International Seminar on the Promotion, Development, Support and Evaluation of Innovation

STI Policies' Impact Evaluation: Results and Trends:

Searching Beyond Average Treatment Effects

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BID

Why Do We Evaluate?

IE is a powerful tool to tackle two critical public policy issues:

I) **To foster accountability and transparency → GEN I**

- To measure effectiveness of intervention
- To inform about the efficiency of the use of public resources

II) **To improve development policies (to learn)→GEN II**

- To test innovative approaches, adopt policy designs that maximize impact
- To guide the allocation of (scarce) public resources

A key concept: The attribution problem

The results that the beneficiaries achieve after participating in the program

vs.

The results that those same beneficiaries would have achieved if they had not participated in the program

Counterfactual

Key elements of an impact evaluation

Main question	To what extent are the observed results due to the intervention?
Empirical problem	The counterfactual is unobservable
Empirical approach	Build an artificial counterfactual through a control group

(1) Experimental methods
(2) Non-experimental methods

What do we want to learn?

	Evaluation questions	Policy implications
I GEN	**Basic Attribution:** Is the project effective in reaching its development outcomes (final and intermediate)?	Renewal or termination of the policy
II GEN	**1. Heterogeneity**: Are the effects different among different categories of beneficiaries?	Targeting of the beneficiaries
	2. Dosage effects: Do the effects depend on the intensity of the treatment?	Dimensioning of the treatment
	3. Dynamic effects: ¿How long does it takes to observe the project's effects and do these effects vary over time?	Identification of possible bottlenecks /Definition of flows of benefits (CBA & CEA)
	4. Multi-treatment: Are the effects different if combined with other interventions? What is the most effective sequence of interventions?	Coordination of public policies
	5. Externalities and spillovers: Does the program produce any positive (negative) externality?	Definition of flows of benefits (CBA & CEA)
	6. Structural effects: Does the program produce any structural of general equilibrium effects?	Definition of flows of benefits (CBA & CEA)

The Basic Attribution Focus

So far most of the empirical evidence on the IE of STI policies has been focused on two issues:

I)Solving the basic attribution problem.

II)The crowding-in / out problem: Do R&D subsidies increase “net” private R&D investment?

But….I) is not enough for policy learning, while II) might be necessary but not sufficient assess a program (relevant questions mostly ignored….: are these supported R&D projects “productive”, do the results of them spillover on non-beneficiaries?

The Basic Attribution Focus

Most of IEs estimate a basic model such as:

$$Y_{ijt} = \alpha_i + \delta T_{ijt} + \beta X_{ijt} + \varepsilon_{ijt}$$

Y_{ijt} is R&D investment (sometimes net) and T_{ijt} is the treatment R&D subsidy or soft credit (0/1).

The model compares the results for beneficiary firms with control non-beneficiary firms which are similar across (Xs) and it follows both groups along time controlling also for non-observables (DID).

If $\delta>0$ we claim that the program has been effective. But …..this tells us nothing on why is effective or how to make it more effective.

The Basic Attribution Focus

Zuniga-Vicente et.al. (2012) carried out a survey of more than 76 studies at the firm level finding that:

Table 2. Summary Distribution of Econometric Studies of the Effect of R&D Subsidies on Private R&D Spending According to the Aggregation Level and Data Source.

Aggregation level	'crowding-in hypothesis'	'crowding-out hypothesis'	Non-significant effects	Total number of studies
Firm or lower[a]	48	15	13	76[b]
	(63.15%)	(19.74%)	(17.11%)	(64.41%)
Based only on US data	10	8	4	22
Based only on EU	33	6	7	46
Based on R. of the W. data	5	1	2	8
Industry	10	5	5	20
	(50%)	(25%)	(25%)	(16.95%)
Based only on US data	4	3	2	9
Based only on EU data	4	1	1	6
Based on R. of the W. data	2	1	2	5
Country	13	3	6	22
	(59.09%)	(13.63%)	(27.28%)	(18.64%)
Based only on US data	6	0	2	8
Based only on EU data	2	1	2	5
Based on R. of the W. data	5	2	2	9
Total number of studies	71	23	24	
	(60.17%)	(19.49%)	(20.34%)	118[b]

The Basic Attribution Focus

Zuniga-Vicente et.al. (2012) carried out a survey of more than 76 studies at the firm level finding that:

- Even when the first studies are from the 60s there is an exponential growth during 2000 suggesting the growing interest on EI.
- Studies used different methodological approaches and data, however they found that.
- In 63% of the cases there is evidence of crowding-in effects, while in 20% of the cases there is evidence of crowding-out and in 17% of the cases there is no evidence at all.

