Intangible Intensity, Recessions and Growth Potential in Europe

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Abstract

This paper analyses the evolution of intangible intensity in Europe, in normal times and following a negative shock. I show that intangible intensity has been on the rise in Europe, both due to research and development expenditure ($R\&D$) and other firm specific intangibles. I find that smaller firms invest relatively more in intangibles, larger firms tend to have a higher share of intangible capital and that firms that invest more in intangibles tend to grow faster in revenue. Moreover, I find evidence of a slowdown in the rise of intangible intensity brought about by the Great Recession of 2008-2009, driven by a slowdown in $R\&D$ investment. Overall, the paper offers insights on the drivers and evolution of intangible intensity in Europe, and its effect on firm growth. Moreover, it provides evidence on the long lasting scarring effects of recessions on the structural transformation process towards a more intangible intensive economy, and on economic growth potential.

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1 Introduction

Intangible investment pertains to firms' spending in assets which enable their operations, but that cannot be categorised as traditional tangible capital as they are not physical in nature. Although there are different ways of categorising intangible investment, in this paper I will focus on the distinction between research and development ($R\&D$) and firm specific intangibles (FSI), encompassing software and databases, but also marketing and training. Firms have been investing increasingly more in intangibles across advanced countries in absolute terms as well as with respect to output, implying that production relies more on intangibles. Figure 1 shows the rise of intangible intensity in EU28 countries, as measured by national accounts (LHS) and firm balance sheet data (RHS). National accounts report $R\&D$ and Software and Databases investment, where the latter is the only component of FSI measured. Although not all categories of intangibles are included in national accounts, efforts to estimate intangible investment categories more widely offer a similar picture.[1]

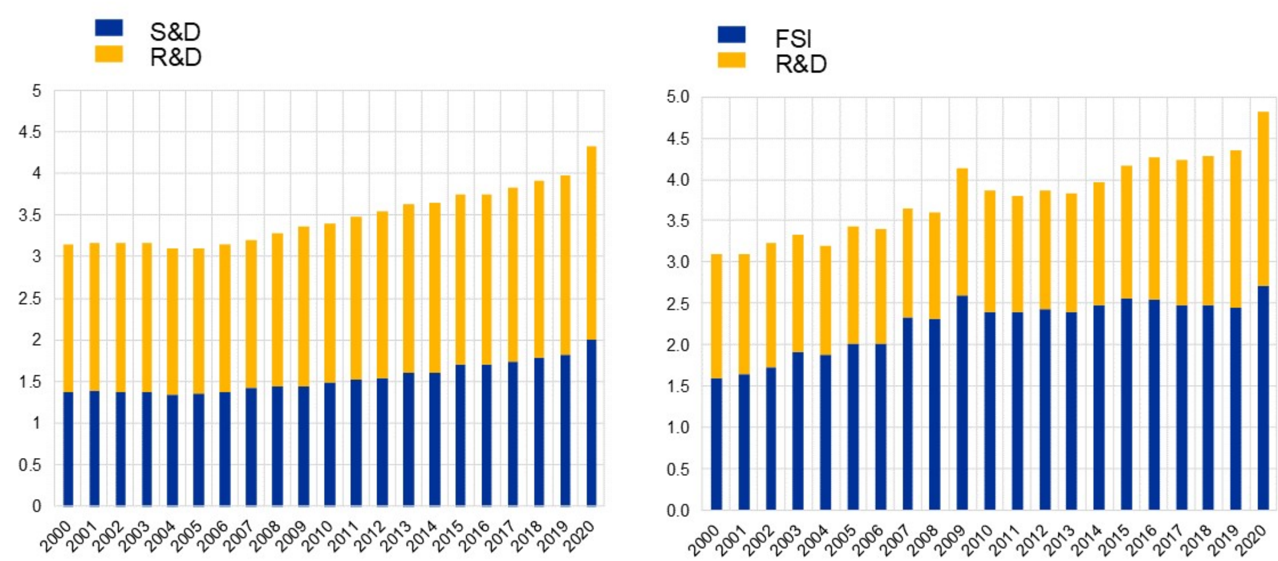

Figure 1: EU28 Intangible intensity over time: national accounts (LHS) vs firm balance sheet data from Standard and Poor's Compustat Global dataset (RHS).
Note: National accounts measures are defined as software and databases ($S\&D$) and research and development ($R\&D$) expenditure as a share of GDP, while the balance sheet measure is defined as total firm specific intangibles expenditure and total $R\&D$ expenditure on total sales. The latter excludes the agriculture and finance sector.

The roles played by these two categories of intangibles, $R\&D$ and FSI, are not yet fully understood, but a large body of research shows the $R\&D$ is an important driver of potential growth (see for example Akcigit and Ates (2020) or Romer (1990)), allowing firms to improve their products or introduce new ones.

[1] See for example Haskel and Westlake (2018), Peters and Taylor (2017) or Crouzet and Eberly (2019).

R&D spending is thus commonly referred to as innovation. Conversely, firm specific intangibles are linked to firms' ability to bring their products to the market, reaching consumers, gaining and retaining market share (Sedláček and Sterk (2017), Roldan and Cavenaile (2021)). The structural transformation process towards a more intangible economy has important implications for the economy's productive capacity through the level and composition of investment, as illustrated by Andersson and Saiz (2018) as well as its growth potential as shown by De Ridder (2019), and thus it matters for policy-making. Concerning monetary policy, research shows that promoting intangible investment might require targeted interventions, as the low value of intangibles as collateral can hamper the efficacy of monetary policy to stimulate investment through the bank borrowing channel. Döttling and Ratnovski (2020) as well as Caggese and Pérez-Orive (2022) argue that a reduction in the policy rate has a smaller impact on intangible investment compared to tangible investment, because firms that rely more on intangible assets have less collateral to pledge for loans. Thus, the more intangible intensive the economy is, the less investment reacts to monetary policy. As for fiscal policy, *R&D* investment can be stimulated through subsidies and interventions can help promote the EU's digitalization agenda, as shown by Benedetti-Fasil et al. (2021) as well as Weiss (2021), among others. Overall, the structural transformation process towards a more intangible intensive economy affects how policy objectives and tools should be designed. Moreover, it is important to understand if this process can be affected by recessions, as the L-shaped recovery that followed the financial crisis of 2008 has shown that negative shocks can have long lasting effects on the productive capacity of the economy, i.e. the level of potential output. The level of GDP and investment never recovered to their pre-recession growth trajectory in the vast majority of European countries and potential output was negatively affected.[2] At the same time, the recession may have had an impact also on the growth potential of the economy, as theorised by Benigno and Fornaro (2018). On the one hand, recessions can be considered cleansing periods, where the most productive firms, which tend to be innovative and digital, outperform laggard competitors. Therefore, shocks can bring about a reallocation of production in favour of intangible intensive firms, increasing intangible intensity and improving the economy's growth potential. On the other hand, an L-shape recovery in output and investment could indicate that firms reduced investment efforts, slowing down the rise of intangible intensity and resulting in a scarring effect on the economy's growth potential. These considerations are also important when assessing the impact of the Covid-19 crisis on the European economy. Although it is too early to evaluate the long run effects, recent evidence shows that the crisis has accelerated the adoption of digital technologies in Europe, which include software investment and thus pertain to intangibles. According to the 2020 EIB investment survey, approximately 40% of EU firms report having adopted at least one digital

[2] See Ikeda and Kurozumi (2019), Anzoategui, Comin, Gertler, and Martinez (2019), Vinci and Licandro (2021) Garcia-Macia (2017), Caggese and Pérez-Orive (2022) or De Ridder (2016) for in depth discussion on this topic.

technology in 2020. Despite an increase in the share of digital firms in 2020, EU firms are still lagging behind the United States in digital adoption. In 2020, only 63% of EU firms had implemented at least one digital technology, compared to 73% in the United States. Innovation activities to expand the technology frontier through Research and Development (*R&D*), have also shown resilience through the pandemic, but more investment is needed to reach policy targets. EU *R&D* expenditure as a share of GDP stood at 2.2% in 2019 and provisional data for 2020 report an increase to 2.3%, but this outcome falls short with respect to policy objectives. The European Commission introduced a target level of investment equivalent to 3% of GDP in its Europe 2020 strategy, now set to be achieved by 2030. Despite continued investment, the EU lags behind the United States, which already exceeded 3% in 2019 according to Eurostat estimates.

Thus developing a deeper understanding of intangible investment choices at the firm level can help shed light on the drivers of macroeconomic developments and inform policy design. In this paper I investigate whether intangible intensity matters for firm growth in Europe in normal times as well as during downturns and whether the Great Recession affected the rise of intangible intensity in European countries.

The rest of the paper is organized as follows: Section 2 describes the contribution to the literature, Section 3 describes the data, Section 4 discusses the link between intangible intensity and firm growth, Section 5 focuses on the impact of the Great Recession on the rise of intangible intensity, Section 6 investigate the mechanics, and Section 7 concludes.

2 Contribution to the literature

Recent theoretical literature has proposed ideas to better understand the mechanisms through which intangibles affect firm performance and firm behaviour over the long run and after (large) negative shocks.[3] This paper provides an empirical evaluation of some of these hypotheses. In particular, I conduct an empirical exploration of the drivers of different types of intangible investments, the role they play for firm growth and how they are affected by recessions. I analyse firm level data from Compustat between 1989 and 2020 across sectors for the EU28, with the aim to answer two research questions. Firstly, do intangible intensive firms grow faster? The identification strategy draws inspiration from the work of Haltiwanger, Jarmin, and Miranda (2013), who estimate the relationship between firm size and firm growth, as well as Akcigit and Kerr (2018) and Akcigit (2009), who analyse the connection between firm size and *R&D*. The empirical work in Roldan and Cavenaile (2021) is the closest to my approach, as they investigate the link between firm size and *R&D* intensity as well as adversing intensity in Compustat for the United States. I contribute by defining intangible intensity more broadly, and by investigating the nexus with firm growth. Findings

[3] See for example Akcigit and Kerr (2018), De Ridder (2019), Roldan and Cavenaile (2021), Garcia-Macia (2017) or Caggese and Pérez-Orive (2022).

suggest that firms that invest relatively more in intangibles tend to grow faster in revenue. The majority of empirical studies underpinning theoretical work are focused on United States data. Notable examples include Hall (1987), who identifies a positive relationship between $R\&D$ investment, employment growth and survival, as well as Stiroh (2002), who finds a positive link between IT investment and productivity growth.[4] More recently, Bloom, Sadun, and Van Reenen (2012) show that the combination of IT investment with effective managerial practices drove the success of U.S. firms compared to their European counterparts. Döttling, Gutierrez Gallardo, and Philippon (2017) also compare the United States to Europe and find that the process of intangible deepening is driven by within firm dynamics in Europe, as opposed to between firms in the U.S.

