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ABSTRACT

We take the global financial crisis (GFC), as an example of major crises, to study the trends of intangible investment, the link between industrial performance and intangible assets, and the differences of financing of intangible versus tangible assets during crises. We find an upward trend in investment intensities (investment-to-value added) for several kinds of intangible assets in almost all advanced EU countries, and in almost all sectors based on industry-level data. This trend started well before the GFC and the crisis had little impact on it, in contrast to tangible investment intensities, which declined a lot. Then we explore the potential role that intangible assets may play in weathering the negative effects of major crises using industry-level data. One of the main results about industrial performance is that pre-crisis R&D investment is robustly associated with economic resilience during the GFC, and higher productivity growth in the aftermath. Finally, we investigate how a financial turmoil may affect the financing of different assets. We combine insights from a macro (industry-level) and a micro (firm-level) approach to shed light on the importance of financial shocks in intangible investment. We find differences from tangible investment, mainly that tangibles are more sensitive to demand shocks, while intangible investment is more vulnerable to financial shocks. For the latter, our main explanation is that tight credit conditions create a trade-off between tangible and intangible investment financing.

JEL codes: G01, D22, D24, G31

Keywords: productivity, financial crisis, resilience, intangible assets

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1. INTRODUCTION

Intangible assets are key in the modern economy as drivers of the productivity of firms, and ultimately for the competitiveness of economies, as shown by a couple of recent papers (Thum-Thysen et al., 2019; Corrado et al., 2018; Bauer et al., 2020; Adarov and Stehrer, 2019; Cincera et al., 2020). Intangible assets play a role in digitalisation (e.g. software, databases), innovation (e.g. research and development, design, patents) and embody the business knowledge necessary for the effective functioning of firms (e.g. market knowledge, organisational knowledge, and training for employees). Furthermore, the importance of an intangible asset is amplified by its complementarity to other intangible and tangible assets (Thum-Thysen et al., 2022).

In this paper, we focus on the development and the role of intangible investment during crises with a special attention to its financing. Our findings give insights into several aspects of intangible investment, such as the general trend of adoption of intangible assets, differences in financing of intangible versus tangible assets, the impact of demand and financial shocks, and into the implications of crisis periods like the Global Financial Crisis (GFC) and the COVID-19 crisis.

We take the global financial crisis (GFC) as an example of major crises to study the trends of intangible investment before, during and after such a major crisis. We find an upward trend in intangible investment for several kind of intangible assets in almost all advanced EU countries, and in almost all sectors. This trend started well before the GFC and the crisis had little impact on it, in contrast to tangible investment which declined a lot. We also confirm the relative insensitivity of intangible investment intensity to the GFC at the 2-digit industry-level while taking into consideration the long-term upward trend, i.e. we analyse the deviation from this trend.

Then we explore the potential role that intangible assets may play in weathering the negative effects of major crises. One of the main results about industrial performance is that pre-crisis R&D investment is robustly associated with economic resilience during the GFC, and higher productivity growth in the aftermath.

Finally, we also investigate how a financial turmoil may affect the financing of these assets. We combine insights from a macro (industry-level) and a micro (firm-level) approach to shed light on the importance of financial shocks in intangible investment. We find important differences with respect to tangible investment, mainly that tangibles are more sensitive to demand shocks, while intangible investment is more vulnerable to financial shocks. We explain the latter finding by a trade-off between intangible and tangible investment during crisis periods. During expansions, firms tend to use internally generated cash flows to finance intangibles and use credit to finance tangibles (see Altomonte et al. 2021 for causal evidence on France). When external finance dries up, firms tend to move part of the internal cash flow to finance tangible investment, instead of intangibles.

Using our results, we draw some general lessons that can also be applied to the COVID-19 crisis. Our hypothesis is that - despite the differences in the GFC and the COVID-19 crisis, - intangible assets are important for the resilience of businesses, and that intangible assets were

less affected by the pandemic compared to tangible assets. This latter expectation seem to be confirmed by preliminary National Accounts data.

2. DATA AND METHODOLOGY

We use the Global Financial Crisis (GFC) as an episode of severe crisis to investigate the behaviour of intangible investment. We use both macro data (2-digit NACE industry-level data from EUKLEMS database, 2019) for EU15 countries[1] and the US and firm-level data (Orbis database) for three major European economies, France, Italy and Spain for the analysis. In the macro analysis, we consider a rich set of intangible assets (including elements of computerised information, innovative property and economic competency) in-line with their widespread definition at the macro-level (Corrado et al., 2009).[2] In the micro analysis, intangible assets are derived directly from the balance sheet of firms.

2.1. Data and methodology in the macro analysis

For the macro analysis, we first analyse trends in intangible investment intensity across countries, industries and different intangible assets. Investment intensity is defined as nominal investment over nominal value added.[3] We estimate the behaviour of investment during the GFC using 2-digit level industry data controlling for pre-crisis linear trends.

We then exploit the country-industry variation in intangible investment intensity to analyse the contribution of intangible investment to industrial performance, by estimating:

$$\bar{y}_{csT} = \alpha\, \overline{Int}^{M}_{cs,2005-2007} + \beta\, \overline{Int}^{I}_{cs,2005-2007} + \delta_c + \mu_s + u_{cs}, \qquad (1)$$

where $\bar{y}_{csT}$ is the average annual growth rate of the outcome variable in country c, industry s and over period T (2005-2007, 2008-2009, 2010-2013 or 2014-2017). The outcome variables are real value added, employment (persons), hours worked, hours/employment, labour productivity (real value added per hour) and TFP. $\overline{Int}^{M}_{cst}$ and $\overline{Int}^{I}_{cst}$ are average tangible and intangible investment intensity (as a share of value added), respectively, before the GFC. Several intangible assets were used in the regression for intangible intensity (e.g. software, R&D, etc). δ_c and μ_s are country and industry fixed effects, respectively, and u_{cs} an error term.

When investigating the role of finance in intangible investment, financial stress in year t is captured by a country-level indicator, $CLIFS_{ct}$ (country-level indexes of financial stress reported by the ECB). Monthly data of CLIFS were annualised by simply taking an average.

[1] We have data for Austria, Germany, Denmark, Spain, Finland, France, Italy, Netherlands, Sweden and for the UK.

[2] We compared intangible data from EUKLEMS with another widely used dataset, Intan-Invest. We did not find major discrepancies between the two datasets for most of the countries and assets at the 1-digit industry level (the most detailed industry level available from Intan-Invest).

[3] Value added was not adjusted by non-National Accounts intangibles.

The exposure to financial stress, EFD_{cs}, is measured by external financial dependence at the country-industry level. The idea behind our measure of EFD goes back to the seminal paper of Rajan and Zingales (1998), and the calculation is based on the approach of Balta and Nikolov (2013). We use the BACH database from the Banque de France containing balance sheet data for a number of countries.[4] We calculate the share of investments that is not covered by cash-flow by country and 2-digit level industry (we calculate shares for services as well as for manufacturing). Cash-flow is approximated by gross operating surplus, while investment is calculated as the change in tangible and intangible fixed assets plus depreciation of these assets.[5] The higher the share of investments not covered by cash-flow the stronger the need for external finance for these investments (i.e. the higher the EFD indicator is). We average this share over the period of 2000-2004, substantially far away from the GFC during a period of abundant liquidity, so that this measure is a good proxy for the country-industry specific demand for external finance. For the values of EFD see Table 14 in the Appendix.

Now, we exploit the country-industry variation in intangible investment intensity Int^I_{cst} and regress it on the interaction of financial stress and external financial dependence:

$$Int^I_{cst} = \beta\ EFD_{cs} * CLIFS_{ct} + \lambda_{cs} + \mu_{ct} + \rho_{st} + u_{cst}, \quad (2)$$

controlling for country-industry, country-year and industry-year fixed-effects (λ_{cs}, μ_{ct} and ρ_{st}, respectively), with u_{cst} being the residual error term. For a preliminary analysis of the impact of financial shocks, we replace the variable CLIFS with year dummies. In this way, we can show how external financial dependence affected intangible investment during the crisis years:

$$Int^I_{cst} = \beta^t\ EFD_{cs} * \delta_t + \lambda_{cs} + \mu_{ct} + \rho_{st} + u_{cst}, \quad (3)$$

where δ_t are year dummies, and β^t is the coefficient showing the differential impact of external financial dependence on intangible investment intensity in year t.

For comparison with micro data (see next subsection), we construct an indicator of capital intensity. Capital intensity is based on data coming from the EUKLEMS (2019) database, and it is calculated as real capital stocks divided by real value added in the manufacturing sector by country and year. Real capital stocks are constructed in the database using PIM (Perpetual Inventory Method) asset by asset. For tangible assets, real capital stocks is the part of the total real capital stocks that are not intangible assets in National Accounts and include machinery, equipment, other buildings and structures. For intangible assets, real capital stocks is the sum of National Accounts intangibles plus most of the non-National Accounts intangibles.

[4] We have 6 countries where the data could be used for our purpose: Austria, Germany, Denmark, Spain, France, Italy.

[5] Balta and Nikolov (2013) used a somewhat different version of this calculation: they used net operating profit as cash-flow and considered only tangible fixed assets for investment. We find the gross numbers a more adequate proxy of cash-flow if we want to explain gross investment (i.e. investment that includes replacement investment). As for the type of investment, our main goal is to explain intangible investment, thus it is natural for us to include intangible fixed assets as well even if balance sheet data and macroeconomic statistical data may differ substantially in case of intangible investment. A further reason is that depreciation cannot be separated between tangible and intangible assets in the dataset.

2.2. Data and methodology in the micro analysis

For the micro analysis, the relevant dataset has been retrieved from the Orbis database provided by Bureau van Dijk and mainly contains firm-level balance-sheet data. Differently from the macro analysis, which looks at the entire economy, here the sector of interest is manufacturing, with a time span covering the years from 2004 to 2017. All the variables are deflated using an output deflator specific for the two-digit manufacturing industry at 2010-level. The deflators have been retrieved from the OECD STAN database. To ensure representativeness of the sample across the three considered countries and industries, an appropriate weighting scheme has been introduced in our analysis. Weighting is based on the number of active enterprises, as reported by Structural Business Statistics (SBS) and Business Demography (BD) statistics of Eurostat. Weights are applied at the size class-industry-year level in each country. After cleaning balance sheet data for missing values and outliers, we end up with some 1.9 million observations over the considered time span.