The II Generation of IE Studies

However, we would like to estimate a different model:

$$Y_{ijt} = \alpha_i + \delta_{jt} T_{ijt} + \beta X_{ijt} + \varepsilon_{ijt}$$

Where Y_{ijt} is productivity (or other performance indicator) and the treatment effect can vary across firms, sectors or along time.

Even more we would like to expand the model to test whether the treatment has effects on non-treated firms:

$$Y_{ijt} = \alpha_i + \delta_{jt} T_{ijt} + \delta_{jt}^{S} \bar{T}_{jt} + \beta X_{ijt} + \varepsilon_{ijt}$$

If $\delta^S>0$ one could claim that the program generates spillovers on treated and non-treated firms.

Some Examples

With data from two R&D programs from Chile (INNOVA-CORFO y FONDEF-CONICYT) we seek to answer the following questions regarding the impacts of these programs on productivity:

(I) Are there any dynamic effect? How long does it take to detect any impact?

(II)Is within sector competition more or less encouraging to higher impact?

(III)How should we allocate the grants within a sector? Supporting variate vs. national champions.

(iv)Which policy designs are more favorable to generate spillovers?

(v)Are there any complement between STI and other policies? So, is there any sequence?

(I) The Dynamic Effects of STI Policy

We know that innovation investments are uncertain and require learning, so it is expected that would take time for the results to unfold.

We need also time for within firm diffusion so that innovations might show up on sales or cost reductions.

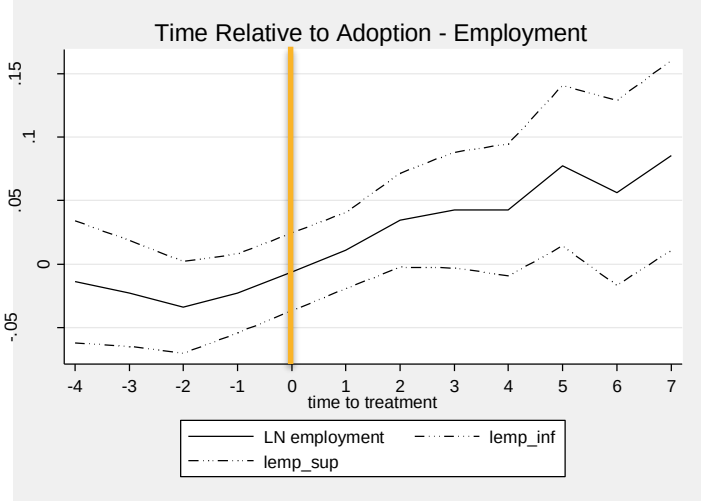
So to tackle this issue Crespi et.al. (2012) estimate the following model:

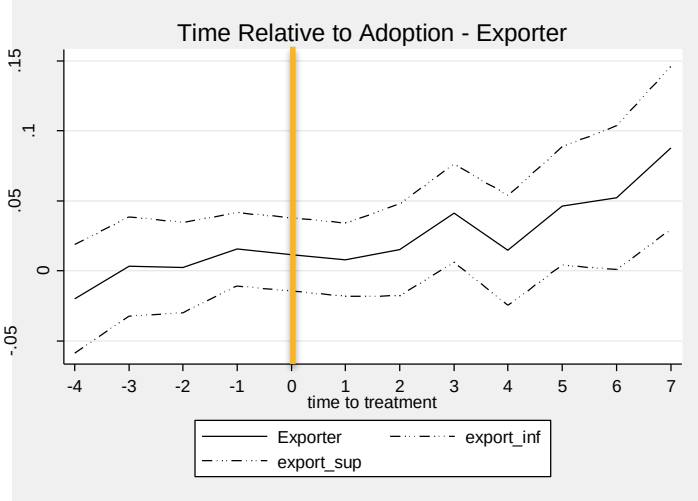
$$Y_{ijt} = \alpha_i + \sum_{\tau=0}^{m} \delta_{-\tau} T_{ij,t-\tau} + \sum_{\tau=1}^{q} \delta_{+\tau} T_{ij,t+\tau} + \beta X_{ijt} + \varepsilon_{ijt}$$

