On the additionality of innovation policy:

behavioural additionality and innovation co-operation
at the regional and extra-regional level

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Course: Economics and Management of Innovation

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Outline

1. Innovation policy: a resume.
2. The additionality of innovation policy: a conceptual framework.
3. Behavioral additionality and innovation/research cooperation: regional and extra-regional.
5. Conclusions.
Main references


1. Innovation policy: a resume

■ 1.1. Innovation policy: What is intended to?

■ 1.2. Innovation policy: Does it reach its intents?
1. Innovation policy: What is intended to?

Three different response framings (Schot & Steinmueller, 2016).

1 **Framing 1, Innovation for growth:**
   - Timing: Second World War.
   - Rationale: market failure model (Nelson, 1959; Arrow, 1962; ...).
   - Practices: R&D support (e.g. tax treatments, direct subsidies, ...).

2 **Framing 2, National Systems of Innovation:**
   - Rationale: system failures (Malerba, 1996; ...; Metcalfe, 2005).
   - Practices: system coordination, entrepreneurship, innovation diffusion, ....

3 **Framing 3, Transformative Change:**
   - Timing: 2015 (UN, SDGs).
   - Rationale: socio-technical systems (Schot, 2003; ... Geels, 2014).
   - Practices: mission-oriented and transformative policies (Mazzucato, 2015; 2016; ...).
1.2. Innovation policy: Does it reach its intents?

Evaluating the impact of innovation policy (e.g. Khandker et al., 2010, World Bank):

1. **Monitoring**: “in-progress” (intermediate) evaluation;
   - Goals;
   - Indicators;
   - Targets;
   - Monitoring systems.

2. **Operational evaluation**: “retrospective” evaluation;
   - Realized vs. planned objectives;
   - Gaps and/or spillovers;
   - Lessons for future policy design and implementation.

3. **Impact assessment**: evaluation of policy vs. non-policy effects ("economic background noise").
   - Qualitative;
   - Quantitative;
   - Mixed-methods approaches.
1.2. Innovation policy: Does it reach its intents (cont’d)?

Quantitative impact assessment:

- **Ex-post evaluation methods**: after the policy implementation.
  - Objective: estimate the “actual additionality” of a policy, collecting data on policy outcomes for participants and nonparticipants, as well as on accompanying socio-economic factors about the intervention.

- **Ex-ante evaluation methods**: before setting a new policy, or alternative versions of an existing policy, at work.
  - Objective: predict and/or simulate the “potential additionality” of a policy, given a targeted areas current situation and an assumed description of the involved agents (“structural model”).

- **NB**: Reference to a specific and exclusive policy scheme (no “hidden treatment”, like policy-mixes, as confounding factor).
2. The additionality of a policy: a conceptual framework

Policy’s "additionality" (in general): extent to which desirable outcomes would have occurred without public intervention (the “counterfactual”).

- Three forms of additionality (in general):
  1. "Input additionality": the extent to which intervention supplements or substitutes for inputs provided by other means (e.g. the market, firms own resources, …).
  2. "Output additionality": the proportion of outputs that would not have been created without public intervention.
  3. "Behavioural additionality": the difference in behavior of a target population from public intervention.
Three possible outcomes in terms of additionality (in general):

1. Positive (significant) additionality, or *additionality as such*: the policy actually supplements for inputs, and/or outputs, and/or behaviors, which *would not* have been created without public intervention.

2. Negative (significant) additionality, or *crowding out*: the policy actually substitutes for inputs, and/or outputs, and/or behaviors, which *would* have been created without public intervention.

3. No-significant additionality, or *neutrality*: the policy does not supplement and does not substitute either.
The three kinds of additionality with respect to innovation policy: linear vs. chain model, and market vs. system failures (Kline & Rosenberg, 1986).

1. **Input additionality**: amount of innovative inputs (e.g. R&D investments), which would not have been allocated without the policy (Georghiou, 2002, 2004; Clarysse et al., 2004; David et al., 2000; Cerulli, 2010).