As for European studies, a growing literature has focused on recession periods. Garcia-Macia (2017) employs a rich dataset of Spanish firms to estimate a model of heterogeneous firms, to show that the lower value of intangibles as collateral plays a role in amplifying negative shocks during financial crises. Schmitz (2017) focuses on innovation in Spain and adds that negative shocks have long lasting effects on $R\&D$ investment as small, radically innovative firms are disproportionately affected. Grimm, Laeven, and Popov (2021) find that corporate $R\&D$ investment was higher among companies eligible for the ECB's Corporate Asset Purchase Programme in the aftermath of the Great Recession, compared to similar ineligible companies operating in the same country and sector. Deng and Liu (2021) analyse Italian aggregate and firm-level data, and find that firms reduced their investment and reallocated resources away from intangible assets, towards tangible assets, during the sovereign debt crisis.

Moreover, theoretical studies focusing on the link between $R\&D$ and business cycle dynamics, such as Benigno and Fornaro (2018), and Anzoategui et al. (2019), show that an $R\&D$ intensive economy is more likely to display slow and incomplete recoveries. They show that a fall in $R\&D$ investment leads to a persistent decline in aggregate productivity and potential output.

The available evidence thus points to the fact that intangible assets matter for firm growth, and therefore for the growth potential of the economy, and also to the fact that recessions can negatively affect intangible investment over the medium term, generating scarring effects.

These considerations motivate the second research question in this paper: do recessions slow down or accelerate the rise of intangible intensity? How do firms respond to negative shocks when they have the option to invest in $R\&D$ as well as firm specific intangibles? The Schumpeterian view suggesting that negative shocks could trigger creative-destruction led reallocations of productive resources, and thus improve the efficiency of the economy after the recession, is supported by some recent studies, who found complementarity between innovation and FSI investment to promote firm performance in bad times. Gulati, Nohria, and Wohlgezogen

[4] For an in-depth discussion of the literature see García-Manjón and Romero-Merino (2012).

(2010) analyse the performance of U.S. public firms during the recessions of 1980, 1990, and 2000 and find that firms who continued investing in $R\&D$ as well as FSI were able to flourish after negative shocks. Gupta (2019) adds that innovative firms were able to diversify through marketing and this made them more resilient during the Great Recession in Spain. In this scenario, large negative shocks would accelerate the structural transformation process towards intangible intensive production.

On the other hand, Aghion et al. (2012) argue that credit constraints cause $R\&D$ investment to plummet during recessions and find that the subsequent recoveries are not strong enough to sustain the creative destruction hypothesis. Consequentially, it is reasonable to expect a financial crisis not to be cleansing. Foster, Grim, and Haltiwanger (2016) focus on the dynamics of job creation and job destruction and confirm the hypothesis that the Great Recession was not cleansing for the United States, as productivity enhancing reallocation was impaired, in contrast with past downturns.

I answer this research question through empirical analysis, drawing from the estimation strategy of Hershbein and Kahn (2018) and the methods developed as part of my PhD Thesis (Vinci, 2020), applied to United States data, which allow to disentangle the effect of the negative shock on the path of intangible intensity over time by exploiting cross-sectional variation in the exposure to the Great Recession negative shock. The results of the estimation suggest that the Great Recession was associated with a slowdown in intangible intensity, driven by a slowdown in $R\&D$ intensity, suggesting that the Great Recession did not have a cleansing effect in the Schumpeterian sense.

Overall, this paper contributes new evidence on the medium to long term scarring effects of recessions, by documenting a slowdown of intangible intensity, which may lead to the erosion of potential growth.

3 Data

In this paper I analyse empirically European (EU28: EU+UK) firm level panel data from Standard and Poor's Compustat Global, encompassing the period 1989-2020. This dataset offers extensive coverage of publicly listed firms across European countries. All variables are converted into Euro through the conversion tables made available by Compustat.

In line with common practice in this literature, I exclude firms non incorporated in the EU28, as well as firms in the agriculture and finance sectors (A and K NACE industries). Observations are further discarded if they have negative employment (*emp*), sales (*sale*), cost of goods sold (*cogs*), selling, administrative and general expenses (*xsga*), $R\&D$ (*xrd*), property plant and equipment (*ppegt*), or total assets (*at*). I focus on the period 1989-2020 due to data availability and because these years encompass well the process of structural transformation towards a more intangible intensive economy.

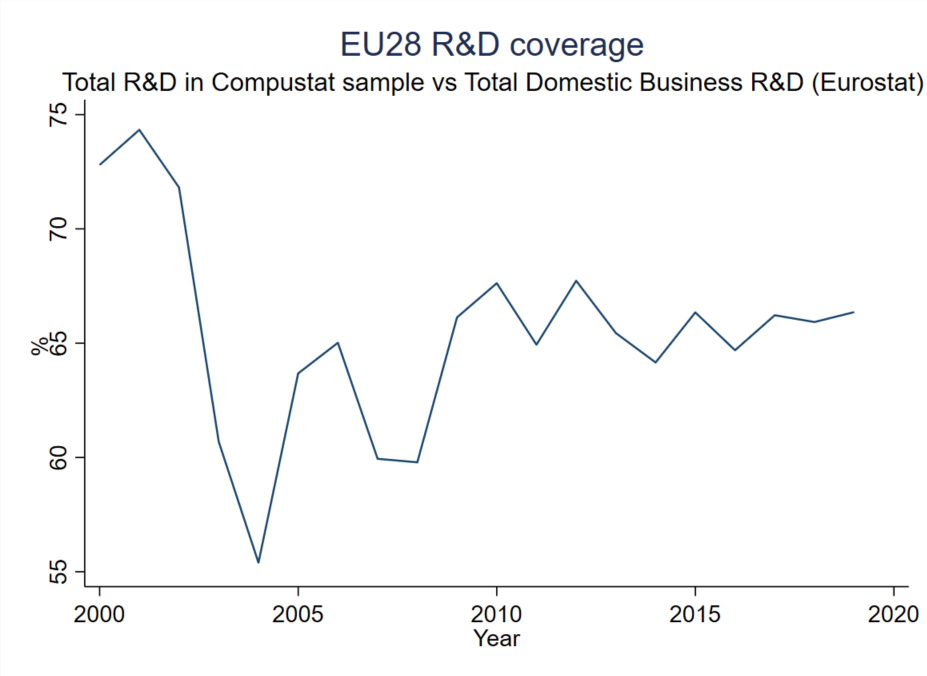

Figure 2: Total $R\&D$ in Compustat sample as a share of domestic EU28 business $R\&D$

The definition of firm specific intangibles (FSI) investment follows the approach of Peters and Taylor (2017), who estimate that 30% of general selling and administrative expenditure constitutes intangible investment. The Compustat measure is then $FSI = 0.3(xsga - xrd)$ where xrd is investment in $R\&D$, which is typically included in the Compustat measure of $xsga$, as documented by Peters and Taylor (2017). $IntanInvest$ is simply the sum of the two intangible categories. These three measures are meant to capture a firm's effort to build intangible capital. Finally, I keep firms with values of intangible investment intensity below 100%, similarly to Roldan and Cavenaile (2021).[5] In order to evaluate the quality of the resulting sample, I compare the $R\&D$ included in the sample with EU28 business $R\&D$ from national accounts and find that the Compustat sample is equivalent to an average of approximately 65% per year, as shown in figure 2. This suggests that a substantial portion of European $R\&D$ is included in Compustat over time.

Table 7 in the Appendix shows that intangible investment observations tend to be concentrated in the manufacturing sector, as well as information and communication, but the sample spans across the whole economy. These sectors also display relatively high average intensity.[6] Table 8 shows the distribution of intangible investment observations, encompassing both $R\&D$ and FSI, across European countries and in-

[5] Focusing on $R\&D$ intensity, Park (2011) argues that firms whose revenue is lower than $R\&D$ investment are mostly in the technology and pharmaceutical sector and their business model is based on venture capital funding. This makes them less likely to make investment choices in the same way as traditional, profit maximising firms and should thus be studied separately.

[6] The distribution of intangible intensities across sectors is broadly in line with estimates proposed by Corrado et al. (2016) for 14 European countries, who build on national accounts data, augmenting the coverage of intangible assets across sectors.

dicates a high degree of concentration of intangibles among firms incorporated in the United Kingdom, Germany, France and Sweden. However, data do not allow the disentangling of investment between domestic and foreign activity, so that the observed degree of concentration does not imply that the intangible investment is conducted entirely in the country where the firm is based. Nevertheless, a recent survey by the European Commission focused on innovation activities highlighted that approximately 72% of $R\&D$ conducted by EU28 firms is carried out within the block.[7] This implies that the dataset is not highly representative of $R\&D$ conducted domestically at the country level, but captures a substantial fraction of $R\&D$ investments at the European level. As for firm specific intangibles, the difference in variable definition between the sample and national accounts makes a comparison on the magnitude of investment less meaningful. Finally, Table 9 in the Appendix shows that firms investing more in FSI also tend to invest relatively more in $R\&D$, suggesting complementarity across intangible investment categories.

4 Does intangible intensity matter for firm growth?

Intangible Intensity and firm size. The first step of the analysis entails investigating the relationship between intangible intensity and firm size. The latter has two important dimensions: identifying firm characteristics associated with investing in intangibles (extensive margin) and firm characteristics associated with investing relatively more in intangibles (intensive margin). In the Compustat sample, similarly to what is observed in the economy as a whole, only a subset of companies report intangible investments. These amounted to 41% of firms in 2020, a figure that increased gradually starting from 11% in 1989. As a result, intangible investments are concentrated among a sub-sample of firms, and these tend to be larger, older and more profitable.[8] However the focus of this paper is on the intensive margins, so I will focus on investigating what drives firms to invest more in intangibles and what effect this has on their revenue growth.

As a first step, I investigate the relationship between intangible intensity of a firm i in country c and industry j at time t and firm size, measured as the log of real total assets, estimating the following specification:

$$IntanIntensity_{i,c,j,t} = \beta_0 + \beta_1 ln(assets)_{i,c,j,t} + \beta_2 ln(assets)_{i,c,j,t} \times Recession + \sum_{\kappa}^{N} \gamma_\kappa X^\kappa_{i,c,j,t} + \alpha_t + \alpha_i + \epsilon_{i,c,j,t} \quad (1)$$

$$IntanIntensity_{i,c,j,t} = \left[\frac{R\&D_{i,c,j,t}}{assets_{i,c,j,t}}, \frac{FSI_{i,c,j,t}}{sales_{i,c,j,t}}, \frac{IntanInvest_{i,c,j,t}}{sales_{i,c,j,t}} \right]$$

[7]See EC (2018) for EU28 and EC (2020) for EU27.
[8]See Table 11 in the Appendix.

	(1) $\frac{R\&D}{sales}$ b/se	(2) $\frac{FSI}{sales}$ b/se	(3) $\frac{IntanInvest}{sales}$ b/se
$ln(assets)_t$	-0.0058**	-0.0050***	-0.0108***
	(0.0023)	(0.0015)	(0.0026)
$ln(assets)_t \times Recession$	-0.0001	0.0003***	0.0002
	(0.0002)	(0.0001)	(0.0002)
$ProfitMargin_{t-1}$	0.0207**	0.0354***	0.0561***
	(0.0081)	(0.0088)	(0.0129)
$Financing_{t-1}$	0.0046***	0.0062***	0.0108***
	(0.0011)	(0.0010)	(0.0017)
age	0.0013	-0.0001	0.0012
	(0.0008)	(0.0008)	(0.0011)
constant	0.0762***	0.0807***	0.1569***
	(0.0144)	(0.0118)	(0.0172)
Number of obs.	24,094	24,094	24,094
R^2	0.020	0.047	0.050
Firm fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 1: Firm size and intangible intensity.

