

23rd of November 2021,

PD Dr. Felix Roth

GLOBALINTO Online Workshop:

Intangibles, Global Value Chains and Productivity Growth
– new evidence and perspectives

**Intangible Capital and Labor Productivity Growth:
Revisiting the Evidence**

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Working Paper

Intangible Capital and Labor Productivity Growth:
Revisiting the Evidence

Hamburg Discussion Papers in International Economics, No. 10

Provided in Cooperation with:

University of Hamburg, Chair of International Economics

Suggested Citation: Roth, Felix; Sen, Ali (2021) : Intangible Capital and Labor Productivity Growth: Revisiting the Evidence, Hamburg Discussion Papers in International Economics, No. 10, University of Hamburg, Chair of International Economics, Hamburg

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<http://hdl.handle.net/10419/242120>

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Reference: Roth, F. and A. Sen (2021). [Intangible Capital and Labour Productivity Growth: Revisiting the Evidence](#), *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

Abstract

- **This paper** analyzes the impact of intangible capital on labor productivity growth across countries at the aggregate and sectoral levels by employing an econometric growth-accounting approach.
- **Our paper presents three novel results:** (1) our results show that intangible capital deepening accounts for around 40 percent of labor productivity growth at both the aggregate and sectoral level. (2) we find that this positive impact of intangible capital on productivity growth at both levels of aggregation is driven by investments in economic competencies, the only intangible group not covered in the national accounts. (3) our results reveal deep sectoral heterogeneities regarding investments and productivity effects of different intangible types.
- **Overall,** the evidence presented in our paper have important implications for future EU industrial policies and are directly relevant to the EU's efforts to close its productivity gap with the US.

1. Introduction

- We find three novel results vis-à-vis the existing literature. **First**, our results point out that **intangible capital deepening accounts for around 40 percent of labor productivity growth at both aggregate and sectoral levels**. Contrary to the existing studies in the literature (Niebel et al., 2017), our results reveal that intangible capital has a greater elasticity at the sectoral level than at the aggregate level.
- **Second**, when analyzing the three dimensions of intangible capital, we observe that the **impact of intangible capital** on labor productivity growth at aggregate and sectoral levels **is largely driven by economic competencies**. Our results therefore point out that the types of intangible capital that are omitted in the national accounts matter the most for labor productivity growth.
- **Third**, our results reveal deep **sectoral heterogeneities regarding the investment and productivity effects** resulting from different intangibles. More specifically, R&D (research and development) makes up a large share of intangible capital investments and strongly impacts labor productivity growth in the manufacturing sector. On the other hand, investments in software and organizational capital in the market services sector constitute the majority of intangible investments. These two intangible types also exert strong effects on labor productivity growth in this sector.

2. Theoretical Background and Measuring Intangibles

- The idea of **intangible capital as a productive input** dates back to the early 1960s, but its conceptualization and introduction to a neoclassical economic growth framework were realized only after the works by Nakamura (2001), Brynjolfsson et al. (2002) and the seminal contribution by Corrado, Hulten and Sichel (hereafter – CHS) (2005).
- CHS (2005) argued that since **expenditures on intangibles** represent foregone consumption today in order to increase output in the future, they **should be counted as investments**.
- Since the publication of CHS (2005), there has been a proliferation of country studies aimed at measuring the impact of intangible capital on labor productivity growth (CHS, 2009, for the US; Marrano et al., 2009, for the UK; Fukao et al., 2009, for Japan). Similarly, many databases influenced by the CHS (2005) framework have been developed: **FP7 INNODRIVE** project, **INTAN-Invest** (Rev. 1), the **INDICSER**, the **SPINTAN** and the **INTAN-Invest** (Rev. 2), all of which have finally led to the official construction of the first harmonized **EU KLEMS** cross-country-(sectoral) dataset.

