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Complementarities in capital formation and production across EU member states: tangible and intangible assets

evidence at macro-, industry- and micro level

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Economic and Financial Affairs

earlier work on intangible assets

*DP 047/2017: "**Unlocking investment in intangible assets**", see also SCED, Vol 51/2019*

Growth accounting exercise:

- Importance of capital component rising (dominant source of growth)
- Variance of the obtained TFP residuals across countries is decreasing when including intangibles, i.e. intangibles could partly explain unobserved 'measure of our ignorance' and thus help understanding productivity differentials among countries

Intangibles and productivity: error-correction model

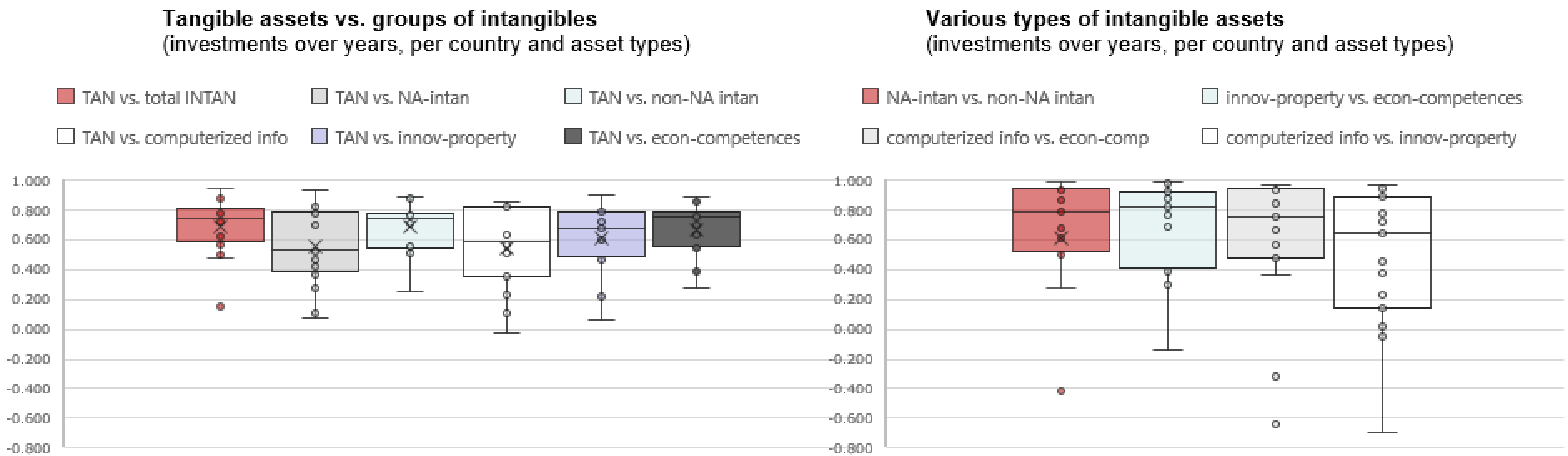
- Evidence of a significantly positive relationship between investments in intangibles and TFP growth
- both NA- and non-NA intangibles help explaining TFP differentials

Investment regressions:

- GDP growth tends to be higher correlated with investment in tangibles than intangibles
- All four sets of drivers/barriers to investment found to be relevant for intangibles
- Tangible and intangible assets are affected differently: human capital and regulation matter more for intangibles; financial conditions more for tangibles
- Some evidence of complementarities among asset types…

Complementarities in terms of co-investment?

Correlation coefficients of investments in various asset types (over years, per country)



Source: own calculations based on ESTAT (National Account) and INTAN-Invest data (released 10/2018)

Observations
- ***high correlation*** of investment series, suggesting interdependence of various assets (i.e. complementarities?)
- *Evident correlations (in investment series), but complementarities?*

work in progress Complementarities of assets

(a joint DG ECFIN – DG RTD Project)

Observations…

- high correlation of investment series suggesting interdependence of various assets (complementarities?)
- In fact, some investments can only be productive if appropriate complementary assets exist (e.g. hardware + software + training / organisational change)
- But, there are several transmission channels / economic trends working partly into opposite directions (e.g. rising importance of intangibles, structural change towards knowledge / service economy, need for investment in digital technologies (i.e. mainly in tangible assets?) + digital skills, decreasing labour share, …)

➢ Factors hindering investment in one asset may affect investment in (productivity of) complementary assets

➢ Hence, understanding more in detail barriers to investment, i.e. what drives and what eventually holds back investments (and thus productivity), is essential for sound policy support

➢ However, non-concluisve evidence concerning complementarities among relevant asset types in the empirical literature…

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What does the literature tell us?

Tangible and intangible assets: mixed evidence!

