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PD Dr. Felix Roth

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EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth

by

Felix Roth and **Alessio Mitra**

Abstract

The European Union (EU) faces challenges such as an ageing population, migratory pressures, geopolitical vulnerabilities, and climate change, highlighting the need to enhance its ability to do more with less. This paper examines the drivers of EU labour productivity before and after the 2007 financial crisis, across goods and services sectors, tangible and intangible assets, and Information and Communication Technologies (ICT) and non-ICT tangibles. Using the EUKLEMS 2022 dataset for 14 EU countries and the UK from 1995-2019 and growth regression analysis, we find that Research & Innovation (R&I) is crucial for productivity growth. Labour productivity in the goods sector benefits most from non-ICT tangible assets, while in the service sector, it benefits more from the non-R&D intangibles software, training, and organisational capital. On the other hand, training and ICT tangibles became more important drivers of labor productivity growth after the economic crisis. We argue that the productivity gap between the EU and the United States is largely due to insufficient investment in non-R&D intangibles like software, training, and organizational capital.

Introduction

- The EU faces challenges for its competitiveness: an ageing population which puts pressure on the European social model, and migratory pressures, fueled by geopolitical unrest and climate-change induced natural disaster.
- Productivity growth becomes increasingly relevant to address these challenges, particularly in the service sector, where there exists a significant untapped potential compared to its transatlantic counterpart, the United States.
- This paper seeks to dissect and understand the multifaceted drivers behind EU labour productivity, offering insights into the pathways through which the EU can bolster its labour productivity growth.
- The paper explores the evolution over time of the contribution of different intangible assets (software, R&D, training, organisational capital), and tangible (ICT tangible and non-ICT tangible) towards labour productivity growth across the EU.

Literature Review

- There has been a slowdown in LPG in both the EA and the US from 1950 to 2022 (EC 2024).
- Potential reasons for this include low rates of technological adoption, with a few leading firms advancing the technological frontier, due to superiority in firm-specific human and organisational capital (Pilat 2005; Arvanitis 2004; Maliranta and Rouvinen 2004, EC 2022).
- EU faces a growing productivity gap with the US, due to i) a middle-technology trap (Fuest, C, et al. 2024), ii) a structural and intrinsic difference in R&D investment (Draghi 2024), iii) and differences in how the EU and the US manage their intangible assets (Van Ark et al. 2008).
- Many cross-country sectoral econometric analyses on intangible capital and LPG present mixed results (Roth and Thum 2013, Roth 2020, 2024, Corrado et al. 2016, Adarov and Stehrer 2019) due to differences in research design, methodology and datasets (see here Roth 2024, 2025).
- We contribute to the above mentioned literature, by i) introducing a novel model specification and targeting four distinct intangibles, ii) expanding our sample to include the EU14+UK from 1995 to 2019, and iii) distinguishing between a before and after the 2008 economic crisis sample.

Model Specification

We use the following Model specification:

$$(\ln q_{c,j,t} - \ln q_{c,j,t-1}) = \alpha(\ln kict_{c,j,t} - \ln kict_{c,j,t-1}) + \beta(\ln knict_{c,j,t} - \ln knict_{c,j,t-1}) +$$
$$\gamma(lnrd_{c,j,t} - lnrd_{c,j,t-1}) + \lambda(lnso_{c,j,t} - lnso_{c,j,t-1}) + \zeta(lnoc_{c,j,t} - lnoc_{c,j,t-1}) + \iota(lntr_{c,j,t} - lntr_{c,j,t-1}) +$$
$$c + gH_{c,t} + mH_{c,t}\frac{(q_{max.t} - q_{c,t})}{q_{c,t}} + n(1 - ur_{c,t}) + \mathrm{p}\sum_{i=1}^{k} X_{i,c,t} + \mu_t + u_{c,j,t} \qquad (6)$$