2. **Output additionality**: proportion of outputs – of supported projects (e.g. patents, scientific papers, prototypes, business plans) or of their economic outcomes (e.g. turnover from new products, processes, services) – which would not have been achieved without the policy intervention (Georghiou, 2002, 2004; Georghiou and Clarysse, 2006).
2. The additionality of innovation policy: a conceptual framework (cont’d)

3. Behavioral additionality: from strictu – change in a company’s way of undertaking R&D (Buisseret et al., 1995) – to largo – the difference in firms behaviour resulting from the intervention (Georghiou, 2004) – sensu.

- Six possible additional behaviours:
  1. knowledge acquisition (e.g. R&D organisation and networking);
  2. human resources (e.g. hiring of researchers and acquisition of management skills);
  3. capital investment strategy (e.g. acquisition of equipment and location of companies facilities);
  4. market positioning (e.g. introduction to new market or customers and acquisition of leadership positions);
  5. strategies for manufacturing or service provision (e.g. changes in the production or service delivery methods);
  6. corporate responsibility and environmental sustainability.
3. Behavioral additionality and innovation cooperation: regional and extra-regional

The focal behavior:

- Cooperation between firms and ROs: access to non-contractable, external knowledge and intangible assets (Sinha and Cusumano, 1991; Katsoutacos and Ulph, 1998); risks sharing and economies of scale in R&D (Hagedoorn, 1993; Tether, 2002)


- *Across* regional boundaries: diversity of the local knowledge base (MacKinnon et al., 2002; Gertler and Levitte, 2005; Boschma and Ter Wal, 2007); escape from local path-dependence and lock-in (Hassink, 2005; Giuliani, 2005)
3. Behavioral additionality and innovation cooperation: some research hypotheses (cont’d)

- **Barriers** to cooperation with ROs (e.g. Busom and Fernandez-Ribas, 2008; Mora-Valentin et al., 2004; Bruneel et al., 2010)
  - different incentives and objectives (Carayol, 2003)
  - conflicting approaches to IPRs (Valentin and Jensen, 2007)
  - asymmetries in knowledge-stock and problems of absorptive capacity (Hall et al., 2003)

- **Cooperation with ROs requires policy intervention**: an R&D subsidy can be used by the recipients to restore incentives to cooperate (Vilasuso and Frascatore, 2000; Mohnen and Hoareau, 2003; Capron and Cincera, 2003), generating behavioural additionality effects (Buisseret et al., 1995; Antonioli and Marzucchi, 2012)

- **HP1**: Receiving an R&D subsidy increases cooperation with ROs (i.e. universities and research institutes).
3.1. Behavioral additionality and innovation cooperation: some research hypotheses (cont’d)

- Costs of cooperating across the region:
  - higher travelling costs, longer times, harder communication (Katz, 1994; Fritsch and Schwirten, 1999; Mora-Valentin et al., 2004)
  - loss of geographical proximity (e.g. Landry et al., 1996; Vedovello, 1997; Arundel and Geuna, 2004; Mora-Valentin et al., 2004; Levy et al., 2009) and costly compensation of other forms of distances (e.g. cognitive, institutional, social) (e.g. Boschma, 2005)

- The extent to which a subsidy can cover firms’ costs of cooperating is higher for regional than for (more expensive) extra-regional cooperation

- **HP2**: Receiving an R&D subsidy increases cooperation more with regional than extra-regional ROs.
3.1. Behavioral additionality and innovation cooperation: some research hypotheses (cont’d)

- Extending the geographical range of the cooperation across the region allows firms to overcome the constraint of local search ("boundary-spanning exploration" (Rosenkopf and Almeida, 2003)) and access brand-new, high-quality knowledge (Belussi et al. 2010; D’Este and Iammarino, 2010; Laursen et al., 2011)

- The advantage of cooperating across the regional borders runs against the losses of geographical proximity (+ cognitive and institutional) and implies the additional cost that distant cooperation entails
3.1. Behavioral additionality and innovation cooperation: some research hypotheses (cont’d)