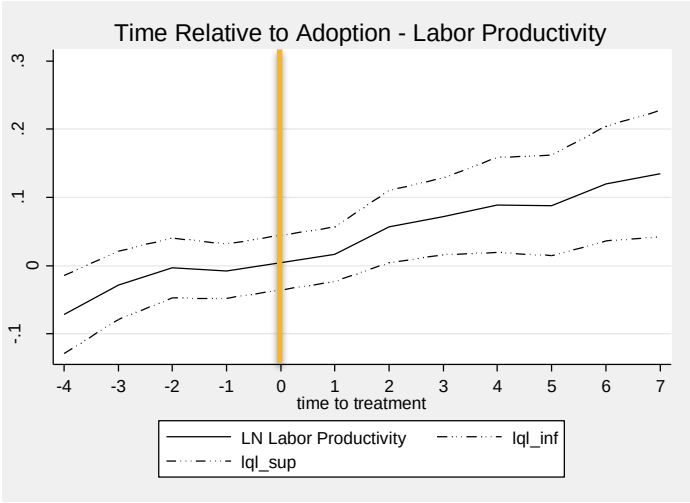
Whe ects (q). Post treatment effects are important to untangle dynamics while anticipatory effects are important to test the validity of the model (we should not expect impacts of the treatment *before* the treatment!!!).

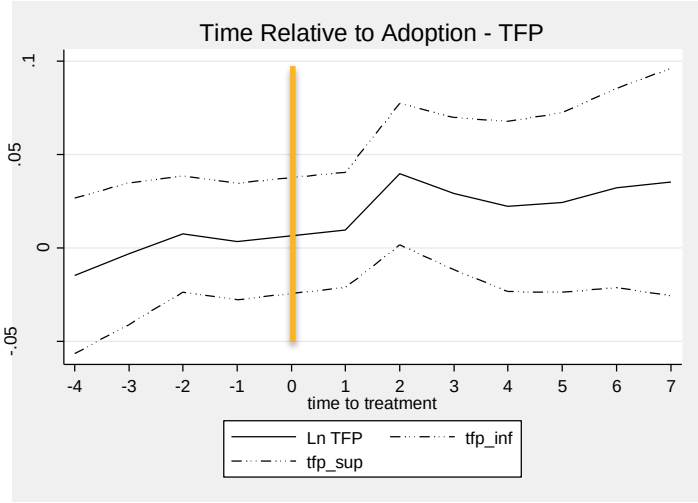
(I) The Dynamic Effects of STI Policy:

Impacts: Employment, Exports and productivity.









