Business cycles and investment in intangibles: Evidence from Spanish firms

Paloma Lopez-Garcia, Jose Manuel Montero and Enrique Moral

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Content

Business cycles and long-run growth

- **We start having a painful idea of the short-term consequences of the current crisis; but what about its long-term impact?**

- **For a very long time, cycles and long-run growth were seen as independent phenomena**
  - Long-run growth depended on some exogenous technology growth whereas short-term cycles were determined by demand shocks

- **The RBC theory and, above all, Romer's endogenous growth theory at the beginning of the 90s changed radically this dichotomy**
  - Technology growth depends on the optimal decision of agents on human accumulation and R&D investment
  - Those optimal decisions can be affected by the moment of the cycle…

Business cycles and long-term growth (II)

- **There are several ways cycles can affect long-term growth**
  - Learning-by-doing (Arrow 1962): people have ideas on how to improve production efficiency when they are producing
  - Reallocation of resources:
    - *Creative destruction (Schumpeter 1934, Caballero and Hammour 1994): Recessions have a cleansing effect (shift of productive resources across production units)*
    - *Opportunity-cost theory (Bean 1990, Hall 1990, Gali & Hammour 1993): The forgone cost of investing in Productive-Enhancing Activities (PEA) decreases during recessions, whereas its benefit is spread along time*
      - ❑ Hence it is optimal to devote more of the limited resources to those PEA in crisis, which would have a positive impact on long-run productivity growth
      - ❑ Empirical studies (VAR approach) testing for the impact of cycles on TFP growth seem to support this theory

Which Productive-Enhancing Activities?

- **Research and Development (R&D) is the most obvious productive-enhancing activity of a firm**
- **A pile of papers have been devoted to explore the cyclicality of R&D**
  - But most of them find a positive relation with the cycle!! –also in Spain
- **Why?**
  - Barlevy (2007): Existence of R&D spillovers
  - Ouyang (2011): Aggregation bias
  - Aghion et al (2005, 2007): Credit constraints
    - *The opportunity cost argument works when firms can borrow enough funds to invest in R&D or reorganize activities*
    - *With credit markets imperfections, firms are deterred from reorganizing and investing in R&D, even if it optimal for them*
    - *R&D can turn procyclical*

Other Productivity-Enhancing Activities

- **But R&D is by no means the only PEA a firm can invest in**
- **The next one in importance is staff training**
  - During downturns, the opportunity cost of the time devoted by hoarded labour to improve its human capital is lower
  - There is some empirical evidence confirming that firms devote more resources to training in crisis (Bean 1990, Geroski and Gregg 1995)
- **Other PEA relate to managerial reorganization (Nickell et al 1995)**
- **Other investment in intangibles able to increase firm-level productivity have not received much attention yet**
  - For example, firms' investment in patents
    - *Understood as acquisition of the right to exploit knowledge produced elsewhere*
    - *Interesting to explore how both "produced" versus "acquired" R&D move along the economic cycle*

Our contribution

This paper contributes to the literature on cycles and long-term growth in several ways:

1. It tests the opportunity-cost theory for Spain using firm-level data for the period 1991-2010
2. As in Aghion et al (2005, 2007), it allows the impact of the cycle to differ for credit constrained and unconstrained firms
   - *For that purpose, we construct a direct indicator of firm's financial obstacles from the survey information provided by PITEC*
3. It looks at the investment devoted to R&D along the cycle by firms, but also at other PEA:
   - *Training spending*
   - *Purchase of patents*
4. It studies the complementarity/substitution pattern of different production inputs
   - *It pays special attention to different investment in intangibles*