Substantial heterogeneity across sectors in terms of complementarity vs. substitutability (Belitz *et al* (2017), Hosono *et al* (2016); country-specific micro data (DE, JP))

ICT equipment and full set of intangible capital: evidence of complementary (Corrado *et al* (2017); sectoral data for 10 EU member states and 26 market industries)

ICT equipment and organizational capital: IT use complementary to high skills, decentralization of decisions and team-oriented production (Brynjolfsson *et al* (1999, 2000, 2002), Black and Lynch (2001), Autor, Levy and Murname (2000) , Crass and Peters (2014); based on country-specific micro data (mainly US)

R&D and skills of employees: evidence of complementary (Hall *et al* (2012), Crass and Peters (2014); country-specific micro data (IT, DE)

ICT and R&D investment: no conclusive evidence (Hall *et al* (2012) vs. Mohnen et al (2018); country-specific micro data (IT, NL)

- Most studies based on country-specific micro data, mixed evidence…
- Heterogeneity across sectors and asset types

Q: What would be the bigger picture at macro-level (generalizing)?

Main research questions

- Do we find evidence of **complementarities** among different assets types?
- How important are intangibles not accounted for in the national accounts ("**non-NA**")?
- What lessons can be learnt with a view at ensuring a '**balanced mix**' of investments (portfolio of investments in tangible and intangible asset types)?
- Do we need to revamp our horizon when looking at drivers for and barriers to investment, i.e. looking at all relevant asset types jointly (including non-NA intangibles)?

Conceptually, we pursue three levels of analyses

- **Macro-economic** evidence based on EU-wide data on intangibles and translog production functions
- **Sectoral evidence** based on EU-wide data on intangibles; system of factor demand functions
- **Firm-level** evidence as arising from EIB Investment Survey (EIBIS), several approaches…

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Analysis at macro and industry level

Macro evidence: translog production functions

Method

extend Cobb-Douglas function to allow for non-linear elasticities and complementarity/substitutability between tangible and intangible capital deepening:

$$\ln\left(\frac{Y}{L}\right) = \ln(A) \;+\propto_{K^T} \ln\left(\frac{K^T}{L}\right) +\propto_{K^I} \ln\left(\frac{K^I}{L}\right) + \frac{1}{2}[\beta_{K^T K^I} l\,n\left(\frac{K^T}{L}\right) \ln\left(\frac{K^I}{L}\right)] + \frac{1}{2}[\,\beta_{KK^T} \ln\left(\frac{K^T}{L}\right) + \beta_{KK^I} \ln\left(\frac{K^I}{L}\right)]$$

**Note: we further split intangible in NA- and non-NA- intangibles*

Data

GVA, labour, investment in tangible and intangible capital, for 15 EU countries 1995-2015, taken from Eurostat National Accounts data and INTAN-INVEST database (released 10/2018)

Macro evidence: translog production functions

Y_L	(1) baseline	(2) add new intan	(3) add new intan FE	(4) add all terms	(7) add all terms FE	(5) add interaction terms FE	(6) add interaction terms	(8) add interaction terms seperately	(9) add interaction terms seperately	(10) add interaction terms seperately	(11) add interaction terms seperately	(12) add interaction terms seperately FE	(13) add interaction terms seperately FE	(14) add interaction terms seperately FE
K_L											0.545***	0.192***	0.209***	0.108**
											(0.119)	(0.0463)	(0.0435)	(0.0426)
KT_L	0.443***	0.322***	-0.0836***	-1.336***	-0.875***	0.0914	-0.322**	0.471***	0.512***	0.271***				
	(0.0354)	(0.0296)	(0.0313)	(0.372)	(0.234)	(0.0623)	(0.138)	(0.0421)	(0.0790)	(0.0255)				
KIipp_L	0.191***	0.0334*	0.275***	1.424***	0.790***	0.153	1.674***	0.477***	0.00925	0.212***				
	(0.0186)	(0.0189)	(0.0243)	(0.201)	(0.116)	(0.102)	(0.161)	(0.0751)	(0.0282)	(0.0366)				
KInew_L		0.389***	0.117***	-0.826***	-0.0814	-0.115	-1.874***	0.398***	0.777***	0.519***				
		(0.0291)	(0.0446)	(0.267)	(0.151)	(0.142)	(0.285)	(0.0303)	(0.154)	(0.0505)				
KTxKIipp_L				-0.305**	-0.413***	-0.0802	-0.808***	-0.243***			-0.103**	-0.0144	-0.0154	-0.0226
				(0.142)	(0.0757)	(0.0536)	(0.0870)	(0.0413)			(0.0489)	(0.0198)	(0.0186)	(0.0169)
KTxKInew_L				-0.295	0.0260	0.0481	1.131***		-0.190***		0.0918**	-0.0358**	-0.0309	0.0313*
				(0.195)	(0.108)	(0.0759)	(0.147)		(0.0687)		(0.0358)	(0.0154)	(0.0194)	(0.0190)
KIippxKInew_L				-1.171***	-0.203**	0.223***	-0.0217			-0.172***	0.146**	0.207***	0.220***	0.165***
				(0.128)	(0.0955)	(0.0289)	(0.0717)			(0.0339)	(0.0709)	(0.0258)	(0.0245)	(0.0231)
KT_L2				0.536***	0.324***									
				(0.114)	(0.0784)									
KInew_L2				1.245***	0.183**									
				(0.129)	(0.0831)									
KIipp_L2				0.345***	0.293***									
				(0.0484)	(0.0369)									
Constant	1.502***	1.411***	2.925***	4.980***	3.780***	2.540***	3.999***	0.896***	0.689**	1.378***	0.950***	3.215***	2.144***	2.628***
	(0.120)	(0.0960)	(0.117)	(0.660)	(0.372)	(0.216)	(0.466)	(0.156)	(0.310)	(0.0964)	(0.329)	(0.150)	(0.132)	(0.163)
Observations	315	315	315	315	315	315	315	315	315	315	315	315	315	294
R-squared	0.732	0.830	0.984	0.916	0.991	0.989	0.878	0.852	0.834	0.841	0.824	0.986	0.989	0.992
Country FE	no	no	yes	no	yes	yes	no	no	no	no	no	yes	yes	yes
Year FE	no	no	yes	no	yes	yes	no	no	no	no	no	no	yes	yes
Adj. R-squared	0.731	0.828	0.982	0.914	0.990	0.987	0.875	0.850	0.832	0.839	0.822	0.985	0.987	0.991
Wooldridge test AR(1) (p	4.88e-08	4.88e-08	1.67e-06	1.41e-07	8.46e-07	1.55e-09	1.45e-06	5.51e-07	6.24e-07	9.94e-07	5.21e-06	5.21e-06	9.25e-07	2.43e-07
highest VIF	1.934	3.161	67.98	1756	4572	1753	691.5	58.50	108.6	25.07	88.95	178.6	179.8	187.8
Wald country dummies (p					0	0								
Wald year dummies (p-va					2.47e-09	3.86e-05								