(II) STI policy and Competition

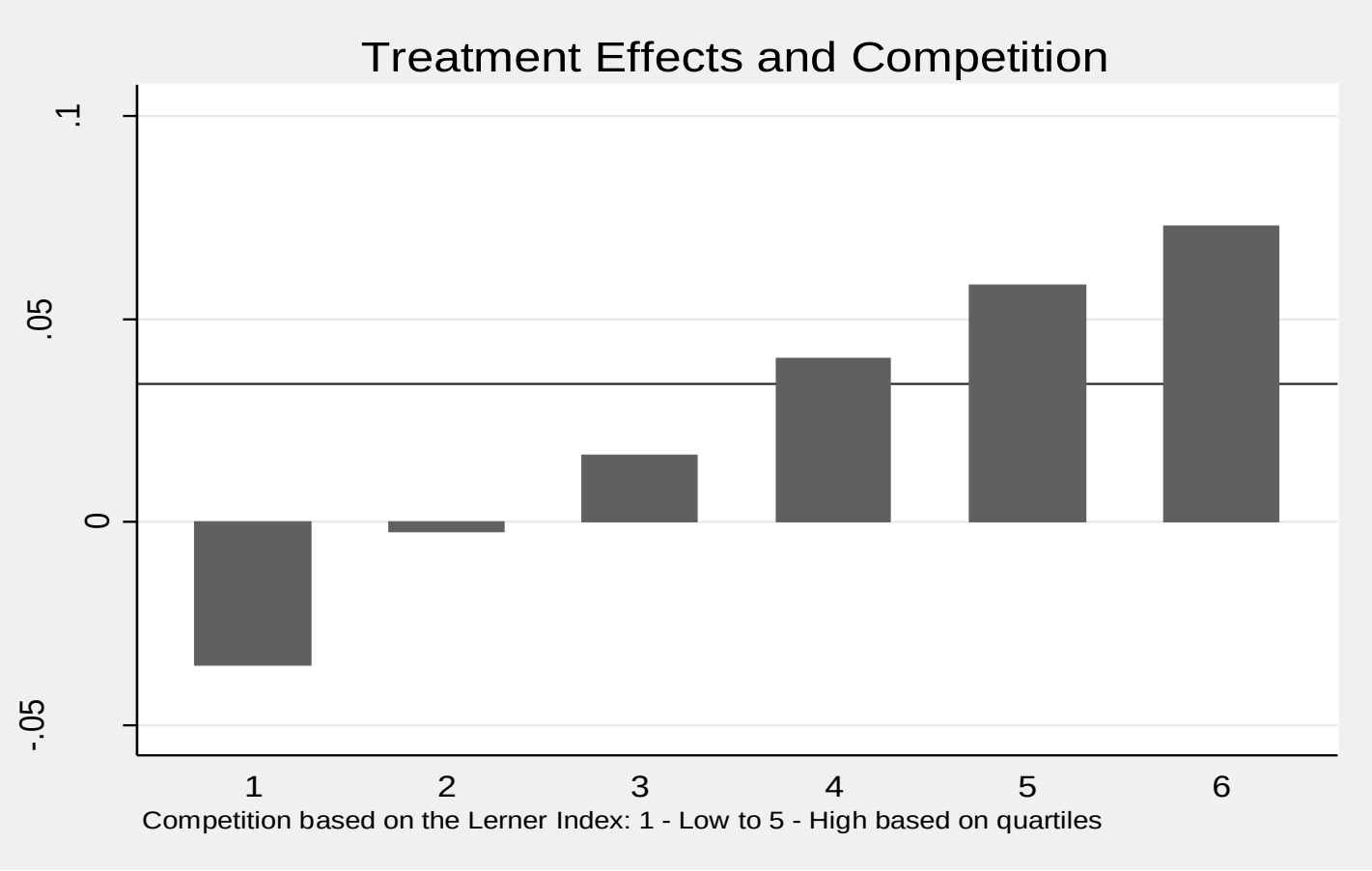
There are plenty of studies on the relationship between innovation and competition (since Schumpeter !!!). Most of them suggest that at least for a certain degree of competition the effects are positive on innovation investments.

However, there is far less evidence on the complementarity between innovation *policy* and competition. Aghion et.al (2013) suggests that innovation policies should be more effective (on productivity) when firms are actually trying to innovate and this is more likely to happen when firms want to "*escape from competition*".

If this conjecture is correct, we should find higher effects in more competitive sectors. So we split the sample in sub-samples according the intensity of competition based on the sector mark-ups (or Lerner Index)

(II) STI Policy and Competition

The flat line is when we estimate the impact in the whole sample (Crespi, et.al. 2014).



(III) Allocating STI policy support

Related to competition, they way how one allocate the support could either favor or could block competition.

