

Did financial frictions stifle R&D investment in Europe during  
the Great Recession?

Online Appendix

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Table A1: Alternative measures of financial constraints

Dependent variables:	R&D			$\frac{R\&D}{Sales}$			$\frac{R\&D}{Investment}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<b>Panel A: Firms in industries with high dependence on external finance</b>									
$Small_i \times Crisis_{t-1}$	-0.123*** (0.024)			-0.132*** (0.021)			-0.009** (0.004)		
$Liquidity_i \times Crisis_{t-1}$		-0.073*** (0.025)			-0.050** (0.021)			0.003 (0.016)	
$Leverage_i \times Crisis_{t-1}$			-0.094*** (0.023)			-0.068*** (0.019)			0.013 (0.015)
Observations	12,704	12,851	13,976	12,496	12,653	13,706	8,207	6,698	7,574
R-squared	0.0391	0.0301	0.0286	0.0311	0.0226	0.0197	0.419	0.587	0.549
<b>Panel B: Firms in industries with low dependence on external finance</b>									
$Small_i \times Crisis_{t-1}$	0.021* (0.012)			0.010 (0.019)			0.013 (0.012)		
$Liquidity_i \times Crisis_{t-1}$		-0.070*** (0.012)			-0.049*** (0.014)			0.012 (0.023)	
$Leverage_i \times Crisis_{t-1}$			-0.036** (0.014)			-0.019* (0.011)			0.018 (0.023)
Observations	11,703	16,446	17,847	11,549	16,277	17,611	7,921	8,773	9,773
R-squared	0.0222	0.0190	0.0193	0.0230	0.0219	0.0214	0.440	0.571	0.533
<i>Controls:</i>									
$Crisis_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Small_i$	Yes			Yes			Yes		
$Liquidity_i$		Yes			Yes			Yes	
$Leverage_i$			Yes			Yes			Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table presents the estimates of Eq. (4) in the paper and corresponds to Figure 5. The dependent variable in columns (1)-(3) is the growth rate of R&D investment in year  $t$ , in columns (4)-(6) is the growth rate of the ratio of R&D to sales, while in columns (7)-(9) it is the share of R&D to total investment. Panel A includes industries with an above the median dependence on external finance, while Panel B those with a below the median dependence.  $Crisis_t$  is a dummy taking the value one in 2008-2010 and 2012-2013.  $Small_i$  is a dummy that takes the value of 1 if a firm is in the 25<sup>th</sup> percentile of the distribution of firms by total assets in a given industry and 0 if it is in the 75<sup>th</sup> percentile.  $Liquidity_i$  is a dummy that takes the value of 1 if a firm is in the 25<sup>th</sup> percentile of the distribution of firms by liquidity in a given industry in 2007 and 0 if it is in the 75<sup>th</sup> percentile.  $Leverage_i$  is a dummy that takes the value of 1 if a firm is in the 25<sup>th</sup> percentile of the distribution of firms by liquidity in a given industry in 2007 and 0 if it is in the 75<sup>th</sup> percentile. \*/\*\*/\*\* represents significance at 10, 5 and 1% level.

Table A2: Alternative measures of financial constraints: including country-by-industry-by-year fixed effects

