IFC-ECCBSO-Bank of Spain Workshop on "New insights from financial statements"

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Superstar firms, intangibles, and productivity mismeasurement: evidence from firm-to-firm transactions[1]

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[1] This contribution was prepared for the workshop. The views expressed are those of the authors and do not necessarily reflect the views of the European Committee of Central Balance Sheet Data Offices (ECCBSO), the Bank of Spain, the BIS, the IFC or the other central banks and institutions represented at the event.

KU LEUVEN

VIVES

Superstar Firms, Intangibles, and Productivity Mismeasurement: Evidence From Firm-To Firm Transactions

Madrid
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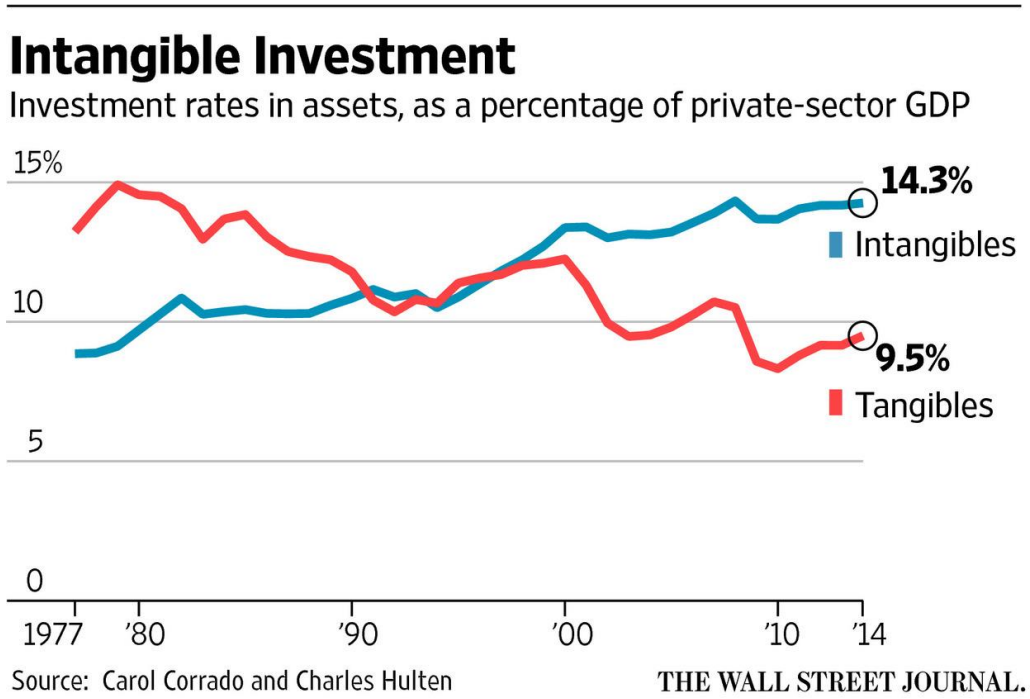
Motivation

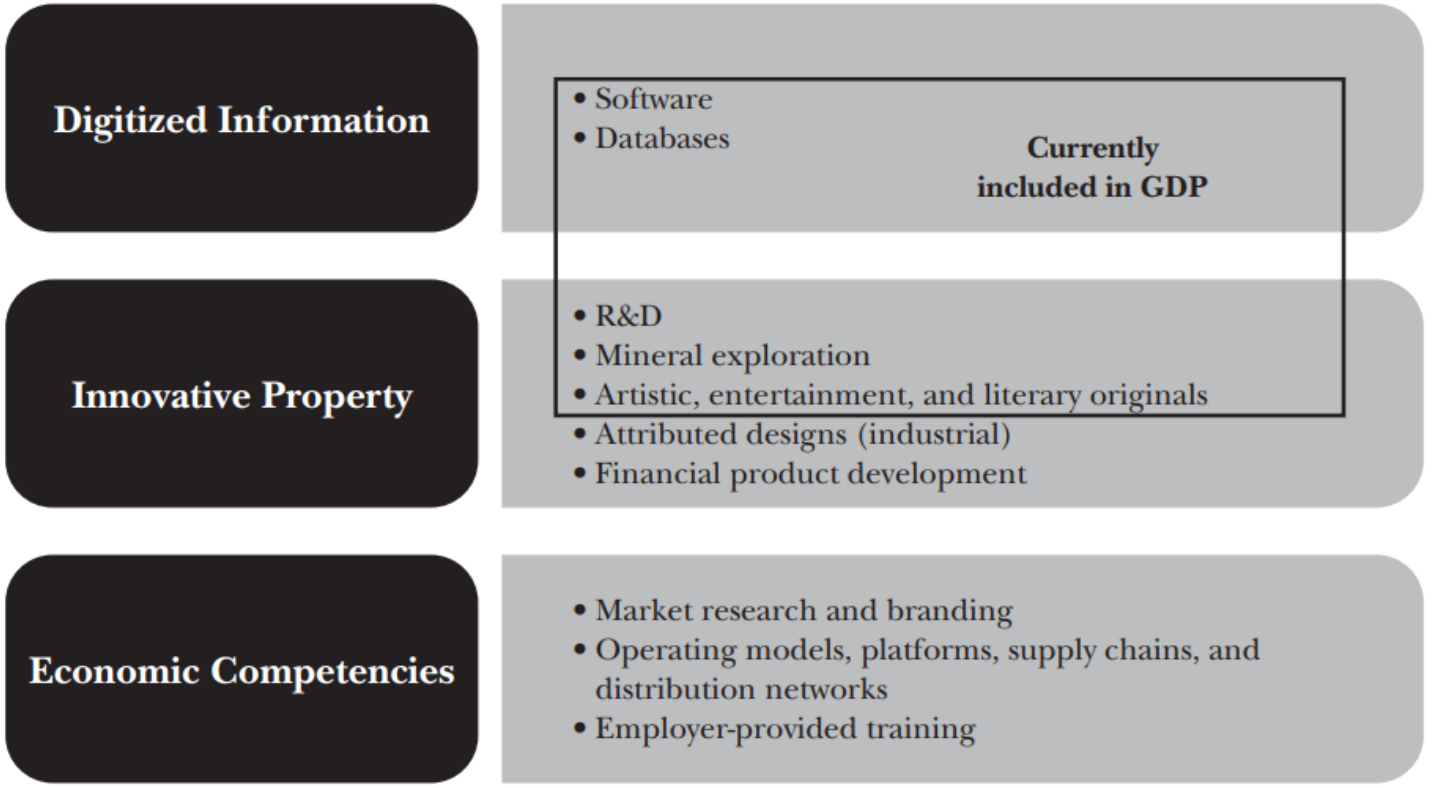
- Solow Paradox, 1986: *"You can see the computer age everywhere but in the productivity statistics"*
- Brynjolfsson et al., 2021: "*Solow's Paradox is not unique. It is one example of a more general phenomenon resulting from the need for intangible investments in early stages of new general-purpose technologies*"
- The past decades witnessed a rapid increase in the use of intangible investment
- The measurement of productivity crucially depends on the measurement of intangible assets



Motivation

Can we just use the balance sheet information on intangibles?

- International Accounting Standard generally disallows the capitalization of most intangible assets
- Balance sheet intangibles largely arise from acquisitions
- Reported assets do not reflect actual intangible investment flows



Source: Authors' elaboration of Corrado, Hulten, and Sichel (2005, 2009).

Motivation

Can we just use the **balance sheet information** on intangibles?

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Can we use **survey data** on intangibles?

- Survey information on intangible asset results in a selection bias and a lack of insights on heterogeneity in returns on intangibles
- Not all intangibles captured

Research objectives

Investigate the returns from intangible capital at the micro level and examine how this affects productivity patterns at the macro level.

How:

- Trace *all* yearly intangible asset purchases of a firm from a B2B transaction level dataset
- Build a firm(-year) level intangible capital stock (2002-2019)
- Estimate an augmented production function
- Compare returns from intangible capital across the firm size distribution
- Examine how these findings at the firm level affect productivity growth at the macro level

Data

National Bank of Belgium (2002-2019):

- VAT customer listing (yearly)
- VAT declarations (periodical)
- Research and development expenditure (R&D)

from ECOOM Leuven

- Annual company accounts

} Intangible investments and tangible investments

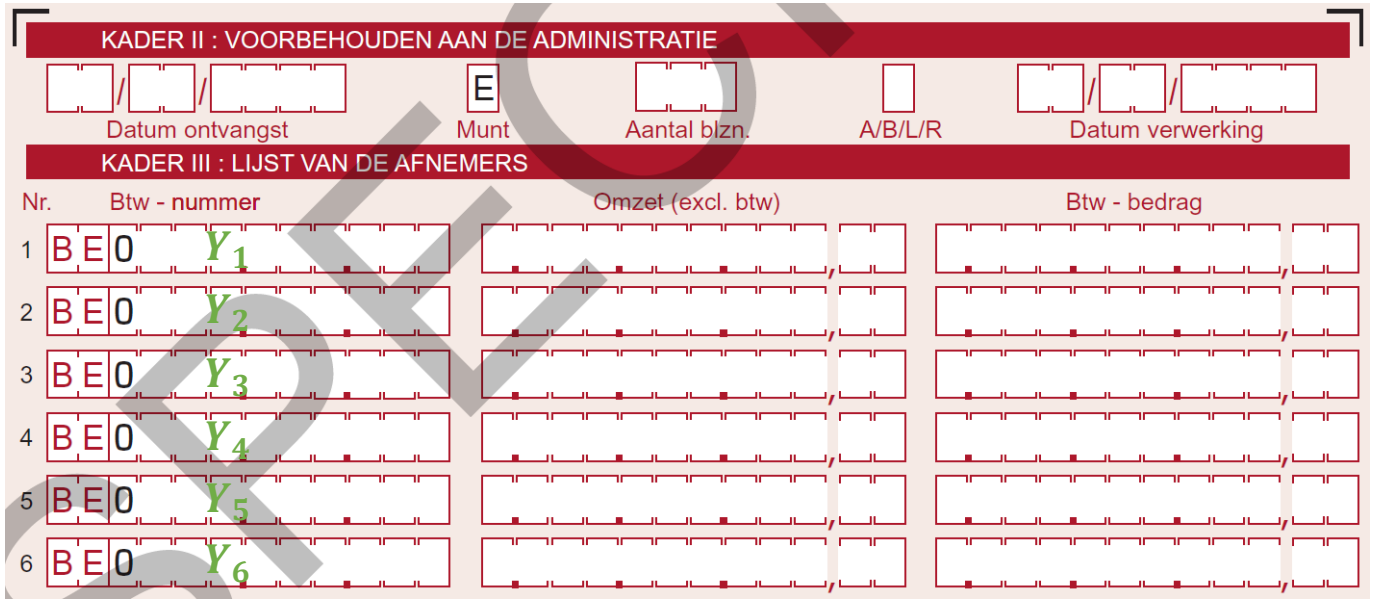
Additional data:

- 2-digit deflators from Eurostat
- 2-digit deflators from EU Klems

→ Panel of 1,603,254 firm-year observations over the period 2002-2019

Data: VAT declarations (I)

- Take the VAT customer listing of computer programmer **X**, active in NACE 6201
- From the VAT form of firm **X**, we know to which firms **Y** it sells and the value of the sales
- Since we have the yearly VAT transactions of *ALL* **X** firms, we can deduce for each firm **Y** how much it purchases from type **X** firms. The sum of all intangible purchases in year *t* across type **X** firms, is our intangible investments measure of year *t* for firm **Y**



Data: Intangible producing industries

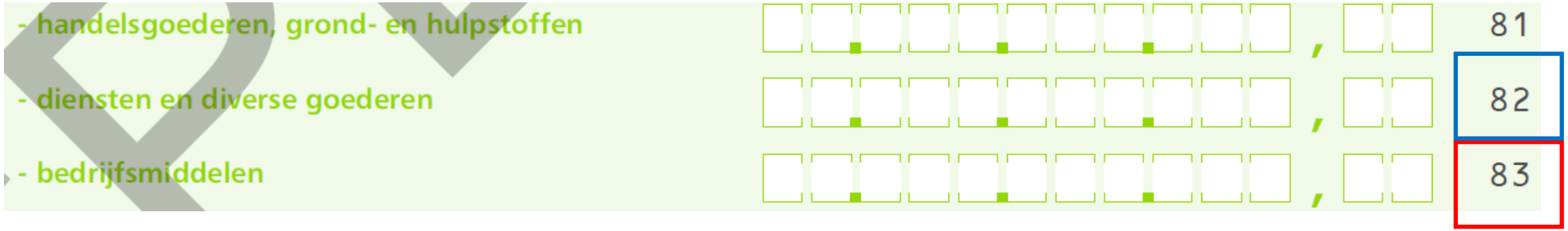
Intangible Asset Type	NACE Rev. 2 Code
	A. Computerized Information
(i) Software	6201, 6209, 6312
(ii) Database	6202, 6203, 6311
	B. Innovative Property
(i) R&D (Scientific)	7211, 7219, 7220
(ii) Entertainment & Artistic Originals	7410, 7420, 7430, 7911, 7912, 7990, 8810, 8891, 8899, 9001, 9002, 9003, 9004, 9311, 9312, 9313, 9319, 9321, 9329, 9604
(iii) Design & other new Product/Systems	7111, 7112, 7120
	C. Economic Competencies
(i) Advertising/Market Research	7311, 7312, 7320
(ii) Employer-provided Training/Organizational Structures	7021, 7022, 7490, 7810, 7830, 8510, 8520, 8531, 8532, 8541, 8542, 8551, 8552, 8559, 8560

Notes: Table 1 shows the NACE Rev. 2 that produce or sell intangible services. Intangible asset categories and types are based on Corrado et al. (2005, 2009, 2012). Table A.1 shows the description of each NACE Rev. 2 Code considered as intangible providers.

Data: VAT declarations (II)

From periodical VAT transactions, we know total intangible investments.

From the VAT declarations, firms must report total purchases of all goods that have an investment character. Intangible investment are mostly considered as a service, and hence not included here



Data

- Use the Perpetual Inventory Method to construct the firm-year capital stock

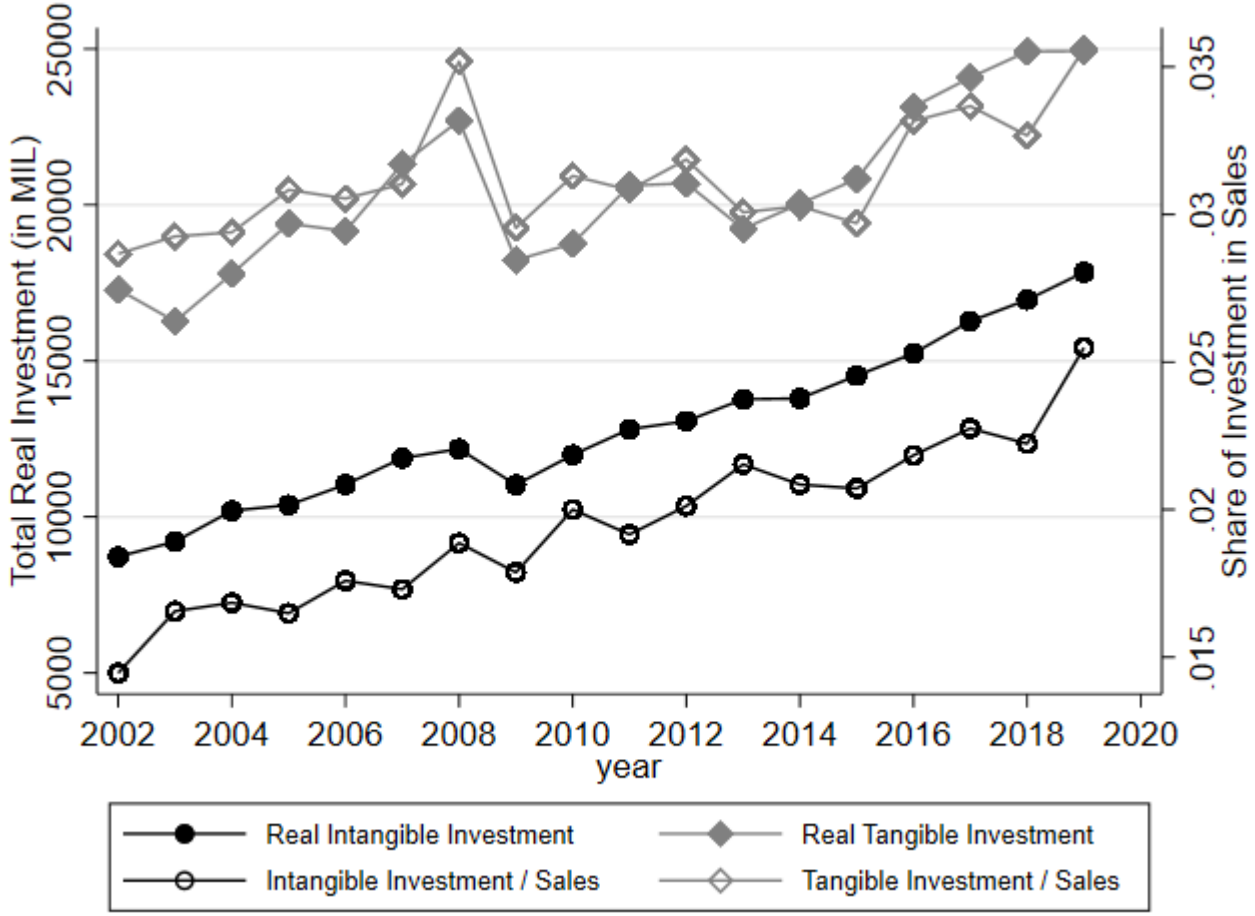
$$K_{it}^{U} = K_{it-1}^{U} \times (1 - \delta_{U}) + I_{it}^{U}$$

- Depreciation rates δ^{U} are obtained from EU Klems
- Investments $\tilde{I}_{it}^{U}$ are obtained from VAT and ECOOM data
- Initial intangible capital stock based on average intangible investment intensity in the first three years

Descriptives

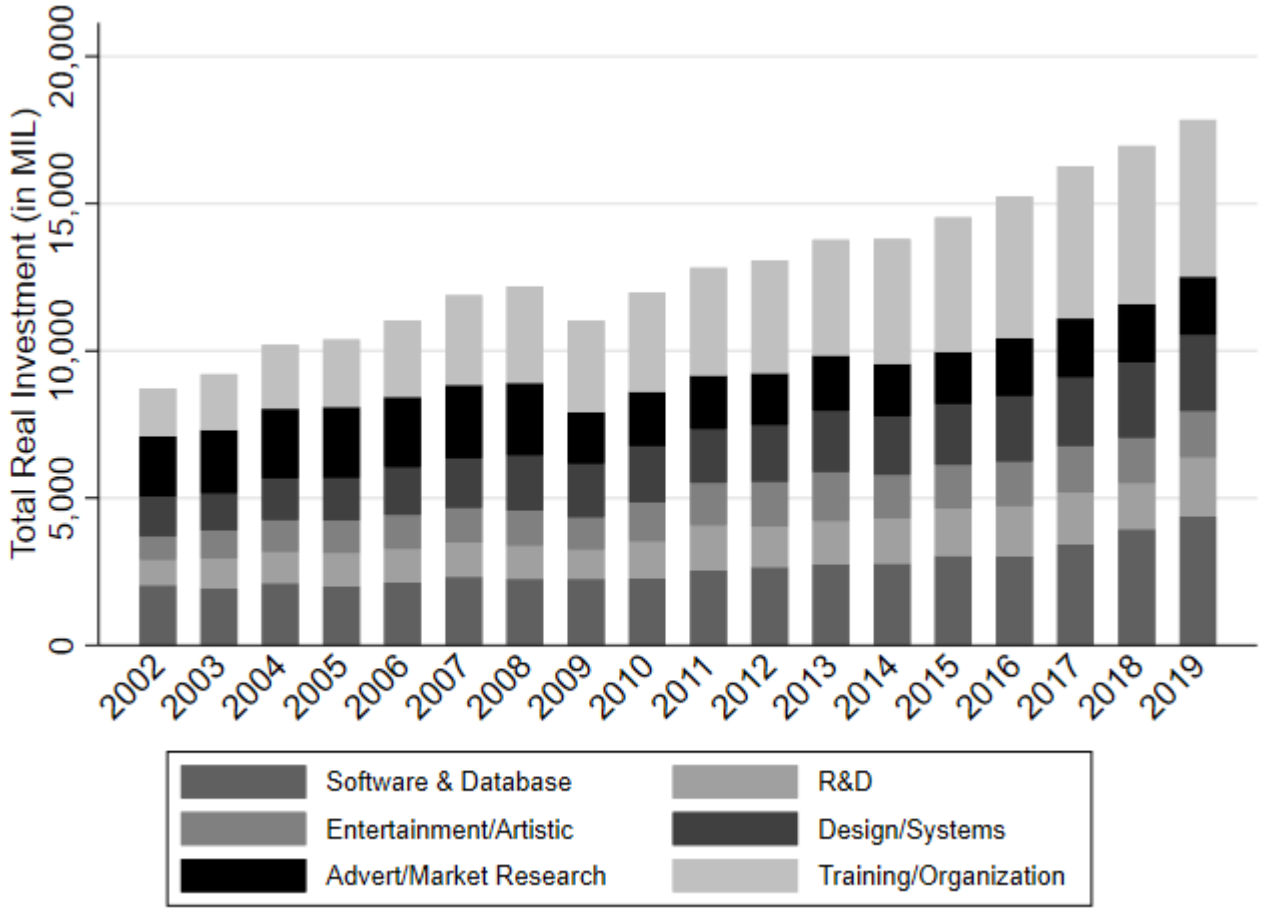
Robustness

- Fact 1: Intangibles have become more important over time.
  - Investment in intangible capital rose from **8** billion EUR in 2002 to almost **17.5** billion EUR in 2019.