Standard errors in parentl

*** p<0.01, ** p<0.05, *

- complementarities suggested by the joint effect of NA and non-NA intangibles on labour productivity (reg. 11-14; controlling for direct impact of all assets). But….

Sectoral evidence: factor demand functions

Haskel & Goodridge (2018), study commissioned by DG RTD

Method

Initial investigations into estimating the primal production function or the dual cost function were unsuccessful (inconsistent input demand elasticities)

Instead, estimating demand elasticities for factor inputs and combinations of inputs based on a cost minimization problem and '*Seemingly Unrelated Regression Equations*' (SURE)

Data

INTAN-INVEST, 11 EU MS + US for 13 market sector industries (B-K, M-N and S)

tangible capital split in ICT equipment and non-ICT

intangible capital split in "computerized information" (CI), "innovative property" (IP) and "economic competences" (EC)

Findings

- Price elasticities (ε_{ii}) and elasticities of substitution (σ_{ij})
- some (weak) evidence of complementarities (i.e. negative signs) between ICT equipment and CI (i.e. hardware and software)
- evidence of factor substitutability in investment and production between e.g. 'labour and non-ICT (tangible)', 'labour and CI', 'labour and EC', and 'IP and EC'

➢ Results confirm some previous findings (lit) but contradict others…

	1: cluster (ind)		2: cluster (ctry)		3: cluster (ctry-ind)	
ε_{ii}	ε	$se(\varepsilon)$	ε	$se(\varepsilon)$	ε	$se(\varepsilon)$
i=L	-0.356***	(0.0763)	-0.356***	(0.0769)	-0.356***	(0.0610)
i=ICT	-1.047***	(0.201)	-1.047***	(0.313)	-1.047***	(0.224)
i=CI	-0.845***	(0.182)	-0.845***	(0.169)	-0.845***	(0.254)
i=IP	-1.799***	(0.611)	-1.799***	(0.496)	-1.799***	(0.522)
i=EC	-1.005***	(0.261)	-1.005***	(0.289)	-1.005***	(0.239)
i=non-ICT	-0.653***	(0.145)	-0.653***	(0.142)	-0.653***	(0.143)
σ_{ij}	σ	$se(\sigma)$	σ	$se(\sigma)$	σ	$se(\sigma)$
i=L; j=non-ICT	1.114***	(0.147)	1.114***	(0.176)	1.114***	(0.139)
i=L; j=ICT	0.668	(0.453)	0.668	(0.847)	0.668	(0.625)
i=L; j=CI	1.139***	(0.389)	1.139*	(0.587)	1.139**	(0.509)
i=L; j=IP	1.157	(0.858)	1.157*	(0.665)	1.157*	(0.671)
i=L; j=EC	0.512**	(0.243)	0.512*	(0.283)	0.512**	(0.203)
i=ICT; j=CI	-4.909	(5.073)	-4.909	(5.490)	-4.909	(4.475)
i=ICT; j=IP	4.112	(3.310)	4.112	(3.958)	4.112	(6.061)
i=ICT; j=EC	2.147	(2.851)	2.147	(2.072)	2.147	(2.784)
i=CI; j=IP	0.128	(3.639)	0.128	(3.485)	0.128	(3.647)
i=CI; j=EC	2.962	(3.668)	2.962	(5.356)	2.962	(4.263)
i=IP; j=EC	8.142**	(3.797)	8.142	(5.030)	8.142**	(3.553)
Observations	2,940		2,940		2,940	
Standard errors in parentheses						

