980–2001	1980–1985	1986–1992	1993–1996	1997–2001
Ln( $E_{it}$ )	0.014 (5.57)	0.016 (2.29)	-0.059 (-3.78)	-0.0083 (-0.22)	0.11 (3.78)
Wald Test Sig.	30.99 (D.F.=1)	5.022 (D.F.=1)	14.31 (D.F.=1)	0.047 (D.F.=1)	14.29 (D.F.=1)

D.F. = degree of freedom. T-statistics in brackets.

Table 4. Labour Productivity Convergence and its components. Fixed effects model.

Period	Y/L	EFF	TECH	TECH <sup>a</sup>	TECH <sup>r</sup>	TFP	KACCUM	K/L	P/L	E/L	KACCUM <sup>r</sup>
	$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	$\beta_7$	$\beta_8$	$\beta_9$	$\beta_{10}$	$\beta_{11}$
1980–2001	-0.0051	-0.032	0.076	0.0011	0.075	0.041	-0.047	-0.017	-0.0044	-0.0084	-0.017
	(-0.34)	(-1.84)	(3.55)	(3.56)	(3.55)	(2.067)	(-2.78)	(-2.78)	(-2.78)	(-2.78)	(-2.78)
	W = 27.41	W = 3.38	W = 12.61	W = 12.67	W = 12.61	W = 4.28	W = 7.72	W = 7.73	W = 7.73	W = 7.71	W = 7.72
1980–1985	-0.076	-0.041	0.18	0.0029	0.17	0.13	-0.21	-0.031	-0.016	-0.031	-0.13
	(-0.72)	(-0.57)	(1.504)	(1.51)	(1.504)	(1.14)	(-3.24)	(-3.23)	(-3.23)	(-3.23)	(-3.24)
	W = 0.51	W = 0.33	W = 2.26	W = 2.29	W = 2.26	W = 1.29	W = 10.48	W = 10.46	W = 10.46	W = 10.46	W = 10.47
1986–1992	-0.13	0.21	-0.703	-	-	-0.49	0.36	0.11	0.069	0.095	0.0903
	(-2.301)	(2.25)	(-5.41)	-	-	(-4.66)	(3.36)	(3.35)	(3.36)	(3.35)	(3.35)
	W = 5.29	W = 5.082	W = 29.28	-	-	W = 21.73	W = 11.27	W = 11.25	W = 11.26	W = 11.25	W = 11.25
1993–1996	-0.013	1.066	-1.45	-	-	-0.35	0.33	-	-	-	-
	(-0.55)	(15.84)	(-20.93)	-	-	(-18.97)	(11.16)	-	-	-	-
	W = 0.29	W = 250.85	W = 437.87	-	-	W = 359.74	W = 124.47	-	-	-	-
1997–2001	-0.35	0.44	-0.63	-0.069	-0.56	-0.19	-0.16	-	-	-	-
	(-3.12)	(2.62)	(-4.34)	(-4.34)	(-4.34)	(-1.086)	(-1.25)	-	-	-	-
	W = 9.73	W = 6.88	W = 18.84	W = 18.81	W = 18.85	W = 1.18	W = 1.56	-	-	-	-

Note:  $\beta_1 = \beta_6 + \beta_7$ ;  $\beta_6 = \beta_2 + \beta_3$ ;  $\beta_3 = \beta_4 + \beta_5$ ;  $\beta_7 = \beta_8 + \beta_9 + \beta_{10} + \beta_{11}$

W = Wald test of joint significance.



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