2. Theoretical Background and Measuring Intangibles

Table 1. Measuring Business Intangibles in the EU KLEMS 2019 Dataset

No.	Dimension	Acc.	No.	Indicators	Acc.	NA
I.	Computerized Information	CI	1.	Computer Software and Databases	Software	Yes
II.	Innovative Property	IP	2.	Research and Development	R&D	Yes
			3.	Other Intellectual Property Products	OIPP	Yes
			4.	Design and Other Product Developments	D&O	No
III.	Economic Competencies	EC	5.	Advertising, Market Research and Branding	A&M	No
			6.	Vocational Training	VT	No
			7.	Purchased Organizational Capital	POC	No
			8.	Own-Account Organizational Capital	OOC	No

Notes: No.=Number, Acc.=Acronyms. NA=National Accounts.

Sources: CHS (2005) and Stehrer et al. (2019).

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

3. Cross-Country Sectoral Evidence

Table 2. Summary of Cross-Country Aggregate and Sectoral Studies on Intangibles and Productivity Growth

No.	Authors	Countries	Method	Time Period	Coverage	Data Source(s)	CRS	Elasticity of IC	Main Results
Cross-Country									
1	Roth and Thum (2013)*	EU13	CCGA	1998-2005	Market Economy excluding Agriculture	INNODRIVE, EUKLEMS, Eurostat	Yes	0.29	Intangible investment makes up around for 10% of GVA in EU13 countries. The econometric cross-country growth accounting shows that intangible capital explains 50% of LPG.
2	Corrado <i>et al.</i> (2013)*	EU15,US	GA	1995-2007	Market Economy	INTAN-Invest (Rev. 1), EUKLEMS	Yes	-	EU15 invests less than the US on intangibles (6.6% vs. 10.6% of GVA). Intangible capital deepening accounts for 23.8% of LPG in the EU and 28.4% of that in the US.
3	Roth (2020)*	EU16	CCGA	2000-2015	Market Economy excluding Agriculture	INTAN-Invest (Rev. 2), EUKLEMS, Eurostat	Yes	0.26-0.38	Intangible investment rate equals to 11% of GVA. The growth accounting based on econometric estimations shows that intangible capital deepening accounts for 46% to 66% of LPG.
Cross-Country Sectoral									
4	Corrado <i>et al.</i> (2016)*	EU12	GE (OLS and IV)	1995-2010	Market Economy	National Accounts, INTAN-Invest	Yes	0.07, 0.27	Intangible capital deepening explains around 20-25% of LPG. No differences exist between the manufacturing and services regarding the impact of intangible capital deepening.
5	Niebel <i>et al.</i> (2017)*	EU11	GA and GE (POLS, LSDV, FE, GMM-SYS)	1995-2007	Market Economy	EUKLEMS, INDICSER	No	0.174	Their intangible capital elasticity estimations are smaller than found in the macro-studies. The highest intangible capital investment rates are found in the manufacturing, the business services and finance sectors.
6	Piekkola (2018)*	EU20, NO	GA and GE (POLS, MG, CCE, WLP)	2008-2013	Market Economy	Own constructed dataset from EUROSTAT indicators	Yes	0.3	Intangible capital deepening contributes negatively to labor productivity growth during the crisis period (2008-2013).
7	Adarov and Stehrer (2019)	EU20, JP, NO, US	GA and GE (FE, POLS, GMM-SYS)	2000-2017	Total Economy	EUKLEMS 2019 Release	No	-	Intangibles overall do not have a statistically significant effect on labor productivity and real value added growth except for advertising and marketing.

Notes: * SSCI Peer Review Article. GA=Growth Accounting, CCGA=Cross-Country Growth Accounting, GE= Growth Econometrics, POLS=Pooled Ordinary Least Squares, LSDV=Least Squares Dummy Variables, FE=Fixed-Effects Regression, GMM-SYS=System GMM Regression, MG=Mean Group Estimator, CCE=Common Correlated Effects Estimator, WLP=GMM as Wooldridge Modified Petrin-Levinson Estimator, RVA=Real Value Added, EU=European Union. CRS=Constant Return to Scales. IC=Intangible Capital. No.=Number.

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, Univ. of Hamburg, Chair for International Economics, Hamburg.

