Credit Constraints and the cyclicality of R&D investment: Evidence from France

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- Study the role of credit constraints in modifying the cyclicality of long-run, productivity-enhancing investment
- When financial markets are complete, the share of long-run investment is countercyclical because the opportunity cost of such investment is lower in recessions than in booms (Hall (1993), Gali and Hammour (1992), Aghion and Saint-Paul (1991), Bean (1990))
- When financial markets are incomplete, the share of long-run investment turns procyclical
- The presence of credit constraints thus amplifies the business cycle, reduce productivity growth and increase volatility
- Aghion, Angeletos, Banerjee and Manova (2005) support this assertion using macro-data
- Here: Micro Data from the Banque de France

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   - Credit constraint case
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   - Payment Incidents as a proxy for credit constraints
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   - Catch-Up
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Basic environment

- Hypotheses:
  - Two period lived entrepreneurs.
  - Sales shocks $a_t \in [\underline{a}, \overline{a}]$ at t and t+1.
  - Persistance of shocks over time :

$$p = Pr(a_{t+1} = \overline{a}/a_t = \overline{a}) = Pr(a_{t+1} = \underline{a}/a_t = \underline{a})$$

  with

$$\frac{1}{2} < p < 1$$

- At the beginning of period 1, entrepreneur decides between:
  - Short run investment k_t (profit $a_t k_t$, cost $\frac{1}{2} d k_t^2$).
  - Long run investment z_t (profit $E(a_{t+1}/a_t) z_t$, cost $\frac{1}{2} c z_t^2$) .

- Credit market imperfections may prevent a firm from investing more than $\mu a_t k_t$ in R&D ($\mu > 1$) $\Rightarrow z < \mu a_t k_t$.

Benchmark case: no constraint

- The entrepreneur maximizes:

$$\max_{k,z}\{a_t k + E(a_{t+1}/a_t)z - \frac{1}{2}dk^2 - \frac{1}{2}cz^2\}$$

- Which yields (FOC):

$$dk = a_t$$

$$cz = E(a_{t+1}/a_t) = pa_t + (1-p)a_{-t}$$

and

$$\frac{z}{k} = \frac{d}{c}\frac{E(a_{t+1}/a_t)}{a_t} = \frac{d}{c}[p + (1-p)\frac{a_{-t}}{a_t}]$$

- The share of R&D is countercyclical.

- The credit constraint is binding whenever:

$$\frac{E(a_{t+1}/a_t)}{c} > \mu \frac{(a_t)^2}{d}$$

- 3 cases:
  - Never binding (see results above)
  - Only for low sales (1)
  - For high and low sales (2)

Constraint binding only for low sales

- The maximization yields:

$$(\frac{z}{k})^{higha} = \frac{d}{c}[p + (1-p)\frac{\underline{a}}{\overline{a}}]$$

and

$$(\frac{z}{k})^{lowa} = \mu\underline{a}$$

- The share of R&D becomes procyclical:

$$(\frac{z}{k})^{lowa} < (\frac{z}{k})^{higha}$$

- In addition, a lower μ will reduce the share of R&D for low sales, whereas the R&D investment is unchanged in a high sales shock.

Constraint always binding

- The maximisation yields:

$$(\frac{z}{k})^{lowa} = \mu\underline{a} < (\frac{z}{k})^{higha} = \mu\overline{a}$$

- The share of R&D remains procyclical, but a lower μ will reduce more the share of R&D in high sales shocks.

Level of R&D investment

It is possible to derive from the maximization the optimal level of R&D investment:

- If the constraint is not binding:

$$z = \frac{E(a_{t+1}/a_t)}{c}$$

- if it is binding:

$$z = \frac{1}{d + c(\mu a_t)^2}\mu(a_t)^2[1 + \mu E(a_{t+1}/a_t)]$$

- Then R&D investment is procyclical when the credit constraint binds in the low sales state

Main Theoretical Predictions

(i) **A firm's (relative) R&D investment is more procyclical the more credit-constrained the firm is** (in the sense that it reacts more positively to the firm's current sales).

(ii) **Tighter credit constraints interact with sales in an asymmetric fashion over the business cycle**.
$\Rightarrow$ In particular, starting from a situation where credit constraints are more binding in downturns, a tightening of credit-constraints or an increase in the volatility of sales, reduce the firm's R&D investment more in a downturn than it might increase it in an upturn. It thus reduces the firm's average R&D investment.