Our main variables of interest are tangible and intangible investments, as measured through raw balance-sheet data. The original Orbis variables are respectively TFASS, formally defined as ”all tangible assets such as buildings, machinery, etc” and IFASS, formally defined as ”all intangible assets such as formation expenses, research expenses, goodwill, development expenses and all other expenses with a long-term effect”. These variables have been cleaned, removing any negative values, while we do not consider firms with zero values of tangibles or intangibles assets.

In the macro section, the focus is on investment intensities, with the latter calculated by taking the ratio of the tangible and intangible investments to value added (VA). To harmonize the analysis between the macro and the micro sections and ensure comparability of results, we start from the original firm-level stock measures as retrieved from balance sheets, but we look at their variation within each firm (i.e. a proxy of investment) using firm-fixed effects, which also control for firm size and other invariant characteristics.

Moving to the list of relevant covariates, financial independence is proxied by an alternative representation of the original ASCL Index of Mulier et al. (2016), where only cash flows and leverage are considered (CL Index).[6] Our resulting variable can take values 0, 1 or 2, with the latter associated to both a cash flow for a given firm larger than the median value within each industry-year, and a long-term debt exposure lower than median. As a result, higher values of the index indicate higher financial independence. The reasoning behind the choice of variables in the financial indicator is due to the fact that firm age and firm size appear to be correlated to the choice of intangible assets, with smaller and younger firms having a systematically higher

[6] Mulier et al. (2016) aim at approximating ”the elasticity of the supply of finance to firms”, and measure whether a firm is scoring below or above its industry median in a given year in four categories of interest. A firm gets a score of 1 for age if the firm is younger than the median firm in the same industry in a given year, and 0 otherwise. The firm also gets a score of 1 if, respectively, its size (employment) and average cash flow to capital ratio of the previous two years are lower than the median firm in the same industry/year. A firm gets a score of 1 if its average long term debt to total assets ratio of the previous two years is higher than the industry/year median. By summing the four score, the authors obtain for each firm-year observation a score between 0 (unconstrained supply of external finance) and 4 (constrained supply of external finance).

investment intensity. We also experiment with a measure of the index in which the median value cut-offs have been set using data from the period 2004 to 2008 (CL (04 − 08) Index). This specification captures the ex-ante financial structure of firms, removing potential endogeneity concerns in their investment decisions resulting from the breakout of the GFC. As an alternative measure of firm financial exposure we also consider current liabilities, which proxy the availability of credit to the firm. The demand intensity to whichfirms are subject is measured through firms' turnover. In the subsequent analysis both turnover and current liabilities will always appear lagged as regressors. Finally we have calculated an indicator of external financial dependence (EFD) defined at the 2-digit industry-level, the same way as in the macro analysis, i.e. it is measured as percentage share of investment not covered by cash-flow averaged over 2000-2004. Finally, a dummy variable $post$ indicates the periods before and after the Global Financial Crisis, taking the value of 0 before year 2008, and 1 thereafter.

We proceed by first validating the results of the macro analysis, estimating the impact of external financial dependence on intangible investment, before and after the GFC. Then we adopt a firm-level measure of financial independence, i.e. the cash and leverage position of the firm before the GFC, and a measure of credit availability (proxied by current liabilities, lagged), and we estimate similar equations as before, but controlling for firm fixed effects:

$$Inv_{ft} = \beta^{D} D_t + \beta^{V} V_f + \beta^{int} D_t * V_f + \lambda_f + u_{ft} \quad (4)$$

where Inv_{ft} is (log) tangible or intangible assets of firm *f*, *V* the firm-level variable of interest (financial independence or credit availability), *D* a dummy indicating the period vis a vis the GFC (0 until 2008, and 1 from 2009 onwards). λ_f is firm fixed effect and u_{ft} an error term.

Finally, using the same specification, we also associate intangible investment to demand before and after the crisis (proxied by lagged turnover).

3. RESULTS

One of our goals is to investigate the distinct behaviour of intangible versus tangible investment during the global financial crisis. Furthermore, we seek to associate differences in industrial performance during and after the crisis to differences in investment. We also explore the link between intangible investment and financial conditions during the GFC vis-à-vis investments into tangible assets. To achieve these goals, first, we analyse the trends of intangible and tangible investment and the deviation from this trend during the GFC.

3.1. Trends in investment intensity and the GFC at the macro level

Tangible intensity declined during the crisis in the EU15 countries. (Figure 1), while during the late recovery (2014-2017) it rebounded somewhat. Nevertheless, average tangible intensity is lower at the end of the sample period than before the crisis. By contrast, intangible intensity in most assets increased during the crisis and continued throughout the recovery. Exceptions include own-account organisational capital and training. This resilience of intangible assets to the financial crisis is consistent with earlier findings at the country level (Corrado et al., 2018).

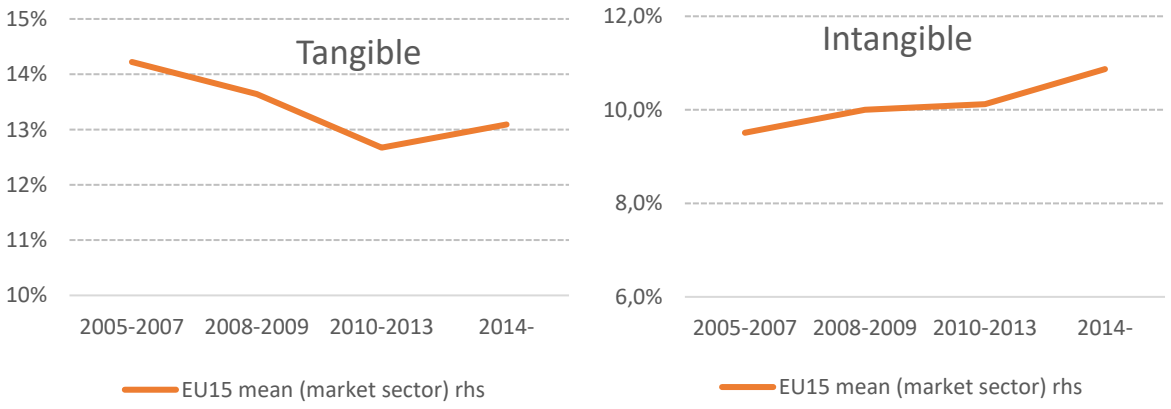
We should emphasise that we analyse intensities, and not overall investments. As value added decreased substantially during the financial crisis, the fact that intangible investment intensity did not decrease still means that intangible investment declined from 2008 to 2009, especially if we compare it to the pre-crisis trend. Thus what we find here is that intangible investment declined more or less proportionally with value added, while the drop was bigger in the case of tangible investment.

It is interesting to see how short-term developments around the GFC fit into a longer-term picture. We observe, since 1995, an upward trend in intangible intensity. This trend was mainly unaffected by the financial crisis (see Figure 2 where we show the estimated pre-crisis trend since 2001). Indeed, the deviation from the pre-crisis trend is not negative for the aggregate intangible asset as opposed to the tangible asset, where it is significantly negative for 2010 (see Table 1). This finding is consistent with previous results in the literature where it is found that intangible investment is relatively insensitive to aggregate demand (Thum-Thysen et al, 2019).

It is remarkable that despite this overall increase in intangible intensity, the ranking of countries by this intensity is quite persistent (Figure 3). These persistent country-specific differences in intangible investment intensity should be taken into account when analysing industrial performance or the link to financial conditions (i.e. that country fixed effects should be included in all panel regressions).

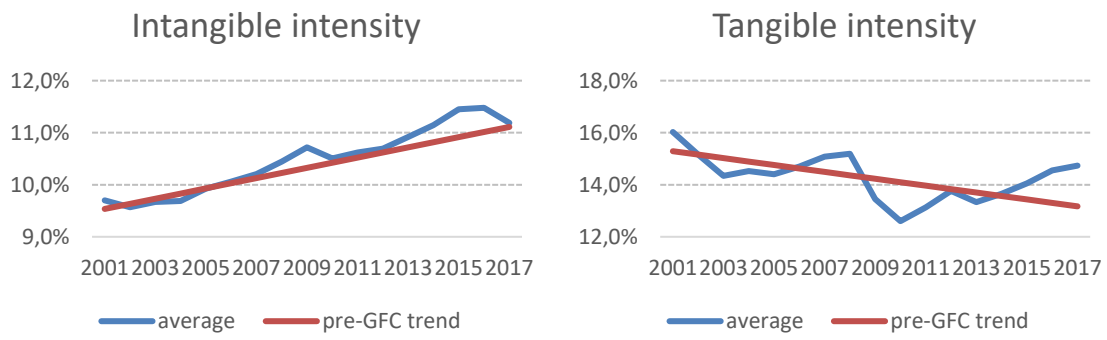
Almost all intangible assets show an upward trend (except own-account org.cap. and training, see the Appendix for figures by individual assets), while the biggest contributor to the aggregate trend is the increase in R&D intensity. Intangible intensity in almost all 2-digit industries follows a positive trend. In contrast to intangible assets, tangible investment intensity exhibited a negative trend already before the crisis. Almost all 2-digit industries follow this negative trend. The crisis reinforced this downward trend, causing a further drop in tangible intensity, while after the crisis there was a partial rebound.

Figure 1. Tangible and intangible investment intensity of EU15 countries (percentage of nominal value added).



Note: The aggregate intangible asset does not include own-account organisational capital and training, while it includes other intellectual property products.

