What kinds of R&D consortia enhance SMEs productivity? A hierarchical Bayesian approach for the analysis of a small-business innovation policy

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SIE Conference 2014, Trento 22-24 October 2014

What kinds of R&D consortia enhance firms performance?

- A relevant question, both for academics (Spence 1984; Katz 1986: Jacquemin and d'Aspremont 1989) and for policy makers (Japan and US policies in favour of R&D collaborations, EU FP …)

- Empirical literature on this point is quite recent (Vonortas, 1997; Branstetter & Sakakibara 2002, …), and:
  - It has mostly focused on large-scale programs
  - It has only rarely focused on SMEs (exceptions of Bougrain and Haudeville, 2002; Hottenrott and Lopes-Bento, 2014)
  - It has been based on firm-level or on dyad-level analysis

- Our empirical contribution:
  - Adopts a Consortium-level perspective (what kinds of consortia do add more to the performance of SMEs?)
  - Explicitly focuses on SMEs Consortia
  - Defines an econometric strategy to estimate consortium effects

Outline

- What's so special about SMEs? Our hypotheses on the peculiar ingredients that can make the SMEs' collaboration work
- Data and empirical strategy: how did we estimate consortium effects, not only net of all firms' characteristics, but also in the presence of firms' simultaneous participations
- Results and discussion

What can make the SMEs' R&D collaboration work?

- Specific features are related to three main themes:

  I. Outgoing spillovers and competition-collaboration dynamics (*H1*)

  II. Incoming spillovers and absorptive capacity (*H2a*, *H2b*, *H3*, *H4*)

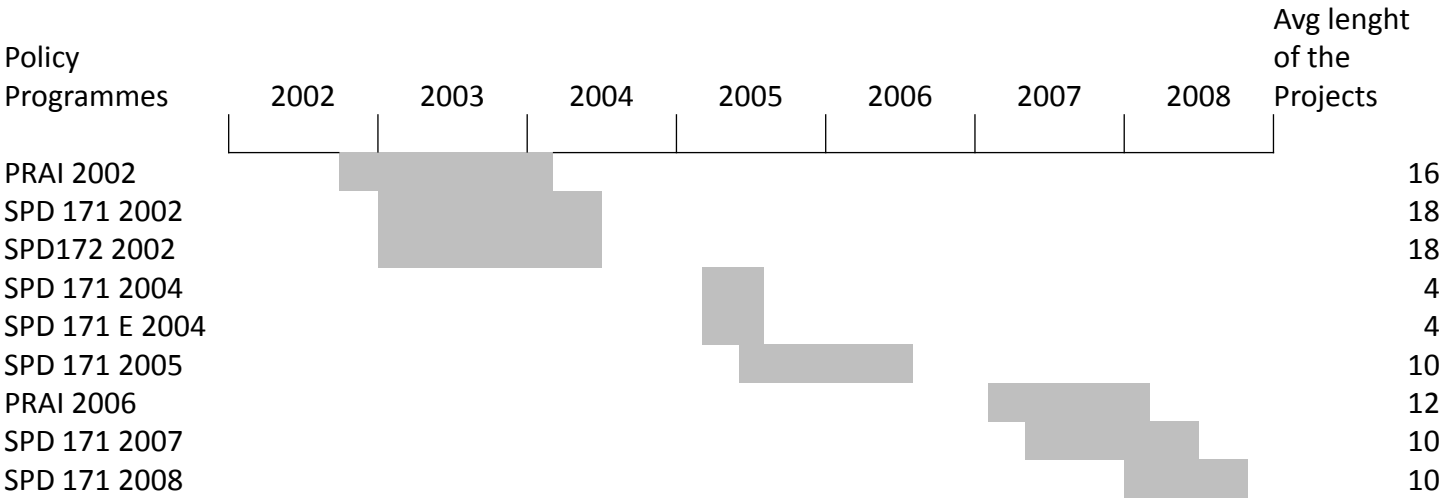
  III. Organizational issues (*H5*, *H6*)

Our hypotheses

- **H1**: Competition or potential competition among SMEs has a negative effect on consortium performances
- **H2a**: Consortia that work better are those in which SMEs having absorptive capacity combine with one or more universities
- **H2b**: Consortia that work better are those in which SMEs having absorptive capacity combine with one or more large firms
- **H3**: Consortia that work better are those in which SMEs having absorptive capacity combine with one or more intermediaries
- **H4**: Complex consortia, including a range of heterogeneous agents work better when one or more intermediaries are called to act as matchmakers
- **H5**: Large-scale consortia perform relatively better than small-scale consortia
- **H6**: Decentralized consortia perform relatively better than hierarchical consortia