4. Model Specification, Research Design and Data

4.1 Model Specification

- We consider the following production function as developed by Roth and Thum (2013) for the aggregate level and enhance it for the *sectoral* level:

$$Q_{c,j,t} = A_{c,j,t} K_{c,j,t}^{\alpha} R_{c,j,t}^{\beta} L_{c,j,t}^{\gamma} \varepsilon_{c,j,t} \quad (1)$$

- After dividing both sides under Cobb-Douglas assumption (2), taking logs (3) and applying Roth and Thum (2013) to the cross-country *sectoral* level (4) the following equation is obtained:

$$\begin{aligned} (\ln q_{c,j,t} - \ln q_{c,j,t-1}) = & c + gH_{c,t} + mH_{c,t} \frac{(q_{max,t} - q_{c,t})}{q_{c,t}} + n(1 - ur_{c,t}) + p \sum_{i=1}^k X_{i,c,t} + \mu_t + \alpha(\ln k_{c,j,t} - \ln k_{c,j,t-1}) + \\ & \beta(\ln r_{c,j,t} - \ln r_{c,j,t-1}) + u_{c,j,t} \end{aligned} \quad (5)$$

where we match $q_{c,j,t}$ as the growth in value added at constant prices. c captures a constant, $H_{c,t}$ captures the innovation capacity, $H_{c,t} \frac{(q_{max,t} - q_{c,t})}{q_{c,t}}$ represents a catch-up term, the term $(1 - ur_{c,t})$ accounts for business cycles and $X_{i,c,t}$ refers to control variables i that might effect TFP growth in a country at time t . μ_t are time-fixed effects. Consistent with the EU KLEMS methodology, the growth of capital inputs ($k_{c,j,t}, r_{c,j,t}$) per labor is measured as the capital services growth.

4. Model Specification, Research Design and Data

4.2 Research Design

- The **base sample** for our econometric analysis consists of **EU10 countries**. NMS were excluded from our base sample given the strong transition dynamics they experienced in their goods sectors during this period, with increases in tangible capital investments.
- For our cross-country sectoral analysis, we consider that the **market economy consists of the following sectors**: Agric., forestry & fishing (A); Mining & quarrying (B); Tot. manufact. (C); Electr., gas, steam & air cond. supply (D); Water supply; sewerage; waste manag. & remediation activities (E); Construction (F); Wholesale & retail trade; repair of motor vehic. & motorcycles (G); Transport. & storage (H); Acc. & food service act. (I); Inf. & communic. (J); Fin. & insurance activities (K); Prof., scientific, techn., administrative & support service activities (M-N); Arts, entertainment & recreation (R); & Other service activities (S). Throughout our analysis we differentiate between the goods-producing sectors (A-F) and the market service sectors (G-K, M-N, R and S).
- We also differentiate **five sub-sectoral categories**: i) manufacturing (C); ii) other goods (A,B,D,E,F); iii) distributive services (G,H); iv) business services (J,K,M-N); and v) other services (I,R,S).

4. Model Specification, Research Design and Data

4.3 Data

- For data we use the **November 2019 release of the EU KLEMS**. We use the following data within our analysis:
 - **LPG** is measured as **real value added at constant 2010 prices divided by the labor**, which is measured as total hours worked by the number of people employed.
 - **Tangible capital**: IT, CT, TraEq, OMach, and OCon.
 - **Intangible capital**: I. CI contains Software, II. IP contains R&D, OIPP and D&O, III. EC contains A&M, D&O, POC and VT.
 - We appr. human capital as educ. attainment at the upper sec. level and measure business cycles as unempl. rate subtracted from one. These data are obtained from Eurostat.
 - Among the control variables included in the robustness analysis are: rule of law, openness to trade, FDI, gov. exp., soc. exp., infl., inc. tax, and stock market capitalization. These variables are obtained from Eurostat and the World Bank.

