THE IMPACT OF INTRAMURAL R&D, CONTRACTED R&D AND THE IMPORT OF TECHNOLOGY ON THE INNOVATION RETURNS OF SPANISH SMEs

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Introduction

- R&D is an important determinant of firm's performance (Griliches, 1979).
  - Productivity, competitiveness.
  - Innovation → firm survival (particularly SMEs).
- However, not all innovations are induced by intramural R&D:
  - Some innovations are purchased through licenses.
  - Some R&D is externally contracted.
- Also, firms use different combinations of R&D strategies. In particular, SMEs increasingly rely on external knowledge sources.

Some figures and facts

- Community Innovation Survey (2008):
  - 44% of the innovative enterprises engaged in intramural R&D.
  - 23% of the innovative enterprises engaged in extramural R&D.
  - 25% of the innovative enterprises engaged in other external knowledge.

Some figures and facts

- Mixed policies:

> "With some of his most profitable medicines going off patent, and the uncertainty of replacement drugs continuing to rise, (...) most large pharmaceutical companies have adopted four strategies to diversify. First, expand the range of products in the research and development pipeline and **the use of external as well as in-house scientists** to discover them" (FT, May 12, 2010).

Aim of the paper

- Analyse the impact of different innovation strategies and their combinations upon the elasticity of R&D with respect to TFP (= innovation returns):
  - intramural R&D;
  - externally contracted R&D;
  - imports of technology.
- We stress the differences between SMEs and Large firms.
- Estimate the R&D returns using recent methodological advances in the estimation of production functions.

Relevance

- Estimates of these returns are of great interest for the management of innovative firms.

- Perhaps more importantly, these estimates are of great importance for for firms that are considering spending some money in R&D (Beneito 2003, Piga and Vivarelli 2004).

  - Community Innovation Survey (2008):

    - 17% of the enterprises were novel (process and product) innovators.

Relevance

- However, an estimate of these returns is also valuable for governments and policy makers, since a good deal of the firms' R&D expenditure is publicly funded.
  - Community Innovation Survey (2008):
    - 17% of the innovative enterprises declared to have received public funds.
  - Main Science and Technology Indicators of the OECD (2009):
    - 7% of the "Business Enterprise Expenditure on R&D" (nearly 600.000 million in constant 2005 USD) was on average financed by governments.

Related Literature

- Large number of theoretical & empirical studies analysing the role of innovation strategies (internal vs. external) and their relation with firm's performance (profits, productivity, etc.).
- Results reveal that each strategy has a different impact. In particular, the empirical literature is inconclusive about potential complementarities between strategies (Ennen & Richter, 2010).
- However, SMEs have been largely ignored as a research population.
- Moreover, most studies focus on intramural vs. externally contracted R&D.

Empirical Strategy

Two-step strategy:

- 1st step: Obtain a consistent estimate of the elasticity of R&D:
  - Estimate a Cobb-Douglas production function → Obtain an estimate of TFP (Endogenous Markov Process, GMM approach, by industry).
  - Obtain the R&D elasticity (analytical derivatives approximation).
- 2nd step: KS Stochastic Dominance Tests for SMEs vs Large Firms on the R&D returns of the different innovation strategies (distinguishing by industries, eventually grouped).

Empirical Strategy: 1st step

- Objective: Obtain an estimate of TFP, from which we will obtain the elasticity of R&D.
- We first estimate a Cobb-Douglas production function with an *Endogenous Markov Process* for TFP (Doraszelsky & Jaumandreu, 2009; see also De Loecker 2007, 2010 and Kasahara & Rodrigue 2008):

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_a a_{it} + \beta_m m_{it} + \omega_{it} + \eta_{it}$$

$$\omega_{it} = E\left[\omega_{it} \middle| \omega_{it-1}, R_{it-1}\right] + \xi_{it} = f(\omega_{it-1}, R_{it-1}) + \xi_{it}$$

Empirical Strategy: 1st step

In particular, our two estimation equations are:

$$y_{it} = \beta_l l_{it} + 1(non\_rd) H_0(k_{it}, a_{it}, m_{it}) + 1(rd) H_1(k_{it}, a_{it}, m_{it}, R_{it}) + \eta_{it}$$

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_a a_{it} + \beta_m m_{it} + 1(non\_rd) F_0(k_{it-1}, a_{it-1}, m_{it-1}) + 1(rd) F_1(k_{it-1}, a_{it-1}, m_{it-1}, R_{it-1}) + u_{it}$$

- Wooldridge (2009) proposes to jointly estimate these equations by GMM. Advantages:
  - increases efficiency relative to alternative (semi-parametric, two-step) procedures;
  - makes unnecessary the use of bootstrapping to calculate standard errors.
- Lastly, we compute the R&D elasticity using analytical derivatives (third degree polynomial).

Empirical Strategy: 2nd step

- Objective: Compare the empirical distribution of the elasticity of R&D for SMEs vs Large firms (KS stochastic dominance tests) for different R&D strategies and across industries.
  - First stage: Test using stochastic dominance techniques whether SMEs or Large obtain higher R&D returns (by industry).
  - Second stage: Identify which R&D strategies lie behind these higher returns.
    - Caveat: Not enough data variability (7 strategies, 9 industries).
    - Thus, we group industries in which SMEs outperform Large firms (i.e. the elasticity distribution dominates) and industries in which Large firms outperform SMEs.

Hypotheses:

- Which R&D strategies explain the differences across industries? What is the origin of the higher returns of SMEs in some industries and of the Large firms in some others?