Figure 2: Average intangible and tangible investment intensity in the EU15 and US, and the pre-crisis trend of these intensities



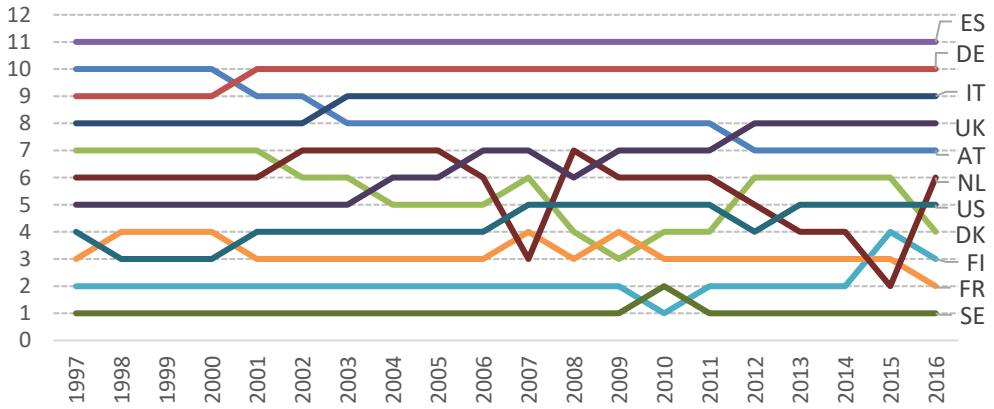
Note: unweighted average of country-industry data at the 2-digit level. Pre-crisis trend is estimated using the 2001-2007 period.

Table 1: Estimated pre-crisis trend growth and after-crisis year-effects of investment intensities for different assets (percentage points)

	tangible	intangible	NA intangi	Software	R&D	Design	Brand	POCap	OOCap	VT
trend	**-0.13%**	**0.10%**	0.05%	0.00%	0.03%	0.01%	0.01%	**0.02%**	**-0.03%**	**-0.01%**
year 2008	**0.83%**	0.22%	0.08%	**0.14%**	-0.01%	0.04%	0.03%	0.03%	-0.01%	**-0.02%**
year 2009	-0.78%	0.40%	0.36%	**0.20%**	0.24%	0.01%	-0.01%	-0.02%	0.02%	**0.07%**
year 2010	**-1.50%**	0.08%	0.21%	0.15%	0.12%	-0.03%	-0.03%	-0.07%	-0.01%	**0.05%**
year 2011	-0.84%	0.10%	0.22%	**0.21%**	0.06%	0.00%	-0.06%	-0.06%	0.04%	**0.08%**
year 2012	-0.07%	0.08%	0.30%	**0.24%**	0.11%	-0.04%	-0.06%	-0.07%	**0.09%**	**0.10%**
year 2013	-0.37%	0.20%	0.37%	**0.29%**	0.10%	-0.03%	-0.08%	-0.03%	**0.13%**	**0.10%**
year 2014	0.09%	0.33%	0.37%	**0.32%**	0.06%	-0.02%	-0.07%	0.01%	**0.16%**	**0.13%**
year 2015	0.62%	0.53%	0.42%	**0.33%**	0.07%	0.00%	-0.05%	0.07%	**0.20%**	**0.12%**
year 2016	1.25%	0.47%	0.39%	**0.39%**	-0.01%	-0.02%	-0.06%	0.05%	**0.24%**	**0.14%**
year 2017	1.49%	-0.04%	0.19%	**0.38%**	-0.15%	-0.01%	-0.05%	0.08%	**0.37%**	**0.12%**

Note: Estimated from 2001, using country and industry fixed effects, on a country-industry-year panel. Bold numbers indicate statistically significant coefficients at the 10% level.

Figure 3: Ranking of EU15+US countries over time according to intangible intensity in the business economy (lower numbers mean higher intensity)



Note: the aggregate intangible asset does not include own-account org.cap. and training.

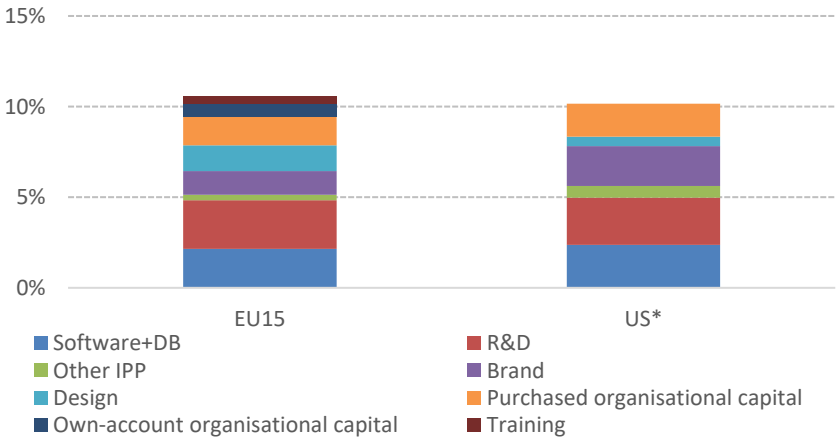
Now, we look at pre-GFC intangible intensity, i.e. during the period of 2005-2007. We do this because we use these intensities as explanatory variables for regressions explaining industry performance.

First, it is worth analysing the share of different intangible assets in overall intangible investment intensity (Figure 4). R&D has the biggest share, followed by software, and purchased organisational capital. Comparing the US to EU15 countries, intangible intensities in the US are quite similar, but with slightly more investment into brand and less investment into design. This is reassuring, because we will include the US together with EU15 countries in our panel regressions to increase the country sample.[7]

Comparing industry investment intensities averaged (unweighted) over EU15 (Table 2), we find large differences across industries. Somewhat surprisingly, manufacturing industries have a lower than average tangible intensity while higher than average intangible intensity. The result for intangibles is mainly explained by the high R&D intensity of manufacturing. This is consistent with the relevant literature (Thum-Thysen et al., 2022) that stresses the importance of complementarities between different assets, like tangibles (e.g. machines) and intangibles. Thus, as manufacturing is already highly capitalised in tangible assets, investments into complementary intangible assets are taking place. As an example of complementary investments, digital transformation of firms not only requires joint investment in hardware and software but also in organisational capital and training.

We observe that the results for tangibles are driven by higher tangible intensity in such non-manufacturing industries as transportation, energy and telecommunication.

Figure 4: Average intangible investment intensity in Europe and the US, 2005-2007 (investment over value added, nominal terms).



* There is no data for own-account organisational capital and training for the US.

[7] The other EU countries, i.e. the EU13, are very different in terms of intangible investment intensities.

Table 2: Average investment intensities of EU15 countries (2005-2007, percentage of value added).

	industry	Tangible	Intangible*	Software+DB	R&D	Brand	Design	Purchased organisational capital	Own-account organisational capital	Training
Manufacturing (C)	Food products	14.9%	9.9%	1.2%	1.4%	4.9%	0.9%	1.6%	0.8%	0.5%
	Textile	7.7%	6.7%	1.4%	1.6%	1.8%	0.7%	1.2%	0.9%	0.6%
	Wood and paper	15.0%	5.6%	1.5%	1.1%	1.0%	0.8%	1.1%	0.9%	0.5%
	Chemicals	15.2%	15.1%	1.8%	8.8%	2.0%	1.0%	1.4%	0.7%	0.4%
	Pharmaceutical	9.2%	25.0%	1.6%	18.6%	2.1%	1.2%	1.3%	0.5%	0.3%
	Rubber and plastics	13.9%	6.8%	1.3%	2.3%	1.0%	1.1%	1.2%	0.9%	0.5%
	Metals	15.4%	5.4%	1.2%	1.8%	0.5%	0.8%	1.0%	0.9%	0.5%
	Computer and electronics	6.9%	30.1%	5.3%	19.9%	1.7%	1.2%	1.7%	0.8%	0.4%
	Electrical equipment	7.8%	15.0%	2.7%	8.6%	1.0%	1.2%	1.4%	0.9%	0.5%
	Machinery	7.5%	12.1%	2.0%	6.4%	0.8%	1.5%	1.5%	0.9%	0.5%
	Transport equipment	11.6%	18.5%	2.2%	11.8%	1.4%	1.8%	1.3%	0.9%	0.5%
	Other manufacturing	7.2%	8.3%	1.7%	3.6%	1.2%	0.8%	1.0%	0.9%	0.5%
D	Energy	37.8%	5.4%	2.0%	0.9%	0.4%	1.0%	0.9%	0.4%	0.3%
E	Water, waste	42.6%	6.6%	1.4%	0.8%	0.6%	2.2%	1.4%	0.7%	0.4%
F	Construction	12.6%	6.4%	0.5%	0.1%	0.3%	4.6%	0.9%	0.6%	0.4%
Trade (G)	Trade of motor vehicles	9.8%	5.5%	1.0%	0.2%	2.4%	0.6%	1.1%	0.8%	0.5%
	Wholesale trade	7.2%	7.8%	2.0%	0.9%	2.1%	0.7%	2.0%	0.8%	0.4%
	Retail trade	9.7%	5.8%	1.5%	0.1%	2.0%	0.4%	1.7%	0.8%	0.5%
Transport (H)	Land transport	23.3%	2.8%	0.7%	0.1%	0.5%	0.7%	0.6%	0.7%	0.5%
	Water transport	56.3%	4.4%	0.7%	0.3%	0.9%	1.2%	2.9%	0.5%	0.4%
	Air transport	42.1%	5.8%	2.0%	0.0%	1.8%	0.6%	1.1%	0.6%	0.5%
	Warehousing	42.2%	5.3%	1.9%	0.1%	0.6%	1.1%	1.2%	0.7%	0.4%
	Postal activities	5.2%	4.2%	1.5%	0.6%	0.8%	0.6%	0.7%	0.8%	0.6%
I	Accomodation and food serv.	10.0%	2.6%	0.5%	0.0%	0.9%	0.4%	0.8%	0.5%	0.4%
Info-comm. (J)	Media	6.8%	22.5%	5.9%	1.5%	3.1%	1.1%	1.9%	0.6%	0.5%
	Telecommunication	22.3%	13.1%	6.3%	2.0%	2.1%	1.5%	1.2%	0.4%	0.3%
	IT services	5.5%	17.7%	10.2%	2.8%	0.8%	1.5%	2.0%	0.8%	0.6%
M-N	Professional and admin. serv.	14.4%	14.2%	2.2%	4.3%	1.5%	3.0%	3.2%	0.8%	0.7%
R	Recreation	20.3%	9.4%	1.6%	1.1%	1.1%	0.6%	1.1%	0.5%	0.4%
S	Other services	9.2%	5.1%	1.5%	0.9%	0.8%	0.6%	1.3%	0.6%	0.4%
	Average	17.0%	10.1%	2.2%	3.4%	1.4%	1.2%	1.4%	0.7%	0.5%

* The aggregate intangible asset composite does not include own-account organisational capital and training, while it includes other intellectual property products (not shown individually).