Dependent variables:	R&D		$\frac{R\&D}{Sales}$			$\frac{R\&D}{Investment}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<b>Panel A: Firms in industries with high dependence on external finance</b>									
$Small_i \times Crisis_{t-1}$	-0.086*** (0.029)			-0.111*** (0.027)			-0.001 (0.005)		
$Liquidity_i \times Crisis_{t-1}$		-0.073*** (0.010)			-0.057*** (0.010)			0.004 (0.012)	
$Leverage_i \times Crisis_{t-1}$			-0.097*** (0.004)			-0.103*** (0.007)			0.007 (0.012)
Observations	12,704	12,851	13,976	12,496	12,653	13,706	8,207	6,698	7,574
R-squared	0.105	0.0860	0.0794	0.0940	0.0799	0.0722	0.494	0.647	0.614
<b>Panel B: Firms in industries with low dependence on external finance</b>									
$Small_i \times Crisis_{t-1}$	0.015 (0.024)			-0.012 (0.014)			0.007 (0.014)		
$Liquidity_i \times Crisis_{t-1}$		-0.090*** (0.002)			-0.071*** (0.002)			-0.001 (0.003)	
$Leverage_i \times Crisis_{t-1}$			-0.037*** (0.001)			-0.030*** (0.001)			0.010*** (0.003)
Observations	11,703	16,446	17,847	11,549	16,277	17,611	7,921	8,773	9,773
R-squared	0.0835	0.0549	0.0598	0.0857	0.0587	0.0633	0.568	0.669	0.646
<i>Controls:</i>									
$Crisis_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Small_i$	Yes			Yes			Yes		
$Liquidity_i$		Yes				Yes		Yes	
$Leverage_i$			Yes				Yes		Yes
Country-industry-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table presents the estimates of Eq. (4). The dependent variable in columns (1)-(3) is the growth rate of R&D investment in year  $t$ , in columns (4)-(6) is the growth rate of the ratio of R&D to sales, while in columns (7)-(9) it is the share of R&D to total investment. Panel A includes industries with an above the median dependence on external finance, while Panel B those with a below the median dependence.  $Crisis_{t-1}$  is a dummy taking the value one in 2008-2010 and 2012-2013.  $Small_i$  is a dummy that takes the value of 1 if a firm is in the 25th percentile of the distribution of firms by total assets in a given industry and 0 if it is in the 75th percentile.  $Liquidity_i$  is a dummy that takes the value of 1 if a firm is in the 25th percentile of the distribution of firms by liquidity in a given industry in 2007 and 0 if it is in the 75th percentile.  $Leverage_i$  is a dummy that takes the value of 1 if a firm is in the 25th percentile of the distribution of firms by liquidity in a given industry in 2007 and 0 if it is in the 75th percentile. \*/\*\*/\*\* represents significance at 10, 5 and 1% level.

Table A3: Baseline results: alternative crisis dummy

Dependent variables:	R&D		$\frac{R\&D}{Sales}$		$\frac{R\&D}{Investment}$	
	(1)	(2)	(3)	(4)	(5)	(6)
<b><i>Panel A: Firms in industries with high dependence on external finance</i></b>						
$Private_i \times Crisis_{t-1}$	-0.075*** (0.026)	-0.082*** (0.029)	-0.101*** (0.030)	-0.106*** (0.035)	-0.026** (0.010)	-0.027*** (0.011)
Observations	41,801	40,614	41,294	40,119	29,838	28,773
R-squared	0.0226	0.0330	0.0178	0.0247	0.366	0.399
<b><i>Panel B: Firms in industries with low dependence on external finance</i></b>						
$Private_i \times Crisis_{t-1}$	-0.023 (0.029)	-0.016 (0.025)	-0.021 (0.031)	-0.011 (0.024)	-0.004 (0.009)	-0.006 (0.009)
Observations	43,980	42,938	43,629	42,592	28,610	27,642
R-squared	0.0162	0.0240	0.0161	0.0238	0.388	0.414
<i>Controls:</i>						
Private <sub>i</sub> , Crisis <sub>t-1</sub>	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm-level controls		Yes		Yes		Yes

Table presents the estimates of Eq. (4). The dependent variable in columns (1)-(2) is the growth rate of R&D investment in year  $t$ , in columns (3)-(4) is the growth rate of the ratio of R&D to sales, while in columns (5)-(6) it is the share of R&D to total investment. Panel A includes industries with an above the median dependence on external finance, while Panel B those with below the median dependence.  $Private_i$  is a dummy for private firms.  $Crisis_{t-1}$  is a dummy taking the value one in 2008-2010 and 2012-2013. Different from previous estimations, Germany is excluded as a crisis country during 2012-2013. Standard errors are clustered at the country level. \*/\*\*/\*\* represents significance at 10, 5 and 1% level.

Table A4: Baseline estimations: clustering at the country-industry

Dependent variables:	R&D		$\frac{R\&D}{Sales}$		$\frac{R\&D}{Investment}$	
	High (1)	Low (2)	High (3)	Low (4)	High (5)	Low (6)
<b>Panel A: Robustness of Table 3</b>						
$Private_i \times Crisis_{t-1}$	-0.070** (0.029)	-0.025 (0.026)	-0.090*** (0.030)	-0.019 (0.027)	-0.026*** (0.009)	-0.004 (0.011)
Observations	40,614	42,938	40,119	42,592	28,773	27,642
R-squared	0.0330	0.0241	0.0247	0.0239	0.399	0.415
<b>Panel B: Robustness of Table 4</b>						
$Private_i \times Crisis_{t-1} \times BLS_{c,t}$	-0.193 (0.126)	-0.222** (0.106)	-0.238* (0.131)	-0.222** (0.106)	-0.062** (0.025)	-0.084*** (0.026)
Observations	37,615	39,981	37,367	39,981	25,903	24,823
R-squared	0.0333	0.0240	0.0252	0.0240	0.333	0.313
<i>Other Controls:</i>	<i>Private<sub>i</sub>, Crisis<sub>t-1</sub>, BLS<sub>c,t</sub>, Country-industry FE, Time FE, Firm-level controls</i>					

