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Innovation and firm growth: Does firm age play a role?

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Sixth IRIMA Workshop on
"R&D Investment and Firm Dynamics"

Motivation

- Large interest in Young Innovative Companies (**YICs**) because:
  - Young firms contribute more to job creation (Haltiwanger et al., 2013, Lawless, 2014; Hyytinen and Maliranta, 2013)
  - Potential disruptive capacity (Coad and Reid, 2012, Daunfeldt et al., 2014)
- Evidence: Europe needs young large leading innovators (**Yollies**) (Veugelers and Cincera, 2010)
- **Purpose**:

  Analyse the moderating role of age on the relationship between R&D investment and firm growth

Young firms

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- ✓ A **“fresh perspective”** on the state of the industry .
- ✓ New **market opportunities** or **technological opportunities**.
- ✓ Larger **flexibility** to capitalize on radical innovations, without cannibalizing existing market share.

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- ✓ **Lower stocks** of knowledge, team-level job tenure experience, routines and tacit knowledge.
- ✓ Difficulties to develop **innovation capabilities**.
- ✓ **Liabilities of newness and inexperience**.
- ✓ Possibly **larger uncertainty** surrounding their R&D investments
  - ✓ Older firms have more diversified portfolio of R&D projects, more incremental innovations

Old firms

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- ✓ Accumulation of **resources**, **managerial knowledge** and the **ability to handle uncertainty**.
- ✓ Accumulation of **reputation** and **market position**.

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- ✓ Organizational **inertia** constraining the ability to change and diminishing learning effects.
- ✓ **Obsolescence** if the directions of search activities are not well suited to the contemporaneous technological landscape

Hypotheses

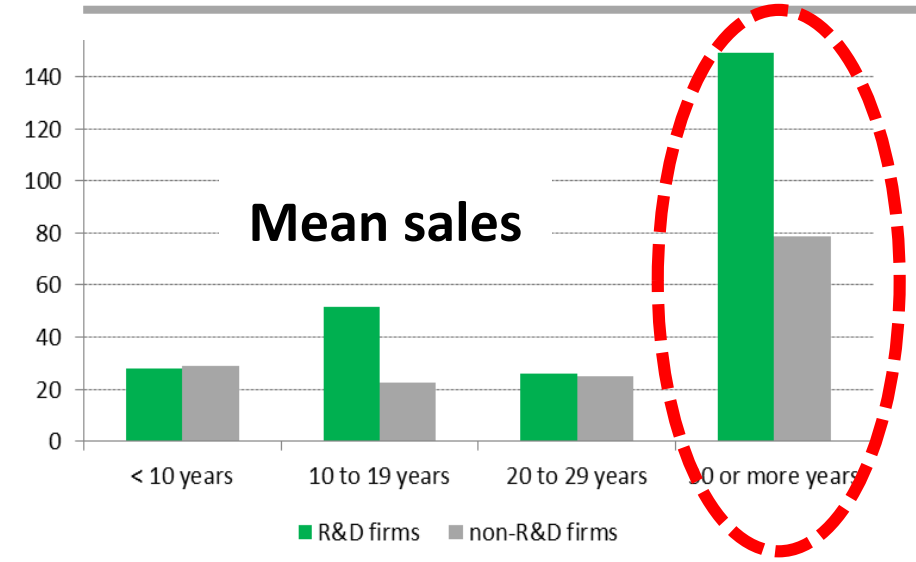
Hypothesis 1: R&D is positively associated with firm growth, on average

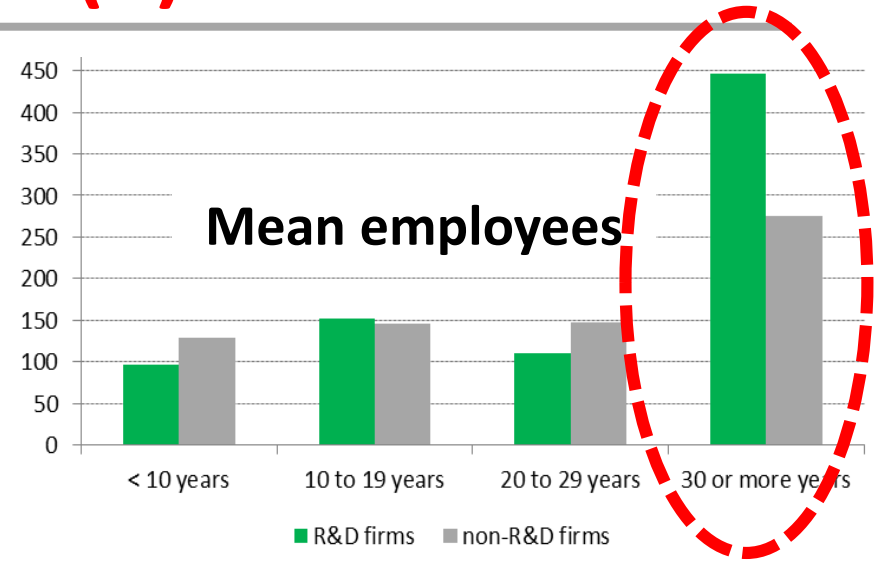
- **Hypothesis 1a: for young firms,** R&D has larger positive effect on growth at the upper quantiles
- **Hypothesis 1b: for young firms,** R&D has more negative effect on growth at the lower quantiles