where $(\ln q_{c,j,t} - \ln q_{c,j,t-1})$ is labour productivity growth, $(\ln kict_{c,j,t} - \ln kict_{c,j,t-1})$ is tangible ICT capital, $(\ln knict_{c,j,t} - \ln knict_{c,j,t-1})$ is tangible non-ICT capital, $(lnrd_{c,j,t} - lnrd_{c,j,t-1})$ is research and development, $(lnso_{c,j,t} - lnso_{c,j,t-1})$ is software and databases $(lnoc_{c,j,t} - lnoc_{c,j,t-1})$ is organizational capital and $(lntr_{c,j,t} - lntr_{c,j,t-1})$ vocational training services growth, c captures a constant, $H_{c,t}$ resembles Human Capital and captures the innovation capacity, $H_{c,t}\frac{(q_{max.t} - q_{c,t})}{q_{c,t}}$ represents a catch-up term, the term $(1 - ur_{c,t})$ resembles 1-unemployment rate and accounts for business cycles and $X_{i,c,t}$ refers to control variables *i* that might affect TFP growth in a country at time t. μ_t are time-fixed effects. $u_{c,j,t}$ is the error term.

Data

This paper uses the most recent harmonized EUKLEMS/INTANProd 2022 data (Bontadini et al. 2023):

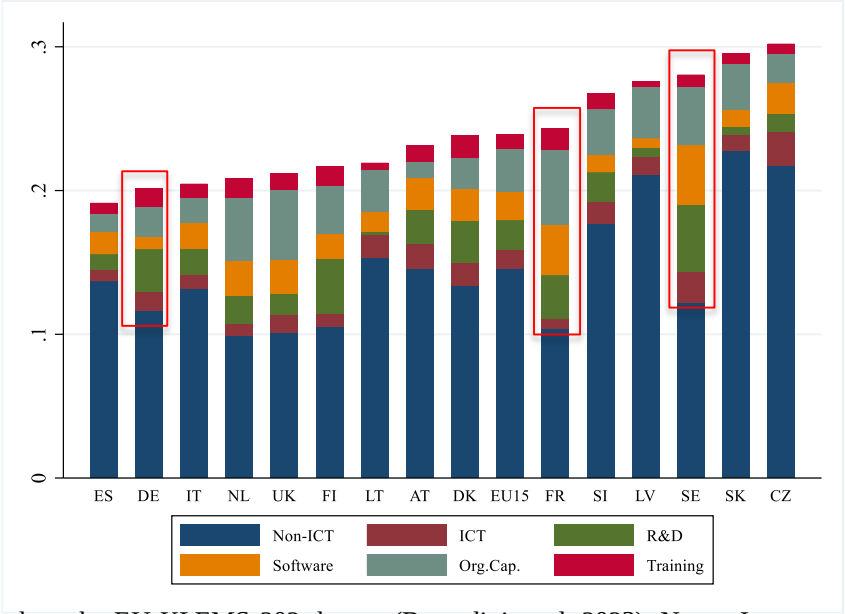
- Labour productivity growth is measured as real value added at con. 2015 prices divided by labour, which is measured as total hours worked by the number of people employed.
- Tangible ICT capital includes computing equipment (IT) and communications equipment (CT).
- Tangible Non-ICT capital includes transport equipment (TraEq), other machinery and equipment (OMach), and total non-residential investment (OCon).
- Intangible capital includes NA-intangibles: Computer Software and Research and Development and non-NA intangibles, but important complementary investment: Organizational Capital and Training.
- Analysis approximates human capital as educational attainment at the upper-secondary level and business cycles as the unemployment rate subtracted from one. The data are obtained from Eurostat.

Research Design

- 14 EU-27 countries (Austria, Czech Rep., Denmark, Finland, France, Germany, Italy, Latvia, Lithuania, Netherlands, Slovakia, Slovenia, Spain, Sweden) and the UK over 1995-2019.
- Market economy sectors: Agriculture, forestry, and fishing (A); Mining and quarrying (B); Total manufacturing (C); Electricity, gas, steam and air conditioning supply (D); Water supply; sewerage; waste management and remediation activities (E); Construction (F); Wholesale and retail trade (G); Transportation and storage (H); Accommodation and food service activities (I); Information and communication (J); Financial and insurance activities (K); Professional, scientific and technical activities (M), Administrative and support service activities (N); Arts, entertainment, and recreation (R); and Other service activities (S).
- Paper differentiates between the goods-producing (A-F) and market service sectors (G-K, M-N, R-S).

