CHAPTER 9

INDUSTRIAL PERFORMANCE AND INVESTMENTS IN INTANGIBLE ASSETS DURING CRISES

Peter Bauer and Aurélien Genty
Joint Research Centre

Summary

We take the global financial crisis (GFC), as an example of a major crisis, to study the trends in intangible investment, the link between industrial performance and intangible assets, and the differences in financing intangible versus tangible assets during crises. We find an upward trend in in intangible investment intensities (investment-to-value added) that started well before the GFC and the crisis had little impact on it, in contrast to tangible investment intensities. We explore the potential role that intangible assets may play in weathering the negative effects of major crises using industry-level data. We find 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 financial turmoil may affect the financing of intangible investment. We show that industries that are more dependent on external finance cut back their intangible investments during the crisis compared to industries that finance their investments mostly from internal sources. In contrast, tangible investments were not sensitive to the dependence on external finance. Our leading explanation is that tight credit conditions create a trade-off between tangible and intangible investment financing. Given the importance of intangible assets for productivity growth, our findings strengthen the case for ensuring uninterrupted financing of firms during crises.

1. Introduction

Intangible assets are a key driver of firm productivity in the modern economy, and ultimately of the competitiveness of economies, as shown by a couple of recent papers (Thum-Thysen et al., 2017; Bauer et al., 2020; Adarov and Stehrer, 2019; Cincera et al., 2020). Intangible assets support firms' digitalisation (software, databases), innovation (R&D, design, patents) and the business knowledge necessary for their functioning (market knowledge, organisational knowledge, training for employees). Furthermore, the impact of an intangible asset on firm performance is amplified by its complementarity to other intangible and tangible assets (Thum-Thysen et al., 2019).

We focus our analysis on the GFC as an example of major crises, to study the trends of intangible investment before, during and after such a major crisis and explore the potential role that intangible assets may play in weathering the negative effects of major crises. In this latter analysis, we analyse not only the association between intangible intensity and growth rates of different economic indicators (e.g. value added), we also use resilience metrics (e.g. strength of recovery) to assess the contribution of intangible assets to the resilience of economies against major shocks.

In parallel, we investigate how financial turmoil may affect the financing of these assets. Finally, we draw some general lessons that can also be applied to the COVID-19 crisis. The novelty of our approach relies on the use of industry-level data from the EU KLEMS (2019) database[1] to analyse industries' intangible investment and their performance in both the short term (output and employment) and the long run (productivity), depending on their intangible investment intensity.

When looking at investment intensity (as a share of value added), we find an upward trend for several kinds of intangible assets in almost all Member States, and in almost all industries. This trend started well before the GFC and overall, the crisis had little impact on it, in contrast to tangible investment intensity, which declined significantly during the GFC. We observe a similar phenomenon during the COVID-19 pandemic based on preliminary data available, despite the differences between the two crises. This suggests that a demand shock does not hit intangible investment as severely as it does tangible investment.

The subsequent detailed analysis sheds light on the dissimilar impact of different types of assets on industrial performance and the important role of finance. Despite the limitations of a comparison exercise between the GFC and other crises, we believe that a number of lessons can be drawn for the current COVID-19 crisis. This is not least because, for example, many economic activities after the outbreak continued to be held away from the workplace, which underscores the centrality of key intangible assets, such as organisational capital. Likewise, investments in training are also bound to be extremely relevant in times of protracted episodes of labour hoarding, where the aim is to avoid a deterioration in workers' skills. These aspects should be taken into account by both policymakers in order to efficiently support certain types of investment to foster faster recovery and stronger resilience as well as by firms in their future investment decisions.

1 For the details of the data, see Stehrer et al. (2019).

2. Investment intensities before, during and after the financial crisis

The pre-crisis period (2005-2007)

In the following, we analyse investments in intangible assets in the form of intensities calculated as an investment-to-value-added ratio based on EU KLEMS (2019) data. First, we focus on the intensities in the pre-crisis period, as we will use these variables in the next part to explain economic performance during and following the crisis.

The EU-15 countries are more intangible-asset intensive than the EU-13 Member States[2]. The main reason is the much higher investment intensity in software and especially R&D, while, e.g., investment intensities in organisational capital (both purchased and own-account) are quite similar. At the same time, **tangible-asset intensity is almost twice as high in the EU-13 Member States as in the EU-15**[3]. The intangible intensities of the USA are quite similar to the EU-15's, but with slightly more investment into **brand** and less investment into **design**.

Comparing industry investment intensities averaged (unweighted) over the EU-15 (Table 1), we find that, somewhat surprisingly, **manufacturing industries have a lower-than-average tangible intensity while a 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., 2019), which stresses the importance of complementarities between different assets, such as tangibles (e.g. machines) and intangibles. Digital transformation of firms, for example, requires not only joint investment in hardware and software but also in organisational capital and training.

The result for tangibles is explained by higher tangible intensity of such non-manufacturing industries as transportation, energy and telecommunication.

2 EU-15: Countries that were members of the EU before May 2004, the 'old Member States' (AT, BE, DK, FI, FR, DE, GR, IE, It, LU, NL, PT, ES, SE, UK). EU-13: Countries that joined the EU in May 2004 or later, the 'new Member States' (BG, HR, CY, CZ, EE, HU, LV, LT, MT, PL, RO, SK, SI).

3 This is not explained by our choice of a flow-type intensity instead of stock-type intensity. Tangible capital per value-added is highest among the EU-13 countries.

Table 9-1: Average investment intensities of EU-15 countries (2005-2007, percentage of value added)

	Industry	Tangible	Intangible*	Software +DB	R&D	Brand	Design	Purchased organisa-tional capital	Own-account organisation-al 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%

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Source: JRC calculation based on EU KLEMS 2019, BACH and ECB data

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

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

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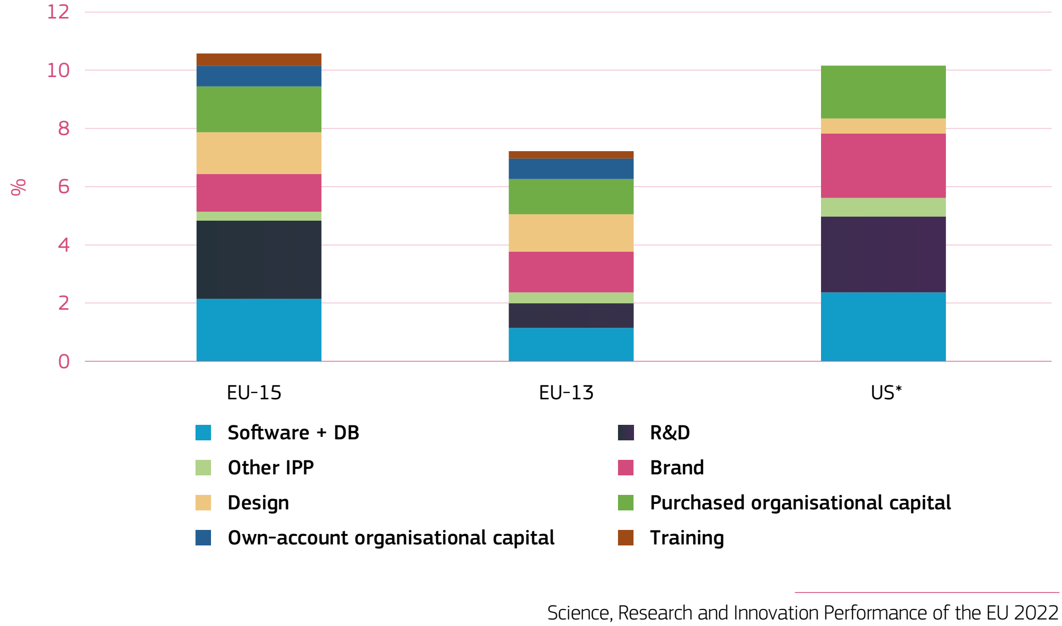
Figure 9-1: Average intangible investment intensity in the EU and the USA 2005-2007 (investment over value added, nominal terms)



Source: JRC calculations based on EU KLEMS 2019
Note: * There is no data for own-account organisational capital and training for the US.
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Change of investment intensities during the GFC and subsequent recovery

Tangible intensity declined during the crisis both in the EU-15 and the EU-13 blocks[4]. (Figure 2). This decline clearly continued for new Member States during the late recovery (2014-2017) while it rebounded somewhat for the EU-15. Nevertheless, average tangible intensity is lower at the end of the sample period than before the crisis. **Intangible intensity in most assets increased** during the crisis and continued throughout the recovery both for the EU-15 and the EU-13 countries.

Exceptions include average investment intensity in software for the EU-13 Member States, own-account organisational capital for both country groups, and training for the EU-13 countries. For training, there was a general decline in investment intensity across industries even before the GFC[5], while for software and own-account organisational capital, intensity declined in some industries (e.g. manufacturing) and increased in others, the info-communication sector, for example.