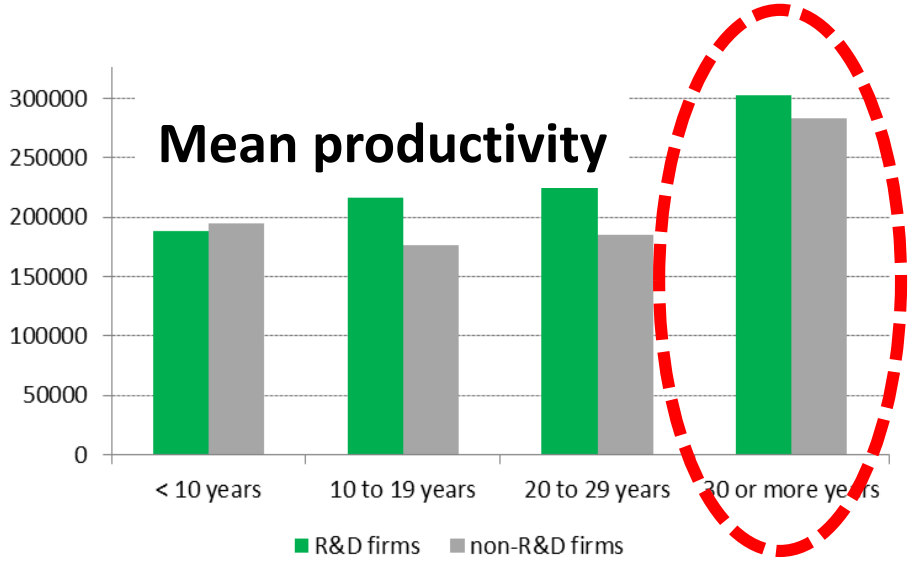
Database (I)

- Panel data 2004-2012 Technological Innovation Panel (PITEC – Panel de Innovación Tecnológica) compiling Spanish CIS.
- Manufacturing & service sectors.
- Representative of Spanish firms
  - all firms 200+ employees, random selection of firms < 200 employees

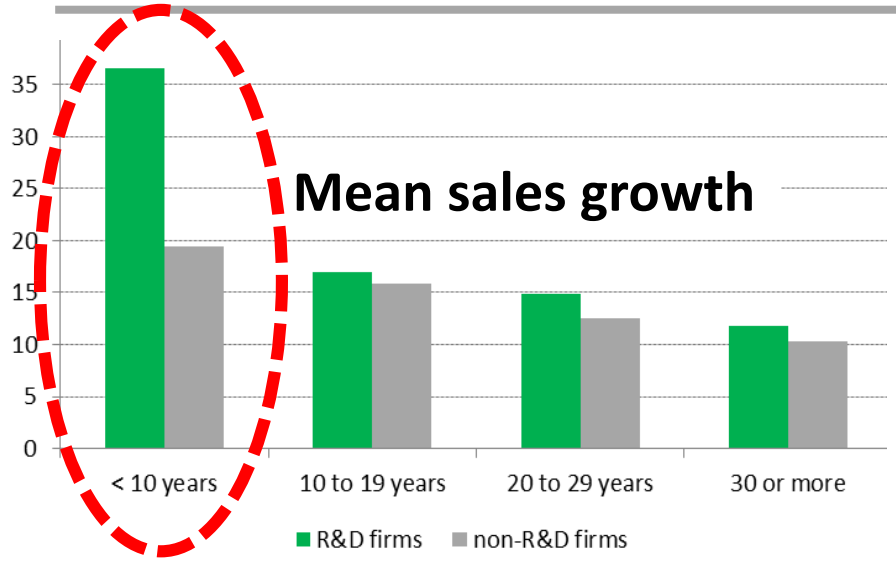
Database (II)