Content

Data

The "Central de Balances" and PITEC

- **The CB contains firm-level detailed information for a sample of about 3,000 Spanish firms operating across all sectors of the economy -- details**
- **Data available for the period 1991-2009**
- **Data quality is outstanding**
  - Firms provide every year information for t and t-1
  - 75% of firms are recalled to clarify inconsistencies or missing data points
- **However, the sample of firms is not representative**
  - Over-representation of the industry and energy sector -- coverage
  - Over-representation of large firms (50% of firms <=250 emp. versus 95% in population in industry sector)
- **We merge the CB with the PITEC survey of innovative firms (INE)**
  - Constructed on the basis of the annual Spanish responses to CIS
  - It covers about 70% of large Spanish firms plus a sample of innovative SMEs
  - It provides information on inputs and outputs of the innovation process

Data

Constructing a direct indicator of financial obstacles

- **PITEC includes the following question:**

"During the two previous years, how important was the lack of finance from sources outside your enterprise for hampering your innovation activities?"

  - Firms have to rank the importance of this factor from 1 (high) to 3 (low) – distribution of credit constrained firms

- **Following Coluzzi et al (2003) we proceed in 2 stages:**

  - We run an ordered probit to estimate the relative importance of several firm-level characteristics to explain the probability of facing financial obstacles
    - *We include variables such as age, size, debt ratio, collateral, debt burden, cash-flow, sector of activity and some proxy for the macro environment*
    - *We use the information on 600 firms per year, between 2004 and 2009, with data in the CB and in PITEC*
    - *Results of first-stage regressions*
  - We use the estimated coefficients to compute the predicted probability for each firm in CB to face financial obstacles for innovation

Content

Empirical methodology

- **We follow closely the model in Aghion et al (2005):**
  - Firms choose between short-term capital investment (returns now) and long-term R&D investment (returns tomorrow if the firm survives liquidity shocks)
  - To invest and overcome shocks, the firm counts on borrowing and earnings
  - If borrowing is restricted, the ex-ante probability to invest in LT investment decreases, above all in recessions: earnings drop and so does the ability to borrow
  - The result is that the share of R&D investment is expected to be more procyclical in firms facing tighter credit constraints.

- **To test the theoretical predictions, we estimate the following equation:**

$$R\,\&\,D_{it}^{share} = \beta_0 + \beta_1 \Delta S_{it} + \gamma_0 CC_{it-1} + \gamma_1 \Delta S_{it} CC_{it-1} + \mu_k + \eta_i + u_{it}$$

- **We use a Within Group (FE) estimator and the GMM estimator**

Restricciones al crédito y comportamiento cíclico de la I+D

DV: Ratio of R&D exp. over total investment	[1] WG	[2] WG	[3] WG	[4] GMM	[5] GMM	[6] GMM
$\Delta Sales_t$	-0.01***	-0.03**	-0.04***	-0.007***	-0.012	-0.04**
	(0.010)	(0.014)	(0.015)	(0.003)	(0.015)	(0.019)
$\Delta Sales_{t-1}$			-0.05***			-0.05***
			(0.013)			(0.015)
$CreditConst._{t-1}$		0.08	0.08		0.06	0.06
		(0.058)	(0.058)		(0.177)	(0.137)
$\Delta Sales_t$ x $CreditConst._{t-1}$		0.07**	0.09***		0.02	0.08**
		(0.032)	(0.035)		(0.033)	(0.041)
$\Delta Sales_{t-1}$ x $CreditConst._{t-1}$			0.11***			0.09***
			(0.032)			(0.031)
Sector Dummies	YES	YES	YES	YES	YES	YES
Firm Dummies	YES	YES	YES	YES	YES	YES
No. Observations	21676	17506	17485	17819	13892	17506
No. of firms	3270	3103	3101	3141	2524	3103
Sargan test (p-value)				0.983	0.727	0.225

Estimates based on WG. Clustered standard errors in parentheses.
*, **, *** denote significance levels at 10%, 5% and 1%.
All columns refer to the period 1991-2010