The control variables are:

$$X^{\kappa}_{i,c,j,t} = [age_{i,c,j,t}, Financing_{i,c,j,t-1}, ProfitMargin_{i,c,j,t-1}]$$

Real assets are defined as a firm's reported total assets in Euro, divided by the country's GDP deflator. I control for age, which represents years since addition to Compustat, the financing ratio, *i.e.* net cash flow from financing activities on total liabilities, and profit margins, *i.e.* sales net of costs of production on sales. I also control for firm fixed effects in all specifications to account for unobserved firm characteristics and attenuate omitted variable bias, and time fixed effects. I also introduce an interaction term between the size variable and a recession dummy, to estimate whether the relationship differs in bad times.

Results are in line with several studies focusing on $R\&D$ intensity, who find that firms with high innovation intensity tend to be smaller (see for example Akcigit (2009) and Akcigit and Kerr (2018)). Table 1 shows a strong negative correlation between intangible intensity measures and firm size, suggesting that firms that invest relatively more in intangible assets tend to be smaller. A one percent increase in real assets is associated with a reduction in intangible intensity of 0.0108 percentage points. The relationship holds in recessions as well, but the effect is somewhat smaller for FSI investment. The analysis complements existing studies, as I show that the inverse relationship also holds for FSI and total intangibles. As for the remaining drivers of intangible investments, several studies have underlined the concern of insufficient funding availability due to the low collateral value of these assets. As a consequence, firms tend to rely on internal resources, such as retained earnings, rather than bank loans in order to invest in intangibles.[9] The

[9]See for example Caggese and Pérez-Orive (2022) and Döttling and Ratnovski (2020).

analysis carried out in this paper confirms this view, as I find that ex-ante profit margins (i.e. realised in the previous year) support intangible investment, and the same holds for the availability of financing cash flow.

As a robustness check, I repeat the analysis adopting the log of sales as a measure of size and find comparable results (see Table 12 in the Appendix).

I then check whether firms that use more intangible capital, *i.e.* have a higher share of intangible capital on total capital, are larger.

I estimate the following specification:

$$\frac{PurchasedIntan_{i,c,j,t}}{Capital_{i,c,j,t}} = \beta_0 + \beta_1 ln(size)_{i,c,j,t} + \sum_{\kappa}^{N} \gamma_\kappa X^\kappa_{i,c,j,t} + \alpha_t + \alpha_i + \epsilon_{i,c,j,t} \tag{2}$$

$$X^\kappa_{i,c,j,t} = [age_{i,c,j,t}, Financing_{i,c,j,t-1}, ProfitMargin_{i,c,j,t-1}]$$

As size measures, I consider both real total assets and sales. The regression includes firm and time effects as well as control variables. To measure the stock of intangible capital, I use the variable *intan* in COMPUSTAT, which measures purchased intangibles. Intangible intensity is then constructed as purchased intangibles on total capital $\left(\frac{intan}{intan+ppegt}\right)$, as in Crouzet and Eberly (2019). This captures the stock of intangible capital that firms declare on their balance sheet, mostly resulting from acquisitions. The measure is far from ideal, as it misses the value of internally built intangibles, but is nonetheless the most accurate representation available of the firm's valuation of its intangible capital. The results displayed in Table 2 confirm the hypothesis that larger firms have a higher share of intangible capital. A one percent increase in real assets is associated with an increase in the share of intangible capital of 0.103 percentage points.

	(1) $\frac{PurchasedIntan}{Capital}$ b/se	(2) $\frac{PurchasedIntan}{Capital}$ b/se
$ln(assets)_t$	0.103***	
	(0.006)	
$ln(sales)_t$		0.056***
		(0.007)
$ProfitMargin_{t-1}$	0.072***	0.089***
	(0.022)	(0.024)
$Financing_{t-1}$	0.002	0.006**
	(0.003)	(0.003)
age	-0.002	-0.002
	(0.004)	(0.004)
Number of obs.	23,348	23,348
R^2	0.292	0.212
Firm fixed effects	YES	YES
Time fixed effects	YES	YES
S.e. clustered at firm level	YES	YES

Table 2: Share of intangible capital in total capital and firm size.

Intensity and firm growth. From the previous results, I conclude that firms putting the most effort into intangible investment across all categories tend to be smaller. On the other hand, firms that have more intangible capital are larger. This motivates the formulation of the hypothesis that intangible investment could be a way to build up demand for smaller firms. To test this hypothesis, I estimate the following specification:

$$SalesGrowth_{i,c,j,t} = \beta_0 + \beta_1 IntanIntensity + \sum_{\kappa}^{N} \gamma_\kappa X^{\kappa}_{i,c,j,t} + \alpha_t + \alpha_i + \epsilon_{i,c,j,t} \quad (3)$$

$$IntanIntensity = \left[\frac{R\&D_{i,c,j,t-1}}{sales_{i,c,j,t-1}}, \frac{FSI_{i,c,j,t-1}}{sales_{i,c,j,t-1}}, \frac{IntanInvest_{i,c,j,t-1}}{sales_{i,c,j,t-1}}\right]$$

$$X^{\kappa}_{i,c,j,t} = \left[age_{i,c,j,t}, Financing_{i,c,j,t-1}, ProfitMargin_{i,c,j,t-1}, ln(\overline{assets})_{i,c,j,t}\right]$$

Where sales growth is calculated as log difference of real sales, year on year. Size is measured as the logarithm of average real assets between t and t-1 ($ln(\overline{assets})_{i,c,j,t}$).[10] Intangible intensity measures are lagged, to allow past investment to cumulate into intangible capital used in production, following the same logic behind standard perpetual inventory methods. Moreover, this way the intangible investment choice is more exogenous to firm performance. Table 3 shows that firms that invested relatively more in intangible capital, across all three categories, reported higher sales growth on average. A one percentage point increase in intangible intensity is associated with an increase in sales growth of 0.765 percentage points.[11]

From these results, I conclude that intangible intensity is associated with higher revenue growth. However, one shortcoming of Compustat data is that it does not disentangle prices and quantities sold, as firms only report revenue. Although this is a standard measure of firm growth in the empirical literature investigating the effects of innovative investments at the firm level (see for example Bloom et al. (2013) or Kogan et al. (2017)), it is possible for intangible capital to have an effect on the firm's ability to raise prices, rather than quantities. I partially addressed this concern by including profit margins as a control variable, but as a robustness check, I also consider a firm mark-up measure. The latter captures the ratio of a firm's marginal revenue to marginal cost, and is built following De Loecker et al. (2020). Appendix B describes the procedure and Table 13 in the Appendix shows that the main results hold when controlling for mark-ups.

Normal times vs Recessions The analysis presented so far shows that firms that invest relatively more in intangibles tend to grow faster. To investigate whether this result holds over the business cycle, I repeat

[10] This measure is widely used in the literature investigating the relationship between firm size and firm growth, as it allows to avoid regression to the mean bias. For a detailed discussion see Haltiwanger et al. (2013). Nonetheless, using the size measure at base year (t-1) or current assets yields similar estimates for the coefficient of interest.

[11] As a robustness check, I also consider alternative measures of size and find that these results hold.

	(1) Sales growth b/se	(2) Sales growth b/se	(3) Sales growth b/se
$\frac{R\&D}{sales}(t-1)$	0.625***		
	(0.078)		
$\frac{FSI}{sales}(t-1)$		1.090***	
		(0.132)	
$\frac{IntanInvest}{sales}(t-1)$			0.765***
			(0.076)
$ProfitMargin_{t-1}$	0.058	0.011	0.026
	(0.064)	(0.061)	(0.058)
$Financing_{t-1}$	0.026***	0.023***	0.021***
	(0.005)	(0.005)	(0.004)
	0.002	0.002	0.002
	(0.004)	(0.004)	(0.004)
$ln(\overline{assets})_t$	-0.001	0.001	0.006
	(0.007)	(0.007)	(0.007)
Number of obs.	24,093	24,093	24,093
R^2	0.119	0.127	0.134
Firm fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 3: Sales growth and intangible intensity.

the baseline analysis, but distinguish across normal times and recession periods. Table 4 shows that the result holds even with this sample restrictions, although the magnitude of the effect shrinks in bad times.

	(Normal Times) Sales growth b/se	(Recessions) Sales growth b/se	(2009) Sales growth b/se	(2020) Sales growth b/se
$\frac{IntanInvest}{sales}(t-1)$	0.782***	0.480**	0.392***	0.338***
	(0.083)	(0.199)	(0.148)	(0.102)
$ProfitMargin_{t-1}$	0.132***	-0.302***	0.079	0.013
	(0.041)	(0.112)	(0.076)	(0.046)
$Financing_{t-1}$	0.022***	-0.001	0.103**	0.013
	(0.005)	(0.012)	(0.042)	(0.012)
age	-0.001	0.020	-0.002	-0.007***
	(0.005)	(0.016)	(0.002)	(0.001)
$ln(\overline{assets})_t$	0.002	-0.017	0.014***	0.013***
	(0.007)	(0.023)	(0.005)	(0.004)
Number of obs.	19,903	4,190	1,177	1,558
R^2	0.121	0.129	0.134	0.110
Firm fixed effects	YES	YES	NO	NO
Time fixed effects	YES	YES	NO	NO
Industry fixed effects	NO	NO	YES	YES
Country fixed effects	NO	NO	YES	YES
S.e. clustered at firm level	YES	YES	YES	YES

Table 4: Sales growth and total intangible intensity: normal times vs recessions.

Robustness. As further robustness checks, I follow Haltiwanger et al. (2013) and define sales growth as $\frac{RealSales_t - RealSales_{t-1}}{0.5(RealSales_t + RealSales_{t-1})}$. These measures are often used in the firm dynamics literature as they allow to smooth out entry and exit effects and they are bounded between -2 and 2. Results in Table 14 show that results are robust to this specification. I also tried winsorizing the top and bottom 2% of sales growth in Table 15 and results are robust.

5 Did the Great Recession accelerate or slow down the rise of intangible intensity?

The analysis presented in the previous section shows a positive relationship between intangible intensity and firm revenue growth, offering a micro-foundation of growth drivers and suggesting that intangible investments matter for growth potential. In this section I address the second research question: did the Great Recession accelerate or slow down the rise of intangible intensity?

The empirical strategy draws from from Hershbein and Kahn (2018) and Vinci (2020), and aims to separate the effects of the Great Recession from the underlying intangible intensity trend.

