Profits, R&D and non-linearities in firm size distribution

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International Conference:
"Innovations and emerging technologies for the prosperity and quality of life in the Polish and EU regions"

Kozminski University
Warsaw, 27-28 November 2014

Presentation's outline

- Main scope, novelty & motivation
- Research questions
- Review of literature
- Dataset
- Methodological approach
- Main results and possible explanations
- Conclusions
- Implications for policy

WHAT IS THIS PAPER ABOUT?

Main scope:

An empirical analysis of the impact of firms R&D investment on their profits, investigating possible non-linear returns from marginal changes in firm size (and from different industrial sectors)

Originality*:*

To investigate innovative firms including, altogether, the following aspects:

- *Impact of R&D investment on firm profits*
- *Effect of marginal changes in firm size on their profits*
- *Controlling for other firm specificities*
- *Using a novel panel of firms micro-data.*

WHY THIS PAPER?

Motivation: problems & dilemmas addressed

- Contribute to limited literature on firm' R&D-Profits relationship
- Analyze how profits "varies" across firm *size* and *sectors*
- Find out if/how much businesses should rely on R&D to foster higher returns
- Identify possible consequences for policies.

Aim*:*

Better understand of returns to R&D investment considering firms' heterogeneity ➔ to contribute to the literature of innovation and firm competitiveness

RESEARCH QUESTIONS

1. *Which is the impact of firm' past R&D investment efforts on its profits?*

2. *Could corporate returns "explain" the firm size distribution?*

3. *Do sector specificities influence Q1. and Q2. above?*

THEORETICAL FRAMEWORK (I)

Firms finance their own R&D because its output is able to generate innovation and subsequent firms' profits

Schumpeter (1942): Innovation provides companies with an innovative rent by shifting the revenue and (or) cost curve costs. These extra profits ensure more general economic growth.

There are firms that look for their optimal size to try maximizing their profits (growing doesn't necessary imply more profits)

Penrose (1959): strong link between firm growth and profitability; profits are the main drivers of firm growth

Cohen and Klepper (1996): larger firms can average the fixed costs associate to innovation on a larger output and therefore their returns to R&D tend to be higher

Acs and Audretsch (1987): smaller firms may benefit from more creative R&D projects and have a more technical scope for their exploitation.

THEORETICAL FRAMEWORK (II)

Higher tech sectors enjoy higher returns because their R&D is more strongly associated to product (than process) innovations

Parisi et al. *(2006): R&D is strongly associated with the probability of introducing product innovations; fixed capital, besides reflecting economies of scale, increases the probability of introducing a process innovation.*

Firms size distribution is highly (and persistently) skewed

Simon and Bonini *(1958);* ***Sutton*** *(1997);* ***Axtell*** *(2001):* ➔ *general law or specific socio-economic factors to explain the highly skewed size distribution of firms ?*

EMPIRICAL EVIDENCE

Link between R&D investment and profits

- Positive due to the build-up of R&D capital stock as a result of R&D activities - **Griliches** (1998); **Hall *et al.*** (2010)

- Depends on the expectation of a higher demand/sales (**Grabowski**, 1968), or on the anticipation of future returns (**Pollak**, 2014)

- Sector specificities: higher R&D investment due to expected higher returns in sectors closer to technological frontier (**Bogliaccino and Pianta**, 2013)

Influence of firm size on profits

- Smaller specialized R&D investors show high performances (**Acs and Audretsch**, 1987)

- Larger firms show higher returns to R&D (**Cohen and Klepper**, 1996)

- Distortion of firm size distribution due to institutional regulations (**Garicano *et al.***, 2013), or scope economies (**Sutton**, 1997), or entrepreneurial strategies (**Brännback *et al.***, 2014)

DATASET

- We rely on **ten** waves (2004-2013) of the **annual** EU Industrial R&D Investment Scoreboard (European Commission): economic and financial micro-data of top world R&D investors.