Mirco-level evidence

Analyses of investments in intangibles at firm-level may provide a clearer picture…

EIB Investment Survey data

Survey question: "*In year X how much did your business invest in each of the following with the intention of maintaining or increasing your company's future earnings?*

A. Land, business buildings and infrastructure
B. Machinery and equipment
C. R&D (includes the acquisition of intellectual property)
D. Software, data, IT networks and website activities
E. Training of employees (includes internal and external training)
F. Organisation and business process improvements (such as restructuring and streamlining)"

Survey data matched with ORBIS

Data on all firms are pooled (EIBIS waves 2016, 2017, 2018 and 2019), resulting sample size is 43,271

Findings

Interactions between investment in various asset types

Outcome variable:	Direct	Interaction with investment in other area				
Labour productivity	effect	B. Machinery	C. R&D	D. Data	E. Training	F. Organisation
Total investment intensity	+					
A. Land and business buildings		+	0	+	0	0
B. Machinery and equipment			+	0	0	0
C. R&D				0	0	0
D. Software and databases					+	0
E. Training of employees						+
F. Organisation improvements						

Source: EIB calculations based on EIB Investment Survey (EIBIS waves 2016, 2017, 2018 and 2019).
Data on all firms are pooled from EIBIS (waves 2016, 2017, 2018 and 2019). The sample size is 43,271. Firms in EIBIS are weighted with value added.

Note: The table is based on an OLS regression, where labour productivity (turnover per number of employees, in logarithm) is the dependent variable and the explanatory variables are the investment intensity in each asset category (investment area divided by the number of employees, in logarithm) and the interactions between investment intensity in different asset categories. Other explanatory variables: country, sector, year, and firm size.

The first column lists the six different investment areas and the second column refers to the estimated coefficient on total investment intensity. Columns 3 to 7 report estimated coefficients on the interaction terms between different asset categories. "+": estimated coefficient is positive and statistically significant at the 10% confidence level; "–": estimated coefficient is negative and statistically significant at the 10% confidence level; "0": estimated coefficient not statistically significant at the 10% confidence level.

Future work

- Refining analyses at the firm-level (EIBIS data), esp. estimating factor demand equations as done for the meso-level analyses
- Macro-/industry-level analyses based on EU KLEMS 2019 vintage (note that this will include information concerning non-NA intangibles in the analytical module, t.b. released in Oct 2019 (tbc)!)
- Bringing all the individual observations together…

Take away messages

- Understanding complementarities among assets is essential (for policy support)
- However, analytically confirming the existence of complementarities is not trivial
- Yet, non-conclusive empirical evidence doesn't mean there are no complementarities…
- More research is needed, notably at the micro-level

- Deploying the right balance of all relevant inputs (assets) is vital
- Disregarding analytically non-NA intangibles tends to provide biased results
- The same holds for setting up initiatives with the general aim of stimulating investments

THANK YOU!

What does the literature say?

Complementarities between tangible and intangible capital:

- Belitz *et al* (2017): tan & intan assets tend to complement each other with remarkable differences across industries in DE
- Hosono *et al* (2016): substantial heterogeneity among industries in terms of substitutability and complementarity in JP
- Brynjolfsson *et al* (2002): Organisations most successful in using ICT (hardware) rely on strong organisational capital in US
- Brynjolfsson and Hitt (2000, 2003): joint investment in ICT & skills increases benefits accruing purely to investment in ICT
- Corrado *et al* (2017): complementarities between ICT hardware and intangible capital; evidence of knowledge spillovers from investments in intangible capital and skills for a set of EU countries
- Hall *et al* (2012), Mohnen *et al* (2018): Empirically, no conclusive relation between ICT and R&D investment in 9 EU-MS

Across intangible assets:

- Crass and Peters (2014): components of 'intellectual property' (R&D and patent stocks) found to be complements, i.e. the more intellectual property a company has, the more productive its R&D investment becomes
- *Ibidem*, complementarity between innovative property and human capital, i.e. skills essential for being able to exploit the benefits of innovation outputs
- Andrews, Nicoletti and Timiliotis (2018) : low managerial quality, lack of ICT skills and poor matching of workers to jobs curbs digital technology adoption and hence the rate of diffusion

➢ *Most evidence based on micro data looking at particular countries – evidence mixed: skills and organizational capital seem to complement technology ; ICT hardware and intangible assets as a whole seem to be complements; but not R&D and ICT*

