Corporate Research and Credit-related Limitations: the Role of Credits in Long-term Innovation Development of Enterprises

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Motivation

- Schumpeterian view of business cycles: recessions provide a cleansing mechanism for correcting organizational inefficiencies and for encouraging firms to reorganize or innovate
- But recessions may also mean tighter credit constraints
- By preventing firms to innovate in recessions, credit constraints may have important impacts have the macro level on volatility and growth
- This paper: assess empirically the effect of credit constraints on the cyclicality of R&D investment, and its implications on the links between volatility and growth

Related literature

- 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, reduces productivity growth and increases volatility
- Aghion, Angeletos, Banerjee and Manova (2005) support this assertion using macro-data
- Here: Micro Data from the Banque de France

1. Theory
2. Data
3. First Stage
   - Payment Incidents as a proxy for credit constraints
4. Second stage
   - Main Specification
   - Symmetry
   - Weighted estimations
   - From R&D to productivity growth
   - Conclusions

Theory: intuition

- Entrepreneurs can chose between short and long term investments
- Short term investments immediately increase production while long term investments increase productivity in the long run
- If the choice of the entrepreneurs is not constrained, they tend to favor short term investments in up-turns and long term investments in down-turn
- How does the credit constraint affect the relation between the prefered structure of investment and the business cycle?

Main Theoretical Predictions

(i) **A firm's 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**.
⇒ 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.

Implications on productivity growth

(iii) **Credit constraints reduce average productivity growth**

(iv) **Volatility has a more negative impact on productivity growth**

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 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 supply, 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:

$$\log(RD_{it}+1) = \sum_{j=0}^{2} \beta_{j+1} \Delta \log s_{i,t-j} + \theta PI_{i,t-1} + \sum_{j=0}^{2} \gamma_{j+1} \Delta \log s_{i,t-j} * PI_{i,t-1}$$

$$+ \mu_{kt} + \nu_i + \varepsilon_{it}$$

- Where RD represents R&D investment, CC_{it} credit constraints and Δs the variation in sales
- R&D investment 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:

- R&D investment is weakly countercyclical without credit constraints
- Credit constraints alone reduces the level of R&D investment
- Positive and significant sign on the interaction terms between credit constraints and variation in sales: R&D investment turns **procyclical** in presence of credit constraints ($\beta_1 + \gamma_1 > 0$)

Main Specification

Dep. var.:			log$(RD+1)$			
	(a)	(b)	(c)	(d)	(e)	(f)
Δ log Sales(t)	-0.032	-0.04	-0.042	-0.062^b	-0.071^b	-0.073^b
	(0.027)	(0.027)	(0.028)	(0.028)	(0.028)	(0.029)
Δ log Sales(t-1)		-0.049^c	-0.052^c		-0.070^a	-0.074^a
		(0.026)	(0.027)		(0.027)	(0.028)
Δ log Sales(t-2)			-0.015			-0.033
			(0.026)			(0.027)
PI(t-1)				0.001	-0.007	-0.017
				(0.021)	(0.021)	(0.021)
Δ log Sales(t)*PI(t-1)				0.355^a	0.368^a	0.371^a
				(0.102)	(0.101)	(0.101)
Δ log Sales(t-1)*PI(t-1)					0.278^a	0.285^a
					(0.100)	(0.100)
Δ log Sales(t-2)*PI(t-1)						0.229^b
						(0.095)
$\sum \beta_i$			-0.110^b			-0.188^a
			(0.053)			(0.055)
$\sum \beta_i + \sum \gamma_i$						0.704^a
						(0.165)
No Obs.			83,803			
No Groups			13,634			
Estimation			Within			

Note: Robust standard errors into parentheses. Significance levels: ^{c}10%, ^{b}5%, ^{a}1%.
All estimations include sector × year dummies. Intercept not reported.