Data

- Two different Banque de France databases: "Incident de paiement" and Fiben
- A: Payment incidents: "incidents sur les effets de commerce"
  - Exhaustive list: Banks have to inform the Banque de France in case of incident
  - Banks have an electronic access to these logs but "droit à l'oubli" (only recent incidents are available for Banks)
- B: Other variables come from Fiben, Banque de France
  - After restricting the sample to firms which present at least one year a positive R&D investment, our sample contains about 13,000 firms, and covers the period 1994-2004
  - Important share of small firms (median size: 32 employees), more likely to be hit by credit constraints.

First Stage : Payment Incidents and credit constraints

- Recall PI are firms' defaults on trade credit. As banks get an access to the PI database, they should reduce their credit supply to those firms.
- To assess the effect of payment incidents on credit summply, we estimate:

$$BkL_{i,t} = \alpha_1 PI_{i,t-1} + \alpha_2 PI_{i,t-2} + \beta_j X_{i,t-1} + \mu_t + \rho_i + \epsilon_{i,t}$$

- Having at least one Payment Incidents (PI) is used as a proxy for credit constraints;
- Table 2: even after controlling by credit constraints determinants, having a PI in t-1 still have a negative and significant impact, both on the probability to contract a new bank loan and on the size of this loan (Logit and Tobit estimations)

Based on this evidence, we use as a proxy for credit constraints a binary variable which equals 1 when the firm has experienced a PI in t-1

Payment Incidents as a proxy for credit constraints

Dep. var. :	New bank loans							Long term/ Total loans
PI(t-1)	-0.264^a	-0.243^a	-0.239^a	-0.238^a	-0.227^a	-0.229^a	-0.228^a	-0.020^a
	(0.038)	(0.040)	(0.040)	(0.040)	(0.042)	(0.043)	(0.043)	(0.003)
PI(t-2)		-0.064	-0.059	-0.068^c	-0.057	-0.062	-0.062	-0.015^a
		(0.041)	(0.041)	(0.041)	(0.042)	(0.045)	(0.045)	(0.003)
Cash-flow(t-1)		0.575^a	0.514^a	0.424^a	0.430^a	0.391^a	0.396^a	0.070^a
		(0.075)	(0.075)	(0.075)	(0.102)	(0.098)	(0.098)	(0.006)
Size(t-1)		0.292^a	0.158^a	0.094	0.006	0.025	0.031	-0.011^c
		(0.107)	(0.107)	(0.111)	(0.101)	(0.137)	(0.137)	(0.006)
Size^2(t-1)		-0.031^c	-0.032^c	-0.023^b	-0.014	-0.017	-0.017	0.000
		(0.017)	(0.017)	(0.017)	(0.015)	(0.021)	(0.021)	(0.001)
Collateral(t-1)			0.288^a	0.327^a	0.324^a	0.340^a	0.333^a	0.010^a
			(0.025)	(0.026)	(0.024)	(0.032)	(0.033)	(0.002)
Bank dep.(t-1)				-1.355^a	-1.378^a	-1.340^a	-1.339^a	0.268^a
				(0.138)	(0.127)	(0.150)	(0.150)	(0.008)
ΔSales(t-1)					0.053^c	0.139^a	0.142^a	0.001
					(0.028)	(0.040)	(0.041)	(0.002)
ΔSales(t-2)					0.109^a	0.155^a	0.157^a	0.004^b
					(0.026)	(0.035)	(0.035)	(0.002)
$R\&D/VA$(t-1)						0.436^c	0.429^b	
						(0.406)	(0.406)	
ΔSales(t)							0.024^a	
							(0.037)	
Obs.	51656	51656	51656	51112	44584	13516	33759	54572
No. Firms	11392	11392	11392	11327	9907	7624	9371	11367
Adjusted R^2	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02

Note: Within estimations, with year dummies. Robust standard errors into parentheses. All variables are computed from Fiben / Centrale des Bilans, Banque de France. PI : Payment Incident (0/1); Bank Dep.: (Banking Debt / Total Debt). Significance levels: ^{c}10%, ^{b}5%, ^{a}1%. Intercept not reported. All variables are in logarithms.