- Extending the geographical range of cooperation with ROs involve important up-front fixed costs (and indivisibilities):
  - more complex (e.g. multilanguage) organizational search routines for distant partners (Ebers and Grandori, 1997; Knoben and Oerlemans, 2012);
  - manifold ‘institutionalisation’ of the cooperative relationship (Ranson et al., 1980; Bonaccorsi and Piccaluga, 1994)
  - more powerful absorptive capacity for more cognitively distant and/or still unexplored knowledge sources (Nooteboom, 2000), as the search of distant partners is motivated by the willingness to interact with cutting-edge ROs (Belussi et al., 2010; D’Este and Lammarino, 2010; Laursen et al., 2011)

**HP3:** Firms’ propensity to extend the cooperation with ROs across the region increases by increasing the amount of R&D subsidy, providing that this latter overcomes a minimum efficient scale.
On the additionality of innovation policy:

3. Behavioral additionality and innovation cooperation: regional and extra-regional

3. Behavioral additionality and innovation cooperation: some research hypotheses (cont’d)

3.1. Behavioral additionality and innovation cooperation: some research hypotheses (cont’d)

1. **HP1**: Receiving a public support to R&D increases innovation cooperation with research organizations (i.e. universities and research institutes).

2. **HP2**: Receiving a public support to R&D increases innovation cooperation more with regional than extra-regional research organizations (i.e. universities and research institutes).

3. **HP3**: The regional firms’ propensity to extend the geographical range of their cooperation with research organizations across the region increases by increasing the amount of public support to R&D they receive.
4. An empirical application: innovation policy in Emilia Romagna

4.1. The context: ER region;

4.2. The Regional Programme for Industrial Research, Innovation and Technology Transfer (PRRIITTT policy-program):
4.1. The context: Emilia Romagna

- The Emilia-Romagna region (North-East Italy, NUTS2):
  - a benchmark model of local development: high SMEs density, specialization, proximity and social capital (*industrial districts* and the ‘Emilian model’ (Brusco, 1982))
  - a particularly innovative region: medium-high innovative (European Regional Innovation Scoreboard, 2004 and 2006 (Hollanders et al., 2009)); an ‘informal learning system’ kind of RIS (Evangelista et al., 2002).

- The Regional Programme for Industrial Research, Innovation and Technology Transfer (PRRIITTT policy-program):
  - General aim: mitigate the RIS weaknesses and exploit the RIS strengths
  - *Measure 3.1, Action A*: R&D subsidy (specific aim: R&D employment, cooperation, IPRs, ...).
4.2. The PPRRITT

- PRRIITTT Measure 3.1, Action A:
  - 2 calls: February and September 2004;
  - n. of submitted projects: 1st call, 363 (353 firms); 2nd call, 869 (850 firms);
  - assessment of the projects (technological-scientific, economic-financial, managerial aspects, regional impact) by an independent expert committee;
  - subsidised projects: 1st call 182; 2nd call 347;
  - funding coverage: up to 50% of the total cost, for industrial research, and up to 25% for precompetitive development (35% for SMEs);
  - granted funding: EUR 96 mil (40% of the total projects’ cost, EUR 236 mil.);
  - average regional contribution by project: EUR 175,000.
4.3. Data

- PRRIITT implementation data (e.g. amount of subsidy) (2004) merged with:

  1. *Unique, CIS-type survey* on manufacturing firms, with more than 20 employees (Antonioli, et al., 2011): innovation strategies, technological and organizational characteristics for a (multi-stratified, representative) random sample of 555 firms, after the policy (2006-2008)


- Working sample: 408 firms (99 subsidised and 309 non-subsidised)
4.4. Econometric strategy

- HP1 and HP2: Propensity Score Matching estimates of the Average Treatment effect on the Treated (Rosenbaum and Rubin, 1983).

