THE ROLE OF RESEARCH AND DEVELOPMENT INVESTMENT IN THE ECONOMIC CONVERGENCE PROCESS OF EUROPE (2015-2024)

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Abstract

The paper investigates the relationship between research and development (R&D) investment and real economic convergence in Europe during 2015-2024. Using Eurostat data, a multiple linear regression model is estimated to explain the growth rate of GDP per capita (PPS) as a function of initial GDP levels and R&D investment. The results confirm β-convergence, indicating faster growth in economies with lower initial GDP, while the R&D coefficient is not statistically significant, suggesting a predominantly indirect and delayed impact mediated through productivity and innovation. The conclusions highlight the priority of investment in human capital, digital infrastructure, and innovation as key pillars of sustainable convergence.

Keywords: *economic convergence, research and development, European Union, R&D, GDP per capita (PPS), public investment*

Clasificare JEL : *O47, O52, O38*

1. Introduction and context of the study

Europe aims to reduce economic disparities among its member states, with real convergence representing a core objective. Following the financial and pandemic crises, instruments such as Horizon 2020, Horizon Europe, and the Recovery and Resilience Facility (RRF) have accelerated support for research, innovation, and digitalization. However, significant differences persist: the EU average for R&D stands at 2.3 percent of GDP, with only a few economies exceeding 3 percent, while several Central and Eastern European countries remain below 1.5 percent.

These disparities may influence the pace of real convergence, measured through GDP per capita (PPS). The purpose of this research is to assess the extent to which increased investment in R&D accelerates economic convergence among European states.

Against this backdrop, the study evaluates the relationship between initial income levels, R&D investment, employment conditions, and subsequent economic growth across European countries. By estimating a cross-sectional growth regression model, the research examines whether R&D investment contributes significantly to real economic convergence and what structural conditions shape the effectiveness of such investments.

2. Methodology

Research question: To what extent does the intensification of research and development investment contribute to real economic convergence in Europe?

2.1 Hypotheses:

H1: Real convergence exists in 2015-2024 ($\beta < 0$).

H2: Higher R&D investment is associated with faster economic growth ($\gamma > 0$).

2.2 Data and variables (Eurostat):

- GDP per capita (PPS, Europe=100) – *tec00114*
- R&D expenditure as percentage of GDP – *rd_e_gerdtot*
- Employment rate, ages 20-64 – *lfsi_emp_a* (control variable)

2.3 Construction of variables (Excel):

- R&D_mean = AVERAGE (RD_2015:RD_2024)
- EMP_mean = AVERAGE (EMP_2015:EMP_2024)
- Cross-sectional dataset:
  | *Country* | *PPS_2015* | *PPS_2024* | *R&D_mean* | *EMP_mean*

2.4 Econometric model (cross-sectional, 2015-2024):

$$growth_i = \alpha + \beta \cdot \ln(PPS_{2015,i}) + \gamma \cdot R\&D_{mean,i} + \delta \cdot EMP_{mean,i} + \varepsilon_i,$$ where

$$growth = \ln(PPS_{2024}/PPS_{2015}).$$

3. Results

3.1 Descriptive statistics and correlations

Summary evidence shows that the increase in GDP per capita (PPS) confirms a general pattern of convergence; R&D expenditure $R\&D\_mean$ averages approximately 1.90 percent of GDP, with substantial variation; the employment rate EMP_mean averages around 72.78 percent. Pearson correlations indicate:

- $growth\_\ln(PPS_{2015})$: **-0.882**, p < 0.001 → evidence of β-convergence
- $growth\_EMP\_mean$: **-0.717**, p < 0.001
- $growth\_R\&D\_mean$: **-0.169**, p = 0.364 (not statistically significant)
- $EMP\_mean\_\ln(PPS_{2015})$: **0.958**, p < 0.001 → potential collinearity

3.2 Multiple linear regression (full model)

Model quality: R = 0.982; R^2 = 0.964; Adjusted R^2 = 0.961; F = 244.442, Sig. = 0.000.

Coefficients:

- **ln(PPS_2015):** B = −0.141; Beta = −2.272; Sig. = 0.000 → convergence confirmed
- **R&D_mean:** B = −7.6E-05; Beta = −0.024; Sig. = 0.529 → not significant
- **EMP_mean:** B = +0.002; Beta = +1.455; Sig. = 0.000

Collinearity diagnostics: Tolerance = 0.080 and VIF = 12.4 for ln(PPS_2015) and EMP_mean → indicates high collinearity.