4 This decline is also statistically significant based on the average change across industries. We will not repeat this, but almost all changes in investment intensities compared to pre-crisis levels were statistically significant (comparing country-industry pairs between the different time periods). The significance level is set at 10 % in all the analysis.

5 We should note that there are reasons to believe that training is the worst-measured asset in EU KLEMS, namely that the data are largely inconsistent with another intangible database, IntanInvest.

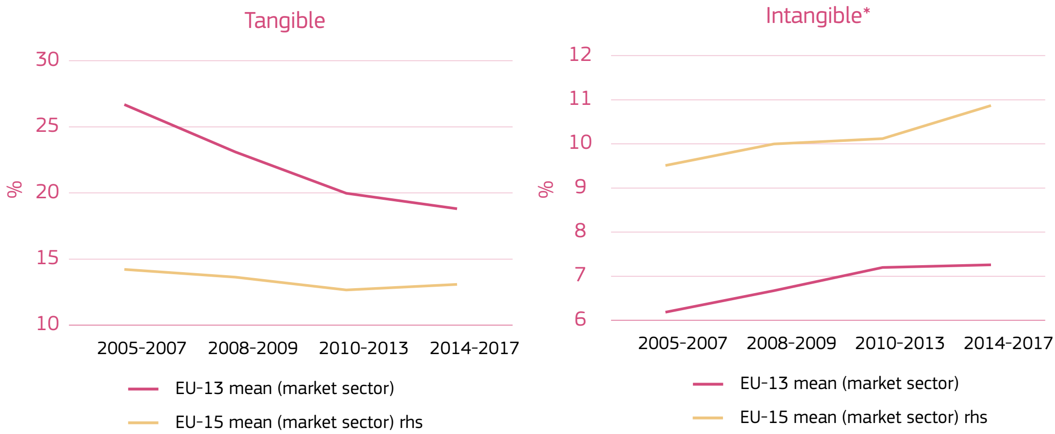
We should emphasise that we are analysing intensities here, and not the investments themselves. As value added decreased substantially during the financial crisis, the fact that intangible investment intensity did not decrease still means that intangible investment declined from 2008 to 2009, especially if we compare it to the pre-crisis trend. Thus, what we find here is that intangible investment declined more or less in proportion to value added, while the drop was bigger in 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 3)[6]. 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., 2017 and 2019). It is remarkable that despite this overall increase in intangible intensity, the ranking of countries by this intensity is quite persistent (Figure 4).

Almost all intangible assets show an upward trend (except own-account organisational capital 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 in case of EU-15 countries**. In the same vein as the old Member States, aggregate intangible intensity in **EU-13 countries** also shows a positive trend, but in this case, **mainly because of non-R&D intangibles**. In EU-13 countries, on average, R&D intensity did not show a positive trend before the crisis but started to grow just after the crisis. We analysed the trend of investment intensities at the detailed sectoral level (at the NACE 2-digit industry level) as well. We find that intangible intensity in almost all such detailed industries follows a positive trend in both country groups. In contrast to intangible assets, tangible investment intensity had a negative trend before the crisis for the EU-15 countries, while no negative trend was observed for the EU-13. Almost all 2-digit industries follow this negative trend in the EU-15. The crisis caused a drop in tangible intensity in both country groups. After the crisis, there was a partial rebound in the EU-15, while no rebound at all for the EU-13 countries.

6 Not only descriptive statistics but also statistical tests support this finding, using a country-industry-year panel regression with country and industry fixed effects. We used investment intensity as the dependent variable and included a linear trend and year dummies since 2008 as explanatory variables.

Figure 9-2: Tangible and intangible investment intensity of the EU-15 and EU-13 countries (percentageof nominal value added)



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Source: JRC calculations based on EU KLEMS 2019

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

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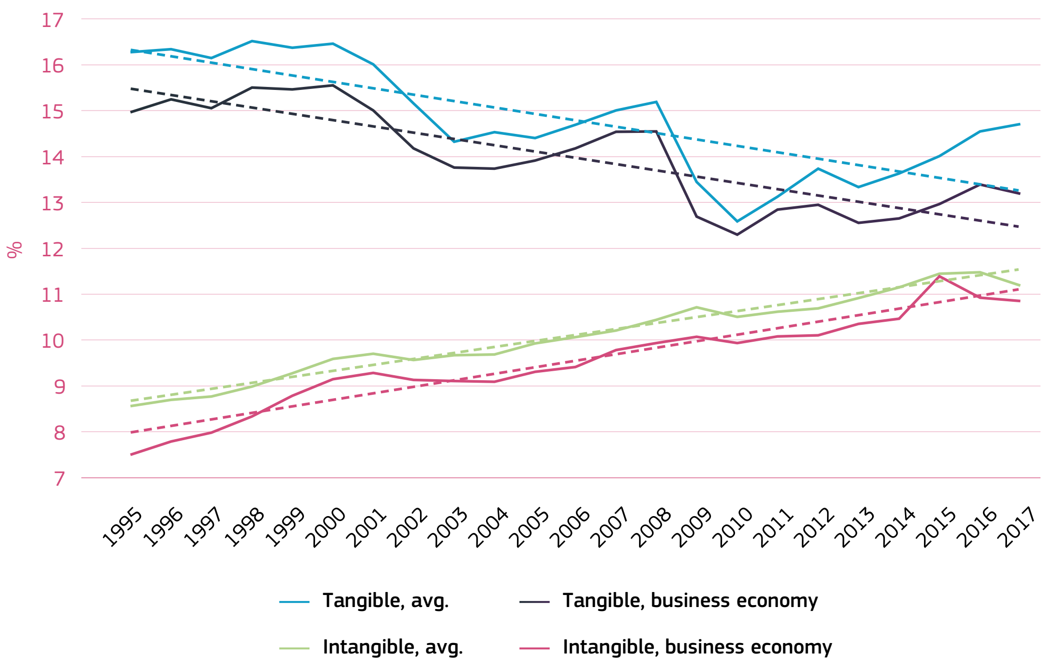
Figure 9-3: Tangible and intangible investment intensity trends for the EU-15 countries (unweighted averages across countries)



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Source: JRC calculation based on EU KLEMS 2019

Note: The aggregate intangible asset does not include own-account organisational capital and training. ‘Avg.’ means an unweighted average across countries and 2-digit industries, while ‘business economy’ means the unweighted average across countries of the aggregate business economy sector (which is a weighted average of industries).

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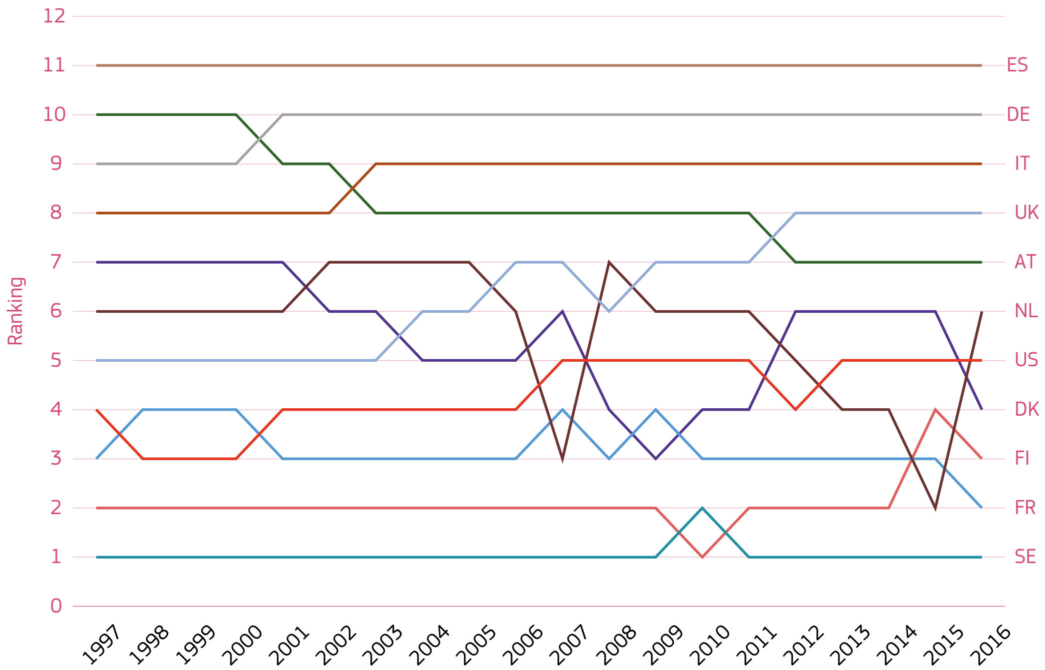
Figure 9-4: Ranking of EU-15 + USA countries over time according to intangible intensity in the business economy (lower numbers indicate higher intensity)



Source: JRC calculation based on EU KLEMS 2019

Note: The aggregate intangible asset does not include own-account organisational capital and training

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3. Growth in output, labour and productivity – results from a panel estimation

We analyse the role of tangible and intangible assets during the global financial crisis in output growth (measured by real value added), growth in labour (measured by the number of persons employed and hours worked) and productivity growth. We estimate the impact on both labour productivity growth (measured by real value added per hours worked) and total factor productivity (TFP) growth[7]. We also look at whether labour hoarding was more widespread in intangible-intensive industries, i.e. a decline in labour utilisation measured by the change in hours/employee.