Descriptive Results

Figure 1. Business Capital Investment Rates, EU14 + UK, 1995-2019

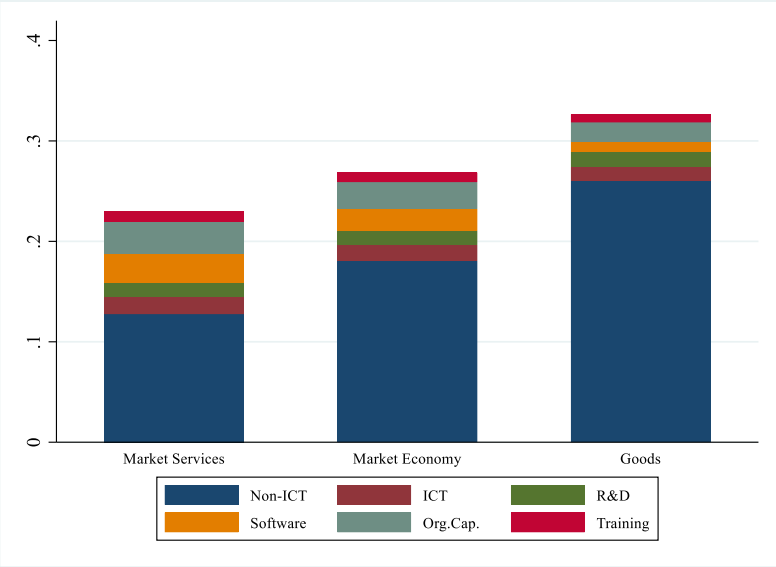


Sources: Author's own estimation based on the EU KLEMS 202 dataset (Bontadini et al. 2023). Notes: Investment rates are in percentage of VA and are obtained by dividing tangible and intangible investments by total value added in the business sector, excluding real estate. Investment rates represent time averages for each country. ICT= Information and Communication Technologies. R&D = Research and Development. OrgCap = Organisational Capital.

Reference: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.

Descriptive Results

Figure 2. Business Capital Investment Rates across broad sectors, EU14 + UK, 1995-2019

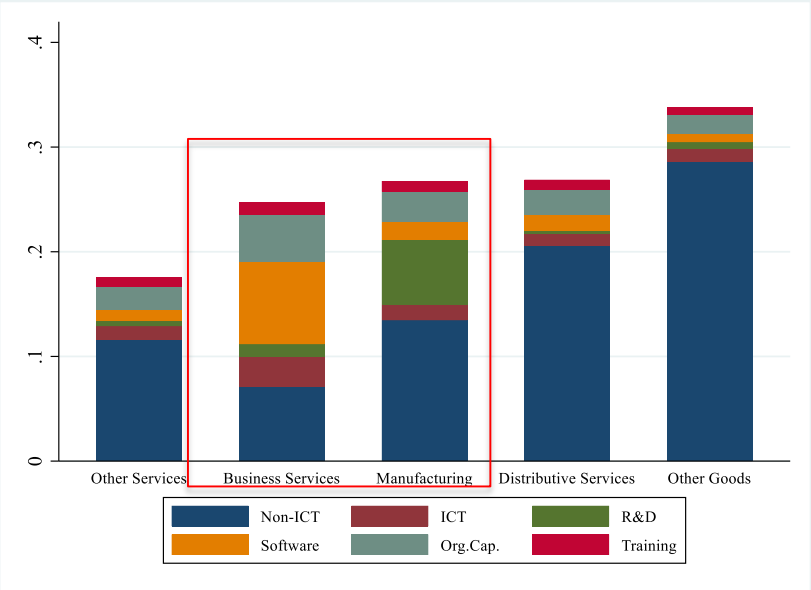


Sources: Author's own estimation based on the EU KLEMS 2022 dataset (Bontadini et al. 2023). Notes: Investment rates are in percentage of VA and are obtained by dividing capital investments by the total value added of sectors. Investment rates represent average values across countries and years from 1995-2019. ICT= Information and Communication Technologies. R&D = Research and Development. OrgCap = Organisational Capital.