Otras variables dependientes

Otros intangibles

Dep. variable:	[1] Training expenditures/ sales	[2] Training expenditures/ sales	2001-2009 [3] R&D investment and IT applications	[4] R&D investment and IT applications	[5] Patent rights, licenses, and others	[6] Patent rights, licenses, and others
$\Delta Sales_t$	-0.001**	-0.002*	-0.057***	-0.147***	-0.023	-0.034
	(0.000)	(0.001)	(0.018)	(0.051)	(0.017)	(0.042)
$\Delta Sales_{t-1}$	-0.00	-0.00	-0.027	-0.133***	-0.02	0.003
	(0.000)	(0.001)	(0.018)	(0.048)	(0.015)	(0.042)
$CreditConst._{t-1}$		-0.01		0.158		0.187
		(0.001)		(0.211)		(0.193)
$\Delta Sales_t$ x $CreditConst._{t-1}$		0.004		0.279**		0.023
		(0.002)		(0.132)		(0.115)
$\Delta Sales_{t-1}$ x $CreditConst._{t-1}$		0.001		0.321***		-0.068
		(0.001)		(0.120)		(0.101)
Sector Dummies	YES	YES	YES	YES	YES	YES
Firm Dummies	YES	YES	YES	YES	YES	YES
No. Observations	15847	15528	9105	8934	9105	8934
No. of firms	2919	2877	2130	2101	2130	2101

Estimates based on WG. Clustered standard errors in parenthes
*, **, *** denote significance levels at 10%, 5% and 1%.

Content

Complementarities between factors of production

- **One of the issues neglected in the literature is the existence of indirect effects of cycles on growth stemming from complementarities of inputs**
- **Besides, we want to explore a bit further the patterns of complemetarity/substatibility of different stocks of intangibles**
- **We depart from a Translog production function and compute Allen substitution elasticities**
- **We use OLS and GMM estimation methods**
- **We consider value added at the firm level as the output measure and labour, physical capital stock and stock of knowledge capital as inputs**
  - We distinguish between investment in R&D and in patents acquisition
- **We find:**
  - Labour and physical capital are substitutes
  - Labour complements both types of intangible capital in production
  - Physical capital and knowledge capital are substitutes
  - R&D and patents purchase are found weakly substitutes

  - Details

Content

Some conclusions

- **The share of R&D investment is countercyclical, as suggested by the OC theory, in the absence of credit constraints**
- **However, that effect could be reversed in credit constrained firms**
- **This result is robust to different measures of R&D investment, including the share of R&D workers in total employment and different estimation methods**
  - Policy implications:
    - *Financial market imperfections are deterring firms from investing optimally in R&D, with implications for long-term growth – Specially in a crisis like the current one, with a significant credit crunch*
    - *Public support to R&D is required more than ever during crisis –just the contrary to what we are seeing…*
- **Other PEA like training expenditures follow a similar countercyclical pattern**
  - With no effect of credit constraints