I estimate the following specification for firm i in country c and industry j :

$$INT_{i,c,j,t} - INT_{i,c,j,2007} = \beta_0 + \beta_1 \widehat{Shock}_{c,j} \times I^t + I^t + \sum_{\kappa}^{N} \gamma_\kappa X^{\kappa}_{i,c,j,2007} + + \beta_2 \Delta Y_{c,t} \times I^t + \epsilon_{i,c,j,t} \quad (4)$$

$$INT_{i,c,j,t} = \left[\frac{R\&D_{i,c,j,t}}{sales_{i,c,j,t}} \times 100, \frac{FSI_{i,c,j,t}}{sales_{i,c,j,t}} \times 100, \frac{IntanInvest_{i,c,j,t}}{sales_{i.c,j,t}} \times 100 \right]$$

$$X^{\kappa}_{i,c,j,2007} = [ln(assets)_{i,c,j,2007}, age_{i,c,j,2007}, ProfitMargin_{i,c,j,2007}, Financing_{i,c,j,2007}]$$

This specification pins down the effect of the shock on the path of intangible intensity over time, disentangling between the underlying trend, captured by the time dummies I_t and the effect of the shock, captured by the interaction between the shock variable and the time fixed effects.[12] The dependent variable is the change in intangible intensity between a year $t \in [2010 - 2019]$ after the trough of the recession in 2009 and the pre-recession peak of 2007.[13] The difference specification implicitly controls for time-invariant factors at the firm level. The right hand side controls for *ex ante* firm characteristics including age, real assets (log), profit margins, and financing, which I found in the previous section can affect intangible investments. In order to control for the heterogeneous impact of the recession shock across European countries, which resulted in the Sovereign Debt Crisis and could affect investment decisions, I include an additional interaction term, controlling for the year on year change in financial stress ($\Delta Y_{c,t}$) in the years considered at the country level.[14]

Finally, to measure the Great Recession shock, I rely on the change in GDP across European countries and industries between the peak and the trough of the recession, i.e. 2007 and 2009. The measure is then

[12] Tables 16, 17 and 18 show the time profile of the shock and time fixed effects for the key specifications.
[13] I exclude 2020 to avoid the potential confounding effects stemming from the covid-19 crisis.
[14] Financial stress is measured by Eurostat's Country-Level Index of Financial Stress (CLIFS).

de-trended using the average two-year growth rate over three years prior to the recession, to accurately capture the deviation brought about by the recession with respect to the pre-trend. The GDP shock variable is defined as:

$$Shock_{c,j} = -(ln(GDP_{c,j,2009}) - ln(GDP_{j,2007}) - \hat{g}_{c,j,2007}) \times 100 \tag{5}$$

where $\hat{g}_{c,j,2007} = \sum_{t=2007-n} \frac{(ln(GDP)_t - ln(GDP)_{t-2})}{3} \quad n = [0, 1, 2]$

This measure captures the severity of the recession shock across countries and industries, where a larger value is associated with a more severe shock, and allows the identification of the deviation of intangible intensity from its trend by exploiting the shock variation across countries and industries. However, this measure has the drawback of being affected by the performance of domestic firms. If firms in a given industry were more resilient to a negative shock for any reason, the GDP measure would fall by less, thus not fully capturing the true magnitude of the shock. The Compustat sample includes large firms, that could have a significant impact on industry GDP at the country level, so this endogeneity concern might lead to biased estimates. In order to address the issue, I draw from the instrumental variable approach to build a shock measure independent from the performance of domestic firms, but highly correlated to the Great Recession shock in two steps. First, for each country c, I compute the average shock across a given NACE industry for all countries except c, which is exogenous by construction for the domestic country. Moreover, although firms in the sample are likely to operate in more than one country, taking the average across all 28 countries reduces significantly the impact that a firm might have on industry outcomes. Secondly, exploiting the significant correlation between this average shock measure and the fall in GDP in country c and industry j, I calculate the shock measure to use in the analysis ($\widehat{Shock}_{c,j}$) as the predicted value stemming from the following regression:

$$Shock_{c,j} = \beta_0 + \beta_1 \overline{(Shock_{-c,j})} + \alpha_j + \alpha_c \ + \epsilon_{c,j} \tag{6}$$

The shock measure $\widehat{Shock}_{c,j}$ thus captures the portion of the fall in GDP in a given industry and country explained by shocks observed in the same industry but in other countries. The estimation includes country and industry fixed effects to fully account for heterogeneity across countries and industries, whilst providing a shock measure independent from the performance of domestic firms. Figure 3 shows the distribution of the shock values, and illustrates the moderate deviation between measured GDP shocks and the predicted measure constructed. Figure 8 in the Appendix also illustrates the comparison of the two measures for EU28's top three countries.

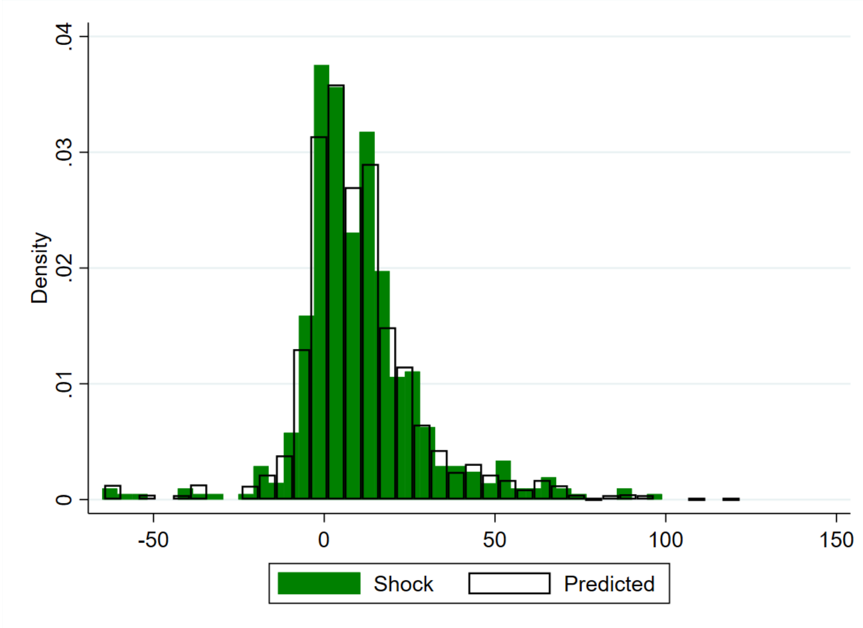

Figure 3: GDP shock in the data vs predicted measure.

R&D Intensity. Figure 4 shows the results of the estimation for $R\&D$ intensity. The graph in the top left shows that firms in industries and countries worst hit by the shock reduced their innovation intensity in the aftermath of the Great Recession, compared to the underlying trend. Moreover, the decline is significant and long lasting, as $R\&D$ intensity remains 0.04 percentage points below trend at the end of the sample for a firm in an industry hit by a 1% shock to GDP. To better understand results, I classify firms according to their pre-Great Recession $R\&D$ intensity, captured in 2006 and 2007 to avoid picking up the aftermath of the Dot-com bubble. A firm is classified as having high innovation intensity if its $\frac{R\&D}{sales}$ in 2007 was above the 75^{th} percentile in its NACE industry, medium if it is between the 25^{th} and the 75^{th} percentile, and low if it belonged to the bottom 25^{th} percentile. This decomposition shows that the aggregate decline in $R\&D$ intensity was mostly the result of a slowdown among medium intensity firms *ex ante*, but also that other firms tended to lower intangible investments. The timing of the estimated impact suggests that the slowdown in the trend manifested in 2015 and persisted until the end of the sample. The result is in line with the estimated time trend, which also picked up pace starting in 2015, as shown in Table 16 in the Appendix. This outcome is well aligned with the time-line of events in Europe in those years. In particular, the Sovereign debt crisis severely affected European economies but support for investment was delayed, as the ECB's quantitative easing only began in 2015.

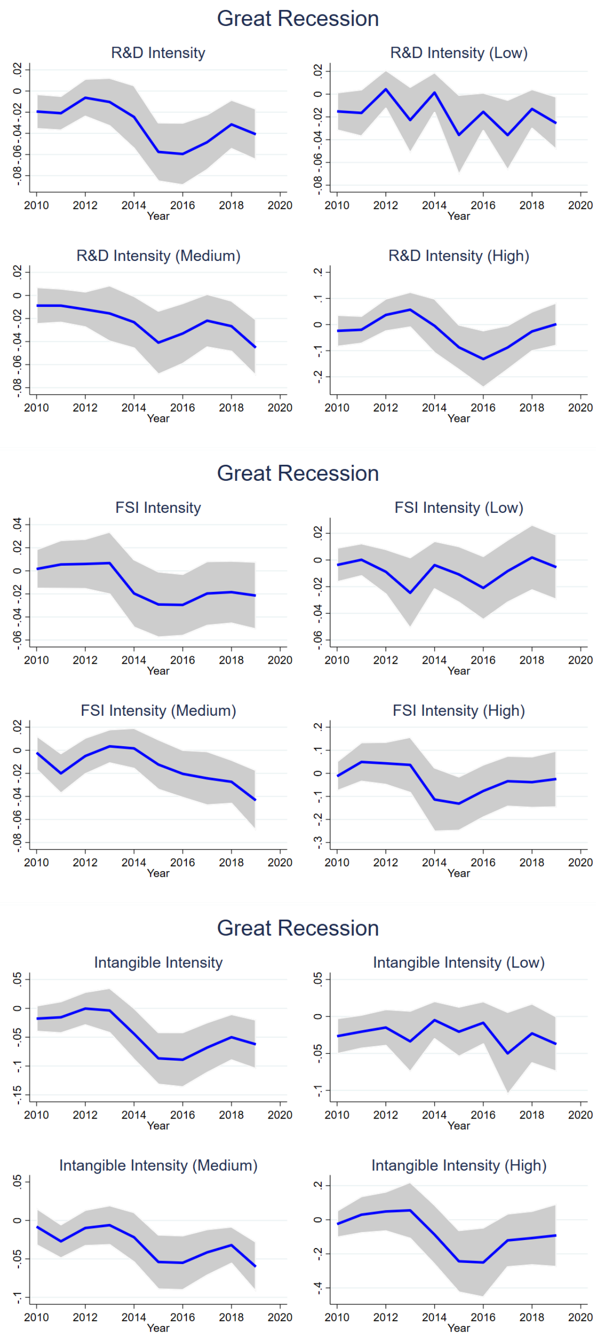

Figure 4: The effects of the Great Recession shock.

The graph plots the coefficients of Time-fixed-effects × GDP shock (predicted) from equation 4, with 90% confidence intervals. Full regression results can be found in tables 16,17,18 in the Appendix.

FSI Intensity. As for firm specific intangibles (FSI), the middle panel in Figure 4 shows that the Great Recession shock had some negative effect on FSI intensity overall, although mostly insignificant, and firms with medium intensity show a significant decline towards the end of the sample.

Intangible intensity. I then estimate the impact of the Great Recession shock on Intangible intensity as a whole, and the bottom panel in Figure 4 shows a long lasting, significant decline. The estimation suggests that the economy's intangible intensity associated with a 1% GDP shock was 0.05 percentage points lower compared to the time trend. The effect was driven by more intangible intensive firms *ex-ante* and by their slowdown in *R&D* intensity.