Note: Minimum value is green, median is yellow and maximum is red. All other cells are coloured proportionally.

3.2. Industry performance and pre-GFC investment intensities

As discussed in the Methodology section, we estimate equation 1, associating investment intensities and industry performance.

We look at results for different sub-periods in 2005-2017. For the sake of simplicity and robustness, we do not estimate year-by-year, but we divided this period into a pre-crisis period (2005-2007), crisis period (2008-2009), recovery (2010-2013) and after-crisis/late recovery period (2014-2017). Our outcome variables are always average annual growth rates.

We present our results as the effect on the outcome variable of an increase of the pre-crisis investment intensity from the bottom 25% to the top 25% (25^{th} and 75^{th} percentile of the intensity distribution across countries and industries, see Table 3). For example, in the case of the overall intangible assets category we calculate the effect of an 8.9% percentage point change in investment intensity.

Table 3: 25th and the 75th percentiles of the investment intensity distribution across countries and industries and difference between them (2005-2007).

	p25	p75	**p75-p25**
Tangible	6.8%	17.9%	**11.0%**
Intangible	4.9%	13.7%	**8.9%**
Software+DB	0.8%	2.3%	**1.6%**
R&D	0.2%	3.8%	**3.6%**
Brand	0.5%	1.7%	**1.2%**
Design	0.3%	1.2%	**0.9%**
Purchased org. capital	0.6%	1.9%	**1.3%**
Own-account org. capital	0.3%	0.7%	**0.4%**
Training	0.2%	0.7%	**0.4%**

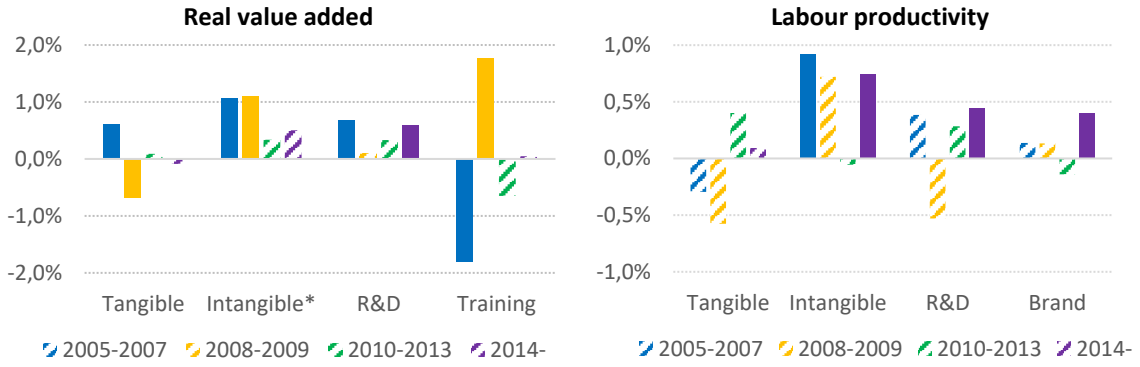
We report our results in tables, but some selected results graphically as well. In those cases, in addition to the point estimate, we will also indicate graphically whether the association between investment intensity and the outcome variable is statistically significant or not at the 10% level.[8]

One of our main results is that R&D investment is robustly associated with economic resilience measured in employment and hours worked during the GFC, and higher productivity growth in the aftermath. The result for R&D is in line with several papers showing the positive impact of R&D on productivity (see e.g. the seminal book of Griliches, 1998).

Looking at the detailed results, one interesting result is that while several intangible assets are associated positively with some outcome measures during or after the financial crisis, the associations with tangibles are never significantly positive. The aggregate intangible asset category is significantly positively related to higher output growth and employment growth during the crisis (2008-2009), and to productivity growth (both labour productivity and TFP) after the crisis (2014-2017). Among non-National Accounts intangibles, training has a positive effect on output growth and productivity during the crisis (2008-2009), and brand and design on productivity after the crisis (2014-2017). Among National Accounts intangibles, as we already mentioned, R&D has a significant positive effect on both labour productivity and TFP growth (2014-2017) and on employment growth and hours (2008-2009). Interestingly, although software investment is several times positively associated with outcomes (e.g. employment and productivity), the coefficients are not statistically significant in any of the cases.

[8] The reason why we do not report the coefficients as our main results is that investment intensities are quite heterogeneous for different assets, thus a 1 percentage point increase can be considered large or small depending on the specific asset.

Figure 5: Effect on real value added (left panel) and labour productivity growth (right panel) of an increase in pre-crisis investment intensity equivalent to moving from the bottom 25% to the top 25% of the intensity distribution



Note: Striped area denotes non-significant coefficient in the panel estimation. Country and 2-digit industry fixed effects were included in the estimation.

Table 4: Estimated effect on the average annual growth in real value added, employment, hours, labour productivity and total factor productivity as a response of an increase in pre-crisis investment intensity equivalent to moving from the bottom 25% to the top 25% of the intensity distribution

RVA	2005-2007	2008-2009	2010-2013	2014-2017	EMP	2005-2007	2008-2009	2010-2013	2014-
Tangible	**0.006098**	**-0.00674**	0.000911	-0.00088	Tangible	**0.002897**	-0.00277	-0.00025	0.00134
Intangible	**0.01056**	**0.01095**	0.003364	0.005032	Intangible	0.000648	**0.006471**	0.002043	-0.00073
Software+	0.002194	0.002777	0.003998	0.001442	Software+	**-0.00252**	0.00061	0.001474	-0.00074
R&D	**0.006735**	0.000973	0.003305	**0.00584**	R&D	0.002788	**0.006174**	0.000284	0.00097
Brand	0.001048	-0.00382	-0.00238	0.000805	Brand	6.17E-05	-0.00291	**-0.00255**	-0.00147
Design	-0.00207	0.00178	0.002556	0.001643	Design	-0.00195	-0.00118	0.00146	-0.00015
Purchased	0.000347	0.005876	0.000597	-0.00211	Purchased	-5.8E-05	-0.00032	0.000409	-0.00126
Own-acco	**-0.00751**	0.000683	0.002921	-0.00149	Own-acco	**-0.00697**	-0.00039	-0.00199	-0.0021
Training	**-0.01808**	**0.017606**	-0.00648	0.000483	Training	**-0.00824**	-0.00613	**-0.00779**	-0.00179

HOURS	2005-2007	2008-2009	2010-2013	2014-	LABPROD	2005-2007	2008-2009	2010-2013	2014-2017
Tangible	0.002168	-0.00261	**-0.0027**	0.000984	Tangible	-0.00295	-0.00576	0.004006	0.000865
Intangible	0.00218	0.00478	0.000924	-0.00227	Intangible	**0.009222**	0.00721	-0.00055	**0.007459**
Software+	-0.00185	0.001635	0.001877	-0.00045	Software+	0.003429	-0.0001	0.001196	0.002172
R&D	0.002685	**0.005823**	0.000779	0.000677	R&D	0.003842	-0.00529	0.002843	**0.004455**
Brand	0.000634	**-0.0047**	**-0.00355**	-0.00138	Brand	0.001373	0.00133	-0.0014	**0.003986**
Design	-0.00184	-0.00333	0.001131	2.42E-05	Design	5.94E-06	**0.006061**	-0.00177	0.002347
Purchased	0.000834	0.000279	-0.00114	**-0.00243**	Purchased	0.000933	0.005928	-0.00042	-0.00015
Own-acco	**-0.00729**	0.001447	-0.0004	**-0.00614**	Own-acco	-0.00277	0.009426	0.00111	-0.00083
Training	-0.00761	-0.00207	**-0.01026**	-0.0028	Training	-0.0077	**0.028759**	-0.0016	0.003099

TFP	2005-2007	2008-2009	2010-2013	2014-
Tangible	-0.00062	**-0.00837**	0.002159	0.001989
Intangible	**0.009352**	0.007926	-0.00054	**0.007372**
Software+	0.001982	0.003577	0.002201	0.00199
R&D	0.004146	-0.00498	0.001003	**0.004075**
Brand	0.001769	0.001158	-0.00212	0.001723
Design	-0.00078	0.00342	-0.0004	**0.003817**
Purchased	-0.00036	0.003754	0.000153	-0.00172
Own-acco	-0.00119	**0.019819**	0.001574	0.0027
Training	-0.00798	**0.037699**	-0.00305	0.000804

Note: Bold numbers mean significant coefficients at the 10% level. All coefficients were estimated from individual country-industry panel regressions with country and industry fixed effects. All regressions included tangible investment intensity as a control when estimating the effect of intangible assets. The overall intangible investment intensity was included as a control when estimating the effect of the tangible asset.

3.3. Intangible investment and finance using industry-level data

Uninterrupted finance of intangible investment is crucial as these investments are of a long-term nature and to a large extent irreversible. Existing results in the literature show that intangible investment is less sensitive to long-term interest rates (Thum-Thysen et al, 2019) and less influenced by monetary policy (Döttling and Ratnovski, 2020). Potential reasons include the fact that intangibles are usually financed to a greater extent by internal sources or equity instead of debt because intangible assets cannot be used as collateral. Furthermore, the higher depreciation rate of intangible assets weakens the link between interest rates and the user cost of capital. At the same time, the degree of financial development has a bigger impact on labour productivity growth in intangible intensive industries, especially if they are more dependent on external finance (Demmou et al., 2019). The explanation is that as intangible investment is facing stronger informational asymmetries and it is harder to value, it is subject to more severe financial constraints. Financial frictions in intangible sectors have been a barrier to productivity growth especially in financially less-developed countries. This finding is underpinned by firm-level evidence as well (Demmou et al., 2020).. In a recent paper, Segol et al. (2021) using an EU-wide firm-level investment survey, document that insufficient loan amounts, high lending rates, and more stringent collateral requirements have a detrimental effect on intangible investment intensity.