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	(0.027)	**(0.027)**	**(0.028)**	(0.028)	(0.028)	(0.029)
Δ log Sales(t-1)		**-0.049^c**	**-0.052^c**		-0.070^a	-0.074^a
		(0.026)	**(0.027)**		(0.027)	(0.028)
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	(0.027)	(0.027)	(0.028)	(0.028)	(0.028)	(0.029)
Δ log Sales(t-1)		-0.049[c]	-0.052[c]		-0.070[a]	-0.074[a]
		(0.026)	(0.027)		(0.027)	(0.028)
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Potential Endogeneity problems (1)

- Firms' R&D investment and sales may be co-determined
- A traditional way to solve this issue is to use an instrumental variable (IV) methodology
- We perform two-stage estimations using two different instrument for variation in sales: real exchange rate and increase in foreign demand
- Both instrument are firm-year specific, but they are determined at a macro level and are thus exogeneous to firm-level behaviour
- Our main results are strengthened since the interaction terms are both positive and highly significant

Main Specification

Depvar:	$\log(RD+1)$	
	(a)	(b)
Δ log Sales(t)	-0.022	-0.028
	(0.035)	(0.053)
Δ log Sales(t-1)	-0.084[b]	-0.089
	(0.036)	(0.057)
Δ log Sales(t-2)	-0.051	-0.077
	(0.035)	(0.053)
PI(t-1)	-0.026	-0.088[b]
	(0.026)	(0.039)
Δ log Sales(t)*PI(t-1)	0.224[b]	0.419[b]
	(0.114)	(0.170)
Δ log Sales(t-1)*PI(t-1)	0.12	0.376[b]
	(0.122)	(0.180)
Δ log Sales(t-2)*PI(t-1)	0.158	0.310[c]
	(0.122)	(0.178)
$\sum \beta_i$	-0.156[b]	-0.194
	(0.079)	(0.137)
$\sum \beta_i + \sum \gamma_i$	0.344	**0.910[a]**
	(0.217)	**(0.342)**
Obs.	52287	33763
Firms	8617	7187
Estimation	FE-2SLS	
Instruments	Std	RER/GDP
Sargan Stat.	15.11	12.76
P-value	0.12	0.39

Note: Robust standard errors into parentheses. Significance levels: [c]10%, [b]5%, [a]1%. All estimations include sector × year dummies. Intercept not reported. Std: Standard instruments, i.e. two differentiated lags of regressors. RER/GDP: New instruments, i.e. current value and two lags of *RER*, and *GDP*.

Potential Endogeneity problems (2)

- Both firms' R&D investment 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 $R\&D$ in t without affecting $R\&D$ 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) or asset tangibility (Braun, 2003)
- No reason for the omitted variable bias to be differently distributed across sectors
- Previous results should be exacerbated in more financially dependent sectors

Main Specification

Depvar:	$\log(RD+1)$							
	Asset Tangibility				Financial Dependence			
	Low	High	Low	High	Low	High	Low	High
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Δ log Sales(t)	-0.240^a	0.062	-0.202^c	0.05	0.003	-0.231^a	0.053	-0.174
	(0.065)	(0.069)	(0.115)	(0.137)	(0.061)	(0.061)	(0.118)	(0.110)
Δ log Sales(t-1)	-0.251^a	-0.012	-0.210^c	-0.078	-0.078	-0.193^a	-0.026	-0.135
	(0.063)	(0.065)	(0.124)	(0.139)	(0.056)	(0.059)	(0.124)	(0.117)
Δ log Sales(t-2)	-0.177^a	-0.088	-0.128	-0.154	-0.096^c	-0.140^b	-0.059	-0.116
	(0.062)	(0.060)	(0.117)	(0.135)	(0.053)	(0.058)	(0.117)	(0.112)
PI(t-1)	0.000	0.006	-0.124	-0.088	0.025	-0.015	-0.024	-0.126
	(0.053)	(0.045)	(0.086)	(0.083)	(0.039)	(0.048)	(0.070)	(0.080)
Δ log Sales(t)*PI(t-1)	0.513^b	0.235	0.732^b	0.494	0.369^c	0.483^b	0.523	0.691^b
	(0.207)	(0.246)	(0.362)	(0.405)	(0.207)	(0.194)	(0.352)	(0.343)
Δ log Sales(t-1)*PI(t-1)	0.460^b	-0.153	0.637^c	-0.349	0.144	0.306	-0.203	0.317
	(0.212)	(0.240)	(0.380)	(0.440)	(0.204)	(0.195)	(0.351)	(0.365)
Δ log Sales(t-2)*PI(t-1)	0.623^a	0.246	0.516	-0.154	0.236	0.490^b	0.201	0.323
	(0.224)	(0.201)	(0.410)	(0.425)	(0.180)	(0.205)	(0.354)	(0.381)
$\sum \beta_i$	-0.668^a	-0.038	-0.540^c	-0.180	-0.171	-0.563^a	-0.031	-0.424
	(0.131)	(0.130)	(0.300)	(0.340)	(0.115)	(0.123)	(0.298)	(0.286)
$\sum \beta_i + \sum \gamma_i$	0.929^a	0.290	1.345^c	-0.191	0.579^c	0.717^a	0.489	0.907^c
	(0.369)	(0.368)	(0.747)	(0.780)	(0.342)	(0.334)	(0.673)	(0.551)
Obs.	18467	15479	8305	6868	21267	20864	8810	9378
Firms	3067	2443	1734	1415	3389	3391	1849	1954
Estimation	Within		FE-2SLS		Within		FE-2SLS	
Instruments			RER/GDP				RER/GDP	
Sargan Stat.			14.28	13.87			23.74	13.54
P-value			0.28	0.31			0.02	0.33