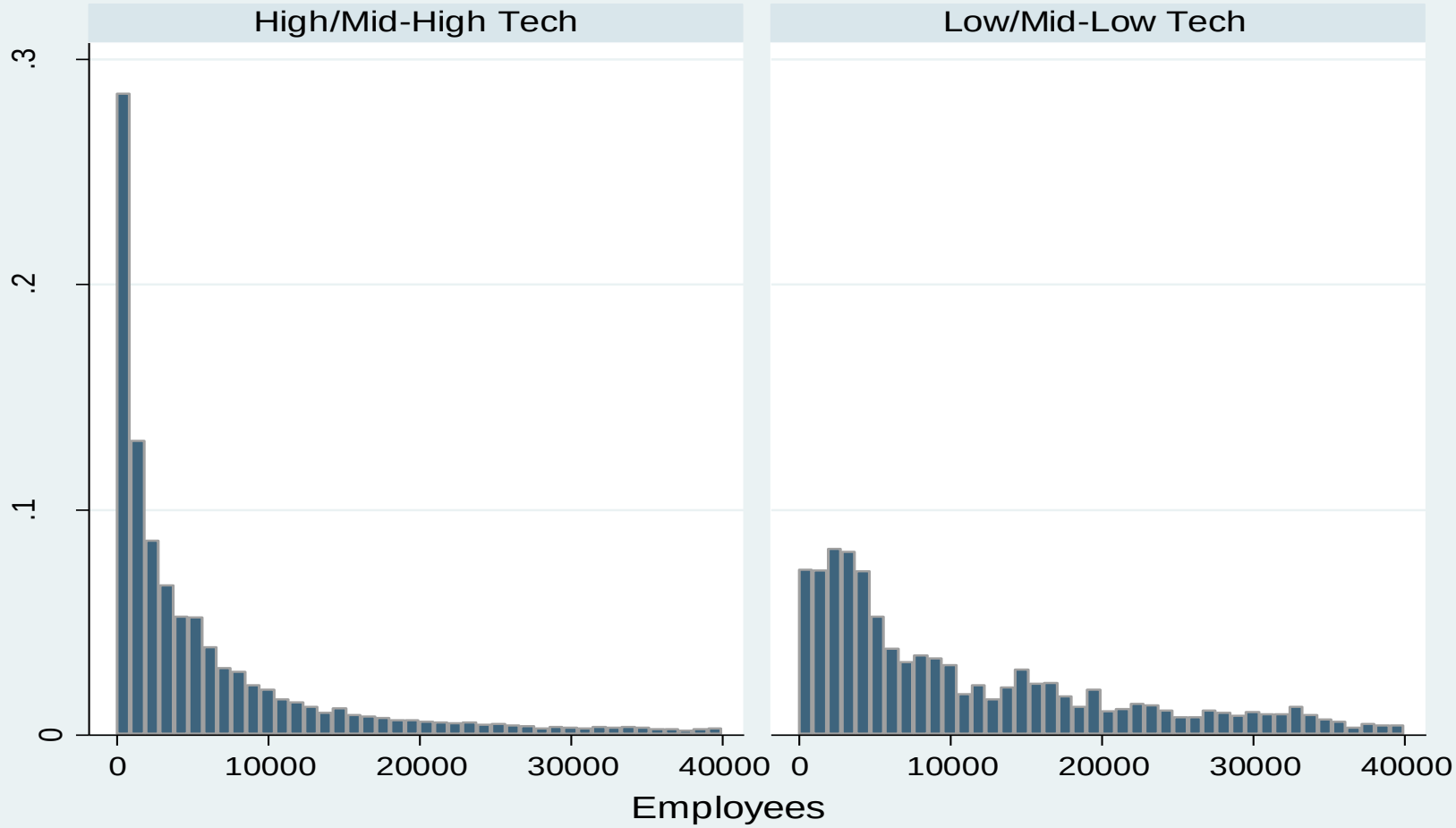
- Overall, a total of 2,000 firms based all over the word - nearly 90% of the global business R&D expenditure -

- The final estimation sample (**unbalanced panel**) composed by **1,538** firms (around 9,900 observations).