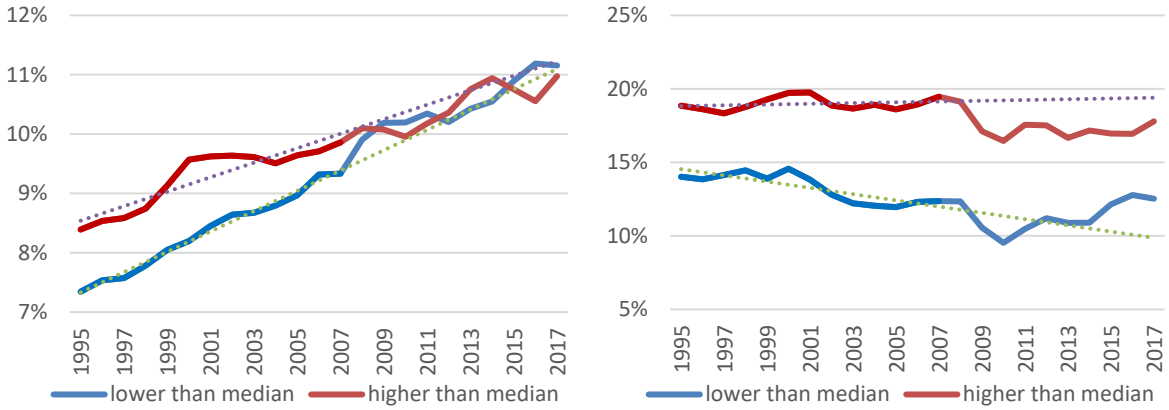
All these evidences reviewed above suggest that intangible investment is exposed to financial shocks. Based on that, the GFC should have had a major negative impact on intangible investment. What is puzzling is that we do not see a significant drop in intangible intensity on average during that period. This is in contrast with the decline in tangible intensity.

A possible solution to this apparent contradiction is that the disruption in finance for intangible investment might not be even across sectors but it could be more severe in industries and in countries where investment is financed from external instead of internal sources. This is similar to the reasoning of Ahn, Duval and Sever (2020) who use cross-country firm level data to show that financially vulnerable firms decreased intangible investment during the GFC by more than firms that were not vulnerable. Furthermore, they also find that firms that are more vulnerable cut intangible investment more than tangible investment. On the other hand, Garicano and Steinwender (2016) find the opposite using Spanish firm level data, i.e. tangible investment declined more compared to intangible investment in more credit-constrained firms during the

financial crisis. They explain this finding by arguing that firms facing credit constraints shift investments from more durable to less durable assets.[9] Focusing only on R&D, Peia and Romelli (2020) find on a large sample of European firms that financially more constrained firms invested less during periods of tight credit supply. This effect is amplified in sectors with high dependence on external finance. Similarly to these findings, Aghion et al., (2012) show, using pre-crisis data, that the R&D investment share in total investment is countercyclical, but more procyclical if credit constraints are binding, and that this effect is magnified for high external financial dependent sectors. Thus, these findings are mostly in-line with our hypothesis about the relevance of external financial dependence for the behaviour of intangible investment during crises.

In the following, we establish a link between a country-industry measure of external financial dependence (EFD) and intangible investment following the methodology presented in the Methodology section. Before turning to the econometric estimation, we illustrate how investment intensity developed differently during the financial crisis depending on the extent of an industry's dependence on external finance (Figure 6). High EFD industries decreased their intangible intensity in 2008 and 2009 compared to the pre-crisis trend while the opposite happened in low EFD industries, where intangible intensity even increased compared to the pre-crisis trend. For tangibles, we do not see a significant difference in the behaviour of investment intensities according to EFD levels during 2008-2009.

Figure 6: Average investment intensities of industries with lower and higher than median values of external financial dependence for intangibles (left panel) and tangibles (right panel)



Note: We include all country-industry cells where we have data for EFD. The linear trend lines are fitted on the pre-crisis period of 1995-2007.

Turning to the econometric analysis, we first show preliminary evidence using year dummies to indicate the period of financial shocks (equation 3 from section 2).

According to the results (see Table 5), industries with higher dependence on external finance experienced a bigger drop in intangible intensity during the crisis compared to pre-crisis. This is true for the overall intangible intensity, R&D intensity, and investment intensity of software, though the exact years when the effect is significantly negative depends on the specific asset. According to our estimates, for example, a 100 percentage points higher external financial dependence - not an extreme difference with respect to the variation observed in our dataset - caused a 0.24 percentage point lower intangible intensity in 2008, a non-trivial effect. The

[9] It is worth noting that according to our data, tangible investment intensity decreased much more in Spain than in any other EU15 countries during the GFC.

estimated impact on tangible intensity is mostly positive, and in some years statistically significantly positive.

Table 5: Effect of External financial dependence on investment intensity by year: estimated coefficients and their p-value

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tangible	Coef.	0.001375	-0.00105	-0.00108	**0.005256**	0.002203	0.000843	**0.006102**	0.002734	0.001576	0.002688
	P>t	*0.603*	*0.693*	*0.683*	*0.047*	*0.405*	*0.75*	*0.021*	*0.302*	*0.552*	*0.321*
Intangible	Coef.	**-0.00241**	**-0.0023**	**-0.00337**	**-0.00252**	-0.00054	-0.00099	2.53E-05	-0.00022	-0.00186	-0.00124
	P>t	*0.033*	*0.042*	*0.003*	*0.026*	*0.631*	*0.383*	*0.982*	*0.845*	*0.1*	*0.285*
R&D	Coef.	**-0.00106**	-0.00056	**-0.00146**	0.000302	0.00044	0.000207	0.00102	0.000568	0.000111	0.000279
	P>t	*0.091*	*0.373*	*0.02*	*0.631*	*0.484*	*0.741*	*0.105*	*0.366*	*0.86*	*0.664*
Software	Coef.	-0.00058	**-0.00085**	**-0.00074**	**-0.00126**	0.000329	7.94E-05	7.42E-05	5.71E-05	-0.00041	-0.00016
	P>t	*0.133*	*0.028*	*0.056*	*0.001*	*0.393*	*0.837*	*0.847*	*0.882*	*0.285*	*0.688*
Brand	Coef.	-0.00023	**-0.00033**	**-0.00043**	**-0.00052**	**-0.0006**	**-0.00054**	**-0.00059**	**-0.00044**	**-0.00031**	**-0.00047**
	P>t	*0.201*	*0.06*	*0.015*	*0.004*	*0.001*	*0.002*	*0.001*	*0.014*	*0.083*	*0.008*
Design	Coef.	-0.00011	0.000042	-7.9E-05	-0.00014	-0.00018	-0.00018	**-0.00036**	0.000258	0.000285	0.000275
	P>t	*0.562*	*0.824*	*0.676*	*0.468*	*0.351*	*0.342*	*0.06*	*0.174*	*0.133*	*0.147*
Purchased org. cap.	Coef.	-0.00016	-9.8E-05	-0.00013	-0.0002	-9.1E-05	-2.4E-05	-7.9E-05	-7.9E-05	-0.00011	-0.00012
	P>t	*0.281*	*0.498*	*0.356*	*0.164*	*0.528*	*0.866*	*0.586*	*0.584*	*0.462*	*0.389*
Training	Coef.	1.15E-05	-3.83E-06	6.38E-06	7.23E-06	-2.1E-05	-3.8E-05	**-4.5E-05**	-2.1E-05	**-5.5E-05**	**-4.5E-05**
	P>t	*0.645*	*0.878*	*0.798*	*0.771*	*0.403*	*0.128*	*0.069*	*0.395*	*0.027*	*0.07*

Note: Estimated on the sample of 2005-2017, countries: Austria, Germany, Denmark, France, Spain and Italy, 2-digit NACE industries. Country-industry, country-time, industry-time fixed effects are included. We omitted the results for own-account organisational capital because its data were available only for two countries in the sample.

Next, we capture the period of financial stress with an indicator of country level financial stress (CLIFS), estimating equation 2. It captures the heterogeneous financial shock of the GFC across countries, both in terms of the size and the timing of the impact.

The results for different assets are reported in Table 6, estimated for the countries for which we have both EFD and intangible investment data (AT, DE, DK, ES, FR, IT).

Table 6: Estimated coefficient of *EFD*CLIFS*

	coef	std.err.	t-value	p-value	num. of obs.
Intangible	**-0.010**	0.004	-2.400	0.016	1858
R&D	**-0.006**	0.002	-2.450	0.014	1858
Software+DB	**-0.004**	0.001	-2.970	0.003	1858
Brand	0.000	0.001	-0.570	0.571	2158
Design	0.000	0.001	0.350	0.725	2158
Purchased orgcap	0.000	0.001	-0.520	0.605	2158
Training	**0.000**	0.000	2.090	0.037	1898
Tangible	-0.005	0.010	-0.530	0.600	1858

Note: Coefficients were estimated in individual panel regressions according to equation 2.

Our results are consistent with the preliminary finding using year dummies. A negative coefficient of the interaction of EFD and CLIFS means that higher financial stress decreases investment intensity more in industries that are more dependent on external finance. According to the results, in case of overall intangibles, R&D and Software, the estimated coefficient is statistically significantly negative, while for tangibles it is not significant (although negative).

For training, it is statistically significantly positive, but the estimated coefficient is very small.[10] On the other hand, for tangibles, we do not find a significant negative effect.

The difference between tangibles and intangibles may be explained by the fact that intangible assets cannot be pledged as collateral and are subject to substantial information asymmetries, which makes intangible investments more sensitive to a tightening of external financial conditions that happened during the GFC. Furthermore, there could be a trade-off between intangible and tangible investment during crisis periods. During expansions, firms tend to use internally generated cash flows to finance intangibles and use credit to finance tangibles (see Altomonte et al. 2021 for causal evidence on France). When external finance dries up, firms tend to move part of the internal cash flow to finance tangible investment, thus we find a significant negative effect on intangibles and no effect on tangibles. We will show findings based on firm-level data in the next section, which is consistent with this explanation.

3.4. Intangible investment and finance using firm-level data

First, we show descriptive statistics on our key variables, then we check the consistency between micro (firm-level) and macro (industry-level) data for France, Italy and Spain for the manufacturing sector.