First, we emphasise that for the analysis, the investment intensity of an industry is measured based on investments made during 2005-2007, i.e. before the crisis, to avoid potential endogeneity problems. As developments in industries during the crisis could depend on industry characteristics other than investment intensities (e.g. a higher drop in demand for high income-elasticity goods), we need to control for inherent industry differences. To this end, we estimated **country-industry panel regressions of the EU-15 countries and the USA**. We controlled for industry and country fixed effects, which means that any average differences between industries or countries were eliminated in terms of both the explanatory variables (investment intensities) and the dependent variables (output, labour and productivity growth). Thus, the intuition behind this setting is that we compare developments in the same industry between countries, or alternatively, we compare developments in the same country between industries.

We also controlled for tangible intensity wherever we estimated the effect of intangible intensity as these intensities are (weakly) correlated[8].

Thus, we estimate the following regression:

$$y_{cs}^{period} = \alpha TangibleInt_{cs}^{2005\text{-}2007} + \beta IntangibleInt_{cs}^{2005\text{-}2007} + \delta_c + \mu_s + u_{cs}$$

where c is country, s is industry and *period* is either 2005-2007, 2008-2009, 2010-2013 or 2014-2017. $TangibleInt$ and $IntangibleInt$ are average tangible investment intensity (as a share of value added) and intangible investment intensity (as a share of value added), respectively, for the pre-crisis period 2005-2007. Several intangible assets were used in the regression for intangible intensity (e.g. software, R&D, etc). y_{cs} is the average annual growth rate of the outcome variable over the specified period. The outcome variables[9] are our indicators of industry performance, such as real value added, employment (persons), hours worked, hours/employment, labour productivity (real value added per hour) and TFP. δ_c and μ_s are country and industry fixed effects, u_{cs} is the error term. We report the partial effect of intangible intensity on the outcome variable in the main text as the effect of a change from the bottom of the intensity distribution to the top, calculated as β *(p75(IntangibleInt)-p25(IntangibleInt)), where p75 and p25 are the 75th and 25th percentiles of the intensity distribution across country and industry.

7 TFP is taken from the EU KLEMS database. It is estimated by a standard growth accounting procedure, taking into account non-national account intangibles as capital inputs as well. We do not report the results for the version where TFP is calculated using only national account capital inputs. These results were qualitatively and quantitatively very similar to the former.

8 Where we report the result for tangibles, the aggregate intangible intensity was included as a control.

9 Outcome variables' in our case simply mean that these are our variable of interest, but they are not only output type variables (such as value added) but input type variables (such as employment) as well.

See Table 2 for the values of these percentiles for different assets. For example, in case of the overall intangible asset, we calculate the effect of a 8.9 percentage point change in the investment intensity. In addition to the point estimate, we also indicate graphically whether the association between investment intensity and the outcome variable is statistically significant or not at the 10 % level[10].

In the following, we will focus on results for the EU-15 countries, while results for the EU-13 countries are discussed only briefly afterwards as these were less conclusive.

Real value added growth

According to our estimates, pre-crisis growth was larger where tangible or intangible investment was higher[11]. Among specific types of intangibles, mainly R&D intensive industries grew faster, while own-account organisational-capital and vocational-training intensive industries were associated with lower growth. During the first phase of the crisis (2008-2009), **more tangible-intensive industries**, (keeping other industry and country characteristics constant) suffered more, while overall **intangible-intensive industries in general, and training-intensive industries in particular, were associated with higher growth**. On the long run (2014-2017), **R&D-intensive industries grew faster.**

Table 9-2: 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 %**

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Note: 'DB' means database, and 'org. capital' means organisational capital.

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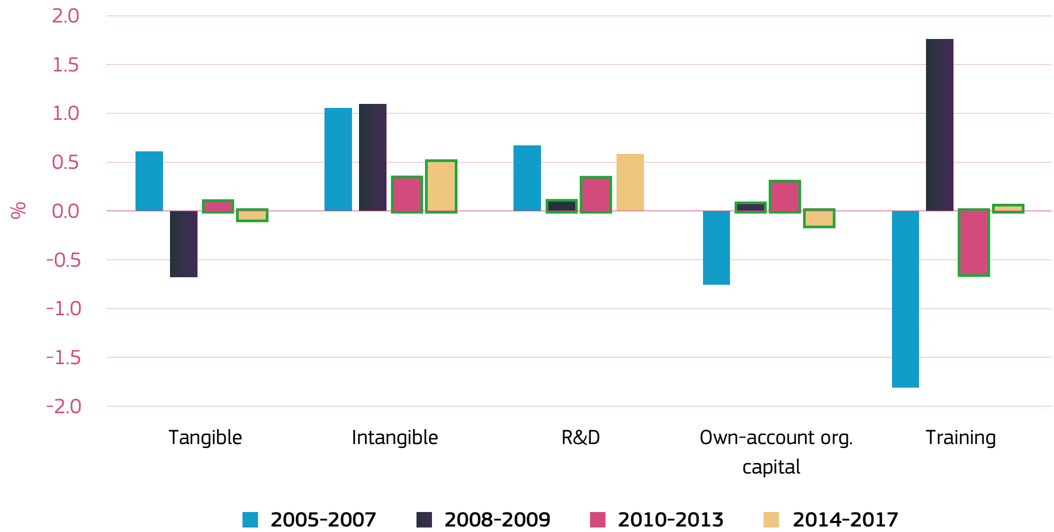
10 We do not report the estimated coefficients as our main results because investment intensities are quite heterogeneous for different assets, thus a 1 percentage point increase can either be considered large or small depending on the specific asset.

11 Results for the 2005-2007 period are only for illustration; they cannot be interpreted as causal effects because of (potential) simultaneity of the outcome variable and investment.

Figure 9-5: Percentage point effect on real value added growth of an increase in pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel



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Source: JRC calculations based on EU KLEMS 2019
Note: The framed bars denote a non-significant coefficient in the panel estimation.
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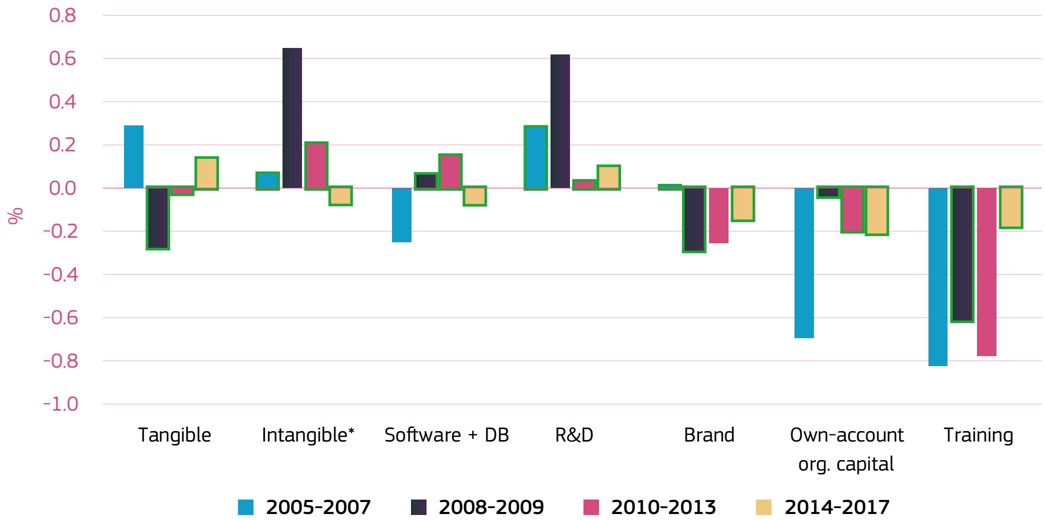
Employment growth

Employment grew faster in more tangible- and intangible-intensive industries before the crisis. From those, only the result for tangible intensive industries is statistically significant. During the first phase of the crisis (2008-2009), **employment growth was significantly positively correlated with overall intangible intensity and R&D intensity**. On the long run (2014-2017), there was no significant relationship between investment intensities and employment growth.