Data

- Tuscany Region policies supporting R&D consortia from 2002 to 2008.
- 4 programs (SPD 171, SPD 172, RPIA02, RPIA06), 9 waves, 168 funded R&D projects/consortia participated by 1127 agents, of which 765 SMEs
- Other consortium members: Large firms; Innovation centers, technology parks and similar infrastructures; Universities and research centers; Business associations, Chamber of commerce; Local governments; other public bodies
- Policy goal: Promotion of process innovations



Data (II)

- Data comes from the following sources:

  - <u>Info on project and consortia:</u>
  - Administrative documents on project admitted to funding
  - Project data provided by the regional administration and by the beneficiaires during intermediate and final evaluation
  - Direct questionnaires to the beneficiaires

  - <u>Info on firms:</u>
  - AIDA data on firms' balance sheet
  - Direct questionnaires to the beneficiaires

The empirical strategy

- Data are laid in a hierarchical structure, with firms on the lower level, and projects/consortia on the upper level, but firms are clustered in non-disjoint groups with simultaneous and over time multiple-membership → in order to account for the complex data structure we adopt a hierarchical approach , adapted so as to estimate the contribution of each consortium
- We first collapse the time dimension of the data into a cross-section, in which every firm is repeated as many times as the years in which its participations occur
- Outcome var: Labor productivity one year after the completion of the project
- Multiple participation over time → for sake of simplicity, we assume that repeated participation are independent conditional on the "updated" lagged values of labor productivity and indicators for prior participations
- Multiple simultaneous participations → inserting consortium dummies = 1 if firm *i* participates in consortium *k* in a given year and 0 otherwise. More than one dummy can be =1 at a given year for a given firm!
- Estimation is carried out using a Bayesian approach.

The empirical strategy (II)

$$Y_i = \beta_0 + \sum_{j=1}^{J} \beta_j x_{ij} + \sum_{k=1}^{K} \gamma_k P_{ik} + \varepsilon_i \qquad (1)$$

$$\gamma_k \sim N(\mu_k, \sigma_\gamma^2) \qquad \text{with} \qquad \mu_k = \alpha_0 + \sum_{h=1}^{H} \alpha_h z_{kh} \qquad (2)$$

Variables:

Y_i labor productivity one year after the completion of the project for each firm-year

x_{ij} **firm-level** explanatory variables

P_{ik} consortium/project dummies

z_{kh} ***consortium-level*** explanatory variables

Parameters:

For $\boldsymbol{\beta} = (\beta_0, \ldots, \beta_J)$; ε_i; $\boldsymbol{\alpha} = (\alpha_0, \ldots, \alpha_K)$ we specify non-informative priors (a relatively flat distribution with very large variance)

$\boldsymbol{\gamma} = (\gamma_1, \ldots, \gamma_K)$ are the **consortium/project effects**: they provide information on the contribution of each consortium to the productivity of the participating SMEs. In this case, we impose a Normal distribution whose mean is a function of consortium characteristics (2)

We simulate the posterior distributions using an MCMC algorithm (100000 iterations)

Firm-level results

- post-consortium productivity levels seems to be positively associated with:
  - firm's productivity levels and trends before consortium inception;
  - previous non-transitory R&D experiences;
  - The fact of being active in sectors other than low- or medium-low technology manufacturing.
- post-consortium productivity levels seems to be negatively associated with:
  - previous attitude to patent;
  - past employment growth.

- Most important: there exist consortia stimulating firms' labour productivity: 68 out of 169 consortium parameters (40% of all consortia) have a positive posterior mean.