Regression analysis: translog production functions

Production function estimation: typical measurement issues	Remedies
Multicollinearity (VIF test)	Estimate the production function in productivity terms; drop terms; demand function approach
Endogeneity/simultaneity	Wooldridge (2009) control function approach
Non-stationarity (panel unit root tests and panel cointegration tests)	Differences or co-integration; control for time trend if variables are trend-stationary
Specification of the production function and underlying assumptions (linearity, returns to scale, elasticity of substitution,..)	Choose among Cobb-Douglas, CES,…
Firm-level: endogenous firm exit/selection (correlated with firm size) and selection bias	Control variables, instrumental variables
Macro-level: aggregation of heterogeneous units	Micro-level data but EU-wide comparable data on full set of intangibles not easily available (EIB survey; intan-invest micro data)

Macro evidence: problematic issues…

- **Multicollinearity:** when adding quadratic and interaction terms the total effects of respective assets change signs and size; high Variance Inflation Factors (VIF)
    - we expressed the model in productivity terms, dropped variables , merged variables,…
- **Endogeneity/Simultaneity:** omitted variables can bias the estimates
    - we tried Wooldridge (2009) and Ackerberg, Caves, and Frazer (2015) control function approaches but results do not change and are unstable as to which method we use (sample size too small?)
- **Number of observations:** sample potentially too small and hence large standard errors and wide confidence intervals; within-country variation too small?
- **Aggregation level:** aggregating across firms and sectors hides heterogeneity in terms of complementarities/substitutability and may provide a blurry overall picture
- **Other potential issues:** non-stationarity, specification of the production function and other underlying assumptions, at micro level: endogenous firm entry/exit,…

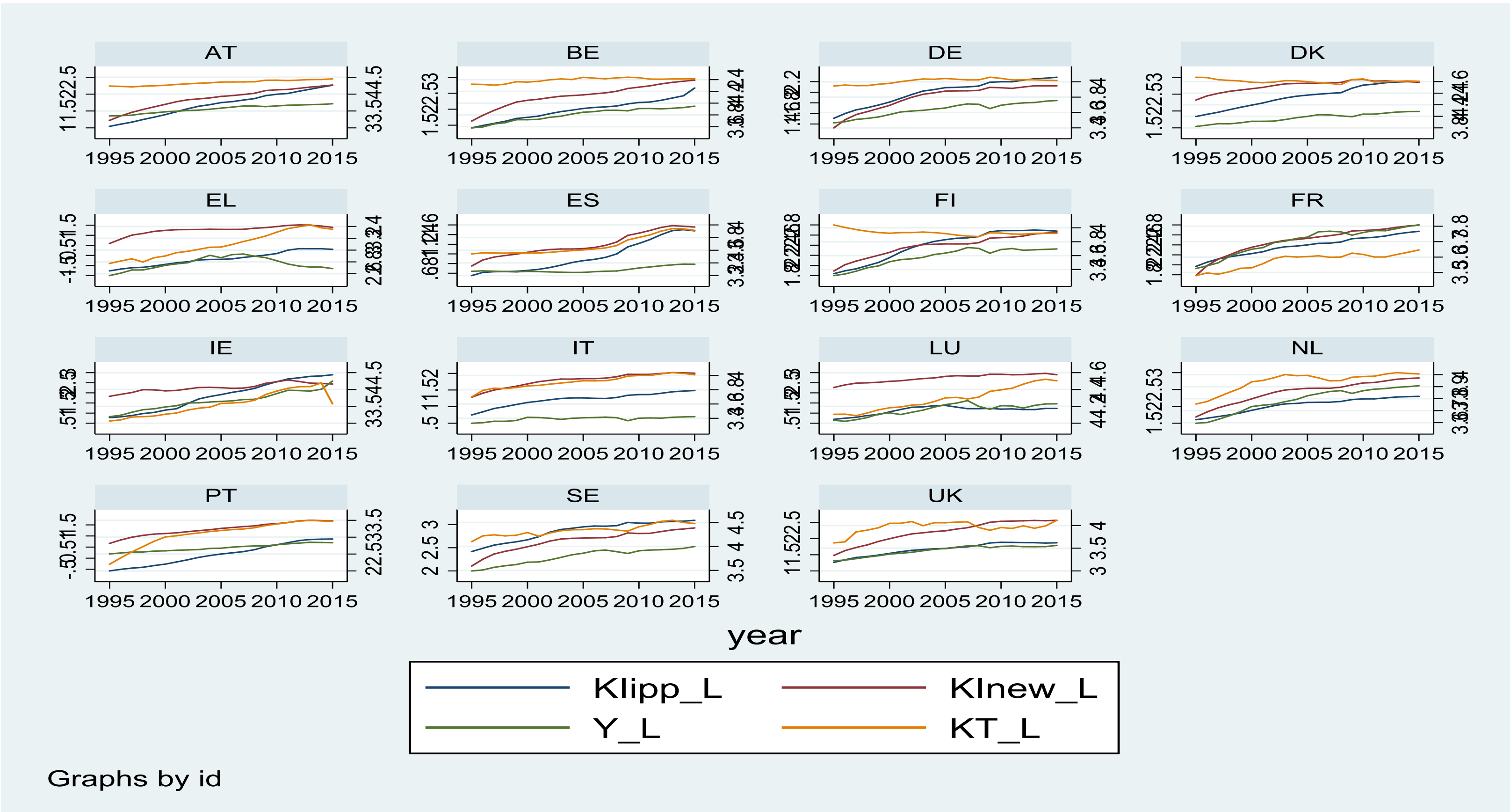
➢ *Rather conduct analysis at less aggregate level (though macro-economic results neat for providing the big picture)*
➢ *Zooming in: Analyses at meso-(industry)- or at micro-level?*