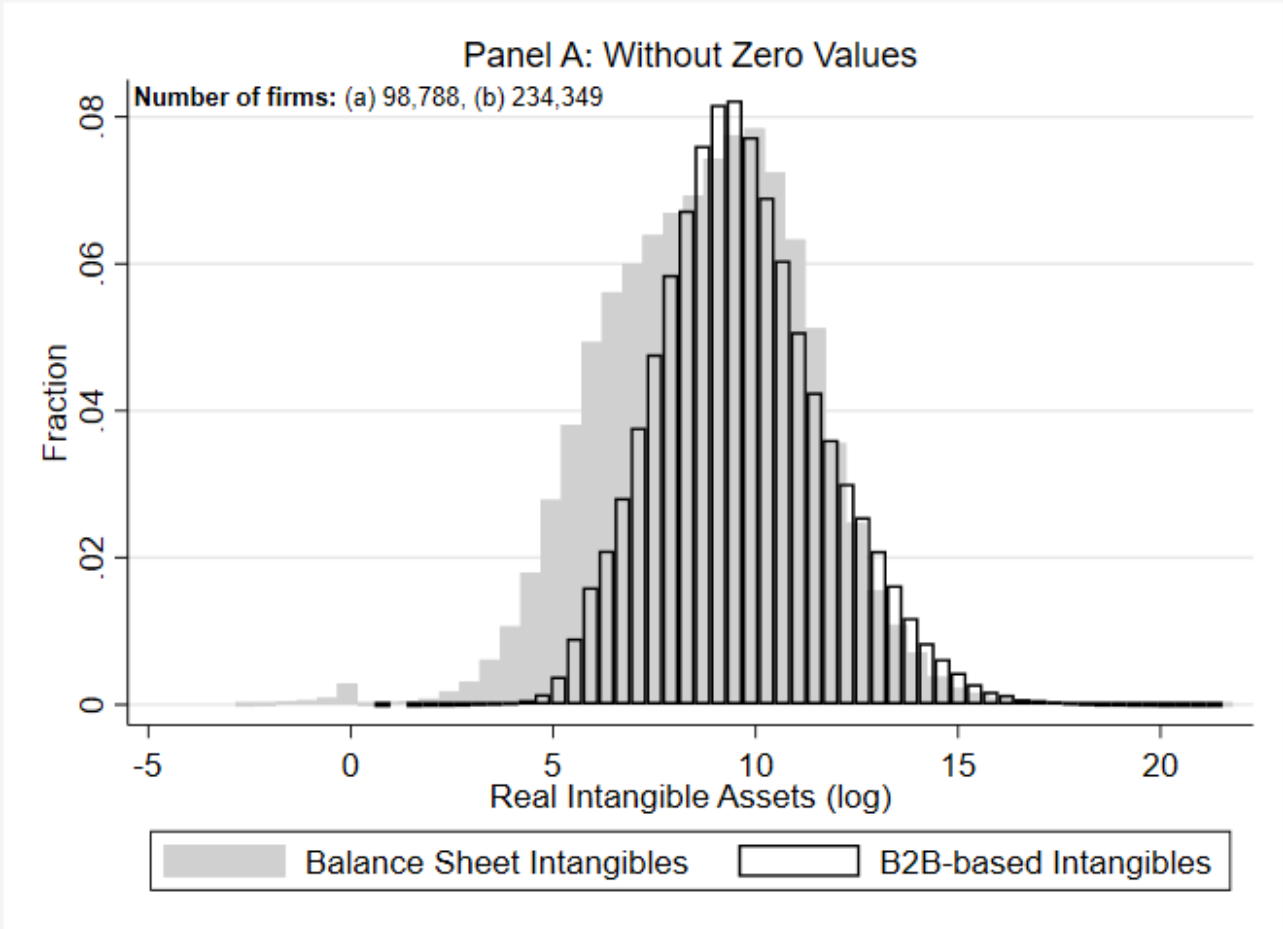
Descriptives

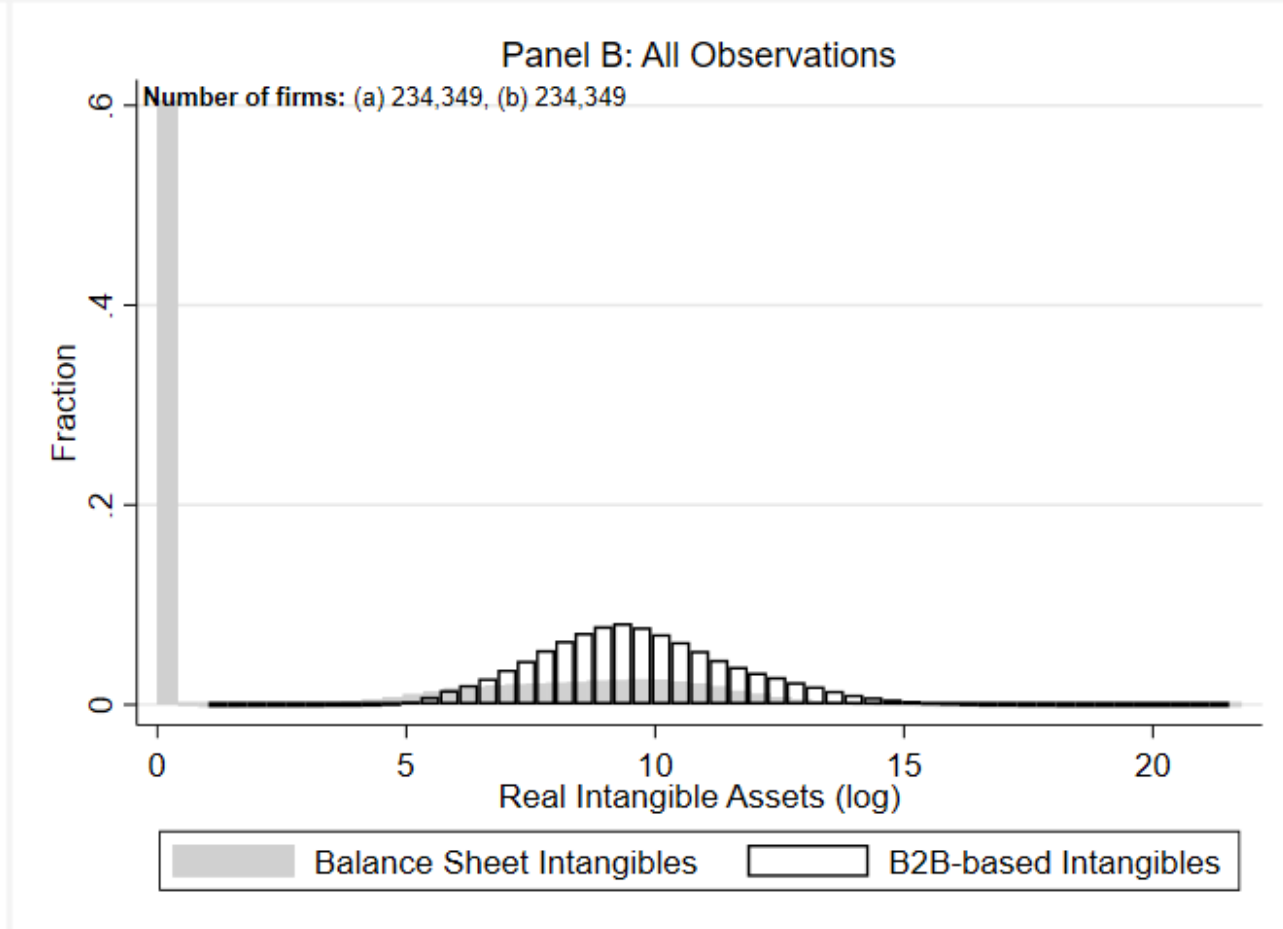
- Fact 1: Intangibles have become more important over time.
  - This increase is mainly driven by the increasing importance of **training/organizational intangibles**
  - **Software/database** investments in 2018-2019 (AI?)