5. Descriptive Analysis

Table 3. Aggregate and Sectoral Labor Productivity Growth Rates: EU10, 1995-2017

	Market Economy	Goods	Market Services	Other Goods	Manu- facturing	Distributive Services	Business Services	Other Services
EU10*	1.51	1.88	1.16	0.78	2.70	1.52	1.19	0.17
Austria	1.73	2.50	1.13	1.54	2.94	1.66	1.36	0.18
Denmark	1.45	1.94	1.16	0.95	2.90	1.44	1.16	0.12
Finland	2.11	2.96	1.30	1.84	3.58	2.07	1.47	-0.14
France	1.46	1.52	1.10	-0.12	3.10	1.45	1.16	0.45
Germany	1.53	2.26	0.96	1.37	2.43	1.64	1.16	0.65
Italy	0.43	0.68	0.19	-0.11	1.26	0.48	0.25	-0.15
Netherlands	1.49	1.74	1.47	0.61	2.77	1.69	1.18	0.19
Spain	0.59	1.48	0.09	1.23	1.69	0.58	0.63	-0.05
Sweden	2.75	2.75	2.67	0.42	4.19	2.75	2.11	0.03
UK	1.58	1.22	1.77	0.10	2.36	1.58	1.47	0.46
USA	2.00	2.21	1.93	0.61	3.42	1.96	1.77	0.50
NMS**	4.03	4.73	2.95	3.60	5.42	3.51	2.19	0.64

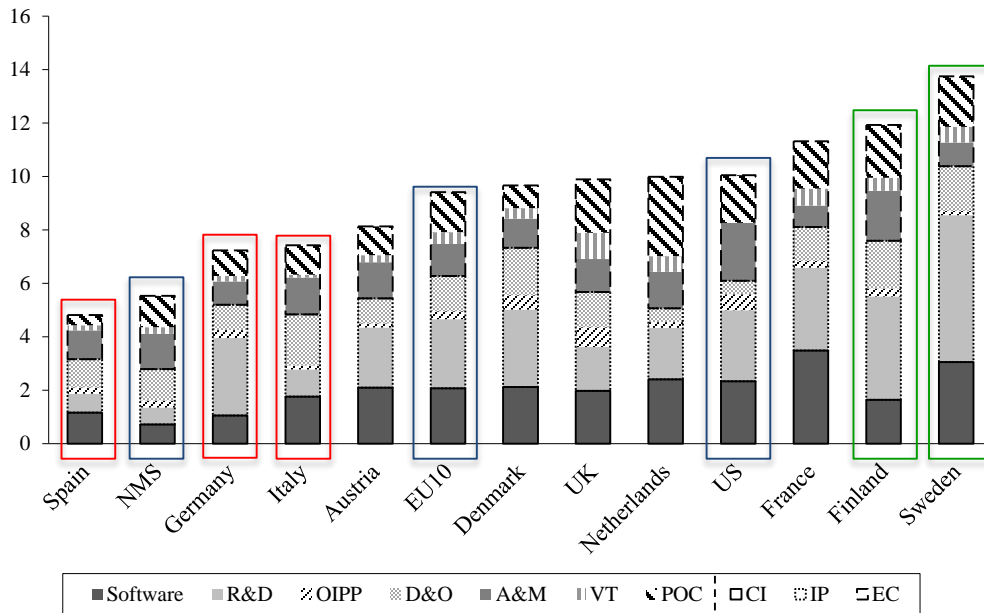
Notes: *EU10 refers to the ten EU countries analyzed in this study. ** Data for NMS reflect the period 2000-17.

Source: Authors' own estimations based on EU KLEMS (Stehrer *et al.*, 2019).

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

5. Descriptive Analysis

Figure 1. Business Intangible Capital Investment (as a percentage of VA), EU10, 1995-2017