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Main specification

- Takes the form:

$$\frac{RD_{i,t}}{I_{i,t}} = \alpha_0 + \beta_1 \Delta s_{i,t} + \beta_2 \Delta s_{i,t-1} + \beta_3 \Delta s_{it-2} + \theta PI_{i,t-1} +$$

$$\gamma_1 \Delta s_{i,t} * PI_{i,t-1} + \gamma_2 \Delta s_{i,t-1} * PI_{i,t-1} + \gamma_3 \Delta s_{i,t-2} * PI_{i,t-1} + \mu_t + \nu_i + \varepsilon_{it}$$

- Where RD represents R&D investment, I total investment, CC_{it} credit constraints and Δs the variation in sales
- The share of R&D is supposed to be countercyclical without credit constraints ($\Rightarrow \beta_1 < 0$ and $\sum \beta_i < 0$), and more procyclical with credit constraint ($\Rightarrow \gamma_1 > 0$ and $\sum \gamma_i > 0$)

- Panel Fixed Effects / Within estimation (results robust to other estimation techniques, including GMM)

Results are in line with predictions:

- the share of R&D is clearly countercyclical without credit constraints
- Credit constraints alone have no impact on this share (suggesting that physical and R&D investments are affected in the same way)
- Positive and significant sign on the interaction terms between credit constraints and variation in sales: credit constraints reverse the impact of business cycles on investment composition. The share of R&D investment turns **acyclical** in presence of credit constraints ($\beta_1 + \gamma_1 \equiv 0$)

Depvar:	*R&D investment / Total Investment*					
$\Delta Sales(t)$	-0.016^a	-0.018^a	-0.020^a	-0.018^a	-0.020^a	-0.022^a
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta Sales(t\text{-}1)$		-0.014^a	-0.016^a		-0.015^a	-0.017^a
		(0.003)	(0.003)		(0.003)	(0.003)
$\Delta Sales(t\text{-}2)$			-0.010^a			-0.011^a
			(0.003)			(0.003)
$PI(t\text{-}1)$				0.003	0.002	0.002
				(0.002)	(0.002)	(0.002)
$\Delta Sales(t)*PI(t\text{-}1)$				0.029^a	0.030^a	0.030^a
				(0.010)	(0.010)	(0.010)
$\Delta Sales(t\text{-}1)*PI(t\text{-}1)$					0.017	0.018
					(0.011)	(0.011)
$\Delta Sales(t\text{-}2)*PI(t\text{-}1)$						0.013
						(0.010)
No Obs.	73,237					
No Groups	12,966					
Estimation	Within					
Adjusted R^2	0.01	0.01	0.01	0.01	0.01	0.01

Note: Panel, within estimation. Robust standard errors into parentheses. Significance levels: ^{c}10%, ^{b}5%, ^{a}1%. All estimations include year dummies. Intercept not reported. All variables are in logarithms.

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$\Delta Sales(t)$	**-0.016**[a]	**-0.018**[a]	**-0.020**[a]	-0.018[a]	-0.020[a]	-0.022[a]
	(0.003)	**(0.003)**	**(0.003)**	(0.003)	(0.003)	(0.003)
$\Delta Sales(t\text{-}1)$		**-0.014**[a]	**-0.016**[a]		-0.015[a]	-0.017[a]
		(0.003)	**(0.003)**		(0.003)	(0.003)
$\Delta Sales(t\text{-}2)$			**-0.010**[a]			-0.011[a]
			(0.003)			(0.003)
$PI(t\text{-}1)$				0.003	0.002	0.002
				(0.002)	(0.002)	(0.002)
$\Delta Sales(t)*PI(t\text{-}1)$				0.029[a]	0.030[a]	0.030[a]
				(0.010)	(0.010)	(0.010)
$\Delta Sales(t\text{-}1)*PI(t\text{-}1)$					0.017	0.018
					(0.011)	(0.011)
$\Delta Sales(t\text{-}2)*PI(t\text{-}1)$						0.013
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Main Specification

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	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta Sales(t\text{-}1)$		-0.014^a	-0.016^a		-0.015^a	-0.017^a
		(0.003)	(0.003)		(0.003)	(0.003)
$\Delta Sales(t\text{-}2)$			-0.010^a			-0.011^a
			(0.003)			(0.003)
$PI(t\text{-}1)$				0.003	0.002	0.002
				(0.002)	(0.002)	(0.002)
$\Delta Sales(t)*PI(t\text{-}1)$				**0.029^a**	**0.030^a**	**0.030^a**
				(0.010)	**(0.010)**	**(0.010)**
$\Delta Sales(t\text{-}1)*PI(t\text{-}1)$					0.017	0.018
					(0.011)	(0.011)
$\Delta Sales(t\text{-}2)*PI(t\text{-}1)$						0.013
						(0.010)
No Obs.	73,237					
No Groups	12,966					
Estimation	Within					
Adjusted R^2	0.01	0.01	0.01	0.01	0.01	0.01

Note: Panel, within estimation. Robust standard errors into parentheses. Significance levels: ^{c}10%, ^{b}5%, ^{a}1%. All estimations include year dummies. Intercept not reported. All variables are in logarithms.