Descriptives

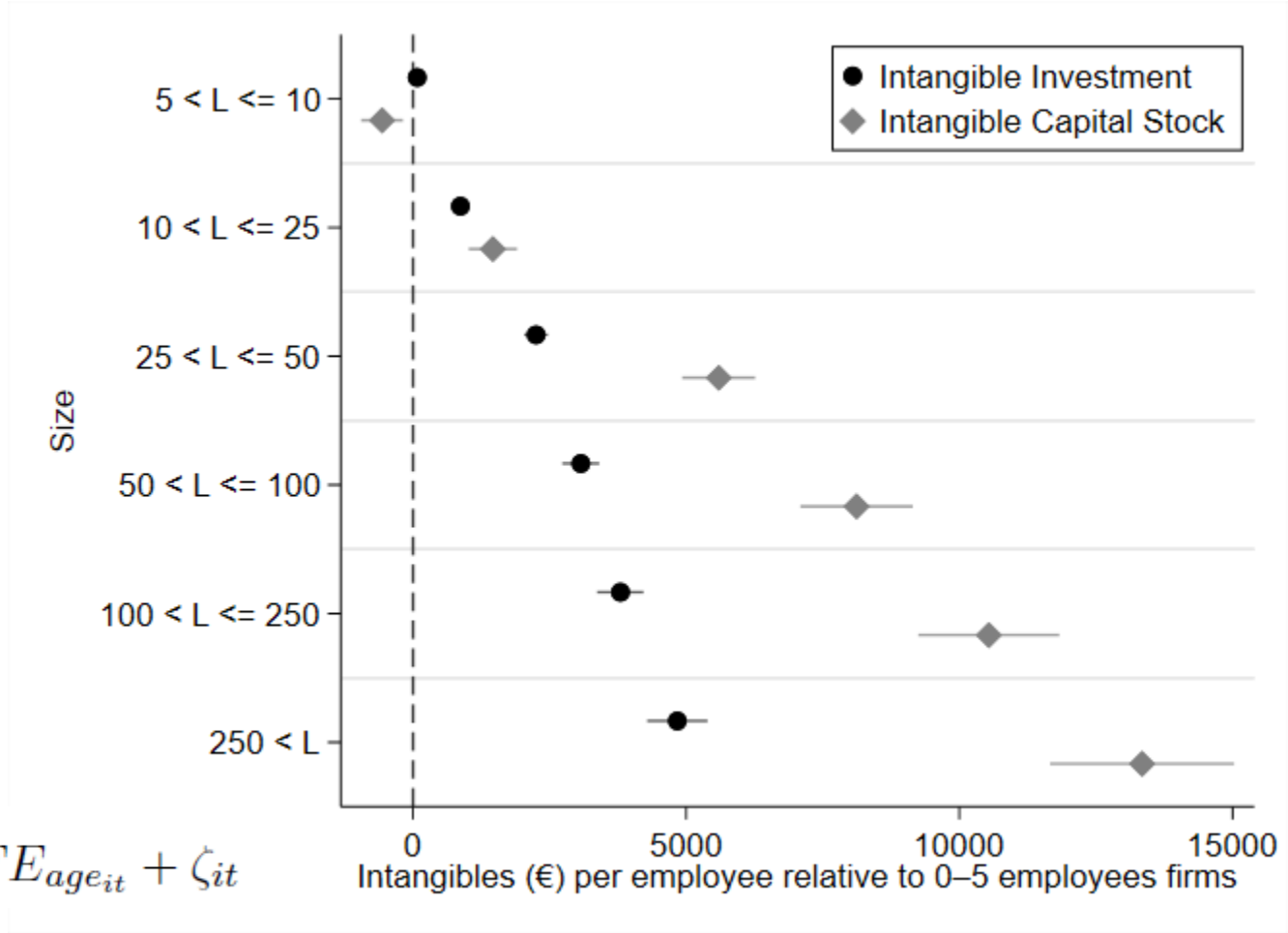
- Fact 2: The B2B-based measure on intangibles is more comprehensive than its balance sheet counterpart





Descriptives

- Fact 3: Bigger firms have a larger amount of intangible capital.
  - a firm with more than 250 employees invests close to €5000 per employee more in intangibles than firms with 0-5 employees



$$Intangiblesperemployee_{it} = FE_{Size_{it}} + FE_{ind_{it}t} + FE_{age_{it}} + \zeta it$$

Descriptives

$$log(Intangiblesperemployee_{it}) = \eta log(Size_{it}) + FE_{ind_{it}t} + FE_{age_{it}} + \zeta_{it},$$

	Within-industry			Within-firm		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Intangible Investment per Employee						
Size (Proxied by Added value)	0.3328***			0.2956***		
	(0.0009)			(0.0035)		
Size (Proxied by Sales)		0.3577***			0.2458***	
		(0.0009)			(0.0041)	
Size (Proxied by Inputs)			0.2977***			0.1157***
			(0.0008)			(0.0037)
Observations	1,425,022	1,425,022	1,424,876	1,425,022	1,425,022	1,424,876
A. Intangible Assets per Employee						
Size (Proxied by Added value)	0.4067***			0.0537***		
	(0.0009)			(0.0027)		
Size (Proxied by Sales)		0.4542***			0.0671***	
		(0.0009)			(0.0034)	
Size (Proxied by Inputs)			0.3880***			0.0325***
			(0.0008)			(0.0029)
Observations	1,638,584	1,638,584	1,638,346	1,638,584	1,638,584	1,638,346

Notes: Table 3 shows the regression results of Equation 2. The dependent variable is the logarithm of intangibles per employee (Panel A considers intangible investments, while panel B takes intangible assets as outcome variable). The independent variable is the logarithm of firm size proxied by added value, sales, and inputs. The time period is 2002-2019. All columns include a full set of four-digit industry classification fixed effects interacted with year fixed effects, and within-industry results also include a full set of age fixed effects. An elasticity of 0.3 means that raising intermediates by a factor of 2 raises intangible investment per employee by 30 percent. Within-firm standard errors are clustered at the level of the firm. *p<0.10, **p<0.05, ***p<0.01.

Increasing added value by a factor of 2, raises intangible investment per employee by 33 percent.

Methodology

- Augmented Cobb Douglas production function including both intangible and tangible capital as inputs (as in Brynjolfsson et al. 1996 and Tambe & Hitt, 2012)

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_u u_{it} + \omega_{it} + \epsilon_{it}$$

- Potential bias in labor and capital coefficients because of unobserved productivity

  → We use control function approach to correct for endogeneity of inputs (Olley and Pakes, 1996; Levinsohn and Petrin, 2003; Ackerberg et al., 2015).

Results

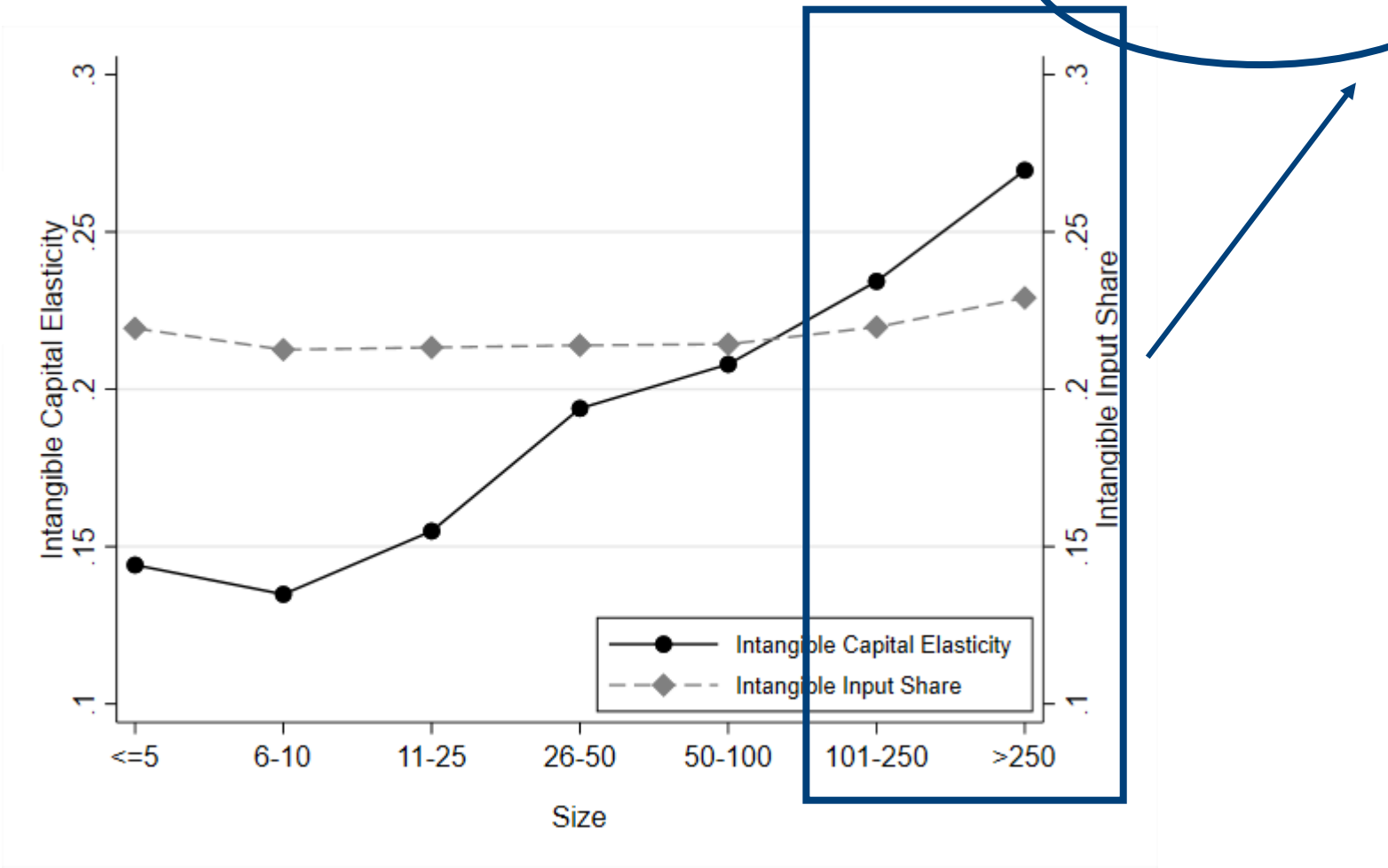
Dependent Variable:	ln(Y)	ln(Y)	ln(Y)	ln(Y)
Estimator:	OLS	Firm FE	First Differences	ACF
Sample:	Private Sector	Private Sector	Private Sector	Private Sector
	(1)	(2)	(3)	(4)
ln(K)	0.1526***	0.0928***	0.0493***	0.1217***
	(0.0008)	(0.0007)	(0.0007)	(0.0023)
ln(L)	0.6210***	0.4799***	0.3074***	0.5968***
	(0.0012)	(0.0016)	(0.0017)	(0.0029)
ln(U)	0.1630***	0.1121***	0.1153***	0.1718***
	(0.0008)	(0.0009)	(0.0010)	(0.0026)
Avg(MP_K)	0.1074	0.0653	0.0347	0.0857
Avg(MP_L)	1.0403	0.8040	0.5149	0.9998
Avg(MP_U)	0.7524	0.5176	0.5322	0.7934
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1,603,254	1,603,254	1,349,804	1,349,634
No. of firms	183,759	183,759	183,759	183,759

Notes: Table 4 shows the production function estimates of Equation 3 estimated using OLS, firm fixed effects, first differences, and the control function approach introduced by Ackerberg et al. (2015). Standard errors are clustered at the firm level. The estimation sample is identical in number of firms. The number of observations is lower due to missing lags. All estimations include year fixed effects and two-digit industry fixed effects, except for columns 2 and 3 where the industry fixed effects are observed by the firm fixed effects and first differences respectively. $*p<0.10$, $**p<0.05$, $***p<0.01$.