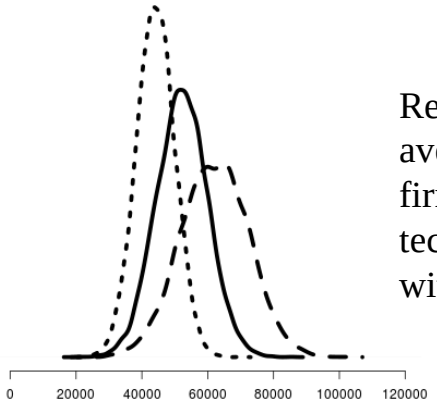
Consortium-level results

Second-level coefficient	Definition	Coeff	Mean	SD	Prob coeff	
					<=0	>0
constant		α_1	5871.87	13777.15	0.34	0.66
competition (H1)	Gini index estimated on SMEs at three-digit sectors within the project	α_2	−13995.60	5972.72	0.99	0.01
RD	Dummy that takes a value of 1 if the SMEs had a permanent R&D dept prior to consortium inception, and 0 otherwise	α_7	7083.39	7440.51	0.17	0.83
large_ent	Dummy that takes the value of 1 if at least one large firm is part of the project, and 0 otherwise	α_8	7108.05	8192.61	0.19	0.81
university	Dummy that takes the value of 1 if at least one university is part of the project, and 0 otherwise	α_9	5088.13	4258.52	0.12	0.88
potential_interfirm_ absorption (PIFA)	Interaction btw rd and large_ent	α_{10}	2790.39	9957.49	0.39	0.61
potential_research _absorption (PRA) (H2a)	Interaction btw rd and university	α_{11}	−13114.85	7504.51	0.96	0.04
Intermediaries	Dummy that takes a value of 1 if at least one intermediary is part of the project, and 0 otherwise	α_{12}	−3853.53	4656.66	0.80	0.20
potential_intermediary_absorption (PINA) (H3)	Interaction btw rd and intermediaries	α_{13}	2668.21	6304.19	0.33	0.67
partners (H5)	Number of partners	α_4	87.35	262.28	0.37	0.63
budget_dispersion (H6)	Reciprocal of the Gini index estimated on the budget shares of all partners.	α_3	−978.47	9956.04	0.54	0.46
near to application	Dummy that takes a value of 1 if project focuses on near-to-application R&D, and 0 otherwise	α_{14}	341.8	3114.94	0.46	0.54
mean_p	Avg group productivity, estimated on SMEs, one year prior to the start of the project	α_5	−0.06	0.08	0.76	0.24
vc_p	Group-level variation coefficient of productivity, estimated on SMEs, one year prior to the start of the project	α_6	−2602.66	3410.34	0.78	0.22
[*control variables coefficients omitted*]						
Variance			22305939.78	17829489.15		

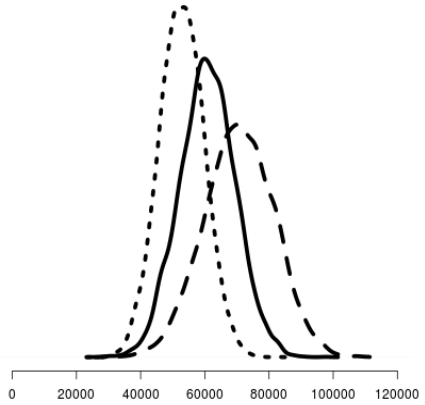
Consortium profiles

Variable	Coeff	Mean	SD	50%	2.50%	97.50%	Prob coeff <=0	Prob coeff >0
RD	α_7	7083.39	7440.51	7120.02	−7528.19	21459.19	0.17	0.83
RD +LE (H2b)	$\alpha_7 + \alpha_8 + \alpha_{10}$	16981.83	10268.63	17098.79	−3197.38	36750.65	0.05	0.95
RD +A (H2a)	$\alpha_7 + \alpha_9 + \alpha_{11}$	−943.32	5630.42	−933.19	−11991.21	10071.18	0.57	0.43
RD +I (H3)	$\alpha_7 + \alpha_{12} + \alpha_{13}$	5898.07	6735.29	5855.95	−7455.15	19000.77	0.19	0.81
RD +LE+A (H4)	$\alpha_7 + \alpha_8 + \alpha_9 + \alpha_{10} + \alpha_{11}$	8955.12	8360.22	8943.94	−7228.96	25267.79	0.15	0.85
RD +LE+I	$\alpha_7 + \alpha_8 + \alpha_{10} + \alpha_{12} + \alpha_{13}$	15796.51	8878.17	15724.99	−1574.96	32693.81	0.04	0.96
RD +A+I	$\alpha_7 + \alpha_9 + \alpha_{11} + \alpha_{12} + \alpha_{13}$	−2128.64	5518.77	−2092.14	−12943.07	8574.88	0.65	0.35
RD +LE+A+I (H4)	$\alpha_7 + \alpha_8 + \alpha_9 + \alpha_{10} + \alpha_{11} + \alpha_{12} + \alpha_{13}$	7769.79	7212.66	7737.73	−6401.13	21965.75	0.14	0.86
LE	α_8	7108.05	8192.61	7048.80	−8993.10	23393.57	0.19	0.81
A	α_9	5088.13	4258.52	5029.84	−3001.78	13618.13	0.12	0.88
I (H3)	α_{12}	−3853.53	4656.66	−3877.27	−13129.65	5391.36	0.80	0.20
LE+A	$\alpha_8 + \alpha_9$	12196.18	9237.88	12085.40	−5665.90	30497.02	0.09	0.91
LE+I	$\alpha_8 + \alpha_{12}$	3254.52	9626.13	3134.48	−15470.23	21763.39	0.36	0.64
A+I	$\alpha_9 + \alpha_{12}$	1234.60	5717.66	1254.68	−9953.21	12394.53	0.42	0.58
LE+A+I	$\alpha_8 + \alpha_9 + \alpha_{12}$	8342.65	10185.98	8315.03	−11842.37	28404.88	0.20	0.80