Potential Endogeneity problems

- Both firms' investment structure and whether it is subject to a payment incident may hinge on some omitted variable
- This omitted variable cannot be firm specific, sector specific, year specific, sector-year specific, and have to co-determine PI in t-1 and $R\&D/I$ in t without affecting $R\&D/I$ in t-1 in the same way
- To deal with this potential omitted variable bias, estimations on two different sub-samples, according to the sectors' degree of financial external dependence (Rajan and Zingales 1998)
- No reason for the omitted variable bias to be differently distributed across sectors
- Previous results should be exacerbated in more financially dependent sectors

Depvar:	*R&D investment / Total Investment*			
	Fin. Dependence		*Collateral*	
	Low (a)	High (b)	Low (c)	High (d)
$\Delta Sales(t)$	-0.021^{a}	-0.038^{a}	-0.027^{a}	-0.012^{a}
	(0.005)	(0.006)	(0.005)	(0.004)
$\Delta Sales(t\text{-}1)$	-0.012^{b}	-0.032^{a}	-0.019^{a}	-0.015^{a}
	(0.005)	(0.006)	(0.005)	(0.004)
$\Delta Sales(t\text{-}2)$	-0.013^{a}	-0.027^{a}	-0.010^{b}	-0.013^{a}
	(0.005)	(0.006)	(0.004)	(0.004)
$PI(t\text{-}1)$	0.003	0.002	0.001	0.002
	(0.004)	(0.005)	(0.004)	(0.003)
$\Delta Sales(t)*PI(t\text{-}1)$	0.026	0.049^{b}	0.043^{a}	0.010
	(0.020)	(0.020)	(0.016)	(0.012)
$\Delta Sales(t\text{-}1)*PI(t\text{-}1)$	-0.001	0.011	0.029^{c}	0.005
	(0.019)	(0.023)	(0.017)	(0.014)
$\Delta Sales(t\text{-}2)*PI(t\text{-}1)$	0.000	0.049^{b}	0.012	0.017
	(0.018)	(0.021)	(0.014)	(0.012)
No Observations	20028	18457	36639	36598
No Firms	3403	3221	8212	6589
Estimation	Within			
Adjusted R^2	0.01	0.01	0.01	0.01

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	(0.004)	(0.005)	(0.004)	(0.003)
$\Delta Sales(t)*PI(t\text{-}1)$	**0.026**	**0.049**^{b}	0.043^{a}	0.010
	(0.020)	**(0.020)**	(0.016)	(0.012)
$\Delta Sales(t\text{-}1)*PI(t\text{-}1)$	-0.001	0.011	0.029^{c}	0.005
	(0.019)	(0.023)	(0.017)	(0.014)
$\Delta Sales(t\text{-}2)*PI(t\text{-}1)$	0.000	0.049^{b}	0.012	0.017
	(0.018)	(0.021)	(0.014)	(0.012)
No Observations	20028	18457	36639	36598
No Firms	3403	3221	8212	6589
Estimation	Within			
Adjusted R^2	0.01	0.01	0.01	0.01

Depvar:	*R&D investment / Total Investment*			
	Fin. Dependence		*Collateral*	
	Low (a)	High (b)	Low (c)	High (d)
$\Delta Sales(t)$	-0.021^{a}	-0.038^{a}	-0.027^{a}	-0.012^{a}
	(0.005)	(0.006)	(0.005)	(0.004)
$\Delta Sales(t\text{-}1)$	-0.012^{b}	-0.032^{a}	-0.019^{a}	-0.015^{a}
	(0.005)	(0.006)	(0.005)	(0.004)
$\Delta Sales(t\text{-}2)$	-0.013^{a}	-0.027^{a}	-0.010^{b}	-0.013^{a}
	(0.005)	(0.006)	(0.004)	(0.004)
$PI(t\text{-}1)$	0.003	0.002	0.001	0.002
	(0.004)	(0.005)	(0.004)	(0.003)
$\Delta Sales(t)*PI(t\text{-}1)$	0.026	0.049^{b}	**0.043^{a}**	**0.010**
	(0.020)	(0.020)	**(0.016)**	**(0.012)**
$\Delta Sales(t\text{-}1)*PI(t\text{-}1)$	-0.001	0.011	0.029^{c}	0.005
	(0.019)	(0.023)	(0.017)	(0.014)
$\Delta Sales(t\text{-}2)*PI(t\text{-}1)$	0.000	0.049^{b}	0.012	0.017
	(0.018)	(0.021)	(0.014)	(0.012)
No Observations	20028	18457	36639	36598
No Firms	3403	3221	8212	6589
Estimation	Within			
Adjusted R^2	0.01	0.01	0.01	0.01