Results

Large firms benefit more from Intangibles

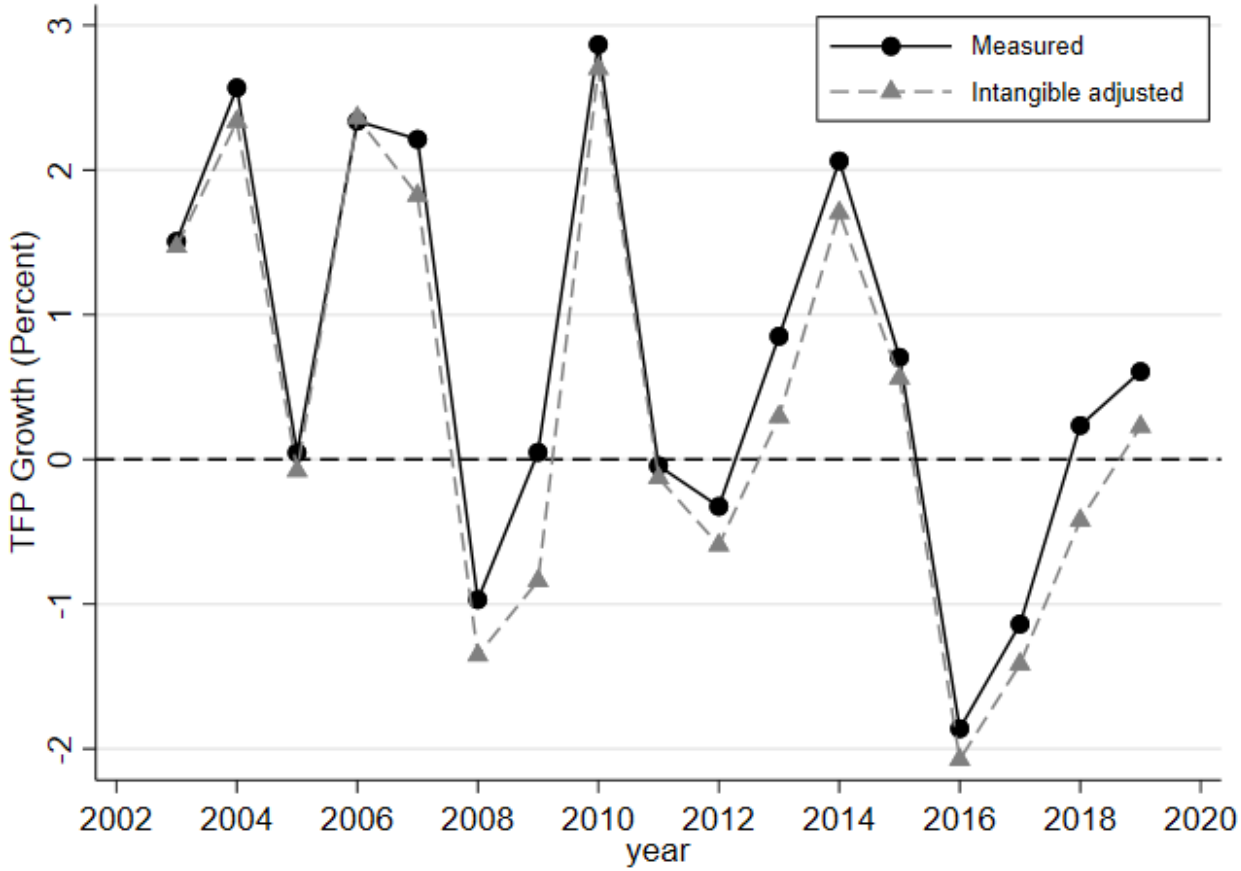
$$MP_U = \frac{\delta Y}{\delta U} = \frac{\delta Y}{\delta U}\frac{U}{Y}\frac{Y}{U} = \beta_u \frac{Y}{U} = \frac{\beta_u}{\frac{U}{Y}}$$