Some conclusions

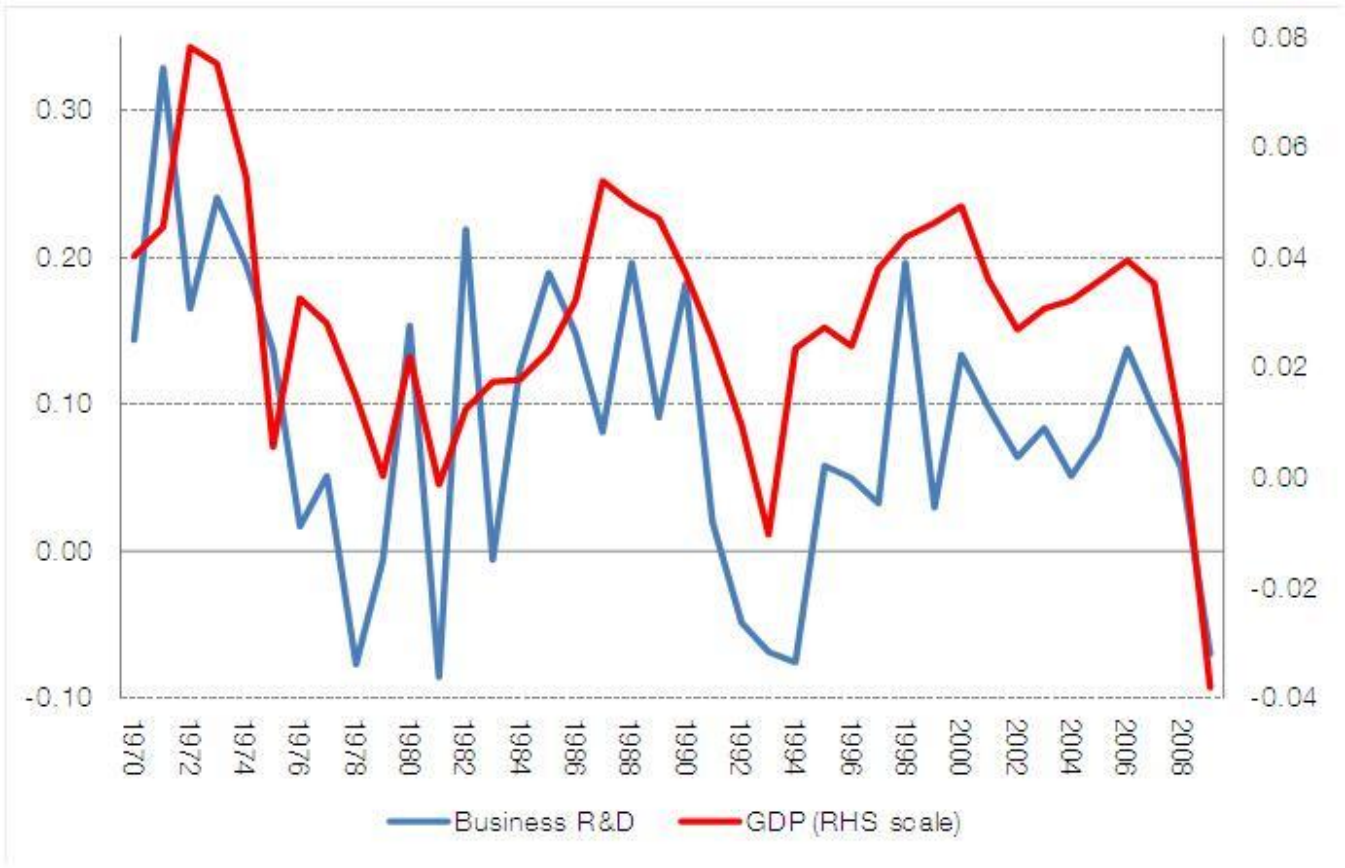
- **The purchase of patent rights seem to be acyclical**
  - There could be some kind of substitution between "produced" and "acquired" R&D
- **This is mildly supported by the estimation of substitute elasticities between the different factors of production**
  - We also find that labour is a complement of physical and knowledge capital in the production process
  - Policy implications: The impact of cycles on growth could be underestimated due to the existence of complementarities between inputs
- **Work in progress:**
  - Explore the asymmetric/symmetric responses of firms to the different phases of the cycle –preliminary results seem to support the fact that CC are binding only during crisis
  - Explore whether the OC theory holds for different types of firms – technology intensive, new innovators and high-growth firms --Results

Y se acabó…

GRACIAS POR VUESTRA ATENCIÓN!!!!!!!!!!