Distribution of the sample by regions and technological sector groups

Regions	Top 2000		Estimation Sample (1538)	Sector Group	Top 2000	Estimation Sample (1538)
	Freq.	Share	Share		Share	Share
EU	527	26%	23%	High-Tech	42%	41%
Japan	353	18%	28%	Medium-High Tech	40%	42%
RoW	462	23%	14%	Medium-Low/Low Tech	18%	17%
USA	658	33%	35%			
Total	**2000**	100%	100%		100%	100%

Size distribution among tech intensity sector groups



METHODOLOGICAL APPROACH

To answer the research questions, we have examined….

The impact of firm's investment in R&D and in physical capital on profits

And controlled for …..

Firm's age, year dummies, industrial and geographical time-invariant effects

The regression model

Generalised Least Square (GLS) approach ➔ autocorrelation and heteroskedasticity in the error term from fixed effects (FE)

Empirical application/estimated equation

A linear-log model

$$op_{it} = \alpha_i + \beta_1 rd_{it-1} + \beta_2 pk_{it-1} + \beta_3 f(emp_{it-1}) + \beta_4 age_{it} + \gamma Controls + u_{it}$$

Explanatory variables: R&D investment, physical capital, firm size, age and a list of controls

Three different specifications for the size of firms (in term of employment):

Model 1: $f(emp_{it-1}) = emp_{it-1}$

Model 2: $f(emp_{it-1}) = D^{Smallest}{}_{it} + D^{Largest}{}_{it}$

Model 3: $f(emp_{it-1}) = emp_{it-1} + emp^2{}_{it-1} + emp^3{}_{it-1}$

Estimation results for the whole sample

MAIN RESULTS

1. Returns to R&D are highly significant

(implied elasticity 10.4-13.7%)

	Model 1	Model 2	Model 3
R&D (t-1)	57.734***	53.897***	53.829***
	(6.061)	(5.918)	(5.099)
Physical Capital (t-1)	73.740***	98.302***	66.756***
	(6.762)	(6.243)	(5.694)
Employment (t-1)	70.138***		869.924***
	(6.001)		(94.936)
Employment square (t-1)			-156.781***
			(12.747)
Employment cube (t-1)			8.577***
			(0.559)
Age	-23.903***	-14.122**	4.575
	(6.484)	(7.112)	(5.736)
Observations	9,895	9,923	9,895
Chi-Square	1761	1699	3082
RMSE	902	901	898
Rho	0.764	0.792	0.713
Within Estimator - statistics			
R2	0.150	0.158	0.244
RMSE	970	967	964
Wooldridge test (serial correlation)	0.001	0.001	0.001
Wald test (groupwise heteroskedasticity)	0.000	0.000	0.000

2. However, sector specificities impact differently

Estimated elasticity results by technological sector group

	Model 1			Model 2			Model 3		
	High Tech	*Med-High Tech*	*Low-/ Med-Low Tech*	*High Tech*	*Med-High Tech*	*Low-/ Med-Low Tech*	*High Tech*	*Med-High Tech*	*Low-/ Med-Low Tech*
Implied elasticity									
R&D Investment	**24.6%**	**19.3%**	1.8%	**21.3%**	**19.2%**	3.4%	**20.3%**	**10%**	3.6%
Physical Capital	**33.4%**	**29.2%**	**26.3%**	**28.6%**	**36.5%**	**38.3%**	**18.8%**	**23.7%**	**20.3%**

2.1 Firms in high *and* medium-high tech sectors: elasticity much higher than for the whole sample (10.4-13.7%)

2.2 Firms in low and medium-low tech sectors: no significant returns from R&D investments

2.3 Returns to physical capital investment: generally higher in medium-high *and* medium-low/low tech than in high tech sectors

3. The relationship between firm size and corporate returns

$$profits = \beta_1 \text{emp} + \beta_2 \text{emp}\text{\^{}}2 + \beta_3 \text{emp}\text{\^{}}3$$

- Differences between sectors
- Profits' growth varies with firm size
- Two size thresholds (for all sample: 50 - 2400)