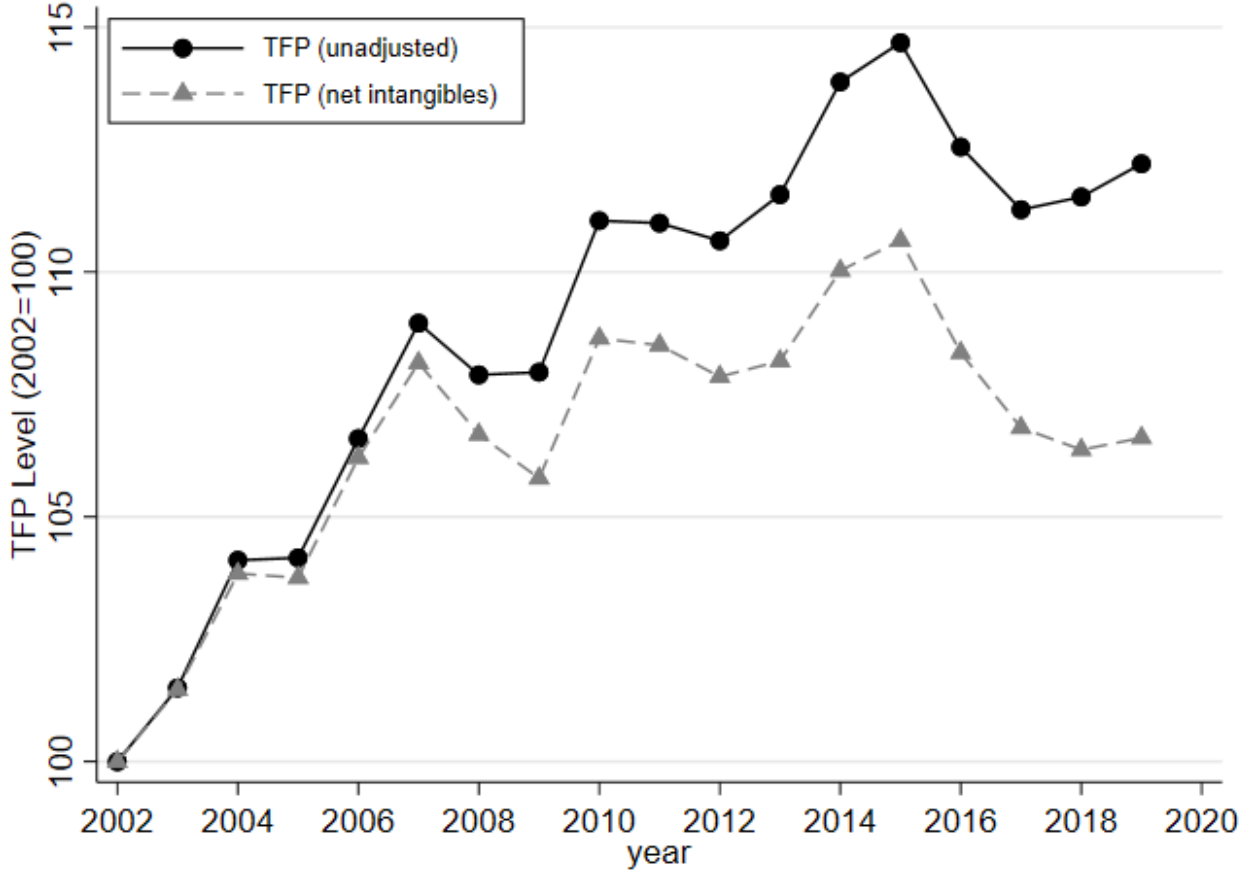


Excess Returns only for big firms

Results

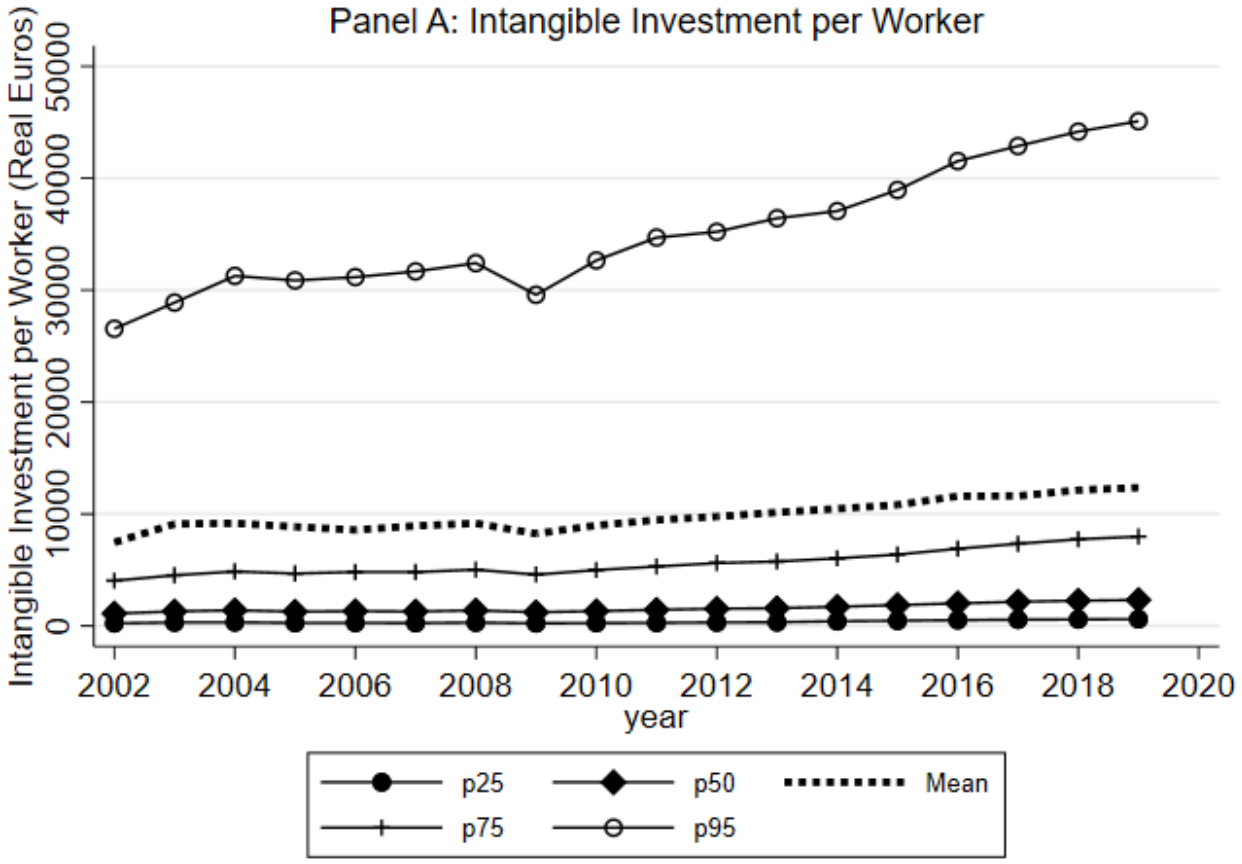
Productivity Mismeasurement

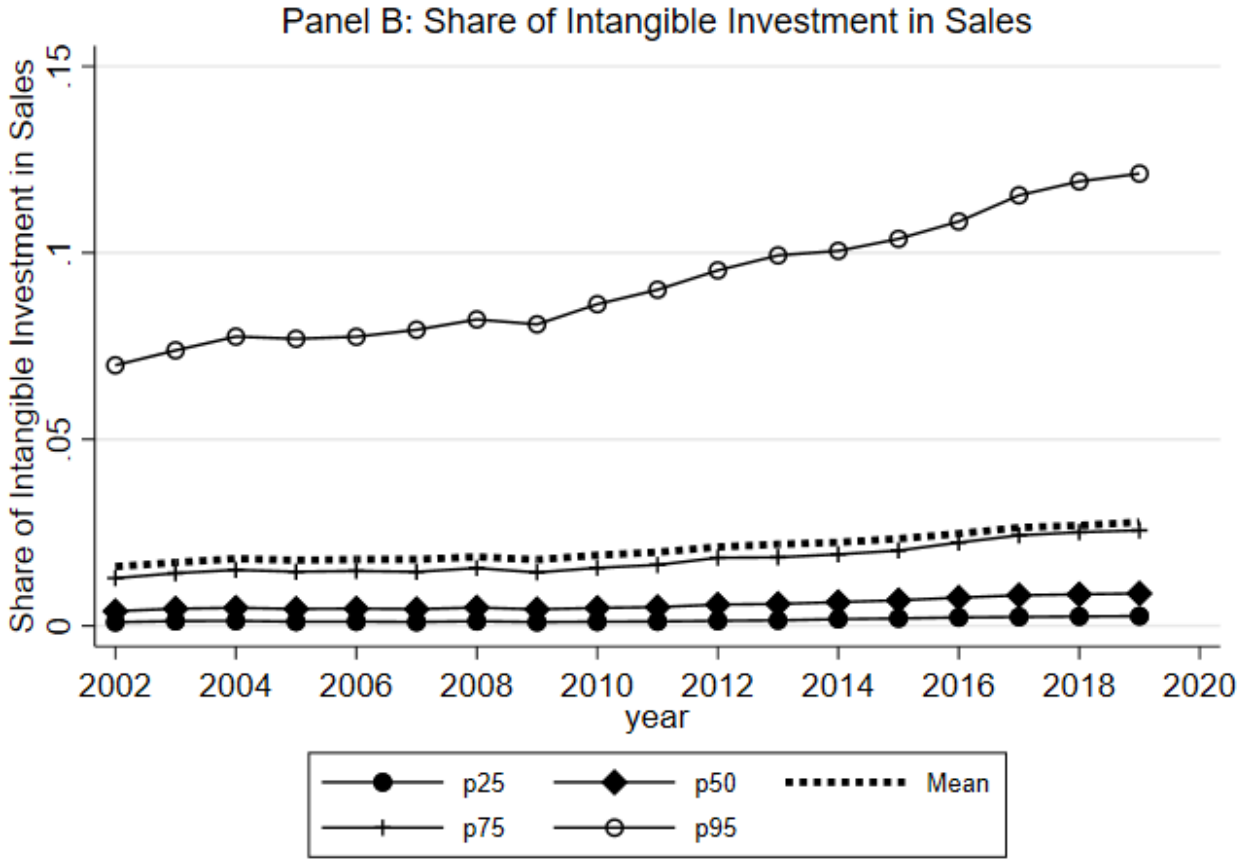




Results

Intangible Capital Deepening





Conclusion

- New data to measure returns to intangibles, allowing to include ***all*** firms and sectors of the private economy
- Findings:
  - Intangibles have become more important over time, mainly due to training/organizational intangibles
  - Bigger firms do most of these intangibles
  - Investing an additional 1€ in intangibles has a gross rate marginal product of €0.8
  - Big firms have excess returns
  - Neglecting intangibles will lead to overestimation of intangibles (intangible capital deepening is labeled as productivity growth)
  - The top 5% firms are driving this intangible capital deepening

Thank you
Q & A

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Intangible Asset Type	NACE Rev. 2 code	Description
A. Computerized Information:		
(i) Software	6201	Computer Programming Activities
	6209	Other Information Technology and Computer Service Activit
	6312	Web Portals
(ii) Database	6202	Computer Consultancy Activities
	6203	Computer Facilities management Activities
	6311	Data Processing, Hosting and Related Activities
B. Innovative Property:		
(i) R&D (Scientific)	7211	Research and Experimental Development on Natural Sciences and Engineering
	7219	Other Research and Experimental Development on Natural Sciences
	7220	Research and experimental development on social sciences and humanities
(ii) Entertainment & Artistic Originals	7410	Specialized design activities
	7420	Photographic activities
	7430	Translation and interpretation activities
	7911	Travel agency activities
	7912	Tour operator activities
	7990	Other reservation service and related activities
	8810	Social work activities without accommodation for the elderly and disabled
	8891	Child day-care activities

Intangible Asset Type	NACE Rev. 2 code	Description
	8899	Other social work activities without accommodation n.e.c.
	9001	Performing arts
	9002	Support activities to performing arts
	9003	Artistic creation
	9004	Operation of arts facilities
	9311	Operation of sports facilities
	9312	Activities of sport clubs
	9313	Fitness facilities
	9319	Other sports activities
	9321	Activities of amusement parks and theme parks
	9329	Other amusement and recreation activities
	9604	Physical well-being activities
(iii) Design and other new	7111	Architectural Activities
Product/Systems	7112	Engineering Activities and Related Technical Consultancy
	7120	Technical Testing and Analysis
C. Economic Competencies:		
(i) Advertising/Market	7311	Advertising agencies
Research	7312	Media representation
	7320	Market research and public opinion polling
(ii) Employer-provided	7021	Public relations and communication activities
Training/	7022	Business and other management consultancy activities
Organizational	7490	Other professional, scientific and technical activities n.e.c.
Structures	7810	Activities of employment placement agencies
	7830	Other human resources provision

Intangible Asset Type	NACE Rev. 2 code	Description
	8510	Pre-primary education
	8520	Primary education
	8531	General secondary education
	8532	Technical and vocational secondary education
	8541	Post-secondary non-tertiary education
	8542	Tertiary education
	8551	Sports and recreation education
	8552	Cultural education
	8559	Other education n.e.c.
	8560	Educational support activities

Notes: Table A.1 shows the NACE Rev. 2 that produce or sell intangible services. Intangible asset categories and types are based on Corrado et al. (2005, 2009, 2012).

Summary Statistics

	Mean	Median	SD
Measured Value Added (X1,000 €)	877	137	12,077
Corrected Value Added (X1,000 €)	964	147	13,030
Tangible Capital (X1,000 €)	935	129	16,039
Intangible Capital (X1,000 €)	268	14	3,988
Employment	10,55	2	159
Tangible investment (X1,000 €)	146	18	2,717
Intangible Investment (X1,000 €)	88	4	1,331
Sales (X1,000 €)	4,889	538	153,059
Wage Bill (X1,000 €)	530	72	7,222
Measured Intermediate inputs (X1,000 €)	3,557	341	74,598
Corrected Intermediate inputs (X1,000 €)	3,467	328	74,048

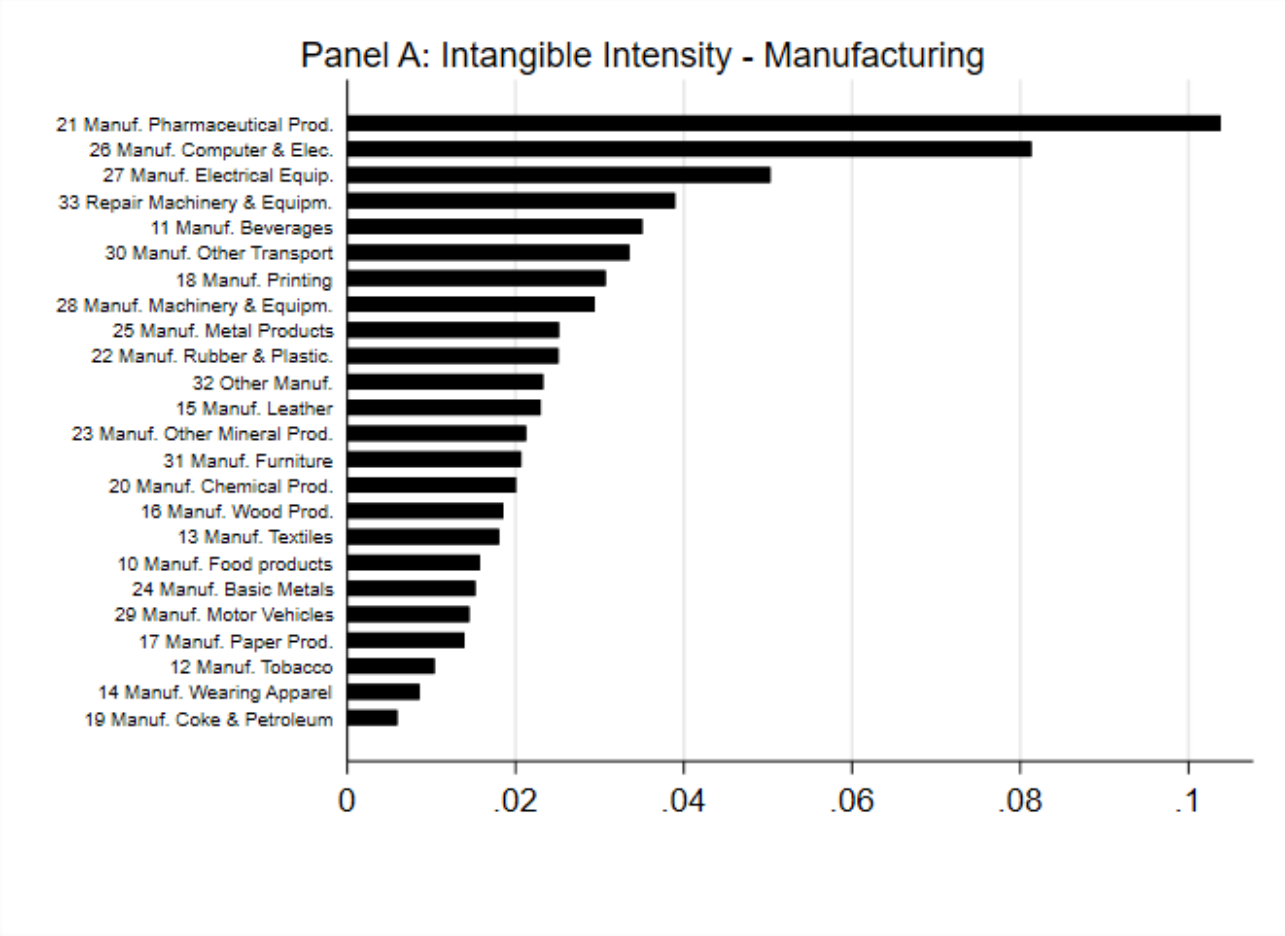
Notes: Table 2 shows the descriptive statistics of the main variables in the analysis. These descriptive statistics are based on our main analysis sample of firms with non-missing values for value added, labor, tangible capital, and intangible capital. Moreover, we do not allow for observations for which expenditures on labor and/or materials are larger than sales (214,304). The average number of observations is 1,638,584. Value added and intermediate inputs are corrected for intangible investments. Descriptive statistics are at the firm level, after taking averages over time per firm. All variables are denoted in 2015 Euros.