- OLS not applicable, given the policy non-exogeneity: “picking the winner” or “aiding the poor” (Cerulli, 2010)

- Consider the policy as a “treatment” \((D = 0, 1)\), and look at the Average Treatment Effect on the Treated (ATT), with respect to a certain outcome variable \((Y)\):

\[
ATT = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1)
\]

- Solve the non-observability of \(E(Y_0|D = 1)\) by referring to a suitable counter-factual of firms: matching \((M)\) the treated ones in terms of their propensity score \((PS)\), \(P(X)\), given a set of pre-treatment characteristics

- Estimate \(ATT\) with \(PSM\):

\[
ATT_{PSM} = E_{P(X)|D=1} \{ E[Y_1|D = 1, P(X)] - E[Y_0|D = 0, P(X)] \}
4.4. Econometric strategy (cont’d)

- HP1 and HP2: *PSM* estimates of the *ATT*.

- Multi-step operationalisation (Caliendo and Kopeinig, 2008):

  1. Probit estimation of the propensity score;
  2. Different matching algorithms implemented: 5 nearest neighbours, 0.05 Caliper, Kernel matching;
  3. Common support condition: “*minima* and *maxima*” comparison and 1% “trim” imposed to the 5NN;
  4. Quality of the matching tested with: Pseudo-$R^2$ test, LR test on joint significance, “regression based” t-Test.
4.4. Econometric strategy (cont’d)

HP3: *GPS* estimates of the *treatment-effect* due to an additional amount of subsidy (Hirano and Imbens, 2004).

- 3-step operationalisation procedure (Hirano and Imbens, 2004; Bia and Mattei, 2008):

  1. Estimate the *Generalised Propensity Score (GPS)*: conditional density of the treatment (*T*), given the covariates (*X*), \( R = r(T, X) \)
  2. Estimate the conditional expectation of the outcome (*Y*) as a function of *T* and *R* → \( E(Y_i | X_i, R_i) = \alpha_0 + \alpha_1 T_i + \alpha_2 T_i^2 + \alpha_3 R_i \)
  3. Calculate the average potential outcome at each level of treatment *t* → \( \hat{E}[Y(t)] = \frac{1}{N} \sum_{i=1}^{N} [\hat{\alpha}_0 + \hat{\alpha}_1 t + \hat{\alpha} t^2 + \hat{\alpha}_3 \hat{r}(t, X_i)] \)

- Estimate the *treatment-effects* as the changes in the average potential outcome due to an additional amount of the treatment, \( \Delta_t \).
4.4. Econometric strategy (cont’d)

- GPS estimates specifications:

1. $Y$ defined as: $Y = 0$ no cooperation; $Y = 1$ regional coop.; $Y = 2$ extra-regional coop.
   - $\rightarrow$ Step 2 estimated with an Ordered Probit;

2. $\Delta_t$ defined with respect to the average size of the regional funding (EUR 175,000), and the average cost of regional research (e.g. the cost of an extra temporary junior researcher in the region);
   - $\rightarrow$ $\Delta_t = EUR \ 20,000$ and EUR $40,000$. 
4.5. Variables

- **Covariates (X)** (pre-policy (2003), or time invariant):
  - $\ln EMP_{2003}$: In employment, size;
  - $PAVITT 1$-$PAVITT 5$: à la Pavitt/OECD SECTOR (Dummy);
  - $GEO 1$-$GEO 10$: province (NUTS3) (Dummy)*;
  - $CASHFLOW_{2003}$: cash-flow, thousands of EUR per employee;
  - $FINCONST_{2003}$: short-term debt index;
  - $RDADV_{2003}$: expenditure in R&D and advertising, thousands of EUR per employee *;
    * excluded from the GPS estimation to respect its balancing propriety.

- **Treatment variables**:
  - Binary variable: $REGSUB$ (HP1 and HP2, Propensity Score Matching);
  - Continuous variable: $CONTREGSUB$ (HP3, Generalised Propensity Score).
4.5. Variables (cont’d)

- **Outcome variables (Y) (post-policy, 2006-2008)**
  - Regional (_REG) and extra-regional (_EXTRA) cooperation with research institutes (COOPRESINS) (Dummies);
  - Regional (_REG) and extra-regional (_EXTRA) cooperation with universities (COOPUNI) (Dummies).