Reference: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.

Descriptive Results

Figure A1. Business Capital Investment Rates across sub-sectors, EU14 + UK, 1995-2019

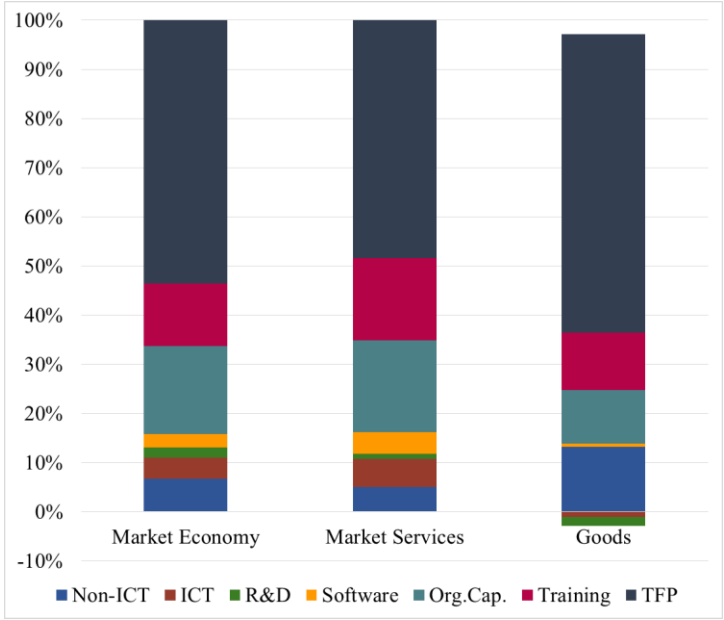


Sources: Author's own estimation based on the EU KLEMS 2022 dataset (Bontadini et al. 2023). Notes: Investment rates are in percentage of VA and are obtained by dividing capital investments by the total value added of sectors. Investment rates represent average values across countries and years from 1995-2019. ICT= Information and Communication Technologies. R&D = Research and Development. OrgCap = Organisational Capital.

Source: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.

Descriptive Results

Figure 3. Cross-country sectoral growth accounting results across broad sectors, EU14 + UK, 1995-2019