Which source of variation matters? Results indicate that the Great Recession shock brought about a slowdown in intangible intensity, driven by a slowdown in *R&D* intensity. The identification relies on the magnitude of the Great Recession shock across industries and countries, but in order to further investigate the driver of the results, I consider one source of variation at the time. Firstly, I estimate the baseline model for the three largest countries in the sample separately, thus exploiting the variation in the severity of the shock across industries only. Figure 5 shows that in Germany, France and the United Kingdom the shock was broadly associated with a decline in *R&D* intensity, but this is not significant, suggesting that another source of variation explains the baseline result. Secondly, I conduct the same exercise, but focusing on the industry dimension. The identification thus relies on the variation of the recession shock across countries but within the same industry. Figure 6 shows that the baseline result is almost entirely explained by the choices of firms in the Manufacturing sector, which represents the bulk of the sample. Conversely, firms in the Information and Communication industry tended to increase their *R&D* intensity temporarily, and so did firms in other industries, although the results are mostly insignificant.

Robustness The previous results suggest that firms in sectors worst hit by the Great Recession reduced their intangible intensity, and *R&D* intensity in particular. However this result could be driven by underlying trends specific to those countries and industries, and not to the Great Recession. To test this hypothesis, I run the same specification, but considering 1999 as the base year. If the decline in intensity was driven exclusively by the Great Recession shock, the interaction of the shock variable and the time dummies should be insignificant before the Great Recession. Results of the estimation illustrated in Figure 9 in the Appendix confirm this hypothesis, supporting the baseline results.

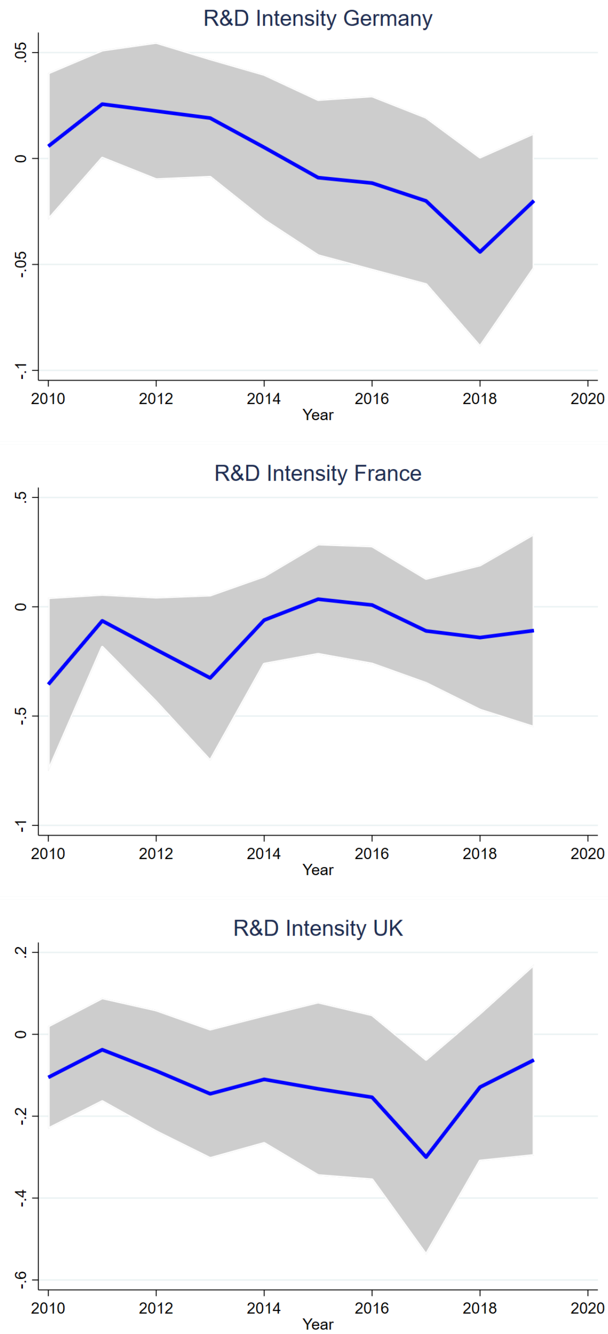

Figure 5: The effects of the Great Recession shock by country.
The graph plots the coefficients of Time-fixed-effects × GDP shock (predicted) from equation 4, with 90% confidence intervals.

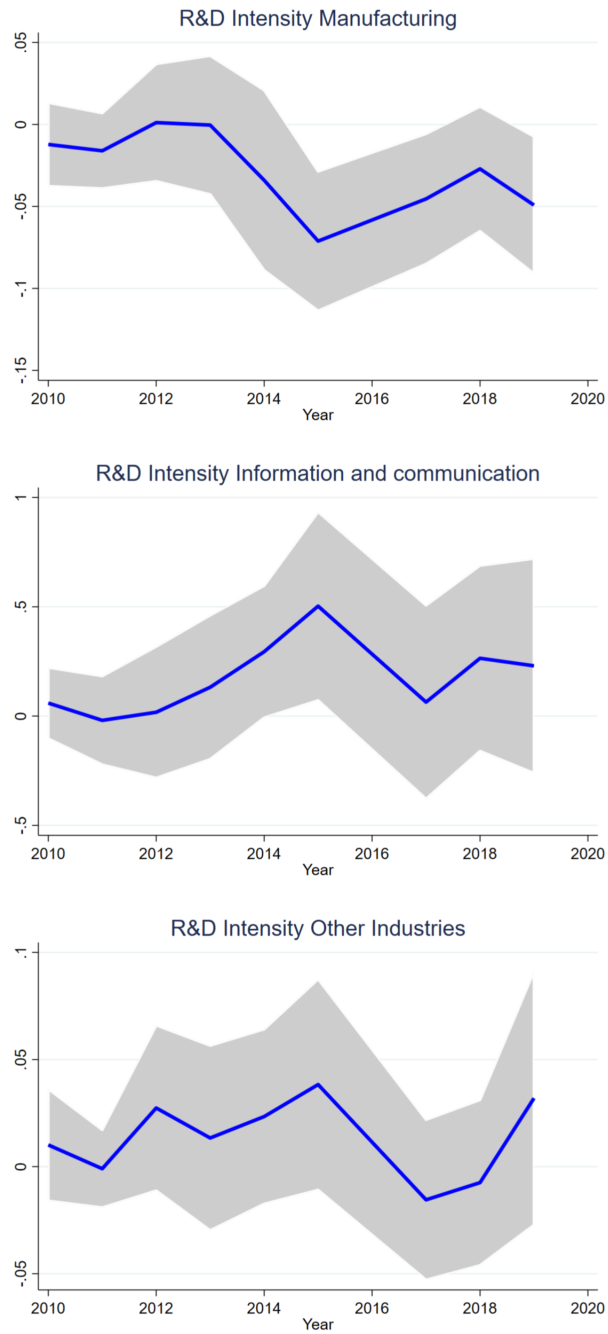

Figure 6: The effects of the Great Recession shock by industry.
The graph plots the coefficients of Time-fixed-effects × GDP shock (predicted) from equation 4, with 90% confidence intervals.

6 Mechanics

In the previous sections, I found that the Great Recession brought about a slowdown in intangible intensity, driven by lower $R\&D$ investment. To further investigate the drivers of this result, I check whether this outcome could be driven by the fact that $R\&D$ intensive firms did not outperform other firms. If this was the case, findings would not support the Schumpeterian hypothesis that recessions are cleansing, and firms closer to the frontier can outperform laggard firms.

To test this hypothesis, I estimate the following specification:

$$OutcomeSales_{i,c,j,t} = \beta_0 + \beta_1 IntanIntensity \times I^t + \beta_2 \times I^t + \sum_{\kappa}^{N} \gamma_\kappa X^{\kappa}_{i,c,j,2007} + \epsilon_{i,c,j,t} \tag{7}$$

$$OutcomeSales_{i,c,j,t} = 100 \times (ln(sales_{i,c,j,t}) - ln(sales)_{i,c,j,2007})$$

$$IntanIntensity = \left[\frac{R\&D_{i,c,j,2007}}{sales_{i,c,j,2007}}, \frac{FSI_{i,c,j,2007}}{sales_{i,c,j,2007}}, \frac{IntanInvest_{i,c,j,2007}}{sales_{i,c,j,2007}}\right]$$

$$X^{\kappa}_{i,c,j,2007} = [ln(assets)_{i,c,j,2007}, age_{i,c,j,2007}, ProfitMargin_{i,c,j,2007}, Financing_{i,c,j,2007}]$$

Sales growth is measured in real terms, relatively to 2007. Table 19 in the Appendix shows that firms that were *ex ante* more $R\&D$ intensive registered higher sales in the aftermath of the recession. The analysis thus confirms the hypothesis that more $R\&D$ intensive firms *ex-ante* gained prominence in the aftermath of the shock, reinforcing the idea that the recession could accelerate the process of structural transformation towards a more intangible production process. I then check whether firms that grew faster relatively to pre-Great Recession levels increased their intangible intensity in the aftermath of the recession.

The specification is:

$$INT_{i,c,j,t} - INT_{i,c,j,2007} = \beta_0 + \beta_1 OutcomeSales_{i,c,j,t} + \sum_{\kappa}^{N} \gamma_\kappa X^{\kappa}_{i,c,j,2007} + \alpha_j + \alpha_c + \alpha_t + \epsilon_{i,c,j,t} \tag{8}$$

$$OutcomeSales_{i,c,j,t} = 100 \times (ln(sales_{i,c,j,t}) - ln(sales)_{i,c,j,2007})$$

$$INT_{i,c,j,t} = \left[\frac{R\&D_{i,c,j,t}}{sales_{i,c,j,t}} \times 100, \frac{FSI_{i,c,j,t}}{sales_{i,c,j,t}} \times 100, \frac{IntanInvest_{i,c,j,t}}{sales_{i,c,j,t}} \times 100\right]$$

$$X^{\kappa}_{i,c,j,2007} = [ln(assets)_{i,c,j,2007}, age_{i,c,j,2007}, ProfitMargin_{i,c,j,2007}, Financing_{i,c,j,2007}]$$

	(1)	(2)	(3)
	$\frac{R\&D}{sales}$	$\frac{FSI}{sales}$	$\frac{IntanInvest}{sales}$
	b/se	b/se	b/se
OutcomeSales	-0.017***	-0.026***	-0.043***
	(0.006)	(0.005)	(0.008)
Number of obs.	7,714	7,714	7,714
R^2	0.145	0.159	0.217
Time-fixed effects	YES	YES	YES
Industry fixed effects	YES	YES	YES
Country fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 5: Sales evolution and and intangible intensity evolution.

Table 5 shows that the fastest growing firms chose not to invest proportionally in intangibles, as higher sales growth is associated with lower growth in intangible intensity. This is not entirely surprising, as investment choices are likely lumpy and subject to adjustment costs. However, these results overall suggest that intangible intensive firms reduced their investment efforts in the aftermath of the recession, and signal that the reallocation of economic activity in favour of *ex-ante* intangible intensive firms did not lead to an increase in intangible intensity. As a result, the rise of intangible intensity was slowed down by the Great Recession.