Figure 9-6: **Percentage point effect on employment growth of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).**



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Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation. DB= database

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Growth in hours worked

Before the crisis, tangible intensity and intangible intensity (in the case of a number of assets) were associated with faster growth in hours worked. However, we could not find any significant positive correlations. During the start of the crisis (2008-2009), **growth in hours was higher in R&D-intensive industries than in non-R&D-intensive industries**. Brand-intensive industries saw hours worked decline by more than less brand-intensive industries. On the long run (2014-2017), **organisational capital-intensive industries** (both purchased and own-account) **showed lower growth in hours.**

Productivity growth

Before the crisis, high overall intangible intensity was associated with higher productivity growth (keeping other industry and country characteristics constant). In contrast, productivity growth in tangible-intensive industries was lower relative to less tangible intensive industries but this effect is not statistically significant. During the crisis and partly during the recovery, measured productivity growth was strongly influenced by volatility in capacity utilisation, therefore we focus our analysis of labour productivity and TFP growth on the period from 2014 onwards.

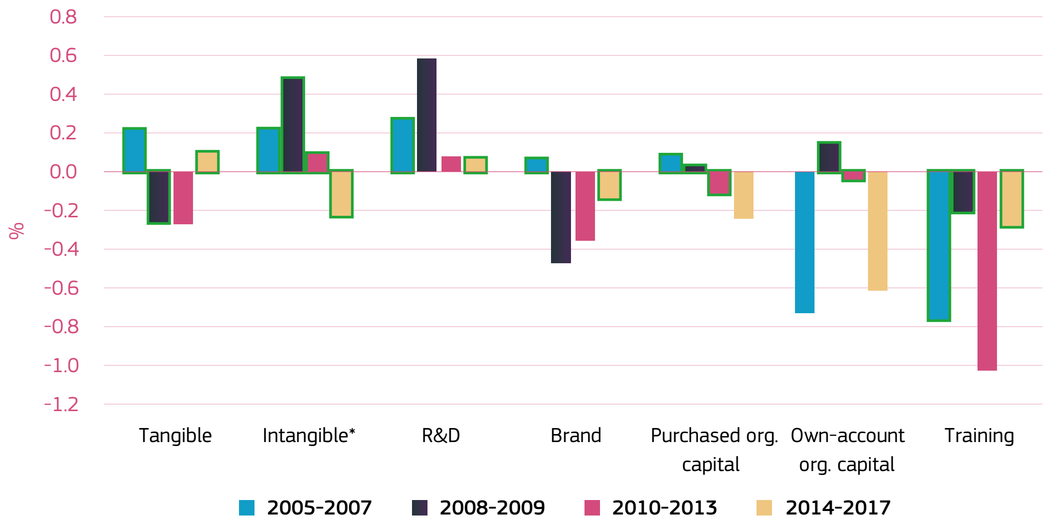
On the long run (2014-2017), **investment intensity** in a wide array of different assets (intangibles but also tangible) was also associated with **higher productivity growth**. Among these assets, **R&D and overall intangible**s bear a **statistically significant relationship** with both **labour productivity** and **TFP growth**. 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). Brand has a significantly positive effect on **labour productivity growth**, while **design** has a significantly positive effect on **TFP growth**. These results show the relevance of both innovative properties (R&D and design) and economic competencies (brand) for long-term productivity growth.

Overall, results for labour productivity growth and for TFP growth are very similar in terms of the importance of intangible assets as driving factors.

Results for selected resilience metrics

As our empirical approach is quite similar to the methodologies used in resilience analysis (see e.g. JRC, 2018), it seems natural to also adopt some of the usual 'resilience metrics' applied in the literature to analyse the role of intangibles in this respect. It is worth emphasising that our metrics are calculated using industry-level data. This is in contrast to the majority of the literature on resilience, which uses country-level aggregate data. We calculate

Figure 9-7: Percentage point effect on growth of hours worked of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation.

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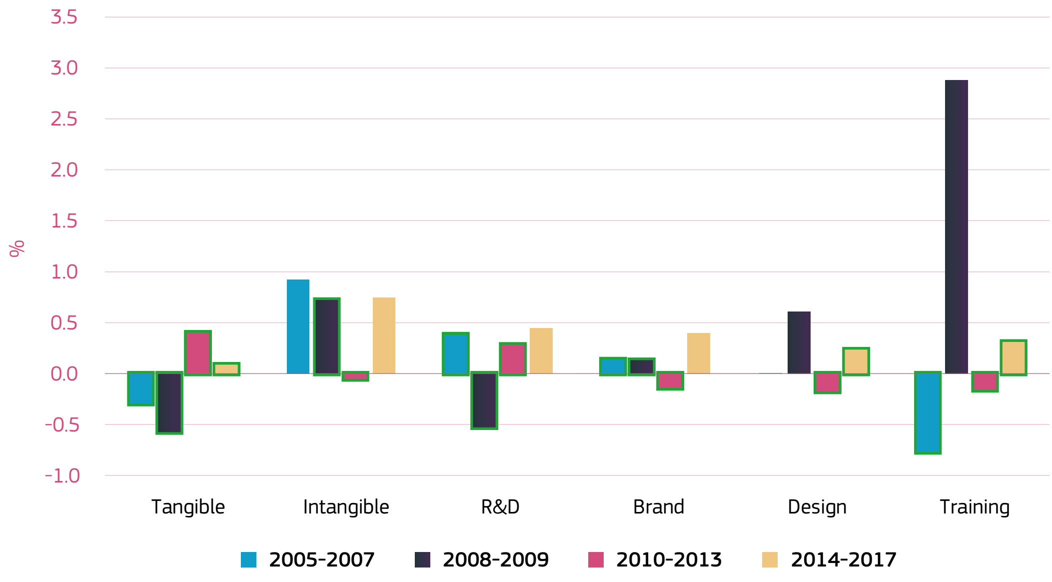
three different metrics taken from the related resilience literature: i) impact; ii) medium-term performance; and iii) speed of recovery. Impact is defined as the percentage difference in levels for a given variable between the worst year during the crisis (when the outcome variable was at a minimum[12] level) and the period just before the crisis. For example, for value added, impact is calculated as the cumulative drop in value added since 2007 until the given industry (in the given country) reached its minimum level. Medium-term performance is defined as the percentage difference in levels for a given variable between an end period long after the crisis for which data are available and the period just before the crisis. Obviously, the end period should be chosen to be before a recession starts again. In our case, 2017, the last available year in our database, was chosen as the end period. Recovery is measured as the percentage difference between the end period and the worst year during the crisis. The determination of the worst year is country and industry specific for both the impact and the recovery metrics. The recovery metric is identical to the difference of the medium-term and impact metrics by definition.

Figure 9-8: Percentage point effect on labour productivity growth of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



Source: JRC calculations based on EU KLEMS 2019
Note: The framed bars denote a non-significant coefficient in the panel estimation.
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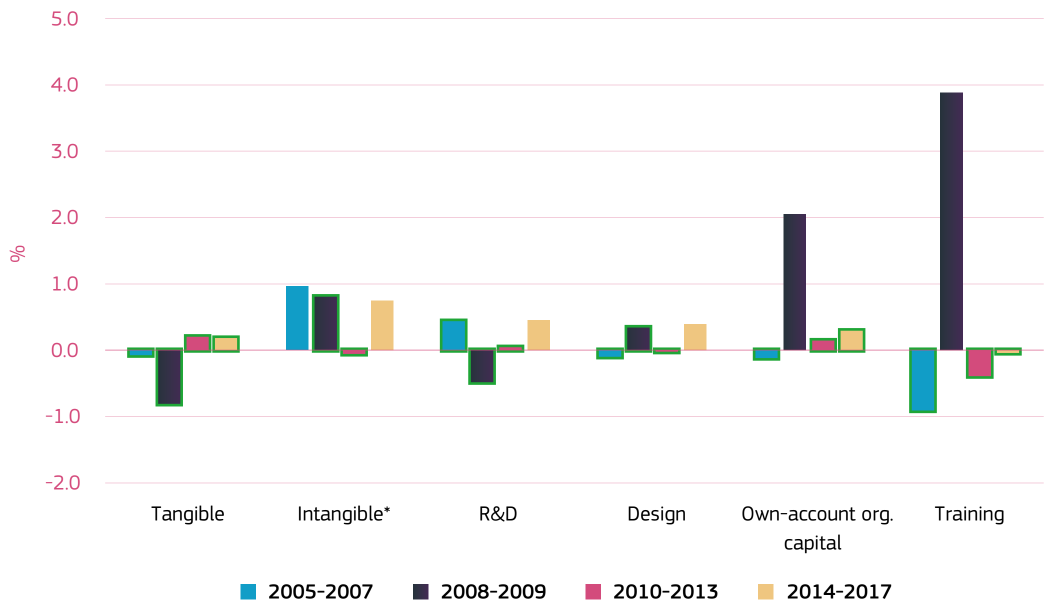
12 For all our variables, we use the minimum level for the determination of the worst year. Of course, if we had used variables where the larger the variable, the worse the performance (e.g. unemployment), we would have calculated the maximum level.