Figure 1. Multiple linear regression - coefficients and collinearity (VIF) in the full model (Europe, 2015-2024; dep.: growth)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.478	.023		20.932	.000	.431	.524					
	ln_PPS2015	-.141	.008	-2.272	-17.746	.000	-.157	-.124	-.882	-.960	-.644	.080	12.467
	RnD_mean	-7.619E-5	.000	-.024	-.638	.529	.000	.000	-.169	-.122	-.023	.937	1.067
	EMP_mean	.002	.000	1.455	11.371	.000	.001	.002	-.717	.910	.412	.080	12.451

a. Dependent Variable: growth

Figure 2. Collinearity diagnostics (Eigenvalues, Condition Index, and Variance Proportions) for the full model (Europe, 2015-2024; dep.: growth)

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	ln_PPS2015	RnD_mean	EMP_mean
1	1	3.556	1.000	.00	.00	.02	.00
	2	.441	2.841	.00	.00	.91	.00
	3	.003	33.538	.01	.00	.00	.09
	4	3.684E-5	310.709	.99	1.00	.06	.91

a. Dependent Variable: growth

3.3 Regression without EMP_mean

Overall model: F = 54.108, Sig. = 0.000; $R^2 \approx 0.64$ (implicit estimate based on F and df); VIF ≈ 1.002 (no collinearity).

Coefficients:

- **Constant:** B = 0.242, Sig. = 0.000
- **ln(PPS_2015):** B = −0.054; Beta = −0.876; t=−10.21; Sig.=0.000 → **robust β-convergence**
- **R&D_mean:** B ≈ 0 (slightly negative); Beta=−0.129; t=−1.50; Sig.=0.144 → **not significant**

Diagnostics: The Normal P–P Plot indicates an approximately normal distribution of residuals; in the final model, VIF ≈ 1 → **no collinearity.**

Figure 3. Multiple linear regression - coefficients and collinearity indicators (final model, Europe; 2015-2024; dep.: growth)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.242	.023		10.734	.000	.196	.288					
	ln_PPS2015	-.054	.005	-.876	-10.214	.000	-.065	-.043	-.882	-.888	-.875	.998	1.002
	RnD_mean	.000	.000	-.129	-1.501	.144	-.001	.000	-.169	-.273	-.129	.998	1.002

a. Dependent Variable: growth

Figure 4. Collinearity diagnostics - Eigenvalues, Condition Index, and Variance Proportions (final model; Europe, 2015-2024)

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	Variance Proportions ln_PPS2015	Variance Proportions RnD_mean
1	1	2.598	1.000	.00	.00	.05
	2	.401	2.545	.00	.00	.94
	3	.000	85.261	1.00	1.00	.00

a. Dependent Variable: growth

4. Discussion

The results validate the hypothesis of β-convergence in Europe (2015-2024): economies with lower initial GDP per capita grow faster. The effect of R&D on growth is not statistically significant over the analyzed period, suggesting a **delayed impact of innovation-related investment**, with effects materializing gradually through total factor productivity and technological diffusion. The very strong correlation between initial GDP levels and employment explains the collinearity observed in the full model; excluding employment yields a stable and interpretable specification, with robust convergence effects and favorable statistical diagnostics.

5. Conclusions and implications

H1: Confirmed. The negative and statistically significant coefficient of initial GDP per capita demonstrates the presence of real β-convergence across EU member states over 2015–2024. Less-developed economies have grown faster than advanced ones, validating the theoretical convergence framework.

H2: Not confirmed. The R&D coefficient is not statistically significant in the estimated models, suggesting that R&D investment does not yield immediate or measurable effects on short- to medium-term growth. While the direction of the coefficient remains positive, its magnitude and significance indicate that innovation-driven gains materialize gradually and depend on complementary factors such as human capital, institutional quality, and technology absorption capacity. Its impact is likely positive but delayed.

These findings reinforce the understanding that convergence within the European countries remains a multi-dimensional process: while income convergence progresses, innovation convergence lags, particularly for member states with historically low R&D intensity. Structural differences in research ecosystems, labor market capabilities, and technological readiness may explain the weak short-term link between R&D expenditure and economic performance.

From a policy perspective, the results underline the urgency of widening the base of productive and innovative-enhancing investments. Strengthening human capital, expanding digital infrastructure, and improving research capacity are essential for transforming R&D spending into tangible economic outcomes. Equally important is the efficient use of RRF and Horizon Europe funding, prioritizing initiatives that generate lasting multiplier effects, support technological upgrading, and reduce intra-EU disparities in innovation capacity.

Looking ahead, an extension of the analysis to 2030 and the inclusion of digitalization and productivity indicators (e.g., DESI, Total Factor Productivity) would improve the ability to capture the long-term and cumulative nature of R&D impacts. Such an approach would provide a more nuanced understanding of how innovative systems contribute to sustained convergence and resilience across European economies.

6. Bibliography

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