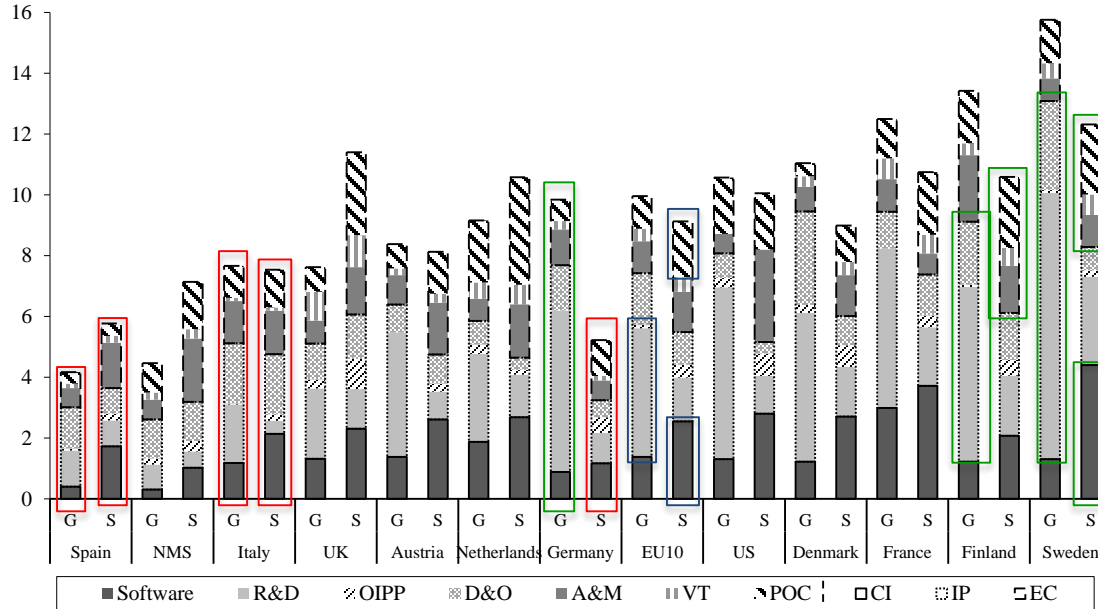


Source: Authors' own estimations based on the EU KLEMS dataset (Stehrer *et al.*, 2019).

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

5. Descriptive Analysis

Figure 2. Business Intangible Investment (as a percentage of VA) – Goods vs. Services Sectors, EU10, 1995-2017

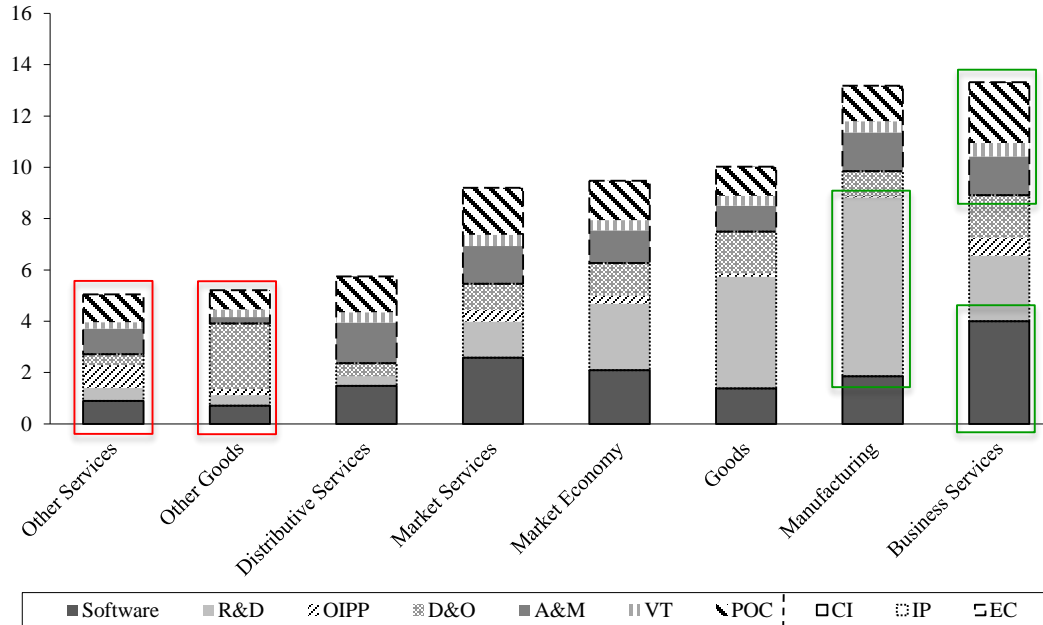


Source: Authors' own estimations based on the EU KLEMS dataset (Stehrer *et al.*, 2019).

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5. Descriptive Analysis

Figure 3. Business Intangible Investment Rates across Sub-Sectors, EU10, 1995-2017



Source: Authors' own estimations based on the EU KLEMS dataset (Stehrer *et al.*, 2019).