Summary statistics

		count	mean	sd	min	max
originals	EU15	315	1	0	1	1
	year	315	2005	6.064935	1995	2015
	gva	315	488003.9	504203.7	16172.25	1883425
	hours	315	14363.76	14259.51	285.797	44796
	tan	315	708700.8	730363.7	17349.6	2460382
	intan_IPP	315	91020.08	107837.6	571.5167	431311.9
	intan_nev	315	116037.6	127525.9	2755.98	508808.6
	intan_tota	315	207057.7	231237.1	3327.496	914960.1
	k_total	315	915758.4	931716.4	20677.1	3240904
	intan_inv	306	82262.87	94794.31	1215.937	458551.4
	tan_inv	315	62460.75	63306.17	1810.887	250913.4
logs	Y	315	12.49932	1.163079	9.691051	14.4486
	L	315	8.950118	1.251875	5.655282	10.70987
	KT	315	12.86668	1.207737	9.761325	14.71583
	KI_IPP	315	10.59129	1.511373	6.348294	12.97459
	KI_new	315	11.06108	1.149884	7.921528	13.13983
	K_total	315	13.12794	1.20604	9.936782	14.99136
	KI_total	315	11.5798	1.248318	8.109976	13.72664
	KTxKI_IPP	315	68.96334	15.32511	30.98388	95.41917
	KTxKI_nev	315	71.80856	13.70299	38.6623	96.49616
	KTxKI_tot	315	75.1982	14.53795	39.58205	99.94575
	KI_IPPxKI_	315	59.4001	14.00098	25.14409	84.90794
	LxKT	315	58.27936	12.98139	27.60152	78.66154
	LxKI_IPP	315	48.16085	12.34211	17.9507	69.36149
	LxKI_new	315	50.13753	11.56581	22.39924	69.46304
	LxKI_total	315	52.49392	12.16108	22.9321	72.65192
quadratic	L2	315	40.83342	10.86932	15.99111	57.3507
	KT2	315	83.50275	15.30797	47.64173	108.2778
	KI_new2	315	61.83277	12.68891	31.37531	86.32752
	KI_IPP2	315	57.22625	15.34468	20.15042	84.16994
	KI_total2	315	67.82252	14.26855	32.88585	94.21027
growth	dY	300	.0213336	.0378734	-.1249943	.2726717
	dL	300	.0046224	.0244487	-.1299319	.0577545
	dK_total	300	.0274836	.0413333	-.3475561	.2069521
	dKT	300	.0210203	.0540515	-.5891333	.2309198
	dKI_IPP	300	.0533887	.0381599	-.0406742	.2452135
	dKI_new	300	.0482486	.0448183	-.0804205	.2047062
	dKT2	300	.2597158	.6612843	-6.921951	3.285362
	dL2	300	.0366322	.212575	-1.036467	.5064964
	dKI_IPP2	300	.5476734	.357242	-.2974205	2.678658
	dKI_new2	300	.5258357	.4751364	-.835186	2.382904
	dKTxKI_IP	300	.4385058	.3886782	-2.656944	1.948296
	dKTxKI_ne	300	.4195172	.4476793	-3.012852	2.185524
	dKI_IPPxK	300	.5382657	.3486081	-.3236618	1.702553
	dLxKT	300	.119372	.3056418	-2.141384	1.292259
	dLxKI_IPP	300	.2549827	.2102501	-.4772339	1.034523
	dLxKI_nev	300	.2387753	.2632012	-.5602951	1.03281
lag	lY	300	12.49204	1.164427	9.691051	14.43262