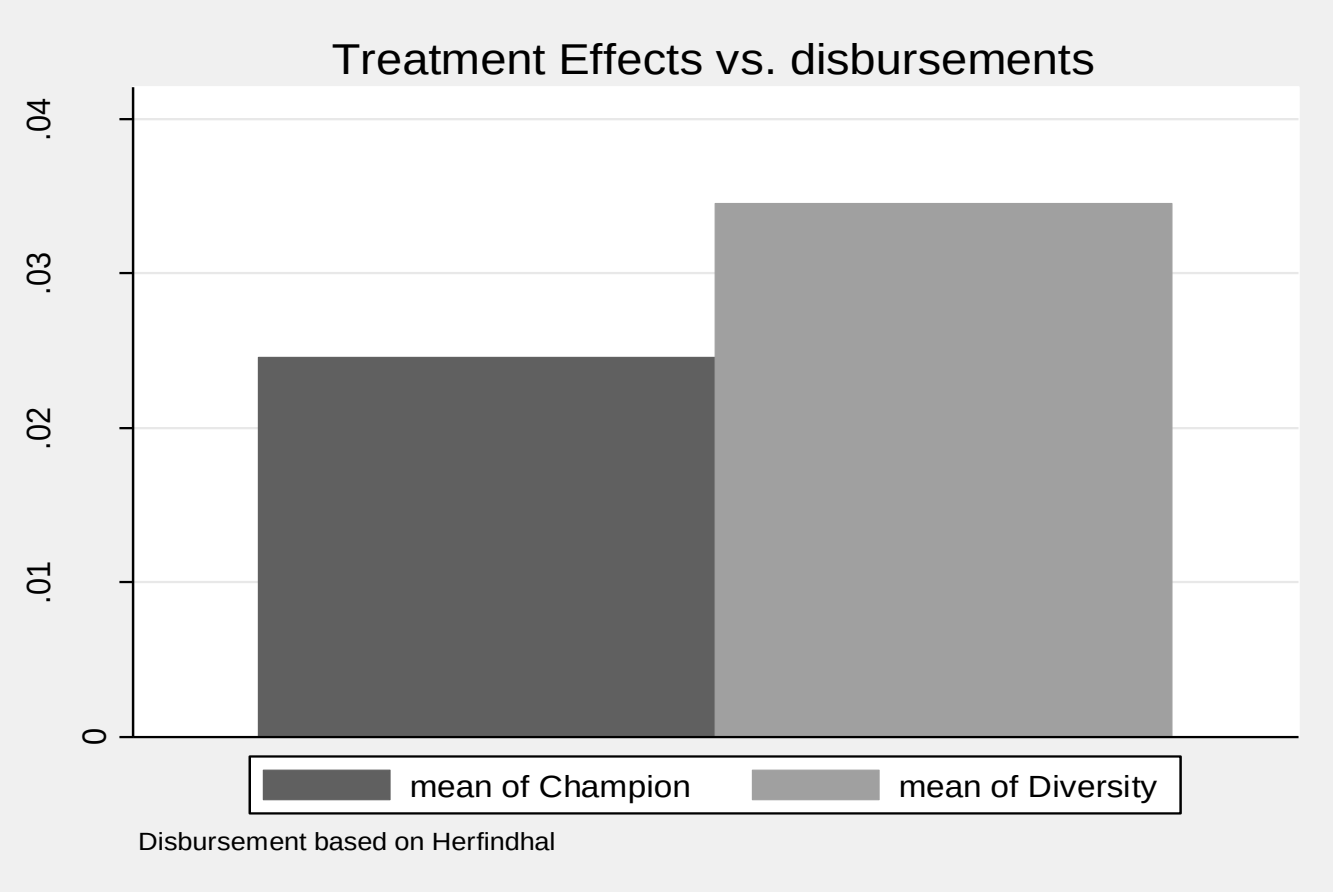
For example, an agency could concentrate the support in a national champion and make it global (so it could accumulate knowledge, scale, etc) but this could distort competition.

On the other hand one could allocate support in a way as to encourage diversity in order to stimulate competition and spillovers but this could lead to fragmentation.

So we compute an index of concentration of subsidies within a sector (at a four digit level) and we split the sample between high concentration (champions) vs low concentration (diversity) sectors and we estimate the model in each one.

(III) Allocating STI policy support

Should we promote champions? Or Should we promote diversity?



(IV) STI policy externalities

Do STI policy correct for externalities? Which program designs are more accurate for this?

Most of the times STI policy, in particular when it takes the form of direct subsidies or tax incentives, is justified due to the presence of spillovers. However, very few studies try to identify these spillovers.

In the case of Chile there are two programs: (a) FONTEC which supports individual firms that carry-out internal R&D and (b) FONDEF which supports university-industry collaboration.

We should expect that knowledge generated in (b) will be more generic, hence less appropriable and more likely to generate knowledge spillovers.