7 Conclusion

This paper investigates the dynamics of intangible investment across European firms and contributes empirical evidence on the positive link between intangible intensity and firm growth, distinguishing between *R&D* and firm specific intangibles, as well as considering their combined effect. Moreover, this paper documents a slowdown in intangible intensity as a consequence of the Great Recession. Results suggest that this downward deviation from the intangible intensity trend was the result of a sizeable reduction in *R&D* effort, especially driven by firms in the Manufacturing sector. The analysis also indicates that *ex ante* intangible intensive firms outperformed others but that even the most successful firms reduced their investment effort, on average. The paper hence supports findings from the recent literature emphasising the negative and permanent effects of the Great Recession on the productive capacity of the economy, driven by destruction, without a proportional rise in creation (Anzoategui et al., 2019) (Vinci & Licandro, 2021). Several avenues for future research remain open, to shed light on the root cause of the slowdown in innovation intensity. Many factors highlighted by the literature are likely to influence a firm's decision to invest in innovation, including credit constraints, uncertainty or pessimistic expectations over future demand. It would also be interesting to explore the connection between intangible intensity and firms' productivity developments compared to their peers, to learn more about the rewards associated with investing, in normal times and in recessions.

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Appendix

A Sample Characteristics

	Mean	SD	Min.	Max.	N
Sales (Millions of 2015 euros)	3503.01	15072.54	0	379489	30764
Employees (Thousands)	13.60	42.91	0	671	25039
PPE (MIllions of 2015 euros)	306780.29	1597659.09	0	43261112	27032
Financing ratio	0.10	0.97	-14	47	29285
Sales growth YoY	0.04	0.27	-6	5	25353
$\frac{FSIInvest}{sales}$	0.08	0.08	0	1	30766
$\frac{R\&D}{sales}$	0.06	0.09	0	1	30766
$\frac{IntanInvest}{sales}$	0.14	0.14	0	1	30766
Observations	30766				

Table 6: Summary statistics COMPUSTAT.

	Mean	sd	Min.	Max.	N
Mining and quarrying	0.08	0.12	0.00	1.00	369
Manufacturing	0.13	0.13	0.00	1.00	20145
Electricity, gas and air con	0.05	0.06	0.00	0.65	536
Water supply, sewerage waste	0.06	0.03	0.02	0.14	73
Construction	0.06	0.04	0.00	0.23	504
Wholesale and retail	0.09	0.08	0.00	0.96	980
Transportation and storage	0.06	0.09	0.00	0.95	339
Accomodation and food	0.06	0.05	0.00	0.36	59
Information and communication	0.20	0.16	0.00	0.99	5785
Real estate activities	0.38	0.05	0.34	0.41	2
Professional and scientific	0.12	0.13	0.00	0.84	809
Administrative and support	0.12	0.13	0.00	1.00	359
Education	0.23	0.16	0.01	0.70	47
Human and social work	0.09	0.10	0.00	0.68	141
Arts entertainment and recreation	0.14	0.12	0.01	0.90	204
Other services	0.10	0.04	0.01	0.15	33

Table 7: Intangible Intensity by Nace industry

	Mean	sd	Min.	Max.	N
AUT	0.09	0.08	0.00	0.85	619
BEL	0.10	0.11	0.01	0.95	729
BGR	0.11	0.12	0.02	0.56	33
CYP	0.08	0.05	0.01	0.22	69
CZE	0.04	0.03	0.00	0.12	61
DEU	0.12	0.09	0.00	0.88	4783
DNK	0.17	0.13	0.01	0.97	943
ESP	0.10	0.11	0.00	0.95	681
EST	0.04	0.02	0.00	0.16	57
FIN	0.11	0.12	0.00	0.98	1223
FRA	0.15	0.14	0.00	1.00	3250
GBR	0.16	0.15	0.00	1.00	9336
GRC	0.08	0.07	0.01	0.52	1050
HRV	0.09	0.06	0.01	0.27	91
HUN	0.11	0.08	0.01	0.34	92
IRL	0.13	0.14	0.01	0.94	398
ITA	0.09	0.08	0.00	0.85	619
LTU	0.05	0.03	0.01	0.14	40
LUX	0.09	0.08	0.00	0.85	619
LVA	0.10	0.05	0.01	0.19	103
MLT	0.17	0.09	0.07	0.44	47
NLD	0.12	0.10	0.00	0.97	839
POL	0.10	0.11	0.00	0.94	1242
PRT	0.07	0.05	0.01	0.20	86
ROU	0.07	0.04	0.00	0.27	150
SVK	0.06	0.04	0.01	0.14	26
SVN	0.12	0.06	0.00	0.22	48
SWE	0.19	0.19	0.00	1.00	3241

Table 8: Intangible Intensity by Country

	($R\&D$BelowMean)		($R\&D$AboveMean)		(Difference)	
	mean	sd	mean	sd	b	t
Low FSI Intensity	0.29	0.45	0.21	0.41	-0.08***	(-16.37)
Medium FSI Intensity	0.52	0.50	0.48	0.50	-0.04***	(-7.69)
High FSI Intensity	0.19	0.39	0.31	0.46	0.12***	(25.43)
Observations	15383		15382		30765	

Table 9: FSI Intensity by $R\&D$ intensity

B Mark-up

Mark-ups are unobserved, but I draw from the work of De Loecker et al. (2020) to estimate them at the firm level. In an economy with N firms, indexed by i, we can define the production function as:

$$Q_{it} = Q_{it}(\Omega_{it}, V_{it}, K_{it},) \tag{9}$$

and firm's profits are:

$$Q_{it} - P_{it}^{V} V_{it} - r V_{it}^{K} K V_{it} \tag{10}$$

Where, Ω_{it} is productivity, V_{it} is a variable input bundle, K_{it} is tangible capital. cost minimization problem can be expressed as:

$$\ell(V_{it}, K_{it}, \lambda_{it}) = P_{it}^{V} V_{it} + r^{K} K_{it} - \lambda_{it}(Q_{it}(.) - \bar{Q}) \tag{11}$$

where P_{it}^{V} is the price of the variable input, r^{K} is the user cost of capital, $Q_{it}(.)$ is the technology and $\bar{Q}$ is a scalar and λ_{it} is the Lagrange multiplier. The FOC w.r.t. V is then:

$$P_{it}^{V} - \lambda_{it} \frac{\partial Q_{it}(.)}{\partial V_{it}} = 0 \tag{12}$$

Where λ_{it} is measure of marginal cost. Multiplying by $\frac{V_{it}}{Q_{it}}$ and rearranging yields the definition of the elasticity of production to the variable input:

$$\theta_{it} = \frac{\partial Q_{it}(.)}{\partial V_{it}} \frac{V_{it}}{Q_{it}} = \frac{1}{\lambda_{it}} \frac{P_{it}^{V} V_{it}}{Q_{it}} \tag{13}$$

And defining the mark-up μ_{it} as the wedge between output price and marginal cost ($\mu = \frac{P}{\lambda}$), I find:

$$\mu_{it} = \theta_{it} \frac{P_{it} Q_{it}}{P_{it}^{V} V_{it}} \tag{14}$$

I then use this expression to calculate mark-ups at the firm level in Compustat, which provides data on sales ($P_{it}Q_{it}$) as well as variable input costs ($P_{it}^{V} V_{it}$) directly. To measure the variable input, I use the cost of goods sold variable (*cogs*), which includes costs for materials and intermediate inputs, labour costs, energy costs and expenses linked to production of the firm's output. As for θ_{it}, De Loecker et al. (2020) suggest two alternative approaches that yield comparable results. I choose their non-parametric approach, which remains agnostic concerning the shape of the production function. I thus use the cost share of the variable input as a measure of θ_{it}, such that:

$$\theta_{it} = \frac{P_{it}^{V} V_{it}}{P_{it}^{V} V_{it} + +r^{K} K_{it}} \tag{15}$$

Where r^K is the user cost of capital, calculated following De Loecker et al. (2020), employing lending rates as proxies for the return to capital, K_{it} is property plant and equipment (*ppegt* in Compustat).

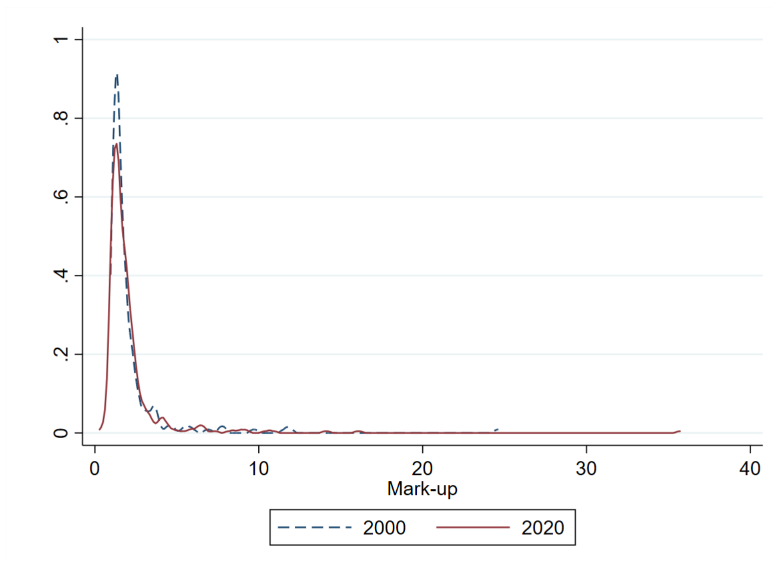

Figure 7: Distribution of Mark-ups

	(1) Mark-up b/se	(2) Mark-up b/se	(3) Mark-up b/se
$(\frac{R\&D}{sales})_{t-1}$	-0.348		
	(0.852)		
$(\frac{FSI}{sales})_{t-1}$		2.629	
		(1.664)	
$(\frac{IntanInvest}{sales})_{t-1}$			0.758
			(0.854)
$log(assets)_t$	-0.232**	-0.211**	-0.215**
	(0.105)	(0.102)	(0.102)
Number of obs.	18,437	18,437	18,437
R^2	0.003	0.004	0.003
Firm fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 10: Intangible Intensity and Mark-up.

I then investigate how intangible investment intensity affects mark-ups by running regressions with firm and year fixed effects, controlling for firm size. I find that no measures of past intangible intensity, i.e. $R\&D$, FSI and total intangibles, is positively and significantly correlated with mark-ups. However, these results are simplistic, and this topic deserves in depth analysis to investigate the channels at play, which is beyond the scope of this paper. I thus control for the mark-up measure as a robustness check, to take into account the potential role of intangible investment on the firm's ability to charge higher prices.