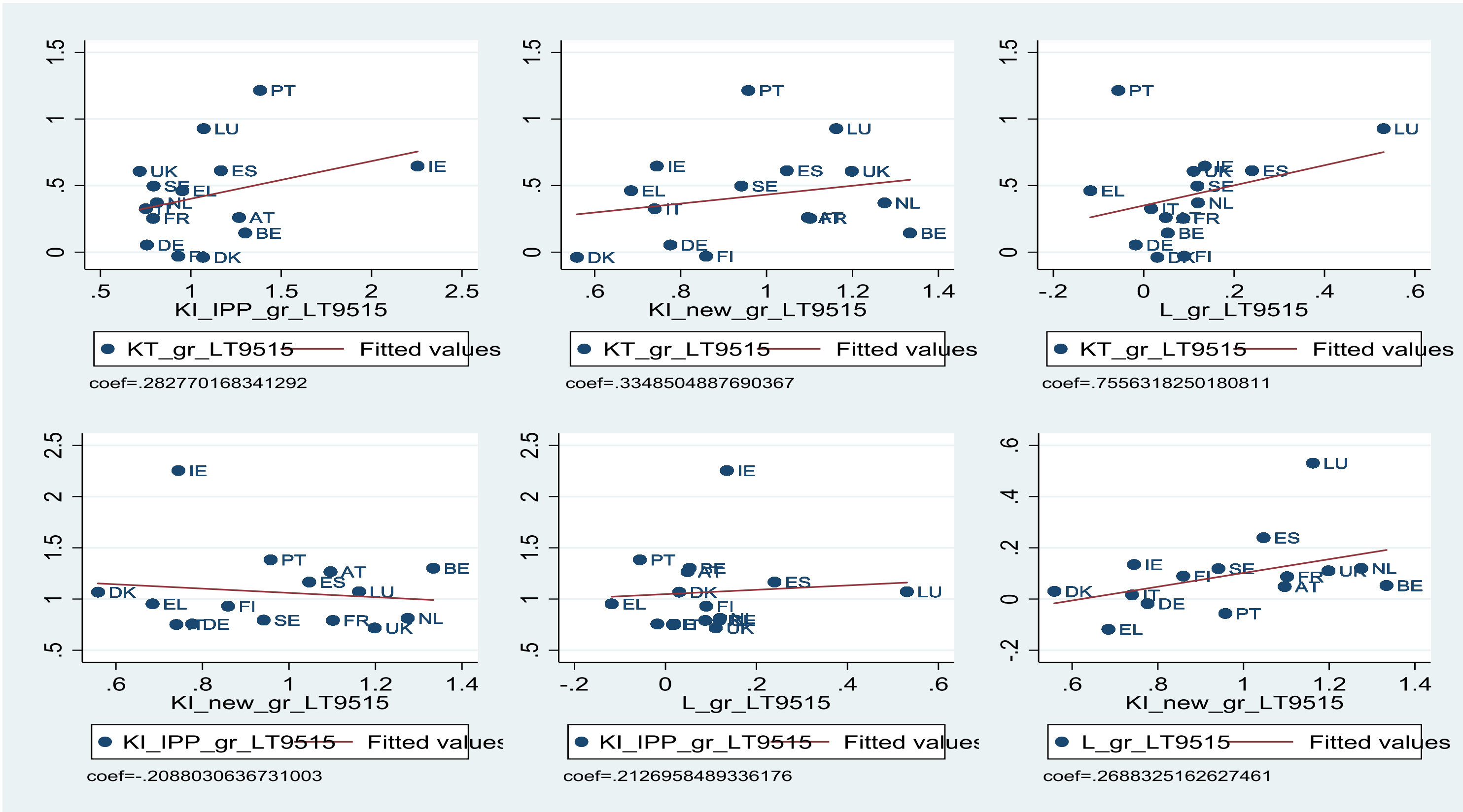
prod terms	Y_L	315	3.549197	.4038965	2.504927	4.268593
	K_L	315	4.177825	.4743044	2.442825	4.934626
	KT_L	315	3.916563	.4648492	2.196887	4.675299
	KI_L	315	2.629678	.6498718	.8213086	3.706817
	KIipp_L	315	1.641176	.8859786	-.7673793	3.092399
	KInew_L	315	2.110963	.5719674	.5929095	2.961664
	KTxKIipp_L	315	3.356536	1.858325	-1.064067	6.973284
	KTxKInew_L	315	4.225082	1.441723	.7312155	6.821023
	KTxKItotal_L	315	5.258331	1.667131	1.010239	8.349941
	KIippxKInew_L	315	1.935139	1.222783	-.3225987	4.527595
	K_L2	315	8.839237	1.889062	2.983697	12.17527
	KT_L2	315	7.777434	1.747633	2.413156	10.92921
	KI_L2	315	3.6681	1.59927	.3372739	6.870247
	KIipp_L2	315	1.737962	1.275443	.0001528	4.781465
	KInew_L2	315	2.391135	1.138309	.1757708	4.385726
	dY_L	300	.0167113	.0273239	-.0687811	.2428775
	dK_L	300	.0228612	.0418007	-.3773503	.195344
	dKT_L	300	.0163979	.0541637	-.6189282	.2193115
	dKIipp_L	300	.0487664	.0414359	-.0812962	.2513766
	dKInew_L	300	.0436262	.0454954	-.0806682	.2177314
	dKT_L2	300	.0576042	.2023914	-2.404883	.822464
	dKIipp_L2	300	.0743403	.0824425	-.1088686	.6138802
	dKInew_L2	300	.0849176	.0876907	-.2035313	.3791883
	dKTxKIipp_L	300	.1007834	.1079639	-.7784724	.5344329
	dKTxKInew_L	300	.0980023	.1135548	-.8082957	.501493
	dKIippxKInew_L	300	.0811401	.0735696	-.1168196	.3958404
	lY_L	300	3.542377	.4007646	2.504927	4.268593
long term growth	Y_gr_LT9515	315	.4266724	.2682596	.0008812	1.192187
	L_gr_LT9515	315	.0924472	.1437987	-.1181164	.5306945
	KT_gr_LT9515	315	.4204053	.3379794	-.0386009	1.214602
	KI_IPP_gr_LT9515	315	1.067774	.3817318	.7173862	2.254171
	KI_new_gr_LT9515	315	.9649718	.2251907	.5585699	1.33367
	Y_L_gr_LT9515	315	.3342252	.2228225	.0924819	1.05714
	K_L_gr_LT9515	315	.457224	.2735924	.0885592	1.241204
	KT_L_gr_LT9515	315	.3279581	.3219599	-.1202164	1.270988
	KIipp_L_gr_LT9515	315	.9753271	.39699	.5409161	2.119124
	KInew_L_gr_LT9515	315	.8725245	.2100558	.5284703	1.280677
total observations	N	315				