Figure 9-9: Percentage point effect on TFP growth of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation.

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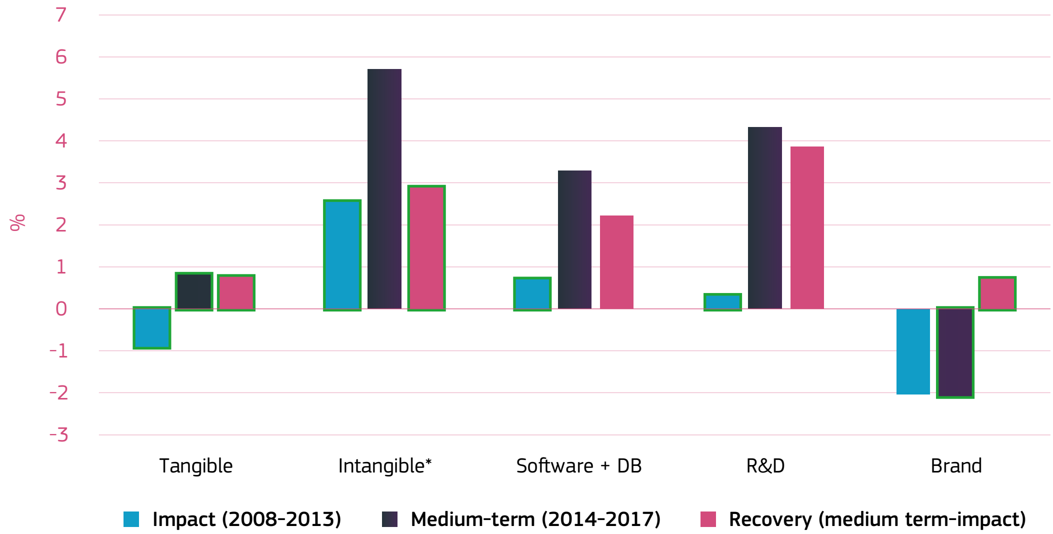
After calculating the metrics, we did the same panel analysis as we did before for average growth rates (see the equation on page 6), but this time using these three metrics as dependent variables instead. The results are for the EU-15 + USA country group and reported as the effect of an increase in pre-crisis investment intensity from the bottom 25 % to the top 25 %.

We highlight only the most interesting results from this exercise. Overall intangible intensity is significantly positively associated with real value added, employment and hours in the medium-term. It is also significantly positively associated with employment and hours on impact. Positive association with the impact measure means a smaller decline. No statistically significant association with productivity is found (neither for labour productivity nor for TFP), although the estimated effects are positive. The effect of tangible intensity is never statistically significant. The effect of **R&D intensity is significantly positive** for **real value added (medium-term and recovery), for employment and hours (impact and medium-term), and for labour productivity** and **TFP (recovery)**. Other than R&D, the only assets that are significantly positively associated with TFP are own-account organisational capital and training (impact and medium term).

Figure 9-10: Percentage point effect on real value added of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



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Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation.

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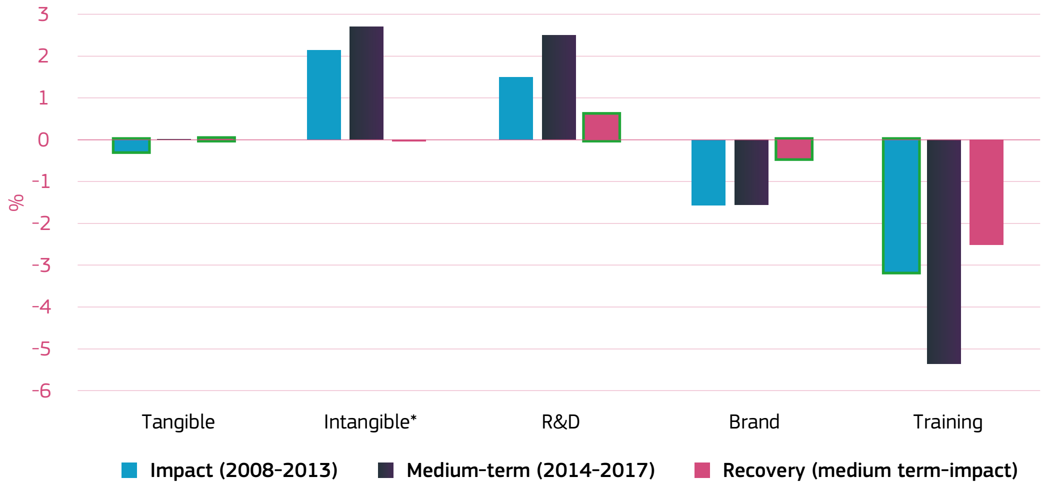
Figure 9-11: Percentage point effect on employment of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



Science, Research and Innovation Performance of the EU 2022

Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation.

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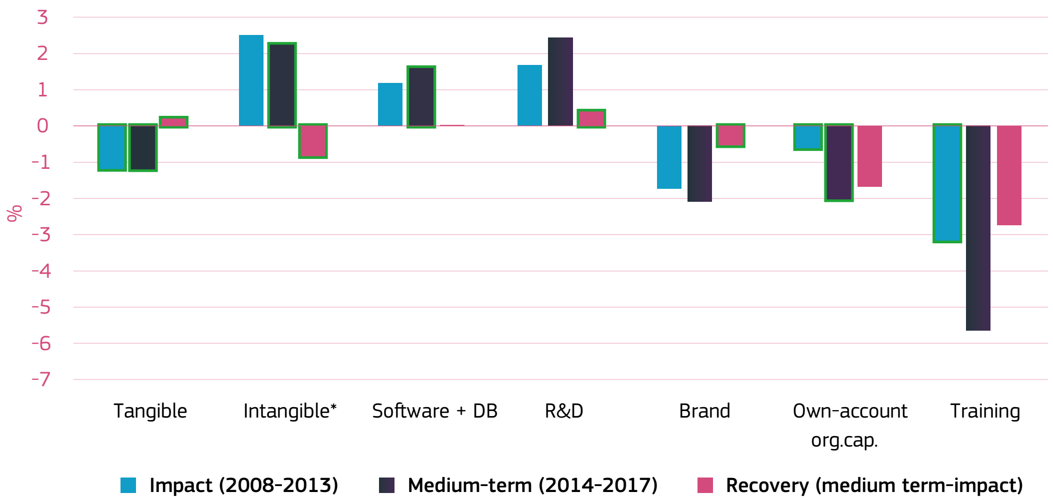
Figure 9-12: Percentage point effect on hours worked of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



Science, Research and Innovation Performance of the EU 2022

Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation.

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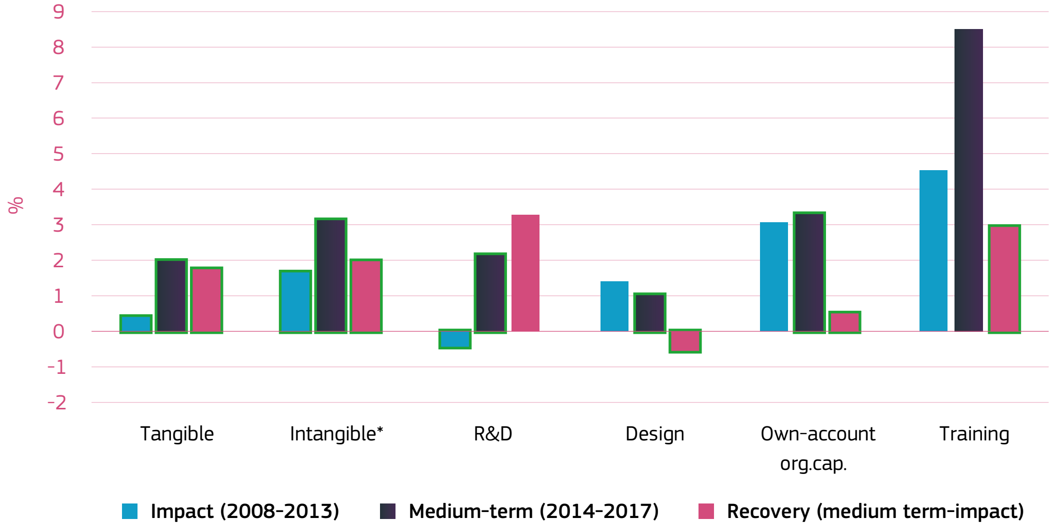
Figure 9-13: Percentage point effect on labour productivity of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



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Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation.