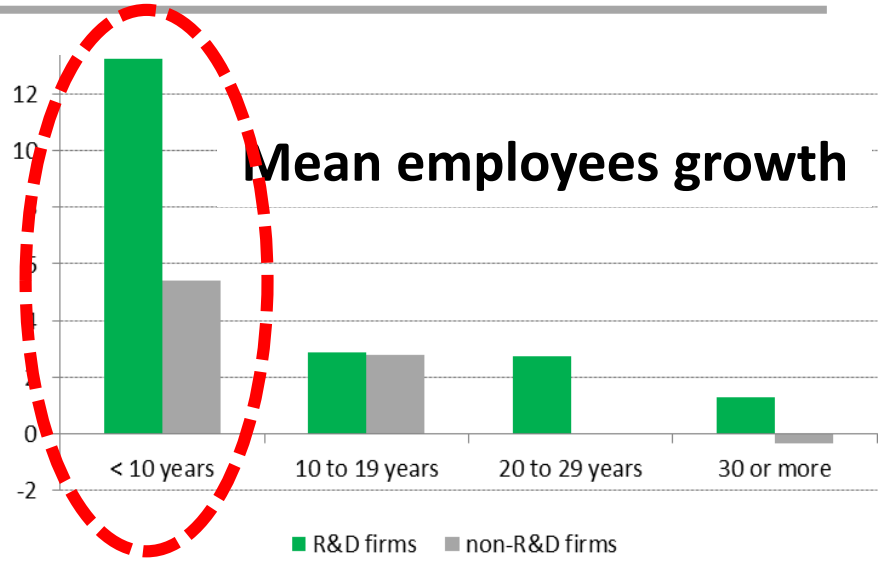

Mean sales
140
120
100
80
60
40
20
0
< 10 years
10 to 19 years
20 to 29 years
30 or more years
R&D firms
non-R&D firms

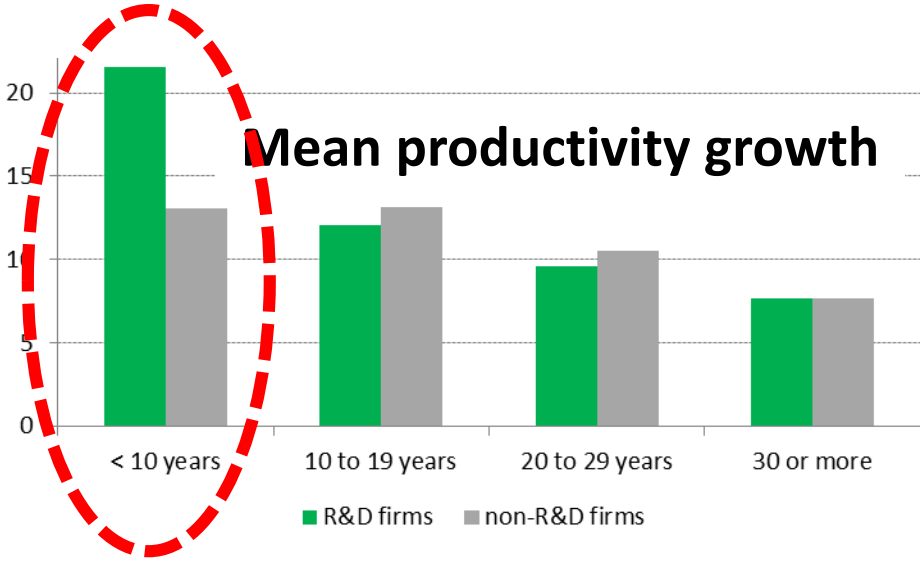

Mean employees
450
400
350
300
250
200
150
100
50
0
< 10 years
10 to 19 years
20 to 29 years
30 or more years
R&D firms
non-R&D firms


Mean productivity
300000
250000
200000
150000
100000
50000
0
< 10 years
10 to 19 years
20 to 29 years
30 or more years
R&D firms
non-R&D firms