Procyclacility of aggregate R&D in Spain

Annual growth rate of GDP and business R&D expenditures



The CB – details

Period average	***Full sample: 1991-2010***
Number of firms	3278
Number of observations	26543
Minimum nº of consecutive obs. per firm	3
Median nº of consecutive obs. per firm	7
Balanced?	no
% innovating	23
Sector distribution	
manufacturing	44.5
construction	7.4
services	41.8
other	6.4
Size distribution	
Small	7.1
Medium	47.1
Large	45.9
% exporting	55.3
% public	7.4
% stock market	6.1

Coverage

Database coverage[1], 2005

	Value-added	*Employment*	*Wages*
Energy	71.3	57.5	79.1
Industry	28.5	18.1	27.4
Mkt. Services	20.4	23.7	26.3
Other[2]	7.6	6.7	10.2

[1] *Ratio of CB firms to National Accounts´non-financial sector aggregate*

[2] *Includes agriculture, fishing, extraction and construction*

PITEC – Distribution of constrained firms

Period average, % constrained firms	*Matched sample: 2004-2009*
Overall	23%
by sector of activity	
manufacturing	21%
construction	33%
services	23%
other	31%
By size	
Small	28%
Medium	25%
Large	22%
By age	
< 10 years	27%
Between 10 and 19	25%
More than 20	20%
By debt ratio	
Lower than p10 (by sector and year)	11%
Higher than p90 (by sector and year)	24%
By total debt burden	
Lower than p10 (by sector and year)	13%
Higher than p90 (by sector and year)	24%
By cash-flow	
Lower than p10 (by sector and year)	32%
Higher than p90 (by sector and year)	20%
By collateral	
Lower than p10 (by sector and year)	26%
Higher than p90 (by sector and year)	17%

Indicador directo de restricciones financieras

	(1)	(2)	(3)	(4)	(5)	(6)
DV: probability of facing credit constraints	Ordered probit	Ordered probit	Ordered probit	Ordered probit	Ordered probit	Probit (=1 if high or medium CC)
Young	0.02	0.02				
Small	.15***		.14***	.18***	.14***	.52***
lnedad			-.03**	-.02	-.02**	-.03
lnn		-.01				
Quoted	0.01	0.01	0.02	0.02		0.03
Manufacturing	-.11***	-.12***	-.11***		-.11***	
Construction (omitted)						
Services	-.08**	-.08**	-.08**		-.08**	
Leverage ratio	.13**	.12***	.12***	.12***	.12***	.11*
Total debt burden	.00**	.00**	.00**	.00**	.00**	.00**
Cash-flow (Top 50%)	-.05***	-.05***	-.05***	-.06***	-.05***	-.06**
Colateral (Top 50%)	-0.03	-0.02	-0.03	-0.01		0.02
GDP growth	-0.001	-.001	-.001	-.001		-.01**
10 sector dummies	no	no	no	yes	no	yes
Observations	3059	3059	3059	3059	3059	3059
Clusters	946	946	946	946	946	946
% firms correctly placed	71.4	72.2	72.1	71.3	72.3	57.8

Robust standard errors in parentheses.

, **, * denote significance levels at 10%, 5% and 1%.*

All regressions include sector and time dummies, and a constant, not reported.

Transparencias de apoyo –variables (I)

Personal dedicado a I+D

		Todos los sectores		Sector de empresas	
	Definición (según el manual Frascati)	UE-15	España	UE-15	España
Total	En "head counts"	2906229	299069	1277252	108124
Investigadores	Profesionales dedicados a la dirección, concepción o creación de conocimiento, productos y procesos, métodos y sistemas, en % del total	61.3	62.8	53.1	44.4
Técnicos	Realizan tareas científicas y técnicas, incluyendo larealización de experimentos, preparación de programas informáticos, realización de cálculos etc., bajo la supercisión de los investigadores		20.8		37.7
Personal de apoyo	Incluye personal cualificado y no cualificado realizando tareas administrativas de apoyo a los investigadores		16.4		17.9

Transparencias de apoyo –variables (II)
Variables dependientes

Variable	*Definition*
Dependent variable	
R&D/investment	Computed as the ratio between R&D spending and te sum of R&D spending and investment in physical capital
R&D/GVA	R&D spending over gross value added
R&D/GOS	R&D spending over gross operating surplus
R&D per capita	Real R&D spending over firm's average employment in year t, deflated with value-added sector deflator
R&D personnel	Percentage of total employment devoted to R&D activities
Tangible investment	Investment in tangible assets in year t over physical capital stock at the end of the previous period, t-1
Training spending	Firm's spending in training over the sum of training spending and total (tangible and intangible) investment. Available from 1991 to 2007.
Investment in R&D and IT	Investment in R&D and IT with success prospects and that can be assigned to a specific project. Computed as a share of total investment. Available from 2001 to 2009.
Investment in other intangibles	Investment in purchase of patent rights, goodwill, franchises and licenses, as a share of total investment. Available from 2001 to 2009.