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

6. Econometric Analysis

Table 4. Production Function Estimations for EU10 (Market Economy, 1995-2017)

	(1)	(2)	(3)	(4)	(5)	(6)
	Country	Industry	Country	Industry	Country	Industry
	RE	RE	RE	RE	RE	RE
Intangible Capital	0.19*** (2.49)	0.25*** (6.89)	-	-	-	-
Tangible Capital	0.22*** (2.87)	0.20*** (3.89)	0.24*** (2.83)	0.20*** (3.57)	0.22** (2.50)	0.17*** (3.26)
Computerized Information	-	-	0.03** (2.05)	0.05** (2.00)	-	-
Innovative Property	-	-	0.03 (0.70)	0.07* (1.65)	-	-
Economic Competencies	-	-	0.09*** (2.97)	0.13*** (4.84)	-	-
Computer Software & Databases	-	-	-	-	0.02 (1.40)	0.05* (1.89)
Research & Development	-	-	-	-	0.04 (1.15)	0.02 (0.86)
Design & Other Product Developments	-	-	-	-	0.01 (0.20)	0.15*** (3.06)
Advertising, Market Research & Branding	-	-	-	-	0.05 (1.39)	0.01 (0.36)
Organizational Capital	-	-	-	-	0.07*** (2.84)	0.05 (1.25)
Vocational Training	-	-	-	-	-0.02 (0.98)	0.02 (1.41)
Nelson-Phelps Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.65	0.24	0.66	0.18	0.67	0.18
Observations	207	1,897	207	1,897	207	1,897

Notes: ***p < 0.01, **p < 0.05, *p < 0.1. RE=Random Effects. Nelson-Phelps Controls and time dummies are included in every specification.

Source: Authors' own estimations based on the EU KLEMS dataset (Stehrer *et al.*, 2019).

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

6. Econometric Analysis

Table 5. Production Function Estimations for EU10 (Sectoral Level, 1995-2017)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Industry	Goods	Services	Other Goods	Manu- facturing	Distributive Services	Business Services	Other Services
	RE	RE	RE	RE	RE	RE	RE	RE
Computer Software & Databases	0.04 (0.99)	0.03 (0.93)	0.07*** (2.60)	0.03 (0.72)	0.01 (0.26)	0.01 (0.57)	0.08** (2.18)	0.08*** (3.35)
Research & Development	0.08*** (3.40)	0.13*** (3.27)	0.02 (1.11)	-0.01 (-0.34)	0.20*** (6.23)	0.00 (-0.10)	0.03 (0.97)	-0.01 (-0.33)
Design & Other Product Developments	0.06 (1.20)	0.04 (0.82)	0.12** (2.18)	0.20** (2.32)	0.01 (0.19)	0.05 (0.56)	0.05 (0.47)	0.19*** (3.36)
Advertising, Market Research & Branding	0.00 (0.06)	0.00 (0.01)	-0.01 (-0.40)	-0.01 (-0.17)	-0.01 (-0.11)	-0.06 (-1.60)	-0.02 (-0.69)	0.14*** (2.65)
Organizational Capital	0.05 (1.34)	0.04 (0.92)	0.12*** (4.06)	0.02 (0.51)	0.04 (0.62)	0.12*** (4.53)	0.16*** (2.62)	0.05 (1.16)
Vocational Training	0.03 (0.99)	0.03 (0.54)	0.03* (1.82)	0.01 (0.24)	0.01 (0.20)	0.05 (1.56)	0.06 (1.48)	0.02 (1.17)
Tangible Capital	0.02 (0.19)	0.01 (0.13)	0.08* (1.87)	0.31** (3.24)	-0.01 (-0.09)	0.04 (0.68)	0.14 (1.58)	0.06*** (3.24)
Nelson-Phelps Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.09	0.09	0.24	0.23	0.11	0.32	0.24	0.49
Observations	3,834	2,765	1,069	621	2,144	351	516	202

Notes: ***p < 0.01, **p < 0.05, *p < 0.1. RE=Random Effects regression. Nelson-Phelps Controls and time dummies are included in every specification.

Source: Authors' own estimations based on the EU KLEMS dataset (Stehrer *et al.*, 2019).