Note: Robust standard errors into parentheses. Significance levels: ^{c}10%, ^{b}5%, ^{a}1%. All estimations include sector $\times$ year dummies. Intercept not reported. Rajan and Zingales (1998) data for sectoral financial dependence. Braun (2003) data for sectoral asset tangibility. RER/GDP: New instruments, i.e. current value and two lags of RER_{it} and GDP_{it}.

Main Specification

Depvar:	log$(RD+1)$							
	Asset Tangibility				Financial Dependence			
	Low	High	Low	High	Low	High	Low	High
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Δ log Sales(t)	-0.240[a]	0.062	-0.202[c]	0.05	0.003	-0.231[a]	0.053	-0.174
	(0.065)	(0.069)	(0.115)	(0.137)	(0.061)	(0.061)	(0.118)	(0.110)
Δ log Sales(t-1)	-0.251[a]	-0.012	-0.210[c]	-0.078	-0.078	-0.193[a]	-0.026	-0.135
	(0.063)	(0.065)	(0.124)	(0.139)	(0.056)	(0.059)	(0.124)	(0.117)
Δ log Sales(t-2)	-0.177[a]	-0.088	-0.128	-0.154	-0.096[c]	-0.140[b]	-0.059	-0.116
	(0.062)	(0.060)	(0.117)	(0.135)	(0.053)	(0.058)	(0.117)	(0.112)
PI(t-1)	0.000	0.006	-0.124	-0.088	0.025	-0.015	-0.024	-0.126
	(0.053)	(0.045)	(0.086)	(0.083)	(0.039)	(0.048)	(0.070)	(0.080)
Δ log Sales(t)*PI(t-1)	0.513[b]	0.235	0.732[b]	0.494	0.369[c]	0.483[b]	0.523	0.691[b]
	(0.207)	(0.246)	(0.362)	(0.405)	(0.207)	(0.194)	(0.352)	(0.343)
Δ log Sales(t-1)*PI(t-1)	0.460[b]	-0.153	0.637[c]	-0.349	0.144	0.306	-0.203	0.317
	(0.212)	(0.240)	(0.380)	(0.440)	(0.204)	(0.195)	(0.351)	(0.365)
Δ log Sales(t-2)*PI(t-1)	0.623[a]	0.246	0.516	-0.154	0.236	0.490[b]	0.201	0.323
	(0.224)	(0.201)	(0.410)	(0.425)	(0.180)	(0.205)	(0.354)	(0.381)
$\sum \beta_i$	-0.668[a]	-0.038	-0.540[c]	-0.180	-0.171	-0.563[a]	-0.031	-0.424
	(0.131)	(0.130)	(0.300)	(0.340)	(0.115)	(0.123)	(0.298)	(0.286)
$\sum \beta_i + \sum \gamma_i$	**0.929[a]**	**0.290**	**1.345[c]**	**-0.191**	**0.579[c]**	**0.717[a]**	**0.489**	**0.907[c]**
	(0.369)	**(0.368)**	**(0.747)**	**(0.780)**	**(0.342)**	**(0.334)**	**(0.673)**	**(0.551)**
Obs.	18467	15479	8305	6868	21267	20864	8810	9378
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Symmetry