Transparencias de apoyo –variables (III)

Variables explicativas

Explanatory variables	
Sales growth	Growth rate of real sales of the firm in year t-1, deflated with a value-added deflator
Credit Constraint (CC)	Estimated probability that a firm faces financial obstacles important enough to hamper its innovative activity. Computed using a two-stage approach. In the first stage, an ordered probit was run to estimate the relative importance of dummies for young age, small size, sector of activity, time dummies and the leverage ratio of the firm to explain a positive answer to a survey on financial obstacles to innovation (PITEC). The regression was run for firms both in the CB and PITEC. In the second stage the estimated coefficients and value fo the explanatory variables were used to estimate the probability of facing financial obstacles for innovation investment across all firms in the CB database.

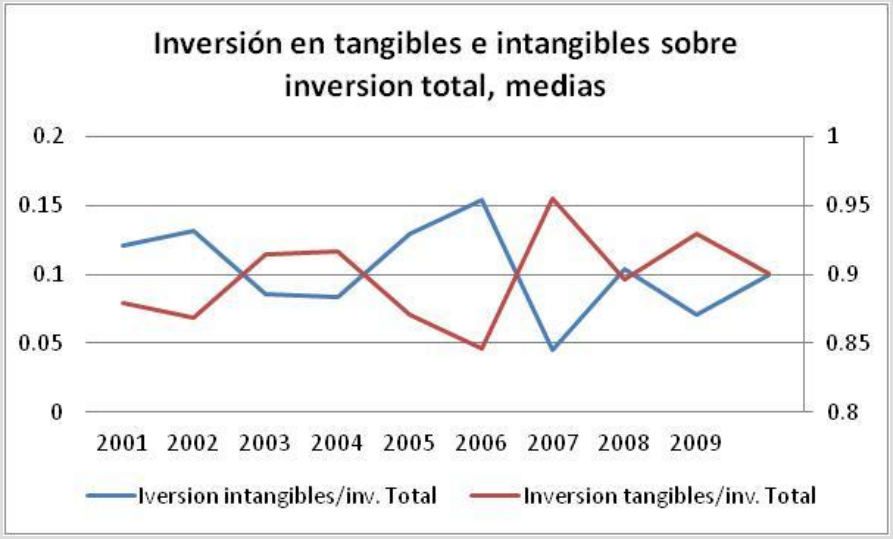
Transparencias de apoyo –variables (IV)

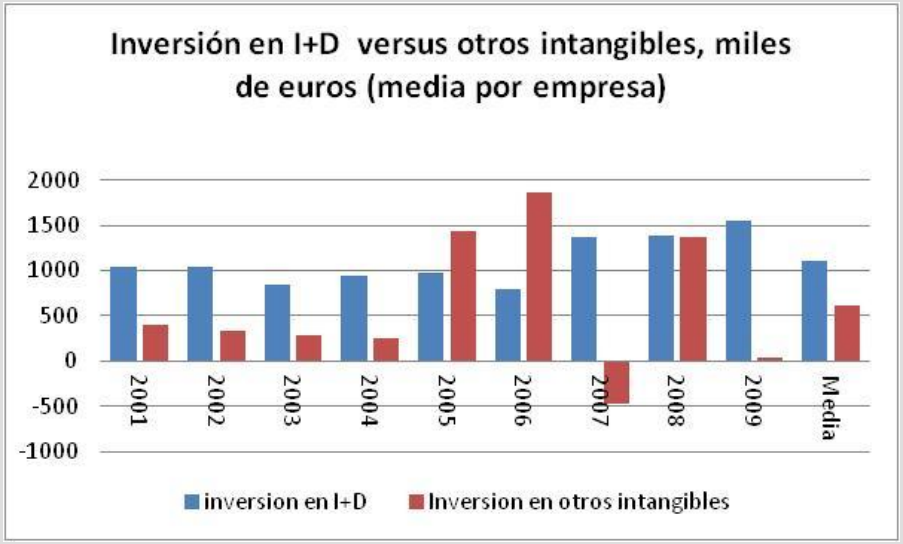
Variables para la construcción del indicador de CC