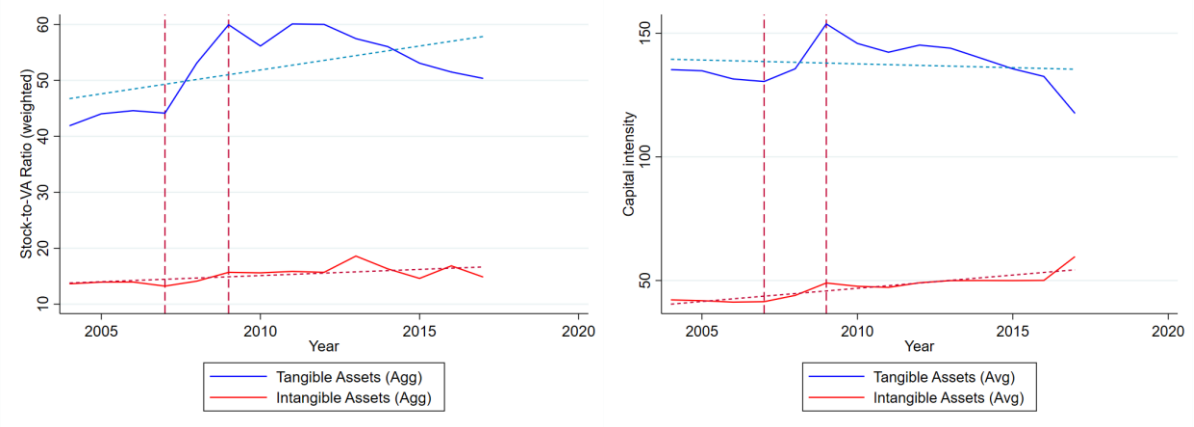
Table 7: Summary statistics of the firm-level data

	Obs.	Mean	St. Dev.	P25	Median	P75	Min	Max
Dependent Variables								
Intangibles	1,230,332	130,482	342,382	5,311	24,218	97,000	933	3,916,187
Tangibles	1,525,946	877,070	2,115,020	38,151	153,000	653,000	994	20,470,268
Covariates								
Turnover	1,899,948	8,398,502	153,391,024	443,364	1,218,673	3,775,553	-10,314,741	50,225,479,680
Current Liabilities	1,899,221	3,306,545	55,919,720	160,277	476,601	1,518,510	-92,779,704	21,223,014,400
CL Index	1,899,994	0.87	0.70	0	1	1	0	2
CL (04-08) Index	1,899,994	0.45	0.50	0	0	1	0	2
EFD	1,897,691	-1.17	0.91	-1.21	-0.97	-0.62	-3.96	0.38

Figure 7 draws a parallel between the micro and macro-level analysis. The first graph on the left measures the firm-level weighted average of tangible and intangible intensities overtime. The ratios are defined starting from the stock variables of tangible and intangible investments (as retrieved by balance sheet information) divided by a measure of value added at the firm-level. The value added of interest is defined as the deflated value of ”Revenues - Material Cost”. We compare this firm-level graph with the one retrieved from macro-level data on the right, using capital intensity (see details in the Data section), which is a stock variable arithmetically averaged across the three countries of interest (France, Italy and Spain).

[10] Furthermore, there are reasons to beleive that training is the least robustly measured intangible asset in the EUKLEMS database based on our comparisons with the Intan-Invest database.

Figure 7: Micro-Macro comparison of tangible and intangible investment behaviour



The resemblance in the behaviour of stock data coming from two different levels of analysis and two different databases give large credibility to the discussion. In fact, tangible investment intensity is much larger than intangibles' and the relative size is three to four times bigger for the former with respect to the latter. In both graphs, we observe the strong growth of tangible investment intensity during the GFC and a successive slight drop in 2010. From 2012 onward, both time-series report a steady decrease. With respect to intangible investment intensity, we can clearly describe a positive trend throughout the time range of interest and a mild increase during the crisis, more accentuated at macro-level. It is worth pointing out that the last observation in 2017 is less significant at macro-level as the data for Spain have not been reported.

Table 8 highlights the overall impact of the crisis on the two types of investments. It seems that intangible asset investments have dropped more after the financial crisis compared to tangibles. Figure 7 might not seem completely in line with this statement, but the dependent variables are different in this case, because we use stock variables and not intensities in the regressions. Still, the presence of firm fixed-effects allow us to interpret the dependent variable as a flow variable, differently from the referenced graph. Moreover, there are clearly important missing regressors in this specification, as the following work will highlight. Among all, the impact of financial factors will be crucial in determining the resilience and the response to the crisis.

Table 8: The role of the GFC

	(1)	(2)
	OLS	OLS
VARIABLES	ln Intan	ln Tang
Post	-0.0532***	-0.0220***
	(0.00520)	(0.00324)
Observations	1,107,877	1,470,556
R-squared	0.804	0.912
Year FE	No	No
Firm FE	Yes	Yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Then, results on the role of finance in intangible investment based on macro data (previous section) are complemented by micro-level analyses using firm-level data for France, Italy and Spain. Our findings using the same indicator of external financial dependence are quite similar to the ones for industry-level data (Table 9). These results are consistent with Ahn, Duval and Sever (2020), who showed, in a large cross-country panel, that in the event of a financial shock firms that are more financially vulnerable reduce their intangible investments more than less vulnerable firms.

Table 9: External Financial Dependence

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
VARIABLES	ln Intan	ln Intan	ln Tang	ln Tang
Post	-0.144***		-0.184***	
	(0.0331)		(0.0353)	
EFD	-0.132***		0.125***	
	(0.0156)		(0.0131)	
Post*EFD	-0.0738***	-0.0946***	-0.135***	-0.0412
	(0.0148)	(0.0281)	(0.0141)	(0.0301)
Observations	1,125,570	1,125,570	1,483,277	1,483,277
R-squared	0.046	0.092	0.016	0.093
Year-Sector FE	No	Yes	No	Yes
Year-Country FE	No	Yes	No	Yes
Country-Sector FE	No	Yes	No	Yes
Country FE	Yes	No	Yes	No

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

We explore further the impact of firm-level measures of financial independence and credit availability on tangible and intangible investments, with consistent results. On the one hand, we find that greater financial independency, i.e. higher ex-ante liquidity and better leverage position of firms, increased intangible investment more than tangible investment before the GFC (Table 10). After the onset of the crisis, financial independence did not help intangible investment anymore (the sum of the coefficient of financial independence and the coefficient of the interaction term is close to zero). This finding indicates the different financing of intangible and tangible investments: when liquidity is abundant, firms tend to use internally generated cash flows (liquidity) to finance intangibles and use credit to finance tangibles. This hypothesis is consistent with causal evidence on France from Altomonte et al. (2021), while Ferrando and Preuss (2018) also confirm this type of financing based on an EU-wide firm-level investment survey. During a financial crisis, when external finance dries up, firms tend to move part of the internal cash flow to finance tangible investment. Thus, we observe a decrease in the importance of liquidity on intangible investment.

Table 10: The liquidity channel: financial independence

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
VARIABLES	ln Intan	ln Intan	ln Tang	ln Tang
Post	-0.0315***		-0.0425***	
	(0.00856)		(0.00489)	
ln CL (04-08)	0.0644***	0.0592***	0.0133	0.0215**
	(0.0207)	(0.0208)	(0.0105)	(0.00987)
Post*ln CL (04-08)	-0.0620***	-0.0627***	0.0739***	0.0640***
	(0.0193)	(0.0194)	(0.0103)	(0.00979)
Observations	1,107,877	1,107,877	1,470,556	1,470,556
R-squared	0.804	0.805	0.912	0.913
Year FE	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

When looking at credit availability at the firm level, we find that the variable has a relatively higher elasticity for tangible vs. intangibles in the post-crisis context (Table 11). This is consistent with the finding that intangible investments are impacted more in industries dependent on external finance, because there the trade-off is stronger between the financing of intangible and tangible assets during periods of financial stress.

Table 11: The liquidity channel: credit availability

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
VARIABLES	ln Intan	ln Intan	ln Tang	ln Tang
Post	-0.302***		-0.624***	
	(0.0485)		(0.0298)	
ln Cliab (Lagged)	0.211***	0.215***	0.182***	0.183***
	(0.00961)	(0.00983)	(0.00505)	(0.00507)
Post*ln Cliab (Lagged)	0.0175***	0.0161***	0.0469***	0.0476***
	(0.00361)	(0.00364)	(0.00221)	(0.00222)
Observations	1,002,534	1,002,534	1,318,663	1,318,663
R-squared	0.808	0.809	0.923	0.923
Year FE	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Finally, we find a lower sensitivity for intangibles versus tangibles to demand effects (proxied by lagged turnover), both before the GFC and after the crisis, even when controlling for

financial independency (Table 12 and Table 13). This result confirms that both demand and financial conditions play a role in intangible and tangible investment decisions.