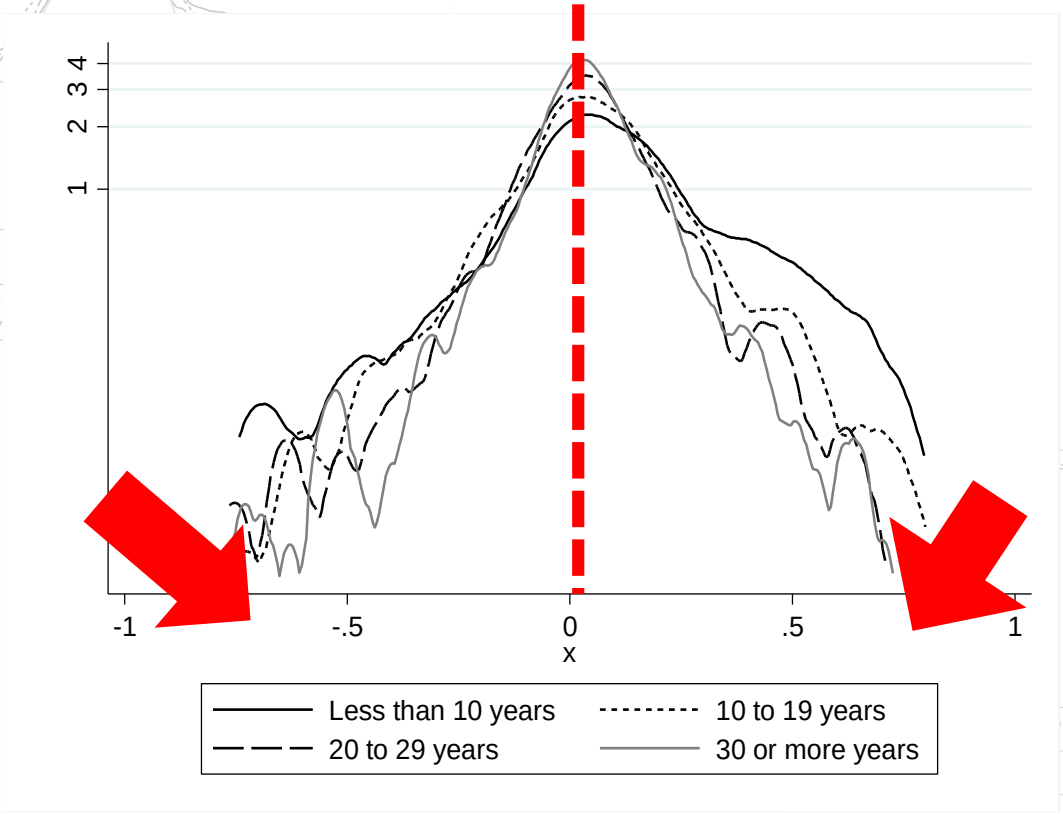
Database (III)







Firm growth distribution



Econometrics

- Panel quantile regression (Canay, 2011):

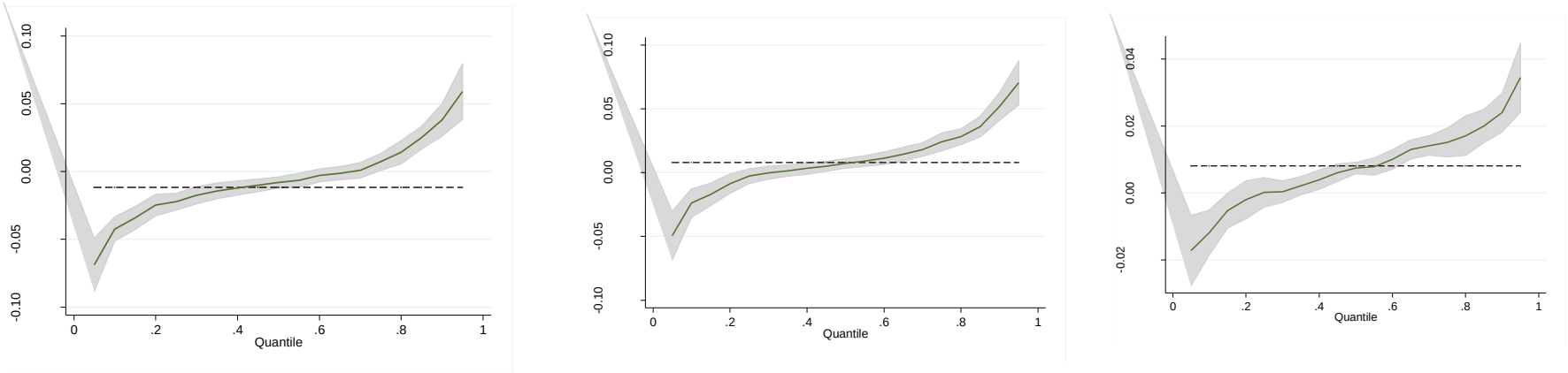
$$\mathbf{GrSales}_{i,t} = \alpha_{10} + \alpha_{11}\text{LogSales}_{i,t-1} + \alpha_{12}\text{GrEmpl}_{i,t} + \alpha_{13}\,\text{GrInv}_{i,t} + \alpha_{14}\text{RDintensity}_{i,t-1} + \alpha_{15}\,\mathbf{Young \times RDintensity}_{\mathbf{i,t-1}} + \alpha_{16}\,\text{Controls}_{i,t} + u_1 + \varepsilon_{1i,t} \quad [1]$$