- **COOPRESINS_ORD**: coop. with research institutes (0: no coop., 1: regional coop., 2: extra-regional coop.);

- **COOPUNI_ORD**: coop. with universities (0: no coop., 1: regional coop., 2: extra-regional coop.).
4.6. Results

1. Propensity score estimation.
2. Firms-ROs cooperation additionality of the regional policy.
3. Extra-regional cooperation for additional amounts of policy:
   1. Cooperation with research institutes;
   2. Cooperation with universities.
4.6.1. Propensity score estimation

<table>
<thead>
<tr>
<th>Coeff.</th>
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<tr>
<td>ln_EMP2003</td>
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<tr>
<td>GEO1</td>
<td>3.420 ***</td>
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<tr>
<td>GEO2</td>
<td>1.755 *</td>
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<tr>
<td>GEO3</td>
<td>0.789</td>
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<tr>
<td>GEO5</td>
<td>1.839 *</td>
</tr>
<tr>
<td>GEO6</td>
<td>2.639 **</td>
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<tr>
<td>GEO7</td>
<td>1.531</td>
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<tr>
<td>GEO8</td>
<td>2.184 **</td>
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<td>GEO9</td>
<td>1.849 *</td>
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<td>GEO10</td>
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<td>PAVITT1</td>
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<tr>
<td>PAVITT3</td>
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<tr>
<td>PAVITT4</td>
<td>0.575 **</td>
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<td>RDADV.2003</td>
<td>0.162 ***</td>
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<tr>
<td>_cons</td>
<td>-2.671**</td>
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</tbody>
</table>

N | 408  
Pseudo R² | 0.217 
Prob> χ² | 0.000

***, **, * indicate a significance level of 1%, 5%, 10%.

A VIF test excludes the presence of multicollinearity among the covariates (all the VIF values are lower than 10)
4.6.1. Propensity score estimation

- Identified policy-propensity predictors generally significant and with the expected sign:
  - research experience: (+) RDADV2003;
  - financial soundness: (-) FINCONST2003;
  - technology-intensive and dynamic sectors: (+) PAVITT3, PAVITT4, PAVITT5.

- The PRRIITT seems to target relatively more virtuous firms (picking the winner): non-fully exogenous innovation policy.
4. An empirical application: innovation policy in Emilia Romagna

4.6.2. Firms-ROs cooperation additionality of the regional policy

<table>
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<tr>
<th></th>
<th>5NN</th>
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<th>Kernel</th>
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<td><strong>Intra-RIS</strong></td>
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<td>COOPUNI_REG</td>
<td>0.374 *** 0.082</td>
<td>0.393 *** 0.082</td>
<td>0.402 *** 0.072</td>
<td>0.381 *** 0.077</td>
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<td>COOPRESINS_REG</td>
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<td></td>
<td>N treated total</td>
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<td>99</td>
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<tr>
<td></td>
<td>N non treated</td>
<td>309</td>
<td>309</td>
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</table>

Standard errors are estimated with a 200-replication bootstrap procedure.
** *, **, * indicate a significance level of 1%, 5%, 10%.
4.6.2. Firms-ROs cooperation additionality of the regional policy (cont’d)

- **HP1 supported**

- Funded firms are more likely to cooperate than non-funded ones, irrespectively from the research partner and from its location: extremely robust result;

- Receiving a subsidy spurs firms to search more basic than applied knowledge, within the region, and the reverse, across its boundaries: the policy ATT within (across) the region is higher with respect to universities (research institutes) than with respect to research institutes (universities);

- Given the ER weaknesses in terms of ‘innovation enablers’ (Hollanders et al., 2009; Evangelista et al., 2002), this result suggests an ‘illuminated’ action by the policy-makers.
### 4.6.2. Firms-ROs cooperation additionality of the regional policy

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4.6.2. Firms-ROs cooperation additionality of the regional policy (cont’d)

- **HP2 supported**

- Funded firms are more likely to cooperate with regional than with extra-regional universities, and the same holds true for research institutes: extremely robust result;

- ‘Geographical-proximity’ could actually favour innovation cooperation (Boschma, 2005; Ponds et al., 2007); still, the policy adds extra-regional cooperation too.