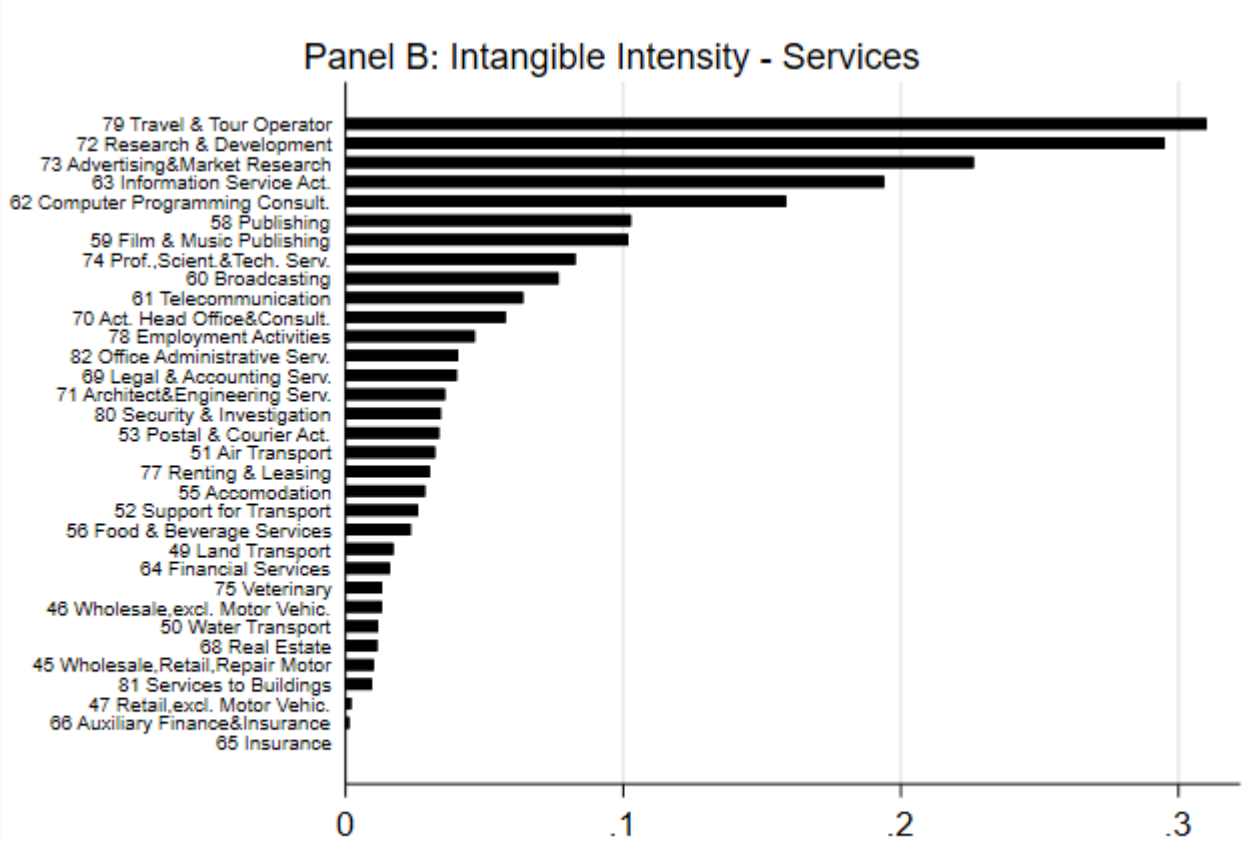
Data: VAT database

Back

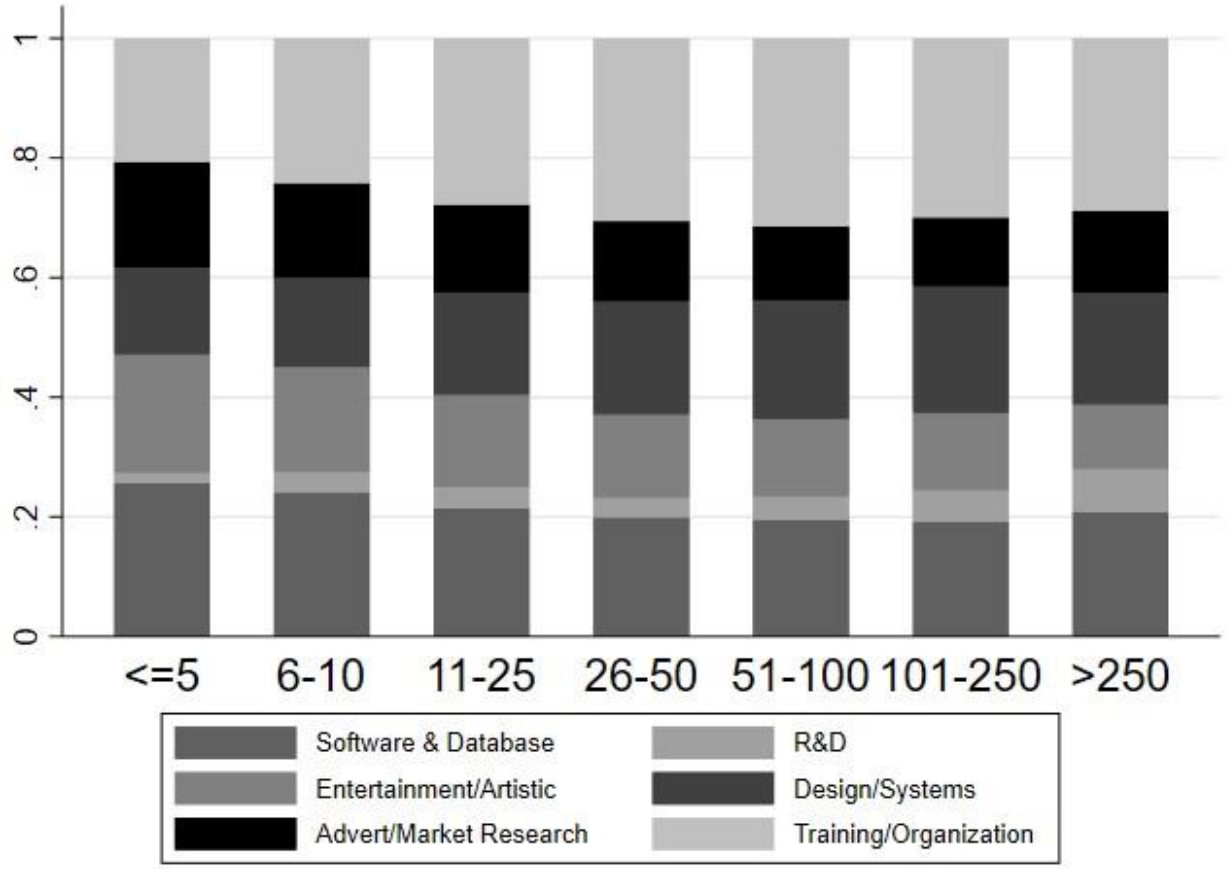
- Database with VAT declarations records transactions between firms
- For each active firm, its sales and identity of each buyer is recorded for the period 2002-2019
- Flip around database to obtain for each firm its domestic suppliers and purchases from each supplier
- Identify intangible purchases based on the detailed activity code of the supplier
- If supplier active in intangible producing sector, purchases are classified as intangible investment