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

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

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

- 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 : R&D investment turns **procyclical** only during down-cycle periods

Symmetry

Depvar:	log($RD+1$)		
	(a)	(b)	(c)
High Δ log Sales(t)	-0.049	-0.049	-0.063
	(0.041)	(0.041)	(0.042)
Low Δ log Sales(t)	-0.027	-0.026	-0.081
	(0.050)	(0.050)	(0.052)
High Δ log Sales(t-1)	-0.110[a]	-0.109[a]	-0.137[a]
	(0.039)	(0.039)	(0.040)
Low Δ log Sales(t-1)	0.04	0.04	0.027
	(0.050)	(0.050)	(0.052)
High Δ log Sales(t-2)	-0.062[c]	-0.062[c]	-0.068[c]
	(0.038)	(0.038)	(0.039)
Low Δ log Sales(t-2)	0.065	0.065	0.027
	(0.049)	(0.049)	(0.051)
PI(t-1)		0.006	0.007
		(0.021)	(0.031)
High Δ log Sales(t)*PI(t-1)			0.244
			(0.170)
Low Δ log Sales(t)*PI(t-1)			0.492[a]
			(0.165)
High Δ log Sales(t-1)*PI(t-1)			0.125
			(0.175)
Low Δ log Sales(t-1)*PI(t-1)			0.394[b]
			(0.158)
High Δ log Sales(t-2)*PI(t-1)			0.074
			(0.136)
Low Δ log Sales(t-2)*PI(t-1)			0.458[b]
			(0.182)
$\sum \alpha_j$	-0.220[a]	-0.220[a]	-0.268[a]
	(0.075)	(0.075)	(0.077)
$\sum \gamma_j$	0.078	0.079	-0.027
	(0.096)	(0.096)	(0.098)
$\sum \alpha_j + \sum \theta_j$			0.176
			(0.290)
$\sum \gamma_j + \sum \lambda_j$			1.317[a]
			(0.312)

Symmetry

Depvar:	log($RD+1$)		
	(a)	(b)	(c)
High Δ log Sales(t)	-0.049	-0.049	-0.063
	(0.041)	(0.041)	(0.042)
Low Δ log Sales(t)	-0.027	-0.026	-0.081
	(0.050)	(0.050)	(0.052)
High Δ log Sales(t-1)	-0.110[a]	-0.109[a]	-0.137[a]
	(0.039)	(0.039)	(0.040)
Low Δ log Sales(t-1)	0.04	0.04	0.027
	(0.050)	(0.050)	(0.052)
High Δ log Sales(t-2)	-0.062[c]	-0.062[c]	-0.068[c]
	(0.038)	(0.038)	(0.039)
Low Δ log Sales(t-2)	0.065	0.065	0.027
	(0.049)	(0.049)	(0.051)
PI(t-1)		0.006	0.007
		(0.021)	(0.031)
High Δ log Sales(t)*PI(t-1)			0.244
			(0.170)
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			(0.165)
High Δ log Sales(t-1)*PI(t-1)			0.125
			(0.175)
Low Δ log Sales(t-1)*PI(t-1)			0.394[b]
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			(0.182)
$\sum \alpha_j$	-0.220[a]	-0.220[a]	-0.268[a]
	(0.075)	(0.075)	(0.077)
$\sum \gamma_j$	0.078	0.079	-0.027
	(0.096)	(0.096)	(0.098)
$\sum \alpha_j + \sum \theta_j$			**0.176**
			(0.290)
$\sum \gamma_j + \sum \lambda_j$			**1.317[a]**
			(0.312)

Weighted estimations

- So far, our estimations give the exact same weight to each firm in the database, whatever its size.
- The effect we estimate may not be significant at a macro level, especially since most R&D investment is concentrated on a few large firms.
- To check the robustness of our results, we thus weight our estimations by the size of each firm (either value added or number of employees).
- This leaves our results largely unaffected, suggesting that the effect of credit constraint should be significant at a macro level. This is all the more true since our estimations do not account for dynamic effects.

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 R&D investment more procyclical
- The effect is asymmetric, only observed during downturns
- Average R&D investment is lower on average when credit constraints are observed
- By preventing 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)