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

6. Econometric Analysis

Table 6. Robustness Checks

	IC Coeff.	SE	Observations
(1) Benchmark	0.25***	(6.89)	1,897
<i>Alternative Estimation Methods</i>			
(2) POLS	0.26***	(9.07)	1,897
(3) 2FE	0.25***	(6.28)	1,897
(4) 2GLS	0.24***	(3.70)	1,897
(5) System-GMM	0.22**	(2.60)	1,897
<i>Country/Sector Exclusions/Inclusions</i>			
(6) EU10 (Excluding Sweden and Sector J)	0.24***	(5.35)	1,877
(7) EU10 (Excluding Sweden)	0.27***	(4.71)	1,677
(8) EU10 (Including NMS)	0.27***	(4.58)	2,661
<i>Control Variables</i>			
(9) Rule of Law	0.23***	(6.63)	1,475
(10) FDI (% of GDP)	0.24***	(6.25)	1,605
(11) Government Expenditures (% of GDP)	0.25***	(7.27)	1,741
(12) Social Expenditures (% of GDP)	0.25***	(7.18)	1,741
(13) Education Expenditures (% of GDP)	0.26***	(7.18)	1,667
(14) Inflation (in %)	0.25***	(7.14)	1,741
(15) Income Tax (% of GDP)	0.25***	(7.16)	1,741
(16) Stock Market Capitalization (% of GDP)	0.26***	(3.91)	1,301
<i>Across Different Time Periods</i>			
(17) EU10 (Before 2008)	0.28***	(4.11)	980
(18) EU10 (Between 2008 and 2013)	0.13**	(2.16)	572
(19) EU10 (After 2013)	0.26***	(6.63)	345

Notes: ***p < 0.01, **p < 0.05, *p < 0.1. Results refer to the random effects estimator. SE=Standard Error. IC=Intangible Capital, Coeff.=Coefficient, NMS=New member States. Nelson-Phelps Controls and time dummies are included in every specification.

Source: Authors' own estimations based on the EU KLEMS dataset (Stehrer *et al.*, 2019).

Reference: Roth, F. and A. Sen (2021). Intangible Capital and Labour Productivity Growth: Revisiting the Evidence, *Hamburg Discussion Papers in International Economics* No. 10, University of Hamburg, Chair for International Economics, Hamburg.

7. Conclusion and Outlook (1)

- Analyzing intangibles and the market economy at different aggregation levels for the EU10 over the period 1995-2017, our analysis has produced **three novel results**:
- **First**, our aggregate and sectoral results suggest that **intangibles play a prominent role in labor productivity growth**. Intangible capital deepening accounts for around 40 percent of labor productivity growth at both the aggregate and sectoral levels. In contrast to the existing studies in the literature, we find that intangible capital has a greater elasticity at the sectoral level than at the aggregate level.
- **Second**, when we differentiate between three intangible capital dimensions, we observe that the **impact of intangible capital on labor productivity growth at the aggregate and sectoral levels is largely driven by economic competencies**. Considering the fact that this type of intangibles is not included in the National Accounts, we argue that recognition of this fact would lead to a better assessment of the effects of intangible capital investment on productivity.

7. Conclusion and Outlook (2)

- **Third**, our disaggregated analysis points towards a deep **sectoral heterogeneity in the use of intangible capital**. While **R&D** dominates intangible capital investments in the **goods sector**, it is **software and organizational capital** that drive intangible capital investments in **market services**. Furthermore, certain intangibles such as software, vocational training, and organizational capital influence productivity growth more strongly in market services sector than the goods sector. Considering that market services also account for the productivity gap between the EU and the US (van Ark et al., 2008), we argue that our results suggest that **intangibles, and especially organizational capital, could play a critical role in explaining and closing this gap**.
- We think that our results on intangible capital in the services sector have important **policy implications**. It appears that while R&D is highly consequential for manufacturing, a different set of intangibles (software, vocational training, and organizational capital) shapes productivity within the services sectors. The lack of the EU's success in improving its productivity growth in services could be related to the fact that its **industrial policy concentrates too much on R&D**, which is less relevant for services. We believe that acknowledging this fact as a reality could open up new avenues for policy discussions following the Europe 2020 strategy.

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