C Intangible Intensity and Firm Growth

	(1) P(IntanInvest>0) b/se
$ln(assets)_t$	0.144***
	(0.009)
age	0.008**
	(0.004)
$Financing_t$	-0.002
	(0.004)
$ProfitMargin_t$	0.491***
	(0.060)
Number of obs.	62,828
Year fixed effects	YES
Country fixed effects	YES
Industry fixed effects	YES
S.e. clustered at firm level	YES
Pseudo R^2	0.2359
Log-likelihood	-30174.055

Table 11: Drivers of positive intangible intensive reporting - Probit model

	(1) $\frac{R\&D}{sales}$ b/se	(2) $\frac{FSI}{sales}$ b/se	(3) $\frac{IntanInvest}{sales}$ b/se
$ln(sales)_t$	-0.0217***	-0.0196***	-0.0412***
	(0.0023)	(0.0015)	(0.0029)
$ln(sales)_t \times Recession$	-0.0001	0.0003**	0.0001
	(0.0002)	(0.0001)	(0.0002)
$ProfitMargin_{t-1}$	0.0172**	0.0322***	0.0494***
	(0.0079)	(0.0080)	(0.0116)
$Financing_{t-1}$	0.0040***	0.0057***	0.0096***
	(0.0011)	(0.0010)	(0.0016)
age	0.0014*	0.0001	0.0015
	(0.0008)	(0.0008)	(0.0011)
constant	0.1586***	0.1561***	0.3147***
	(0.0153)	(0.0121)	(0.0193)
Number of obs.	24,094	24,094	24,094
R^2	0.063	0.109	0.148
Firm fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 12: Firm size (sales) and intangible intensity.

	(1) Sales growth b/se	(2) Sales growth b/se	(3) Sales growth b/se	(4) Sales growth b/se	(5) Sales growth b/se	(6) Sales growth b/se
$\frac{R\&D}{sales}(t-1)$	0.575***	0.577***				
	(0.093)	(0.093)				
$\frac{FSI}{sales}(t-1)$			1.104***	1.103***		
			(0.160)	(0.160)		
$\frac{IntanInvest}{sales}(t-1)$					0.770***	0.770***
					(0.091)	(0.091)
$Financing_{t-1}$	0.024***	0.024***	0.021***	0.021***	0.021***	0.021***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
age	0.004	0.004	0.005	0.005	0.004	0.004
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)
$markup_{t-1}$		0.001		0.000		0.001
		(0.001)		(0.001)		(0.001)
$ln(\overline{assets})\_t$	0.011	0.012	0.011	0.011	0.017*	0.017*
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Number of obs.	15,661	15,661	15,661	15,661	15,661	15,661
R^2	0.107	0.107	0.115	0.115	0.120	0.120
Firm fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES	YES	YES	YES

Table 13: Sales growth and intangible intensity - Controlling for markups.
Note that the employment of the mark-up measure reduces the sample size, due to data availability limitations.

	(1) Sales growth_avg b/se	(2) Sales growth_avg b/se	(3) Sales growth_avg b/se
$\frac{R\&D}{sales}(t-1)$	0.551***		
	(0.067)		
$\frac{FSI}{sales}(t-1)$		0.934***	
		(0.107)	
$\frac{IntanInvest}{sales}(t-1)$			0.665***
			(0.061)
$ProfitMargin_{t-1}$	0.068	0.027	0.040
	(0.044)	(0.041)	(0.039)
$Financing_{t-1}$	0.024***	0.022***	0.020***
	(0.004)	(0.004)	(0.004)
age	0.002	0.002	0.001
	(0.003)	(0.003)	(0.003)
$ln(\overline{assets})_t$	-0.002	-0.000	0.004
	(0.006)	(0.006)	(0.006)
Number of obs.	24,093	24,093	24,093
R^2	0.132	0.138	0.146
Firm fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 14: Intangible intensity and sales growth (average base).
Sales growth is defined as $\frac{RealSales_t - RealSales_{t-1}}{0.5(RealSales_t + RealSales_{t-1})}$.

	(1) Sales growth_w b/se	(2) Sales growth_w b/se	(3) Sales growth_w b/se
$\frac{R\&D}{sales}(t-1)$	0.420***		
	(0.053)		
$\frac{FSI}{sales}(t-1)$		0.662***	
		(0.075)	
$\frac{IntanInvest}{sales}(t-1)$			0.490***
			(0.044)
$ProfitMargin_{t-1}$	0.065**	0.036	0.045*
	(0.028)	(0.026)	(0.025)
$Financing_{t-1}$	0.020***	0.018***	0.017***
	(0.003)	(0.003)	(0.003)
age	-0.000	-0.000	-0.000
	(0.003)	(0.003)	(0.003)
$ln(\overline{assets})_t$	-0.002	-0.001	0.002
	(0.005)	(0.005)	(0.005)
Number of obs.	24,093	24,093	24,093
R^2	0.153	0.157	0.163
Firm fixed effects	YES	YES	YES
Industry-time fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 15: Sales growth regression after winsoring top and bottom 2% of the dependent variable.

D GDP shock

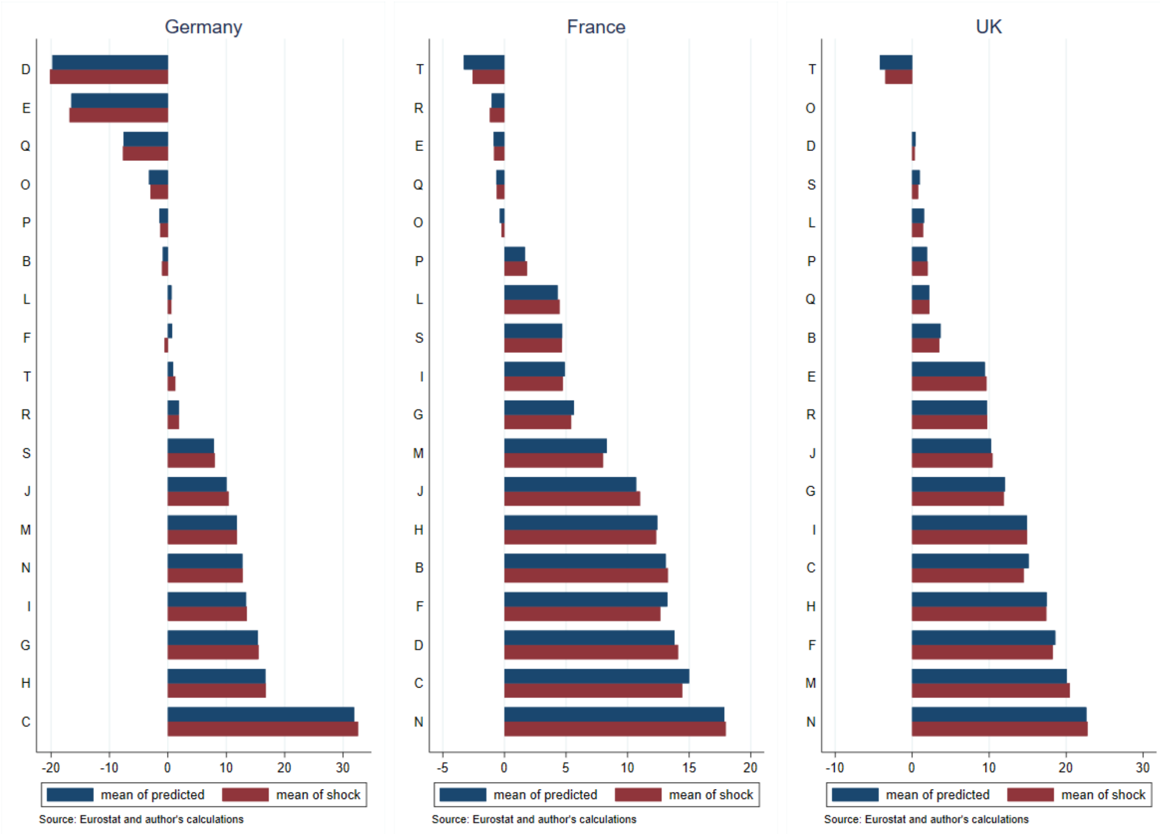

Figure 8: Great Recession GDP shock over NACE industries.

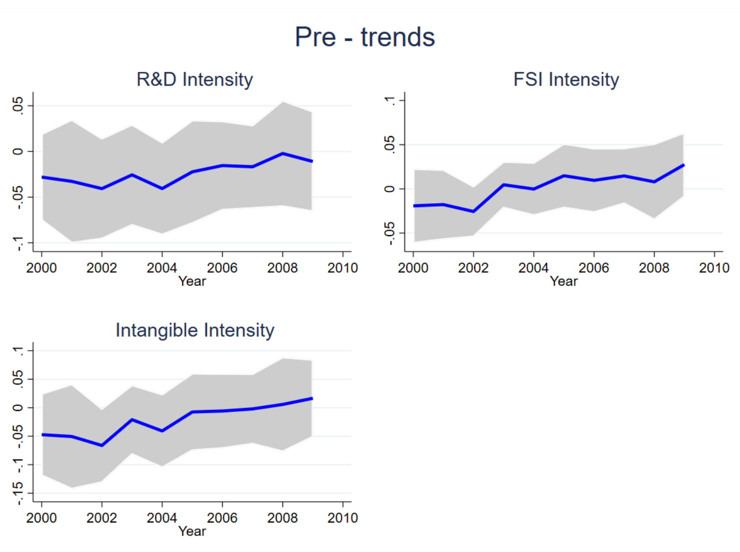

Figure 9: Pre-trends robustness check.

	(1) $\frac{R\&D}{sales}$ b/se	(2) $\frac{R\&D}{sales}(Low)$ b/se	(3) $\frac{R\&D}{sales}(Medium)$ b/se	(4) $\frac{R\&D}{sales}(High)$ b/se
2010	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
2011	-0.036	0.390*	0.084	-0.175
	(0.303)	(0.236)	(0.280)	(1.298)
2012	-0.241	0.082	0.375	-1.950
	(0.382)	(0.276)	(0.358)	(1.565)
2013	0.224	0.907	0.761	-1.961
	(0.498)	(0.569)	(0.584)	(1.652)
2014	0.052	0.290	0.780	-1.697
	(0.496)	(0.326)	(0.507)	(1.919)
2015	1.189**	1.717**	1.288**	0.683
	(0.520)	(0.800)	(0.632)	(1.632)
2016	1.352***	0.914**	1.502**	1.830
	(0.505)	(0.393)	(0.617)	(1.850)
2017	0.605	1.024*	0.682	0.670
	(0.549)	(0.610)	(0.559)	(1.856)
2018	0.290	0.497*	0.779	-0.095
	(0.532)	(0.286)	(0.554)	(1.825)
2019	1.360**	1.365***	2.207***	-0.690
	(0.531)	(0.449)	(0.647)	(1.855)
2010× GDP shock (predicted)	-0.019*	-0.015	-0.009	-0.024
	(0.010)	(0.010)	(0.010)	(0.037)
2011× GDP shock (predicted)	-0.021**	-0.016	-0.009	-0.020
	(0.010)	(0.013)	(0.009)	(0.032)
2012× GDP shock (predicted)	-0.006	0.004	-0.012	0.037
	(0.011)	(0.010)	(0.009)	(0.038)
2013× GDP shock (predicted)	-0.010	-0.023	-0.016	0.057
	(0.014)	(0.018)	(0.015)	(0.041)
2014× GDP shock (predicted)	-0.025	0.001	-0.023*	-0.005
	(0.018)	(0.011)	(0.014)	(0.063)
2015× GDP shock (predicted)	-0.058***	-0.036*	-0.041**	-0.087
	(0.017)	(0.021)	(0.017)	(0.053)
2016× GDP shock (predicted)	-0.060***	-0.015	-0.033**	-0.132**
	(0.018)	(0.010)	(0.016)	(0.067)
2017× GDP shock (predicted)	-0.048***	-0.036*	-0.022	-0.088*
	(0.016)	(0.019)	(0.014)	(0.052)
2018× GDP shock (predicted)	-0.032**	-0.013	-0.027**	-0.026
	(0.014)	(0.011)	(0.013)	(0.046)
2019× GDP shock (predicted)	-0.041***	-0.026*	-0.045***	0.002
	(0.015)	(0.014)	(0.015)	(0.050)
Constant	1.983***	2.052***	1.307*	-0.077
	(0.564)	(0.484)	(0.706)	(1.715)
Number of obs.	7,447	1,830	3,921	1,696
R^2	0.089	0.157	0.084	0.208
Firm level controls	YES	YES	YES	YES
Country level controls	YES	YES	YES	YES
Clustered s.e. at firm level	YES	YES	YES	YES

Table 16: $R\&D$ intensity response to GDP shock (predicted).