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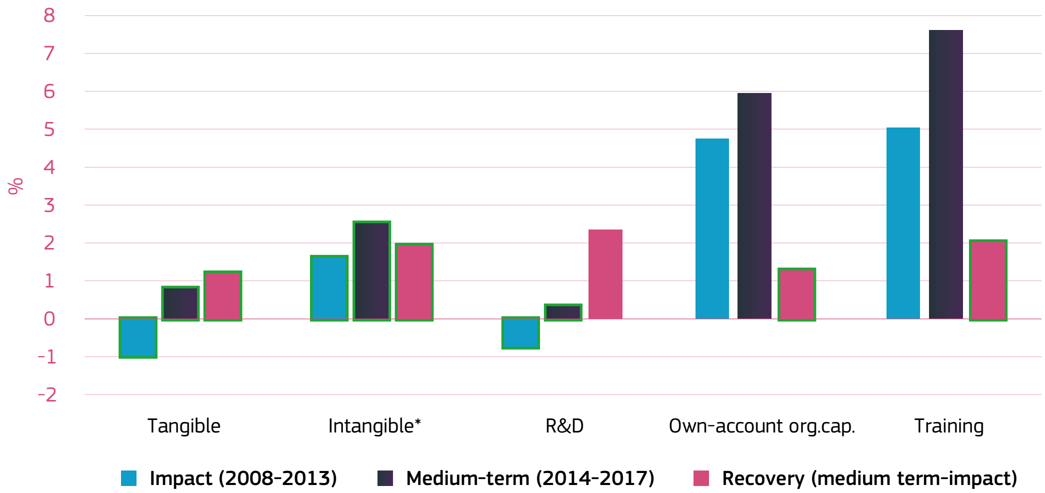
Figure 9-14: Percentage point effect on TFP of an increase of pre-crisis investment intensity equivalent to jumping from the bottom 25 % to the top 25 % of the intensity distribution (controlled for country and industry effects in a panel setting).



Science, Research and Innovation Performance of the EU 2022

Source: JRC calculations based on EU KLEMS 2019

Note: The framed bars denote a non-significant coefficient in the panel estimation.

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Results for the EU-13

The results for the role of intangibles as drivers of the different economic performance outcomes analysed for the EU-13 countries are generally inconclusive. Most of the results that we obtained for the EU-15 + USA country group become statistically insignificant if we add the EU-13 countries to the sample. Estimated separately, most of the results for the EU-13 are insignificant[13]. What we can highlight is that tangibles are most of the time associated significantly positively with the long-term values of outcome variables.

By contrast, among intangibles, only investments in software are associated significantly positively with long-term productivity growth. In case of the resilience metrics, we observe again that tangible investment seems much more important for the EU-13 countries compared to the EU-15 Member States. For example, tangibles are significantly positively associated with medium-term performance and recovery of labour productivity.

Why are results weaker for intangible investment in new Member States? Although this remains a question for future research, we can hypothesise a number of reasons.

First, it might be the case that for these countries, tangibles really are more important than intangibles, or that the countries lack some necessary ingredients (e.g. a critical mass of researchers) to successfully invest into intangibles. Furthermore, there may be a measurement issue in terms of the gap between the different locations of investment and the use of intangible assets. This problem is prone to be more binding in the case of the EU-13 countries, where a major part of economic output is produced by multinationals.

13 It is important to note that panel regressions run on the EU-13 sample have a small number of observations due to missing intangible investment data for many of these countries.

4. Intangible investment and finance

Uninterrupted financing of intangible investment is crucial as these investments are of a long-term nature and to a large extent, irreversible. For example, R&D investments are generally assumed to take longer to be productive (see, e.g., Aghion et al., 2010), while some of the investments (e.g. salaries paid to researchers) cannot be liquidated. 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 that intangibles are usually financed more by internal sources or equity instead of debt, and that 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 faces stronger informational asymmetries and 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.

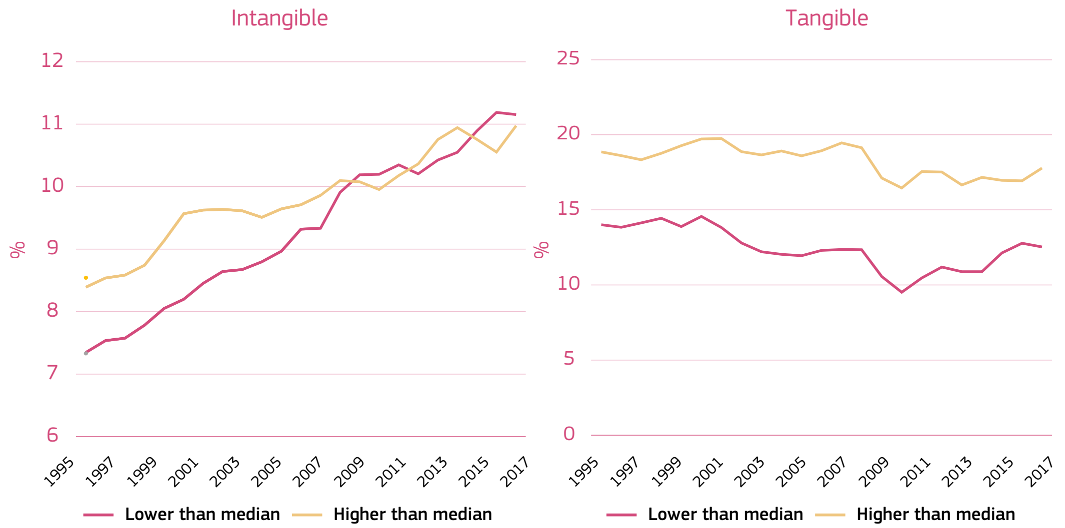
All this evidence reviewed above suggests that intangible investment is exposed to financial shocks. Based on that, the GFC should have had a major negative impact on intangible investment. What is puzzling is that we do not see a significant drop in intangible intensity on average during that period (see 'Investment intensities before, during and after the financial crisis'). This is in contrast with the large 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 especially true if it is intangible investment that is financed externally (by credit or by equity). However, the external financing of tangible investment might also have a detrimental effect on intangible investment indirectly, as we will explain later. We already cited the papers of Demmou et al. (2019) and (2020), which show the importance of external financial dependence (EFD) for intangible investment. Focusing only on R&D, Peia and Romelli (2022), on a large sample of European firms, find 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, Aghion et al. (2012) show, using pre-GFC 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 highly external-finance dependent sectors.

Thus, these findings are mostly in line with our hypothesis about the relevance of EFD for the behaviour of intangible investment during crises.

To investigate this issue, we established a link between a country-industry measure of EFD and intangible investment. Following Rajan and Zingales (1998), EFD is defined as the share of investments (including both tangible and intan-

Figure 9-15: **Average investment intensities of industries with lower and higher than median values of external financial dependence for intangibles (left panel) and tangibles (right panel)**



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Source: JRC calculation based on EU KLEMS 2019, BACH and ECB data

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.

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gible investment) that is not covered by cash flow. Thus, the higher the value of EFD, the higher the dependence on external finance. In our case, it is calculated by country and by 2-digit-level NACE industry. Examples of high EFD industries are air transport (in Spain and in Italy), construction (in Austria) and chemicals (in Denmark), while EFD is low in telecommunications (in Germany) and in food production (in Spain and in France) (see the Appendix for details of the calculation of EFD, and its tabulated values).

Before turning to the econometric estimation, we show an illustration of how differently investment intensity developed during the financial crisis depending on whether an industry's dependence on external finance is high or low (Figure 15). High EFD industries decreased their intangible intensity in 2008 and 2009 compared to the pre-crisis trend while the opposite happened with low EFD industries: intangible intensity increased, even compared to the pre-crisis trend. For tangibles, we do not see a characteristic difference in the behaviour of investment intensities by EFD during 2008-2009.

Now we turn to the formal econometric analysis. We use a country-industry-year panel with investment intensity (for different assets) as the dependent variable and EFD interacted with year dummies as explanatory variables. We include a rich set of fixed effects in the regression.

Thus, our regression equation is the following:

$$InvInt_{cst} = \beta^{2008} EFD_{cs} * \delta_t^{2008} + \beta^{2009} EFD_{cs} * \delta_t^{2009} + \ldots$$

$$+ \beta^{2017} EFD_{cs} * \delta_t^{2017} + \lambda_{cst} + \mu_{cst} + \varrho_{st} + u_{cst}$$

where c is country, s is industry, t is year, InvInt is the investment intensity in a specific asset in year t (tangible, aggregate intangible, R&D, etc.). EFD is the EFD of industry s in country c calculated over the period 2000-2004. δ_t is the year dummy, which is 1 when t is in the specific year (2008, 2009, ..., 2017) and otherwise is 0. λ_{cs}, μ_{ct} and ρ_{st} are country-industry, country-year and industry-year fixed effects. u_{cst} is the error term. The estimated β is the partial effect of a unit increase of EFD on investment intensity in the specific year compared to the average of the pre-crisis period.