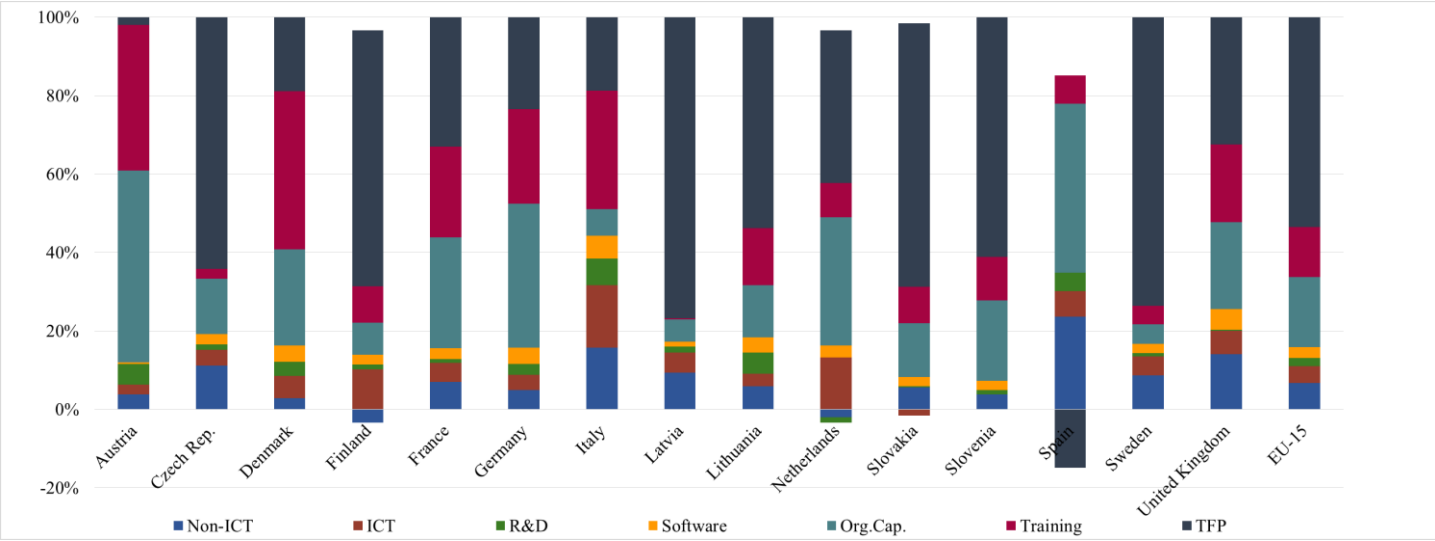


Sources: Author's own estimation based on the EU KLEMS 2022 dataset (Bontadini et al. 2023) and Eurostat. Notes: The figure is based upon the econometric results of regressions 1-3 in Table 1. ICT=Information and Communication technology. R&D=Research and Development. OrgCap=Organisational Capital. TFP= Total Factor Productivity.

Reference: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.

Descriptive Results

Figure 4. Cross-country sectoral growth accounting results across individual countries, Market Economy, EU-14 + UK, 1995-2019.



Sources: Author's own estimation based on the EU KLEMS 2022 dataset (Bontadini et al. 2023) and Eurostat. Notes: The figure is based upon the econometric results of regressions 1 in Table 1. ICT=Information and Communication Technology. R&D=Research and Development. OrgCap=Organisational Capital. TFP= Total Factor Productivity.

Reference: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.

Econometric Results

Table 1. Tangibles, Intangibles and Labor Productivity Growth, System GMM Estimation at the Sectoral Level, EU 14 + UK, 1995-2019

	(1) FS ME	(2) FS Services	(3) FS Goods	(4) BC ME	(5) BC Services	(6) BC Goods	(7) AC ME	(8) AC Services	(9) AC Goods
ICT Capital	0.021*	0.028**	-0.0055	0.027*	0.013	0.025	0.021	0.043***	-0.027
	(1.93)	(2.03)	(-0.28)	(1.89)	(0.70)	(1.48)	(1.39)	(3.01)	(-0.89)
Non-ICT Capital	0.12***	0.088**	0.25***	0.11	0.078	0.30***	0.11**	0.074	0.10
	(2.67)	(2.10)	(2.71)	(1.65)	(1.11)	(2.82)	(2.30)	(1.30)	(1.11)
Research & Development	0.017	0.0092	-0.016	0.021	0.023	0.0034	0.016	0.011	0.0057
	(1.11)	(0.57)	(-0.36)	(0.91)	(0.79)	(0.06)	(0.80)	(0.51)	(0.09)
Software & Databases	0.032*	0.050***	0.0083	0.054**	0.057***	0.094**	-0.0012	0.061**	-0.031
	(1.76)	(3.00)	(0.20)	(2.52)	(3.07)	(2.21)	(-0.05)	(2.30)	(-0.65)
Organizational Capital	0.18***	0.18***	0.11	0.31***	0.34***	0.16*	0.12***	0.14***	0.12
	(4.74)	(5.43)	(1.34)	(3.92)	(3.00)	(1.94)	(3.34)	(3.49)	(1.40)
Vocational Training	0.15***	0.20***	0.15*	0.11*	0.13	0.00025	0.15***	0.17***	0.17**
	(4.89)	(4.97)	(1.89)	(1.82)	(1.65)	(0.00)	(4.19)	(3.19)	(2.36)
Upper-Secondary Education	0.0010**	0.00083	0.0015*	0.00061**	0.00061*	0.00064	0.0014**	0.0012	0.0023
	(2.52)	(1.42)	(1.73)	(2.13)	(1.70)	(1.26)	(2.06)	(1.47)	(1.54)
Catchup	-0.00027	-0.00042	-0.000082	-0.000010	-0.000083	0.00030	-0.00017	-0.00037	-0.00052
	(-1.30)	(-1.33)	(-0.16)	(-0.05)	(-0.33)	(0.77)	(-0.44)	(-0.78)	(-0.66)
Business Cycle	-0.20***	-0.20*	-0.56***	-0.15	-0.14	-0.34	-0.29**	-0.22	-0.59**
	(-2.84)	(-1.87)	(-3.05)	(-1.51)	(-0.98)	(-1.16)	(-2.26)	(-1.63)	(-2.31)
First-Lag Instruments	1 15	1 5	1 5	1 8	1 5	1 2	1 10	1 4	1 5
No. Of instruments	168	78	78	104	77	46	112	58	67
AB Test AR(2)	0.36	0.10	0.65	0.85	0.35	0.01	0.37	0.09	0.53
Hansen Test	0.20	0.22	0.29	0.22	0.30	0.17	0.20	0.28	0.18
N Sectors	196	126	70	162	107	55	196	126	70
Time Series	23	23	23	11	11	11	12	12	12
Observations N x T	3696	2415	1281	1584	1045	539	2112	1370	742