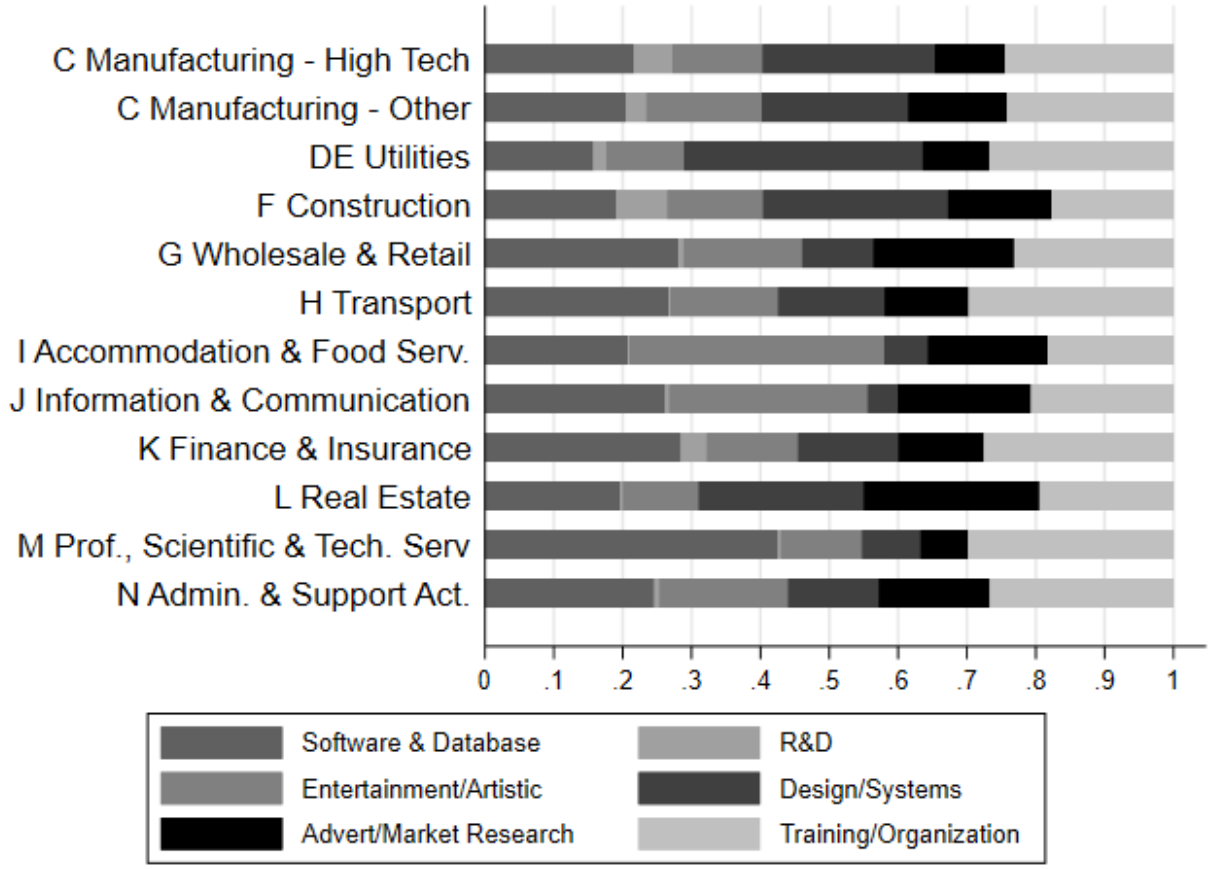
Data: Intangible intensity per industry





Data: Distribution across size and industry





Methodology – ACF (2015)

Back

- Invert material demand function to control for unobserved productivity

$$y_{it} = \beta_l l_{it} + \beta_{IT} k_{it}^T + \beta_{NIT} k_{it}^U + f^{-1}\left(k_{it}^T, k_{it}^U, l_{it}, m_{it}\right) + \epsilon_{it}$$
$$= \tilde{\phi}_t\left(l_{it}, k_{it}^T, k_{it}^U, m_{it}\right) + \epsilon_{it}$$

- Run this regression in a first step to seperate out the pure measurement error
- In a second step, all the input coefficients are identified
- Assumption that productivity follows a first order Markov process

$$\omega_{it} = g(\omega_{it-1}) + \xi_{it}$$

Methodology – ACF (2015)

Back

- Use timing assumptions to identify input coefficients

$$E\left[(\xi_{it})\begin{pmatrix} l_{it} \\ k_{it}^{T} \\ k_{it}^{U} \end{pmatrix}\right] = 0$$

- Practically:
  - Compute for a candidate vector of the input coefficients an estimate for
  - Non-parametrically regress this estimate on its lagged value to recover
  - Bring the sample analogue of the moment conditions as close as possible to 0 by changing the input coefficients

Results

Back

Dependent Variable:	$\ln(Y)$	$\ln(Y)$	$\ln(Y)$	$\ln(Y)$
Estimator:	OLS	OLS	ACF	ACF
Sample:	Manufacturing	Services	Manufacturing	Services
	(1)	(2)	(3)	(4)
$\ln(K)$	0.1695***	0.1498***	0.1422***	0.1159***
	(0.0021)	(0.0010)	(0.0073)	(0.0028)
$\ln(L)$	0.6455***	0.6118***	0.6098***	0.5919***
	(0.0032)	(0.0015)	(0.0094)	(0.0036)
$\ln(U)$	0.1508***	0.1682***	0.1699***	0.1755***
	(0.0011)	(0.0010)	(0.0055)	(0.0036)
$\text{Avg}(MP_K)$	0.1084	0.1049	0.0910	0.0811
$\text{Avg}(MP_L)$	1.0149	1.0710	0.9588	1.0361
$\text{Avg}(MP_U)$	0.7512	0.6945	0.8463	0.7246
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	240,940	1,072,858	206,150	875,782
No. of firms	26,017	145,870	23,271	123,810

Notes: Table 5 shows the production function estimates of Equation 3 estimated using OLS and the control function approach introduced by Ackerberg et al. (2015). Standard errors are clustered at the firm level. All estimations include year fixed effects and two-digit industry fixed effects. $*p<0.10$, $**p<0.05$, $***p<0.01$.

Results

Dependent Variable:	$\ln(Y)$	$\ln(Y)$	$\ln(Y)$	$\ln(Y)$	$\ln(Y)$	$\ln(Y)$
Estimator:	ACF	ACF	ACF	ACF	ACF	ACF
Asset:	Software & Database	R&D	Entertainment & Artistic Orig.	Design & New Products/systems	Advertising & Market Research	Training & Organizational
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(K)$	0.1250***	0.1210***	0.1230***	0.1206***	0.1262***	0.1221***
	(0.0027)	(0.0024)	(0.0026)	(0.0027)	(0.0026)	(0.0025)
$\ln(L)$	0.6236***	0.5982***	0.6170***	0.6137***	0.6205***	0.6145***
	(0.0024)	(0.0025)	(0.0024)	(0.0024)	(0.0025)	(0.0025)
$\ln(U)$	0.0259***	0.0215***	0.0196***	0.0258***	0.0143***	0.0323***
	(0.0003)	(0.0004)	(0.0003)	(0.0004)	(0.0003)	(0.0003)
$\ln(\tilde{U})$	0.1016***	0.1489***	0.1147***	0.1142***	0.1274***	0.1072***
	(0.0014)	(0.0023)	(0.0016)	(0.0019)	(0.0018)	(0.0019)
Avg Intangible						
Cost Share	0.0360	0.0025	0.0456	0.0346	0.0179	0.0541
Avg(MP_U)	0.7238	8.6364	0.4303	0.7456	0.7944	0.5965
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,349,634	1,349,634	1,349,634	1,349,634	1,349,634	1,349,634
No. of firms	183,759	183,759	183,759	183,759	183,759	183,759

Notes: Table 6 shows the production function estimates of a Cobb-Douglas ACF (Ackerberg et al., 2015) production function by intangible capital type. All estimations include year fixed effects and two-digit industry fixed effects. Standard errors are clustered at the firm level. $*p<0.10$, $**p<0.05$, $***p<0.01$.

Results

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Dependent Variable:	ln(Y)	ln(Y)	ln(Y)	ln(Y)	ln(Y)	ln(Y)	ln(Y)
Estimator:	ACF	ACF	ACF	ACF	ACF	ACF	ACF
Size Group:	*0-5*	*6-10*	*11-25*	*26-50*	*51-100*	*101-250*	*250+*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log(L)	0.3967***	0.7079***	0.7506***	0.7892***	0.7347***	0.7217***	0.6995***
	(0.0030)	(0.0267)	(0.0332)	(0.1237)	(0.2348)	(0.2531)	(0.0697)
Log(K)	0.1466***	0.0714***	0.0600***	0.0545***	0.0574***	0.0673***	0.0904***
	(0.0034)	(0.0049)	(0.0051)	(0.00744)	(0.0103)	(0.0193)	(0.0380)
Log(U)	0.1441***	0.1348***	0.1549***	0.1939***	0.2079***	0.2343***	0.2696***
	(0.0039)	(0.0081)	(0.0096)	(0.0190)	(0.0436)	(0.1079)	(0.0812)
Avg Intangible							
Cost Share	0.2194	0.2131	0.2138	0.2144	0.2148	0.2202	0.2295
Avg(MP_U)	0.7114	0.6812	0.7793	0.9741	1.0470	1.1508	1.2670
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	599,925	175,065	154,512	64,814	26,111	17,646	10,996
No. of firms	118,852	38,655	26,704	10,802	4,478	2,484	1,192

Notes: Table 7 shows the production function estimates of a Cobb-Douglas ACF (Ackerberg et al., 2015) production function. All estimations include year fixed effects and two-digit industry fixed effects. Standard errors are clustered at the firm level. *p<0.10, **p<0.05, ***p<0.01.

Results

	Total	Within-Firm	Reallocation	Entry	Exit
	(1)	(2)	(3)	(4)	(5)
2003	0.0972	-1.0527	0.8726	-0.1844	0.4405
2004	0.3556	-0.1717	0.4181	-0.2182	0.3284
2005	0.1527	0.4861	-0.2140	-0.3789	0.2717
2006	-0.0051	0.5233	-0.1812	-0.5375	0.1979
2007	0.2561	0.5067	-0.1354	-0.3226	0.2181
2008	0.3924	0.6263	-0.1976	-0.2268	0.2052
2009	0.9600	1.2908	-0.2430	-0.3360	0.2766
2010	0.0962	0.4615	-0.2894	-0.2917	0.2255
2011	-0.1026	0.4764	-0.4882	-0.2678	0.1855
2012	0.2763	0.6325	-0.2197	-0.3186	0.1944
2013	0.6984	0.7683	-0.2396	0.0190	0.1673
2014	0.3554	0.9979	-0.1777	-0.3901	-0.0536
2015	0.1991	0.9626	-0.4508	-0.4750	0.1828
2016	0.1880	0.9215	-0.5668	-0.3367	0.1893
2017	0.3512	0.6853	-0.2354	-0.2491	0.1649
2018	0.6351	0.9711	-0.2249	-0.3342	0.2421
2019	0.2670	0.7206	-0.3988	-0.3098	0.2695

Notes: Table 8 shows the results of a decomposition of the change in TFP mismeasurement using the dynamic (Melitz and Polanec, 2015) methodology as described in the text. We divide the change in the overall TFP mismeasurement (column (1)) into four components: column (2) indicates the change in TFP mismeasurement due to a general increase across all surviving firms; column (3) captures reallocation among incumbent (surviving) firms; columns (4) and (5), respectively, indicate the contribution of firm exit and firm entry to the increase in the aggregate TFP mismeasurement.