The dependent variable in columns (1)-(2) is the growth rate of R&D investment in year  $t$ , in columns (3)-(4) is the growth rate of the ratio of R&D to sales, while in columns (5)-(6) it is the share of R&D to total investment. Columns (1), (3) and (5) include industries with an above the median dependence on external finance, while columns (2), (4) and (6) those with a below the median dependence.  $Small_i$  is a dummy that takes the value of 1 if a firm is in the 25th percentile of the distribution of firms by total assets in a given industry and 0 if it is in the 75th percentile.  $Crisis_t$  is a dummy taking the value one in 2008-2010 and 2012-2013. Firm level controls include: the log of total assets, the log of sales, liquidity, leverage and investment to total assets. Standard errors are clustered at the country-industry level. \*/\*\*/\*\* represents significance at 10, 5 and 1% level.

Table A5: Alternative measures of financial constraints: clustering at country-industry level

Dependent variables:	R&D			$\frac{R\&D}{Sales}$			$\frac{R\&D}{Investment}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<b>Panel A: Firms in industries with high dependence on external finance</b>									
$Small_i \times Crisis_{t-1}$	-0.123** (0.048)			-0.132** (0.052)			-0.009 (0.011)		
$Liquidity_i \times Crisis_{t-1}$		-0.073** (0.032)			-0.050 (0.035)			0.003 (0.010)	
$Leverage_i \times Crisis_{t-1}$			-0.094*** (0.030)			-0.068** (0.029)			0.013 (0.009)
Observations	12,704	12,851	13,976	12,496	12,653	13,706	8,207	6,698	7,574
R-squared	0.0393	0.0303	0.0289	0.0312	0.0229	0.0200	0.419	0.587	0.549
<b>Panel B: Firms in industries with low dependence on external finance</b>									
$Small_i \times Crisis_{t-1}$	0.021 (0.075)			0.010 (0.072)			0.013 (0.012)		
$Liquidity_i \times Crisis_{t-1}$		-0.070** (0.036)			-0.049 (0.036)			0.012 (0.010)	
$Leverage_i \times Crisis_{t-1}$			-0.036 (0.035)			-0.019 (0.034)			0.018* (0.010)
Observations	11,703	16,446	17,847	11,549	16,277	17,611	7,921	8,773	9,773
R-squared	0.0222	0.0192	0.0195	0.0230	0.0221	0.0216	0.440	0.571	0.533
<i>Controls:</i>									
$Crisis_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Small_i$	Yes			Yes			Yes		
$Liquidity_i$		Yes			Yes			Yes	
$Leverage_i$			Yes			Yes			Yes
Country-industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable in columns (1)-(3) is the growth rate of R&D investment in year  $t$ , in columns (4)-(6) is the growth rate of the ratio of R&D to sales, while in columns (7)-(9) it is the share of R&D to total investment. Panel A includes industries with an above the median dependence on external finance, while Panel B those with a below the median dependence.  $Crisis_{t-1}$  is a dummy taking the value one in 2008-2010 and 2012-2013.  $Small_i$  is a dummy that takes the value of 1 if a firm is in the 25th percentile of the distribution of firms by total assets in a given industry and 0 if it is in the 75th percentile.  $Liquidity_i$  is a dummy that takes the value of 1 if a firm is in the 25th percentile of the distribution of firms by liquidity in a given industry in 2007 and 0 if it is in the 75th percentile.  $Leverage_i$  is a dummy that takes the value of 1 if a firm is in the 25th percentile of the distribution of firms by liquidity in a given industry in 2007 and 0 if it is in the 75th percentile. Firm level controls include: the log of total assets, the log of sales, liquidity, leverage and investment to total assets. Standard errors are clustered at the country-industry level. \*/\*\*/\*\* represents significance at 10, 5 and 1% level.