Sources: Authors' own estimations based on the EU KLEMS 2022 dataset (Bontadini et al. 2023) and Eurostat. Notes: ***p < 0.01, **p < 0.05, *p < 0.1. Numbers in parentheses are t-ratios. Time dummies are included in every specification. Specification choices include the usage of a collapsed instrument set, orthogonal deviations, small-sample corrections, two-step estimation, and Windmeijr-corrected cluster-robust errors.

Reference: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.

Econometric Results

Table B1. Tangibles, Intangibles and Labor Productivity Growth, Fixed-Effects Estimation at the Sectoral Level, EU 14 + UK, 1995-2019

	1 FS ME	2 FS Services	3 FS Goods	4 BC ME	5 BC Services	6 BC Goods	7 AC ME	8 AC Services	9 AC Goods
ICT Capital	0.023**	0.030**	0.0089	0.024	0.0034	0.039**	0.019	0.039**	-0.012
	(2.20)	(2.33)	(0.55)	(1.51)	(0.14)	(2.01)	(1.19)	(2.41)	(-0.47)
Non-ICT Capital	0.11***	0.075**	0.21***	0.064	0.042	0.25*	0.13***	0.10**	0.19*
	(2.70)	(2.03)	(2.79)	(1.20)	(0.95)	(1.96)	(2.89)	(2.30)	(1.83)
Research & Development	0.031**	0.030**	0.022	0.020	0.032*	-0.061	0.038**	0.031*	0.052
	(2.57)	(2.47)	(0.70)	(1.09)	(1.88)	(-1.07)	(2.23)	(1.92)	(1.12)
Software & Databases	0.040***	0.042***	0.035	0.039**	0.032*	0.050	0.020	0.026	0.0055
	(2.74)	(3.04)	(1.15)	(2.30)	(1.81)	(1.40)	(0.87)	(1.11)	(0.13)
Organizational Capital	0.18***	0.21***	0.13**	0.33***	0.39***	0.14	0.16***	0.17***	0.14*
	(5.94)	(6.11)	(2.34)	(4.41)	(4.54)	(1.08)	(4.29)	(5.13)	(1.84)
Vocational Training	0.13***	0.17***	0.073*	0.17***	0.18***	0.15	0.097***	0.13***	0.044
	(5.58)	(5.50)	(1.73)	(3.06)	(2.81)	(1.41)	(2.71)	(2.80)	(0.74)
Upper Secondary Education	0.00052	0.00043	0.00092	0.00038	0.0011	-0.00061	0.0013	-0.00086	0.0046
	(1.10)	(0.88)	(0.88)	(0.44)	(1.15)	(-0.35)	(0.92)	(-0.61)	(1.51)
Catchup	-0.00047**	-0.00059**	-0.00027	-0.00036	-0.00044	-0.00017	-0.0015***	-0.0015***	-0.0016**
	(-2.49)	(-2.47)	(-0.86)	(-1.25)	(-1.13)	(-0.49)	(-4.53)	(-4.40)	(-2.18)
Business Cycle	-0.16***	-0.12*	-0.19	-0.087	-0.17	0.081	-0.13	-0.054	-0.28
	(-2.60)	(-1.68)	(-1.55)	(-0.83)	(-1.37)	(0.42)	(-1.21)	(-0.70)	(-1.03)
R-squared	0.16	0.19	0.16	0.2	0.24	0.12	0.07	0.07	0.13
N Sectors	196	126	70	162	107	55	196	126	70
Time Series	23	23	23	11	11	11	12	12	12
Observations N x T	3696	2415	1281	1584	1045	539	2112	1370	742