Computing a direct indicator of financial obstacles	
FinObst	Response of firms in both PITEC and CB to the question "During the two previous years, how important was the lack of finance from sources outside your enterprise for hampering your innovation activities?" Responses were ranked from 1 (high) to 3 (low)
Young	=1 if a firm has less than 5 years of operations
Small	=1 if a firm has less than 50 employees
Quoted	=1 if firm is quaoted in the stock market
Leverage ratio	Firm's external funds with cost to internal funds, at t-1
Cash-flow	Gross operating surplus plus financial interests received over stock of capital of the previous period, at t-1
Total debt burden	Short-term debt with cost plus interests paid over cash-flow, at t-1
Collateral	Share of tangible assets over total assets, at t-1

Transparencias de apoyo –variables (V)

Inversión en tangibles e intangibles





Otras proxies de la intensidad en I+D

Dep. Variable:	[1] R&D exp./GVA	[2] R&D exp./Empl.	[3] R&D exp./GOS	[4] Ratio R&D empl.
$\Delta Sales_t$	-0.041**	-0.745	-0.354***	-0.003*
	(0.016)	(0.562)	(0.071)	(0.002)
$CreditConst._{t-1}$	0.02	1.42	-2.196	-0.018**
	(0.021)	(1.593)	(1.749)	(0.006)
ΔSalest x CreditConst.t-1	0.082**	1.545	0.782***	0.007*
	(0.032)	(1.154)	(.0169)	(0.005)
Sector Dummies	YES	YES	YES	YES
Firm Dummies	YES	YES	YES	YES
No. Observations	17518	17518	17518	15572
No. of firms	3103	3103	3103	2879

Estimates based on WG. Clustered standard errors in parentheses.
*, **, *** denote significance levels at 10%, 5% and 1%.
All columns refer to the period 1991-2009

Volver

Efectos heterogéneos (I)

- **¿Afecta de forma diferente este canal a las empresas de alta tecnología? ¿Y a las empresas que incian su actividad innovadora? ¿Y a las de alto crecimiento?**

- **Permitimos que el efecto del ciclo sea diferente para algunas empresas:**

$$RD_{it}^{share} = \beta_0 + \beta_1 \Delta sales_{it} + \beta_2 \Delta sales_{it} D_{it} + \gamma_0 cc_{it-1} + \gamma_1 \Delta sales_{it} cc_{it-1} + \gamma_2 \Delta sales_{it} cc_{it-1} D_{it} + D_{it} + \mu_t + \eta_i + \nu_{it}$$

donde D_{it} es una variable dicotómica que toma el valor 1 si la empresa *i* en el año *t* es de alta tecnología, nueva innovadora o de alto crecimiento.