According to the results (see Table 1), industries with higher dependence on external finance (keeping other industry and country characteristics constant) experienced a bigger drop in intangible intensity during the crisis compared to pre-crisis.

This link between EFD and the change in investment intensity holds 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-point higher EFD (which is not an extremely high difference in our dataset) caused a 0.24 percentage-point lower intangible intensity in 2008, a non-trivial effect. The estimated impact on tangible intensity is mostly positive, in some years statistically significantly positive.

In the following, we take into account the heterogeneous nature of financial shocks across countries during the GFC. Because of this heterogeneity in timing and size between countries, capturing the effect of the GFC with year dummies can only give a preliminary and imprecise estimate. Thus, instead of year dummies, a country-level indicator of financial stress (CLIFS) provided by the European Central Bank will be used as a measure of the timing and size of the financial crisis by countries.

Monthly observations of the original CLIFS indicator were averaged over a year to get an annual indicator. The following equation is estimated:

$$InvInt_{cst} = \beta EFD_{cs} * CLIFS_{ct} + \lambda_{cs} + \mu_{ct} + \varrho_{st} + u_{cst}$$

Where $InvInt$ is the investment intensity of an asset (we estimate the equation asset-by-asset), c is country, s is the 2-digit sector, t is time (year), EFD is external financial dependence (at the country-sector level) and $CLIFS$ is the country level indicator of financial stress (with variation across countries and years). β is the differential impact of the GFC on more externally financed industries compared to less externally finances industries, our main target of interest. We also include all the possible fixed effects (country-sector, country-time, sector-time, λ, μ, ϱ), and u is the error term. Our expectation is that β is negative, which means that at the same level of financial stress, more dependence on external finance decreases investment intensity. Phrasing this differently, higher stress decreases investment intensity while keeping EFD constant.

Table 9-3: 25th and the 75th percentiles of the investment intensity distribution across countries and industries and difference between them (2005-2007).

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Tangible	Coef.	0,0013754	-0,0010458	-0,0010791	**0,0052562**	0,0022034	0,0008434	**0,0061021**	0,0027343	0,0015757	0,0026875
	P>t	0,603	0,693	0,683	0,047	0,405	0,75	0,021	0,302	0,552	0,321
Intangible	Coef.	**-0,0024103**	**-0,0023037**	**-0,0033721**	**-0,0025208**	-0,0005426	-0,0009861	0,0000253	-0,0002203	-0,001859	-0,0012366
	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.	-0,0010631	-0,0005592	-0,0014581	0,0003018	0,0004401	0,0002073	0,0010197	0,0005684	0,0001112	0,0002793
	P>t	0,091	0,373	0,02	0,631	0,484	0,741	0,105	0,366	0,86	0,664
Software	Coef.	-0,0005781	**-0,0008454**	**-0,000738**	**-0,0012557**	0,0003287	0,0000794	0,0000742	0,0000571	-0,000412	-0,0001581
	P>t	0,133	0,028	0,056	0,001	0,393	0,837	0,847	0,882	0,285	0,688
Brand	Coef.	-0,0002274	**-0,0003347**	**-0,0004322**	**-0,000516**	**-0,0005966**	**-0,0005448**	**-0,0005866**	**-0,0004385**	**-0,0003083**	**-0,0004709**
	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	-0,0000793	-0,0001375	-0,0001767	**-0,0001803**	-0,0003564	0,000258	0,0002849	0,0002749
	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.	-0,000156	-0,000098	-0,0001335	-0,0002016	-0,0000914	-0,0000244	-0,0000789	-0,0000793	-0,0001065	-0,0001248
	P>t	0,281	0,498	0,356	0,164	0,528	0,866	0,586	0,584	0,462	0,389
Training	Coef.	0,0000115	-3,83E-06	6,38E-06	7,23E-06	-0,0000208	-0,0000379	**-0,0000453**	-0,0000212	**-0,000055**	**-0,000045**
	P>t	0,645	0,878	0,798	0,771	0,403	0,128	0,069	0,395	0,027	0,07

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Note: Estimated on the 2005-2017 sample, 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 data were available for only two countries in the sample. 'Coef.' in the table means the estimated coefficient for the specific asset.

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The results for different assets are the following, estimated for the countries that we have both EFD and intangible data (Austria, Germany, Denmark, Spain, France, Italy):

Table 9-4: Estimated coefficient of the interaction of EFD and CLIFS for different assets

	Coefficient	Standard error	t-value	p-value	Number of observations
Intangible	**-0.010**	0.004	-2.400	0.016	1 858
R&D	**-0.006**	0.002	-2.450	0.014	1 858
Software + DB	**-0.004**	0.001	-2.970	0.003	1 858
Brand	0.000	0.001	-0.570	0.571	2 158
Design	0.000	0.001	0.350	0.725	2 158
Purchased org. cap.	0.000	0.001	-0.520	0.605	2 158
Training	**0.000**	0.000	2.090	0.037	1 898
Tangible	-0.005	0.010	-0.530	0.600	1 858

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Source: JRC calculation based on EU KLEMS 2019, BACH and ECB data
Note: 'DB' and 'org.cap.' mean 'database' and 'organisational capital', respectively.
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According to the results, in the case of overall intangibles, R&D and software, the estimated impact is statistically significantly negative, while for tangibles it is not significant (although it is negative). For training, it is statistically significantly positive, but the estimated coefficient is very small[14].

In sum, this latter analysis also shows very similar results as the one based on year dummies, namely that there is a different response of tangible vs intangible investment to financial shocks. The finding that intangible investment is sensitive to external financial conditions is consistent with the results of the reviewed literature in the beginning of this section. As intangible assets cannot be pledged as collateral and are subject to substantial information asymmetries, intangibles are typically financed from liquidity as opposed to tangible assets, which tend to be financed from credit (see Altomonte et al., 2021, for causal evidence on France, and Ferrando and Preuss, 2018, for a representative sample of EU-28 firms).

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 a small or no effect on tangibles (Altomonte et al., 2022, provide indirect evidence for this mechanism using cross-country firm-level data).

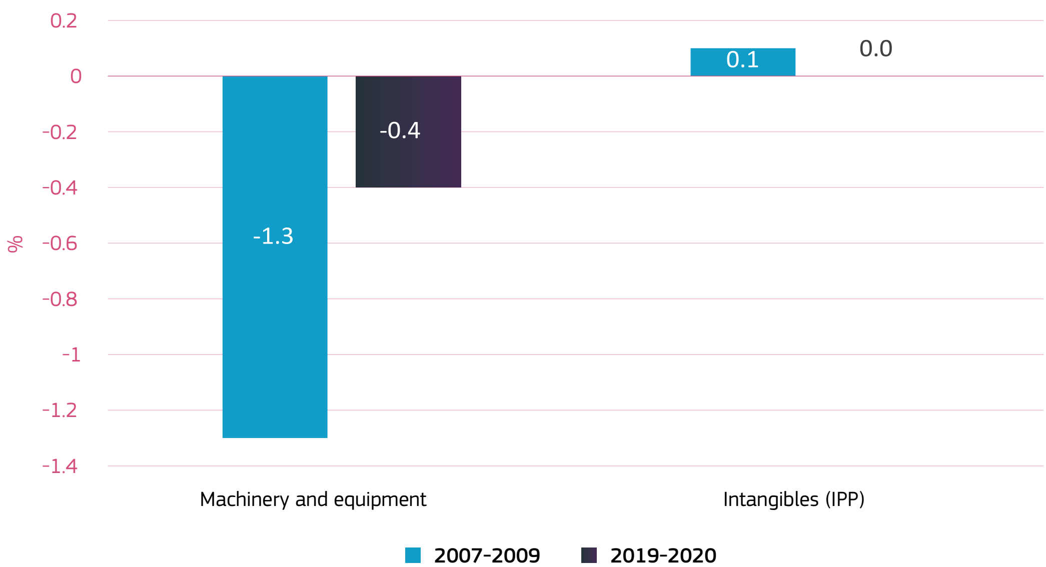
Thus we find that intangible investment is vulnerable to financial shocks. At the same time, we know that intangibles are important drivers of productivity, and we showed earlier in this chapter that intangibles may contribute to resilience against crises. Considering the importance of intangible investments, and their vulnerability at the same time, it is logical to suggest that supporting the financing of intangible investment during times of financial distress might contribute to further productivity growth and resilience of the economy.

14 Furthermore, there are reasons to think that training is the least robustly measured intangible asset in the EU KLEMS database, based on comparisons with the IntanInvest database, another data source on intangible investment.