$$\mathbf{GrProd}_{i,t} = \alpha_{20} + \alpha_{21}\text{LogProd}_{i,t-1} + \alpha_{22}\text{GrEmpl}_{i,t} + \alpha_{23}\,\text{GrInv}_{i,t} + \alpha_{24}\text{RDintensity}_{i,t-1} + \alpha_{25}\,\mathbf{Young \times RDintensity}_{\mathbf{i,t-1}} + \alpha_{26}\,\text{Controls}_{i,t} + u_2 + \varepsilon_{2i,t} \quad [2]$$

$$\mathbf{GrEmpl}_{i,t} = \alpha_{30} + \alpha_{31}\text{LogEmpl}_{i,t-1} + \alpha_{32}\text{GrInv}_{i,t} + \alpha_{33}\text{RDintensity}_{i,t-1} + \alpha_{34}\,\mathbf{Young \times RDintensity}_{\mathbf{i,t-1}} + \alpha_{35}\text{Controls}_{i,t} + u_3 + \varepsilon_{3i,t} \quad [3]$$

Results

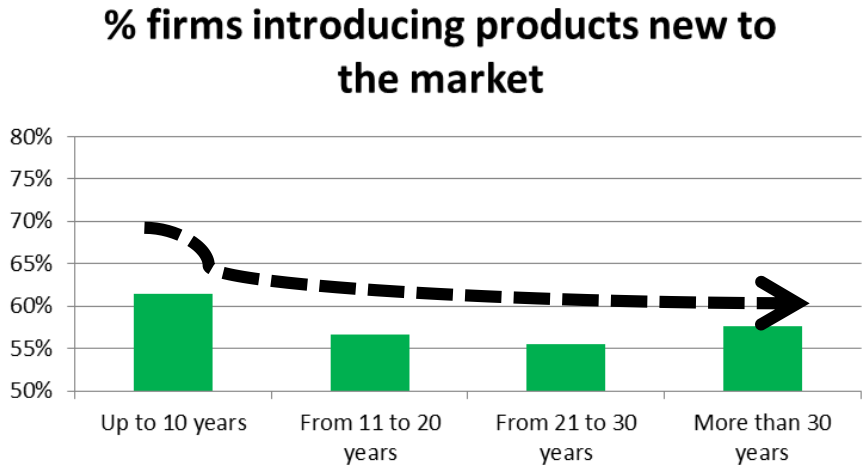
Figure 3: Quantile regression plots. Effects of the interaction term **Young × RDintensity$_{i,t-1}$** (see equations [1] - [3]) on firm growth (i.e. growth of sales (left), growth of productivity (centre), and growth of employment (right)).