(IV) STI policy externalities

In this case we estimate a model similar to this:

$$Y_{ijt} = \alpha_i + \delta \ T_{ijt} + \delta^S \bar{T}_{jt} + \beta X_{ijt} + \varepsilon_{ijt}$$

Where the treatment is having received a subsidy from any program and the spillovers are geographical being capture by the fraction of firms in the same sector and region that received public support.

Then we augment the model by splitting the treatment into the two programs (and also the spillovers term). So:

$$Y_{ijt} = \alpha_i + \delta_I \ T_{ijt,I} + \delta_I^S \bar{T}_{jt,I} + \delta_F \ T_{ijt,F} + \delta_F^S \bar{T}_{jt,F} + \beta X_{ijt} + \varepsilon_{ijt}$$

Where I means FONTEC and F means FONDEF , the dependent variable is total factor productivity and X capture firm observable characteristics.

(IV) STI policy externalities

In this case we estimate a model similar to this:

Table 3: Direct and spillover effects of innovation programs on productivity

	Total Factor Productivity (TFP)			
	(1)	(2)	(3)	(4)
Treatment	0.0431***		0.0421***	0.0425***
	(0.016)		(0.016)	(0.016)
FONTEC		0.0461**		
		(0.020)		
FONDEF		0.0384		
		(0.024)		
Spillover share			0.0859	
			(0.077)	
Spillover share FONTEC				-0.1055
				(0.110)
Spillover share FONTEF				0.1987**
				(0.099)
Age & Age^2	Yes	Yes	Yes	Yes
Firm effect	Yes	Yes	Yes	Yes
Sector-Year effect	Yes	Yes	Yes	Yes
Region-Year effect	Yes	Yes	Yes	Yes
Number of firms	8,837	8,837	8,837	8,837
Observations	65,648	65,648	65,648	65,648
R-squared	0.937	0.937	0.937	0.937

SE clustered by 4-digit sector in parentheses
*p<.1; **p<.05; ***p<.01

(IV) STI policy externalities

Although the program that finances intramural R&D has the higher impacts on the treated, it is the program that finances R&D collaboration the one that generates higher spillovers.

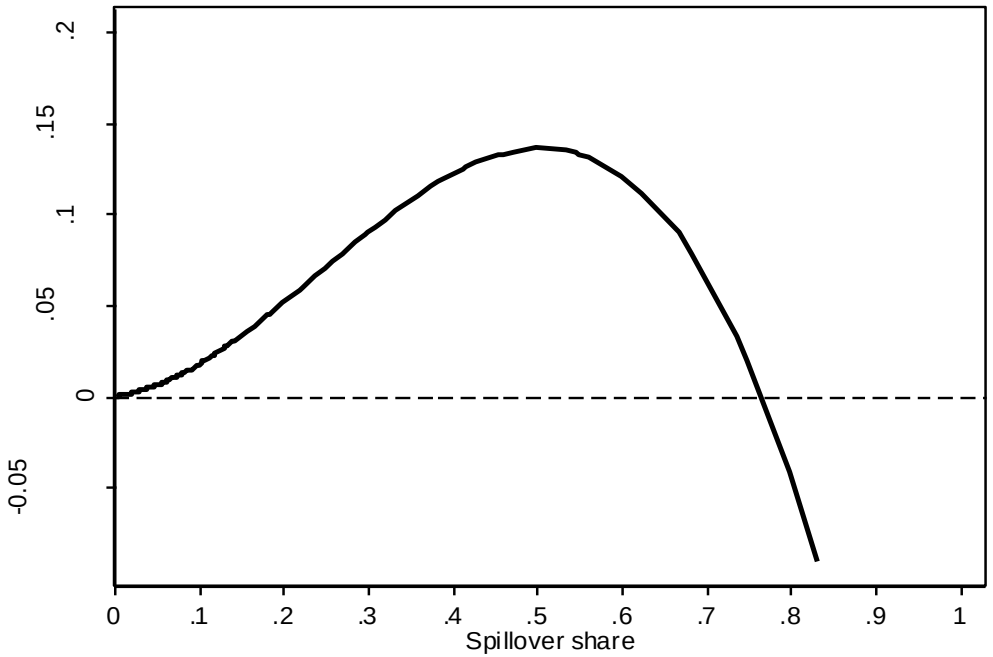
We also explore whether a critical mass of firms is needed in order to generate spillovers. So we approximate the spillovers by a polynomial function. In other words, we estimate:

$$Y_{ijt} = \alpha_i + \delta \quad T_{ijt} + \delta_I^S \bar{T}_{jt,I} + F(\delta_F^S, \bar{T}_{jt,F}) + \beta X_{ijt} + \varepsilon_{ijt}$$

Why spillovers might be non-linear? Because a combination of pure knowledge spillovers and business stealing effects might be in operation.