Table 12: The demand channel: lagged turnover

	(1) OLS	(2) OLS	(3) OLS	(4) OLS
VARIABLES	ln Intan	ln Intan	ln Tang	ln Tang
Post	-0.289***		-0.861***	
	(0.0502)		(0.0317)	
ln Turnover (Lagged)	0.249***	0.265***	0.334***	0.338***
	(0.00910)	(0.00877)	(0.00593)	(0.00602)
Post*ln Turnover (Lagged)	0.0146***	0.0135***	0.0609***	0.0636***
	(0.00346)	(0.00344)	(0.00218)	(0.00219)
Observations	1,002,758	1,002,758	1,319,427	1,319,427
R-squared	0.808	0.808	0.924	0.925
Year FE	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 13: Investment elasticity

	(1) OLS	(2) OLS
VARIABLES	ln Intan	ln Tang
ln CL (04-08)	0.0550**	0.0169
	(0.0231)	(0.0112)
ln Turnover (Lagged)	0.269***	0.336***
	(0.00885)	(0.00606)
Post*ln CL (04-08)	-0.106***	0.0162
	(0.0212)	(0.0109)
Post*ln Turnover (Lagged)	0.0125***	0.0636***
	(0.00345)	(0.00221)
Observations	1,002,758	1,319,427
R-squared	0.808	0.925
Year FE	Yes	Yes
Firm FE	Yes	Yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4. CONCLUSION

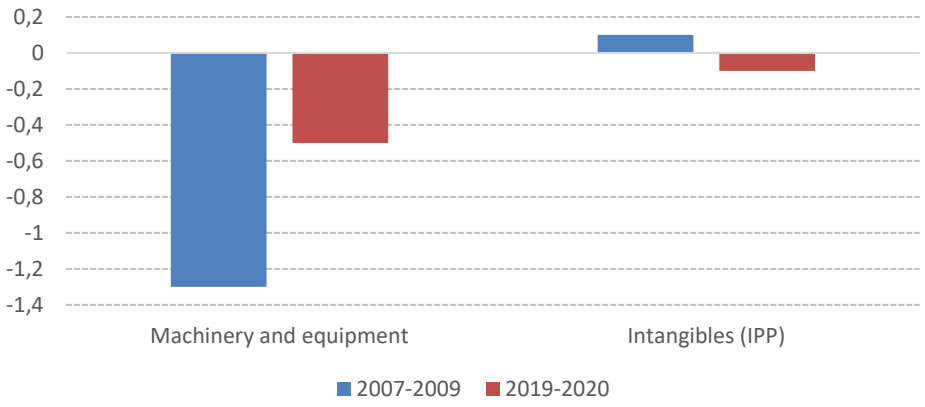
To summarise our results, we find that tangible investments are more elastic to demand and less to financial conditions, compared to intangible investments. The higher sensitivity of intangible investments to financial conditions is likely related to the different channels through which intangible assets are financed. As intangible assets cannot be pledged as collateral, mostly internal cash flow (liquidity) is used for intangible investment. During a crisis, with the tightening of credit conditions and liquidity, remaining cash flow is used for financing tangible investments to preserve the functioning of the firm, leading to a general decline in intangible investment.

We also find evidence that various intangible assets are associated with the resilience of industries, in terms of output, employment and productivity growth.

These findings point to the importance of sustained financing for intangible investment, in particular during crises. This has implications for the recent COVID-19 crisis as well: due to the prompt reaction of economic policy to the crisis, a credit crunch similar to the one of the GFC was largely avoided and ample liquidity support was provided. Thus, we cannot expect that financial conditions would play a large role in 2020. On the other hand, the demand shock was much larger than in the past.

Based on these priors, and given our results, we would thus expect that tangible investment decreased much more than intangible investment in 2020 (high demand shock vs. relatively small financial shock). Preliminary macro data at the country-level confirm this expectation, as total investments have dropped by around 10 per cent on average in the three countries considered for the micro analysis, while intangible investments[11] dropped by less than 2 percent.

Figure 8: Change in investment intensity (as a share of GDP), EU27 (%point)



[11] Intangible investment in the National Accounts, i.e. intellectual property products (IPP) which include software and databases, research and development, and other smaller items (mineral exploration, artistic originals).

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6. APPENDIX

Figure 9: Tangible investment intensity of EU15+US countries by industry, average of 2005-2007 (as a share of value added)

code	AT	DE	DK	ES	FI	FR	IT	NL	SE	UK	US
C10-C12	12.7%	12.9%	17.4%	17.6%	15.1%	11.7%	24.9%	13.2%	14.3%	9.0%	9.6%
C13-C15	5.9%	8.5%	13.9%	7.6%	6.7%	4.4%	10.2%	7.7%	9.4%	2.5%	6.3%
C16-C18	14.9%	14.0%	12.6%	22.6%	13.9%	13.9%	18.6%	12.7%	20.0%	6.7%	11.2%
C20	16.2%	11.9%	12.8%		13.9%	14.7%	31.7%	11.6%		9.0%	8.5%
C21	10.4%	9.2%	13.5%		3.2%	6.8%	17.5%	7.2%		6.1%	
C22_C23	14.9%	11.1%	15.5%	20.3%	10.7%	9.1%	22.2%	11.4%	14.3%	9.4%	11.8%
C24_C25	14.7%	9.9%	11.8%	15.1%	8.7%	14.5%	19.8%	9.1%	12.9%	37.7%	8.0%
C26	7.5%	9.5%	6.8%		3.0%	5.8%	18.9%	3.3%	2.9%	4.0%	7.6%
C27	9.3%	7.8%	5.4%		5.6%	6.6%	18.9%	7.1%	5.7%	4.0%	5.3%
C28	7.5%	7.9%	10.4%	5.3%	4.7%	7.3%	13.1%	6.4%	8.7%	4.1%	7.4%
C29_C30	8.9%	11.4%	12.5%	9.2%	7.5%	15.6%	18.8%	6.2%	16.5%	9.3%	7.7%
C31-C33	6.3%	5.3%	8.3%	7.2%	5.2%	6.8%	14.3%	5.0%	9.0%	4.7%	7.4%
D	28.6%	21.6%	29.9%		32.6%	29.9%	45.9%	40.0%	45.9%	40.8%	34.3%
E	42.6%	44.0%	45.9%		45.9%	45.9%	37.6%	28.4%	43.0%	41.7%	15.7%
F	10.6%	4.0%	9.3%	41.8%	7.0%	7.9%	11.3%	6.0%	10.4%	18.0%	5.9%
G45	8.7%	6.6%	18.4%		6.0%		9.7%		15.2%	4.2%	
G46	6.2%	6.0%	8.6%		6.0%		10.8%		8.1%	4.8%	6.0%
G47	8.2%	6.4%	10.1%		7.7%		11.8%		13.0%	10.7%	9.3%
H49	32.6%	25.2%	30.5%		16.2%		14.5%		26.3%	17.9%	23.2%
H50	45.9%	45.9%	45.9%		25.4%		45.9%		45.9%	7.7%	24.1%
H51	39.1%	42.2%	45.9%		34.5%		4.3%		-3.7%	45.9%	16.1%
H52	45.9%	35.7%	28.3%		17.0%		45.9%			45.9%	7.7%
H53	5.9%	13.0%	2.8%		1.9%		4.4%			3.1%	3.2%
I	10.0%	7.5%	13.5%	7.6%	7.6%	10.5%	14.2%	7.3%	13.3%	8.6%	9.9%
J58-J60	3.4%	4.0%	13.2%	16.5%	3.5%	4.3%	11.1%	3.2%	5.3%	3.9%	16.2%
J61	30.8%	16.7%	28.6%	21.6%	14.7%	14.9%	13.7%	27.5%	29.5%	25.1%	
J62_J63	6.7%	6.8%	10.9%	1.7%	4.7%	2.8%	7.5%	3.9%	5.2%	4.9%	2.8%
M_N	28.2%	27.7%	14.4%	20.2%	8.0%	11.0%	9.3%	8.8%	9.8%	7.1%	9.6%
R	13.1%	28.8%	24.5%		24.5%	29.5%	21.5%	5.8%	21.0%	13.8%	13.7%
S	11.4%	5.3%	24.6%		8.8%	4.5%	10.2%	7.4%	6.4%	4.6%	8.8%

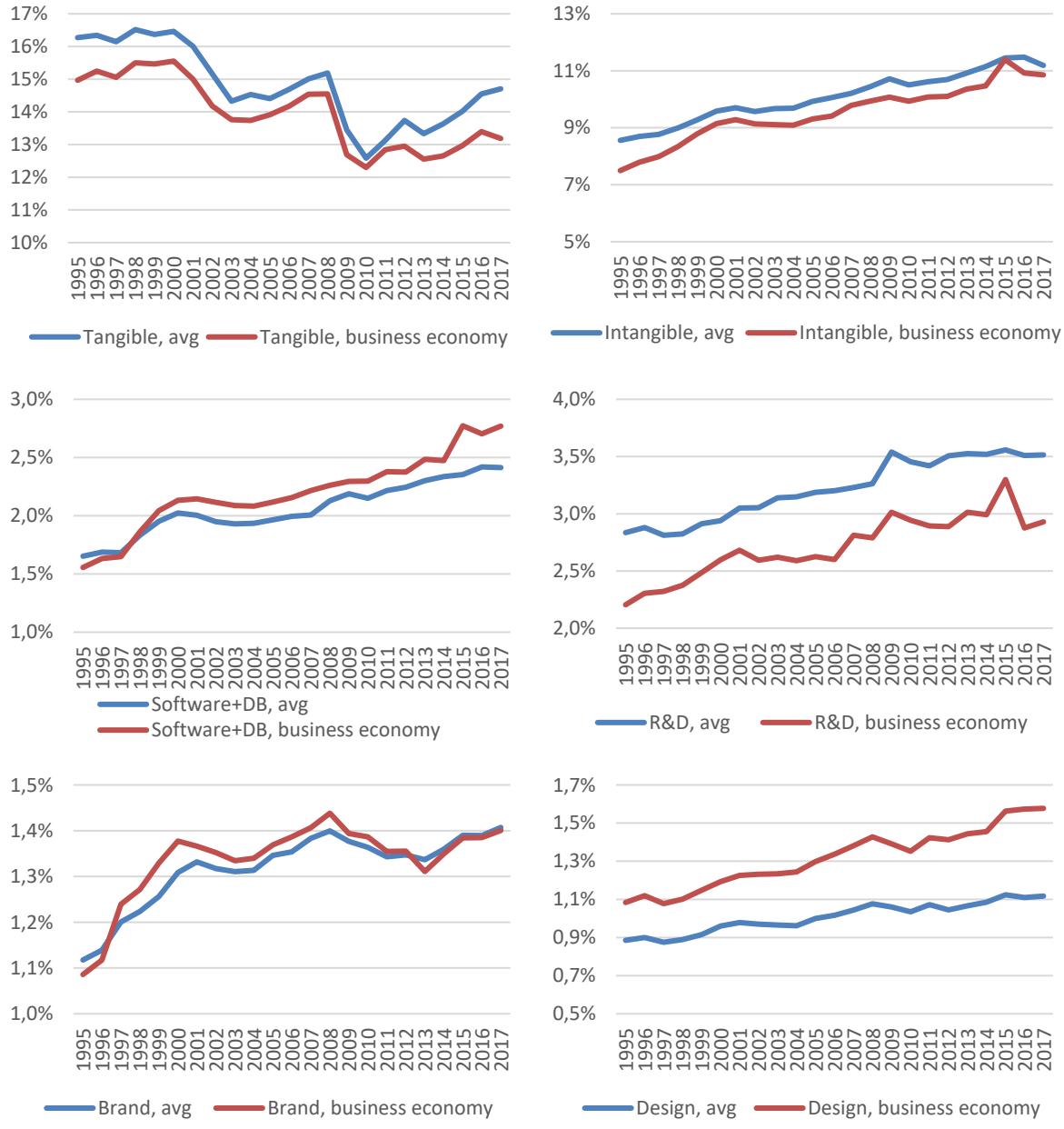
Note: values winsorized at the 95th percentile of the distribution