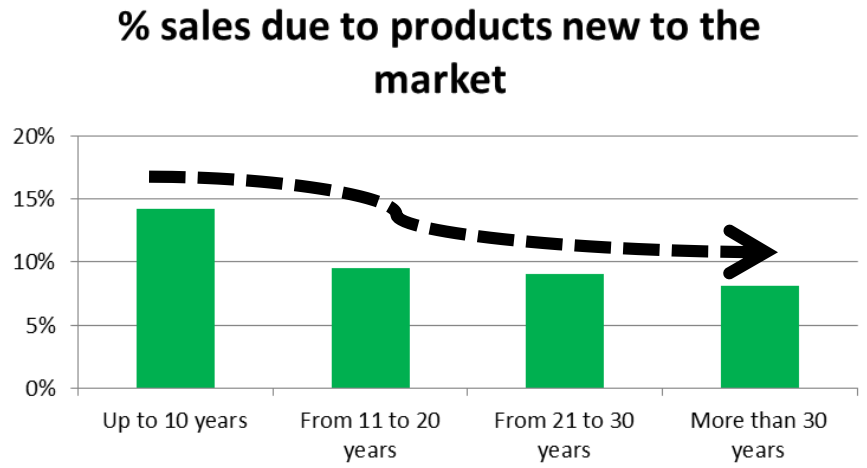


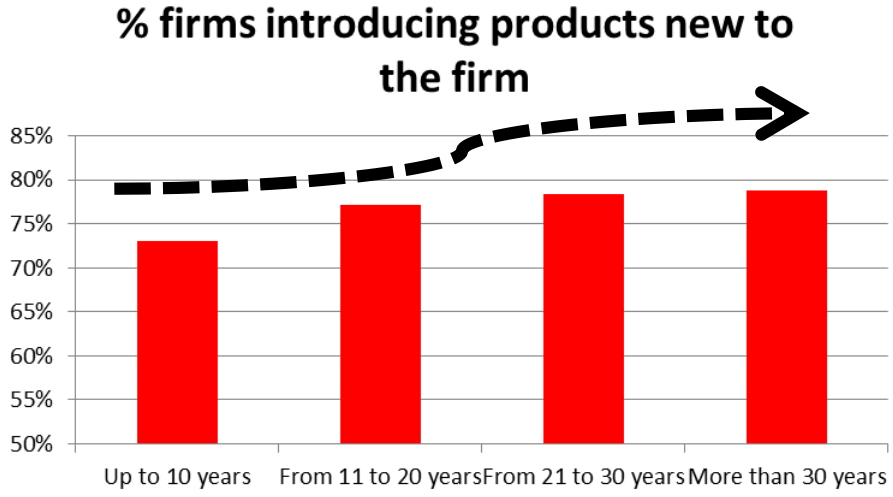
Notes: Coefficients of **Young × RDintensity$_{i,t-1}$** across quantiles. The panel quantile regression estimates are connected by a solid black line along with an estimated 95%-confidence interval (non-bootstrapped in these plots). The OLS coefficient is a broken horizontal line.

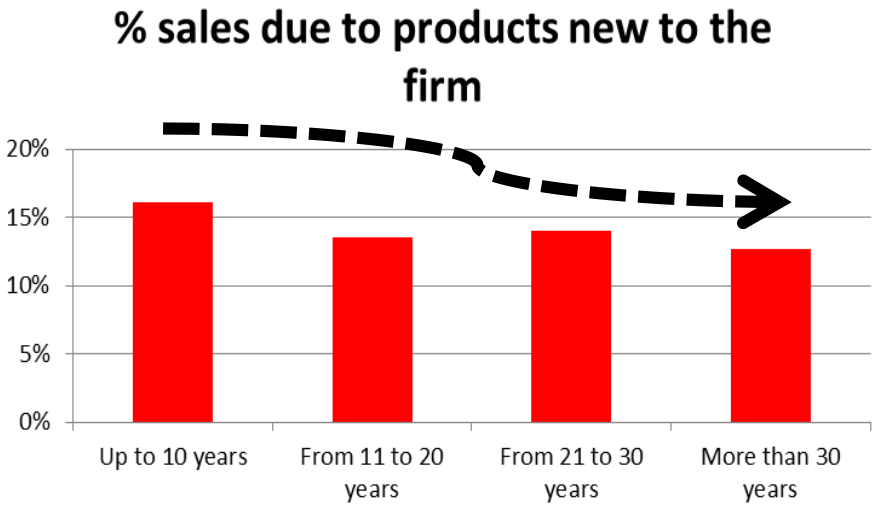
- ✓ R&D for young firms seems to be specially risky.
- ✓ Faster and lower growth rates

Alternative indicators of radicalness of innovation









Conclusions

- **R&D** is associated with higher growth rates in the upper quantiles, and negative in the lower quantiles (with the exception of labour growth).
- At the median, **R&D has a positive impact on labour and productivity, while negatively related to sales growth.**

- Young firms investing in R&D face higher risks
  - **double-edged sword:** higher or lower growth rates
- Young firms' investment in R&D is more **"labour friendly"**
  - young firms contribute more to employment growth
- **Return** of young firms' R&D investment is more **unequally distributed and more unpredictable**.

Conclusions

- **Policy implications:**
  - Make R&D support conditional on firm age?
    - focused more in young firms, where older firms are less eligible
  - Challenges for age-dependent innovation policy:
    - Young firms have higher death rates
    - 'Reincarnation' of old firms to become eligible again?

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Thanks for your attention!