Co-investment: within-country correlation



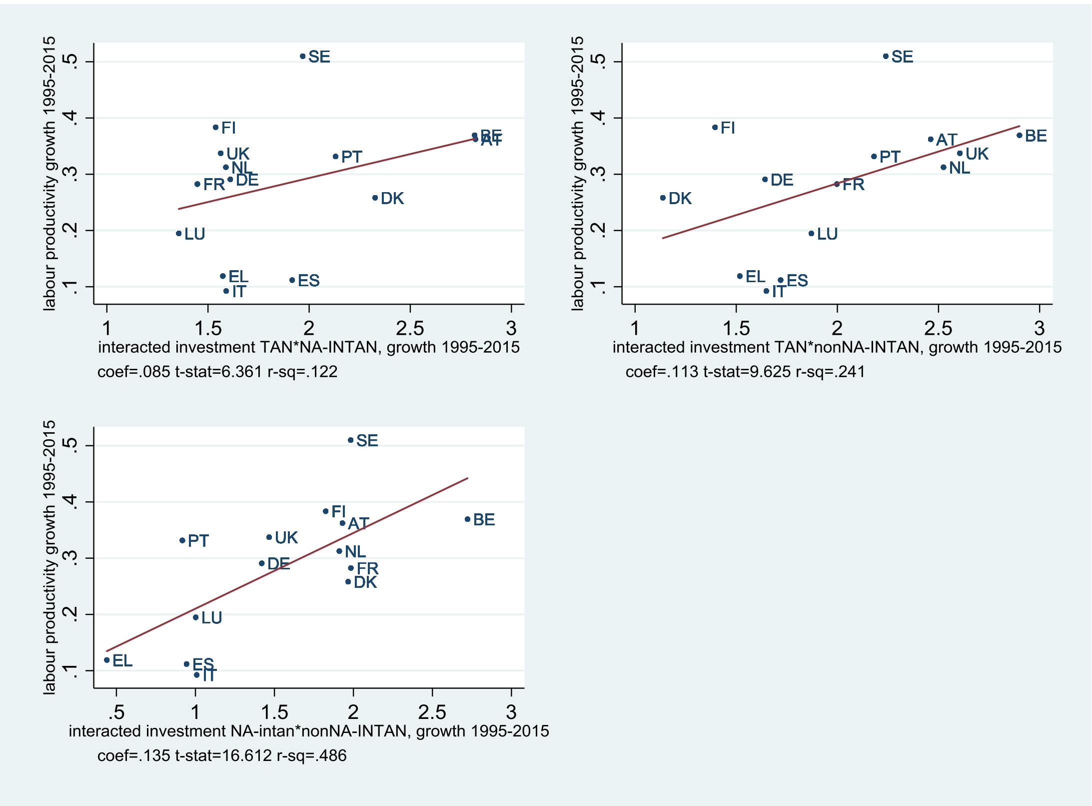
Observation: Co-investment over time in NA and non-NA intangibles; evidence less clear for tangible assets

Co-investment: correlation across countries



Note: IE is considered an outlier as it had a bit of an atypical surge in NA intangible capital

Complementarities with a view at labour productivity



Observations:

- Pairwise interaction terms (1) tangible-NA intangible, (2) tangible-nonNA intangible, (3) NA – nonNA intangibles are positively correlated with labour productivity across countries
- Strongest correlation found in terms of (3) NA – nonNA intangibles

Notes: graphs show long-term growth between 1995 and 2015; Ireland was excluded as an outlier since there was an atypical surge in IPP capital stock over the sample period

➢ *With a view at productivity, some evidence that assets are complementary…*