Table A6: Baseline model: different attrition rule

Dependent variables:	R&D		$\frac{R\&D}{Sales}$		$\frac{R\&D}{Investment}$	
	(1)	(2)	(3)	(4)	(5)	(6)
<b><i>Panel A: Firms in industries with high dependence on external finance</i></b>						
$Private_i \times Crisis_{t-1}$	-0.061*** (0.022)	-0.071*** (0.026)	-0.081*** (0.027)	-0.087*** (0.031)	-0.022** (0.009)	-0.022*** (0.008)
Observations	46,822	45,465	46,167	44,837	33,728	32,518
R-squared	0.0132	0.0101	0.0108	0.0103	0.134	0.146
<b><i>Panel B: Firms in industries with low dependence on external finance</i></b>						
$Private_i \times Crisis_{t-1}$	-0.024 (0.022)	-0.024 (0.022)	-0.015 (0.023)	-0.013 (0.019)	-0.002 (0.009)	-0.004 (0.008)
Observations	47,549	46,388	47,115	45,963	31,281	30,205
R-squared	0.0176	0.0268	0.0166	0.0245	0.379	0.409
<i>Other Controls:</i>	<i>Private, Credit, Country-industry FE, Time FE, Firm-level controls</i>					

Table presents the estimates of Eq. (4) for a sample of firms that report at least 5 years of R&D data. The dependent variable in columns (1)-(2) is the growth rate of R&D investment in year  $t$ , in columns (3)-(4) is the growth rate of the ratio of R&D to sales, while in columns (5)-(6) it is the share of R&D to total investment. Panel A includes industries with an above the median dependence on external finance, while Panel B those with below the median dependence.  $Private_i$  is a dummy for private firms.  $Crisis_t$  is a dummy taking the value one in 2008-2010 and 2012-2013. Standard errors are clustered at the country level. \*/\*\*/\*\* represents significance at 10, 5 and 1% level.

Table A7: Industry-level measure of dependence on external finance

NACE Rev.2	Description	ExtDep
10	Manufacture of food products	0.02
11	Manufacture of beverages	-0.04
12	Manufacture of tobacco products	-1.49
13	Manufacture of textiles	0.10
14	Manufacture of wearing apparel	0.17
15	Manufacture of leather and related products	-0.02
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.01
17	Manufacture of paper and paper products	0.02
18	Printing and reproduction of recorded media	0.19
20	Manufacture of chemicals and chemical products	0.15
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	4.88
22	Manufacture of rubber and plastics products	0.18
23	Manufacture of other non-metallic mineral products	0.06
24	Manufacture of basic metals	0.24
25	Manufacture of fabricated metal products, except machinery and equipment	0.11
26	Manufacture of computer, electronic and optical products	0.36
27	Manufacture of electrical equipment	0.17
28	Manufacture of machinery and equipment n.e.c.	-0.11
29	Manufacture of motor vehicles, trailers and semi-trailers	-0.15
30	Manufacture of other transport equipment	-0.14
31	Manufacture of furniture	-0.26
32	Other manufacturing	1.00
33	Repair and installation of machinery and equipment	0.94
35	Electricity, gas, steam and air conditioning supply	-0.44
36	Water collection, treatment and supply	0.24
38	Waste collection, treatment and disposal activities; materials recovery	0.61
41	Construction of buildings	0.78
46	Wholesale trade, except of motor vehicles and motorcycles	0.43
47	Retail trade, except of motor vehicles and motorcycles	0.35
52	Warehousing and support activities for transportation	0.18
55	Accommodation	0.31
56	Food and beverage service activities	0.28
58	Publishing activities	0.59
59	Motion picture, video and television programme production, sound recording and music publishing activities	0.34
60	Programming and broadcasting activities	0.34
61	Telecommunications	0.56
62	Computer programming, consultancy and related activities	1.15
63	Information service activities	0.56
68	Real estate activities	0.32
70	Activities of head offices; management consultancy activities	0.74
71	Architectural and engineering activities; technical testing and analysis	0.10
73	Advertising and market research	0.03
74	Other professional, scientific and technical activities	0.23
77	Rental and leasing activities	0.42
79	Travel agency, tour operator, reservation service and related activities	1.01
80	Security and investigation activities	0.09
82	Office administrative, office support and other business support activities	0.46

Table presents the Rajan and Zingales (1998) measure of dependence of external finance re-computed by Peia (2017) for a sample of US Compustat firms for the period 1990-1999.



## References

Peia, O. (2017), 'Banking crises and investment in innovation', *UCD Centre for Economic Research Working Paper Series WP17/27*. Available at SSRN: <http://ssrn.com/abstract=2761057> .