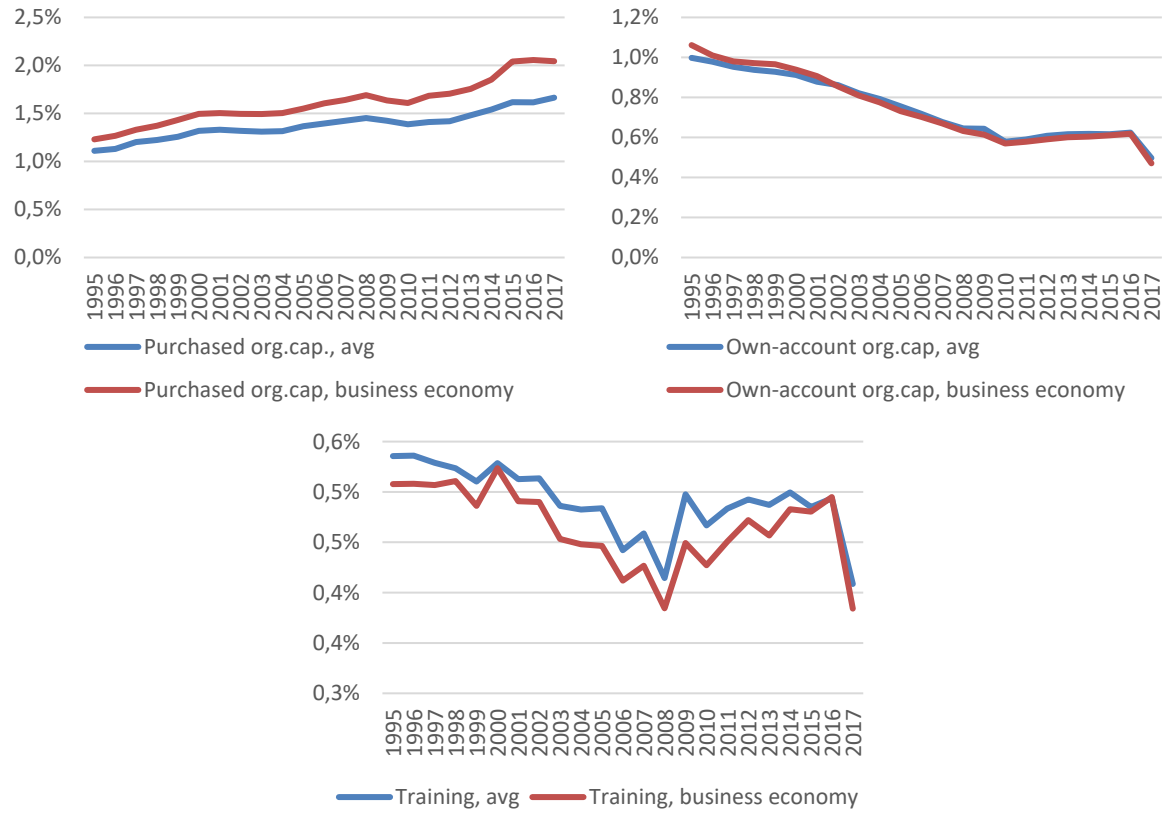
Figure 10: Intangible investment intensity of EU15+US countries by industry, average of 2005-2007 (as a share of value added)

code	AT	DE	DK	ES	FI	FR	IT	NL	SE	UK	US
C10-C12	9.6%	11.9%	10.4%	4.9%	14.6%	8.7%	13.8%	8.5%	8.8%	8.1%	9.1%
C13-C15	7.2%	4.4%	5.1%	3.6%	7.8%	11.1%	9.9%	7.1%	5.4%	5.8%	11.6%
C16-C18	5.0%	3.6%	4.4%	3.4%	8.1%	7.9%	5.3%	6.4%	7.4%	3.8%	8.1%
C20	10.3%	15.5%	25.4%		15.9%	18.3%	10.4%	13.2%		11.9%	26.4%
C21	18.6%	26.3%	26.4%		25.8%	26.4%	13.4%	25.8%		26.4%	
C22_C23	7.5%	7.6%	5.7%	4.2%	8.3%	8.7%	7.2%	7.5%	7.0%	4.7%	8.4%
C24_C25	6.6%	4.2%	3.2%	3.1%	6.8%	8.3%	4.6%	5.2%	7.4%	4.1%	6.4%
C26	19.9%	25.4%	21.0%		26.4%	26.4%	19.2%	21.3%	26.4%	17.3%	26.4%
C27	14.9%	10.7%	11.3%		15.1%	16.1%	10.7%	26.4%	18.3%	6.3%	10.8%
C28	12.8%	9.3%	11.5%	6.4%	17.8%	13.7%	8.1%	17.8%	13.8%	10.0%	13.2%
C29_C30	17.3%	20.8%	8.7%	9.9%	9.8%	26.4%	20.0%	11.9%	26.4%	22.1%	19.6%
C31-C33	7.7%	7.6%	9.2%	3.8%	14.4%	8.3%	8.6%	5.1%	10.5%	7.5%	13.0%
D	3.7%	4.4%	2.8%		5.4%	5.4%	3.9%	12.7%	5.0%	5.0%	4.4%
E	1.5%	8.1%	13.9%		4.1%	5.2%	8.5%	4.9%	10.0%	3.5%	5.7%
F	4.6%	1.9%	14.0%	4.5%	6.8%	5.1%	5.4%	5.3%	12.6%	3.8%	2.8%
G45	4.7%	2.9%	4.0%		9.0%		8.0%		5.2%	4.9%	
G46	7.6%	2.6%	8.5%		12.4%		9.4%		7.2%	6.8%	8.5%
G47	5.0%	3.9%	4.9%		9.6%		4.9%		6.3%	6.1%	6.7%
H49	2.0%	2.9%	2.1%		2.1%		3.1%		2.9%	4.2%	2.9%
H50	3.3%	0.4%	1.8%		6.7%		2.6%		10.2%	5.8%	17.3%
H51	4.8%	2.1%	3.2%		12.7%		2.3%		9.0%	6.7%	3.3%
H52	5.0%	2.0%	6.2%		3.0%		5.0%			10.8%	2.7%
H53	3.3%	1.6%	6.8%		5.3%		4.3%			4.0%	0.9%
I	1.1%	1.3%	3.0%	0.7%	5.5%	1.8%	2.7%	4.7%	1.9%	3.6%	6.8%
J58-J60	18.9%	19.4%	24.3%	13.7%	21.8%	26.4%	26.2%	11.5%	21.4%	26.4%	22.3%
J61	16.1%	5.6%	18.7%	14.6%	13.6%	7.2%	9.6%	8.6%	23.4%	14.0%	
J62_J63	15.9%	9.0%	26.4%	9.2%	17.9%	21.6%	26.4%	13.7%	20.0%	12.9%	22.0%
M_N	14.9%	7.5%	12.7%	11.7%	17.9%	17.2%	9.5%	16.0%	20.3%	14.5%	13.0%
R	9.6%	5.2%	14.9%		6.1%	4.4%	15.4%	11.1%	9.6%	8.4%	13.0%
S	4.3%	1.1%	5.4%		2.9%	5.1%	5.5%	10.1%	4.7%	6.7%	4.8%

Note: values winsorized at the 95th percentile of the distribution

Figure 11: Investment intensities by asset for the EU15 countries





Note: “avg”: arithmetic average of 2-digit industries, “business economy”: aggregated intensities over the business economy (weighted average of 2-digit industries)

Table 14: External financial dependence for different countries and industries (percentage share of investment not covered by cash-flow, averaged over 2000-2004)

code	AT	DE	DK	ES	FR	IT
C10-C12	-67%	-88%	-864%	-319%	-395%	-1%
C13-C15	-98%	-240%	-864%	-144%	-213%	-102%
C16-C18	-46%	-91%	-664%	-90%	-59%	-60%
C20	-123%	-146%	108%	-109%	-77%	-78%
C21	-69%	-98%		-181%	-186%	-134%
C22_C23	-91%	-109%	-378%	-122%	-97%	-60%
C24_C25	-98%	-88%	-399%	-105%	-83%	-61%
C26	-132%	7%	-864%	-145%	-10%	-72%
C27	-180%	-126%	-864%	-165%	-109%	-100%
C28	-176%	-123%	-184%	-253%	-151%	-126%
C29_C30	-357%	-23%	-864%	34%	-73%	35%
C31-C33	-194%	-134%	-700%	-107%	-119%	-90%
D	-45%	-219%		-83%	-57%	-77%
E	-70%	-70%		-7%	-66%	-14%
F	108%	-101%	-864%	-64%	-98%	-114%
G45	-122%	-151%	-864%	-117%	-130%	-65%
G46	108%	-219%	-864%	-154%	-209%	-111%
G47	-139%	-101%	-864%	-49%	-99%	18%
H49	-12%	56%	-175%	-42%	-4%	64%
H50	-237%	-105%		-477%	-74%	29%
H51	-54%			108%		108%
H52	-59%	-58%	-864%	-3%	108%	-52%
H53	-517%			9%		-129%
I	45%	-58%	-763%	-52%	-46%	-12%
J58-J60	-60%	-152%	-850%	-153%	-57%	-49%
J61	-40%	-531%		-123%		-86%
J62_J63	-67%	-77%	-769%	-182%	-58%	-90%
M_N	-56%	-169%	-784%	-24%	-48%	-17%
R	-148%	108%		-24%	-83%	99%
S	-50%	6%		-83%	-37%	1%

Note: The table shows the values used in the regression, which were winsorised at the 5th and 95th percentile of the distribution.