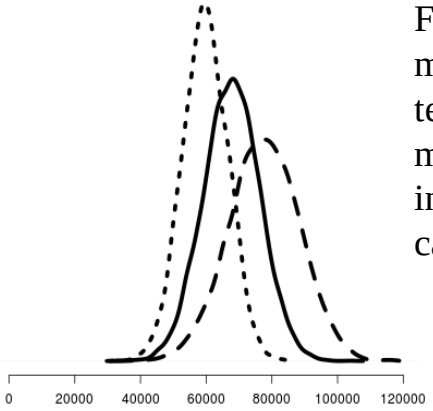
Firm and consortium profiles



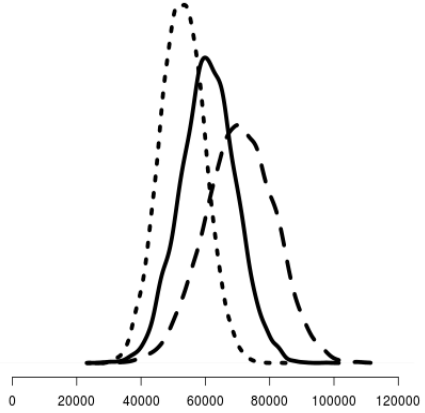
Representative firm: average productive small firm, active in relatively low technology manufacturing, with no absorptive capacity



Firm active in low technology manufacturing, with individual absorptive capacity



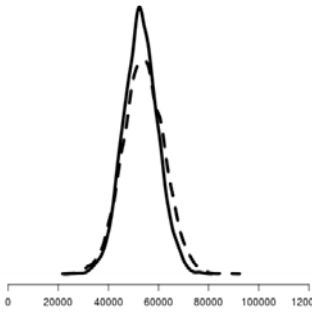
Firm active in medium-high technology manufacturing, with no individual absorptive capacity



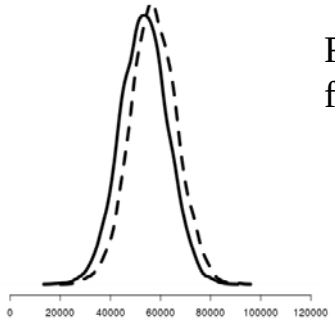
Firm active in medium-high technology manufacturing, with individual absorptive capacity

Posterior predictive distributions of labor productivity for hypothetical firms participating in a consortium involving:
(**solid line**) some firms with some absorptive capacity;
(**dashed line**) firms with some absorptive capacity and large enterprises;
(**dotted line**) firms with some absorptive capacity and universities.

Firm and consortium profiles (I)

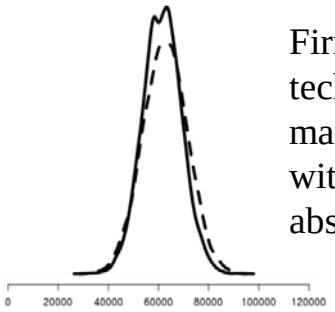


(a)



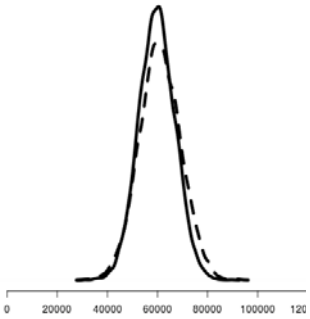
(b)

Representative firm



(a)

Firm active in low technology manufacturing, with individual absorptive capacity



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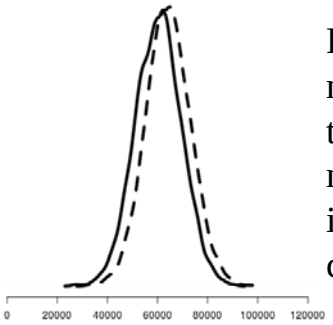
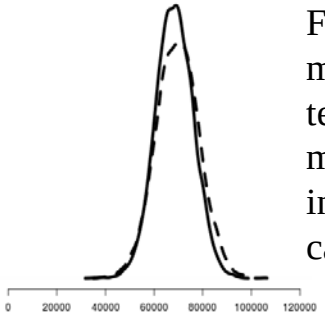


(b)

Firm active in medium-high technology manufacturing, with no individual absorptive capacity



(a)

Firm active in medium-high technology manufacturing, with individual absorptive capacity

Posterior predictive distributions of labor productivity for the hypothetical firms participating in a consortium with:

a) **absorptive** capacity, large enterprises and universities with (**solid line**) and without (**dashed line**) the presence of intermediaries;

b) **no absorptive** capacity, large enterprises and university with (**solid line**) and without (**dashed line**) the presence of intermediaries

Policy implications

- *Filiére* can be a good base for promoting consortia
- Universities are better placed in large scale, highly innovative projects
- The inclusion of intermediaries is not always beneficial
- … however, perhaps the contribution of these types of agents might have been more evident had we taken into account the learning and behavioral dimensions of SMEs, without expecting these dimensions to raise productivity or performance in the short run