Symmetry

An important question is whether the effect is to play both in high and low sales states. We thus estimate:

$$\frac{RD_{i,t}}{I_{i,t}} = \alpha_0 + \sum_{j=0}^{2} \left(\alpha_j \Delta s^H_{i,t-j} + \gamma_j \Delta s^L_{i,t-j} \right) + \alpha_4 PI_{i,t-1}$$

$$+ \sum_{j=0}^{2} \left(\theta_j \Delta s^H_{i,t-j} * PI_{i,t-1} + \lambda_j \Delta s^L_{i,t-j} * PI_{i,t-1} \right) + \mu_t + \nu_i + \varepsilon_{it}$$

- Decompositions of shocks into two categories: low (under the firms' mean of sales variation) and high (above the mean) (Results are robust to the use of different methods of shocks' decomposition, by quartiles)
- We expect this effect to play during down-cycles periods only
- Results emphasize a non-symmetrical effect, which is only observed in low sales periods : the share of R&D investment turns **procyclical** during down-cycle periods

Depvar:	*R&D investment / Total Investment*					
	Decomposition by firm (1)					
High ΔSales(t)	-0.020[a]	-0.023[a]	-0.020[a]	-0.023[a]	-0.021[a]	-0.023[a]
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Low ΔSales(t)	-0.008	-0.011[b]	-0.008	-0.010[c]	-0.014[b]	-0.016[a]
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
High ΔSales(t-1)		-0.015[a]		-0.015[a]		-0.017[a]
		(0.004)		(0.004)		(0.004)
Low ΔSales(t-1)		-0.012[b]		-0.011[b]		-0.012[b]
		(0.006)		(0.006)		(0.006)
PI(t-1)			0.004[c]	0.004[c]	0.003	0.003
			(0.002)	(0.002)	(0.003)	(0.003)
*High ΔSales(t)*PI(t-1)*					0.005	0.005
					(0.016)	(0.016)
*Low ΔSales(t)*PI(t-1)*					0.054[a]	0.055[a]
					(0.017)	(0.017)
*High ΔSales(t-1)*PI(t-1)*						0.024
						(0.016)
*Low ΔSales(t-1)*PI(t-1)*						0.005
						(0.021)
Adjusted R^2	0.01	0.01	0.01	0.01	0.01	0.01
No Obs.	73,237					
No Groups	12,966					
Estimation	WITHIN					

Note: (1) Decomposition by firm: above (high) and below (low) firm's mean sales' variation. Panel, within estimations. Standard errors into parentheses. Significance levels: [c]10%, [b]5%, [a]1%. All estimations include year dummies. Intercept and lag of the dependent variable not reported. All variables are in logarithms.

Depvar:	*R&D investment / Total Investment* *Decomposition by firm (1)*					
High ΔSales(t)	-0.020[a]	-0.023[a]	-0.020[a]	-0.023[a]	-0.021[a]	-0.023[a]
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Low ΔSales(t)	-0.008	-0.011[b]	-0.008	-0.010[c]	-0.014[b]	-0.016[a]
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
High ΔSales(t-1)		-0.015[a]		-0.015[a]		-0.017[a]
		(0.004)		(0.004)		(0.004)
Low ΔSales(t-1)		-0.012[b]		-0.011[b]		-0.012[b]
		(0.006)		(0.006)		(0.006)
PI(t-1)			0.004[c]	0.004[c]	0.003	0.003
			(0.002)	(0.002)	(0.003)	(0.003)
*High ΔSales(t)*PI(t-1)*					0.005	0.005
					(0.016)	(0.016)
*Low ΔSales(t)*PI(t-1)*					**0.054[a]**	**0.055[a]**
					(0.017)	**(0.017)**
*High ΔSales(t-1)*PI(t-1)*						0.024
						(0.016)
*Low ΔSales(t-1)*PI(t-1)*						0.005
						(0.021)
Adjusted R^2	0.01	0.01	0.01	0.01	0.01	0.01
No Obs.	73,237					
No Groups	12,966					
Estimation	WITHIN					

Note: (1) Decomposition by firm: above (high) and below (low) firm's mean sales' variation. Panel, within estimations. Standard errors into parentheses. Significance levels: [c]10%, [b]5%, [a]1%. All estimations include year dummies. Intercept and lag of the dependent variable not reported. All variables are in logarithms.