POSSIBLE EXPLANATIONS

Firms finance their own R&D because R&D output is able to generate innovation and subsequent firms' profits (Schumpeter, 1942)

Higher tech sectors enjoy higher profit returns because their R&D is more strongly associated to product (than process) innovations (Parisi *et al.*, 2006)

Smaller firms may have strategic incentive to invest in R&D that goes behind economies of scale – e.g. because of tech specialisation (Acs and Audretsch, 1987, Matsumura & Matsushima, 2010)
Larger firms exploit economy of scale in R&D investment (Cohen and Klepper, 1996; Peretto & Smulders, 2002)

There are **"firms in transition**": e.g. because of adjustment of resources and restructure of the organization (Hannan and Freeman, 1984; Montresor and Vezzani, 2014)

CONCLUSIONS

A. Positive impact of past R&D investment on current profits (between 10.4% and 13.7% in the whole sample)

B. Sector specificities in the R&D-Profits relationship

- R&D money value is particularly high for High- (20%-25%) and Medium High-Tech (10%-19%) firms
- In medium-Low/Low-Tech R&D plays a marginal (if any) role, while capital investment is the driver for profits
- *But capital* investment is important in every sector
- *Firms' size become more important when moving towards less R&D intensive (lower tech) sectors*

C. Non-linear relationship between firms' size and profits:

- Smaller and larger firms obtain higher profits
- 2 threshold values of profits for firms' size.

IMPLICATIONS FOR R&I POLICY

Enterprises:

- Managers should consider that **higher returns to R&D investment is not "one size fits all":** profits strategy could be different for different phases of firm growth, sector specificities, technological scope ...

Policy-makers:

- **Differentiate public support to innovative firms**:
  - R&D investment vs physical capital investment according to the sectors where firms operate
  - Focus on "firms in transition" (smallest firms are not necessarily the targets)

- Avoid "barriers" constraining firms.

Thank you

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JRC - Joint Research Centre: http://ec.europa.eu/dgs/jrc/index.cfm

Descriptive statistics

	Operating Profits	R&D	Capex	Employment	Age
High Tech					
Average	458	315	186	14,957	31
Standard Deviation	1,608	814	553	36,708	30
Median	55	52	26	3,163	20
Minimum	-5,686	0.3	0.1	4	1
Maximum	35,913	6,768	8,975	434,246	199
Medium-High Tech					
Average	484	225	416	28,537	56
Standard Deviation	1,250	618	1,306	55,363	40
Median	165	59	103	11,178	54
Minimum	-11,394	0.2	0.2	32	1
Maximum	20,561	8,684	24,833	961,000	324
Low/Mid-Low Tech					
Average	2,328	149	1,845	47,351	58
Standard Deviation	5,277	254	3,815	74,930	44
Median	486	59	391	19,009	58
Minimum	-16,440	0.4	2	89	1
Maximum	49,888	2,735	38,757	537,784	348
Whole sample					
Average	757	253	534	25,440	45
Standard Deviation	2,554		1,841	679	39
Median	129	56	76	7,515	30
Minimum	-16,440	0.2	0.1	4	1
Maximum	49,888	8,684	38,757	961,000	348

Technological sector groups

High R&D intensity sectors *(R&D intensity above 5%)*
Pharmaceuticals & biotechnology; Health care equipment & services; Technology hardware & equipment; Software & computer services and Aerospace & defence.
Medium-high R&D intensity sectors *(R&D intensity between 2% and 5%)*
Electronics & electrical equipment; Automobiles & parts; Industrial engineering & machinery; Chemicals; Personal goods; Household goods; General industrials; Support services.
Medium-low and Low R&D intensity sectors *(R&D intensity less than 2%)*
Food producers; Beverages; Travel & leisure; Media; Oil equipment; Electricity; Fixed line telecommunications. Oil & gas producers; Industrial metals; Construction & materials; Food & drug retailers; Transportation; Mining; Tobacco; Multiutilities.

Source:
European Commission (2004-2013). Industry classification: ICB (Industry Classification Benchmark), 3-digit level