APPENDICES

Variables

RDintensity	R&D intensity measured as the logarithm of R&D investment per employee
Young	Dummy variable equal to 1 if the firm is aged less than 10 years; otherwise it is equal to 0.
Young *x* *RDintensity*	Interaction term
LogSales ***LogProd*** ***LogEmpl***	The natural log of size, measured in terms of sales, productivity (i.e. sales per employee), or number of employees.
GrInv ***GrSales*** ***GrProd*** ***GrEmpl***	Annual growth rate calculated by taking log-differences of the respective size levels
Cooperation	Dummy variable for R&D cooperation activity.
Exports	Percentage of exports with respect to total sales
Concentration	Percentage of sales by firms with more than 250 employees.

Results (II)

Table 3. Fixed effects quantile regression estimates for sales growth (100 bootstrap replications).

	5%	10%	25%	50%	75%	90%	95%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LogSales $_{t-1}$	-0.560***	-0.562***	-0.568***	-0.574***	-0.577***	-0.584***	-0.589***
	(0.0033)	(0.0019)	(0.0012)	(0.0009)	(0.0011)	(0.0023)	(0.0034)
GrEmpl $_{t}$	0.342***	0.327***	0.315***	0.321***	0.319***	0.293***	0.296***
	(0.0335)	(0.0209)	(0.0131)	(0.0075)	(0.0129)	(0.0195)	(0.0198)
GrInv $_{t}$	0.0023***	0.0013***	0.0007***	0.0007***	0.0005***	0.0005**	0.0008*
	(0.0005)	(0.0003)	(0.0002)	(0.0001)	(0.0002)	(0.0003)	(0.0004)
RDintensity $_{t-1}$	-0.0298***	-0.0197***	-0.0105***	-0.0036***	0.0038***	0.0069***	0.0122***
	(0.0038)	(0.0026)	(0.0012)	(0.0008)	(0.0012)	(0.0020)	(0.0030)
Young x RDintensity $_{t-1}$	-0.0687***	-0.0424***	-0.0223***	-0.0081***	0.0072**	0.0381***	0.0590***
	(0.0100)	(0.0045)	(0.0031)	(0.0021)	(0.0031)	(0.0061)	(0.0105)
Young $_{t}$	0.365***	0.233***	0.116***	0.0344**	-0.0583**	-0.259***	-0.369***
	(0.0714)	(0.0348)	(0.0254)	(0.0170)	(0.0266)	(0.0459)	(0.0811)
Cooperation $_{t-1}$	-0.0010	0.0051	0.0033	0.0119***	0.0126***	0.0228***	0.0370***
	(0.0117)	(0.0067)	(0.0036)	(0.0024)	(0.0033)	(0.0059)	(0.0093)
Exports $_{t-1}$	0.108***	0.0742***	0.0718***	0.0748***	0.0715***	0.0751***	0.0779***
	(0.0190)	(0.0127)	(0.0066)	(0.0049)	(0.0078)	(0.0129)	(0.0180)
Concentration $_{t-1}$	-0.0005***	-0.0005***	-0.0005***	-0.0005***	-0.0006***	-0.0007***	-0.0005***
	(0.0001)	(7.57e-05)	(4.82e-05)	(3.27e-05)	(4.80e-05)	(0.0001)	(0.0002)
Constant	8.773***	8.854***	9.057***	9.235***	9.354***	9.577***	9.705***
	(0.0716)	(0.0438)	(0.0238)	(0.0174)	(0.0241)	(0.0466)	(0.0710)
Pseudo-R2	0.7257	0.7575	0.7886	0.8016	0.7888	0.7578	0.7282
Observations				26,600			

Time and sectoral dummies are included.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results (III)

Table 4. Fixed effects quantile regression estimates for productivity growth (100 bootstrap replications).