Shock and the cyclical position of the firm

Dep. var.	*R&D investment/ Total Investment*	
Initital State:	High	Low
High ΔSales(t)	-0.002	-0.025***
Low ΔSales(t)	-0.018***	-0.027***
PI(t-1)	0.004	0.003
*High ΔSales(t)*IP(t-1)*	0.025	0.007
*Low ΔSales(t)*IP(t-1)*	0.042**	0.060**
No. Obs.	34,360	38,877
No. Firms	11,563	12,597
Adj. R^2	0.002	0.004
Estimation	Within	

- We assume that the large shocks determine the position of the firm within its business cycle. To handle this caveat, we cut our sample according to the initial position of firms, and run our regressions.

- Results are not affected by this distinction, suggesting that sales shocks are a good proxy for firms' position within the cycle

R&D Level

Dep. var.	$\frac{I_t}{K_{t-1}}$		
$Inv(t-1)/K(t-2)$	0.064***	0.064***	0.064***
$\Delta Sales(t)$	0.128***	0.127***	0.125***
$\Delta Sales(t\text{-}1)$	0.094***	0.094***	0.094***
$PI(t\text{-}1)$		-0.016***	-0.016***
$\Delta Sales(t)$ * $PI(t\text{-}1)$			0.023
$\Delta Sales(t\text{-}1)$ * $PI(t\text{-}1)$			-0.002
Adjusted R^2	0.08	0.08	0.08
No Obs.	73,237	73,237	73,237
No Groups	12,966	12,966	12,966
Estimation		Within	

Necessary to check that the previous results indeed come from an adjustment of the level R&D investment (and not only from an adjustment of physical investment)

$\Rightarrow$ Level of investment negatively and uniformly affected by credit constraints whatever the position of the firm within the cycle

Catch-up

- Possible catch-up phenomenon: as credit constrained firms decrease more their R&D share more in downturns, they may increase more that share in upturns, leaving the average R&D level unaffected

- Attempts to find such a catch-up phenomenon failed: suggests that credit constraints reduce the average level of R&D

Dep. var.:	MEAN TFP Growth (t+2) to (t+5)			
Initial TFP	-0.031***	-0.031***		
Shock	-0.063***	-0.017	-0.037*	0.001
Sect. R&D Intensity	1.104***	1.095***		
*Shock*Sect R&D Intensity*		-3.936***		-3.284***
No obs.	33,973	33,973	33,973	33,973
R^2	0.05	0.06	0.05	0.05
Est.	OLS		Fixed Effects / Within	

- Effect of the interacted effect of PI and sales shocks on productivity growth: do credit constraint firms' productivity growth react more negatively to a sales shock?
- Negative coefficient on the interaction term, no longer significant when we include sectoral R&D intensity
- Suggests that the negative effect of adverse shocks on productivity growth comes from their impact on R&D investment

Volatility, Growth and Credit Constraints

Est. :	(a)	(b)	(c)	(d)	(e)	(f)
Dep. Var	TFP Growth		TFP Growth High R&D intensity		TFP Growth Low R&D intensity	
Initial TFP	-0.021[a]	-0.020[a]	-0.021[a]	-0.020[a]	-0.022[a]	-0.022[a]
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Growth Volatility	0.003	-0.037	-0.012	-0.074[c]	0.012	-0.015
	(0.022)	(0.028)	(0.035)	(0.039)	(0.026)	(0.038)
*Growth volatility*Fin. Dep*		-0.033[c]		-0.066[c]		-0.018
		(0.018)		(0.037)		(0.021)
No. Observations	4459	4459	2249	2249	2310	2310
R^2	0.141	0.146	0.152	0.164	0.089	0.090

- Cross section estimations
- No impact of volatility on growth on average, but more negative impact when the firms belongs to a more financially dependent sector
- This negative relationship between volatility and growth is only observed in R&D intensive industries (above median)

- Strong evidence of the role credit constraints in making the share of R&D investment more procyclical
- The effect is asymmetric, only observed during upturns
- Average R&D investment is lower on average when credit constraints are observed
- By preventing the share of R&D investment from being countercyclical, credit constraints magnifies the negative impact of volatility on productivity growth and decrease overall productivity growth
- Future work: economic policy implications (role of countercyclical monetary or budgetary policies)