  - **H1.A: Large firms outperform SMEs because they exploit internal knowledge resources better (financial constraints, complementarities, risk diversification).**

  - **H1.B: SMEs outperform Large firms because they can exploit a wider range of strategies (more flexible organisations, easier coordination and communication, etc. allow them to switch between strategies).**

Data

- Source: Encuesta sobre Estrategias Empresariales.
- Period: 1990-2005.
- Sample:
  - After a process of data cleaning (retain firms observed for at least 3 consecutive periods that perform R&D) = 448 SMEs + 403 Large firms.
  - Unbalanced panel.

R&D Strategies (%)

	SMEs	Large
Internal ***	23,77	18,4
External	7,15	3,57
Import. Tech.	6,08	5,3
Int. & Ext. ***	24,39	32,43
Int. & Imp.	3,49	6,33
Ext. & Imp.	1,97	1,69
Int. & Ext. & Imp.	33,13	32,28

1st Step: R&D Elasticities

	SMEs	Large	SMEs	Large	SMEs	Large	SMEs	Large
	p25		*p50*		*p75*		Weighted mean	
Metals	0,0025	0,0122	0,0070	0,0157	0,0110	0,0211	0,0087	0,0149
Minerals	-0,0132	-0,0085	-0,0070	-0,0012	-0,0017	0,0035	-0,0064	-0,0031
Chemical	0,0230	0,0248	0,0310	0,0298	0,0360	0,0340	0,0231	0,0243
Machinery	0,0187	0,0027	0,0271	0,0107	0,0378	0,0170	0,0193	0,0028
Transport	0,0045	0,0048	0,0110	0,0129	0,0203	0,0188	0,0115	0,0151
Food	0,0049	-0,0018	0,0140	0,0059	0,0228	0,0135	0,0089	0,0032
Textile	-0,0077	0,0141	0,0022	0,0239	0,0109	0,0338	0,0101	0,0276
Timber	-0,0008	0,0139	0,0060	0,0172	0,0108	0,0192	0,0079	0,0166
Paper	-0,0289	-0,0205	-0,0219	-0,0151	-0,0162	-0,0091	-0,0162	-0,0115

2nd Step: KS Tests for Dominance of Large Firms

			Distributions are equal		Distribution of Large dominates	
	Large	Small	st1	pval1	st2	pval2
Metals	57	50	3,339	0,000	0,000	1,000
Minerals	26	35	1,129	0,104	0,187	0,933
Chemical	65	79	0,741	0,080	1,201	0,056
Machinery	64	35	0,000	0,000	3,593	0,000
Transport	33	59	0,331	0,743	0,638	0,443
Food	46	64	0,288	0,003	1,715	0,003
Textile	59	35	3,173	0,000	0,000	1,000
Timber	28	13	2,325	0,000	0,000	1,000
Paper	27	22	1,290	0,042	0,258	0,875

2nd Step: KS Tests for Dominance of SMEs

			Distributions are equal		Distribution of SMEs dominates	
	Small	Large	st1	pval1	st2	pval2
Metals	50	57	0,000	0,000	3,339	0,000
Minerals	35	26	0,187	0,104	1,129	0,078
Chemical	79	65	1,201	0,080	0,741	0,334
Machinery	35	64	3,593	0,000	0,000	1,000
Transport	59	33	0,638	0,743	0,331	0,803
Food	64	46	1,715	0,003	0,288	0,847
Textile	35	59	0,000	0,000	3,173	0,000
Timber	13	28	0,000	0,000	2,325	0,000
Paper	22	27	0,258	0,042	1,290	0,036

2nd Step: KS Tests for Dominance of Large Firms (Industries where Large outperform)

			Distributions are equal		Distribution of Large dominates	
	Large	**SMEs**	**st1**	**pval1**	**st2**	**pval2**
Internal	66	68	2,705	0,000	0,000	1,000
External	35	28	0,732	0,563	0,338	0,796
Import. Tech.	18	20	0,616	0,767	0,291	0,845
Int. & Ext.	63	79	2,434	0,000	0,000	1,000
Int. & Imp.	8	21	0,817	0,387	0,229	0,900
Ext. & Imp.	5	7	0,244	0,207	0,976	0,149
Int. & Ext. & Imp.	197	155	3,140	0,000	0,000	1,000

2nd Step: KS Tests for Dominance of SMEs (Industries where SMEs outperform)

			Distributions are equal		Distribution of SMEs dominates	
	SMEs	**Large**	**st1**	**pval1**	**st2**	**pval2**
Internal	71	71	0,014	0,011	0,009	2,601
External	18	18	0,014	0,016	0,017	1,333
Import. Tech.	20	17	0,015	0,013	0,007	1,275
Int. & Ext.	93	58	0,013	0,010	0,008	2,144
Int. & Imp.	37	13	0,010	0,004	0,004	0,864
Ext. & Imp.	9	7	-0,005	0,004	-0,001	0,535
Int. & Ext. & Imp.	178	175	0,014	0,008	0,008	2,660

Conclusions

- We analyse the returns of R&D strategies using recent methodological advances in the estimation of production functions.

- We find that SMEs firms outperform Large firms in some industries (Metal, Minerals, Textile, Timber and Paper), while Large firms outperform SMEs in some others (Chemical, Machinery and Food).

Conclusions

- In those industries in which Large firms outperform SMEs, they do so by exploiting their internal capabilities.

- In those industries in which SMEs outperform SMEs, they do so by exploiting their flexibility to use a wider variety of strategies.

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