- Given the role that this kind of relationship plays in opening-up the RIS (e.g. Hassink, 2005), this is another very welcomed policy result.
### 4.6.3.1. Cooperation with research institutes for additional amounts of policy

<table>
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<th>Treatment Level</th>
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<th>SE</th>
<th>Y=2</th>
<th>SE</th>
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<td>0.141*</td>
<td>0.078</td>
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Standard errors are estimated with a 200-replication bootstrap procedure.

**, **, * indicate a significance level of 1%, 5%, 10%. Critical values of the two sided t-test (df=100): 10% 1.660; 5% 1.984; 1% 2.626
4.6.3.1. Cooperation with research institutes for additional amounts of policy (cont’d)

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Standard errors are estimated with a 200-replication bootstrap procedure.

**, **, * indicate a significance level of 1%, 5%, 10%. Critical values of the two sided t-test (df=100): 10% 1.660; 5% 1.984; 1% 2.626
4.6.3. Extra-regional cooperation for additional amounts of policy

- **HP3:** supported, but with a difference between UNI and RESINS

- **Research institutes**
  - Non-significant treatment effects on $Y = 2$ below 200,000 Euros $\Rightarrow$ fixed costs, indivisibilities and minimum efficient scale of public funding to extend the geographical range of the cooperation;
  - Significantly positive treatments effects on $Y = 2$ above 200,000 Euros (e.g. with $\Delta t = 20,000$, from $+6.4\%$ to $+14\%$) $\Rightarrow$ Increasing policy support to cover the increasing costs of using boundary-spanning alliances
  - Non-significant treatment effects on $Y = 1$ $\Rightarrow$ extra-regional cooperation with research institutes neither substitutive of, nor complementary to regional one... *Are they simply different?*
  - *Mutatis mutandis*, robust results for $\Delta t = 40,000$ Euros.
### 4.6.3.2. Cooperation with universities for additional amounts of policy

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Standard errors are estimated with a 200-replication bootstrap procedure. ***, **, * indicate a significance level of 1%, 5%, 10%. Critical values of the two sided t-test (df=100): 10% 1.660; 5% 1.984; 1% 2.626
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Standard errors are estimated with a 200-replication bootstrap procedure. ***, **, * indicate a significance level of 1%, 5%, 10%. Critical values of the two sided t-test (df=100): 10% 1.660; 5% 1.984; 1% 2.626
4.6.3. Extra-regional cooperation for additional amounts of policy

- **HP3**: supported, but with a difference between UNI and RESINS

- **Universities**
  - As for research institutes, but with a different threshold (180,000 Euros) $\Rightarrow$ fixed costs, indivisibilities, min. efficient scale ...
  - As for research institutes, but with a different impact (from $+5.6\%$ to $+20.4\%$) $\Rightarrow$ Increasing policy support to cover the increasing costs of using boundary-spanning alliances
  - Significantly negative treatment effects on $Y = 1$ (from $-2.4\%$ to $-15.9\%$) $\Rightarrow$ substitution effect between an ‘inward-looking’ and an ‘outward-looking’ cooperation strategy... *Is academic research more similar in ‘breath’ than non-academic one?*

- **Mutatis mutandis**, robust results for $\Delta t = 40,000$ Euros.
5. Conclusions and policy implications

- The PRRIITTT appears an ‘illuminated’ policy-action, supporting intra-regional and extra-regional firms-ROs cooperation in a RIS with an ‘informal learning system’
  - R&D subsidies can induce behavioural additionality effects, which mitigate “system-failures” and enhance the transition towards “Open Regional Innovation Systems”

- Distant industry-research cooperation seems to imply indivisible costs
  - The amount of public support makes a difference, providing it’s above a minimum efficient scale

- The policy can induce the substitution of regional cooperation with extra-regional ones (firms-uni cooperation in our application)
  - Something that policy-maker should consider
Thanks for the attention