	(1) $\frac{FSI}{sales}$ b/se	(2) $\frac{FSI}{sales}(Low)$ b/se	(3) $\frac{FSI}{sales}(Medium)$ b/se	(4) $\frac{FSI}{sales}(High)$ b/se
2010	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
2011	-0.364	-0.105	0.138	-1.844
	(0.373)	(0.301)	(0.289)	(1.370)
2012	-0.662	0.410	-0.267	-2.501*
	(0.425)	(0.466)	(0.338)	(1.510)
2013	-0.899*	1.304*	-0.654	-3.156*
	(0.522)	(0.693)	(0.406)	(1.826)
2014	-0.316	0.843	-0.436	-0.238
	(0.433)	(0.580)	(0.408)	(1.508)
2015	-0.092	1.296*	0.026	-0.731
	(0.466)	(0.717)	(0.448)	(1.490)
2016	0.316	1.490**	0.316	-0.159
	(0.444)	(0.627)	(0.475)	(1.402)
2017	0.033	0.790	0.405	-1.506
	(0.523)	(0.589)	(0.486)	(1.636)
2018	-0.066	0.476	0.303	-1.475
	(0.469)	(0.556)	(0.399)	(1.588)
2019	-0.236	0.657	0.828	-2.532
	(0.521)	(0.504)	(0.579)	(1.560)
2010× GDP shock (predicted)	0.002	-0.004	-0.002	-0.013
	(0.010)	(0.008)	(0.009)	(0.039)
2011× GDP shock (predicted)	0.006	0.000	-0.020*	0.049
	(0.013)	(0.007)	(0.011)	(0.052)
2012× GDP shock (predicted)	0.006	-0.009	-0.005	0.043
	(0.013)	(0.010)	(0.010)	(0.056)
2013× GDP shock (predicted)	0.007	-0.025	0.003	0.037
	(0.017)	(0.016)	(0.009)	(0.074)
2014× GDP shock (predicted)	-0.020	-0.004	0.002	-0.114
	(0.018)	(0.011)	(0.011)	(0.084)
2015× GDP shock (predicted)	-0.029*	-0.011	-0.012	-0.131*
	(0.017)	(0.013)	(0.013)	(0.071)
2016× GDP shock (predicted)	-0.030*	-0.021	-0.020	-0.077
	(0.016)	(0.015)	(0.013)	(0.070)
2017× GDP shock (predicted)	-0.020	-0.008	-0.024*	-0.034
	(0.017)	(0.014)	(0.014)	(0.067)
2018× GDP shock (predicted)	-0.018	0.002	-0.027**	-0.038
	(0.017)	(0.015)	(0.012)	(0.068)
2019× GDP shock (predicted)	-0.021	-0.005	-0.043***	-0.025
	(0.018)	(0.015)	(0.016)	(0.075)
Constant	-0.832	2.246***	2.669***	-10.682***
	(1.178)	(0.850)	(0.794)	(2.162)
Number of obs.	7,447	1,973	3,789	1,685
R^2	0.038	0.090	0.048	0.260
Firm level controls	YES	YES	YES	YES
Country level controls	YES	YES	YES	YES
Clustered s.e. at firm level	YES	YES	YES	YES

Table 17: FSI response to GDP shock (predicted).

	(1) $\frac{IntanInvest}{sales}$ b/se	(2) $\frac{IntanInvest}{sales}(Low)$ b/se	(3) $\frac{IntanInvest}{sales}(Medium)$ b/se	(4) $\frac{IntanInvest}{sales}(High)$ b/se
2010	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
2011	-0.400	0.209	0.054	-1.731
	(0.482)	(0.341)	(0.429)	(2.121)
2012	-0.903	0.337	-0.227	-2.983
	(0.583)	(0.503)	(0.506)	(2.531)
2013	-0.675	1.031	-0.160	-2.827
	(0.735)	(1.021)	(0.646)	(2.975)
2014	-0.265	0.121	0.655	-1.946
	(0.658)	(0.605)	(0.654)	(2.745)
2015	1.097	0.401	1.533*	2.475
	(0.702)	(0.577)	(0.901)	(2.509)
2016	1.668**	0.567	1.737**	4.005
	(0.703)	(0.582)	(0.817)	(2.744)
2017	0.638	1.757	1.067	-0.942
	(0.743)	(1.089)	(0.740)	(2.673)
2018	0.224	0.997	0.658	-0.587
	(0.647)	(0.618)	(0.621)	(2.630)
2019	1.124	1.519**	1.783**	0.417
	(0.717)	(0.650)	(0.792)	(2.807)
2010× GDP shock (predicted)	-0.018	-0.027*	-0.008	-0.025
	(0.014)	(0.015)	(0.015)	(0.048)
2011× GDP shock (predicted)	-0.015	-0.021	-0.027**	0.030
	(0.017)	(0.014)	(0.013)	(0.066)
2012× GDP shock (predicted)	-0.000	-0.015	-0.010	0.049
	(0.018)	(0.015)	(0.014)	(0.071)
2013× GDP shock (predicted)	-0.004	-0.034	-0.006	0.055
	(0.024)	(0.025)	(0.016)	(0.101)
2014× GDP shock (predicted)	-0.044	-0.005	-0.022	-0.087
	(0.027)	(0.016)	(0.020)	(0.107)
2015× GDP shock (predicted)	-0.087***	-0.021	-0.054**	-0.244**
	(0.028)	(0.021)	(0.022)	(0.111)
2016× GDP shock (predicted)	-0.089***	-0.009	-0.055**	-0.251**
	(0.029)	(0.018)	(0.022)	(0.124)
2017× GDP shock (predicted)	-0.068**	-0.050	-0.041**	-0.121
	(0.027)	(0.034)	(0.018)	(0.096)
2018× GDP shock (predicted)	-0.050**	-0.023	-0.032**	-0.107
	(0.024)	(0.025)	(0.015)	(0.097)
2019× GDP shock (predicted)	-0.062**	-0.037*	-0.060***	-0.092
	(0.026)	(0.023)	(0.020)	(0.112)
Constant	1.150	4.028***	3.934***	-9.614***
	(1.372)	(1.248)	(1.183)	(3.191)
Number of obs.	7,447	1,932	3,983	1,532
R^2	0.094	0.101	0.051	0.239
Firm level controls	YES	YES	YES	YES
Country level controls	YES	YES	YES	YES
Clustered s.e. at firm level	YES	YES	YES	YES

Table 18: Intangible intensity response to GDP shock (predicted).

	(1) OutcomeSales b/se	(2) OutcomeSales b/se	(3) OutcomeSales b/se
2010× $\frac{R\&D_{2007}}{sales_{2007}}$	-0.122		
	(0.317)		
2011× $\frac{R\&D_{2007}}{sales_{2007}}$	-0.446		
	(0.418)		
2012× $\frac{R\&D_{2007}}{sales_{2007}}$	-0.119		
	(0.535)		
2013× $\frac{R\&D_{2007}}{sales_{2007}}$	-0.149		
	(0.627)		
2014× $\frac{R\&D_{2007}}{sales_{2007}}$	0.036		
	(0.651)		
2015× $\frac{R\&D_{2007}}{sales_{2007}}$	0.905*		
	(0.469)		
2016× $\frac{R\&D_{2007}}{sales_{2007}}$	1.284**		
	(0.543)		
2017× $\frac{R\&D_{2007}}{sales_{2007}}$	1.685***		
	(0.616)		
2018× $\frac{R\&D_{2007}}{sales_{2007}}$	1.298**		
	(0.640)		
2019× $\frac{R\&D_{2007}}{sales_{2007}}$	1.885**		
	(0.789)		
2010× $\frac{FSI_{2007}}{sales_{2007}}$		0.101	
		(0.823)	
2011× $\frac{FSI_{2007}}{sales_{2007}}$		-0.411	
		(0.692)	
2012× $\frac{FSI_{2007}}{sales_{2007}}$		-0.212	
		(0.746)	
2013× $\frac{FSI_{2007}}{sales_{2007}}$		0.030	
		(0.794)	
2014× $\frac{FSI_{2007}}{sales_{2007}}$		0.014	
		(0.766)	
2015× $\frac{FSI_{2007}}{sales_{2007}}$		1.200*	
		(0.644)	
2016× $\frac{FSI_{2007}}{sales_{2007}}$		1.665*	
		(0.935)	
2017× $\frac{FSI_{2007}}{sales_{2007}}$		1.705*	
		(0.960)	
2018× $\frac{FSI_{2007}}{sales_{2007}}$		2.231**	
		(0.867)	
2019× $\frac{FSI_{2007}}{sales_{2007}}$		2.510***	
		(0.875)	
2010× $\frac{IntanInvest_{2007}}{sales_{2007}}$			0.055
			(0.374)
2011× $\frac{IntanInvest_{2007}}{sales_{2007}}$			-0.260
			(0.371)
2012× $\frac{IntanInvest_{2007}}{sales_{2007}}$			-0.035
			(0.445)
2013× $\frac{IntanInvest_{2007}}{sales_{2007}}$			0.018
			(0.515)
2014× $\frac{IntanInvest_{2007}}{sales_{2007}}$			0.102
			(0.515)
2015× $\frac{IntanInvest_{2007}}{sales_{2007}}$			0.868**
			(0.355)
2016× $\frac{IntanInvest_{2007}}{sales_{2007}}$			1.215***
			(0.464)
2017× $\frac{IntanInvest_{2007}}{sales_{2007}}$			1.420***
			(0.500)
2018× $\frac{IntanInvest_{2007}}{sales_{2007}}$			1.442***
			(0.509)
2019× $\frac{IntanInvest_{2007}}{sales_{2007}}$			1.864***
			(0.538)
Constant	8.282	6.764	7.846
	(14.161)	(14.037)	(13.563)
Number of obs.	7,714	7,714	7,714
R^2	0.112	0.115	0.121
Firm level controls	YES	YES	YES
Year fixed effects	YES	YES	YES
Country fixed effects	YES	YES	YES
Industry fixed effects	YES	YES	YES
S.e. clustered at firm level	YES	YES	YES

Table 19: Sales evolution and *ex ante* intangible intensity.