(IV) STI policy externalities

The non-linear effects of spillovers:



Very small programs in terms of coverage does not generate any spillovers, while very large programs could even harm the performance of non treated firms (business stealing effect, Bloom, et.al. (2013))

(IV) STI policy externalities

The mobility of skilled workers has been identified as a source of knowledge transfer between and within firms.

The FONTAR (*Fondo Tecnológico Argentino*) program has been one of the pillars of Argentina's innovation policy. It has different funding mechanisms:

Matching grants (since 2000): the ANRs target innovation projects with higher risk and less tangible assets.

Credit: the CAEs target technological modernization projects with relatively lower risk and higher tangible assets.

Tax credit: the CF target both innovation and technological modernization projects.

(IV) STI policy externalities

Two sources of data: FONTAR's Administrative records. Administrative data of the Social Security System and Customs managed by OEDE.

Unique dataset:

Matched employer-employee data.

Long panel data with the whole population of firms and employees (1,2 million of firms in the period 1998-2008).

Data on employment, wages, exports, firms' age and type, industry, location, years workers have been in the firm, gender, firm survival.

The data allows to:

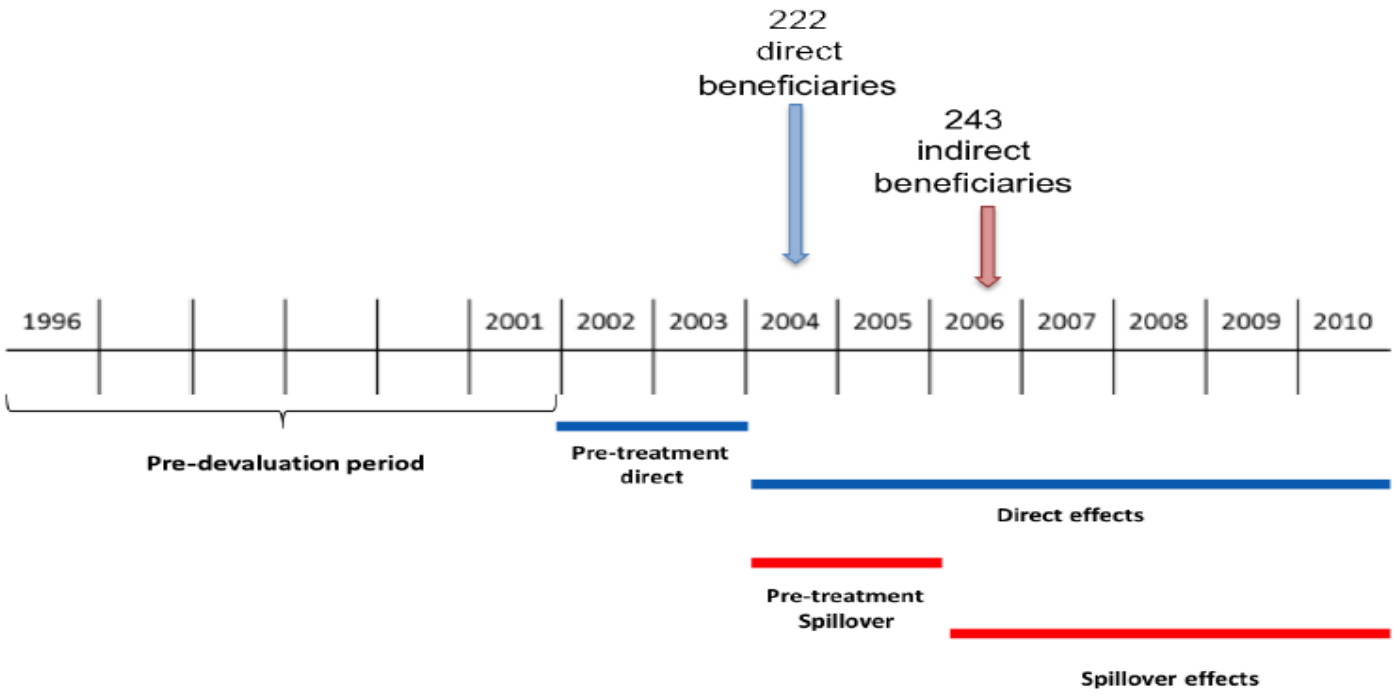
Identify all direct (and indirect) beneficiaries.