Sources: Authors' own estimations based on the EU KLEMS 2022 dataset (Bontadini et al. 2023) and Eurostat. Notes: ***p < 0.01, **p < 0.05, *p < 0.1. Numbers in parentheses are t-ratios. Time dummies are included in every specification.

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Econometric Results

Table B2. Tangibles, Intangibles and Labor Productivity Growth, Fixed-Effects Estimation, Manufacturing Sector, EU 14 + UK and EU9 + UK, 1995-2019

	(1) EU14+UK Manuf. 1-D	(2) EU14+UK Manuf. 2-D	(3) EU14+UK High-Tech.	(4) EU14+UK Med.-Tech.	(5) EU14+UK Low-Tech.	(6) EU9+UK Manuf. 1-D	(7) EU9+UK Manuf. 2-D	(8) EU9+UK High-Tech.	(9) EU9+UK Med.-Tech.	(10) EU9+UK Low-Tech.
ICT Capital	-0.024**	0.00056	0.00041	-0.097	0.022	0.00087	0.00057	0.00032	-0.19	0.0019
	(-2.62)	(1.43)	(1.12)	(-0.91)	(1.16)	(0.04)	(1.37)	(0.91)	(-1.41)	(0.06)
Non-ICT Capital	0.11	0.30	0.10	0.59***	0.015	0.19	0.42*	0.13	0.66***	0.18**
	(1.02)	(1.65)	(1.22)	(3.15)	(0.14)	(1.47)	(1.98)	(1.09)	(4.31)	(2.25)
Research & Development	0.069*	0.018	0.0041	0.022	0.093**	0.18***	0.058	0.17***	0.027	0.095***
	(1.82)	(0.30)	(0.04)	(0.20)	(2.37)	(4.11)	(1.05)	(3.38)	(0.18)	(3.81)
Software & Databases	0.021	-0.020	0.029	-0.038	-0.040	-0.019	-0.033	0.0075	-0.0099	-0.020
	(0.75)	(-0.76)	(1.06)	(-0.54)	(-1.34)	(-1.08)	(-0.93)	(0.22)	(-0.11)	(-1.11)
Organizational Capital	0.068	0.21**	0.15	0.47*	0.085	-0.050	0.11	-0.044	0.53*	-0.022
	(1.11)	(2.40)	(1.26)	(1.94)	(1.15)	(-0.59)	(1.37)	(-0.46)	(1.99)	(-0.61)
Vocational Training	0.040	0.089	0.20	-0.077	0.22*	0.013	0.057	0.27**	-0.14	0.011
	(0.64)	(0.86)	(1.58)	(-0.38)	(2.02)	(0.17)	(0.47)	(2.38)	(-0.62)	(0.12)
Secondary Education	-0.00093	-0.0014**	-0.0014	-0.0028	-0.0014*	-0.00065	-0.0013**	-0.0018**	-0.0030	-0.0011*
	(-0.94)	(-2.42)	(-1.53)	(-1.46)	(-1.86)	(-0.97)	(-2.24)	(-2.26)	(-1.40)	(-1.86)
Catchup	-0.00023	-0.0000020	-0.000030	-0.0000056	0.000087***	-0.00020	-0.0000037	-0.00015	-0.0000073	0.000078***
	(-0.80)	(-0.11)	(-0.78)	(-0.44)	(3.93)	(-0.30)	(-0.19)	(-1.65)	(-0.64)	(3.86)
Business Cycle	-0.36***	-0.35***	-0.43***	-0.35**	-0.084	-0.24**	-0.30***	-0.36***	-0.29**	-0.025
	(-3.20)	(-4.13)	(-3.04)	(-2.51)	(-0.91)	(-2.90)	(-3.34)	(-3.01)	(-2.19)	(-0.27)
R-Squared	0.25	0.07	0.09	0.09	0.06	0.34	0.07	0.08	0.10	0.05
N Sectors	15	124	55	27	31	10	102	45	23	25
Time Series	23	23	23	23	23	23	23	23	23	23
N	328	2553	1122	559	636	230	2192	950	494	552