	5%	10%	25%	50%	75%	90%	95%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LogProd $_{t-1}$	-0.686***	-0.682***	-0.687***	-0.697***	-0.700***	-0.710***	-0.719***
	(0.0073)	(0.0039)	(0.0025)	(0.0018)	(0.0025)	(0.0047)	(0.0056)
GrEmpl $_{t}$	-0.336***	-0.342***	-0.343***	-0.353***	-0.373***	-0.399***	-0.395***
	(0.0353)	(0.0170)	(0.0119)	(0.0065)	(0.0111)	(0.0156)	(0.0219)
GrInv $_{t}$	0.0019***	0.0012***	0.0006***	0.0007***	0.0004*	0.0007**	0.0012***
	(0.0005)	(0.0003)	(0.0002)	(0.0001)	(0.0002)	(0.0003)	(0.0004)
RDintensity $_{t-1}$	-0.0191***	-0.0065***	0.0031***	0.0108***	0.0176***	0.0279***	0.0371***
	(0.0038)	(0.0022)	(0.0012)	(0.0008)	(0.0012)	(0.0021)	(0.0031)
Young x RDintensity$_{t-1}$	-0.0495***	-0.0239***	-0.0027	0.0072***	0.0240***	0.0517***	0.0704***
	(0.0098)	(0.0057)	(0.0029)	(0.0019)	(0.0036)	(0.0055)	(0.0088)
Young $_{t}$	0.243***	0.106**	-0.0173	-0.0712***	-0.176***	-0.349***	-0.442***
	(0.0726)	(0.0457)	(0.0245)	(0.0161)	(0.0299)	(0.0396)	(0.0665)
Cooperation $_{t-1}$	-0.0065	-0.0061	-0.0018	0.0018	0.0035	0.0032	0.0177*
	(0.0113)	(0.0058)	(0.0029)	(0.0023)	(0.0033)	(0.0058)	(0.0098)
Exports $_{t-1}$	0.0215	0.0139	0.0099*	0.0230***	0.0083	0.0295**	0.0292
	(0.0207)	(0.0124)	(0.0053)	(0.0050)	(0.0076)	(0.0148)	(0.0195)
Concentration $_{t-1}$	-0.0006***	-0.0006***	-0.0007***	-0.0007***	-0.0007***	-0.0008***	-0.0006***
	(0.0001)	(8.33e-05)	(5.08e-05)	(3.57e-05)	(4.95e-05)	(0.0001)	(0.0002)
Constant	7.901***	7.879***	8.023***	8.193***	8.291***	8.461***	8.599***
	(0.0906)	(0.0517)	(0.0311)	(0.0228)	(0.0318)	(0.0589)	(0.0723)
Pseudo-R2	0.5688	0.6126	0.6560	0.6751	0.6698	0.6455	0.6264
Observations				26,600			

Time and sectoral dummies are included.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Results (IV)

Table 5. Fixed effects quantile regression estimates for employment growth (100 bootstrap replications).

	5%	10%	25%	50%	75%	90%	95%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LogEmpl $_{t-1}$	-0.332***	-0.337***	-0.343***	-0.347***	-0.349***	-0.354***	-0.357***
	(0.0023)	(0.0016)	(0.0008)	(0.0005)	(0.0007)	(0.0013)	(0.0017)
GrInv $_{t}$	0.0010***	0.0006***	0.0005***	0.0004***	0.0004***	0.0003*	0.0001
	(0.0003)	(0.0002)	(0.0001)	(4.42e-05)	(0.0001)	(0.0002)	(0.0003)
RDintensity $_{t-1}$	0.0053**	0.0084***	0.0093***	0.0126***	0.0150***	0.0175***	0.0205***
	(0.0026)	(0.0015)	(0.0007)	(0.0004)	(0.0006)	(0.0011)	(0.0017)
Young x RDintensity $_{t-1}$	-0.0172***	-0.0119***	0.0002	0.0074***	0.0151***	0.0240***	0.0345***
	(0.0054)	(0.0034)	(0.0022)	(0.0009)	(0.0022)	(0.0030)	(0.0052)
Young $_{t}$	0.0556	0.0363	-0.0300	-0.0669***	-0.103***	-0.144***	-0.204***
	(0.0453)	(0.0284)	(0.0195)	(0.0070)	(0.0187)	(0.0253)	(0.0430)
Cooperation $_{t-1}$	0.0047	-0.0009	0.0046**	0.0027***	0.0026	0.0017	0.0016
	(0.0052)	(0.0030)	(0.0018)	(0.0009)	(0.0017)	(0.0035)	(0.0054)
Exports $_{t-1}$	0.0757***	0.0521***	0.0230***	0.0202***	0.0129***	-0.0022	-0.0142
	(0.0098)	(0.0077)	(0.0037)	(0.0023)	(0.0041)	(0.0084)	(0.0117)
Concentration $_{t-1}$	0.0001	0.0002**	0.0001***	3.56e-05**	-4.65e-05*	-0.0002***	-0.0002**
	(7.55e-05)	(6.21e-05)	(3.09e-05)	(1.54e-05)	(2.59e-05)	(4.71e-05)	(8.64e-05)
Constant	1.021***	1.132***	1.252***	1.307***	1.352***	1.430***	1.492***
	(0.0320)	(0.0177)	(0.00812)	(0.0048)	(0.0067)	(0.0130)	(0.0200)
Pseudo-R2	0.6896	0.7171	0.7542	0.7677	0.7469	0.7062	0.6731
Observations				26,612			

Time and sectoral dummies are included.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1