Compute various measures of performances.

(IV) STI policy externalities

Direct beneficiaries: treated firms i.e. firms that applied and received support from the FONTAR program in 2004.

Indirect beneficiaries: non-treated firms that in 2007 hired skilled employees (top quintile in the firm wage distribution) that had worked in a firm that received FONTAR in 2004 for at least two years (cohort of interest).



(IV) STI policy externalities

	Employment	Wages	Prob. of exporting	Survival probability
(A) Direct effect				
Average effect	17.2%	6.15%	6.23p%	3.71p%
Dynamic effect ***(6 years window)***	From the third year (22%) to the sixth year (26.5%)	In the sixth year (9.4%)	From the third year (8.45p%) to the sixth year (10.4p%)	From the first year (3.04p%) to the sixth year (3.12p%)
(B) Indirect effect (spillovers)				
Average effect	14.9%	3.57%	4.82p%	0p% (NS)
Dynamic effect ***(3 years window)***	From the first year (17.2%) to the third year (21%)	In the third year (6.27%)	From the second year (5.97p%) to the third year (6.88p%)	0p% (NS)

(V) STI policy in a multi-treatment context.

An important policy space is about the complementarities among innovation policies and “other” policies.

In the case of Chile, (Alvarez, et.al. (2014)) analyzed whether there are complementarities between innovation policies and export promotion policies. Why should we expect complementarities among these policies?

Export promotion policies correct the market failure associated with searching externalities: when firms explore a market and experiment they generate information for other firms that do not bear the cost of experimentation.

In the same extent innovation policies correct for knowledge spillovers.

(V) STI policy in a multi-treatment context

If both failures are present, we should expect complementarities among these two policies. In order words supporting firms with one instrument when two failures are present might no be enough.

However, when multiple treatments are present there is a second problem: which is the right sequencing?

One could deliver both programs at the same time, or one could deliver first innovation support and the export promotion support or otherwise.

In Chile we merge data from FONTEC with data from PROCHILE (the export promotion agency) to see whether there is complementarity and to explore the right sequencing.

(V) STI policy in a multi-treatment context

So we estimate the following model:

$$Y_{it} = \beta_0 + \beta_1 T_{1,it} + \beta_2 T_{2,it} + \beta_3 T_{1,it} T_{2,it} + \beta_4 T_{1,it} T_{2,it-1} + \beta_5 T_{1,it} T_{2,it-2} + + \beta_6 T_{2,it} T_{1,it-1} \beta_7 T_{2,it} T_{1,it-1} + \gamma X_{it} + \delta_1 Y_{it-1} + \delta_2 Y_{it-2} + \varepsilon_{it}$$

Y_{it} means exports, $T_{1,it}$ is export promotion, $T_{2,it}$ is innovation support. The β's capture both simultaneous and sequencing effects.

		Innovation Promotion		
		t	t-1	t-2
Export Promotion	t	-0.056	0.190*	-0.114
		(0.704)	(0.062)	(0.848)
	t-1	-0.025		
		(0.630)		
	t-2	-0.036		
		(0.732)		

Conclusions

Additionally of being a powerful tool for accountability, IE can also be an important support for policy learning. In the examples we have shown, we learned that untangling the complex relationship between innovation support and productivity is not easy, because this relationship actually depends on:

- The time frame of the analysis (never less than 3 years to see any impact).
- The industrial organization of the sector.
- The way how the support is delivered.
- The extent to which the programs promote collaboration.
- The extent to which the programs reach critical mass.
- Policy coordination between productive development policies.

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