Sources: Authors' own estimations based on the EU KLEMS 2022 dataset (Bontadini et al. 2023) and Eurostat. Notes: ***p < 0.01, **p < 0.05, *p < 0.1. Numbers in parentheses are t-ratios. Time dummies are included in every specification. Manuf.=Manufacturing. D.=Digits. Tech.=Technology. Med.=Medium.

Source: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.

Discussion

- First, we find that non-ICT investments of tangible capital (transport equipment, other machinery, and non-residential assets) are crucial determinants for productivity in the goods-producing sector. In line with Roth (2024) this suggests that tangible investments plays a primary role in the goods-prod. sector.

- Second, we find that LPG in the service sector benefits most from the non-R&D intangibles software, training, and organisational capital. In the case of training and ICT capital, such findings are driven by the period after the economic crisis. Organizational capital impacted LPG throughout the 25 years of analysis. Such results align with Brynjolfsson et al.'s (2019, 2021) findings.

- Third, once we combine the results from Van Ark et al (2008) with our above econometric results, we conclude that the LPG gap between the EU and the United States is strongly due to insufficient investment in non-R&D intangibles like software, training, and organisational capital.

- Fourth, we find that in line with the arguments provided by Draghi (2024) R&D investments in AI are important to close the LP gap between EU and the US, in particular in the European high-tech sector.

Conclusion

- We find an instrumental role of Research & Innovation (R&I) in enhancing EU's LPG. In the goods sector, productivity growth is driven by non-ICT tangible assets. In the service sector, the non-R&D intangibles, software, training, and organisational capital are the contributors to LPG. Notably, the importance of training and ICT tangibles as drivers of productivity growth increases following the economic crisis, indicating a shift in the factors influencing productivity in the post-crisis period.

- We argue that the productivity gap between the EU and the United States can be largely attributable to the EU's insufficient investment in non-R&D intangibles such as software, training, and organisational capital. Addressing this gap is crucial for the EU to enhance its economic competitiveness and sustain its socio-economic model.

- To close this productivity gap the EU should prioritise investments that offer the highest added value per euro spent. The analysis suggests that investments in R&I, including organisational capital, training, software and ICT tangibles will be most effective. This approach is crucial for the EU to achieve its economic goals, maintain fiscal sustainability, and implement the Green Deal.

Thank you for your attention

Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. *Hamburg Discussion Paper in International Economics* No. 19, University of Hamburg.

is available at:

https://www.econstor.eu/handle/10419/306282

Appendix A

Table A1. Summary Statistics

	Obs	Mean	Std. dev.	Min	Max
Labor Productivity Growth	3,696	0.010	0.062	-0.40	0.41
R&D per Labor Services Growth	3,696	0.021	0.12	-0.62	0.61
Organizational Capital per Labor Services Growth	3,696	0.019	0.055	-0.29	0.31
Software per Labor Services Growth	3,696	0.045	0.11	-0.58	0.66
Training per Labor Services Growth	3,696	0.010	0.061	-0.31	0.34
ICT Capital per Labor Services Growth	3,696	0.044	0.13	-0.92	1.55
Non-ICT Capital per Labor Services Growth	3,696	0.010	0.064	-0.68	1.48
Upper Secondary Education	3,696	75.75	13.95	33.7	95
Catchup	3,696	25.05	25.83	0	107.16
Business Cycle	3,696	0.92	0.040	0.74	0.98

Sources: Author's own estimation based on the EU KLEMS 2022 dataset (Bontadini et al. 2023) and Eurostat.
Source: Roth, F. and Mitra, A. (2024). EU Competitiveness: The Critical Role of Intangible Assets in EU Labour Productivity Growth. Hamburg Discussion Paper in International Economics No. 19, University of Hamburg.