5. Development of intangible investment in the COVID-19 crisis

The COVID-19 pandemic induced a major supply and demand shock on the global economy in 2020. Despite substantial differences from the global financial crisis in the cause of the crisis, in its pace of development and in the strength and speed of the policy response, the huge drop in GDP in almost all EU countries caused a significant decline in investment activity of firms. Lessons from the GFC suggest that a large decline in demand causes a less severe drop in intangible investment than for tangible investment, while financial stress affects intangible investment more than tangibles in financially exposed industries. In the COVID-19 crisis, a credit crunch similar to the GFC was avoided and firms were supported by ample liquidity due to the swift policy reaction. This suggests that financial conditions played a minor role in this crisis. On the other hand, the decrease in demand was much larger than before. All these indicate a larger drop in tangible investment than in intangible investment, similarly to the GFC, while we do not expect a differential impact on intangibles depending on the financial exposure of a given industry. We have limited data so far to check these hypotheses. From national accounts, intangibles include a limited number of assets, collectively called IPP (intellectual property products: software and databases, R&D, other intellectual property products). This preliminary data confirms our first hypothesis: while intangible investment decreased, this was much more muted than the drop in tangible investment. Furthermore, thanks to the policy response, even the decline in tangibles was smaller compared to the drop in GDP than during the GFC.

Figure 9-16: Change in overall and intangible investment intensity (investment/GDP) in the EU (percentage points)



Source: Eurostat (national accounts)
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6. Conclusion

A number of papers already showed the relevance of intangible capital as a factor of production and driver of productivity. In this chapter, we focused on the economic performance in terms of output, employment and productivity of countries and industries in Europe around the period of the global financial crisis. We linked this performance to the difference in intangible investment intensity. We found that intangible intensity, in general, contributed to better performance and resilience of economies. We also analysed trends of intangible investment before, during and after the financial crisis. We found an upward trend of intangible investment intensity in nearly all countries and industries, which started well before the crisis and continued almost uninterruptedly through the recession periods. Finally, we investigated the sensitivity of intangible investment to the availability of external finance. According to our results, intangible investment was more sensitive to financial conditions than tangible investment.

Despite significant differences between the reasons for and the unfolding of the GFC and the current COVID-19 crisis, our results emphasise the significance of intangible investments in making economies more resilient. Furthermore, we find a link between external financing and intangible investments, which indicates the financial vulnerability of these investments. Among intangible assets, we find this link for R&D and software investments.

Our leading explanation for the sensitivity of intangible investment to the tightening of external financial conditions is based on the trade-off between tangible and intangible investment induced by financial stress. During expansion periods, liquidity of firms is mostly used for financing intangible investment while credit is used for financing tangible investment. Financial stress makes financing tangible investment from credit more difficult. Firms thus tend to use part of their liquidity to finance tangibles, creating a trade-off between tangible and intangible investment (Altomonte et al., 2022).

These findings strengthen the case for supporting uninterrupted financing of firms during crises. At the same time, targeted support of finance for intangible investment might pose a challenge, given that intangibles cannot be pledged as collateral. However, there are several possibilities to overcome this difficulty. First, financing is not necessarily bank lending; it can be equity finance or grants. These instruments are already widely used in financing R&D investments. Furthermore, bank lending can be facilitated by using loan guarantees (see Demmou and Franco, 2021, for experiences with loan guarantees during the COVID-19 crisis). Finally, there are examples in some Asian countries where intangibles are accepted as collateral (see Manigart et al., 2020).

In the COVID-19 crisis, demand played a larger role than financing conditions. Preliminary data on the COVID-19 crisis supports the conclusion that intangibles are less sensitive to a drop in demand, which materialises in the much larger decline in tangible investment compared to intangible investment.

References

Aghion, P., Angeletos, G. M., Banerjee, A., & Manova, K. (2010), Volatility and growth: Credit constraints and the composition of investment, *Journal of Monetary Economics*, Elsevier, vol. 57(3), pp. 246-265, April.

Aghion, P., Askenazy, P., Berman, N., Cette, G., & Eymard, L. (2012), Credit Constraints and the Cyclicality of R&D Investment: Evidence from France, *Journal of the European Economic Association* 10, 5, pp. 1001–1024.

Altomonte, C., Favoino, D., Morlacco, M., & Sonno, T. (2021), *Markups, Intangible Capital and Heterogeneous Financial Frictions*. Centre for Economic Performance, London School of Economics and Political Science, Discussion Paper 2021/1.

Altomonte, C., Bauer, P., Gilardi, A. M., Soriolo, C. (2022), *Intangible assets, industry performance and finance during crises*, Manuscript.

Balta, N. and Nikolov, P. (2013), Financial dependence and industrial growth in the euro area during the crisis. Part II/ Chapter 3 in: Product Market Review (2013), *Financing the real economy*, European Economy 8/2013.

Bauer, P., Fedotenkov, I., Genty, A., Hallak, I., Harasztosi, P., Martínez-Turégano D., Nguyen D., Preziosi, N., Rincon-Aznar, A., Sanchez-Martinez, M. (2020), *Productivity in Europe – Trends and drivers in a service-based economy*, EUR 30076 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-10610-4, doi:10.2760/469079, JRC119785.

Cincera, M., Delanote, J., Mohnen, P., Santos, A., Weiss, C. (2020), *Intangible investments and productivity performance*. GEE Papers 0145, Gabinete de Estratégia e Estudos, Ministério da Economia, March 2020.

Demmou, L., Stefanescu, I., Arquié, A. (2019), *Productivity growth and finance: The role of intangible assets – A sector level analysis*, OECD Economics Department Working Papers 1547.

Demmou, L., Franco, G., Stefanescu, I. (2020), *Productivity and finance: the intangible assets channel – a firm level analysis*, OECD Economics Department Working Papers 1596.

Demmou, L. and Franco, G. (2021), *From hibernation to reallocation: Loan guarantees and their implications for post-COVID-19 productivity*, OECD Economics Department Working Papers 1687.

Döttling, R. and Ratnovski, L. (2020), *Monetary policy and intangible investment*, ECB Working Paper Series 2444, July 2020.

Ferrando, A. and Preuss, C. (2018), What finance for what investment? Survey-based evidence for European companies. *Economia Politica*: Journal of Analytical and Institutional Economics, Springer; Fondazione Edison, 35(3), pp. 1015-1053, December.

Griliches, Z. (1998), *R&D and Productivity: The Econometric Evidence*, The University of Chicago Press, Chicago.

JRC (2018), *The resilience of EU Member States to the financial and economic crisis: What are the characteristics of resilient behaviour?*, EUR 29221 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-85746-1.

Manigart S., Vanacker T., Knockaert M., Verbouw J. (2020), *Financing intangibles: Is there a market failure?*, Mimeo.

Peia, O., and Romelli, D. (2022), Did financial frictions stifle R&D investment in Europe during the great recession? *Journal of International Money and Finance*, Volume 120, February.

Rajan, R. G. and Zingales, L. (1998), Financial Dependence and Growth. *The American Economic Review*, 88(3), pp. 559-586.

Segol, M., Kolev, A., Maurin, L. (2021), *The impact of bank loan terms on intangible investment in Europe*, EIB Working Papers, No. 2021/05, ISBN 978-92-861-5036-4, European Investment Bank (EIB), Luxembourg, http://dx.doi.org/10.2867/974979.

Stehrer, R., A. Bykova, K. Jäger, O. Reiter and M. Schwarzhappel (2019), *Industry level growth and productivity data with special focus on intangible assets*, wiiw Statistical Report 8.

Thum-Thysen, A., Voigt, P., Bilbao-Osorio, B., Maier, C., Ognyanova, D. (2017), Unlocking Investment in Intangible Assets, *European Economy Discussion Paper* 047.

Thum-Thysen, A., Voigt, P., Bilbao-Osorio, B., Maier, C., Ognyanova, D. (2019), Investment dynamics in Europe: Distinct drivers and barriers for investing in intangible versus tangible assets? *Structural Change and Economic Dynamics*, Volume 51, December, pp. 77-88.

Appendix: Calculation of EFD

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. We have six countries where the data could be used for our purpose: Austria, Germany, Denmark, Spain, France, Italy. 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[15]. The higher the share of investments not covered by cash flow, the stronger the need for external finance for these investments. We average this share over the 2000-2004 period, substantially far away from the GFC during a period of abundant liquidity. Thus we hope that this measure reflects the country-industry specific demand for external finance. For the EFD values see Table 5.

15 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 the case of intangible investment. A further reason is that depreciation cannot be separated between tangible and intangible assets in the dataset.

Table 9-5 EFD 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%

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Note: The table shows winsorised values at the 5th and 95th percentile of the distribution.

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