Efectos heterogéneos (II)

Dep. variable: ratio of R&D exp. over total investment	[1]	[2]	[3]	[4]	[5]	[6]
	High Tech. Firms (D_t)		New Innov. Firms (D_t)		High Growth Firms (D_t)	
$\Delta Sales_t$	-0.006**	-0.018	-0.007**	-0.024*	-0.010***	-0.035**
	(0.003)	(0.012)	(0.003)	(0.014)	(0.003)	(0.015)
$\Delta Salest \times D_t$	-0111**	-0.159	-0.111**	-0.394	0.001	0.018
	(0.040)	(0.213)	(0.057)	(0.262)	(0.014)	(0.054)
$CreditConst._{t-1}$		0.08		0.077		0.080
		(0.058)		(0.058)		(0.058)
$\Delta Salest \times CreditConst.t\text{-}1$		0.038		0.051*		0.076**
		(0.028)		(0.031)		(0.033)
$\Delta Sales_t \times CreditConst._{t-1} \times D_t$		0.168		1.11		-0.072
		(0.895)		(0.939)		(0.125)
Sector Dummies	YES	YES	YES	YES	YES	YES
Firm Dummies	YES	YES	YES	YES	YES	YES
No. Observations	21676	17506	21676	17506	21676	17506
No. of firms	3270	3103	3270	3103	3270	3103

Estimates based on WG. Clustered standard errors in parentheses.

*, **, *** denote significance levels at 10%, 5% and 1%.

All columns refer to the period 1991-2010

- **Función de producción translog:**

$$Y_{it} = \alpha_K \ln K_{it} + \alpha_L \ln L_{it} + \alpha_C \ln C_{it} + \alpha_{KK} (\ln K_{it})^2 + \alpha_{LL} (\ln L_{it})^2 + \alpha_{CC} (\ln C_{it})^2$$
$$+ \alpha_{KL} \ln K_{it} \ln L_{it} + \alpha_{KC} \ln K_{it} \ln C_{it} + \alpha_{CL} \ln C_{it} \ln L_{it} + \mu_t + \delta_j + \nu_{it}$$

Y es VA, *L* es trabajo (descontando el dedicado a I+D), *C* es el stock de capital intangible (distinguiendo entre I+D y patentes) y *K* es el stock de capital físico

- **Consideramos la elasticidad de sustitución parcial de Allen.**
- **Para capital (K) y trabajo (L) sería:**

$$\sigma_{KL} = \frac{Kf_K + Lf_L + Cf_C}{KL} \frac{|H_{KL}|}{|H|}$$

$$\sigma_{KL} > 0 \Rightarrow \text{sustitutos}$$

$$\sigma_{KL} < 0 \Rightarrow \text{complementos}$$

Complementariedades
Detalles II

3 inputs	[1] OLS	[2] GMM
η_K	0.23***	0.23***
	(0.007)	(0.008)
η_L	0.61***	0.59***
	(0.011)	(0.013)
η_C	0.03***	0.04***
	(0.004)	(0.004)
σ_{KL}	-0.73***	-0.68***
	(0.132)	(0.124)
σ_{CK}	2.14**	1.78**
	(1.076)	(1.039)
σ_{CL}	-2.60***	-2.53***
	(0.951)	(0.997)
No. Obs.	19734	16564
No. Firms	3169	3105
R^2	0.82	-

*, **, *** denote significance levels at 10%, 5% and 1%.

η refers to elasticity

σ refers to Allen partial elasticity of substitution

Columns [1]-[2] refer to the period 1991-2009.

Columns [3]-[4] to 2001-2009.

4 inputs	[3] OLS	[4] GMM
η_K	0.22***	0.21***
	(0.010)	(0.010)
η_L	0.61***	0.61***
	(0.013)	(0.015)
η_{C1}	0.03***	0.03***
	(0.006)	(0.007)
η_{C2}	0.01**	0.01**
	(0.005)	(0.007)
σ_{KL}	-0.55***	-0.53***
	(0.106)	(0.111)
σ_{C1K}	0.58	0.72*
	(0.49)	(0.53)
σ_{C2K}	1.39**	1.26**
	(0.65)	(0.644)
σ_{C1L}	-0.96***	-1.06***
	(0.387)	(0.446)
σ_{C2L}	-1.32***	-1.27**
	(0.527)	(0.570)
σ_{C1C2}	1.90	1.65
	(2.885)	(3.079)
No. Obs.	8424	6266
No. Firms	2060	1897
R^2	0.80	-